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1901-1904.

NATURAL HISTORY

VOL. I.

GEOLOGY

(FIELD-GEOLOGY: PETROGRAPHY)

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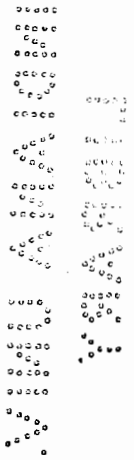

PREFACE.

When, in 1901, the Expedition of the S.S. 'Discovery,' under Captain Scott, R.N., was sent to the Antarctic Regions, the Trustees of the British Museum gave their assistance to this national enterprise by allowing the cases containing the natural history specimens which might be obtained by the Expedition to be sent to the Natural History Museum for unpacking and sorting. They further undertook to publish a detailed report on the collections so obtained, under the superintendence of the Director of the Natural History Departments.

Some of the most important collections have been dealt with by naturalists who were members of the Expedition. Thus, the Mammals and Birds are described by Dr. Edward A. Wilson, the Isopoda and Pycnogonida by Mr. T. V. Hodgson, and the Rocks (in relation to Field Geology) by Mr. H. T. Ferrar. Other groups have been dealt with by members of the staff of the Natural History Departments of the British Museum: Mr. Boulenger describes the Fishes; Mr. E. A. Smith, the Gastropoda, Lamellibranchia, and Brachiopoda; Mr. Jeffrey Bell, the Echinoderma; Dr. Calman, the Crustacea Decapoda, and the Cumacea; Mr. Kirkpatrick, the non-calcareous Sponges; whilst Dr. G. T. Prior has prepared a petrographical description of the Rock-specimens.

It has been necessary to obtain the assistance of other specialists in order to deal with the rest of the collections. So far as the latter group of contributors is concerned, the following is a list of the subject-matters, together with the name of the naturalist who has undertaken the work in each case :—

Embryos of Seals	Dr. Marrett Tims.
Anatomy of Emperor Penguin	Mr. W. P. Pycraft.
Tunicata	Prof. Herdman.
Cephalodiscus	Dr. Ridewood.
Cephalopoda	Dr. Hoyle.
Nudibranchs and Pteropods	Sir Charles Eliot, K.C.M.G.
Polyzoa	Mr. H. W. Burrows.
Eggs and Young of Asterias	Prof. MacBride.
Amphipoda	Mr. A. O. Walker.
Schizopoda	Mr. Holt.
Nebaliæ	Dr. J. Thiele.
Ostracoda	Prof. Brady.
Copepoda	Dr. Wolfenden.

Cirripedia	Prof. Gruvel.
Myzostoma	Prof. v. Graff.
Acari	Dr. Trouessart.
Collembola	Prof. Carpenter.
Polychæta	Prof. Ehlers.
Gephyria	Mr. A. E. Shipley.
Chætognatha	Dr. Fowler.
Nemertines	Prof. Hubrecht.
Free Platyhelminthes	Mr. F. F. Laidlaw.
Cestoda	Mr. A. E. Shipley.
Nematoda	Dr. v. Linstow.
Zoantharia	Mr. Clubb.
Alcyonaria and Pennatulida	Prof. Hickson.
Hydromedusæ	Mr. E. T. Brown.
Calcareous Sponges	Mr. Frewen Jenkin.
Radiolaria	Mr. Lewis H. Gough.
Mosses	M. Jules Cardot.
Lichens	Mr. Darbishire.
Algæ (Marine)	Mrs. Gepp.
Algæ (Fresh-water)	Dr. Fritsch.
Algæ (Calcareous)	Dr. Foslie.
Phytoplankton	Dr. Lewis H. Gough.

The work of securing the assistance of these specialists and of distributing the collections has been performed by Mr. Jeffrey Bell, of the Zoological Department, who has also acted as sub-editor of the Zoological and Botanical portions of the reports. The Keeper of Minerals, Mr. Fletcher, has superintended the reports in the subjects belonging to his department.

The Director desires to acknowledge the ability and energy which have been brought to bear on the preparation of the Zoological reports by Mr. Jeffrey Bell. Owing to his care, the reports have been got ready by the various contributors and published within a reasonable time after the return of the 'Discovery' from the Antarctic Regions. Neither trouble nor expense has been spared in order to render the illustration and presentation of the Natural History of the Expedition worthy of the generous efforts both of Captain Scott and his fellow-explorers and of those who provided the funds for that enterprise.

E. Ray Lankester.

October, 1906.

PREFACE TO VOLUME I.

THE mineral-specimens collected during the 'Discovery' Antarctic Expedition being virtually all of them rock-specimens, their importance depends, not merely on their own characters, but on the mutual relations of the masses which they represent; in these circumstances, a Report descriptive of the specimens themselves can be of little scientific value unless preceded by an account of the rock-masses of which they have formed part.

Mr. H. T. Ferrar, Geologist to the Expedition, had lived in the region and collected nearly all the specimens, and was obviously the one to be invited to prepare a monograph of the Field-geology. Fortunately he was able to accept the invitation, and to submit the manuscript of his Report before leaving England to take up an appointment on the Geological Survey of Egypt.

The scientific description of the specimens was entrusted to Dr. G. T. Prior, Assistant in the Mineral Department, who had already examined and described the mineral-specimens collected during the 'Ross' and the 'Southern Cross' Antarctic Expeditions.

The points regarded by the authors as deserving special attention are conveniently indicated in the respective Summaries (pp. 98, 139).

The elaborate Index to the volume has been made by Dr. Prior.

It has been my duty, as Keeper of the Mineral Department, to supervise the preparation and publication of these Reports, but the scientific part of the work has been done entirely by the respective authors.

L. FLETCHER.

MINERAL DEPARTMENT,
BRITISH MUSEUM (NATURAL HISTORY),
May 1, 1907.

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REPORT ON THE FIELD-GEOLOGY

OF THE REGION EXPLORED DURING THE

'DISCOVERY' ANTARCTIC EXPEDITION, 1901-4.

By H. T. Ferrar, M.A., F.G.S., *Geologist to the Expedition.*

Chapter I.

ISLANDS, CHIEFLY OFF THE COAST OF SOUTH VICTORIA LAND.

The part of South Victoria Land known to us consists of a great range, or series of mountain-ranges, stretching in an almost straight line from latitude 71° S. to lat. 82° S., a distance of about 800 miles. Some of the mountains rise to a height of 13,000 feet, and it is remarkable that there is no extensive area of land lower than 4000 feet. Off this bold coast-line is a shallow sea (Ross Sea), with occasional islands arranged along a line roughly parallel to the coast and close in under it.

The earliest specimens brought back from the Ross Quadrant were those obtained by Captain Balleny in the year 1839 from the Balleny Islands. Shortly afterwards the 'Erebus' and 'Terror' Expedition under Sir James Clarke Ross brought back rock-specimens from other outlying islands, and until the year 1895 no additional specimens of Antarctic rocks were obtained from this area. It was also known that (1) the Balleny Islands are volcanic, one of them possessing an active volcano; (2) South Victoria Land consists of a great range of mountains probably volcanic,* and with at least one volcano still active. The specimens include scoriæ and olivine-basalt from Young Island, one of the Balleny group,† basalts, palagonite-tuffs, and granites from the largest of the Possession Islands, and basalt from Franklin Island, one of the isolated islands off the coast.‡

A French expedition contemporary with that of Ross also obtained granites § from

* Ross, 'Voyage in the Southern and Antarctic Regions, 1839–43,' 1847, vol. ii, p. 415.
† 'The Antarctic Manual' (Roy. Geogr. Soc.), 1901, p. 341.
‡ Prior, Mineralogical Magazine, 1899, vol. xii, p. 91.
§ 'The Antarctic Manual' (Roy. Geogr. Soc.), 1901, p. 449.

low rocky islets lying off the coast of Adélie Land, and these strongly suggested the existence of a continental mass of land.

The fact that blocks of gneiss and granite, probably dropped from icebergs, were dredged up in high southern latitudes during the 'Challenger' expedition was also regarded as evidence of the existence of a continent. Fragments of mica-schists, sandstones, limestones and shales, were also dredged up at the same time.* This fact was sufficient to render it extremely probable that sooner or later fossiliferous sedimentary rocks would be discovered.

In the year 1895 Mr. BORCHGREVINK obtained schistose and granitic rocks from Cape Adare.

The 'Southern Cross' collection described by Dr. PRIOR† includes various plutonic and volcanic rocks as well as siliceous slates, the latter being apparently the first sedimentary rocks found *in situ* in South Victoria Land. The slates are noted as occurring at the head of Robertson Bay. These slates are directly covered by the basalts of Cape Adare on the east, and they have been followed northward along the coast for some five miles.

The islands may be conveniently considered in the order of increasing latitude, commencing with the Balleny group near the Antarctic circle.

BALLENY ISLANDS.

This group consists of five islands lying between longitudes 161° E. and 165° E., and latitudes 66° S. and 68° S., that is to say, about the Antarctic circle. They were discovered by Captain BALLENY in 1839. He brought back specimens from Young Island, and reported the presence of an active volcano on Buckle Island, a report afterwards confirmed by the 'Southern Cross' Expedition.‡

Rowe Island, the most northerly of the group, was very distant from the 'Discovery's' track. Balleny remarks that it is low and offers no remarkable feature.

Young Island, one of the largest, is roughly 10 miles long and 5 miles broad, and, according to BALLENY, is the highest. It rises to an estimated height of 12,000 feet. It is girt by a high cliff and has the form of a terraced cone. The rock-specimens collected here in 1839 were the first obtained from what is now known as the Ross Quadrant. They "prove to be scoriæ and basalt with crystals of olivine."§

Borradaile Island is about 500 feet high and 2 miles long, and, like the others, is bounded by vertical cliffs.

* See also 'Nature,' 1898, vol. lvii, p. 420.
† Prior, Rep. 'Southern Cross' Collections (British Museum), 1902, p. 325.
‡ 'The Antarctic Manual' (Roy. Geogr. Soc.), 1901, pp. 499, 500.
§ 'The Antarctic Manual' (Roy. Geogr. Soc.), 1901, p. 341.

Buckle Island, which bears the active volcano, is probably 15 miles long. The surrounding cliff varies from 100 to 1000 feet in height, while above it the land rises as a dome to a height of about 4000 feet. The volcano is situated on the north end, which is otherwise low and flat.

Sturge Island (Fig. 1) is about 20 miles long and 7 broad, and rises to a height of over 10,000 feet. It is claviform and smooth in outline, and appears as an elongated dome surrounded by a rock-cliff which varies from 1000 to 3000 feet in height. At the north end are seen roughly parallel irregular lines, dipping at an angle of about 15° to the west. Approximately parallel to them are numerous conspicuous lenticular bands of light-yellow colour. The soundings in this area are uniform over great

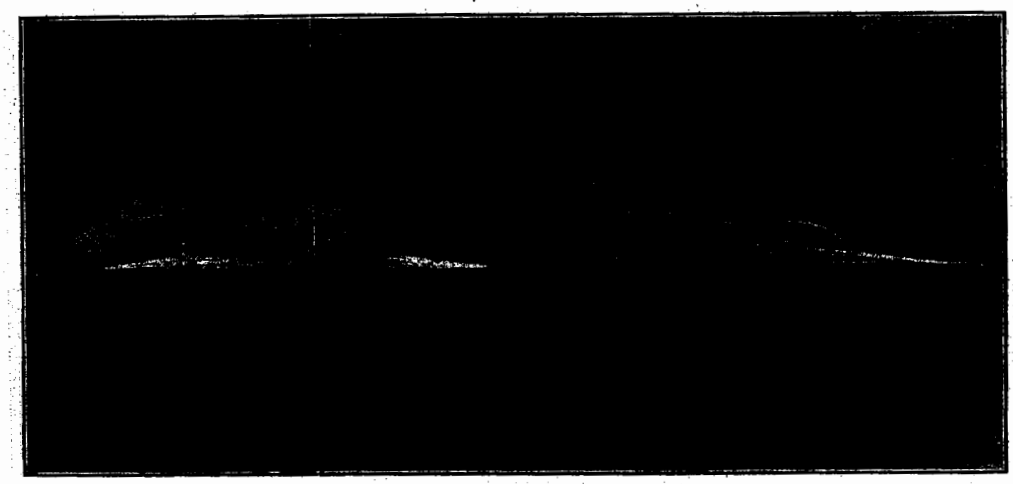


FIG. 1.—STURGE ISLAND, BALLENY ISLANDS, SHOWING TRANSITION FROM "PIEDMONT-AGROUND" TO "PIEDMONT-AFLOAT."

distances, ranging from 260 to 270 fathoms. The sea-bottom is covered with a mixture of rock-flour (902)* and ice-scratched stones (866),* including fragments of dolerite and micaceous schists (see pp. 135 and 139).

SCOTT ISLANDS.

The Scott Islands were discovered by Captain COLBECK in December, 1902,† and are flat-topped rocky islets, which rise 300 feet sheer out of the shallow sea. The smaller is practically an isolated pillar (Haggitt's Pillar), while the larger is about two miles across. Mr. J. D. MORRISON landed on the larger island and collected specimens of a trachytic rock (see p. 114) regarding which he gave the following information:—"No. 1 was taken from the south-east side, lat. 67° 24·5′ S., long. 179° 55·5′ W.,

* The numbers refer to the author's List of Specimens.
† Colbeck, Geog. Journ., 1905, vol. xxv, plate, p. 402.

being broken off the highest accessible point, about 12 feet above water-level. The strata seemed about 2 feet thick, dipping to the south-east side at an angle of 45°, striking S.W. and N.E."

The Possession Islands.

This group consists of two large and five small islands, close under the highest peaks of South Victoria Land and about 5 miles off shore and a little north of the 72nd parallel of latitude (Fig. 2). They were discovered by Sir James Clarke Ross in 1841, when a landing was made and rock-specimens were collected. They include basalts, palagonite-tuff, phonolite, and fragments of granite, but the latter were probably not found *in situ*.* Mr. C. E. Borchgrevink and Captain Jenssen both landed here in

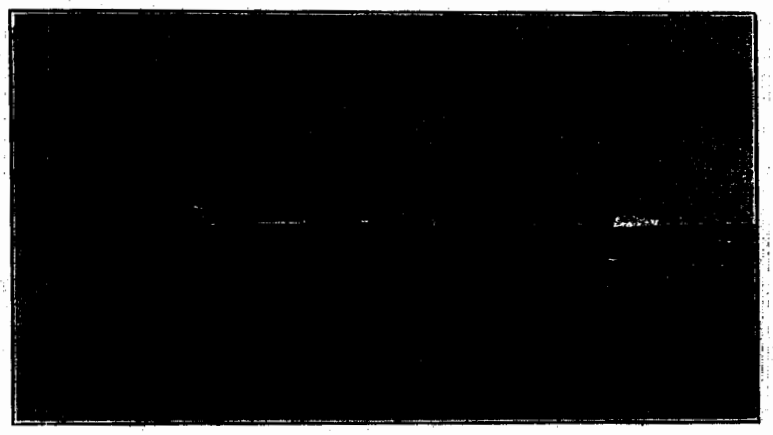


Fig. 2.—Two of the Possession Islands.
The taller one shows the junction of two types of rock.

1895, and collected rock-material. The specimens brought back by the former have been described by Messrs. T. W. E. David, W. F. Smeeth and J. A. Schofield.†

In December, 1902, Mr. Morrison, landing from the relief ship 'Morning,' collected rock-specimens. He obtained only two types of rock *in situ*: one (No. 2) is a palagonite-tuff and the other (No. 3) a grey hornblende-basalt. He gave the following information relative to them:—"No. 2 was taken from the south-west shore of Possession Island, 18 feet above water-level, lat. 71° 56′ S., long. 171° 10′ E. There are no signs of stratification, but there is a very distinct vertical line-of-parting between the rocks forming Nos. 2 and 3. No. 3 was taken from a piece of ice floating close in shore on the S.S.E. side. The cliffs are about 150 feet high and overhanging."

From the view seen from the deck of the 'Discovery,' it would appear that the higher part is composed of palagonite-tuff, and the south side, ending in a bold cliff 300

* Prior, Mineralogical Magazine, 1899, vol. xii, p. 75.
† Journ. Roy. Soc., New South Wales, 1895, vol. xxix, pp. 461–492.

feet high, of basalt. This island, the largest of the group, is 2 miles long in a north-and-south direction. The landing place is at the northern end, which is low, flat and prominently terraced. The next largest island may be a mile across: like the first it has vertical sides. Of the other islands, three are flat-topped, about a quarter of a mile in diameter, and 50 feet high. They appear to be roughly rectangular in shape, and have bare vertical sides. A fourth forms an isolated pillar appearing to be made up of vertical columns, while a fifth is less than a quarter of a mile across and over 100 feet high. This last shows an uneven junction of two rocks at about 50 feet above the sea (Fig. 2). The distribution of snow would seem to show that the rocks are tuff and basalt, the tuff being uppermost. The junction is irregular, but on the whole slopes from west to east, away from the high land.

FIG. 3.—EAST SIDE OF COULMAN ISLAND, SHOWING THE HORIZONTAL STRUCTURE OF THE ROCKS, AND THE "PIEDMONT-AGROUND" WHICH SURROUNDS THE ISLAND.

COULMAN ISLAND.

This island is situated in latitude 73½ S., longitude 170° E. It was discovered by Sir JAMES CLARKE ROSS, but the first rock-specimens were brought back by the 'Southern Cross' expedition; they were determined to be hornblende-basalt and basalt-agglomerate,* but no details were given as to the distribution of the rocks. Here also the land is characterised by bare rock-cliffs more than 1000 feet high, which fall sheer away to the sea. The island has an even outline. Its top is nearly flat at Cape Wadworth, the north end, but at the south end rises to nearly 3000 feet. It is about 20 miles long, and averages 7 miles in breadth. Cape Anne, the south end, terminates in a bare cliff over 2000 feet high. It shows chrome-yellow patches in several places,

* Prior, Rep. 'Southern Cross' Collections (British Museum), 1902, p. 322.

and, by analogy with the yellow lenticular patch of basalt-agglomerate (82) at Cape Wadworth, we may infer that the south end is also partly of the same rock. As the yellow patches lie almost horizontally it is highly probable that the island consists of alternating sheets of basalt and basalt-agglomerate (Fig. 3).

In addition to bedding-planes visible near Cape Wadworth, there are dykes running vertically up the cliffs. Among the specimens collected by the 'Discovery' from this Cape, there are basalt-scoria (80), basalt-agglomerate (82), and a basalt (81) obtained from a dyke standing out on the cliff-face. Such dykes do not reach the top of the cliff but, after extending some way up a steep slope, end off at the base of the agglomerate. Only a quarter of an hour could be allowed on shore, but as the ship steamed into Lady Newnes Bay quite similar structure-lines were seen on the west side of the island and on the mainland (Cape Jones), areas which were possibly at one time continuous. The distribution of snow on the west side of the island points to gentle folding of the rocks about an east-and-west axis, but soundings of over 150 fathoms in the channel show no continuation of this fold towards the west.

Franklin Island.

Franklin Island is situated in latitude 76° 8′ S. and longitude 168° 12′ E., and until the 'Southern Cross' Expedition this was the most southerly land from which rock-specimens had been obtained. The island was discovered by Sir James Clarke Ross, who gave its length as 12 miles and its breadth as 6 miles. He described its north side* as a line of dark precipitous cliffs between 500 and 600 feet high, exposing several longitudinal broad white bands and two or three bands of a red-ochre colour. The specimens he collected are all basalts of one type,† while in the 'Southern Cross' collection there is a specimen of magma-basalt (limburgite) remarkable for the number and large size of the olivine-enstatite nodules.‡

From Mr. J. D. Morrison of the 'Morning' five specimens of similar magma-basalts with olivine-enstatite nodules were received; with them was the following note:—"Nos. 4 and 5 were taken from Franklin Island, from a belt of rock about 30 feet thick running horizontally along one side about 300 feet above sea-level. Height of hill about 700 feet; very difficult to ascend, as the slope is composed of small stones lying at an angle of about 45°. Nos. 6 and 7 were broken from a large boulder lying at the foot of the hill. The beach is about half a mile broad and a mile long, almost flat and about 10 feet above sea-level. Large boulders and heaps of shingle are scattered over the beach, which is on the south-west corner of the island."

* Ross, 'Voyage in the Southern and Antarctic Regions, 1839–43,' 1847, vol. i, p. 215.
† Prior, Mineralogical Magazine, 1899, vol. xii, p. 79.
‡ Prior, Rep. 'Southern Cross' Collections (British Museum), 1902, p. 328.

Beaufort Island.

This island lies in latitude 77° S., longitude 167° E., and about 12 miles off Cape Bird, which is the north extremity of Mount Erebus. Sir James Clarke Ross described it as small and conical;* we saw it from many points of view and estimate its length to be 5 miles, its breadth 2 miles, and height 1000 feet. It has a rugged outline, with a very steep snow-covered slope on the west side and a bare precipitous cliff on the east side. Its summit is a narrow ridge running north-and-south. No specimens have been obtained from this island.

Table of Distances.

A brief table which shows roughly the distances between some of the volcanoes and islands will not be out of place here.

Mount Erebus	to	Cape Horn	3000 miles
„	„	to Mount Haddington (Swedish Expedition)	2500 „
„	„	to Mount Gauss (German Expedition)	1600 „
„	„	to Tongariro (an active volcano in New Zealand)	2600 „
„	„	to Buckle Island Volcano	720 „
„	„	to King Edward VII Land	500 „
„	„	to Cape Adare	420 „
„	„	to Mount Longstaff	380 „
„	„	to Possession Islands	375 „
„	„	to Coulman Island	260 „
„	„	to Mount Melbourne	200 „
„	„	to Franklin Island	90 „
„	„	to Mount Discovery	70 „
„	„	to Mount Terror	25 „

* Ross, 'Voyage in the Southern and Antarctic Regions, 1839–43,' 1847, vol. i, p. 217.

Chapter II.

THE ROSS ARCHIPELAGO.

This group of islands includes practically all the land within 50 miles of the 'Discovery's' winter quarters, and is the most extensive area not directly joined to the mainland. The group is important because it has long been a centre of volcanic activity, which continues even to the present day.

Ross Island.

Ross Island is practically made up of the volcanic cones, Mounts Erebus and Terror, Cape Bird (Mount Bird, as it may be called), and another convex dome, Mount Terra Nova, lying between Mount Erebus and Mount Terror. This island therefore consists of four distinct volcanoes, and of these the greatest, Mount Erebus, is still active. This mass of ejected material lies between latitudes 77° 9′ and 77° 49′ S., and longitudes 166° 8′ and 169° 10′ E. It forms an island having roughly the shape of an equilateral triangle with a side of 50 miles.

Soundings in the waters around this island are unfortunately incomplete, but the few that we have would seem to show that the depth is greatest close to the shore and decreases gradually outwards. Whether or not this anomalous deepening is due to overweighting of the crust by so many huge volcanic piles close together is not clear, but the occurrence is suggestive.

Mount Erebus (Fig. 4) is 12,922 feet high, and was active when seen by Sir James C. Ross in 1841, "emitting flame and smoke in great profusion." * During our two years' stay in Winter Quarters at its base the snow was always white and continuous to the summit, and only steam was ever seen to be erupted. On three sides the mountain rises directly from sea-level, and has flowing convex curves, which give it a very massive and undenuded aspect. Three stages in its history appear to be recorded in its contours. Of these the first was by far the most violent, and produced a cone with crater about 8 miles in diameter. The walls of this still stand, and encircle it as a girdle about 6000 feet above sea-level. In profile, on the north side this ring appears as a strong outstanding crag, and is separated from the mountain-side by a deep notch, while on the south side there is only a mere shoulder to interrupt the regular convex curve. The second stage is rendered evident by the existence of the lip of a later crater at a height of nearly 11,000 feet. Old lava-streams from it, swept bare of snow, can now be seen. The latest stage is recorded by the present small cone, which has been built up asymetrically within the second, and from this steam now issues. Dr.

* Ross, 'Voyage in the Southern and Antarctic Regions, 1839–43,' 1847, vol. i, p. 216.

WILSON has recorded five or six other steam-jets issuing from the north-east side, but from the ship it was unusual to distinguish more than two. Mount Erebus bears a very striking resemblance to Mount Etna as shown in VON WALTERSHAUSEN'S picture,* and is much more dome-like than is suggested by the published pictures of the better-known active volcanoes.

Owing to the difficulty of access, few rock-specimens could be obtained from Mount Erebus itself. Specimens, however, were got from the following localities: (a) *The Turk's Head*, a bare cliff which rises sharply from the sea to a height of about 300 feet on the south-west side of the mountain. Mr. Hodgson tells me that the tuffs which build up this headland are exposed for a length of about 200 yards along the shore, are bedded, and dip to the north-west at an angle of nearly 40°. (b) *Cape Royds*, a promontory on the west side of Mount Erebus, having an area of about 3 square miles. This area is bare of snow, and consists of dyke-outpourings of basalt with lenticular crystals of felspar (818) (leucite-kenyte, see p. 111). The Cape is rectangular in shape and displays many outstanding dykes which rise to heights of 200 and 300 feet, but are now being rapidly disintegrated. A similar, but vesicular, rock (lava) (820) forms a small knoll, 1500 feet up this side of Mount Erebus, but, as the rest of the surface was covered with snow, no relations between these rocks could be made out. (c) *Cape Barne*, the bare rocks which lie about 3 miles south of Cape Royds and are separated from the latter by a shallow bay. The Cape consists of black vesicular basalt-lava (813) which dips to the west away from Mount Erebus. The extreme end of the Cape is a pinnacle rising 200 feet sheer from the sea, and is separated from the main mass of the Cape by a scree which prevents the junction of the vesicular rock and the basalt-agglomerate (815) of the pinnacle being seen. (d) *The Skuary*, an area of bare land, between Cape Barne and the Turk's Head. This is about 2 square miles in extent, and except along the shore, where rock *in situ* is visible, is covered by moraines. The moraines include fine tuffs (808) and a compact, grey alkaline-basalt or kenyte (812) containing parallel lenticular crystals of felspar. Below them, and extending to the shore, vesicular glassy basalt-rock (811) of the same character is seen *in situ*. This last is over 100 feet thick, and appears to consist of

FIG. 4.—CASTLE ROCK AND MOUNT EREBUS.

* Scrope, 'Volcanos,' 2nd edit., 1862, p. 190, fig. 48.

successive lava-flows laid horizontally one upon another. These rocks are similar in character to the lavas with lenticular felspars of Cape Royds, and are also related to the rocks of the neighbouring Dellbridge Islands, to be considered later.

Mount Bird is a flattened dome over 3000 feet high and, like Mount Terra Nova, which attains a height of about 7000 feet, is an undenuded volcanic cone. No specimens have been obtained from either of these mountains.

Mount Terror (Plate I) is a quiescent volcano 10,750 feet high. It forms the eastern part of Ross Island, and, though not quite so high as Mount Erebus, covers almost as great an area. Its base is circular and has a diameter of perhaps 20 miles; its surface is almost completely snow-covered. On the south side the covering is so thick that no parasitic vents, if present, could be distinguished. On the north side, especially above Cape Crozier, is the largest area of rock-exposure, and here all eminences which have been examined were of the nature of subsidiary surface lava-flows. Some of these are quite conspicuous, and from them many specimens have been collected.

Fig. 5.—Cape Crozier and Mount Terror.

The 'Southern Cross' Expedition* obtained hornblende-basalts from a bare rock-cliff 10 miles or so to the west of Cape Crozier, and from the red and yellow "blazes" that occur in this cliff it would seem that basalt-agglomerate is also present. From the cones on the east side of the mountain above the Great Ice Barrier of Ross, Dr. Wilson collected basalt-scoriæ (824) and limburgite (825) and proved the cones to be due to subsidiary eruptions. From the bare rock-cliffs (Crozier Cliffs), against which the ice-sheet abuts, Dr. Wilson also collected rock *in situ*. His specimens are of two kinds: (1) columnar basalt (830 and 848), which forms the mass of the cliffs and reaches a height of 800 feet above sea-level; and (2) a yellow trachytic rock (831), occurring in irregular lenticles in the mass of the cliff. At one spot a rough stratification was observed, and it is possible that stratified tuffs are there developed.

From a locality he termed the *V-Cliffs Hogsback*, Mr. Hodgson collected specimens of coarse yellow tuff (783), red vesicular basalt (778) and a basaltic bomb (776). This locality is on the south-east side of Mount Terror, 20 miles south of Cape Crozier and 30 from the ship. It is one of two exposures which have been found on

* Prior, Rep. 'Southern Cross' Collections (British Museum), 1902, p. 322.

the south side of the mountain. The other exposure has been termed the *Sultan's Head*, and Mr. Hodgson here obtained some bedded yellow tuffs (785 to 793), also some fragments of vesicular basalt (795).

At *Cape Crozier* (Fig. 5) itself, at sea-level, a stratified palagonite-tuff (228 to 230) was seen bedded parallel to the present slope of Mount Terror and dipping to the west beneath a basaltic lava-flow. This tuff is brown in colour and is very friable, crumbling easily into rounded pellets about an eighth of an inch in diameter. The surface of the rock was whitened by crystallisations of hydrated sodium sulphate (glauber salt). Bombs and a great variety of volcanic rocks, also granites (197), dolerites (210) and sandstones (214), were found lying about at this height, but these were usually ice-scratched (186). A boss about 900 feet high appears to be a pipe or plug of some now defunct volcanic vent; the rock (176) is a limburgite containing red and green olivine-augite nodules. A rounded knoll of trachyte (224), half a mile east of this boss, attains a height of 1400 feet. Black pebbles of glassy basalt (217, 218, 219), quite similar to the majority of the pebbles composing the terraces a short distance lower down the hill, were scattered all over the surface of this trachyte-dome, and appeared to have been included in it, but in the short time allowed on shore no trachyte actually enclosing basaltic pebbles was met with. On the south side, the 900-foot boss of rock mentioned above adjoins a mass of yellow tuff (231) through which a grey green trachytic rock (188, see p. 114) seems to have been forced. From the ship many other parasitic vents were seen on the slopes of Mount Terror, but were not visited.

The Winter Quarters.

Winter Quarters were taken up near the end of a long peninsula which juts out southward from the base of Mount Erebus in latitude 77° 51′ S., longitude 166° 45′ E., and in this district not much information could be obtained relative to the general geological history of South Victoria Land (Plate II). The peninsula is 10 miles long by 2 miles broad, and has an average height of 700 feet. It is entirely composed of recent volcanic rocks, and only about four of its twenty square miles are free from snow.

At *Hutton Cliffs*, a stratified basalt-tuff occurs as a cliff 500 feet high. This tuff-cliff is quite isolated, and is divided into two parts by the snow which falls over the cliff as a small glacier. The northern part (452–457) is composed of rather coarse tuff and is more definitely stratified than the southern (458–462); but for each mass the dip is the same, and is about 60° to the north-north-west. The rock consists mainly of fragments of vesicular basalt-glass and varies from yellowish-green to almost black in colour, but some of the hand-specimens have reddish bands of palagonite, and others have incrustations of calcium carbonate. These cliffs are about 5 miles distant from Castle Rock and 10 miles from the Turk's Head.

The *Sulphur-Cones* lie on the north side of the peninsula at the foot of Castle Rock and at a distance of three miles from the ship, and are so called because native

sulphur was found scattered over their surfaces. They rise 50 to 100 feet above the ice, and consist of black hornblende-basalt and olivine-basalt (382–386, see p. 103) which have apparently filled up volcanic necks now undergoing rapid denudation. The sulphur (379) is found thickly distributed over the surface of the frost-riven rock and is sometimes in quite perfect crystals.

Castle Rock (Fig. 4), 3 miles distant from Winter Quarters, rises to a height of 1400 feet as a bold crag. It is surrounded by vertical cliffs 400 feet high. On the south the foot of the crag is snow-covered, but on the north the land falls sheer away for 1000 feet. On the east and west sides black basalt can be seen forming the lower part of the crag, which consists above entirely of palagonite-tuff (380). The tuff varies much in texture; sometimes it consists of yellow and black angular fragments of olivine-basalt and basalt-glass half an inch across and very uniform in size; in other places the black masses attain as much as a foot in diameter; sometimes they are almost circular in section, and are often arranged in parallel rows. The summit of the rock is flat and strewn with loose black fragments of olivine-basalt (319), more than two inches in diameter and very uniform in shape and size. About a mile to the northward of this rock occurs another crag consisting of tuff quite like the former and possibly of similar age.

Crater Hill. Along the south-east side of the peninsula there are three scoria-craters. Two of these are rather insignificant, but the third, Crater Hill, rises to a height of over 1000 feet, and the crater-lip at its summit is almost perfect. On the north side the lip rises about 200 feet above the bottom of the crater, but on the south side it has been broken down. The rocks obtained from this hill include black vesicular basalt (341) and red scoriaceous basalt-glass: the latter has obviously flowed over the lip of the crater and now forms the highest point of the hill. Near the south foot of Crater Hill, porphyritic olivine-basalts (656 and 659, see pp. 105–6) rise sheer out of the sea and form a cliff. They appear to extend as horizontal sheets right under both Crater and Observation Hills.

The *Harbour Heights*, or *Arrival Bay Heights*, as they have been sometimes called, include the three prominent eminences between Castle Rock and Hut Point. They rise over 100 feet above the general level of the snow-covered peninsula. Numerous vesicular olivine-basalts (323) and basalt-bombs (367) have recently been ejected from these vents, and an occasional flat space, bare of snow, exhibits massive but vesicular lava-flows of olivine-basalt (366) (Plate II). These volcanoes have a general resemblance to the Pleistocene* volcanoes of Auckland in New Zealand. Between the southernmost crater of the Harbour Heights and Crater Hill there is a basin-shaped depression, the vent of another small volcano. Near this depression occurs a large rock-mass measuring quite 15 feet across and 12 feet high. This rock appears to be the remains of a dyke, and from it the specimens (369–378) were taken. It is a limburgite with abundant foreign inclusions. Of these some are of

* Hutton, Trans. New Zealand Inst. (1899), 1900, vol. xxxii, p. 178.

pure transparent felspar, while others have the mineral composition of gabbro and peridotite (see p. 107). Most of the coloured inclusions are quite angular, but a few are rounded; the largest of them are about three inches long.

On the south-east side of the crater a non-vesicular black olivine-basalt, approaching limburgite in character (326, see p. 105), forms a rugged hillock about 100 feet high. The exposure of rock is quite 50 yards across, but the material is crumbling rapidly away and fresh rock is only obtainable near the summit.

Observation Hill. At the extreme south-west point of Ross Island is Observation Hill, which is separated from its neighbour, Crater Hill, by a narrow *col* called The Gap. Observation Hill has very steep slopes which make an angle of 40° to the horizontal, and, almost meeting in a point, produce a strikingly pyramidal hill (Plate II). The south-west side slopes away more gradually and terminates in Cape Armitage. This prolongation appears to be due to the presence of a sheet of rock which is bedded horizontally. This rock (553) occupies but a small area, about 200 yards long and 50 yards broad. The rock is a porphyritic olivine-basalt, almost black in colour and containing phenocrysts of green olivine up to one-eighth of an inch in diameter. Observation Hill appears to have been built up of successive flows of trachytic lava which have welled up through one single outlet. These flows are now to a great extent denuded; but on the south-east side the remains of a sheet occupy the greater part of the hillside, and rest upon another similar sheet (412). The lower sheet spreads out and forms the flatter south-east side of the hill.

On the north shoulder of the hill the trachytic lavas show a rather greater variety of texture, especially near the 400-feet contour. A dark-grey hornblende-trachyte (273 and 281), with abundant lapilli-like inclusions (see p. 118), up to an inch in diameter, forms the shoulder on which a perched block of black vesicular basalt is prominent. The rock with these inclusions has a conspicuous platy structure, and the upturned edges of the slabs into which it weathers may be traced across the Gap to the base of Crater Hill. This platy rock is considerably contorted and its apparent strike is exceedingly variable, sometimes turning through more than two right angles in 50 yards. It is obviously older than, and unconformably overlain by, the yellow hornblende-trachytes (278, 279, 280) of the higher part of the hill. Higher up the hill occurs a dyke of grey hornblende-trachyte (277, see pp. 117 and 119). The dyke is not more than 10 feet broad, but is traceable 100 feet vertically up the hill. The top of the hill consists of a yellow trachyte; locally it is streaked with grey ribbon-like bands (288) which follow the flow-structure. The weathered surface of the rock is honeycombed, but as here the wind removes the snow immediately after its fall very little frost-action seems to take place. On the southern side of the summit the darker rock begins to preponderate, and at a point some 30 yards away from the top, and 50 feet below it, the yellow rock gives place to a dark-grey hornblende-trachyte (290). Below this rock comes another dark-grey hornblende-trachyte with spheroidal structure (655). The spheres which make up the mass of this exposure sometimes attain a diameter of over 2 feet and are visible over

an area of some 200 square feet. The spheres are all planed off to an even surface, and there is no change in the slope of the hill to correspond with the junction of the two rocks.

Turtle Back Island.

Turtle Back Island, low and insignificant in aspect, lies in the bay between the Winter Quarters peninsula and the ice-tongue in Erebus Bay. It is less than a quarter of a mile long and about 100 yards broad, is rectangular in plan, and rises to a height of 50 feet. The loose rock-material on the surface of the island is bedded, and the layers of dark rock form a small anticline, of which the axis is the longer or N.E.-S.W. diameter of the island. Two boulders of kenyte (trachydolerite) with lenticular crystals of felspar (447 and 484) were found on this island. They are similar to the rock-specimens brought from the lower slopes of Mount Erebus, but are more glassy and of a black colour. Black augite-olivine nodules (448 and 451) are common, but the mass of the island consists of fine-grained fragments of olivine-basalt (449).

Black Island.

In point of size Black Island comes next to Ross Island. It lies south of latitude 78°, and is roughly triangular in plan, having a side about 15 miles long (Fig. 32, p. 58). It shows two central peaks, each over 3000 feet high, and appears to be composed entirely of volcanic rock. It is quite surrounded by glacier-ice, and is therefore almost a nunatak. It is probably connected with White Island, situated to the eastward, by an isthmus rising about 200 feet above sea-level. Specimens from rock *in situ* were obtained from a hill, 900 feet high, near the north end of the island. Compact and vesicular basalt-lavas (593, 594, 595) were obtained high up, but no specimens of rock *in situ* could be obtained from the lower slopes, which were completely covered with rock-*débris*. At the south-east end is a yellow trachytic rock (609, 610); it appeared to be a dyke nearly a quarter of a mile wide breaking through the black basaltic rock. The rock forms a bold headland nearly 400 feet high. The major joints, which are vertical, strike north-west and south-east, and notable variations in the appearance of the rock occur on either side of the joints. There are two other apparently similar rock-exposures near this spot, but time did not permit their examination.

White Island.

This island is 20 miles long, but is less than 5 miles broad. Its longer axis is nearly north-and-south; the island lies between the longitudes 167° and 168° E., and is south of latitude 78° S. The land rises very suddenly out of the ice which surrounds it, and attains a height of 2000 feet. The only rock *in situ* obtained from it is a

black hornblende-olivine-basalt (311), which occurs as a boss on the summit. One or two crateriform depressions occur on the lower portions of the island, and there seems little doubt that the whole island consists of volcanic rock.

"Brown Island."

This mass of land, about 15 miles long and 5 miles broad, is only apparently an island, for it is connected by a narrow isthmus about 8 miles long to Mount Discovery, a volcanic cone on the edge of the mainland. As the peninsula is so nearly isolated, and bears so great a resemblance to the other islands, it is convenient to include it in this chapter. When the ice was at a maximum "Brown Island" was certainly cut off from the mainland, which lies to the west. If the moraines covering the isthmus could be removed it is probable that even now an island would be produced.

"*Brown Island*" is 2812 feet high and entirely composed of volcanic rocks. The northern end is comparatively low and flat. Since many patches of rock of a bright-red colour occur scattered over it, we may presume that scoria-cones are present. The southern and higher end consists of a single crateriform hill, and around the crater are red vesicular basalt-lavas (605) which have flowed over the sides of the rim. A hornblende-basalt (608, see p. 104) occurs on the east side at a height of about 2000 feet. This rock dips north at an angle of 63°, and from the fact that it ends abruptly as a cliff there is little doubt that much of the original lava-stream has been removed. On the north side of the crater a subsidiary peak of banded yellow rock forms a massive hill 500 feet high. The crater is at least half a mile in diameter, and a small shallow pool about 100 yards long occupies its centre. There is little ice or snow in the crater, the lip of which is about 100 feet above the pond. On the west side a white trachytic rock (606) has forced its way through the covering of basalt-glass, and was found on the crater-lip. On the lower slopes no rock *in situ* was observed, but the whole surface was covered with black smooth loose fragments of basalt (603), like the black pebbles at Cape Crozier described on p. 11.

The Dailey Islands.

A number of conical islands, the Dailey Islands, rise through the floating ice at the head of McMurdo Sound. They are five in number, and all lie almost on the same east-and-west line. Four of these are small and conical, and not more than a quarter of a mile in diameter. The fifth is perhaps a mile long, half a mile wide, and 200 feet high; it is the only one that is at all easily accessible. It is situated on the western margin of the pinnacled ice* (Fig. 44, p. 79). The specimens collected are all of basaltic rocks of limburgite type (510), but plutonic boulders

* Ferrar, Geog. Journ., April 1905, vol. xxv, plate, p. 374.

lie on the surface and in the small crateriform hollow at the centre of the island. There are one or two dykes which project slightly above the loose scoriaceous matter of the general surface.

The Dellbridge Islands.

These four islands lie three or four miles south-west of the base of Mount Erebus and twelve miles north of Winter Quarters; although the nearest together are two miles apart, they are probably all remnants of a once continuous land-mass.

Inaccessible Island, the most northerly of the group, is elongated in an east-and-west direction, and has an almost sheer cliff facing the south. Its north side slopes at about 40°, and is therefore too steep in places to hold the disintegration-products of the rocks which form its higher peaks. The dimensions of the island are, roughly, length two miles, breadth half a mile, and height 500 feet. Mr. Hodgson collected specimens here, and tells me that the rocks are much confused, but generally dip to the north. The specimens include a red vesicular trachytic lava (802), porphyritic basalts (805), yellow trachytes (803), and trachydolerite of intermediate character (804); on the south-east end there are many irregularly bedded chrome-yellow bands. *Tent Island* is nearly rectangular in plan, and has sides about a mile long. Its greatest height is about 400 feet, and the highest point is close above the steep north-west cliff. The upper surface of the island slopes to the south-east and agrees with the dip of the lava-beds. The lowest rock exposed is a basalt-agglomerate (817) which occupies the lowest 100 feet on the north-west cliff. It is covered by sheets of a vesicular glassy kenyte (463–466), with lenticular porphyritic crystals of felspar, like the rock of Cape Royds. These sheets have a dip of about 20°, are parallel, and are each about 20 feet thick. *Razor Back Island* is merely a ridge of rock rising 100 feet above the water. Its sides meet to produce a central ridge of which the angle is not much greater than a right angle. The long axis is perhaps half a mile long, and along the same straight line is the *Little Razor Back Island*. The specimens obtained are vesicular lavas of olivine-basalt (470, 471) and of trachytic rocks (473, 476).

Chapter III.

THE MAINLAND OF SOUTH VICTORIA LAND.

Cape Adare.

It will not be out of place to supply here a few additional notes on the rocks of Cape Adare, latitude 71° S. It may be pointed out that the Cape lies at the foot of the gigantic Admiralty Range, and is formed of horizontal sheets of basalt and basalt-

Fig. 6.—Cape Adare Peninsula, from Ross Sea.

agglomerate, similar to those which occur in Coulman Island and perhaps the other islands off the coast.

The peninsula of Cape Adare (Fig. 6) consists mainly of nearly horizontal sheets of basaltic lava laid one above another to form a flat-topped promontory, which gradually increases in height from north-west to south-east. Dykes occasionally cut across these sheets.* The successive sheets are thinner and more numerous at the north-west

* Prior, Rep. 'Southern Cross' Collections (British Museum), 1902, p. 327.

extremity, but they become thicker, and are slightly inclined upwards two miles or so towards the south-east. The following sections may be of interest:—

(A) near the north end of the Cape—

Top. (6) 100 feet—red basalt-glass (865)
(5) 300 feet—black hornblende-basalt (859–861)
(4) 50 feet—tuff (857)
(3) 100 feet—basalt with vertical joints (856)
(2) 50 feet—vesicular basalt (854)
Bottom. (1) 200 feet—talus

(B) about two miles south of the end of the Cape—

Top. (6) 600 feet—(unexamined)
(5) 100 feet—tuff
(4) 50 feet—boulder-breccia (54)
(3) 60 feet—black olivine-basalt, weathering into vertical columns (49)
(2) 100 feet—red scoriaceous basalt (51)
Bottom. (1) 100 feet—scree-slope

This approximately horizontal structure appears to be characteristic of the steep coast line between Cape Adare and Cape Jones, a distance of about 150 miles. This part of the coast is a cliff varying between 1000 and 2000 feet in height. Sometimes anticlinal and synclinal folds, whose axes appear to run east-and-west, are seen. Occasional red bands, possibly like those on Coulman Island and Cape Adare, can be distinguished.

The Volcanic Cones on the Mainland.

The number of volcanic cones on the mainland is less than has been hitherto supposed,* but those seen are interesting from their occurrence on what is probably a great line of fault. These cones all rise from the low foothills that form the coast, and the latter is always parallel to the mountain-ranges. The volcanoes, being isolated cones and having as a background the massive main range, stand out most prominently.

The Summit of Cape Jones (Fig. 7).

The summit of Cape Jones may be taken as a type of these. The hill near the end of the Cape rises to a height of over 3000 feet, and shows admirably the even convex curves of mountains of accumulation. The whole is covered by a deep pall of snow, which either breaks off at the edge of the high sea-cliff, or blends gradually with the ice-sheet of Lady Newnes Bay. This volcano occurs in latitude 73½° S., longitude 170° E. It lies to the west of Coulman Island, and on the strip of foothills which is here nearly 20 miles broad. From the north these

* J. W. Gregory, 'Nature,' 1901, vol. lxiii, p. 610.

foothills can be seen to be decreasing slightly in height westwards towards the base of the Admiralty Range, and thus appear to mark off a great longitudinal valley running parallel to the coast.

Cape McCormick.

On the end of Cape McCormick, latitude 72° S., there are two bare cones which rise 1000 feet above the sea-cliff. They have crateriform summits which bear a striking resemblance to Crater Hill near the Winter Quarters of the Expedition.

FIG. 7.—A VOLCANIC CONE ON THE MAINLAND; THE SUMMIT OF CAPE JONES. THE 'DISCOVERY' IN A GULF IN THE LADY NEWNES "PIEDMONT-AFLOAT."

Mount Brewster.

Mount Brewster, on the north-east side of Lady Newnes Bay, though it does not attain a great altitude, is noteworthy. The mountain is about 3000 feet high, and rises from the flat lowland at the base of the mountain range. The range with its angular spurs towers above the foothills, and Mount Brewster with even outline rises but little above the snow-covered land around it. The summit of this hill is slightly flattened, and some part of the crater may still remain.

Mount Melbourne.

This mountain, 8000 feet in altitude, is situated in latitude 74½° S., longitude 165° E., and on three sides rises directly from the sea; on the fourth side it is joined to a range of higher peaks. The slopes of the mountain are not markedly convex, but

appear symmetrical from all points of view. The base is less than 20 miles in diameter, and the mountain, though 8000 feet high, is not nearly so voluminous as Mount Erebus or Mount Terror.

Basalts* appear to be developed at its base, and but few parasitic vents or obvious lava-flows are seen upon its sides. The only specimens brought back by the 'Discovery' Expedition are rounded pumice-fragments (899). These were obtained from the floating ice of Wood Bay, and must have been transported by the wind during the winter months.

Between Cape Washington and Cape Bernacchi, or in other words between Mount Melbourne and Mount Evans, no volcanic cone has been noted. This is important when we remember that here the foothills are absent, and that the coast is straight and uniform for a distance of over 200 miles. South of Cape Bernacchi, foothills composed of gneissic rocks are developed for some 50 miles. These are separated from Mount Morning and Mount Discovery by the valley of the Koettlitz Glacier, which trends north-west and lies parallel to a line joining the two volcanoes.

Mount Morning.

Mount Morning is a low dome 5779 feet high, and is almost circular. At its base it is 10 miles in diameter. On the south side the mountain slopes down to sea-level, and on the south-west it is separated from the main ranges by low foothills. The Koettlitz Glacier, which opens out north-eastward, occupies part of the above-mentioned depression between foothills and mountain-range. Radiating lava-flows are a prominent feature of this mountain, but no specimens could be obtained from them.

Mount Discovery.

Mount Discovery, the last volcanic cone which we shall note, is 9085 feet high, and lies in latitude 78½° S., longitude 165° E. (Fig. 32, p. 58). It adjoins Mount Morning on the west, but is cut off from the nearest mainland by Discovery Gulf, the ice-filled gulf into which the Koettlitz Glacier flows. The mountain is symmetrical in outline and has the form of a bell. The inflected curves of its sides unite at the summit without indicating the presence of a crater, and they spread out to give the mountain a circular base, some 15 miles in diameter at sea-level. This mountain was not visited, but the moraines stranded in the land-locked bay on its north-east side show that basaltic fragments are the commonest ejectamenta.

The Minna Bluff.

The Minna Bluff is a long and narrow promontory which projects south-eastward from the foot of Mount Discovery. It seldom attains a height of more than 2000 feet. It is 35 miles long, but its breadth is rarely greater than 5 miles. Its sides are

* Prior, Rep. 'Southern Cross' Collections (British Museum), 1902, p. 322.

very steep and almost parallel, and their wall-like appearance is unbroken by glacier or ice-cascade. No structural features are very evident, but specimens of basaltic and phonolitic rocks (619 and 622) obtained from two spots near its south-east end prove its volcanic origin. On the north-eastern extremity there are lava-flows quite like those of the east side of Black Island and of the Harbour Heights, Winter Quarters. The outline is unbroken and therefore it is impossible to say whether this peninsula is composed of lava-sheets, or is a series of scoria-cones like those which make up the Harbour Heights.

The Continental Range.

South Victoria Land, as previously mentioned, consists of a great range of mountains stretching in a north-and-south direction for 800 miles at least, and is apparently the eastern edge of a vast plateau, for between latitudes 77° and 78° S. Captain Scott travelled 200 miles westward over a level region having a uniform height of about 7600 feet above the sea.

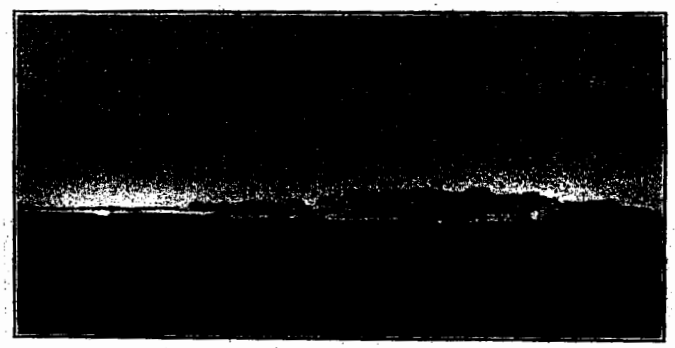


Fig. 8.—Mount Nansen, the tabular mountain south of Cape Washington.

The range maintains a uniform high level. Any peaks, such as Mount Sabine, that rise to heights of over 10,000 feet do so from correspondingly high surroundings, so that there are practically no peaks rising to great altitudes from low levels and towering above the surrounding land. In fact, the land does not show great relief.

Surgeon McCormick, of H.M.S. 'Erebus,' considered the whole range to be volcanic; but this is obviously not the case, for all the higher peaks are pyramidal in outline, and exhibit a house-roof shape which could not have resulted from the eruption of rocks from local centres. The Ross Expedition was less fortunate than the 'Discovery,' for the latter was able to steam in close to the land and see the peaks from nearer points of view. Thus, just south of Cape Washington, a tabular mountain, Mount Nansen (Fig. 8), was observed from the 'Discovery' to have apparently horizontal bedding planes and almost perpendicular scarps showing plateau-structure. The earlier explorers were too far from the land to perceive these characters.

The range, or chain of mountain-ranges, naturally divides itself into sections or links, and these may be conveniently considered separately.

(1) The area between Cape Adare and Cape North, a distance of 100 miles, is

more snow-covered than is the land further to the south, and the coast, which is parallel to the mountains, faces north-east. The mountains here form the main part of the Admiralty Range of Ross. They diminish in altitude as one passes westward to Cape North, and with the decrease in height there is a corresponding increase in the proportion of the snow-covered area. At Cape North itself the covering of snow is almost uninterrupted. Here the peaks which form the horizon are all of the pyramidal type, and they have their easterly shoulders truncated sharply at the shore. There are no deep valleys, but the snow often exhibits prominent series of terraces, one above another and parallel to the coast, and the whole is somewhat suggestive of the existence of some horizontal structure in the rock beneath.

(2) The Range which occupies the 250 miles of coast between Cape Adare and Cape Washington forms the highest, and perhaps the largest, land-mass. This area lies to the south of area (1), the Cape North portion, and is continuous with it. In the south its line of peaks recedes so far from the coast that the connection between this area and the third, or Prince Albert, section is not yet known. Here one sees the possibility of a division into two distinct geological areas, for low foothills are almost continuous along the whole length of the coast from the Cape Adare promontory to Cape Sibbald or even Cape Washington itself. Behind these foothills there appears to be a depression, which takes the form of a series of valleys running north-and-south, and behind the depression is a wall, or possibly a fault-face or escarpment, which rises to heights of 10,000 feet, and has weathered into a series of fine pyramidal peaks.

Many photographs illustrate the form of the range, and some show peaks, such as Mount Minto and Mount Adam, which rise as enormous gables from a plateau already high, and thus do not greatly overshadow the surrounding mountains.

At the head of Robertson Bay the depression at the foot of the mountains resolves itself into a valley, and even the bay itself may be considered a continuation of this. On the south side of Mount Melbourne this depression is again prominent; here it resolves itself into a valley running out to the south-east, and having the volcano (Mount Melbourne) as a part of its left bank, affording evidence that the mountain is situated upon a line of fault.

(3) The Prince Albert Mountains, 200 miles in length and trending due north and south, is the lowest large area of land seen by the Expedition. This range is important, not only because it is practically new, but because of its extreme uniformity of character. It is highest at the north end, where Mount Nansen, mentioned above, rises to 8788 feet, is lowest about the centre, latitude 76° S., where it is only about 3500 feet (Mount George Murray, 3591 feet), and rises again to 8000 feet (Horseshoe Mount, 8228 feet) on the latitude of Mount Erebus. It is remarkable that here the eastern border is always steep and gives one the impression that it is only the outlying edge of some great plateau from which streams of ice come down between

the nunataks. Later, when the former extent of the Beacon Sandstone Formation is considered, it will be seen that this uniformity of landscape is not surprising.

(4) The Royal Society Range has a length of some 50 miles; this length is almost bisected by the 78th parallel of latitude, and is the only part of South Victoria Land which has been examined in detail. In the main all the structures observed in the Admiralty Range are again seen, but are much more strikingly developed (Fig. 9). There are foothills of insignificant height, a north-and-south valley separating the foothills from the main mountain-mass, and a mountain-mass

FIG. 9.—MOUNT HUGGINS AND THE ROYAL SOCIETY RANGE.

rising in a uniform cliff behind to a height of 10,000 feet and having occasional peaks over 12,000 feet in altitude.

From our Winter Quarters this range could always be seen, though quite 50 miles away; and so clear was the atmosphere that, even at this great distance, the plateau-form was always evident and was rendered still more striking by the broad band of lighter-coloured rock below. This band must be at least 2000 feet thick; it is apparently bedded horizontally and extends from end to end of the range. The peaks rising above the plateau are of darker-coloured rock and in strong contrast with it.

Thus, the form of the range appears to be determined by the horizontality

of the rocks which compose it, a character abundantly proved by the sledge-parties who passed along the deep glacier-filled valleys that cross it eastward to the sea.

(5) The four separate ranges which determine the 300 miles of almost straight coast to the south of latitude 79° S. appear to be exactly similar to those already considered, and may be dismissed with the mention of the plateau-character which is strikingly shown and beautifully illustrated by Dr. WILSON'S sketches, made during the great journey to the south, when Captain SCOTT, Lieutenant SHACKLETON, and Dr. WILSON reached latitude 82° 16′ 33″ S. These sketches are all the more valuable in that they were made by an unprejudiced observer.

Each of the four ranges averages 8000 feet in height; they are separated by wide channels far below the level of the plateaux, and such channels, having straight and exceedingly steep sides, appear to be typical features in the geography of all South Victorian mountain ranges.

FIG. 10.—KING EDWARD VII LAND.

KING EDWARD VII LAND (Fig. 10).

This land lies at the eastern end of the Great Ice Barrier of Ross, and is, therefore, connected with the mainland by ice at least. It lies between latitudes 76° and 78° S., and longitudes 148° and 160° W. It rises 2000 to 3000 feet high and is almost wholly snow-covered. The coast trends N.E.-and-S.W., and appears to be banked with low foothills completely covered with snow. It consists of two parts: (1) an isolated headland, some 1500 feet high and 10 miles long, standing well before (2) which, except for the low and isolated peak at the north-east end, is smooth and tabular, but is completely snow-covered. The two areas are separated by a comparatively low snow-covered depression.

The headland is unsymmetrical in shape and has a steep cliff on its north side; at three places, where too steep to hold the snow, there are good rock-exposures. The land was not visited, but specimens obtained from a dredge-haul (256–258) and from two icebergs consist of granites and gneisses and not of volcanic rocks. As the current is south-west along the coast, the rocks dredged up cannot have been carried far; it is also quite improbable that the icebergs can have travelled any great distance.

Chapter IV.

THE GNEISSIC ROCKS AND CRYSTALLINE LIMESTONE.

As the gneissic rocks occur at sea-level at the foot of the highest part of the Royal Society Range, and as they are found in the Range below a sequence of rocks which is 12,000 feet thick, they may be safely regarded as forming the ancient platform on which the central part of South Victoria Land is built. Above the gneisses, come successively, over a very large area, granites, sandstones and dolerites. Little is known of the field-relations of these except the order in which the rocks occur. The important deposit of sandstone provides a convenient stratigraphical datum-line, with reference to which the positions of the other rocks will be considered. The above order seems, however, to be chronological, for, where the junctions between any two rocks were examined, the lower rock usually appeared to be the older. With regard to the gneissic series, the localities at which they have been examined may be considered in three groups:—

(1) The Foothills of the Royal Society Range.
(2) The Kukri Hills.
(3) The Cathedral Rocks.

The Southern Foothills (Fig. 11).

South Side of the Blue Glacier.

On the hill J_1,* 5400 feet high and 15 miles from the sea, occur masses of crystalline limestone which rise at least 1000 feet above the snow. The limestone is almost pure white, and the constituent crystals are often an eighth of an inch across. It becomes so crumbly, on weathering, that it is difficult to get a hand-specimen from the rounded surfaces that are exposed.

The rock (568) has important structural planes which dip at 70° to the east, while the strike is north-and-south. The hill appears to be wholly composed of limestone; its western slope is very straight and steep, and is suggestive of a fault. Parallel to the bedding-planes or, more probably, joint-planes are bands of a dark fine-grained hornblende-biotite-granite (569) from 4 inches to 2 feet in thickness and about 50 yards apart. At this spot there were no obvious metamorphic features near the junction of the two rocks.

* For localities indicated by letters, see the map of the district near the 'Discovery' Winter Quarters, and the sections in Plate VII.

The south end of the Foothills.

Before leaving the discussion of this locality, mention must be made of the specimens brought back by Dr. WILSON from 30 miles further south, close by the Koettlitz Glacier. From the specimens themselves (834–853) and from what he has reported about their occurrence in the field, it would appear that the Foothills are composed of the rocks of the metamorphic series.

Barne Inlet. Latitude 80° *S. Longitude* 161° *E. (about).*

At the entrance to this inlet, Lieutenant M. BARNE collected fragments of granite, gneiss and mica-schist (734) from a scattered moraine. These fragments must

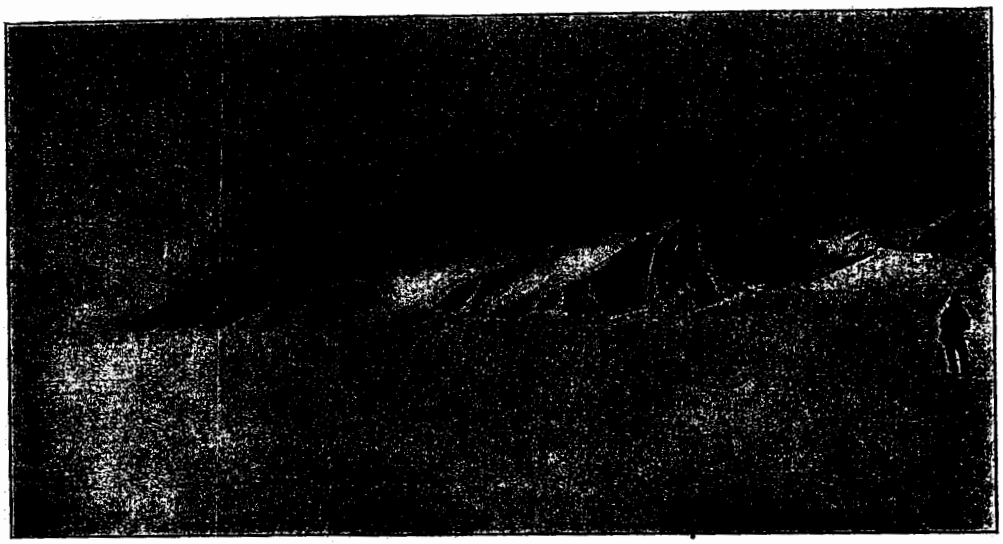


FIG. 11.—THE CRYSTALLINE LIMESTONE ON THE HILL J_1, SOUTH SIDE OF THE BLUE GLACIER.

have been derived from the mass of land lying south of the inlet and quite 170 miles south of the Blue Glacier.

THE NORTHERN FOOTHILLS.

The Northern Foothills occupy an almost rectangular area about 12 miles long and 10 miles broad. The Northern Foothills are separated from the Southern Foothills by the Blue Glacier, which occupies a deep and rather steep-sided valley from 5 to 6 miles across. They appear to be mainly composed of crystalline limestone.

The west side of the foothills, on the north side of the Blue Glacier.

Two miles north of G_4, the limestone is similar to that of J_1, 6 miles distant (Fig. 12). Here, however, the dominant structure-planes strike N.N.E.–S.S.W.,

and dark veins of a doleritic rock (566) make an angle of about 30° with them. From the floor of the Snow Valley, the snow sloped steeply up to the rock-face at an inclination which was too great for us to get the sledges up. Leaving these at the bottom of the slope for a couple of hours, a very risky proceeding when no landmarks are available, we obtained specimens without mishap. The fault-face on the Northern Foothills is more obvious than on the Southern; it is brought into prominence by the fine, bare and apparently glaciated peak (g), which rises over 4000 feet high.

Half-way down the Blue Glacier.

Working down the Blue Glacier, Dr. KOETTLITZ collected somewhat similar specimens from a hill 5 miles east of G_4; here, as nearer G_4, the bedding-planes dip to the E.S.E., and the dark veins cut across the strike to the E.N.E. On this hill one of the structure-lines is remarkably prominent and suggests a thrust-plane, but no difference in the characters of the rocks on the opposite sides of the line was obvious to the naked eye. The specimens collected by Dr. KOETTLITZ in this neighbourhood include dioritic dyke-rocks (572, 574) and a schist (570).

FIG. 12.—THE CRYSTALLINE LIMESTONE ON THE NORTH SIDE OF THE BLUE GLACIER, AT G_4.

The north-east end of the Blue Glacier.

At G_1, the most south-eastern of the Northern Foothills, the arrangement of the rocks is well seen from a distance. Here, however, the rock is so planed down by ice-action that the rapid alternations of dark dyke-rocks and light-coloured limestone are rendered evident. The dykes crossing the brow of the hill are plainly visible from the glacier. A dyke of kersantite (579, see p. 130), 20 yards wide, cuts the crystalline limestone (575, 576). The hill is 4000 feet high; the snow wraps its base and reaches quite up to the 1000-foot contour. Here again the sledges had to be left more than a mile away from the exposure. On this occasion, owing to the snow-storm that began during our absence, they were difficult to find when we returned.

The right bank of the Ferrar Glacier, between G_2 *and* G_3 (Plate IV).

The Northern Foothills, as stated above, form a rectangular mass with the north side some 12 miles long, forming the terminal portion of the right bank of the Ferrar

Glacier. The hill G_2 occurs at the north-west corner and sends out a shoulder four miles to the west. This shoulder is cut off from the granite-hills, G_3, by a glacier which flows northward out of the Snow Valley. The shoulder runs out as a narrow promontory along the same line as the north edge of the foothills, and rarely rises much more than about 1000 feet. The tributary glacier flowing north causes an inconvenient belt of hummocks two miles in width, and it is not till a height of 700 feet has been ascended that rock is found *in situ*. The slope of the hill makes an angle of between 30° and 40° to the horizontal, and is covered with loose morainic matter; but at a height of 700 feet a crag of gneiss (729) appears. The rock is dark,

FIG. 13.—THE GNEISS AT THE EAST END OF THE LOWER KUKRI HILLS, NEAR THE HILL H.

fine-grained, and very streaky. The foliation dips to the south-west at an angle of 60°, a fact of some importance, as we shall see when we consider the Kukri Hills.

THE KUKRI HILLS.

This name has been given to the hills lying immediately north of the Ferrar Glacier, as in plan they have the outline of that implement. They separate the North Fork from the East Fork, and are themselves divided, both topographically and geologically, just at that point where the Ferrar Glacier floats off into its deep fiord-like channel. The western and higher part includes all hills denoted by the letter D on the map; while the eastern and lower part is defined by the hills *m* and H, at its western and eastern extremities, respectively.

The Eastern or Lower Kukri Hills hardly rise above 3000 feet, but maintain this height most uniformly over the whole of their length between *m* and H, a distance of 15 miles. These hills form a narrow promontory about two miles in breadth with steep, sometimes almost vertical, sides. They lie six miles or so north of the Northern Foothills.

New Harbour Height (H) (Fig. 13).

At the extreme eastern foot of the hill H, or New Harbour Height, specimens (730, 731) of hornblende-schist and gneiss were obtained. The gneiss belongs to the dark variety, the structure-lines dipping at an angle of 30° to the north-east. About

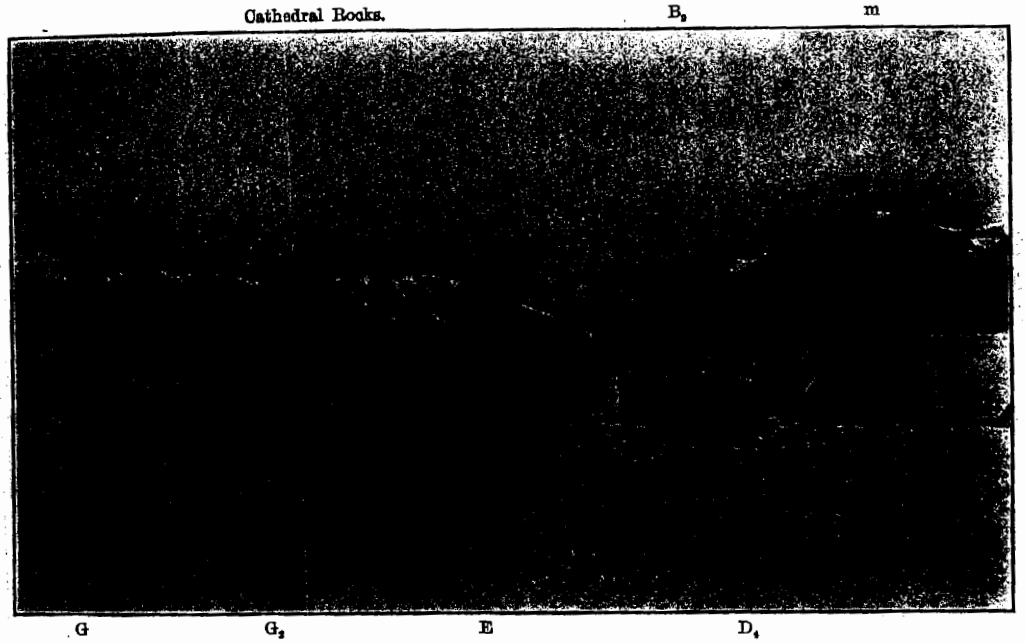


FIG. 14.—LOOKING UP THE FERRAR GLACIER, NORTHERN FOOTHILLS ON THE LEFT, CATHEDRAL ROCKS NEAR THE CENTRE, AND THE KUKRI HILLS ON THE RIGHT.

a mile west of this point, where a small hanging glacier on the south side of the hill occurs, the dip suddenly changes to one of 20° to the west. The dip is emphasised by the fact that the snow always lies only in sheltered hollows. The hanging glacier lies on what appears to be a fault.

Below the hill D_4.

Below *m* at the western end of the Lower Kukri Hills a white crystalline limestone occurs, and the bedding-planes of this rock dip to the north-east at 70°. The apparent thickness is about 1000 feet, and the strike is N.W.—S.E. Between this white

limestone and the dark foliated gneiss at the east end, a long stretch of the valley-side appears to be gneiss with foliation-planes dipping to the west, and therefore to agree with that met with on the south side of the valley near G_2 (Fig. 14). The white limestone (728) abuts upon a grey augen-gneiss (727), but the actual junction could not be examined as a hanging glacier lay upon it. The augen-gneiss appears to be part of the great mass which forms the lower and greater part of the hill and rises to quite 4000 feet.

Below H_2.

At Cape Bernacchi, 20 miles north of the Northern Foothills, the rock composing the hill H_2 has apparently the same structure as that of New Harbour Height, or the hill H, while the elongate hill h_4 is a replica of the portion between H and *m*, and has structural planes dipping to the west. The rocks were not examined at this spot, but the serrated outline and the trend of the snow-water channels point to the structural lines being exactly parallel to those on the Lower Kukri Hills.

The Cathedral Rocks.

These rocks lie 40 miles from the coast, and rise to heights of over 6000 feet. The glacier-surface at their base is about 1500 feet above sea-level, and the summits of the Royal Society Range, of which the Cathedral Rocks are the northern extremity, rise to altitudes of over 12,000 feet directly behind them. The Cathedral Rocks slope steeply down to the Ferrar Glacier, and form its right bank for a distance of 10 miles. They form three of the shoulders of the range just mentioned, and are separated by tributary glaciers which run out northward along narrow and steep-sided valleys. These shoulders project as *arêtes* from the main plateau of the Royal Society Range. They are composed of gneiss, granite and dolerite, and may be topped by small outliers of sandstone (Plate III and Section II, Plate VII).

There is an exposure of gneiss at the foot of the central shoulder, which is designated E_2 on the map. This exposure rises 500 and 600 feet above the ice (Plate IV). The line dividing it from the granite is very sharp, and can be followed for a distance of some 3 miles along the glacier. On the west it is hidden by a sudden rise of the surface of the ice, and on the east is cut off by a boss of diorite (715), which appears to have burst through from below.

The diorite forms the eastward half of this shoulder as well as the whole lower portion of the eastern shoulder E_1. The gneiss is overlain by a sheet of pink granite, which, once known, is easily recognisable at a distance by the fact that the latter forms screes, whereas the former produces a cliff. The upper surface of the gneiss is a well-marked undulating line, cut off short on the east where it meets the diorite. In certain other places several much smaller dykes transgressing the gneiss were observed. Of these dykes some are grey granite and

some are pink granite, and both kinds are more abundant towards the eastern end of the exposure. Here the pink rock displays augen-structure (716), and occasional isolated patches and wisps of the ordinary foliated gneiss were observed in the middle of the masses of augen-rock. The dykes form a rough network over the face of the gneiss, and their thicknesses vary from 6 inches to 12 feet. The most prominent consists of a pink quartz-porphyry (709), cutting through the gneiss perpendicularly to the foliation. The gneiss here is dark in colour, and its alternating laminæ are usually under a quarter of an inch in thickness. These foliations are themselves folded into series of anticlinal or isoclinal folds, with amplitudes of about 8 feet, the various bands remaining parallel.

Other specimens from later veins or dykes traversing the augen-rock may be mentioned, namely :—

(1) A green actinolite-rock (725).
(2) A white pegmatite-vein (723).
(3) A thin seam containing mica-plates up to half-an-inch across.

Chapter V.

THE GRANITES.

Though granitic rocks had not been found *in situ* in the Ross Sea area, the frequency with which fragments had been dredged up by the various ships proved, if not a wide distribution, at any rate a great local development of this kind of rock in the area under consideration. If we neglect the occurrence in moraines such as those found on the basaltic peninsula of Cape Adare or on the slopes of the volcano

Fig. 15.—Dolerite upon Granite on the north side of Granite Harbour.

Mount Terror, there are two localities where granite has actually been found in place. At the first, which has been called Granite Harbour, in latitude 77° S., the granite abounds; though no other rock could be examined in the time available, a dark rock was seen capping the granite (Fig. 15); that this is dolerite is almost certainly proved by the plateau-like form of the hills on the side of the harbour remote from our landing-place, and by the finding of dolerite-fragments on the scree-slopes (see p. 54). The second locality is the Royal Society Range; here the granite has been examined at several spots over a distance of some 20 miles, and appears to occupy an area of quite 200 square miles. This district may conveniently be subdivided into two areas—(1) the Snow Valley west of the Northern Foothills, where the granite occurs in isolated hills, and no other kind of rock has been seen; (2) on the two sides of the Ferrar Glacier, where granite, and its relations to the rocks both above and below, have been examined.

Granite Harbour (Fig. 15).

In this harbour there is a prominent headland some 500 feet high and two miles long; in form it is distinctly like a bursting cabbage. Where a landing was made the rock proved to be entirely granite. The rock-surface is absolutely bare of snow, and is weathering under desert-conditions apparently analogous to those described by Walther as obtaining in Sinai.* The joints tend to be platy and parallel to the surface, but the edges of the joint-blocks are ragged, and the curve is usually convex downwards. In other places the joints are vertical; there the rock breaks up more rapidly, and produces talus-slopes which extend almost the whole height of the cliff-face. Dark circular patches, in rows which are often parallel to the joint-planes, are seen on the surface, and it came as a surprise to find that the rock is coarsely crystalline.

The greater portion of the boss consists of a grey biotite-granite (129), and the larger talus-slopes always follow certain veins or dykes which extend up the whole face of the cliff. The centres of these veins consist of a coarse pink granitic rock (155) with idiomorphic crystals of red orthoclase up to half an inch in diameter, but within a distance of some fifteen feet these phenocrysts become paler in colour, the rock meanwhile becoming less porphyritic, and thirty feet from the centre it has graded into the ordinary grey granite of the main mass of the boss. These pink dykes are about one hundred yards apart; it is noteworthy that in many cases the change from grey to pink is not quite gradual, but takes place in stages at the joint-planes, thus suggesting multiple dykes. These stages of the passage are marked by bands, a foot or so across, which become successively coarser and pinker as one passes from the sides towards the centre.

Thin seams of micaceous schist (96), narrow black basalt-dykes (113), and numerous other varieties of rock, were met with, and specimens of these were collected during our hasty scramble ashore (see p. 126).

The Snow Valley west of the Northern Foothills.

In the area between the Foothills and the Royal Society Range, a district which I have called the Snow Valley, isolated hills just raise their heads above the snow, and expose to view occasional masses of granite-blocks, which at first sight would appear not to be *in situ*. There are five or six of such hillocks, with summits about 3500 feet above sea-level, which form the watershed between the Blue Glacier and the ice-cascade separating the hill G_2 from the hill G_3.

The points η_1, η_2, etc., on the map indicate the positions of these hillocks, but of the four only η_2 was visited; it proves to consist of grey hornblende-biotite-granite (561, 562). The mass exposed is about 100 yards long, and rises 200 feet

* Walther, Abhand. math.-phys. Cl. d. k. sächs. Ges. Wiss., 1891, Bd. xvi, p. 364.

above the snow which surrounds it. When traced from west to east the rock becomes finer grained. In places it encloses many vertical quartz-veins (560).

Near E_4, at a height of 5000 feet, Mr. SKELTON obtained a specimen of grey granite (626), and another from a boss of rock just peeping above the snow. In this exposure the joint-planes dip to the south, and, in places, kersantite-veins (625) cross the mass.

From the "3500 feet Knoll," e_5, Mr. SKELTON brought back a specimen of a somewhat coarse-grained pink granite with phenocrysts of felspar up to a quarter of an inch across (555, 556). The exposure is much weathered, and it is here that the type (A) of hollowed rock* with the white (calcium carbonate) incrustation (554) occurs (Fig. 16). This will be referred to later (see p. 88).

FIG. 16.—HOLLOWED GRANITE-BOULDER IN THE SNOW VALLEY NEAR THE ROYAL SOCIETY RANGE.

At e_6 Dr. KOETTLITZ got a specimen of dark grey hornblende-granite (563) with idiomorphic crystals of pink felspar up to one inch in length. The height at which this exposure occurs is more than 3000 feet, and the rock forms the eastern end of a spur of the Royal Society Range. The joint-surfaces are conspicuously developed, and are arranged as a syncline with east-and-west axis. Other specimens from this locality are a grey biotite-augen-gneiss (564) and a doleritic rock (565).

THE GRANITE HILLS BETWEEN G_2 AND G_3 (PLATE IV).

The hill G_3 rises to a height of 3500 feet above sea-level; it is 1000 feet above the level of the Snow Valley, and nearly 2000 feet above the ice in the valley below. Eastwards the height decreases to 2000 feet, where this patch of bare rock is separated from the gneiss of G_2 by the ice-cascade previously mentioned. As a whole this G_3 block is a series of rounded hills; as viewed from the surface of the Ferrar Glacier (Fig. 43, p. 78), it has no very conspicuous valleys, but presents an almost straight and even valley-wall.

The specimens (557, 558) from near the summit of G_3 are all of hornblende-granite with large pink porphyritic crystals of orthoclase. It is here that type B of hollowed crystalline rock is found, and owing to the rapid weathering the ground

* Ferrar, Geol. Mag., Dec. V, 1905, vol. ii, p. 190.

around is covered with large loose fragments of felspar. At the foot of G_3, 1500 feet above sea-level, the felspars in the rock are even larger than those on the summit, and a dark dyke (714) (see p. 131) with phenocrysts of hornblende up to two inches long is exposed a few feet above the ice. In addition, below this "dark dyke," there is a green band of a fine-grained rock (732) about five feet thick. The dark dyke produces a dark patch on the hillside, which, owing to the contrast, can be seen at least 10 miles away. On the opposite side of the glacier, above d_3, there are three or four similar patches which, though larger, are probably due to a similar occurrence of dykes.

Fig. 17.—Dolerite-cliff standing back from the edge of the Granite of Cathedral Rocks.

The Cathedral Rocks.

These rocks already referred to (see p. 30) form a very imposing triple headland on the south side of the Ferrar Glacier, and are as important as they are picturesque, for here, there seems no doubt, is contained the whole history of the Royal Society Range. At the base, as already stated, is banded gneiss. Above it, and divided sharply from it, is the granite, which must be about 4000 feet thick. Above the granite is a sheet of dolerite, which is rendered conspicuous by its weathering back faster than the granite and leaving a prominent ledge. Upon the dark dolerite-sheet is a yellow cap, presumably of sandstone, which forms the summits of all three headlands (Fig. 17). (See Sections I and II, Plate VII.)

At the foot of E_2, dykes of fine-grained pink (711) and grey (710) granite force their way into the gneiss and blend with the sheet of granite. East of the shoulder E_2, a tongue of granitic rock ends the gneissic exposure, as if here bursting through from below. At the edge this tongue is mainly pink in colour, and occasionally there are large patches of almost pure pink-felspar-rock in it. When traced eastward it passes into a diorite, becoming gradually darker in colour (715) and coarser in texture, while well-formed black crystals of hornblende appear and increase in size up to a quarter of an inch in diameter.

The relation of this rock to the granite making up the hill G_3 cannot be traced owing to the great mass of snow in the Descent Pass, but the sharp dividing line between the granite and the dark-coloured dolerite above it can be followed round all three shoulders and across to the tabular hill E, and thence along the east side of the South Arm for a distance of more than 10 miles, keeping almost exactly the same level all the way. This sheet-like mode of occurrence of the granite appears to be a constant feature in this area and is seen over the whole south side of the Upper Kukri Hills (Fig. 18).

The Kukri Hills.

The Kukri Hills project as a wedge into the depression where the ice from the South Arm meets that flowing east from the inland plateau. From them granite has been actually obtained at three spots, namely, (1) the western extremity below D, (2) near the middle of the south side below D_2, and (3) the eastern end of the upper portion below the peak D_4. (See Section III, Plate VII.)

The hill D, as seen from the south, shows about 2000 feet of dark rock (dolerite) occupying the whole of the cliffs, which fall sheer to the level of the ice, here about 3000 feet above sea-level. In the middle of this great mass of dark rock are three large triangular masses of a light-coloured rock which are plainly visible eight miles away. At the western foot of D is a still larger mass of pale rock which must be 1000 feet thick at least. Viewed from the north and west, this rock, which proved to be a pink granite, could be seen sending tongues into the columnar dolerite, and the junction of the two (699, 700, see p. 128) was seen to be quite irregular; it is quite clear that the granite is here the later intrusion. The joint-planes of the granite dip to the north-east at an angle of nearly 30°; the granite (701), though generally pink in colour, has occasional dark-grey masses (702–703) locally contained in it.

The eastern end of Solitary Rock (D_{5a}) shows four bands of rock with regular horizontal junctions. Two of these bands are dark-brown and two are light-yellow in colour, and the alternation of the colours suggests that the rocks are like those seen on the north side of the North Fork, where yellow and black bands occur in the same order and with similar thickness.

When the Kukri Hills are observed from Knob Head Mountain, or from the summit of Descent Pass, they present an almost sheer wall facing south. This wall is broken at regular intervals by glaciers, which usually occupy hanging valleys. At the mouth of each valley there is a well-marked junction of dark-coloured and light-coloured rock, and in places the colours alternate regularly as before. The hill D contains a straight yellow band near its summit which is formed by a dark rock. The yellow band continues towards the east, and gives to the hill D_1 a tabular outline. On the hill D_2 it is only represented by a small outlier. Below this yellow band on

FIG. 18.—THE HORIZONTAL UPPER SURFACE OF THE GRANITE ON THE SOUTH SIDE OF THE KUKRI HILLS.

the hill D_1 there is a horizontal black band about 1000 feet thick, which appears to be part of the dolerite of D, and this black band extends eastwards beneath the yellow outlier of D_2. Below the black band there is an attenuated wedge of yellow rock, which begins about the middle of the cliff D_1, and, rising slightly, reaches the top of the cliff-face a little to the east of D_2. This yellow wedge shows prominent joint-planes which dip to the east, and appears to weather in quite a different way to the outliers on the summits of D_1 and D_2. It is possible that this is part of the intrusive granite of the promontory D. Below this again is a second dark band, which was subsequently proved to consist of dolerite (704). This, too, is a part of the D mass, and maintains

a uniform thickness of about 2000 feet. As it rises to the eastward it forms the highest third of the hill D_3 and caps the hill D_4.

Below D_2 another light-coloured rock, a grey biotite-granite (708), protrudes through the ice, and may be followed for a distance of over 10 miles along the side of the valley. The upper surface of the granite is very well marked and forms an almost horizontal straight line, but near the hill D_3 it becomes somewhat undulating (Fig. 18). This granite forms the greater part of D_4, and finally forms the summit of the hill *m*. It is probably at least 4000 feet thick. Below D_2 the junction of the lower dolerite with the grey granite is 500 feet above the ice, as measured with an aneroid barometer, and about 3000 feet above sea-level, and it would seem that the surface of the granite slopes west at an angle of about 2°. This spot is five miles east of the pink granite at D, eight miles N.N.W. of the granite at Cathedral rocks, and ten miles N.W. of the granite at G_2.

Grey augen-gneiss forms the base of D_4, and was again encountered at the foot of *m* (727). At this last-mentioned spot, as stated in the foregoing chapter, the augen-gneiss adjoins the metamorphic limestone, but a glacier completely covers their junction. From a distance it was seen that the junction must occur just where the higher and western part of the Kukri Hills ends and the lower and more uniform eastern part begins. The augen-rock must be more than 3000 feet below the dolerite-granite junction and at least eight miles east of the hill D_2.

From a consideration of the above it would seem that the grey granite of these hills is older than the dolerite which rests upon its even upper surface, but that the pink granite of D is intrusive and later than the dolerite.

In Moraines.

Fifty miles inland, at a height of 4000 feet above sea-level, small and large boulders of both grey and pink granite (693) were found on the side of Beacon Height West. They were resting upon a surface of the Beacon Sandstone. The spot where these fragments occur is some distance up one of the Dry Valleys. As the land south of the Dry Valleys rises to over 7000 feet in height, it is possible that among these peaks granite occurs at a greater elevation than 4000 feet, and has been brought down to its present place upon the sandstone by the ice which once occupied the valleys.

On the slope of Knob Head Mountain (B_9) there were huge boulders of granite at a height of 4000 feet above the sea, but no granite was found in the upper part of the mountain itself. About one-third of the material of the moraines in the South Arm consists of granite-blocks, and all varieties appear to be there represented.

Chapter VI.

THE BEACON SANDSTONE FORMATION.

The existence of fossiliferous sedimentary rocks in South Victoria Land has been considered probable ever since H.M.S. 'Challenger' dredged up sandstones, limestones and shales* in a high southern latitude, but as it was thought that the coastal belt of the land was composed entirely† of volcanic rocks, there was little to encourage the hope that fossiliferous strata would be met with in the course of the 'Discovery' Expedition.

In dredging off Coulman Island several small fragments of a white granular quartz-grit were brought up, and when just south of the conical Mount Melbourne a tabular mountain, Mount Nansen, was seen, our hopes of finding sandstone were raised to a very high pitch. This mountain showed well-marked horizontal structure, and steep scarp-slopes which vividly recalled Table Mountain at Cape Town in South Africa. Further south, in about latitude 75° 57′, many tabular hills with black caps could be seen fronting the sea, and the possibility of such tabular mountains being composed of plateau-basalt had to be considered. However, when the 'Discovery' anchored on the south extremity of Ross Island, the Western Mountains (the Royal Society Range of our present nomenclature) were seen to be made up of differently coloured horizontal bands which run from end to end of the range. These rock-belts are well brought out in some of the photographs, and at a distance of 50 miles the contrasts of colour were more obvious than in any of the photographs taken close at hand.

Lieut. A. B. Armitage's pioneer-journey through these mountains proved that horizontal structure and plateau-features are extremely constant. The specimens (628, 630, 639–642) he brought back included a sandstone which is somewhat like the Millstone Grit of the top of Ingleborough in Yorkshire, and suggested the probability of the existence of fossiliferous sediments in the district.

Lieut. Armitage reported that the sandstones attained a height of nearly 8000 feet and were accessible at a spot 60 miles inland on the very edge of the Inland-ice. The photographs taken by Lieut. R. W. Skelton on this journey (Fig. 19) showed that the sandstone has a marked effect on the scenery, and the name Beacon Sandstone Formation, which I propose to give to the deposit, is derived from the remarkable mountains B_3 and B_4 to which Lieut. Armitage has given the name Beacon Heights.

Accordingly Captain Scott arranged that I should go with him as far as the edge of the Inland-ice and do as much geological work as was possible on the return

* Murray, Geol. Mag., Dec. IV, 1898, vol. v, p. 270; Prior, Mineralogical Magazine, 1899, vol. xii, p. 81, note.

† Gregory, 'Nature,' 1901, vol. lxiii, p. 609.

journey. A second attempt had to be made, owing to the sledges breaking down on the first, and, even then, bad weather confined the parties to their tents for a period of six and a half days; when the weather had moderated I had but one month in which to examine the 600 square miles of new country.

From what we had seen on the way out, plateau-dolerite would be found overlying the Beacon Sandstone. The latter was not exposed at Depôt Nunatak, but in the moraine at the foot of the rock I found abundant sandstone blocks, and the majority of these were locally blackened by carbonaceous matter (743, 744). None of these blocks contained fossils, other than the small lenticles of carbonaceous material which I thought suggestive of organic origin. These were our first evidences of Antarctic life in the geological past, and as my companions, KENNAR (P. O.) and WELLER (A. B.) spread out our sodden gear in the sun under the lee of the nunatak, hopes indeed ran high, and all looked forward to the joy of further new discoveries.

FIG. 19.—DOLERITE-SILL IN THE BEACON SANDSTONE NEAR FINGER MOUNTAIN.

Next day therefore found the camp near the foot of the hill B_1, where three hundred feet or so of the sandstone could be seen cropping out below the overlying dolerite. Imagine my delight when, arriving with bag and hammer at the rock-face, I found thin, black, irregular bands in a pure white sandstone. Though the bands were two hundred feet below the capping dolerite, their carbonaceous material was much charred; hence, after collecting a few specimens, we left this promising locality, perhaps prematurely, and moved diagonally down the valley to the vast exposures of the Inland Forts. Here I had hoped to find better specimens, but neither here nor elsewhere did we meet with anything nearly so good as at our first locality near the dolerite-junction. The sandstone of these Inland Forts is quite 2000 feet thick, and, though we carefully sought for its base, no indications of that base or of the relations to the underlying rocks could be found.

The Beacon Sandstone is also present at the foot of Knob Head Mountain, which is over 30 miles to the east of Depôt Nunatak and about 3000 feet lower. The localities at which the Beacon Sandstone was examined will therefore be considered in turn, in the order in which we came to them.

Below the Hill B_1.

From a position on the side of the hill B_1, we could see some miles away striking alternations of dark and light bands just peeping up from below the brown rock of a_{15}. The dark bands are conspicuously paler than the overlying rock (dolerite) and are presumably carbonaceous sandstone. If we take this into consideration and the fact that carbonaceous sandstone is found in the Depôt Nunatak moraine, and bands of it occur below B_1, it would seem that only the upper portions of the Beacon Sandstone are fossiliferous.

The Beacon Sandstone at B_1 is locally disrupted by the dolerite, but the horizontal bedding is not materially disturbed, except at one place where huge masses of the sandstone have been bodily upraised. One of these dislocated masses is 100 feet thick and a quarter of a mile long. It contains many small black iron-stained nodules (663), which are set in a matrix of very coarse quartz-grains. Of the 300 feet exposed near the camp, the major part is a pure, even-grained, coarse sandstone.

False bedding or current-bedding is displayed, and locally there are discontinuous bands of quartz-pebbles (673, 674). The pebble-bands appear and disappear quite suddenly in the ordinary sandstone, and they are never more than four inches thick; the pebbles themselves vary from the size of a sparrow's egg to that of a hen's egg, and quite 99 per cent. consist of vein-quartz or quartzite (672). Sometimes the pebbles are very sparsely scattered, and a bed 12 feet thick may contain only a single pebble. The quartzite (quartz-schist) pebble (675) was found under such circumstances and measures $8 \times 5 \times 4$ inches. The sandstone-blocks of Depôt Nunatak display abundant lenticular pieces of yellow mudstone up to two inches in length, but these lenticles were not observed elsewhere.

The carbonaceous matter (743–762) only occurs in the lowest hundred of the 300 feet exposed; the carbonaceous bands, like the pebble-bands, are there discontinuous, and often follow the intricacies of the current-bedding. The black bands commonly range from an eighth to a quarter of an inch in thickness; some of them were found to extend horizontally for quite 100 yards, others disappear completely within a very few feet.

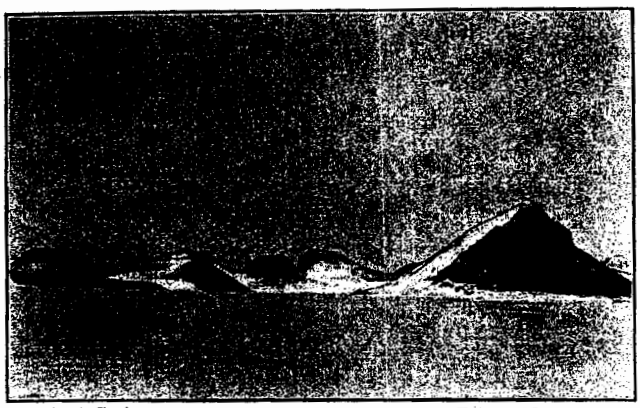
Near this spot the sandstone is partially calcareous, and a blue limestone-band formed a conspicuous shelf projecting from the cliff-face. Just below this was a well-marked band of pebbles set in incoherent sand, or in sand only slightly cemented by carbonaceous matter. The following sequence, in order of superposition, will give some idea of the nature of the Beacon Sandstone at this spot.

Top. (7) 200 feet—almost pure sandstone with occasional pebbles (665)
(6) 2 feet—band containing carbonaceous substance (745–762)
(5) 12 feet—sandstone with brown bands
(4) 12 feet—hard white sandstone with a three-inch strip of fibrous mineral (wollastonite) (676)
(3) 12 feet—black shale and shaly sandstone (754)
(2) 6 inches—limestone-band (671)
Bottom. (1) 6 feet—black shale (754)

The carbonaceous band (6) had been slickensided and baked to such an extent that it has proved impossible to determine the fossils which it contains (see report by Mr. E. A. Newell Arber, on p. 48).

The Inland Forts (Fig. 20).

Five miles west of the Inland Forts, at the spot marked γ_2 on the map, the cliff forming the north side of the glacier is composed of two rocks, a yellow one below and a dark one above. The junction as usual is regular and almost horizontal. On examination the yellow rock proved to be sandstone. The only accessible part was the base of the cliff where the rock is a sandstone barren of fossils. It is subdivisible into a series of alternate yellow and white beds, and a few pebble-patches were noted. The following section from the level of the ice upwards, shows the order of succession:—



East Groin Round Mount, C,

Fig. 20.—The Inland Forts. Sandstone capped by Dolerite.

Top. (4) 100 feet—brown columnar rock (dolerite)
(3) 100 feet—yellow sandstone
(2) 100 feet—uniformly light-coloured sandstone
Bottom. (1) 100 feet—a yellow and much banded sandstone.

At the Inland Forts, where the hills are at about the same level as those below γ_2, 2000 feet of the Beacon Sandstone are exposed, and of this nearly 1500 feet have been examined. The Forts are four conspicuous hills mainly composed of sandstone, but they are capped by dolerite (Fig. 20). They are separated by well-marked *cols* through which the ice once forced its way northwards into the adjoining drainage-system. The exposure is well illustrated by the photographs of this side of the valley. The sandstone is part of a great deposit which is buried westwards beneath the Inland-ice and determines the distinctive features of the mountains on each side of the main valley of the Ferrar Glacier.

Extending southwards from C_6 and C_8 are two ridges of similar sandstone. These ridges have rounded outlines and resemble groins built against a sea-wall to break the force of the waves. Though now above the level of the ice, they formerly acted like groins and thus collected rock-material on their westward side. These ridges, which I have termed the West and the East

Groin respectively, are low and attenuated spurs of the horizontally bedded sandstone, which is here cut into *cirques*. The groins afford the most easily accessible exposures of sandstone in the whole region. The slope was seldom too steep to be climbed, and, as the horizontal structure is well etched out by denudation, any particular bed may be traced along the whole length of the ridge. Here, too, the rock was a white or yellowish sandstone with not so much as a sign of a shale or a limestone-band. So far as could be ascertained, only one of its horizons contained organic remains, and these of a most doubtful nature. These were found on West Groin, where the surface of a sandstone-bed was covered by what appeared to be cylindrical casts of some organism (763–767). Possibly these cylinders may be entirely a result of weathering, but, as they are all of much the same diameter and cross and intercross in all directions, I thought at the time that they are probably more than this, and I still think that they may be of organic origin. There is no sign of actual structure in the boundaries of the cylinders, but there is usually a slight depression parallel to, and close along, their sides. The length of the cylinders varies from six inches to three feet, and the diameter is usually about half an inch; they project nearly half an inch above the smooth surface of the surrounding sandstone.

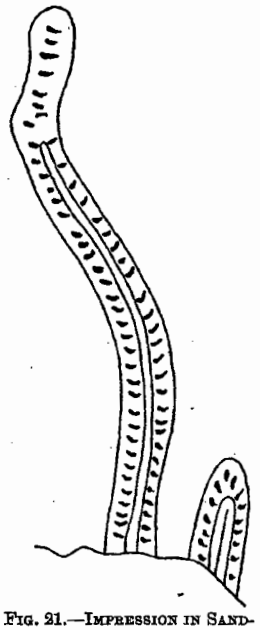


Fig. 21.—Impression in Sandstone at West Groin. Copy of Sketch made in the Field.

At another spot on West Groin, 800 feet above the level of the ice, there occurred an impression (763, 764) on the surface of the sandstone. This appeared as a shallow hollow, somewhat like the imprint of a flat crooked stick with a blunt rounded end (Fig. 21). The impression was an eighth of an inch deep, two inches wide, and one and a half feet long. Along the central line there are two markings parallel to the outer boundary and about a quarter of an inch apart. These run nearly the whole length of the impression, and on either side of them are rows of rather deeper pits about a quarter of an inch apart, which alternate on the two sides of the central lines (see note by Mr. E. A. Newell Arber, on p. 48).

Sundry other, but smaller, rod-like markings (765–769) occur on other specimens, and with the same alternate pits, and I am inclined to think that these impressions are, at least remotely, derived from bodies with organic structure. One of the smaller impressions, which are 6 inches to 1 foot long and about half an inch across, still retains fragmentary remains of dark carbonaceous matter. The following table of the succession, from the bottom of West Groin to the top of its corresponding hill, shows how uniform is the Beacon Sandstone Formation.

Top. (14) 100 feet—dolerite, which caps the sandstone
(13) 200 feet—yellow sandstone
(12) 100 feet—sandstone with occasional yellow bands
(11) 100 feet—sandstone with ferruginous concretions (677)
(10) 200 feet—yellow sandstone
(9) 100 feet—sandstone with cylindrical casts (764–767)
(8) 200 feet—yellow sandstone with ferruginous concretions
(7) 50 feet—white sandstone
(6) 200 feet—yellowish sandstone
(5) 100 feet—marble-like sandstone (679)
(4) 50 feet—nearly white sandstone
(3) 10 feet—stalagmitic sandstone (678)
(2) 60 feet—almost white sandstone
Bottom. (1) 80 feet—variegated brown and yellow sandstone (hard).

The variegated brown sandstone (1) at the base appeared to be altered to a slight extent; it is harder than most of the higher beds, and the ferruginous concretions in it are sometimes two feet across. They are flattened horizontally, and are sometimes joined together.

The stalagmitic sandstone (3) is so called because stalagmites stand out between successive beds on the rock-face, and it would appear that the rock had been locally hardened by infiltration. It is made up of alternate hard and soft layers which are each about a foot thick.

The marble-like sandstone (5) (679) was harder than that above and below, and locally its surface has a superficial glaze. The ferruginous concretions (11) (677) in the upper band often weather out as balls up to a foot in diameter; sometimes, however, the concretions have disintegrated faster than the rocks in which they were imbedded and have left spherical hollows.

Finger Mountain (B) (Fig. 22).

Before we entered the district of the Dry Valleys, the Beacon Sandstone was examined near the foot of Finger Mountain; though 10 miles south of the preceding area, it retains the same characters and appears to be barren of fossils throughout. Near the contacts with the dolerite, variegated bands (635) have been produced. At this spot the sandstone, like that at B_1, has been dislocated; but again its general horizontality has not been disturbed, notwithstanding that intrusive sheets of dolerite, up to 500 feet thick, have forced their way along joints and bedding-planes.

Finger Mountain (B) contains a wedge of sandstone which separates two sheets of dolerite (Fig. 22). One of these sheets caps the hill; the other separates the wedge from the major portion of the sandstone which only just appears above the ice. The whole sequence occupies a cliff of about 500 feet high; the wedge of sandstone is about 100 feet thick at its eastward extremity, whence it thins westwards and disappears in a distance of about two miles. One bed of sandstone after another is cut out by the dolerite as it transgresses them upwards to join the mass which caps the hills to

the south of Finger Mountain. Immediately to the south of Finger Mountain the wedge is considerably thinner. It is exposed in the valley, which, cutting back, produces the sharp spur marked b_1, b_2.

Again, on the north side of the glacier in Round Mountain (C_1) is a wedge of yellow rock, which is probably a similar sandstone, and is also caught up by the dolerite in exactly the same way. This mountain, however, differs from Finger Mountain in having a small sandstone-outlier which caps and protects the dolerite at the summit.

Along the right bank of the Ferrar Glacier from B_1 to B the sandstone may be seen above the level of the ice, but local disturbances prevent the upper surface from appearing as a continuous line along this side.

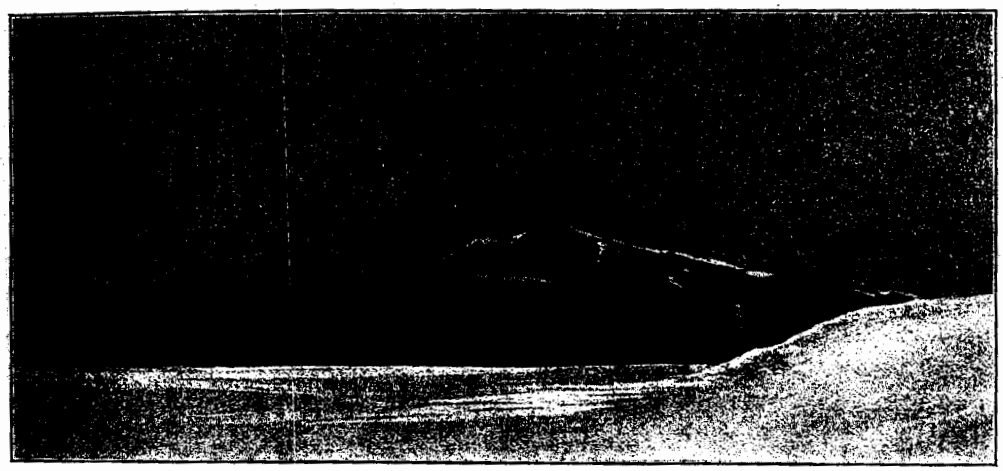


FIG. 22.—FINGER MOUNTAIN. WEDGE OF SANDSTONE IN THE DOLERITE.

THE DRY VALLEYS (Plate V).

These two valleys lie on the south side of the Ferrar Glacier and on the west side of the Beacon Heights (B_4, B_5). Both have vertical sides 500 feet high, which suddenly give place above to less steep slopes as the surrounding mountains are approached. Both are tributaries of the main valley. The smaller lies immediately south of Finger Mountain, and, narrowing the while, trends due west for a distance of two miles; at this point the valley suddenly turns southwards, the ice which occupies it suddenly ends, and displays a bare, flat, stony bed. The confining walls continually approach each other, and one mile above the ice-cliff they suddenly come together in a veritable *cul-de-sac*.

The larger valley is about four miles long and also ends in a cliff. Its sides are steep and parallel, and maintain the same height all the way round. The

valley-bed here also is flat and free from ice; it is strewn with boulders of all sizes, and is therefore exceedingly rough. The breadth is less than two miles, but near the mouth, where it is joined by the smaller valley, it widens, and together they open out into the main depression of the Ferrar Glacier.

The Beacon Sandstone on the north side of the smaller valley is most accessible at a spot west of b_2, where the usual sandstone is capped by dolerite. About 300 feet are exposed, and the beds can be traced horizontally all round the left side until cut off by the dolerite of the hill *x*. The main mass of *x* is dolerite, but a small exposure of sandstone is visible at its western foot. In the middle of the mass there are two other narrow strips of sandstone, each about 20 feet thick and half a mile long, which seem to have been caught up by the intrusion. At the west foot of this hill the Beacon Sandstone shows a new feature, for on the under side of a large block there was a six-inch bed composed of angular quartz-fragments (681). These pieces of quartz are fairly regular, almost cubic, and about an inch long. They are set in a matrix of the usual sandstone, and it is worthy of note that no rounded pebbles were here observed.

There are four very prominent buttresses south of *x*, which form the sides of the larger valley, and in each of the buttresses two bands of yellow rock and two of brown rock were seen alternating regularly. These alternations possibly represent parts of once continuous intrusions of dolerite which follow the same bedding-planes across the whole area. A similar arrangement also holds in the buttresses of the eastern valley wall.

The Beacon Heights (B_4, B_3) (Plate V, and Section I, Plate VII).

On the western side of Beacon Height West (B_4) there is a small outcrop of the Beacon Sandstone. This, as before, has horizontal bedding-planes. The bulk of the rock is coarse, even-grained in texture, and almost white in colour. The greater part of the mountain appears to consist of sandstone, for the lower 2000 feet shows a yellow rock, with horizontal joints or bedding-planes, where the even covering of dark talus-products is wanting. The summit is a small cap of brown rock, which is separated from a larger mass of the same brown rock by a band of yellow about 500 feet thick, also bedded horizontally. The larger mass of brown rock is continued in the summit of B_3, and even extends to the summit of Knob Head Mountain further to the east.

The sandstone crops out as a small cliff on the side of this mountain (B_4); there the cylindrical rugosities (see p. 43) are again developed and appeared to be quite similar to those observed on West Groin. This outcrop was traced for a distance of a quarter of a mile along the hillside, and the cliff is on an average 50 feet high.

The Terra Cotta Mountains (Fig. 23).

The Terra Cotta Mountains (B_6, B_7, B_8) appear to be composed mainly of sandstone. They are abundantly riddled by dykes of dolerite which appear to have had considerable effect on the sandstone. The sandstone has a pale-pink tinge, and in the distance the hills have a dull-red colour, which contrasts strikingly with the dazzling snow and the yellow sandstone elsewhere. Some of the specimens from the moraine show that the sandstone has been altered to quartzite (697). The dykes will be mentioned in the next chapter when the dolerite-rocks are considered.

Knob Head Mountain (B_9) (Plate V).

The last spot where the Sandstone Formation was examined is on the east side of Knob Head, 30 miles from the South-west Arm or the hill B_1, and about 30 miles from the sea. Here a small outcrop, similar to that on the west of Beacon Height, is found at an elevation of about 3500 feet. At a distance the whole lower portion of Knob Head Mountain appears to consist of the sandstone. The mountain, like the Beacon Heights, has a small cap of dark-coloured rock (dolerite), which is separated from a larger sheet below by a narrow and horizontal yellow band. This similarity in the summits of the three mountains makes it probable that all are parts of the same two sheets of dolerite.

Fig. 23.—Terra Cotta Mountains, showing Dykes of Dolerite.

The sandstone-outcrop on Knob Head is less than a quarter of a mile long and about 100 feet high. Here again one bed was observed to have, all over its surface, cylindrical prominences like those described on page 43. At this spot, also, some beds contain alternate dark-coloured and light-coloured laminations, but nowhere did the rock show bands at all like the black bands found near the foot of B_1, nor was there found any structure in these dark laminæ which would suggest organic life.

APPENDIX TO CHAPTER VI.

REPORT ON THE PLANT-REMAINS FROM THE BEACON SANDSTONE.

By E. A. Newell Arber, M.A., F.L.S., F.G.S., University Demonstrator in Palæobotany, Cambridge.

The remains collected by the 'Discovery' Antarctic Expedition, and regarded as probably of the nature of fossil plants, are unfortunately of little value botanically.

The material was derived from two localities, viz., the hill B_1 in the South-west Arm of the Ferrar Glacier, and the Inland Forts. The specimens of Beacon Sandstone, containing much carbonaceous material, from the hill B_1 were collected by Mr. Ferrar on the 12th and 13th of November, 1903, at a height of 50 feet above the level of the ice (see p. 41). Several of these show fair-sized, carbonaceous impressions or markings, which, in all probability, are of vegetable origin. One example somewhat resembles in appearance a piece of petrified wood, but a microscopic section made from this material has failed to show any trace of organic structure.

The specimens from the Inland Forts are pieces of a pale yellow sandstone, obtained by Mr. Ferrar on November 16, 1903, at a spot some 800 feet up the West Groin (see p. 43). Some of these show one or more series of irregular puckerings, consisting of slight pits or depressions, sometimes lined by a small amount of carbonaceous material. It appears, however, to be impossible to form any opinion as to whether these features are due to vegetable agency or otherwise.

The imperfect evidence presented by these specimens will neither permit of any opinion as to the botanical nature or affinities of the fossils themselves, nor of the geological age of the beds in which they occur. Their discovery may, however, be regarded as affording indications that, at some period or other in geological time, vegetation flourished so far south as latitude 77½°. Such a conclusion is of great geological interest, and is in harmony with the fact, now ascertained beyond doubt by the discovery * of abundant evidence of varied vegetations belonging to several different geological epochs, that the climate of the Antarctic, as of the Arctic regions, has been much more genial at more than one period in the past than at the present day.

* Nathorst, A. G., Sur la flore fossile des régions antarctiques, Compt. Rend. Acad. Sci., 1904, cxxxviii, p. 1447.

Chapter VII.

THE DOLERITES.

The doleritic type of rock has been found in practically the same localities as the Beacon Sandstone, and it will, therefore, be convenient to consider the localities in the same order as before. The dolerite of Depôt Nunatak is the highest point from which rock of any kind has been collected in South Victoria Land. Dolerites occur here at an elevation of 7000 feet, and, at the foot of Knob Head Mountain, about 30 miles nearer the coast, they have also been seen only 3500 feet above sea-level. There is no evidence of the presence of surface-outpourings, and as no vesicular or scoriaceous rocks were observed, even in the moraines, it would appear that these rocks are wholly intrusive.

Fig. 24.—Depôt Nunatak, from the East.

Depôt Nunatak (A.) (Figs. 24 & 25).

Lieutenant A. B. Armitage on the first journey through the Royal Society Range obtained weathered dolerite-fragments (632, 633) at Depôt Nunatak, and at the same time Engineer-Lieutenant R. W. Skelton photographed the parent rock which rises as a mass of great columns through the snow. The rock (662) is an outlier, and protrudes through the snow at an elevation of about 6000 feet. The nunatak rises to a height of nearly 500 feet above the snow and is exceedingly columnar throughout. Some of the columns are 12 feet in diameter and, though broken, give the impression that they extend the whole height of the cliff. Depôt Nunatak is 60 miles from the coast and is entirely cut off from the dolerite capping the sandstone eight miles to the east.

The Hill B_1.

Here the dolerite caps the sandstone and produces a cliff which rises vertically for more than 500 feet. This cliff forms the east side of the South-west Arm for a length of ten miles. As before, the columns which go to make up the sheet are