

SCOTT'S LAST EXPEDITION

IN TWO VOLUMES

VOL. I BEING THE JOURNALS OF
CAPTAIN R. F. SCOTT, R.N., C.V.O.

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SCIENTIFIC WORK UNDERTAKEN BY DR. E. A. WILSON AND
THE SURVIVING MEMBERS OF THE EXPEDITION

ARRANGED BY

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WITH A PREFACE BY

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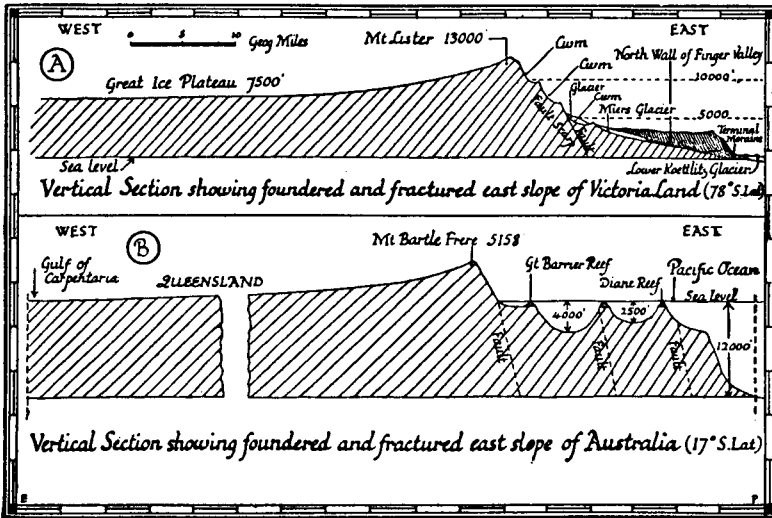
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A RÉSUMÉ OF THE PHYSIOGRAPHY AND GLACIAL GEOLOGY OF VICTORIA LAND, ANTARCTICA

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It is always a wise principle in research to proceed from the known to the unknown. So little has been written on the subject in question that we should have almost a blank sheet were it not for the geologists of Shackleton's Expedition, whose detailed



work is not yet published. Let us glance at a map of the South Polar regions, however, and see if we can deduce any useful principles from neighbouring lands. *

The physiography of the eastern coast of Australia has been subjected to a somewhat detailed investigation during the last ten years, with the result that it is found to exhibit splendid examples of subsidence, trough faulting, and rivers 'drowned' by the sea. Great slices of the coast have sunk below the waves fairly lately in geological times, so that many of the great rivers

* The section across Australia is from a figure by Professor David, F.R.S.

of Eastern Australia now rise on the present coast (the old divide) and flow inland to the central lowlands. The features characteristic of this portion of the crust are therefore: an elevated coastal region sloping gradually to the west and sharply truncated by 'faults' on the east.

Let us now journey southward to Antarctica and take a bird's-eye view of the coast of the Ross Sea and of the great mountain range which leads from the Ross Sea and McMurdo Sound almost to the Pole. We notice at once that this range extends almost due north and south, as was the case in Australia, that it practically constitutes the shore line, that it has a steep eastern slope—often dropping ten thousand feet in a few miles—and that it descends gradually on the west to a uniform land mass of a plateau type.

It seems evident that these points of resemblance are not accidental. The great earth movements which affected Australia in middle and late Tertiary times also affected Antarctica. A readjustment of equilibrium raised the west and depressed the east in both continents. The central portion of Australia, consisting of ancient rocks which have been planed down to a uniform level by the normal agents of erosion—by rivers, wind, &c.—is an example of a *penplain*. It was formed in middle Tertiary times, and bears all the evidence of 'old age' in a land surface. As we have seen, it has been elevated and now the rivers are cutting it down again, forming canyons all round its coastal edges, and the 'cycle of erosion' has commenced anew. In Antarctica the land below the central ice plateau would appear to be a similar penplain. The comparatively slight depth of the *outlet* glaciers seems to indicate that the ice cap is not very thick, probably one or two thousand feet only. The penplain is however elevated to eight thousand feet instead of one to three thousand as in Australia.

It is, however, with the margin of the ice cap that these few pages are concerned. Just as in Australia beautiful canyons and falls have resulted from the attack of the weather on the margins of the plateau, so in Antarctica the ice rivers and agents of frost erosion have carved out their own characteristic topography.

We know from the fossils that warmer conditions existed in Mesozoic times in Antarctica, probably in early Tertiary times. Moreover, the elevation of the land so many thousand feet has

South

Descent Pass

Cathedral Rocks

North



AN 'OUTLET GLACIER' VALLEY COMPLETELY FILLED WITH ICE. LOOKING UP THE FERRAR GLACIER TO THE SOUTH-WEST

Kulri Hills

Lake Bonney

Snout of Taylor Glacier



AN ICE-FREE OUTLET VALLEY, WHOSE GLACIER HAS RECEDED OVER TWENTY MILES FROM THE SEA. LOOKING SOUTH-WEST UP DRY VALLEY TO THE SNOOT OF THE TAYLOR GLACIER



[See p. 209

THE LOWER KOETTLITZ GLACIER, SHOWING THE EFFECT OF THAW-WATERS ON AN ANCIENT GLACIER SURFACE

undoubtedly given rise to a permanent refrigerating system of winds which has made Antarctic coasts much more inclement than they would have been with a less elevated interior.

There is practically no trace of *pre-glacial* topography such as might be shown by a moulding of the inland ice cap. We may picture the rock surface like that of upland Norway, as a gently rolling plateau. As the ice mantle covered Antarctica, occupying the more pronounced swellings first, and then spreading in lobes of ice down the broad depressions, we may imagine that a very little difference in the contour might determine the position of the great outlet glaciers where the ice cap drained away to the sea. In other words, the glacier valleys do not appear to owe much to pre-glacial topography.

Let us now survey the marginal mountain range and the ice plateau more closely. The plateau seems to rise to 11,000 feet near the South geographic Pole, and decreases gradually to the north, being about 7000 feet at the South magnetic Pole. The mountain ranges have peaks, such as Markham and Lister, rising to 15,000 and 13,000 feet respectively, but the average height is perhaps about 9000 or 10,000 feet, while for considerable stretches near Granite Harbour they are only 6000 or 8000 feet high. Every 20 or 30 miles this fairly continuous range is broken by a huge 'outlet' glacier. Many of these are now well known, such as the Beardmore, which is over 100 miles long and 30 miles wide, the Ferrar, Mackay, David, &c. They form the only routes from the coast to the interior, and were it not for the *ice falls* where the glacier covers some irregularity in its rock floor, or the more dangerous *crevassed areas*, where it sweeps round a corner, or receives the thrust of a large tributary, they would not be difficult to traverse with sledges. The grade is not very steep, and they are to some extent sheltered from the blizzard drift which is the great obstacle to Barrier and plateau journeys. Their detailed topography is however very different from that of an area subjected to 'normal' erosion.

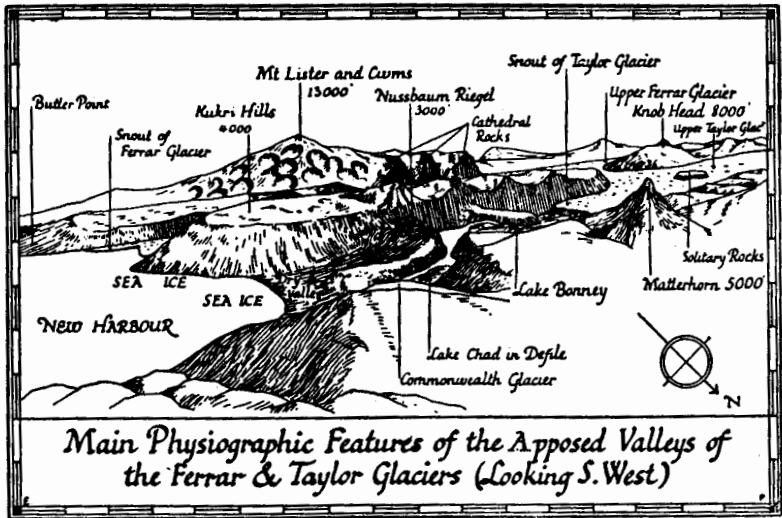
The regions more especially investigated in the two sledge journeys of the Western Geological Parties in 1911 and 1912 were the following:

- (a) The Ferrar and Taylor outlet glaciers ($77^{\circ} 40'$).
- (b) The Koettlitz ice delta and its hinterland ($78^{\circ} 20'$).
- (c) Granite Harbour and the Mackay outlet glacier (77°).

(d) The Great Piedmont glacier between Granite Harbour and New Harbour ($77^{\circ} 20'$).

Each of these regions presented its own peculiar topography, and the four were diverse enough to embody almost the whole cycle of glacial erosion within their domain.

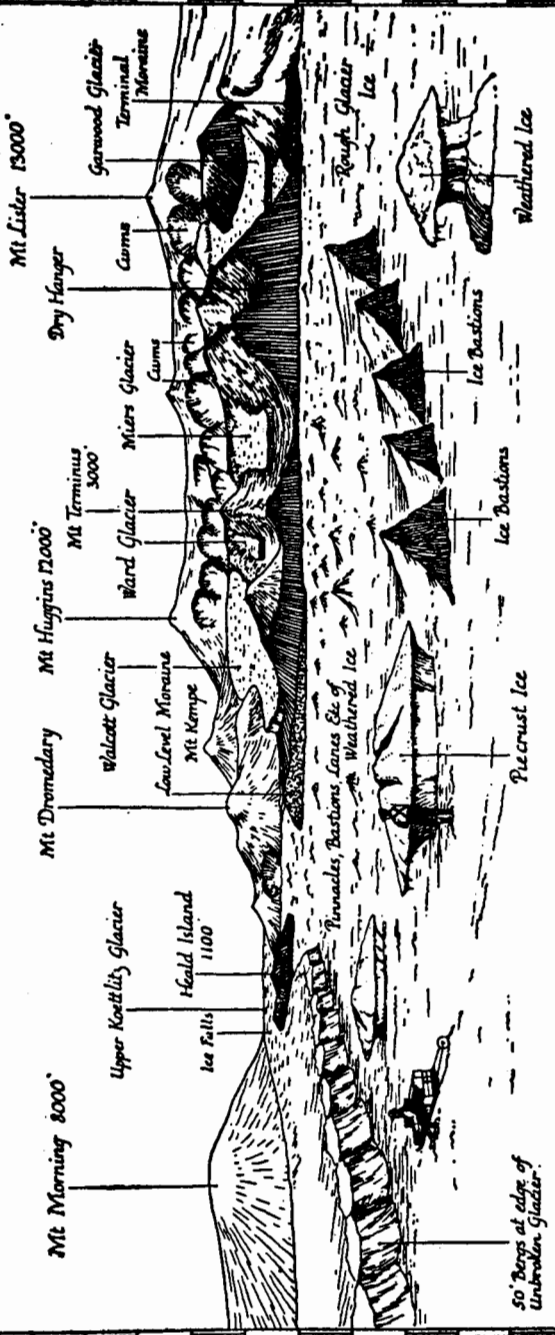
(a) *The Ferrar and Taylor 'Outlet' Glaciers and the Dry Valley.*—These two glaciers are now connected by an ice col near Knob Head Mountain, but were originally distinct parallel gla-



Main Physiographic Features of the Apposed Valleys of the Ferrar & Taylor Glaciers (Looking S. West)

ciars draining the ice plateau. As one marches up the Ferrar Glacier and notes its crevasses and ice falls, one wonders what the rock floor is really like—under the ice river. Just 5 miles to the north is another glacier which furnishes the answer to this question, for the Taylor Glacier now stops short 25 miles from the sea, and in Dry Valley we see how all the other valleys will appear when the ice age shall pass away from Antarctica.

Starting from New Harbour at the mouth of Dry Valley, the latter presents a typical catenary cross-section. A splendid pair of walls with the characteristic slope of 33° defines the glacier trough. There is no large terminal moraine near the sea, which seems to denote a fairly uniform and perhaps rapid retrocession of the glacier. About 6 miles from the coast a narrow defile appears on the north side, but the rounded valley floor rises



Main Physiographic Features of the Koettlitz Glacier showing the Pinnacle Ice in the Western half and the "Finger" Valleys radiating from the Cwm of the Lister Scarp.

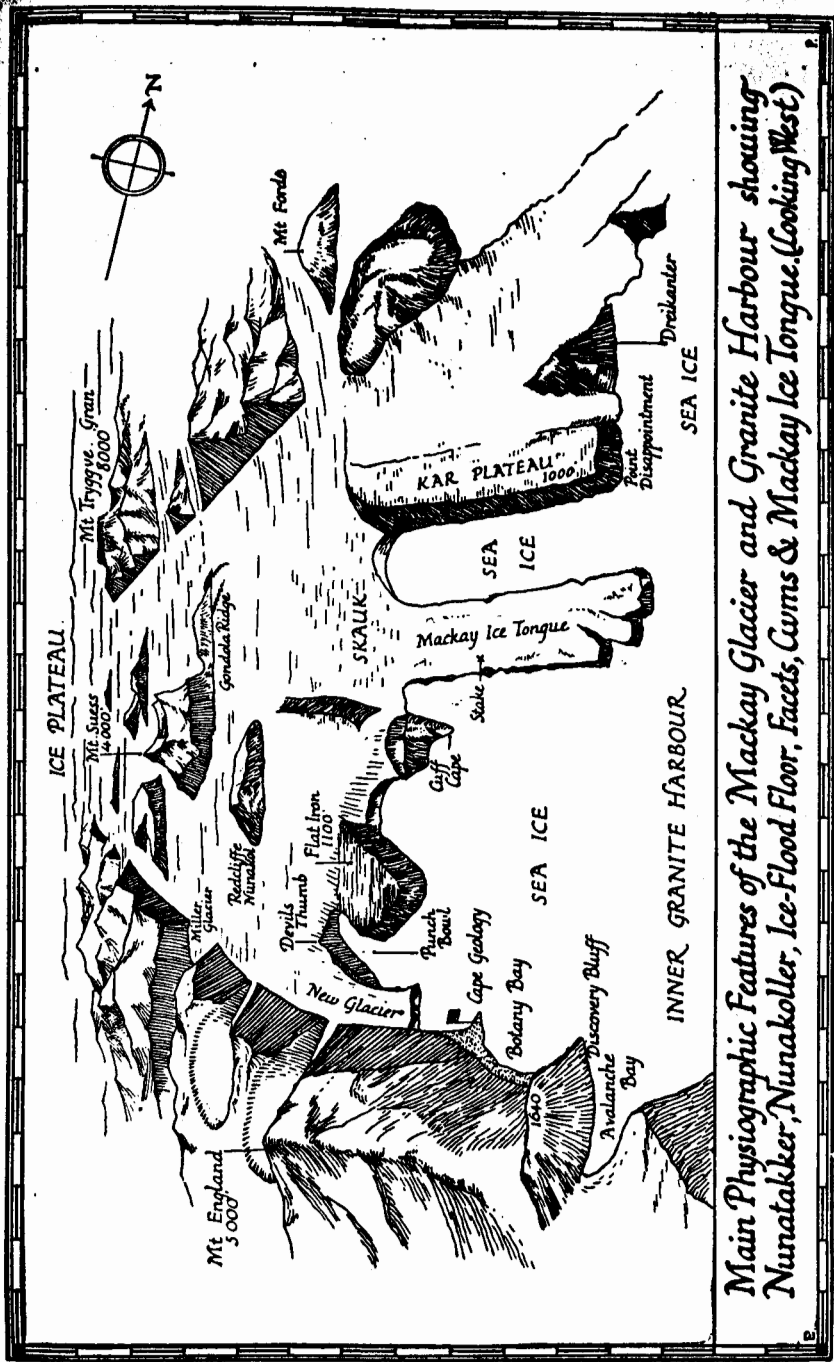
gradually to 2000 feet over the greater part of the trough. West of this point there is a sudden drop from the Nussbaum Bar (or Riegel) into the next 'bowl' of the valley. This is filled with moraine material to the depth of several hundred feet, for the drainage of the 'bowl' is *away* from the sea to the salty waters of Lake Bonney. The defile previously mentioned is about 1500 feet deep, and would seem to be a water-cut gorge denoting an inter-glacial period.

Lake Bonney is about 3 miles long and is separated into two portions by a granite bar 500 feet high. This also is traversed by a narrow gorge on the northern side of the trough and is a smaller edition of the Nussbaum 'Bar' or Riegel. Then about $\frac{1}{2}$ mile farther west we reach the snout of the Taylor Glacier, which appears to be overriding moraine material at its extremity. The surface of the latter rises 600 feet in a very short distance, and is carved into alcoves and gullies by the sun—all of these erosion features presenting a steep face to the north and a gently sloping one to the south. The thaw streams on the glacier and in the moraine-filled Dry Valley all flow to the N.E.

Visitors to Switzerland will recognise how closely this alternation of 'gorge,' 'riegel,' and 'bowl' recalls the classic glacial valley south of the Saint Gothard Tunnel. Moreover, Lake Lucerne owes its cross-like plan to the action of two parallel glaciers—one of which overflowed (near the Rigi) into the adjoining valley. The same process is being carried on to-day where the 'apposed' glaciers of the Ferrar and Taylor valleys are joined in Siamese twin fashion south-east of Knob Head.

(b) *The Koettlitz Glacier* cascades over ice falls near Heald Island and reaches sea level while still 20 miles from its snout. This 20 miles of low-level glacier is extremely interesting, for it would appear to be a stagnant area whose chief characteristics are due to the action of thaw waters on an old glacier surface. The pinnacles, bastions, and bergs have been described in the preceding narrative. Here again the drainage is directed diagonally across the glacier to the north-east. Some movement has taken place, for the edge of uniform glacier sheet on the south is fringed by great bergs which are differently oriented, though all sealed in the extremely ancient water-cut labyrinth of ice which constitutes the north-west portion of the delta.

Below the scarp of the Royal Society Range is a hinterland



Main Physiographic Features of the Mackay Glacier and Granite Harbour showing Nunatak, Nunakoller, Ice-Flood Floor, Facets, Cums & Mackay Ice Tongue. (Looking West)

of parallel valleys. These are about 10 or 12 miles long, and are in many cases occupied by small glaciers in the western half of the valley. They are identical with the 'finger' valleys described in the reports on the glacial geology of the Rocky Mountains, U.S.A. Narrow ridges about 3000 feet high separate them. Some 'hang' a thousand feet above the Koettlitz. Characteristic hills, triangular in plan, occur where these valleys join, and all of them 'head' in beautiful cwms. Above these cwms, and more cwms, fret the scarp of Mt. Lister over the whole extent of its 10,000 foot face. There is little doubt that we have here an example of the way the glacial cycle commences its operations, for this is a fault scarp of comparatively recent date.

(c) *Granite Harbour*, like New Harbour, is probably a relic of the period of glacial maximum when the ice flood exerted tremendous erosive power on its bed, and was able to erode far below sea-level. We shall however never be able to witness these maximum forces in operation. Because a dwindling river has little effect on the topography it would be foolish to deny the action of a great river in flood; just as our observations in the Antarctic on a nearly stagnant or receding glaciation are not to be taken as descriptive of the most active periods in glacial history.

The first feature that strikes the geologist is that as one proceeds north there is less and less land exposed below the snow and ice mantle. This implies, I think, that the precipitation in the south-west corner of McMurdo Sound is extremely little, and increases both northward and southward. The most striking feature in the harbour—the Ice Tongue—has been described in the narrative. The Mackay Glacier moves 3 feet a day, as already recorded. Mention must be made of the ridge separating the new glacier from the Devil's Punch Bowl. This has certainly been covered quite lately by the new glacier. The harder dykes are striated, but the ridge is for the most part covered with granite débris. There is practically no englacial rock débris in the glacier, so that one is led to the important conclusion that the floor of the new glacier is covered with rock débris and that no erosion is taking place under this fairly large glacier. What was the floor of the Mackay Glacier at its period of greater area is exposed in many places 1000 feet above the sea ice in the form of rock-strewn plateaux.

One of the most interesting features is the evolution of the cwm which is indicated on all sides in the steep faceted slopes. On Discovery Bluff are the couloirs or chimneys; on Mt. England these become somewhat funnel-shaped; on the face of the Kar Plateau they deepen to a definite if shallow bowl. They obviously only originate on steep slopes where the icy covering is shallow. Avalanche Bay and the Devil's Punch Bowl are respectively filled and empty cwms, both at sea level. Along the southern crest of the valley are giant cwms each with its own glacier. Here the Miller Glacier has cut through the divide and links the Mackay presumably to the upper Debenham Glacier. The walls are faceted, but not much faceting is visible—for the Mackay would seem to be filling its bed to a greater extent than the Ferrar or Taylor glaciers. Traces of a high level plateau at 3000 feet are evident all around Mt. Tryggve Gran, and the ice sheet drains thence into large tributary glaciers such as the Cleveland.

The upland topography is of three types. There are mountains, such as Tryggve Gran, whose shape is due to their stratigraphy. This peak is flat-topped owing to the presence of a dolerite capping. Others exhibit the typical cusps of the Matterhorn type, due to cwms encroaching on three sides. Others again, such as Mt. Forde, the Whale Back and Whitefinger, are now like giant *nunakoller*,* for the cusps have yielded to the smoothing action of frost erosion.

Scattered over the glacier are the *nunatakker** (such as Mount Suess) and *nunakoller** (Gondola Ridge and Redcliffs), which have been described in the narrative.

(d) Space does not permit of any adequate account of the Great Piedmont Glacier. It has a seaward edge some 200 feet thick over the land, and for a considerable portion its front would appear to be floating, for here the edge is but 30 feet above the sea ice (and presumably 200 feet below water level). It rises to some 2000 feet above the sea about 3 or 4 miles from the coast, and is beautifully moulded over hidden *nunakoller*. One or two of these project above the ice about a thousand feet, and the mountains behind exhibit beautifully the relation of lower glaciated slopes to cusped peaks. The plane separating these

* The two types of islands projecting through the ice sheet need to be distinguished. *Nuna-tak* is 'lonely peak,' and I suggest *nuna-kol* (*vide* Gran) for the rounded ridges which have been covered by the ice-flood.

topographic types is here about 3000 feet high. Behind many of the rocky capes the piedmont appears to be nearly stagnant, or receding slowly, for the ice either begins to thicken very gradually, or is greatly sun-weathered. In no case is there any evidence of pressure or 'overhang' on the capes, though the crevasses opposite the valley glaciers show some movement, no doubt due to the pressure of the latter.

In conclusion it will be of interest to trace the features accompanying the growth of an ice age as exhibited in Victoria Land. Near Cape Evans the change of a snow drift into a *glacieret*, and of the latter into a glacier, can be studied in many places. The later stages depend greatly on the topography. If the land is flat—i.e. part of an old peneplain—the ice sheet merely spreads out in great lobes, of which examples occur near the Solitary Rocks on the flattened slopes north of the Taylor Glacier. This grows larger and spreads out laterally, and, to my mind, plays a protective part, as in the Great Piedmont.

If, however, we are dealing with steep contours, the incipient glaciation—accompanied by water at this stage—cuts out couloirs and shallow cwms. The next stage is probably that represented by the scarp of Lister. Ultimately some cwms encroach on others and dominating 'finger valleys' are initiated. These ultimately become 'outlet' glaciers.

The 'outlet' glaciers rise to a maximum, overriding the slopes and carving out what later appear as shoulders or benches. At this period there is true glacial erosion. The *riegel* are overridden and planed down, the fiords are cut out, the lakes are deepened. Later the snowfall diminishes and the erosive power decreases, and the glaciers dwindle through all the stages recorded by Hobbs. The Beardmore Glacier with its tributaries largely entering at grade, the Mackay with a few 'hanging' glaciers, the Ferrar with a preponderating number of tributaries hanging on the slopes of the main trough, are examples of the earlier stages in this decline. The Koettlitz with its tributaries 5 miles back from the main glacier and the Taylor Glacier with its extraordinary ice-free outlet trough 25 miles long are later stages in the retrocession of the ice mantle.