THE GEOLOGY OF THE LAKE ST. CLAIR DISTRICT, TASMANIA.

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(Maps.)

In the following paper an attempt is made to give some account of the main geological features of the district about Lake St. Clair. The observations were made during a recent visit to the lake by a party, including Professor Spencer, of Melbourne University, myself, and several others. Owing to the inclement weather we experienced, we were unable to make as extensive observations as we would have wished, and the present account does not purport to be more than a geological sketch.

Lake St. Clair is situated on the great central greenstone plateau of Tasmania. This plateau, according to Mr. R. M. Johnston, "preserves a general rugged or undulating level of about 4,000 feet altitude, and its higher bosses and peaks and its valleys do not vary much more than 1,000 feet above or below this uniform level." Lake St. Clair, the queen of Tasmanian lakes, lies near the western boundary of this plateau, and a little to the north of the central part, its northern shore being cut by the parallel 42° S. lat. Its elevation above the sea is about 2,400 feet. It lies in a long, deep, narrow valley, bounded on the east by the Traveller Range and its offshoots, Mount Ida, and the rugged mountains between it, and the Ducane Range, and on the west by Mounts Olympus, Byron, and Manfred. The length of the lake is about 11 miles, while its greatest breadth is about 2 miles. A depth of 590 feet is recorded.

At the north end the valley extends to the foot of the Ducane Ranges, some 10 miles beyond this extremity of the lake. The southern shore shelves up to a succession of low greenstone ridges and button-grass flats. The shores of the lake are remarkably regular, and at this end (southern) occur the only indents of importance, viz., Cynthia Bay on the W. and the lake basin on the E. The latter is almost land-locked. From it the Derwent starts on its way to the south. The lake is fed by numerous streams and torrents, the principal ones being the Narcissus (Hamilton) on the N., flowing from the Ducane Mountains; on the E. a stream from Lake Laura and another from the mountains behind Mount Ida, while Cynthia Bay receives the Cuvier. The latter river rises from Lake Petrarch, a small sheet of water just under Olympus, on the opposite side from Lake St. Clair, and about 560 feet, according to our aneroid, above it. The Cuvier flows down a broad, undulating valley known as the Vale of Cuvier. This valley runs in a S.E and N.W. direction, and is bounded on the one side by the Olympus Range and on the other by Mount Hugel.

Having thus briefly sketched the main physical features of the lake and its surroundings, we will be in a better position to consider the geology.

According to the map in Mr. R. M. Johnston's excellent work "The Geology of Tasmania," and I believe this is the most recent, the southern and western shores of Lake St. Clair are represented as sedimentary rocks of upper palæozoic, or possibly mesozoic, age. I shall speak of them as carboniferous, provisionally, all to the west of this is put down as greenstone (diabase). A small patch of basalt is represented as occurring about the S.E. extremity of the lake. The carboniferous rocks are marked as abutting on the older palæozoic, along a line running up the northern side of the Vale of Cuvier.

The most important point at present in the geology of this district is the relation of the greenstone to the carboniferous rocks. The earlier geologists, notably Gould, Strzlecki, and Tenison-Wood, were of opinion that the greenstone was post-carboniferous. However, this has been called in question, and Mr. Johnston, though from what he says there would appear to be two greenstones of distinct ages, thinks that "the massive greenstones occupying the more elevated mountain ranges, as well as the greater part of the dividing ranges within the system, have all been erupted prior to the deposit, even of the lower members of the carboniferous system, and that only certain minor ridges, like that at Spring Hill, represent diabasic greenstones of a later date." . . . "The great inland greenstone plateau of the lake country," according to Mr. Johnston, "probably formed an elevated island mass of considerable extent" (in the carboniferous sea).*

It may be said that Mount Olympus affords the key to the geology of the district. As already remarked, the Olympus Range skirts the western shore of Lake St. Clair, terminating at the lower end of the Vale of Cuvier. One of the best views of the mountain is obtained from about half way, or a little more up the lake. Here the crest of the mountain, rising to 2,300 feet above the water, consists of massive columnar greenstone, the columns rising vertically for several hundred feet, their bases being concealed beneath the ruins of their fallen comrades. Below this greenstone crest appear horizontal beds of sandstone, extending to the shore of the lake below, and forming apparently the base of the mountain,

* "Geology of Tasmania," by R. M. Johnston, F L.S., pp. 102, 3.

which is covered up to the greenstone with a luxuriant vegetation of beech *(Fagus Cunninghami)*, sassafras, and ferns, etc. The greenstone crest forms a rugged ridge for the northern half of the mountain. Running from N.W. to S.E. it terminates abruptly in a mighty columnar wall, and the ridge of the mountain is now continued at a much lower level, 950 or 1,000 feet, above the lake. It slopes down to its termination at the Cuvier Valley. This ridge we ascended from the lake side, at a distance of about three miles from the boat-house on Cynthia Bay. We found it to consist of sandstone from the base to the summit, the beds being almost, if not quite, horizontal. The sandstone is of medium texture, and rather soft. It forms vertical cliffs along the sides of the mountain at various levels, and in many places is weathered into caves of limited extent. We were unable to follow this ridge to its termination, and so cannot say definitely if the sandstone occurs on the summit all the way. It is probable that it does, for most of the way at any rate. It appears to form the western shore of the lake for its entire distance. So much for the eastern aspect of Olympus.

Passing along Scott's track up the Vale of Cuvier, we crossed over the lower extremity of the Olympus Range. Here we noticed masses of sandstone, and quartz-conglomerate mingled with greenstone, but we could not from mere inspection decide which was *in situ*. As the Cuvier Valley is followed up, it opens out into button-grass plains of a gently undulating and rising character to Lake Petrarch, which, as before mentioned, is about 560 feet above St. Clair. Through these plains protrude bossy masses of greenstone here and there, reminding one of a scene on a Scottish moorland.

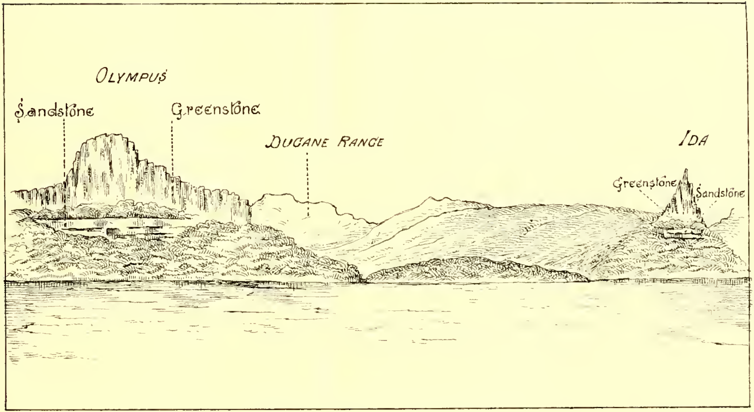
From this side Mount Olympus presents even a grander appearance than on the other, and a more comprehensive view of the mountain is obtained. The greenstone crest is seen rising in giant buttresses, and running almost to the N.W. extremity of the mountain. During our ascent from this side we could not see the character of the underlying rock, owing to the dense vegetation and the mass of *debris* that has fallen from the heights above. On our descent, however, we encountered at 1,500 feet above St. Clair an outcrop of a yellow clayey material, which gave one the impression of a sedimentary deposit that had been baked; but we could not see its actual relation to the greenstone above. About 200 feet below this we found several well-marked outcrops of sandstone, horizontally bedded, and forming the usual vertical cliffs, hollowed out into caves here and there. Springs are very numerous along these sandstone cliffs. There seems to be no reason to doubt that these sedimentary beds extend right along to the N.W. extremity of the mountain, occupying the same position relative to the greenstone on this side that they do on the other. This is indicated by the numerous, and often very large, blocks of sandstone and conglomerate that occur mingled with masses of greenstone towards the upper end of the Cuvier Valley. At one place, just below the southern extremity of Lake Petrarch, these masses of rock form a ridge reaching nearly half-way across the valley. A large boulder of conglomerate can be seen on the S.W. shore of Lake Petrarch, which has evidently fallen from the heights above. The shores of Lake Petrarch are sandy and gravelly, such as would result from the disintegration of sandstone and conglomerate.

The summit of Mount Olympus is much like that of Mount Wellington, a rough, uneven plateau-like surface, formed by the unequal weathering of the greenstone columns, some of which stand up like sentinels among their fellows; many of them are 15 feet or more in diameter. A noticeable feature is the presence of several large fissures, which gape across the mountain in an east and west direction approximately. The largest of these fissures had a great deal of snow lying in it, so that we could not see the depth; 50 or 60 feet would be somewhere near it. These fissures are being filled up by the falling columns. As to their origin I do not care to speak definitely. Perhaps they are due to dislocations, perhaps to the undermining action of water in wearing away the underlying rock.

From Olympus it is seen that the Traveller Range on the opposite side of the lake is really the edge of a plateau stretching away for miles beyond. This plateau is of greenstone, and its roughly undulating surface is studded over with lakes and tarns of all sizes, recalling the Scottish Highlands again. The Traveller Range preserves an even, slightly undulating summit till it is terminated by the deep valley that separates it from Mount Ida. The structure of Mount Ida is a repetition of that of Olympus, a crest of greenstone with horizontally bedded sandstone below. We did not reach the top of Ida, but went about half-way up from the lake side. A stream that flows down between Mount Ida and the ranges to the north we followod up for some distance and found that we were on sandstone all the way. From Lake Laura, lying beneath Mount Ida, and slightly to the N.W., a splendid view of the mountain is obtained, the horizontal beds of sandstone being clearly seen at about two-thirds of the way up the mountain, while the sharp peak of columnar greenstone stands out clearly against the sky. The Eldon Range, to the N.W. of Olympus, according to the geological map, presents the same appearance as Olympus and Ida, viz., a greenstone centre or crest, with a base of sandstone.

The appearances I have described seem to me to point clearly to the greenstone being of later date than the sandstone. Supposing the greenstone to be anterior to the sandstone we should have to believe that the greenstone portions of Mounts Olympus, Ida, Byron, Eldon Range, etc., are much the same to-day as they were in carboniferous times, and we should also have to believe that the sandstone which, according to this theory, was deposited round the greenstone peaks, has weathered in so remarkable a manner as to form regular rings round the greenstone centre. This seems most improbable.

That the greenstone is of later date than the sandstone is supported by further considerations. Suppose the greenstone were of prior date, and a submergence were taking place, on account of the columnar structure of these rocks the amount of *debris* would be very great, and all the shore material, shingle, etc., would be almost entirely composed of greenstone, and there would be comparatively little sand. Now I have not seen a trace of greenstone nor anything like it in any of the sandstone or conglomerate examined. One would expect that so close to the shore, as, for instance, the sandstone of Olympus, must have been deposited, on this theory, the material laid down would be almost entirely a conglomerate of greenstone. So far as we have seen the sandstone is a rather fine or medium-grained silicious one. Where conglomerate occurs the included pebbles consist of material derived from the older rocks, such as quartz, quartzite, jaspar, lydian stone, cornelian, etc. Quartz-porphyry probably also occurs in this conglomerate, as pebbles of this rock are not uncommon on the stretches of gravelly beach here and there along the lake. Further, against such a coast as the greenstone would make, the water would be deep, and the angle of deposition of any sedimentary material would be considerable, dipping away from the shore in all directions. So far as we have seen there is no trace of this in the sandstone ; on the contrary, one of its most striking features is its horizontality, even close up to the greenstone. Again, it seems to me rather improbable that a rock material having the structure of this greenstone could have survived to such an extent since pre-carboniferous times. One of the most noticeable features about the mountains in this district is the enormous amount of greenstone *debris* that covers their flanks, showing how rapidly the work of denudation is proceeding. And is it not likely that if the greenstone were anterior to the sandstone, that the lines of junction between the two formations would be just where we might expect to get the main valleys, as it would be here that erosion and denudation would act most rapidly, and it would be rare to find the sandstone abutting against the greenstone, as we now find it?



View looking up ST CLAIR.

From what I have said about the structure of Mount Olympus, it might be expected that sandstone should form the bed of the Cuvier Valley. But, as before remarked, only bosses of greenstone appear through the button-grass, except at the upper end, where masses of sandstone and conglomerate occur as well. We also found an outcrop of sandstone at one point on the south side of the valley, about half-way up its course. There can be little doubt that the original relative levels of the sandstone and the greenstone have undergone considerable changes, but it is quite impossible to say yet what the extent of such changes may be. There are several feasible explanations of the greenstone masses in the Cuvier Valley.

1. They may simply be the relics of the greenstone which once overspread an originally uneven surface of the sandstone. Once worn down to a certain level, the sandstone, on account of its horizontal bedding, would not tend to form any prominent projections, and would be rapidly concealed beneath the accumulations of peaty matter. The greenstone, on the other hand, on account of its greater hardness and way of weathering, would project here and there through the bogs. Some of these masses may have come from Olympus.

2. They may represent dykes through the underlying sandstone.

3. The Cuvier Valley may occupy the line of a great fault, which seems to me not improbable.

In the accompanying map I have adhered to the first explanation.

We did not see a sign of the older palæozoic rocks represented in Mr. Johnston's map as occurring in the Cuvier Valley. We traversed a good deal of the country lying to the south of Lake St. Clair, and found it all of the same general character, a succesion of button-grass swamps or flats, with low greenstone ridges between. Bedlam Walls, at the entrance to the Navarre Plains, consist of a great mass of greenstone, which differs from that of Oylmpus in not being columnar. The base of Bedlam Walls is about 60 feet above St. Clair. The country between the lake and the Nive Plains, some 18 miles distant, is all of the same general character, greenstone ridges and button-grass flats. The Nive Plains occupy a broad depression, five or six miles across, sloping in towards the River Nive. They are of a roughly undulating surface, covered with dead and fallen trees, the result of a severe frost 50 or 60 years ago. These plains are basaltic, the basalt in places being highly vesicular and decomposed. At the Nive bridge, at Marlborough, columnar structure is well developed.

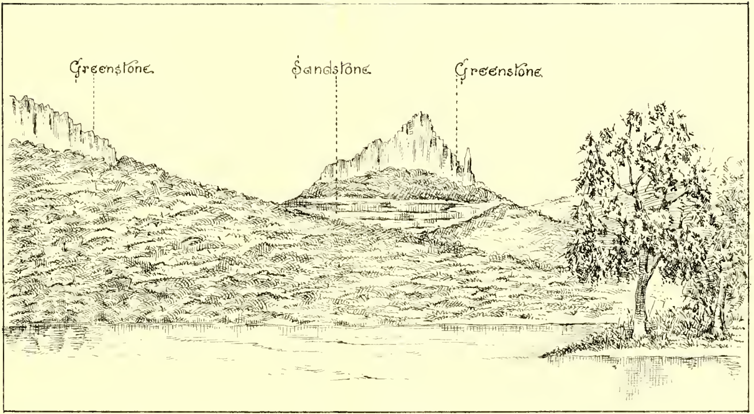
At "Bust-gall" Hill, several miles further on, the greenstone country is again reached, forming a plateau considerably above the Nive Plains. From here right on to the Dee the map represents the rocks as entirely greenstone, but the road crosses several outcrops of sandstone, one being about a mile across. There are no good sections exposed along the track, so that the relations could not be clearly seen.

I think I have now shown good reasons for believing that the greenstone of the lake country is of subsequent date to the carboniferous (?) sandstones. Moreover it seems probable that these sandstones had been elevated and carved into all the varied features of a land surface when the floods of lava, now represented by the greenstone, overwhelmed the country. Since then enormous denudation has taken place, accompanied probably by considerable dislocations and displacements, and the greenstone crests of Olympus, Byron, Ida, and all the other mountains of similar structure (in this district at least) are merely outliers, the remnants of a once vast and continuous sheet of lava. The evidence of this enormous denudation is about the most striking feature that catches the geologist's eye when he ascends Mount Olympus for instance, giving him some idea of the magnitude of those forces which, though apparently trivial in themselves, are yet capable of producing such grand and imposing effects.

The origin of the lakes of the great central plateau is a question which affords ample scope to any geologist who will undertake their investigation.

Lake St. Clair was, I believe, first supposed to be a crater lake, but of this there is no evidence. Mr. Gould explained it on the theory of a flow of basalt damming up the lower end of the valley in which the lake lies. However, I am much inclined to doubt the existence of this basalt. From a mere casual inspection, the rocks about this end of the lake seemed to us to be the ordinary greenstone. We had intended to make a special expedition from our camp to settle this point, but were prevented by bad weather at the last.

The eastern third of the southern shore of the lake is bounded by a bank of sand which is covered sparsely with timber and in places is honey-combed by wombat-holes. The lake is very shallow in this locality, and knobs of greenstone can be seen projecting above the water at a considerable distance out from the shore. The upper end of the lake appears to be shallow as well as the lower. The ridge of sand just mentioned separates the lake from an extensive button-grass flat, which extends eastwards till it merges into the swamps that mark the entrance to the Derwent. It seems pretty certain that the waters of the lake once covered this flat. As Tasmania is undergoing a movement of upheaval the rivers must, geologically speaking, be rapidly lowering their channels. The course of the Derwent affords ample evidence of this. Thus the level of the Lake St. Clair waters must be gradually being reduced. At one place under



Mt IDA from LAKE LAURA.

Mount Ida we noticed an old beach of conglomerate some feet above the surface of the lake. The addition of several feet of water would cause a considerable extension of the lake at both ends.

From the top of Mount Olympus we counted about 30 lakes and tarns on the opposite plateau, occupying undoubted rock basins in the greenstone. On Olympus itself, at the foot of the greenstone columns on the lake side, are two small basins of water, the "Olympian Tarns." All these lakes are at different levels; Lake Laura, at the base of Mount Ida, though only separated from St. Clair by a ridge not more than 400 yards across, is 50 feet above the latter. It appears to be very shallow. Lake Petrarch is about 560 feet above St. Clair. It is also very shallow, and, I am inclined to think, there is a small area of subsidence, its bed being probably sandstone.

There has been an interesting discussion in the columns of *Nature* recently on the origin of rock-basin lakes, and the arguments for the glacial theory have been ably marshalled by Mr. A. R. Wallace. Mr. Wallace cites Tasmania, among others, as a country where these alpine lakes are associated with palpable signs of glaciation.* Now, though such signs of glaciation and associated rock-basin lakes occur on the West Coast, notably about the Pieman River, we do not find the slightest trace of glaciation either in the shape of striated rock surfaces, moraines, or erratic blocks in any part of the region traversed by us. Unfortunately we were unable to traverse the Traveller Plateau, but from its configuration, as observed from Olympus, I feel confident that signs of glaciation do not exist there. Yet, as we have seen, lakes and tarns are exceedingly numerous on the surface of this plateau. It is evident that the glacial theory is of no use here. Many of the button-grass swamps or flats really occupy rock-basins, and perhaps may be regarded as the equivalents of the peat-bogs of Europe. They seem to be directly connected with each other, that is to say, those in the same drainage area. The great rival to the glacial theory is the "Earth-movement" theory. I think that if Mr. Gould's basalt be really mythical, the latter theory will probably account for Lake St. Clair and for other lakes in the district, though the lakes on the Traveller plateau seem to be too numerous to be thus explained. I am much inclined to the opinion that most of the basins of the Traveller Plateau lakes will be found to be satisfactorily explained by the ordinary processes of sub-aerial weathering and denudation.

We found no fossils *in situ* in the sandstone of this region, but on the beach about the boat-house pieces of silicified

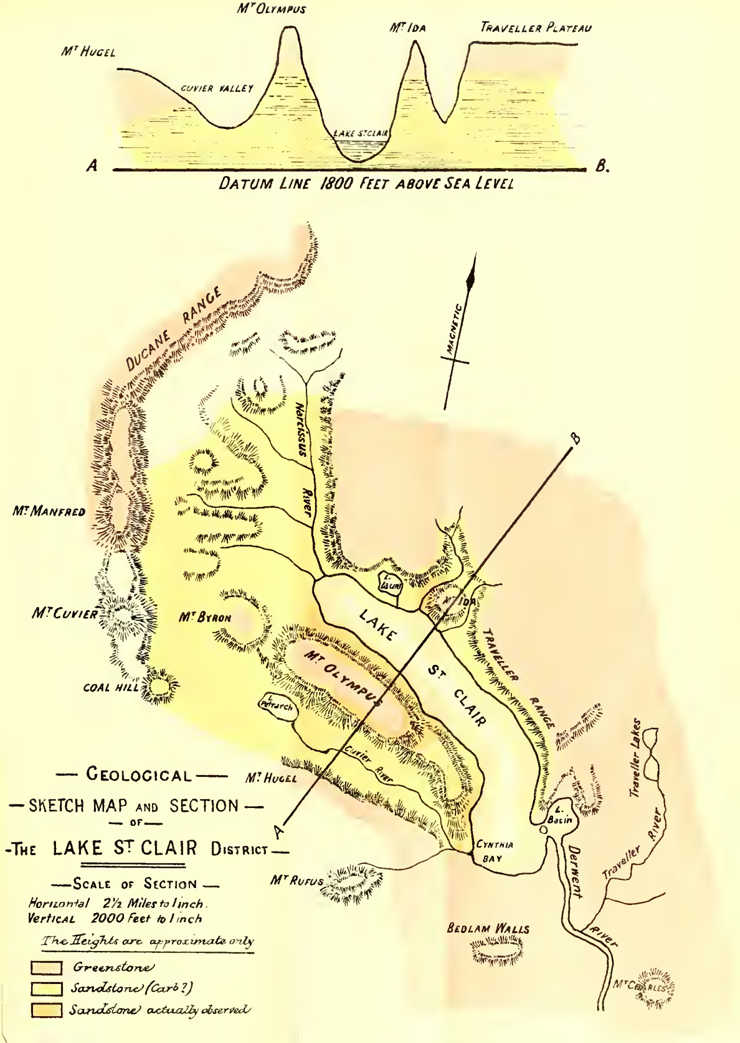
* *Nature*, Vol. 47, No. 1,219.

wood are not uncommon. These may have come from the sandstone. Before concluding I should say that those who desire a fuller account of the principal physical features of the Lake St. Clair highlands should read a paper by Colonel Legge published in the proceedings of this Society. * Colonel Legge gives a clear and accurate description of this region, and we found his paper of much assistance.

In conclusion I can only say that I feel that the present sketch is incomplete, indeed necessarily so, but still I hope that some light, however little, has been shed on the main geological features of the Lake St. Clair district.

In the accompanying map that portion lying to the N. and N.W. of Mount Byron I have filled in only from observations from the top of Mount Olympus, Mount Manfred and the Ducane range are evidently greenstone, as far as their crests are concerned at least, but Coal Hill and several other minor elevations in its vicinity present an even, flat-topped, and terraced structure that strongly suggests horizontal sandstones.

* Proc. Roy. Soc. Tas , 1887.



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