NOTES ON THE GEOLOGY OF THE CRADLE MOUNTAIN DISTRICT,

With a Bibliography of the Pleistocene Glaciation of Tasmania.

By W. N. Benson, D.Sc., B.A., F.G.S.

Plates I.-IV.

(Communicated by W. F. D. Butler, M.Sc., LL.B., B.A.)

(Read 3rd April, 1916. Issued separately 28th July, 1916.)

Owing to the kind invitation of Mr. Rodway and Professor Flynn, the writer had the good fortune to be a member of a party spending the last week of 1915 in Mr. Weindorfer's Accommodation Hut near Cradle Mountain in the north-west of the Tasmanian highlands. Though there was little opportunity for detailed geological work, many interesting features were observed, which, at the request of the leaders of the party, are here recorded, and correlated with the scattered references to this region in the writings of the few geologists that have previously been in the neighbourhood. A sketch map of the geological features, and a topographical sketch map are also given, based on a manuscript map by Franz Malscher, supplied by Mr. Weindorfer, and amended in accordance with surveys made by the present party. The following account must be considered rather tentative, since lack of time prevented complete verification.

Cradle Mountain may be reached most easily by the road from Sheffield through Wilmot and the Middlesex Plains, a distance of forty miles. The track crosses the Isis River and Pencil Pine Creek, and then follows the Dove River to the foot of the mountain. The formations traversed by this route, or adjacent thereto, are the Pre-cambrian schists, the Cambrian sandstones, quartzites and conglomerates, Silurian limestones, Devonian granite, and Tertiary basaltic rocks (which are of several types, varying from dolerite to tachylite), and alluvial deposits. (1).

The four main formations in the vicinity of Cradle Mountain and Barn Bluff are the Pre-cambrian schists and quartzites, the Permo-carboniferous conglomerates, sandstones and mudstones, the Cretaceous dolerite, and

(1) W. H. Twelvetrees. Bibliography No. 42.

the Pleistocene glacial deposits. A little recent alluvium is also present. The general disposition of the first three series is roughly indicated in Mr. Johnston's official Geological Map of Tasmania of 1884, the earliest chart to which the writer has had access. A more accurate representation is found in the map given by Jeffrey Smith, "based on information supplied by the Geological Survey of Tasmania." (2).

The Pre-cambrian rocks of the region have been briefly described by Messrs. Waller (3) and Ward. (4) The latter remarks that at Barn Bluff they strike a few degrees north of west. Between here and the Forth River the strike, according to Waller, is nearly east and west. In the immediate vicinity of Cradle Mountain the writer found the strike to be between E.N.E.-W.S.W. and N.N.E.-S.S.W., the former direction predominating to the north-east of the mountain; while to the north-west, along the Dove River, rocks have been observed striking west of north. Evidently there is a great bend in the Pre-cambrian fold-axes in this region. The rocks are intensely folded; numerous sharp anticlines and synclines are visible. The dips are nearly vertical, and easterly dips are usually steeper than those directed towards the west, while the latter are more common. These facts suggest that overfolding has occurred under the influence of a thrust directed from the west.

The rocks present are all of sedimentary origin. They include dark grey phyllite, coarsely crystalline mica-schist, micaceous quartz-schist, felspathic quartz-schist, and schistose quartzite, showing abundant evidence of recrystallisation, and, indeed, passing locally into vein-like masses of quartz. True veins of quartz traverse the other rocks, occurring lenticularly in the bedding-planes or running obliquely thereto. Four samples have been examined microscopically; the following are brief descriptions of the same, using the terminology adopted by Grubenmann (5):

1461. Puckered Phyllite (helicitic texture). This consists of a granoblastic ground mass of quartz-grains, with wavy bands of finely-divided carbonaceous matter, sericite, and bleached biotite, the whole more or less stained with limonite.

---

(2) A Naturalist in Tasmania. London, 1909.

(3) See Bibliography No. 21.

(4) L. K. Ward. Contributions to the Geology of Tasmania. Systematic Geology. The Pre-cambrian. Proc. Roy. Soc. Tas. 1909.

(5) Die krystallinen Schiefer. Second edition, 1910.

1464. Mica-schist with a lenticular schistose texture consisting of granoblastic quartz, with large irregular porphyroblasts of orthoclase, generally blackened by inclusions of carbonaceous matter. These have resisted the shearing much better than the quartz, and are a frequent cause of the irregularity of the lenticular texture. A pale green mica is abundantly developed in the numerous shearing planes, and extends out from them. Sericite is also present, and a very little andalusite and rutile.

1465. Mica-schist with lenticular texture, consisting of long irregular lenticles of close-packed pale green weakly pleochroic mica, partially chloritised, separated by layers of granoblastic but more or less elongated quartz grains. Large porphyroblasts of felspar, generally orthoclase, but also albite, interrupt the continuity of the lenticles of mica and quartz. Inclusions in these often continue the planes of schistosity. Small grains of magnetite are scattered throughout the rock, and a few grains of andalusite have been noted.

1466. A much crushed schistose quartzite, exhibiting perfectly the klasto-porphyritic structure. It consists of large quartz-grains with very undulatory extinction and shattered margins, a few irregular uncrushed grains of albite, and a ground mass of finely comminuted quartz, with a few shreds of sericite.

All these rocks are characteristic of the uppermost zone of Grubenmann's classification of the crystalline schists. This bears out Mr. Ward's view concerning their nature.

The Permo-carboniferous rocks lie on a very uneven surface of the crystalline schists. The irregularity is particularly clear under Mount Brown, on the southern side of Rodway Gorge. The basal portion of the series consists of conglomerate containing pebbles derived chiefly from the Pre-cambrian series, but also from the Devonian granites and other formations. They pass up into pebbly sandstones and mudstones. A thickness of about seventy feet of conglomerate occurs beneath the north end of Cradle Mountain, but this increases considerably to the south and east. There is apparently not less than five hundred feet of the sediments beneath Mt. Brown, while

Mr. Montgomery records the presence of a thousand feet of sediment beneath Barn Bluff. The basal beds at the last locality comprise a hundred feet of conglomerate, followed by two feet of cannel coal, enclosed in black micaceous shale containing *Glossopteris* (*ovata?*) and *Noeggerathiopsis sp.* Above this lie nine hundred feet of marine mudstone, shale, sandstone and conglomerate similar to those occurring at Mt. Pelion, nine miles to the south-east, which contain such typical Permo-carboniferous fossils as *Fenestella*, *Spirifera*, *Productus*, *Aviculopecten* and *Stenopora*. (6) Mr. Waller has estimated the series at Mt. Pelion to be from a thousand to fifteen hundred feet thick. (7) Thus the Permo-carboniferous basin becomes deeper towards the south-east, and many of the outcrops show a slight tilt in that direction.

At the surface in contact with the overlying dolerite, the mudstones are more or less altered, silicified and indurated. Small veinlets of opal traverse the bands of black carbonaceous shale. The alteration does not extend more than about a foot from the dolerite. It is well exposed on the northern face of Barn Bluff.

The Cretaceous dolerite caps Mt. Brown, Barn Bluff, and Cradle Mountain. It has the same general characters as the Mesozoic dolerite in other parts of the island, and may be considered to be portions of sills once continuous with the dolerites of the Pelion Range. Waller affirmed this former continuity, but doubted the intrusive character of the dolerite. (8) An examination of the base of the dolerite on the northern face of Barn Bluff, however, shows that it transgresses to a small extent across the bedding planes of the mud stones; and in the case of Cradle Mountain the dolerite rests on sandstones in the southern end, but on the underlying basal conglomerate on the northern. No feeding dykes were observed, but attention might well be directed to the north-eastern foot of Cradle Mountain, where, as seen from a distance, the dolerite appears to pass down through the Permo-carboniferous rocks, to come into contact with the Pre-cambrian schist. (See Plate 3.) The dolerite on Barn Bluff is about 650ft. thick, that on Cradle Mt. 700ft., but that on Mt. Brown is perhaps not more than 300ft. Columnar structure is very pronounced in the two former masses; but in places the predominance of one direction of vertical jointing causes instead a platey structure.

(6) See Bibliography No. 13.

(7) See Bibliography No. 21.

(8) Op. cit. supra.

The petrological character of the dolerites is of interest. They are of medium grainsize, and consist predominantly of plagioclase and pyroxene. The plagioclase forms small, more or less, idiomorphic tabulæ, somewhat zoned, the central portion having the composition of bytownite. The pyroxenes are more varied, a rhombic and two types of monoclinic pyroxene are present. In a rock from the lower portion of the dolerite on Cradle Mt. (1458) there is a normal, more or less, ophitic augite (some times subidiomorphic), with the usual large optic axial angle, associated with, and frequently including prismatic crystals of enstatite. In a rock from the summit of the mountain, however, the monoclinic pyroxene, which is partly subophitic, partly subidiomorphic, has two distinct types, namely, those grains which have the normal optic axial angle (which are in the minority), and those which are approximately uniaxial, indicating that they contain a large excess of magnesian silicate, i.e., are magnesium-diopside, or the augite-enstatite of Wahl. This mineral has been previously recorded in the dolerite of Cataract Gorge by Osann ([9]), and is known to be fairly common in other occurrences of dolerite in Tasmania. ([10]) In both these rocks, there is a small amount of magnetite and of very finely crystalline intersertal granophyre, dotted with crystallites of magnetite. The former of these rocks contains grey felspathic veins at first thought to be granophyre. They prove to have a highly ophitic to poikilitic texture. The pyroxenes are sometimes roughly prismatic, ophitic or broken up into isolated patches, which are in optical continuity over quite large areas. The pyroxene is quite fresh, usually uniaxial, but sometimes of the normal character. There are, in addition, small prisms of enstatite. The felspar is slightly zoned, has the general composition Ab_1An_2, and forms a few small phenocrysts. Between the tabulæ is a small amount of minutely crystalline granophyre. A few large grains of magnetite are also present.

Two inches from the chilled margin of the dolerite of Barn Bluff the rock is very fine-grained, with an intersertal structure. It contains small phenocrystic laths of plagioclase and larger prisms of augite, more or less converted into chlorite and carbonates. At the margin itself, the grainsize is extremely minute, and the texture appears to be subvariolitic. Both these rocks contain vesicles

(9) Ueber einen Enstatitaugit-führenden Diabas von Tasmanien. Centbl. für Min., 1907, pp. 705-11. Translation by W. H. Twelvetrees Ann. Rep. Dept. Mines, Tas., 1907.

(10) J. A. Thomson. Journ. and Proc. Roy. Soc. N.S.W., 1911, p. 306

filled with quartz, carbonates, and hæmatite. There is a remarkable absence of magnetite and of glass.

The Pleistocene and Recent deposits will be best considered with the general physiography, which we now proceed to discuss.

The writer is indebted to Mr. Twelvetrees's report on the adjacent Middlesex district for an account of the general relation of the physiographic features to the regional topography of Tasmania. He states, "The entire area is an elevated plain or tableland, dissected by stupendous gorges, and diversified by residual mountain ranges." He indicates that the tableland is separated by faults near Mt. Roland and Bell Mt. from the lower plateau near Sheffield and Wilmot, and lies at an elevation of 2,200-2,600ft. in the neighbourhood of Middlesex. (11) It rises gradually to the south-west, and around Cradle Mt. it lies about 4,000ft. above sea level. The plateau has here cut across the uneven surface of contact of the Pre-cambrian and Permo-carboniferous rocks, so that the surface of the plateau consists of irregular areas of the two formations. The more siliceous Pre-cambrian rocks rise in small residuals, but the three dolerite mountains form the greatest monadnocks. The plateau is trenched by the great gorges of the Forth River and its tributaries, to the east of Cradle Mountain, and by the gorge of the Fury on the west. The effects of the Pleistocene glaciation are everywhere visible, and to these we will devote special attention.

Six periods may be recognised in the development of the present topography. In the first, possibly early Tertiary period, the dolerite-sills were laid bare by erosion, and a roughly horizontal surface of erosion or peneplain was produced in the dolerite. An uplift followed of more than a thousand feet, and the present peneplain-surface was cut out of the older level, fragments of which remain as residuals, such as Cradle Mt. and Barn Bluff. A mature system of valleys was originated between these, and, in particular, the course of the Forth River was outlined. The third period was one of oscillatory uplift, accompanied by gentle tilting. The numerous immense gorges of the Forth and Pieman River systems were produced by revival of the ancient matured valleys. Tributary gorges such as Hanson's, Rodway's, and the Fury cut themselves right back to the foot of the residual mountains, while others, such as Smith's Creek and the Dove River, and Pencil Pine Creek, were considerably deepened in their

(11) Bibliography No. 42.

lower portions, but the gorges had not cut back to the heads of the streams. During this period of alternating uplift and aggradation, flows of basalt occurred on several occasions outside the special area here considered. The oldest basalts, with their intercalated gravels, cover Middlesex Plains, and were probably connected with those above Lorinna on the other side of the Forth Gorge (as shown by Mr. Twelvetrees). The upper portion of the gorge is a wide, open valley, in which there is a thick mass of gravel covered with basalt. Below this there are newer gravel terraces, and the present stream has cut down below these, thus giving a perfect example of a valley-in-valley topography. (See Bibliography 42, Plate IV.) According to Mr. Andrews's view, the gravels were probably deposited during periods of subsidence between the successive uplifts. ([12]).

The remaining periods are those of maximum glaciation, retreat of the glaciers, and finally the period of post-glacial erosion. Possibly further research will show that the period of maximum glaciation comprised two or more maxima with intervening periods of retreat, as has been determined for the glaciation on the mainland, ([13]) but there is not sufficient evidence to permit of this conclusion at present. The period must here be considered as a whole.

Glacial features have been noted in this region by Sprent (3), Montgomery (9, 13), Waller (21), Twelvetrees (31), and Noetling (38), but no detailed description has been given. At the time of maximum glaciation an ice-sheet extended over the whole region, the three main prominences being probably the only points emerging above the snow. The main directions of ice-flow were determined by the pre-glacial valleys that were roughly radial about Cradle Mt., but important overflow-glaciers were developed as the level of the ice rose, and adjacent streams became confluent. In describing the manner in which these influenced the topography, we commence at Barn Bluff. The ice moved radially from this peak. To the west it fell over the gorge of the Fury, and was there broken up and melted. It does not seem likely that any mass of ice moved down this valley, since it appears to be a typical water-worn valley with overlapping spurs. To the south-east the ice moved out on to the plateau, scooping out the broad and probably shallow

(12) E. C. Andrews. Geographical Unity of Eastern Australia. Journ. and Proc. Roy. Soc. N.S.W., pp. 420-480, especially p. 455.

(13) David, Helms, and Pittman. Proc. Linn. Soc. N.S.W., 1901, pp. 26-74. David. Ibid., 1909, pp. 657-668.

basin of Lake Will, at the foot of the Bluff. North-east of the Bluff the ice-sheet moved across the plateau and fell into the gorge of the Forth River. Numerous small lakes were developed, such as Windermere and Agnew, their position probably depending on differential erosion, the mica-schists, and the soft Permo-carboniferous sediments being easily picked out. The ridge running to the south-east from the Bluff separated the northerly from the southerly flow, and is heavily cumbered with morainic material. Plucking of blocks of rock out of their original position must have gone on to a great extent, for one finds large blocks (up to 16 by 11 feet in area) of comparatively fragile coal measures, lying among the debris (Montgomery 13).

The eastern side of the ridge joining Barn Bluff and Cradle Mt. is broken into a great cirque with minor embayments, which surround the heads of tributaries of the Forth River. The ridge consists of horizontal sediments lying on the ancient rocks, which form the floor of the broad and relatively shallow cirque. Its eastern side has been sapped back into a continuous cliff. The floor is heavily glaciated and littered with morainic material. To the east the glacier from this cirque joined the ice-sheet on the plateau and fell over into the Forth River Gorge. West of the connecting ridge there is little sign of glaciation, the surface sloping regularly down into the Fury Gorge. Possibly the dominant west wind prevented the accumulation of much snow on this slope. (14)

East of Cradle Mt. is the grandest example of a cirque in the district. On its floor is the lake for which the name Lake Rodway has been suggested. It lies in a broad and deep trough, around the head of which rises the crescentic ridge of Cradle Mountain. It is probable that the name of the mountain was derived from the resemblance this trough and rim-ridge bear to a miner's cradle. The crescentic form of the ridge is due to the cirque eating deeply into the eastern side of the original monadnock, while the western side has been scarcely affected; a further instance of asymmetry. The cirque is not simple, but is broken into four steps, by transverse bars of quartzite. (See Plate 3.) The "treads" of the two upper steps are narrow, the third is broader, and bears a small shallow lake, the outlet of which falls over a strongly glaciated bar into the main basin of Lake Rodway, the depth of which has not been ascertained. A

(14) Compare G. K. Gilbert. Systematic Asymetry in the High Sierras of California. Journal of Geol., 1904, pp. 570-586.

broad glaciated bar follows, beyond which the stream falls directly into Rodway Gorge, which is a water-cut canyon. The boundary between the glaciated and water-cut surfaces is sharply marked. To the south, the main basin was extended by a cirque, cutting back into the soft Permo-carboniferous rocks of the ridge joining Cradle Mt. and Mt. Brown. This cirque, however, does not contain a lake, and is separated from Lake Rodway by a long moraine.

In the period of maximum glaciation, this great trough must have been filled to overflowing with ice, which was more than a thousand feet deep. Overflow-glaciers made their way over the northern rim of the trough, bearing boulders of dolerite, now scattered erratically. Once over the ridge, they broke up, fell down into a small gorge, were more or less recemented there, and, joined by the overflow-glacier from near the outlet of Rodway Lake, they scooped out a little rock basin before finally falling into the canyon proper. This little basin may be aptly named the Hidden Lake. The passage of the overflow-glaciers has cut the northern ridge, bounding the great trough, into a succession of cross-ridges of quartzite and hollows cut in mica-schist.

North of Cradle Mt. lies Dove Lake, a deep rock basin formed by the enlargement by glacial erosion of the upper part of the Dove River. The ice from the plateau and the north-western face of Cradle Mt., a total area of about 1,000 acres, collected in the head of the stream, passed down a steep fall on to a "tread" 400ft. below the plateau, where Lake Wilks was cut out. A second tread was formed near the lake-level, after a further fall of about 300ft. The further effect of the ice is shown by the soundings. (These were measured from a raft in a strong breeze, and must be considered as rough approximations only, both in depth and position.) The upper end of the lake is a basin at least 108ft. deep, separated from a basin almost 200ft. deep by a quartzite ridge (at one point only 72ft. deep, but rising into islands). The shallow point (48ft.) beyond the second basin probably marks a ridge connecting the quartzites of the great promontory with those of Mt. Campbell, on the opposite side of the lake. Beyond it is another deep (144ft.), separated by a quartzite ridge and islet, from the westernmost basin (46ft.), in which the Dove River ice was joined by the overflow from Crater Lake. The outlet stream passes over a drift-covered plain, probably concealing a rock-bar. Further soundings of this lake are very desirable.

In addition to this moulding of the floor of Dove Lake, the smooth curve of the eastern wall was rounded out by the middle portion of the glacial stream, while above, overflows made their way to the north-east. A large flow went past the northern end of Cradle Mt. to join the ice in the Rodway Valley, a second passed over the ridge south of Hanson's Lake, scooping out the little group of tarns there. A third passed over the gap into Hanson's Valley, converting the head of the valley into a lake basin. The contrast between this beautiful cirque-lake and the rugged water-cut gorge below it is very striking. These three overflow-glaciers were 400ft. above the present level of Dove Lake. At the northern end of Dove Lake overflows of ice passed across the watershed and dolerite boulders may be found high up on the slopes which lead down into Smith's Creek.

Lake Lilla owes its origin to the flow of ice that came down from the Crater Lake. It is a shallow pan, the greatest depth found being 45ft. The ice escaped from here over a rock bar into Dove Lake. An interesting feature is the almost complete removal of the old divide between Lake Lilla and Dove Lake, the ridge between the two lakes rising only thirty feet above the level of Dove Lake. (See Plate 4.) The outlets of the two lakes are separated by a beautiful roche moutonnée hill. The various strata cross this diagonally, and the surface of the hill, otherwise quite smooth, is pitted with jagged hollows, containing lakelets, and marking spots where vast masses of rocks have been plucked out by the moving glacier. No better examples of this process could be desired than are to be seen here.

Crater Lake is another most interesting feature, clearly exhibiting differential glacial erosion. Its southern end is a great cirque-wall rising more than five hundred feet above the lake, and cut into a mass of rather soft felspathic schist between quartzite bands. The lake is here 203 feet deep. The centre of the lake is crossed by a bar of quartzite only 30ft. below the surface. This bar continues to the north-east of the lake, forms the small knoll near the outlet, and extends down to cross the outlet of Lake Lilla. The side of the knoll is polished and grooved by the ice-stream from Crater Lake, which passed down into Lake Lilla. The gap by which this stream escaped from the Crater Lake basin has been filled by a ridge of morainic material which now rises about a hundred feet above the lake. The northern portion of Crater Lake contains two basins, as shown by the soundings, and the outlet passes over a rock-bar, and enters Cradle Valley as a stream hanging nearly 600ft. above the base of the main valley.

Another well-marked cirque appears on the northern side of Cradle Valley, about a mile above the accommodation house. It is cut down out of Hounslow Heath to a depth of about 700ft., and enters the main valley almost at grade. There is a little morainic matter in the floor of this cirque, but no lake. No well-marked cirque occurs at the head of the Cradle Valley, which has, nevertheless, been greatly modified by glacial action. It is a broad, deep, steep-sided valley. The glacier which filled it received tributaries from the Crater, Lilla and Dove valleys, and escaped in part by the present Dove Valley, but also a large overflow passed over the col and down Smith's Creek. Dolerite-erratics have been traced down the Dove River about half a mile below Cradle Valley, and about a mile down Smith's Creek, and probably extend to the commencement of Smith's Gorge a mile or two further down.

No detailed study has been made of these terminal regions, in which the complex record of retreat and advance may ultimately be deciphered. There seem to have been small gorges cut in the older glaciated valleys, and some sign that these have been subsequently occupied by ice, but it is not clear whether this is the work of interglacial river action or merely of subglacial streams. The well-timbered character of these valleys prevents the observer from obtaining a general view of the whole.

The last stages of the period of glacial retreat were responsible for the moraines in Cradle Valley. Typically hummocky moraine fills the lower part of the valley and extends across into Smith's Creek. A lateral moraine extends along the southern side of the Cradle Valley, rising 250ft. above the floor. An arcuate terminal moraine closes the outlet of Lilla Creek, and a thin ridge of moraine extends down towards the outlet of Crater Lake, possibly a remnant of a small terminal moraine. It is interesting as showing the mark of an overflow-channel fifty feet above the present outlet. Small masses of morainic material occur in most of the cirques mentioned.

The final period of post-glacial erosion has had very small results. Some morainic material has been removed, and small outlet valleys notched in the terminal moraine, and patches of alluvium have been formed.

Summarising, we may say. that though the glaciers here were large enough to overflow their valleys, there is no evidence that they extended far to the north, but occupied only the comparatively mature upper portions of a rejuvenated river system, and did not extend beyond the heads of the canyons which then reached to within a few miles of their source. In the gorge of the Fury, which had been cut back almost to its source, no sign of glaciation was observed.

The writer is indebted to all the members of the party for assistance in various ways, especially in raft-building and sounding. Mr. Butler's and Mr. Maxwell's photographs have been most useful in the preparation of the paper. Mr. Butler has provided the amended copy of Malscher's map, which is the basis for the geological map herewith, and Mr. Twelvetrees has kindly discussed with the writer some of the questions here raised and added items to the Bibliography. To his father, Mr. W. Benson, the writer is indebted for Plate 3 herewith, based on photographs, sketches and descriptions. Plate 4 is from a photograph by Mr. Spurling, of Launceston.

BIBLIOGRAPHY OF PLEISTOCENE GLACIATION IN TASMANIA.

(References to Textbooks omitted.)

1. 1855-65. Chas. Gould. Observations of glaciation on the Central Plateau, verbally communicated, and cited by R. M. Johnston in 1893. Also, Report on the Exploration of the Western Country. Tasmanian Parl. Papers, 1860. No. 6.
2. 1883. T. B. Moore. Exploration—Report on the country between Lake St. Clair and Port Macquarie. Tasmanian House of Assembly Journal. Paper No. 56.
3. 1885. C. Sprent Recent Exploration on the West Coast of Tasmania. Trans. and Proc. Geogr. Soc. Australia, Vict. Branch. Vol. III. p. 58.
4. 1886. F. W. Hutton. On the supposed Glacial Epoch in Australia. Proc. Linn. Soc., N.S.W. Vol. 1885 (1886), pp. 334-41.
5. 1887. R. M. Johnston. Observations with respect to the Nature and Classification of the Tertiary Rocks of Australasia. Proc. Roy. Soc. Tas. pp. 135-207.

6. 1888. R. M. Johnston. The Geology of Tasmania.

7. 1893. E. J. Dunn. Remarks on the Glaciation of Tasmania in a Victorian newspaper; also, Glaciation of the North-Western Highlands of Tasmania. Proc. Roy. Soc. Vic., Vol. VI., pp. 133-38.

8. 1893. T. B. Moore. Discovery of Glaciation in the vicinity of Mt. Tyndall in Tasmania. Proc. Roy. Soc. Tas., 1893 (1894), pp. 147-9.

9. 1893. A. Montgomery. Glacial Action in Tasmania. Ibid., pp. 159-169.

10. 1893. R. M. Johnston. The Glacial Epoch of Australasia. Ibid., pp. 96-103.

11. 1893. G. Officer. The Geology of Lake St. Clair District. Ibid., pp. 150-158.

12. 1893. R. M. Johnston. Notes on the Geology of Lake St. Clair and its immediate neighbourhood, together with observations regarding the probable origin of our numerous Tasmanian Lakes and Tarns. Ibid., pp. 135-146.

13. 1893. A. Montgomery. Report on the Country between Mole Creek and the Mt. Dundas Silver Field. Ann. Report Dept. Mines, Tas. passim.

14. 1893. T. W. E. David. Report of the Glacial Research Committee. Proc. Aust. Assoc. Advt. Science, Vol. V. p. 231.

15. 1893. A. R. Wallace. Nature Vol. 47. No. 1219, p. 437.

16. 1894. G. Officer and L. Balfour. Geological Notes on the Country between Strahan and Lake St. Clair, Tasmania. Proc. Roy. Soc. Vic. pp. 123-4.

17. 1894. T. B. Moore. Further Discoveries of Glaciation in Tasmania. Proc. Roy. Soc. Tas. pp. 56-65.

18. 1895. T. B. Moore. Notes on Further Proof of Glaciation at Low Levels. Proc. Roy. Soc. Tas. pp. 73-77.

19. 1898. J. Harcourt Smith. Report on the Mineral Fields in the Neighbourhood of Mt. Black, Ringville, Mt. Read, and Lake Dora. Ann. Rept. Dept. Mines p. xxii. passim.

20. 1900. W. H. Twelvetrees. Report on the Mineral Districts of Mts. Huxley, Jukes and Darwin. Ann. Report Dept. Mines. pp. 109-110.

21. 1901. G. A. Waller. Report on the Mineral Districts of Bell Mt., Dove River, Five-mile Rise, Mt. Pelion, and Barn Bluff. Ann. Rep. Dept. Mines.

22. 1902. W. H. Twelvetrees. Outlines of the Geology of Tasmania. Proc. Roy. Soc. Tas. p. 72.

23. 1902. W. H. Twelvetrees. Report of the Glacial Research Committee, Aust. Proc. Aust. Assoc. Adv. Science. pp. 191-2.

24. 1903. J. W. Gregory. Some Features in the Geography of Tasmania. Proc. Roy. Soc. Vict. p. 181.

25. 1904. J. W. Gregory. A Contribution to the Glacial Geology of Tasmania. Quart. Journ. Geol. Soc. pp. 37-52 (with bibliography).

26. 1904. G. A. Waller and T. W. E. David. Report of the Glacial Research Committee. Aust. Assoc. Adv. Science. pp. 613-7.

27. 1904. T. V. Legge. A Physiographical Account of the Great Lake of Tasmania. Aust. Assoc. Adv. Science. pp. 354 and 357.

28. 1905. J. W. Gregory. The Mt. Lyell Mining Field. Trans. Aust. Inst. Mining Engineers. p. 104.

29. 1907. T. W. E. David. Conditions of Climate at different Geological Periods, with special reference to Glacial Epochs. Comptes Rendus du Xme Congrès Geologique International. p. 33.

30. 1907. W. H. Twelvetrees. Geology of Tasmania. Ann. Report. Dept. Mines. p. 105.

31. 1907-8. W. H. Twelvetrees. Report upon the Geological Exploration of the country from Tyenna to the Gell River. Report of the Department of Lands and Surveys, Tasmania. p. 30.

32. 1908. W. H. Twelvetrees. Geology of Tasmania. Ann. Report Dept. Mines. p. 164 (detailed).

33. 1908. L. K. Ward. The Mount Farrell Mining Field. Geol. Survey of Tas. Bull. No. 3. pp. 5-6.

34. 1908-9. W. H. Twelvetrees. Western Exploration: Report on a Journey to the Gordon River. Report of the Department of Lands and Surveys. p. 2.

35. 1909. L. K. Ward. The Tinfields of North Dundas. Geol. Survey of Tas. Bull. No. 6. pp 8-9.

36. 1909. T. Stephens. Geological Notes on the Country traversed by the Derwent Valley Line Extension. Proc. Roy. Soc. Tas. pp. 170-4.

37. 1909. F. Noetling. Notes on the Glacial Beds of Freestone Bluff (Sandy Cove), near Wynyard. ibid. pp. 157-169.

38. 1909. F. Noetling. Die Glazialschichten der Wynyard in Nord-west Tasmanien. Neues Jahrbuch für Mineralogie 1909. ii. pp. 163-177.

39. 1909. F. Noetling. Entwurf einer Gliedrung der jungtertiaren und diluvialen Schichten Tasmaniens. Centbl. für Mineralogie. pp. 4-11.

40. 1909. H. Basedow. Beiträge zur Kenntniss der Geologie Australiens. Zeits. der deutsch. geol. Ges. p. 352.

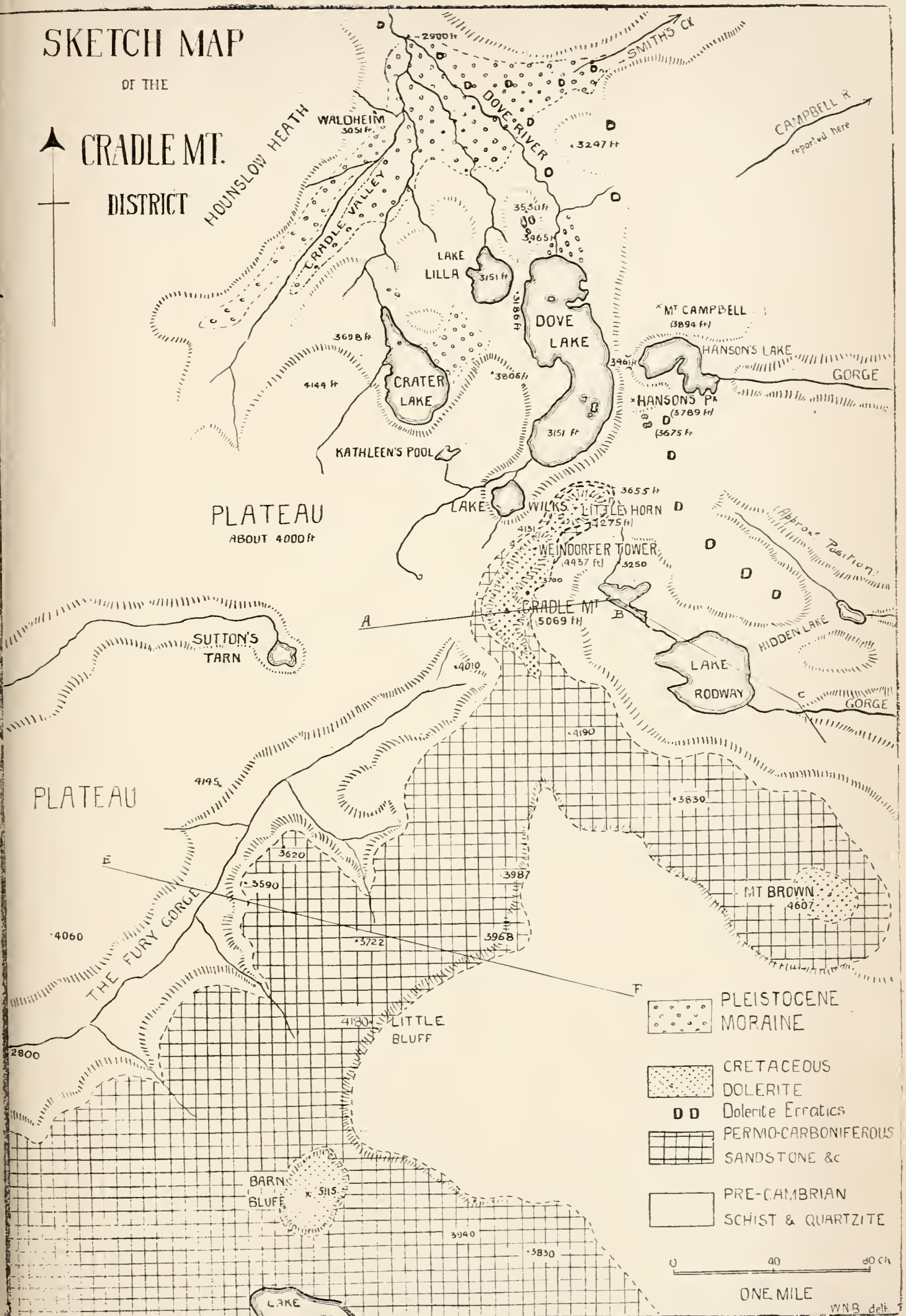
41. 1912. W. Howchin. Australian Glaciations. Journal of Geology. pp. 193-223, especially 220-223.

42. 1913. W. H. Twelvetrees. The Middlesex and Mt. Claude Mining Field. Geol. Survey of Tasmania Bull. No. 14. pp. 9, 31.

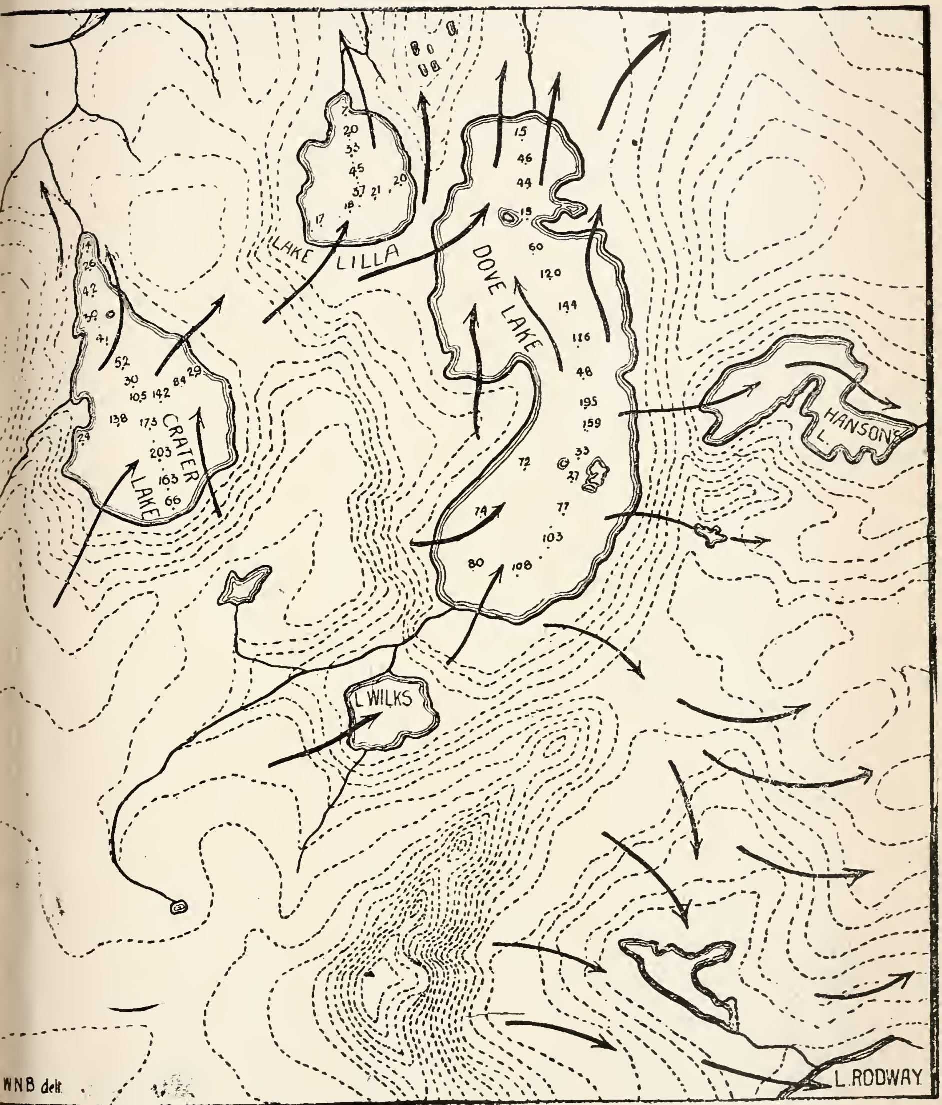
43. 1914. L. Hills. The Jukes-Darwin Mining Field. Geol. Survey Tasmania Bull. No. 16. pp. 14-18, 57-8.

44. 1915. L. Hills. The Zinc-Lead Sulphide Deposits of the Read-Rosebery District. Part I. Geol. Survey of Tasmania Bull. No. 19. pp. 28-9.

45. 1916. L. L. Waterhouse. The South Heemskirk Tinfield. Geol. Survey of Tasmania Bull. No. 21. pp. 8-9.

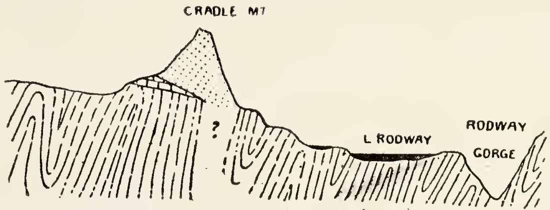


GEOLOGICAL SKETCH MAP OF CRADLE MT. DISTRICT.



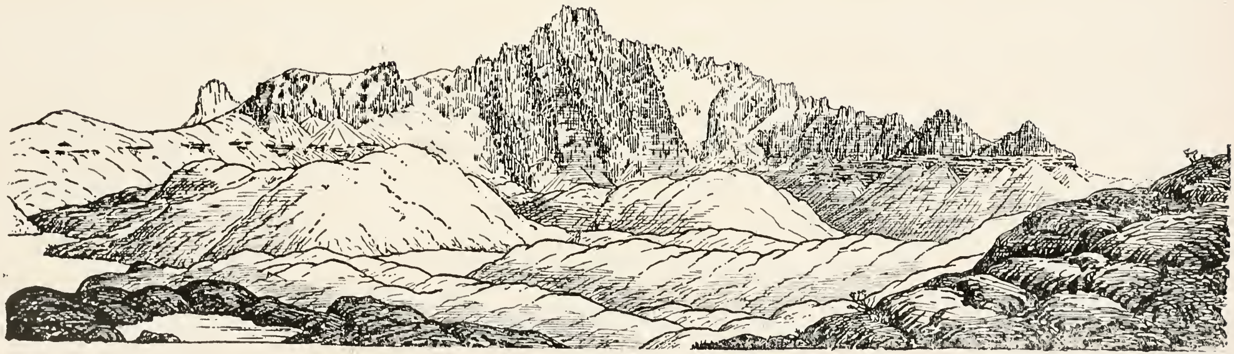
TOPOGRAPHIC SKETCH MAP OF CRADLE MT. AND LAKES.

The arrows indicate direction of Ice movement during Glacial Period. Scale, 1 inch = 640 yards. Contour Interval about 100 feet. Soundings in feet. (Figures approximate only.)



SECTION ALONG THE LINE ABC.

SECTION ALONG THE LINE EF, EXTENDED EASTWARD



GEOLOGICAL SECTIONS ACROSS THE CRADLE MT. DISTRICT (See Plate I.)

VIEW OF CRADLE MT. FROM THE EAST, BARN BLUFF IN THE BACKGROUND (ON LEFT).

Mt. Campbell. Hanson's Peak. Mt. Brown. Little Horn.

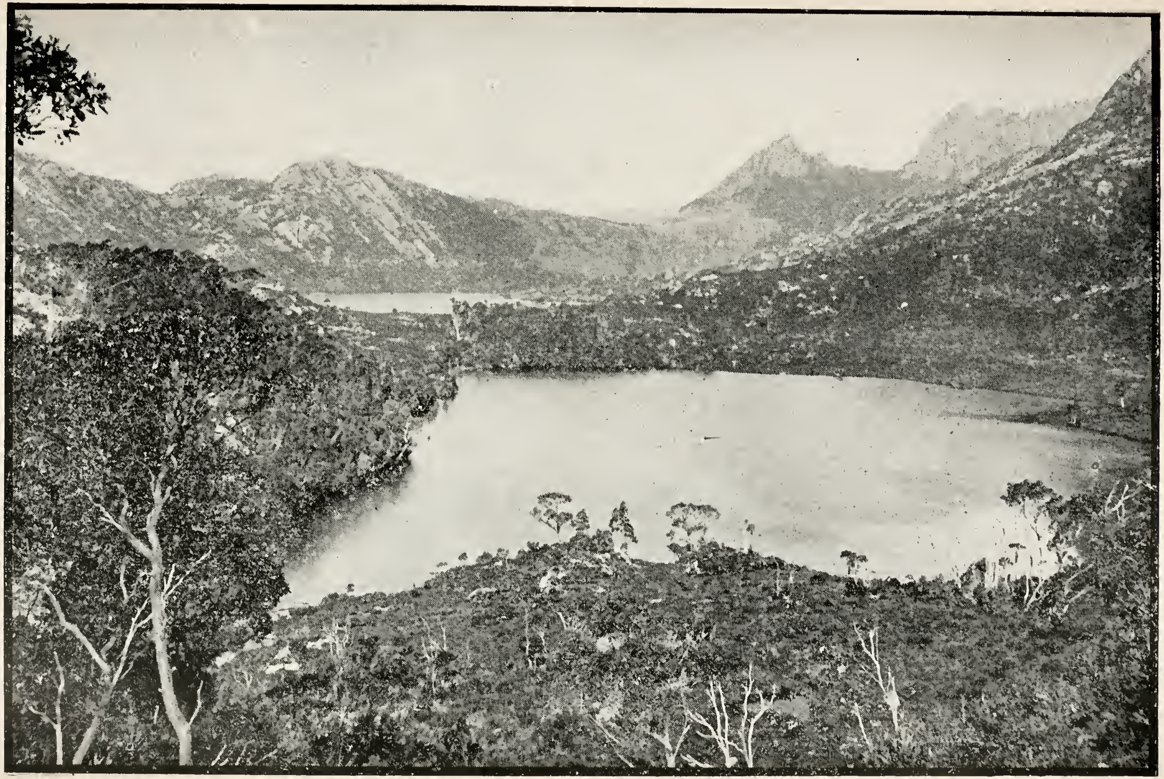


PHOTO. BY SPURLING, LAUNCESTON.

LAKE LILLA (Foreground) AND DOVE LAKE, NORTH END OF CRADLE MT. ON RIGHT, MT. BROWN IN BACKGROUND (Centre).