https://doi.org/10.26749/rstpp.105.49

[*Manuscript received 1st May 1970*]

THE BATHYMETRY OF LAKE ST. CLAIR, WESTERN CENTRAL TASMANIA

By

EDWARD DERBYSHIRE[1]

Communicated by Dr J. L. Davies

ABSTRACT

A bathymetrical survey of Lake St Clair, conducted in January 1965, is described, together with the method of construction of a bathymetric chart. The relationship of the morphology of the lake-bed to lithology, structure and the form of the Pleistocene St Clair glacier are discussed. A series of retreat stages of this glacier is deduced.

1 Department of Geography, University of Keele, Staffordshire, England.

INTRODUCTION

It is now over a century since the pioneer geologist, Charles Gould deputed his colleague Burgess to take soundings of Lake St Clair during his 'Exploration of the western country' (1860). Gould's map, re-drawn here as Figure 1, has remained the only record of the bathymetry and, as such, it has served as a basis for all discussions of the origin of the lake since that time.

While the lakes of the West Coast Range (Dunn 1894: Moore 1894) and the smaller lakes of the Central Plateau and the Cradle Mountain-Barn Bluff plateau were being described before the turn of the century as 'almost *prima facie* evidence of glaciation' (Montgomery 1894), the origin of the larger lakes was a more contentious topic. Johnston opposed a glacial origin for Lake St Clair, preferring to ascribe it to 'the original irregularities of surface' (1894, p. 142). However, Montgomery (1894) and Officer, Balfour and Hogg (1895), despite an earlier hesitation by Officer (1894), proposed the trough to be glacial. Thirty years later, Clemes (1924) firmly supported the glacial explanation, although he accounted for the greater part of the depth of the basin by glacial deposition at the southern end rather than by glacial overdeepening in bedrock. Throughout his published work, A. N. Lewis (e.g. 1933) accepted a glacial origin for Lake St Clair, stressing glaciation as at least a partial explanation of the shallow lakes of the eastern Central Plateau (Lewis 1939). The origin of these lakes is still not known with any certainty, although recent depositional evidence (Derbyshire 1968) appears to rule out late Pleistocene glacial erosion as a cause.

Lake St Clair has been discussed more recently in the context of the glaciation of the Du Cane Range and the western Central Plateau (Derbyshire 1963). While bedrock outcrops near Derwent Bridge were used to discount Clemes' view that the moraine barrage at the foot of Lake St Clair may be 400 to 500 feet thick, the maximum depth of the lake was overestimated at 700 feet, following Lewis (1939). The trough is shown as a piedmont rock basin on the Glacial Map of Tasmania (Derbyshire, Banks, Davies and Jennings 1965), the minimum extent of which was estimated on the basis of associated morphological evidence (notably shorelines of rock or drift). The extent of the rock basin is shown to be somewhat larger on the Glacial Map of Northwest-central Tasmania (Derbyshire 1968a), a revised estimate based on a preliminary appraisal of the echo-sounding profiles reported below.

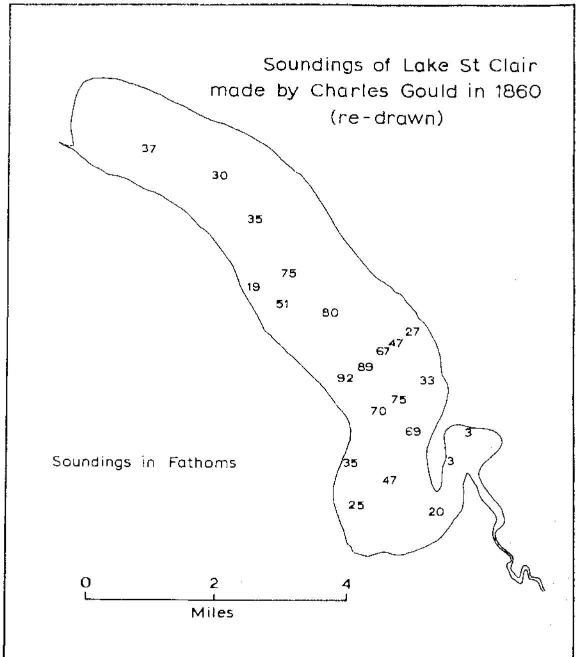

Fig. 1.—Charles Gould's line soundings of 1860.

THE BATHYMETRICAL SURVEY

In order to add to our knowledge of the morphology of glaciated surfaces and, in particular, to assess the degree of glacial overdeepening in the source areas of the Pleistocene glaciers, echo-sounding of many Tasmanian glacial lakes has been undertaken, the results of which will be published subsequently. Priority was given to Lake St Clair due to its relationships to the Central Plateau ice-dispersal area and its uniqueness as the deepest and only fully developed subalpine lake in Australia (Derbyshire and Peterson 1965).

For this echo-sounding programme, a portable device[1], transistorized and using battery power was employed, making possible the survey of a great variety of glacial

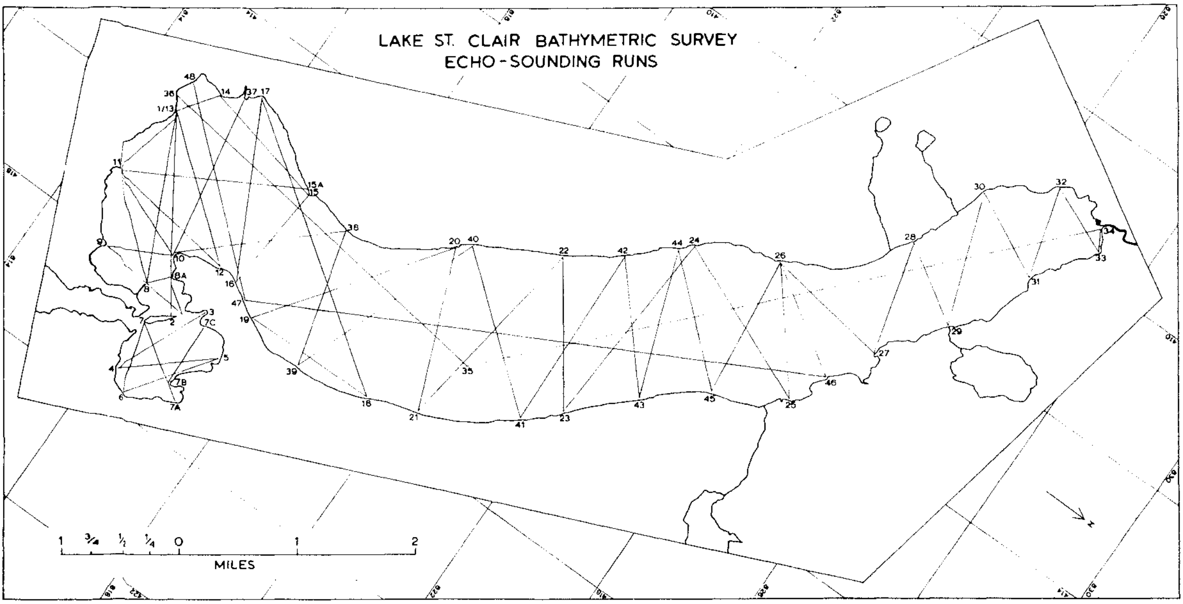

Fig. 2.—Map of echo-sounding traverses made during the bathymetric survey.

lakes. The instrument has four ranges and records continuously to a maximum depth greater than 900 feet in fresh water. The manufacturers quote an accuracy of ±5 per cent, which is greater than the fresh water-sea water adjustment (3 per cent: International Critical Tables 1929). The manufacturer's calibration is based on a velocity of sound of 4,900 feet per second in salt water which is the velocity at 12°C. As the only temperature data available for Lake St Clair is a surface record (2 to 3 feet depth) of 17°C on the day following the survey, direct adjustment of the calibration for temperature is not possible. However, the best means of calibrating echo-sounding equipment is by comparison of echo-profiles with known depths. Fortunately, some line soundings are available for Lake St Clair both published (Gould 1860) and unpublished. It was found that these compare very closely with the unmodified depths recorded during the survey. The greatest depth shown on Gould's map is 552 feet (92 fathoms: see Figure 1) while the echo-sounder recorded 546 feet in the same area of the lake. When it is considered that line sounding penetrates any fine bottom sediment not detected, except at shallow depth, by the echo-sounder, the correspondence may be regarded as very good.

The survey was conducted on January 5 and 6, 1965. Navigation was by the use of prominent landmarks and mountain peaks surrounding the lake, and distance was calculated by dead reckoning using uniform engine revolutions on and throughout all runs. In constructing the chart, allowance has been made for the fact that in leaving any shore station, the selected standard cruising speed was not reached until the first 50 yards had been traversed. The conditions on both days were windless and extremely calm.

1 The 'Koden' SR 385 recorder.

CONSTRUCTION OF THE MAP

The bathymetrical chart was constructed on the basis of 50 echo-profiles, totalling over 60 miles in length as shown in Figure 2. The reference datum, provided by the lake level on the days of the survey, was 2,406.0 feet a.s.l., *i.e.* 11.9 feet below the maximum water level imposed by the weir. This is within 1 ft. of the natural level of the lake before the installation of the weir. The datum, then, is essentially the same as in Gould's survey.

Few of the survey lines are spaced more than 400 yards apart and, at the southern end of the lake, spacing is generally much closer than this. Such coverage is sufficient to provide quite a detailed record of the subaqueous morphology of the lake basin.

Isobaths were drawn at 50 feet intervals on a dyeline base-map at 1:15,840 scale provided by the Department of Lands, Hobart. Isobaths at intermediate 25 feet intervals were then added in areas other than those with severe gradients. Isobaths at intervals of 10 feet were also drawn in for parts of the southern end of the lake, revealing some details of the lake-bottom moraine morphology (Fig. 3). These have had to be omitted from the general chart (Fig. 4) for reasons of scale. The detail shown on the bathymetric chart is, therefore, limited by considerations of scale rather than by deficiencies in the survey data. Cross-checking of depths at points of intersections of runs was generally very good, except for the southern side of the south-eastern peninsula where agreement was only moderate. This is, perhaps, to be expected for the subaerial morphology in this area is complex due to marked differential erosion of the jointed dolerite bedrock.

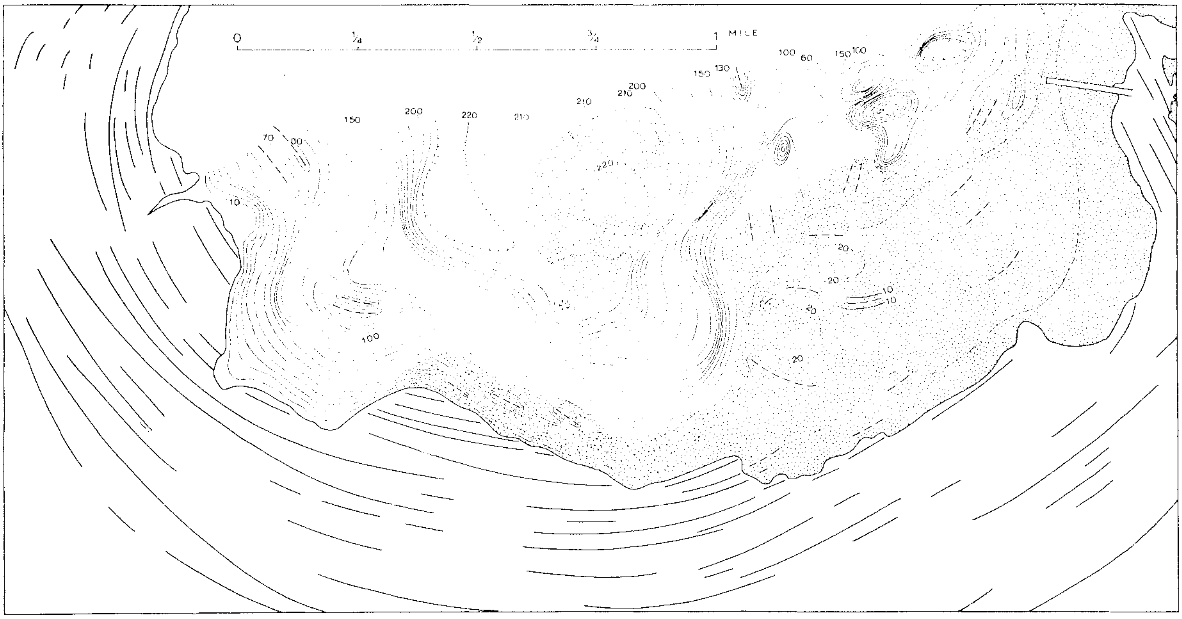

Fig. 3.—Bathymetric chart of the southern part of Lake St Clair, with isobaths at 10 feet intervals. Solid lines—moraine ridges on land; broken lines—submerged moraine ridges; stipple—unconsolidated deposits of the lake floor.

BEDROCK GEOLOGY

Well developed linear elements in the morphology of the district reflect the traces of faults and master joints. Erosion along one of the north to north-westerly faults typical of the western margins of the Central Plateau may account for the general orientation and form in plan of the Lake St Clair trough (Derbyshire, 1963). According to Gulline (1965), Lake St Clair lies along an inferred faulted junction between Permian rocks to the west and north and Jurassic dolerite to the east. The base of the dolerite sill rests on sub-horizontal Triassic and Permian sediments at approximately 4,000 feet on the eastern slope of Mt Olympus. On the eastern shore of the lake, however, the base of the dolerite is below lake level, having downthrown to the east. Accordingly, it is inferred that Permian sediments make up the bedrock floor of the western half of the lake and that Triassic or Permian sedimentary rocks may occupy most of the remainder.

While Lake St Clair lies in a true rock basin, bedrock is exposed along barely one sixth of the lake's 25 mile shoreline. It is best seen at the foot of glacially-over-steepened slopes on the north-west (Permian), south-west (Triassic) and south-eastern shores (dolerite of the south-eastern peninsula). The remainder of the shoreline is made up of a variety of deposits of Quaternary age, mainly tills but including also some washed sands and gravels and some talus and soliflual debris (Fig. 5).

THE MORPHOLOGY OF THE LAKE BASIN

Lake St Clair is an overdeepened basin of compound form. Details of its morphology are presented in Figures 3, 4 and 6. It will be seen that the lake occupies a large, elongated trough aligned N.N.W. to S.S.E., containing four distinct basins with closed contours at 265, 425, 530 and 220 feet depth (Fig. 6), in addition to a lateral basin on the south-east (Derwent Basin). The main trough is simple and remarkably straight, running along a bearing of 145°, between northings 815 and 825 rather to the west of the longitudinal axis of the lake. Complexities in the form of the basin are introduced by lateral elements, the most striking of which are the deep north-south tributary trough on the northern side of the lake along easting 414, the broad deep north and east of Cynthia Bay, and the large bedrock salient referred to here as the south-eastern peninsula. This salient is largely responsible for the complex outline and morphology of the southern end of the trough. The central part of the main trough is remarkably asymmetrical and stepped in transverse profile (Fig. 6), the generally steeper slopes lying consistently on the western side.

These morphological characteristics are the result of the interplay of two main factors, namely the bedrock structure and the behaviour of the Pleistocene glaciers. The outline in plan and the major morphological features of Lake St Clair appear to follow the alignment of two convergent faults, the greatest depths of the lake differing little from the location of these faults as inferred by Gulline (1965: cf. Fig. 4). The bathymetrical evidence suggesting the location of the fault trace is particularly clearly seen in some of the cross-profiles, especially numbers 38-39, 26-46 and 26-25, where the trough has the form of an asymmetrical V, with the steep limb on the west. All the transverse profiles are stepped below lake level, particularly profile 38-39, thus continuing the profile of the subaerial slopes developed on sub-horizontal Triassic and Permian rocks. This

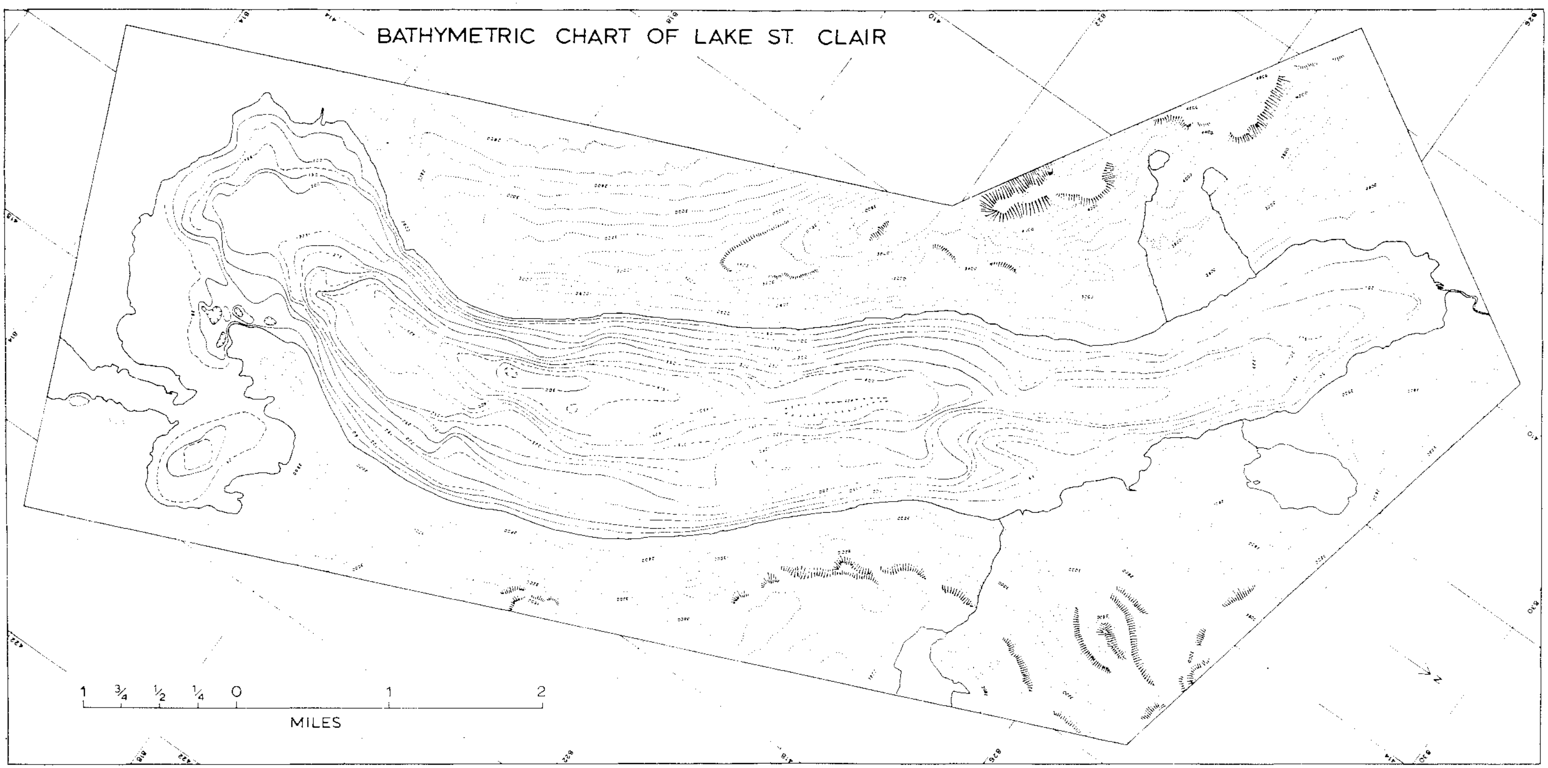

Fig. 4.—Bathymetric chart of Lake St Clair. Isobaths at 50 feet intervals, with interpolated isobaths at intermediate (25 feet) intervals shown by broken lines.

suggests that these sedimentary rocks floor the lake on both sides of the inferred fault along the central trench. The widest, most clearly defined benches include one along the eastern side of the lake at a depth of 200-250 feet (profile 42-43, Fig. 6), those lying south-south-west of Mt Ida (50-100 feet depth: cf. profile 26-25, Fig. 6) and the one running southward along easting 417.

The tri-lobate form of the lake-head shoreline reflects the convergence at this point of three valley ice-streams down the Hamilton Creek, Marion Creek and Narcissus River troughs (Fig. 7). Even more striking is the broad embayment in the north-eastern shore where the ice-enlarged valleys on either side of Mt Ida converge as linear deeps below the present lake surface. This part of the lake is one of rapid southward increase in depth, constituting the northern margin of the main trench enclosed by the 400 feet isobath and containing the second and third closed basins (Figs. 4 and 6). While the general alignment of the main trench is controlled by faulting, as suggested above, its broadly arcuate form (most notable toward the south, with the greatest depths occurring where the lake basin narrows to less than one mile between the southern spur of Mt Olympus and the south-eastern peninsula) is clearly an expression of sculpture by a thick, vigorous but constricted glacier. To the south of this zone of constriction, however, the lake broadens rapidly and reaches a width of almost 3 miles. This terminal basin is compound (Figs. 3 and 4), consisting of Derwent Basin in the east and the main basin north and east of Cynthia Bay, as well as some restricted but deep enclosed depressions close to the south-eastern peninsula. The general form in plan of this terminal basin reflects the spreading of the 'expanded foot' of the St Clair glacier south of the zone of constriction, with associated reduction in lake depth and a shoreline whose constriction and form are largely dictated by a suite of end moraine ridges which can be followed below present water level (Fig. 3).

The echo-traces over a large part of the lake suggest that its bedrock floor has only a thin cover of sediments of little morphological significance. Two exceptions to this general statement should be noted, however. The first are the substantial ridges of probable end moraine origin, having a relative relief in excess of 20 feet. These are part of a much larger feature, the composite moraine barrage, which may reach the 90 feet isobath beneath Cynthia Bay, to judge from the echo-profiles (Fig. 8). This suggests that the moraine barrage is of the order of 130-150 feet in thickness in this area. Eastward, the total moraine thickness appears to be little more than 80 feet. Thus, moraines in the east are of smaller amplitude, both above and below lake water level.

The second exception is the broad bench, most of it lying at a depth of less than 25 feet, which occupies the south-east of the main terminal basin of Lake St Clair. In this area, in addition to some end moraine ridges, the echo-traces suggest that the remarkable uniformity of level is due to unconsolidated sediments up to 15 feet in depth, e.g., along profile 8-9 (Fig. 2). These sediments are predominantly of sand grade, as are the moraines on this south-eastern shore of the lake.

Elsewhere, the only notable area of unconsolidated deposits was found to be in the southernmost enclosed

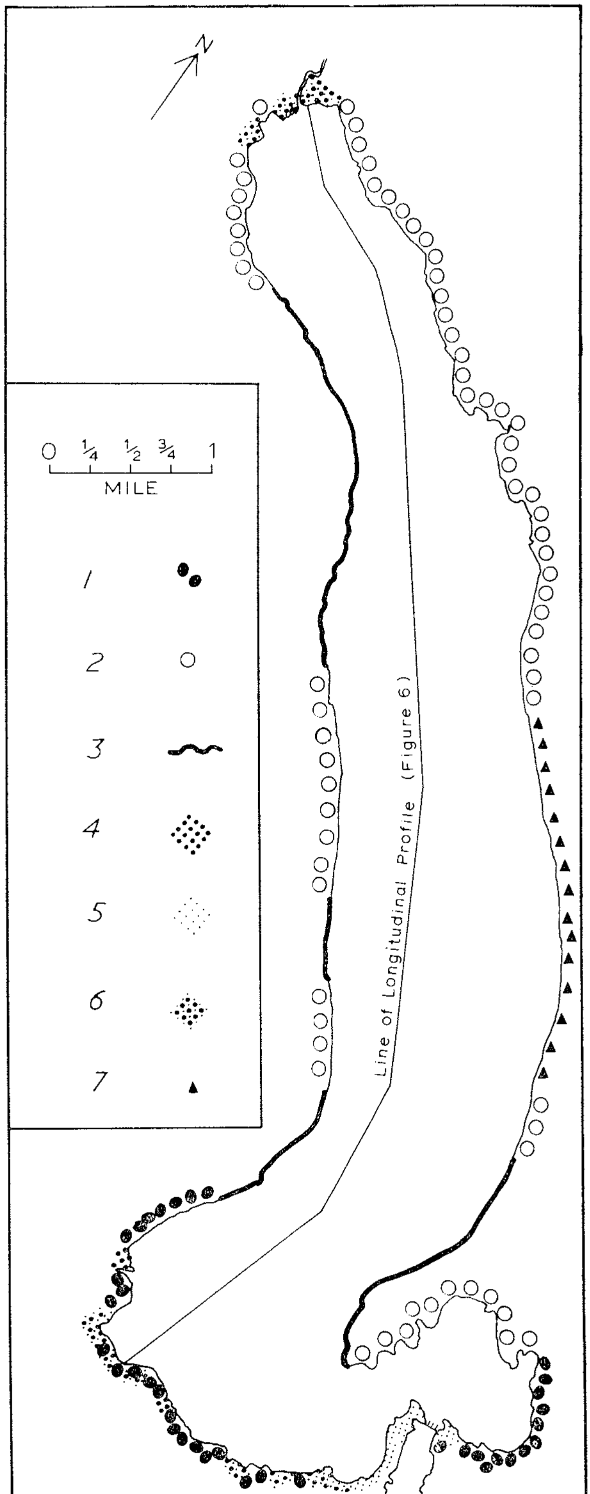

Fig. 5.—Materials making up the shoreline of Lake St Clair. 1.—'conglomeratic' till; 2.—till, undifferentiated; 3.—bedrock; 4.—gravel; 5.—sand; 6.—sand and gravel; 7.—talus.

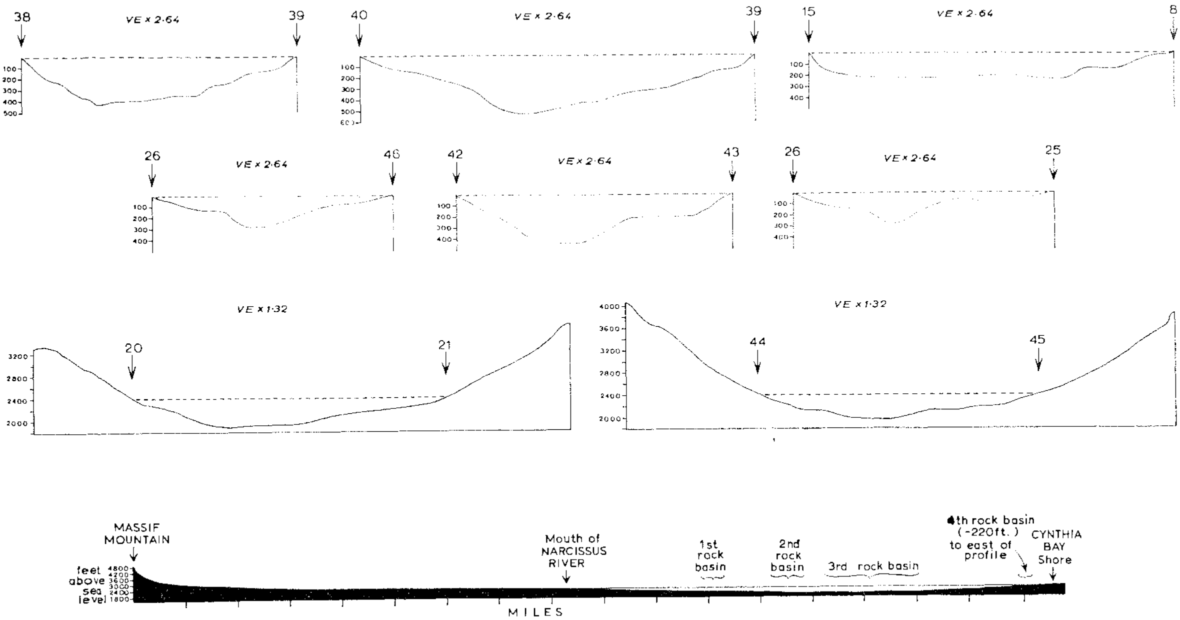

Fig. 6.—Selected transverse profiles and a longitudinal profile of Lake St Clair. Longitudinal profile is at natural scale.

basin of the main trough, where echo-sounding suggests thicknesses of superficial deposits of between 6 and 18 feet.

The steep-sided, deep but small closed basins near the south-eastern peninsula are taken to have been developed in well-jointed bedrock by locally severe glacial quarrying. These basins, and the good double echoes recorded at and below 48 feet on profile 11-12, suggest that the well defined break of slope at about 50 feet depth to be seen in the south-eastern part of the lake approximates the transition from a bedrock floor to a drift floor. If this is so, then of the total present lake volume of 1.6898 km^3, approximately 1.298 km^3 (76.83 per cent) is contained in a glacial rock basin.

DISCUSSION

The basin of Lake St Clair is a glacially-overdeepened reach of the Derwent River Valley. Notable modification by glacial erosion extends from the great valley-head cirque on the south-east slopes of the Du Cane Range southwards only as far as Bedlam Walls, and glacial depositional forms have been traced only a further 15 miles southwards to Mossy Marsh (Derbyshire, Banks, Davies and Jennings, 1965). While the course of the River Derwent appears little modified by Pleistocene glaciation south of Butlers Gorge, severe glacial over-deepening at Lake St Clair and locally thick glacial deposition to the south of the lake appear to have resulted in substantial modifications.

It may reasonably be inferred that the pre-glacial upper Derwent rose, as at present, in the Narcissus River valley and flowed south-eastward under the influence of a fault system. Severe glacial erosion broadened the upper valley to a catenary form and the subsequent glacial and glacifluvial deposition endowed it with a relatively flat floor, so that the Narcissus River now has a markedly underfit relationship to its valley. Convergence of three valley glaciers, the easternmost receiving substantial increments of ice from the western Central Plateau (notably by way of the twin outlet valleys about Mt Ida) resulted in overdeepening and the development of the main trench of the lake. Localization of the greatest depths of the rock basin in this locality was the direct result of the comparatively large reservoir of ice provided by the Central Plateau ice-sheet, the basin terminating only 1 to 2 miles south of the southern margin of the plateau. In the absence of such a reservoir, it appears unlikely that a rock basin of any great size would have developed. Despite its form and disposition, therefore, this subalpine basin is largely the product of sheet ice and not valley glaciers as normally understood.

The great depth of the moraine barrage on the south and south-west shores of the lake implies a southerly extension of the rock basin. The form of the northern part of the Navarre Plains, which are made up of ill-drained glacial deposits of unknown depth bounded sharply on east and west by the bedrock slopes of Bedlam Walls and Mt Rufus respectively, is consistent with such an extension although proof must await the results of seismic surveying.

The present Derwent River, which drains Lake St Clair by way of the Derwent Basin where it breaches the lower moraines typical of the eastern side of the lake foot, flows across glacial and glacifluvial drift as far as Derwent Bridge. Just south of this point, it turns westwards and cuts into a low ridge of dolerite joining Bedlam Walls and Mt Charles, creating a short gorge section between 35 and 50 feet deep. Beyond, it traverses

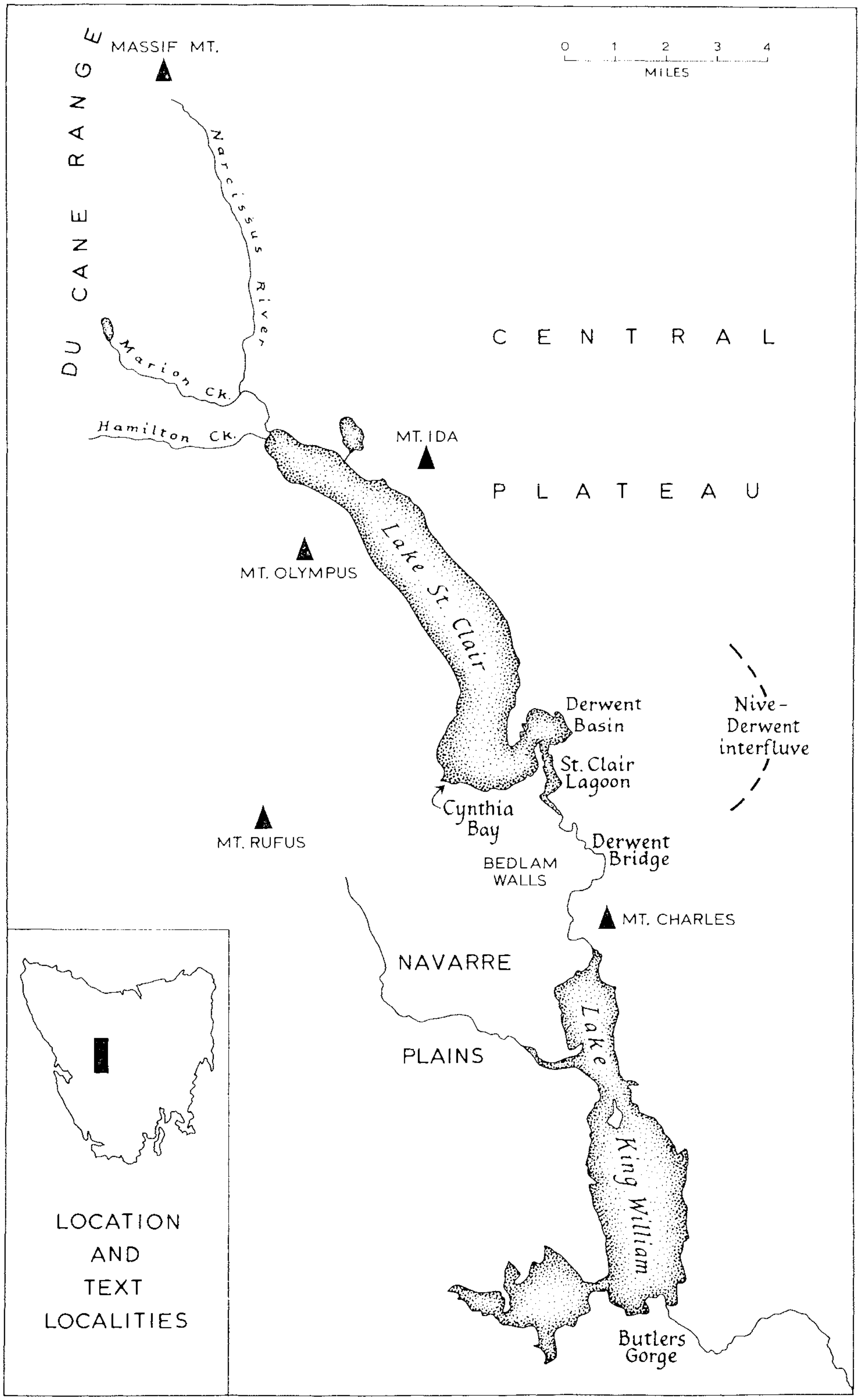

Fig. 7.—Location map of the Lake St Clair district.

a small glacifluvial outwash plain composed of washed sands and gravels with some intercalated rhythmites and some moraine remnants, its banks still being made up of glacial deposits as it descends below the level of the artificial Lake King William.

On the basis of evidence presented elsewhere (Derbyshire, 1963, 1968a: Derbyshire, Banks, Davies and Jennings, 1965), it appears that the route of the present upper Derwent immediately south of Lake St Clair was established by the glacial meltwaters of the down-wasting St Clair glacier. By the time its snout had retreated to the latitude of Mt Charles, the glacier was asymmetrical, its surface being lower in the south-east than in the south-west, thus concentrating meltwater effects in the area of the eastern basin. The moraine ridges, some composed entirely of bedded sands, and the broad, sand-covered floor of the south-eastern bay of the lake are consistent with this interpretation. With a thicker ice lobe to the south-west over the Navarre Plains, the more direct route for meltwater across this gentle plain was not developed, ice gradients and, hence, hydrostatic pressures within the glacier leading englacial and subglacial meltwaters south-eastward to swell the proglacial drainage. The Derwent's gorge section may well have been created at a relatively early stage in the deglaciation by the superimposition of englacial and subglacial drainage across a low point in the ridge. Whether the broad valley containing the Navarre Plains sediments represents the glacially-modified course of the pre-glacial Derwent River is not yet known, but the possibility is worthy of investigation by seismic refraction methods.

Finally, some stages in the evolution of the southern margins of Lake St Clair may be suggested (Fig. 9). The first stage appears to have been one of stillstand of the ice marked by substantial end moraines left by a western lobe which reached the Navarre River, and by an eastern lobe which stood at the Nive-Derwent interfluve. Both during this stage and in the subsequent frontal retreat of the eastern lobe, some ponding of meltwaters occurred, resulting in thick deposits of massive clay-silts to the east of the retreat moraines (l, la, lb on Fig. 9). The gentler gradients of the eastern lobe of the St Clair glacier are reflected in the greater spacing of contemporaneous end moraines in the east relative to the west (cf. Fig. 3, and Derbyshire, 1968a). Thus it may be postulated that, even in the early stages meltwater was guided eastward within thinner ice so that the Derwent gorge may have been initiated as a subglacial drainage line. This was uncovered as a subaerial meltwater route by stage 2, the present course of the Derwent north of Derwent Bridge becoming established, after the abandonment of three easterly channels, between stages 2 and 4. Stage 4 saw the ponding of meltwater in the eastern part of the present Derwent Basin and between moraines on either side of St Clair Lagoon. This enlarged south-easterly embayment of the proto Lake St Clair lasted until at least stage 5, and possibly much longer, for lowering to the present lake level necessitated at least 20 feet of incision into a stiff grey till containing abundant large boulders. It is under such conditions that the deposition of the thick, grey clay-silts (Derbyshire 1963, 1968a) in the inter-morainal swales is envisaged. The St Clair glacier-front retreated below present water level, in at least two stages as indicated by end moraine remnants (Stages 6 and 7, Fig. 9). It is notable that, even at stage 6, the west to east gradient of the ice surface appears to have been maintained. An eighth stage is suggested, based on the gradient of a lateral moraine declining southward between 3,600 and 3,200 feet a.s.l. at 417822 (Fig. 4). By this stage, the ice tongue must have had a floating terminus, for it lay in 400 feet of water. Floating blocks of ice can be expected to have persisted for many seasons on the lake waters, for the snout of the St Clair glacier appears to have retreated slowly but regularly a further 14 miles northward into the Narcissus trough-end (Derbyshire, 1968a). Such floating lake ice may have been instrumental in the breaching of many moraine ridges, especially east of Cynthia Bay, that part of the moraine-girt lakeshore with the longest fetch for winds between west and north.

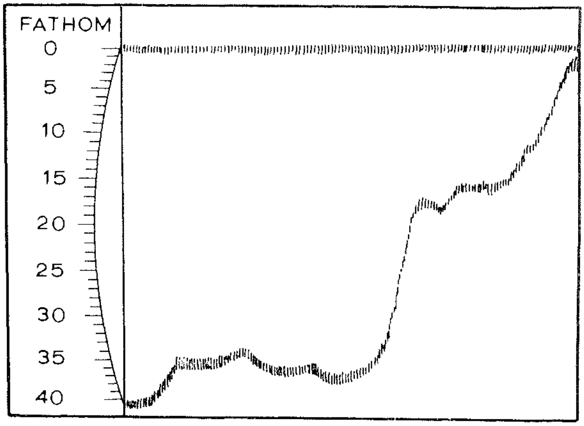

Fig. 8.—Echo-trace of the southern part of run 47-48 (see Fig. 2), showing bottom morphology of Cynthia Bay, including subaqueous moraine ridges.

REFERENCES

CLEMES, W. H., 1925: Notes on a geological reconnaissance of the Lake St Clair district. *Pap. Roy. Soc. Tasm.*, 1924, pp. 59-72.

DERBYSHIRE, E., 1963—Glaciation of the Lake St Clair district, west-central Tasmania. *Aust. Geogr.*, **9**, pp. 97-110.

————, 1968: Two gelifluctates near Great Lake, central Tasmania. *Aust. J. Sci.*, **31** (4), pp. 154-6.

————, 1968a: Glacial map of N.W.-central Tasmania. *Record, Geol. Surv. Tasm.*, **6**, 41 pp.

————, BANKS, M. R., DAVIES, J. L., and JENNINGS, J. N., 1965: Glacial Map of Tasmania. *Roy. Soc. Tasm., Spec. Pub.* **2**, 11 pp.

————, and PETERSON, J. A., 1965: Distribution and morphology of some Tasmanian lakes. *Aust. Soc. Limnol., Newsletter,* **5** (1), pp. 5-8.

DUNN, E. J., 1894: Glaciation of the Western Highlands, Tasmania. *Proc. Roy. Soc. Vic.,* **6** (n.s.), pp. 133-8.

GOULD, C., 1860: Exploration of the Western Country. *Tasm. Parl. Pap.,* 1860, **6.**

GULLINE, A. B., 1965: St Clair. *Explan. Rept Geol. Surv. Tasm.,* 1-mile Geol. Map Ser. K/55-10-59.

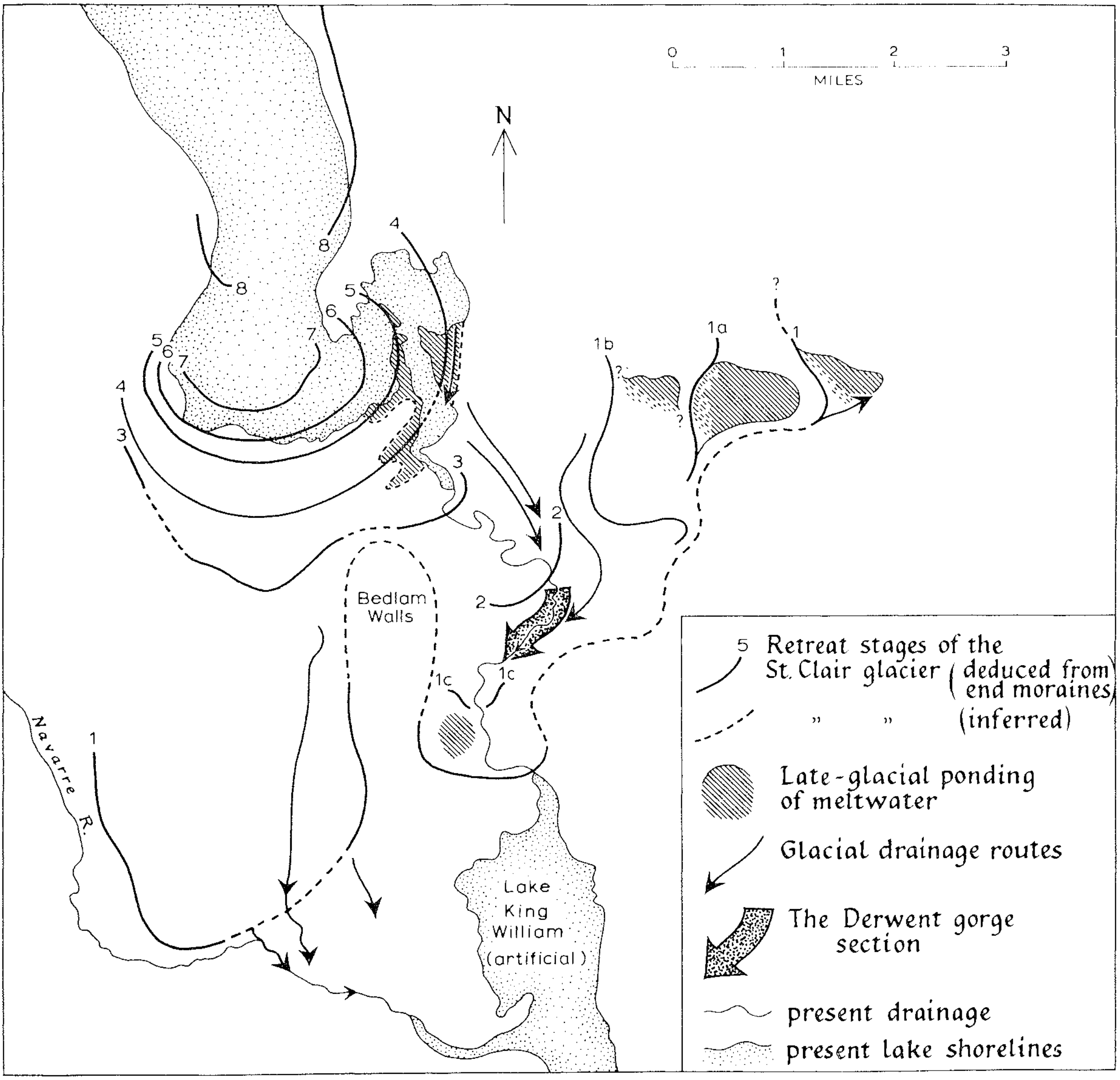

Fig. 9.—Some retreat stages of the St Clair glacier.

JOHNSTON, R. M., 1894: 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. *Pap. Roy. Soc. Tasm.*, 1893, pp. 135-46.

LEWIS, A. N., 1933: Note on the origin of the Great Lake and of other lakes of the Central Plateau. *Pap. Roy. Soc. Tasm.*, 1932, pp. 15-28.

————, 1939: Notes on Pleistocene glaciation, Mount Field to Strahan. *Pap. Roy. Soc. Tasm.*, 1938, pp. 161-73.

MONTGOMERY, A., 1894: Glacial action in Tasmania. *Pap. Roy. Soc. Tasm.*, 1893, pp. 159-69.

MOORE, T. B., 1894: Discovery of glaciation in the vicinity of Mount Tyndall, in Tasmania. *Pap. Roy. Soc. Tasm.*, 1893, pp. 147-9.

OFFICER, G., 1894—The geology of the Lake St Clair district. *Pap. Roy. Soc. Tasm.*, 1893, pp. 150-8.

OFFICER, G., BALFOUR, L., and HOGG, E. G., 1895: Geological notes on the country between Strahan and Lake St Clair, Tasmania. *Proc. Roy. Soc. Vic.*, 7 (n.s.), pp. 119-30.