# PLEISTOCENE DRIFT IN THE MERSEY AND FORTH VALLEYS—PROBABILITY OF TWO GLACIAL STAGES

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(With six text figures and two plates.)

## ABSTRACT

Deposits of Pleistocene drift in the Mersey and Forth Valleys are described. The deposits in the Mersey Valley are referable to one glacial stage, but those in the Forth Valley are thought to indicate two glacial stages.

## INTRODUCTION

This paper describes deposits of Pleistocene drift in the Mersey and Forth Valleys adjacent to the north-western boundary of the Central Plateau in Tasmania. The deposits were examined during investigations for the Mersey-Forth Power Scheme. Those found in the Forth Valley are of special interest because they are thought to indicate two glacial stages during the Pleistocene in this part of Tasmania.

Mather (1956), and Jennings and Ahmad (1957) examined the Central Plateau bordering the Mersey Valley. The latter authors recognised only one glaciation, an ice cap glaciation, during which the ice moved away from a major ice divide that ran SW-NE through the Walls of Jerusalem.

Spry (1958) made a reconnaissance of the Mersey-Forth-Arm area and deduced that the ice spilled over the edge of the plateau in many places during the ice cap phase. It filled the existing Mersey and Forth Valleys and tributary valleys with ice almost 2000 feet thick, and covered Maggs Mount and Borradaile Plains. He concluded that the ice cap phase was followed by a less severe valley glacier phase, but that it was not possible to decide whether the first and second phases were separated by an interglacial period, or whether the ice cap merely shrank leaving valley glaciers that were active for a considerable period with minor advances and recessions.

Jennings and Banks (1958) and Davies (1962) reviewed all the evidence of Pleistocene glaciation in Tasmania and reached the conclusion that it was referable to one glacial stage. These authors abandoned the scheme developed by Lewis (summary, 1945) of three full glaciations—Malana (ice cap), Yolande (valley glacier) and Margaret (cirque glacier)—constituting a series of declining glacial intensity.

## MERSEY VALLEY DEPOSITS

Spry (1958) and Jennings (1963) described U shaped valleys with truncated spurs, hanging valleys, smoothed quartzite outcrops and roches moutonnées in the Mersey-Little Fisher-Arm area. Ford (1960) described till, erratics, moraines and lineations in the Little Fisher Valley, and Macleod et al (1961) briefly described till in the Upper Mersey Valley.

The distribution of drift in this part of the Mersey Valley system is shown on Figure 1. All the deposits examined are referable to one glacial stage.

### Valley Slope Deposits

The western slope of Clumner Bluff is covered with deposits of mixed origin. The material is thought to include ice sheet spillover, ice contact deposits, valley glacier deposits and periglacial solifluction material. The deposits have been examined by pits along the Mersey-Fish and Mersey-Little Fisher Roads. These were dug to a maximum depth of 18 feet.

Typically the pits contain an upper solifluction layer up to 4 feet deep, underlain by a layer up to 6 feet deep of poorly bedded gravels and boulders, which dip towards the valley at about 15°. This layer is underlain by gravelly to bouldery till lacking bedding. An example of the bedded layer, probably an ice contact deposit, is shown on Plate I, Figure 1. A typical particle size distribution curve of material of less than 6 inches diameter of the till from the Mersey-Fish road is shown on Figure 2.

Cuttings along the Arm Valley Road expose bouldery till (Plate 1, Figure 2) within which lie some 20 feet of varves. The varves occur about 300 feet above the floor of the Mersey Valley and are well consolidated and tough. Till is again exposed at a higher level, but its relationship to the varves is not clear. It appears that a lake existed in the Arm Valley, probably dammed by deposits from the main Mersey Glacier.

### Valley Floor Deposits

Ground moraine and fluvioglacial material extends as far downstream as Parangana Damsite ½ mile below the Fisher River Junction. Immediately below the damsite the nature of the valley changes; the straight, broad valley becomes a narrow, winding valley with interlocking spurs. No drift was found at Martha Creek Damsite 1½ miles downstream of Parangana Damsite and 70 feet lower in altitude. The deposits were examined at Rowallan and Parangana Damsites.

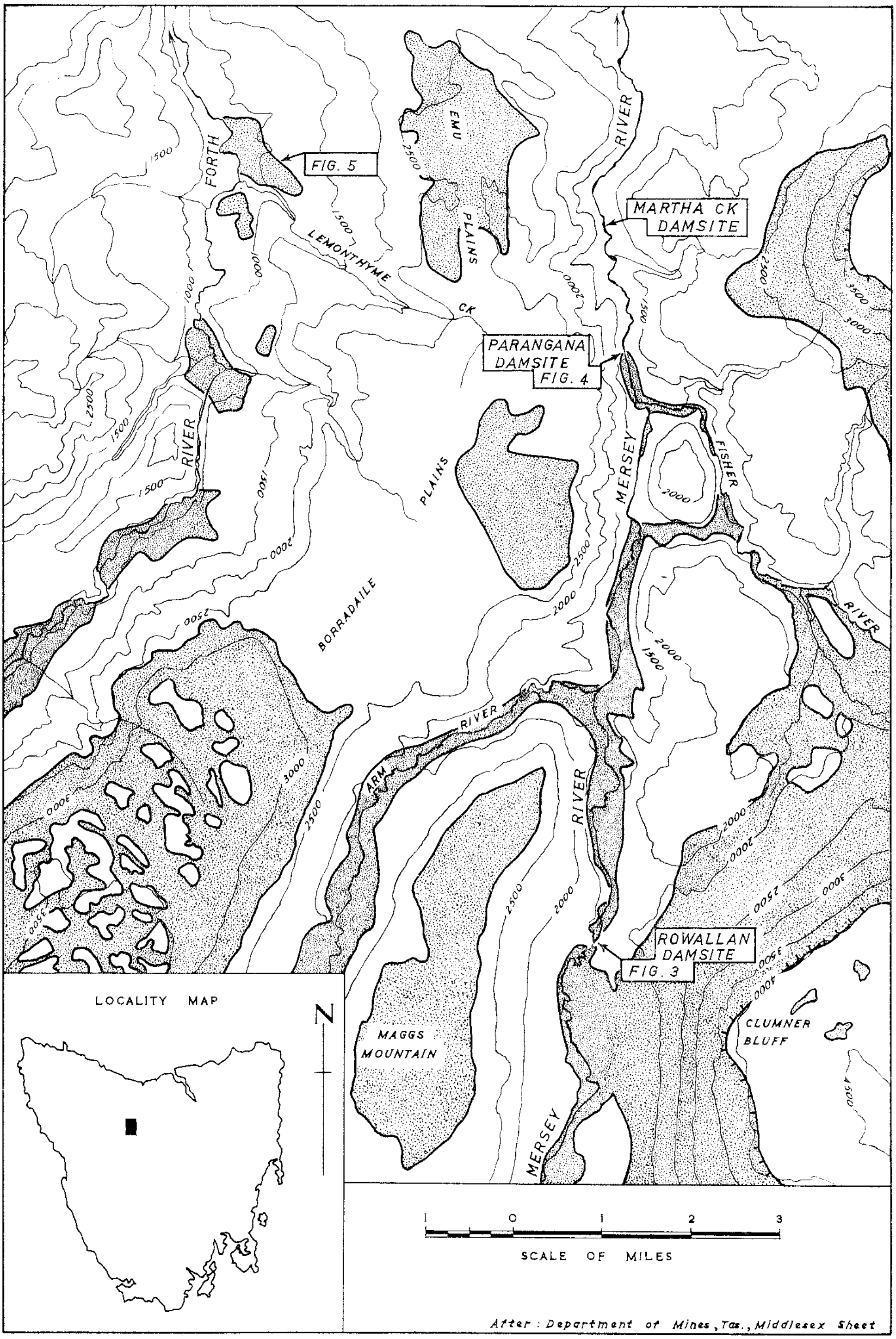


FIG. 1.—Distribution of Drift in the Middle Mersey and Forth Valley systems.

*Rowallan Damsite*:

Rowallan damsite (Figure 3) is situated at the downstream end of a flat drift plain known as Walters Marsh and Howells Plains. It is 6 miles long and ½ mile wide.

At the damsite the Mersey, a superimposed river, flows transverse to the structural trend through Precambrian Howell Group metamorphics. It is constricted to a 10 foot wide channel against the eastern wall of the valley by a ridge, an overturned anticline in quartzite and schist, which forms a local base level protecting the drift plain from erosion. The ridge is separated from the western wall of the valley by a 400 foot wide buried channel of the Mersey River, which is filled with drift. The channel has an asymetrical profile and the drift extends to a maximum depth of 133 feet, The base of the deposit is at an altitude of 1397 feet, which is 90 feet below the present river bed.

The greater part of the drift deposit is till, composed of an unstratified, heterogeneous mixture of boulders, cobbles, pebbles, sand, silt and clay. The coarse material is sub-rounded to sub-angular and ranges up to 6 feet in diameter. The greater part of the deposit was derived from dolerite with quartzite and schist contributing only minor amounts. Weathering extends only a few feet into the deposit, and the fresh matrix is bluish-grey in colour. Drill hole 5746 has shown the presence of one fluvioglacial sand lens or channel 6 feet deep filled with fine yellowish-brown dolerite and quartz sand. Nevertheless water tests in drill holes 5747 and 5748 have shown the drift to be practically water tight. Most tests yielded leakage rates of less than 1 gallon per minute at 100 pounds per square inch pressure.

Spry (1958) carried out a mechanical and petrological analysis of material from near the damsite. He found it to be tough, well consolidated and lacking bedding. Comparatively speaking it was not friable and was tougher than most Tasmanian Permian and Triassic sediments. His histogram and cumulative curve indicate the material to be poorly sorted and to contain a considerable spread of sizes. 80% of the material was in the pebble, granule and sand grades with silt and clay grades comprising only about 20%. Spry found the larger particles were dolerite with a little quartzite, the sand was fine-grained dolerite, quartz, pyroxene and feldspar, and the silt was quartz, pyroxene and plagioclase. The particles were fresh and unweathered and of low roundness and sphericity. He concluded that although the degree of sorting was not unlike that of some river gravels, the composition, particularly its content of fresh, sand-silt size pyroxene and plagioclase, is quite different.

Ford (1964) carried out an X-ray analysis of the matrix of the fresh till. He found it to consist of fine-grained quartz and a mica type mineral. No clay mineral of the kaolinite or montmorillonite groups was found.

*Parangana Damsite*:

Parangana Damsite (Figure 4) is located 7 miles downstream from Rowallan Damsite. Here the Mersey River flows transverse to the structural trend through vertically to near vertically foliated Precambrian Fisher Group quartzites, schists, phyllites and slates.

The site has been glacierized rather than glaciated, but it has a broad upper profile and a narrow central channel. Up to 40 feet of talus overlies drift that has a maximum thickness of 50 feet in the channel section. The material rests on channel filling at an altitude of 1070 feet. The depth of the channel is not known, but drill hole 5768 indicates it to be in excess of 120 feet below the base of the drift. The drift has been investigated by drilling and an adit.

The material visible along the river bank and in the adit is a bouldery till similar to that encountered at Rowallan Damsite. It consists of a well consolidated, unstratified, heterogeneous mixture of boulders, cobbles, pebbles, sand, silt and clay. Seventy per cent of the deposit is in the pebble and larger size ranges, and this material is coated with clay, silt and sand. In contrast with the Rowallan deposit the fine material is weathered yellowish-brown at a depth of 75 feet below the surface. Some properties of the matrix are listed in Table I.

TABLE I.

*Properties of Till Matrix Parangana Damsite.*

| | | |
|---|---|---|
| Sieve Analysis— | | |
| | 83% | passed No. 4 (5 mm.) |
| | 60% | passed No. 30 (0.6 mm.) |
| | 36% | passed No. 200 (0.07 mm.) |
| | 6% | passed 0.02 mm. |
| Liquid Limit | 42 | |
| Plastic Limit | 32 | |
| Plasticity Index | 10 | |
| Linear Shrinkage | 4 | |
| Specific Gravity | 2.77 | |

Most of the deposit has been derived from dolerite with basalt, quartzite and schist contributing minor amounts. The boulders of dolerite, basalt and schist are sub-rounded to rounded and range up to 3 feet diameter, whereas the boulders of quartzite are angular and range up to 10 feet diameter. The quartzite and basalt boulders are probably locally derived scree, but the dolerite boulders have been transported from the Central Plateau. The high proportion of sub-rounded to rounded material is notable. The explanation probably lies in a combination of weathering in the source area, distance of transport, and reworking during advances and retreats of the glaciers.

No striated or faceted boulders have been found. This is in accordance with the experience of Jennings and Ahmad (1957), who were unable to find any such minor erosional features on the plateau. It is presumably the result of chemical weathering to which dolerite is susceptible.

Deposits at the Fisher River Junction show faint gravel and sand bedding dipping upstream at up to 15°. In view of the situation at the junction of two glaciers it seem likely that the deposits were laid down under glaciolacustrine conditions. E. Derbyshire (personal communication), however, has suggested that the upstream dip may indicate layering produced within the ice and thus deposi-

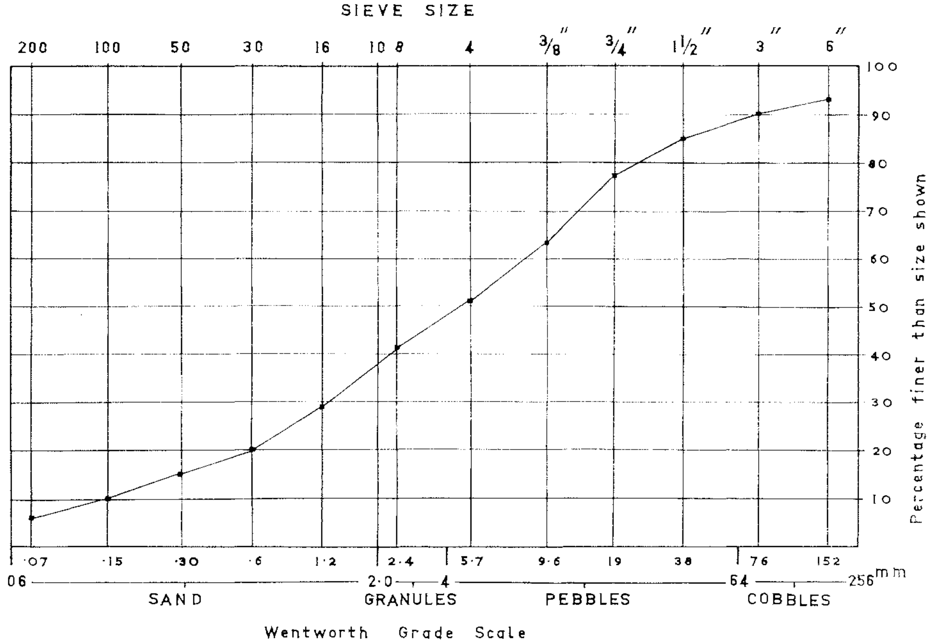


FIG. 2.—Particle Size Distribution Curve of material of less than 6" diameter from the till from the Mersey-Fish Road.

tion under glacial conditions. He (1963) observed similar features in the Lake St. Clair morainal tract, and has suggested that the bedded cores of these moraines represent englacial debris with which the downwasting ice was heavily charged; the moving ice behind depositing the basal till along the planes of shear with the inert ice in front and below.

## FORTH VALLEY DEPOSITS

Spry (1958) and Jennings (1963) briefly described varves occurring along the Forth Valley between Lemonthyme Creek and Lorinna, and noted the presence of a terminal moraine at Lorinna. The deposits at the Forth-Lemonthyme Creek Junction were examined by drill holes and pits along the Lemonthyme Penstock Line (Figures 1 and 5). The underlying bedrock is Precambrian Dove Group schist.

The drift sequence (Figure 6 and Plate 2) consists of a basal tillite[1], interbedded tillite, varves, mudstones and siltstones, gravelly to bouldery till, and carbonaceous clays, sands and silts. These are in part overlain by periglacial solifluction material.

The base of the tillite lies at an altitude of 750 feet. The tillite is gravelly to bouldery, generally hard to well cemented, light to dark grey, without bedding or sorting of constituents. Approximately 70% of the constituents are in the granule to boulder ranges, and the material is angular to subrounded. It is composed of dolerite (Jurassic), basalt (Tertiary), and quartzite and schist (Precambrian) fragments. Some physical properties of the tillite are listed in Table II.

(1) Tillite—used in the rock sense as a consolidated and indurated till, but without the age connotation applied by Penck that the rock formed during glacial epochs anterior to the Pleistocene (Rice, 1955).

TABLE II.

*Properties of Tillite—Lemonthyme Creek.*

| Sample | Dry Density lbs./cu.ft. | Wet Density lbs./cu.ft. | Moisture Content % | Compressive Strength lbs./sq.in. | Indirect Tensile Strength lbs./sq.in. |
|---|---|---|---|---|---|
| 1 | 158.6 | 162.8 | 2.63 | 1827 | 353 (average) |
| 2 | 167.7 | 171.2 | 2.12 | 2568 | |

The tillite forms a blanket over the valley floor, and the deposit has a known width of 3000 feet. A maximum thickness of 80 feet was obtained in drill hole 5803.

The interbedded tillite, varves, mudstones and siltstones appear to have been deposited in a channel about 2000 feet wide near the present channel of the River Forth. A maximum thickness of 93 feet was obtained in drill hole 5808. The rocks are well compacted, but loosely cemented and friable. Except occasionally, the sediments are not a series of graded beds, and Derbyshire (personal communication) considers them inadequate for a worthwhile estimation of time. They are weakly varved and the varved portions are generally gross, averaging 2 to 4 inches.

The interbedded tillite, varves, mudstones and siltstones are overlain by a gravelly to bouldery till at the western end of the penstock line, and by periglacial solifluction material at the eastern end.

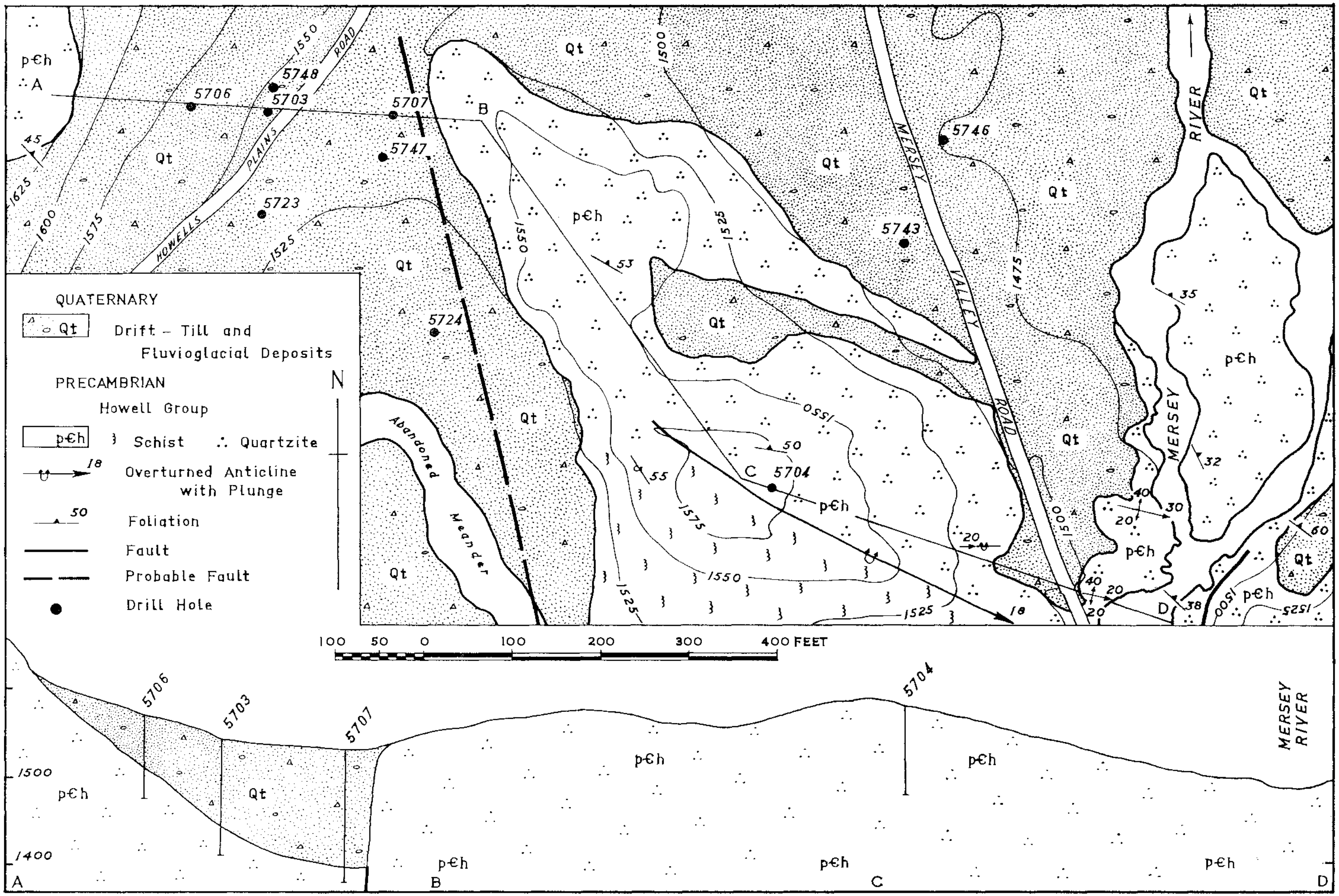


FIG. 3.—Rowallan Damsite.

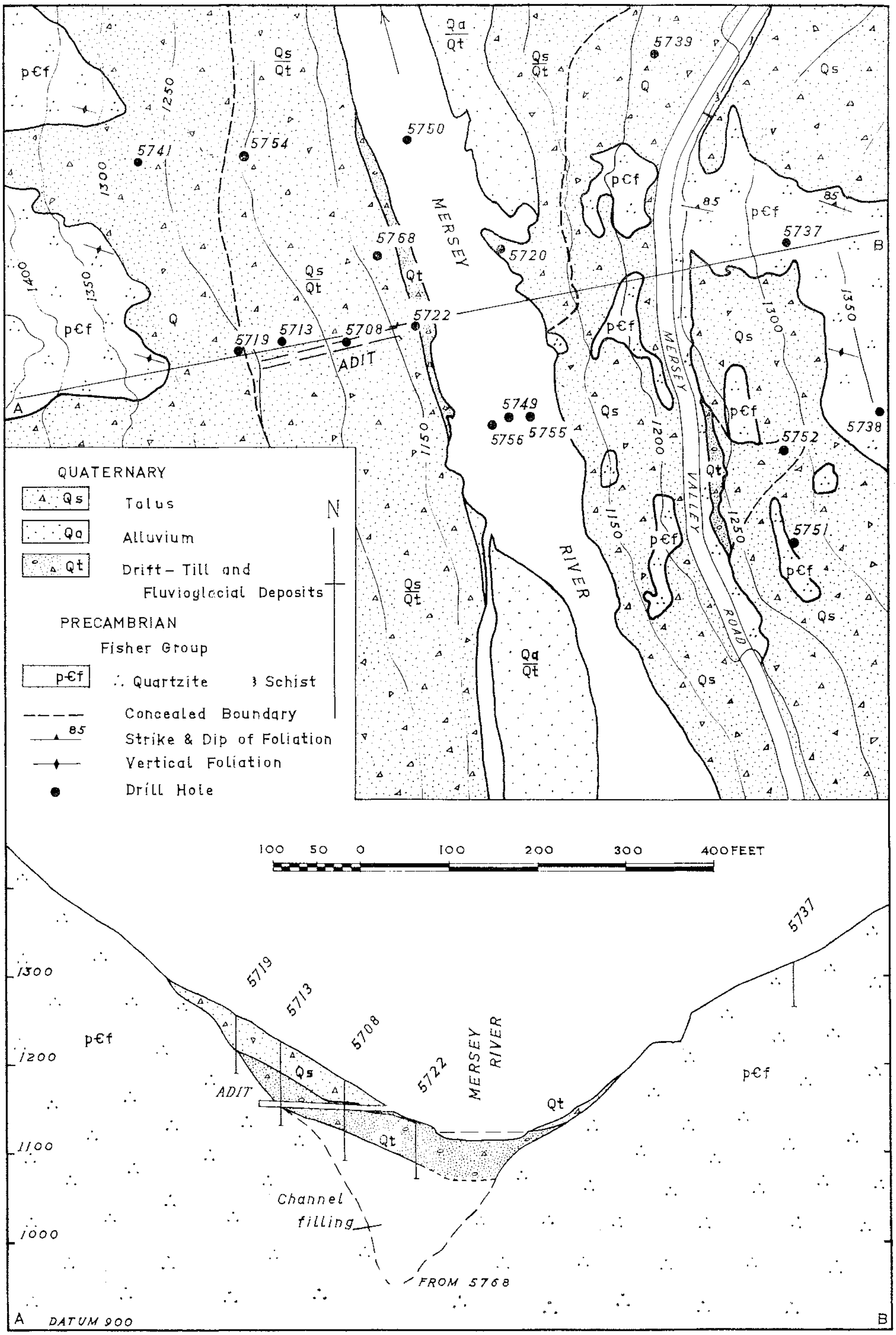


FIG. 4.—Parangana Damsite.

The blanket of gravelly to bouldery till has a known width of 2500 feet and a maximum thickness of 45 feet in drill hole 5802. It consists of an unconsolidated, unstratified, heterogeneous mixture of boulders, cobbles, pebbles, sand, silt and clay. The proportion of coarse material varies from 20% to 70% and consists of sub-rounded fragments of dolerite and basalt, and angular fragments of quartzite and schist. The surface matrix is a soft, yellowish-brown clay of low to high plasticity.

Periglacial solifluction material appears to be the basal deposit in an old channel of Lemonthyme Creek at the eastern edge of the drift deposit. This channel has been traced by drilling and refraction seismic survey for a distance of 2500 feet. The solifluction material is a soft to firm, dark-greenish-grey clay containing up to 10% of angular quartzite pebbles and granules and sub-rounded dolerite and basalt pebbles and cobbles.

Drill hole 5833 encountered 9 feet of solifluction material, but the bulk of the channel is filled with compacted but uncemented black to dark grey laminated carbonaceous clays, silts and sands containing a few pebbly horizons. The beds have a dip of 3°.

Spry (1964a) made a petrographic study of the clays, sands, and silts from drill hole 5825. He found that all the pebbles were derived from Precambrian quartzites and schists; no basalt or dolerite pebbles were found. He observed mud flakes in sandy layers and sandy layers in the clays, which are characteristic of Pleistocene lacustrine sediments. Graded bedding suggested varves, and the strong swelling of many clay-rich samples on immersion in water was similar to the behaviour of the varves from the Arm Valley. Specimens were extremely poor in heavy minerals. No olivine or pyroxene that could be attributed to Tertiary basalt were found, nor pyroxene derived from Jurassic dolerite. Minerals originating in the Precambrian rocks included tourmaline (common), biotite, rutile (very rare); no garnet was found. The most abundant material was black, crusty and ferruginous and appeared to be haematite. Spry concluded that the sediments were Pleistocene glaciolacustrine in origin. The age was later established by drill hole 5833 which indicated that the beds rest on till and tillite. M. R. Banks of the University of Tasmania is examining the abundant carbonaceous material. A maximum thickness of 110 feet of these sediments was found in drill hole 5825, and the beds were overlain by up to 65 feet of solifluction material.

Ferruginous conglomerate and siliceous quartz conglomerate, resembling Ordovician Roland Conglomerate, occur along the southern margin of the buried channel. Spry (1964b) examined specimens petrographically but was unable to make a positive identification. He concluded that they were probably Tertiary greybillies. G. Rawlings (personal communication) has found greybilly at the base of the basalt on the western slopes of Gads Hill, some 400 feet above the channel, and on Emu Plains. It would appear that the channel was in existence in Tertiary time.

The tillite, varves, mudstones and siltstones are thought to have been deposited during the first glacial stage. Drill hole 5808 recorded three tillite layers and two varve-mudstone-siltstone layers, indicating three glacial advances when material was deposited as till and two retreats when glaciolacustrine conditions prevailed. The third retreat may not have left distinguishable deposits, or these may have been reworked during the glacial advance of the second glacial stage and redeposited as till.

The second glacial stage is thought to have commenced with a glacial advance that deposited the blanket of gravelly to bouldery till. It appears that this advance blocked the Lemonthyme Valley and created a lake in which the clays, silts and sands were deposited. The final phase of channel filling was completed by periglacial solifluction.

The probability of two glacial stages is inferred from the marked lithification of the tillite as compared with the overlying till. The marked difference in degree of lithification suggests an age difference, though variations in the weight of overlying ice may have been a major factor. Spry's (1958) observations on the glaciation of Maggs Mount and Borradaile Plains, and Rawlings' (personal communication) observation of till on Emu Plains, indicate a thickness of ice of the order of 2000 feet in the valley areas during the ice cap phase, when presumably the tillite was deposited. This thickness would be considerably less during the decline of glacial activity.

The difference in degree of lithification is reflected in the seismic velocities obtained in the various materials. Velocities were obtained up to 18,000 feet per second in the tillite, up to 5,000 feet per second in the gravelly to bouldery till, up to 7,000 feet per second in the laminated clays, silts and sands, and up to 4,500 feet per second in the solifluction material.

The properties of the tillite given in Table II indicate that the compressive strength of the rock correpsonds to a weak sandstone (Krynine and Judd, 1957), but its tensile strength was better than that usually found in sandstones.

The weathered zone extends into the tillite, and it has not been possible to recognize whether an old weathered surface, indicative of exposure between deposition, exists at the top of the tillite.

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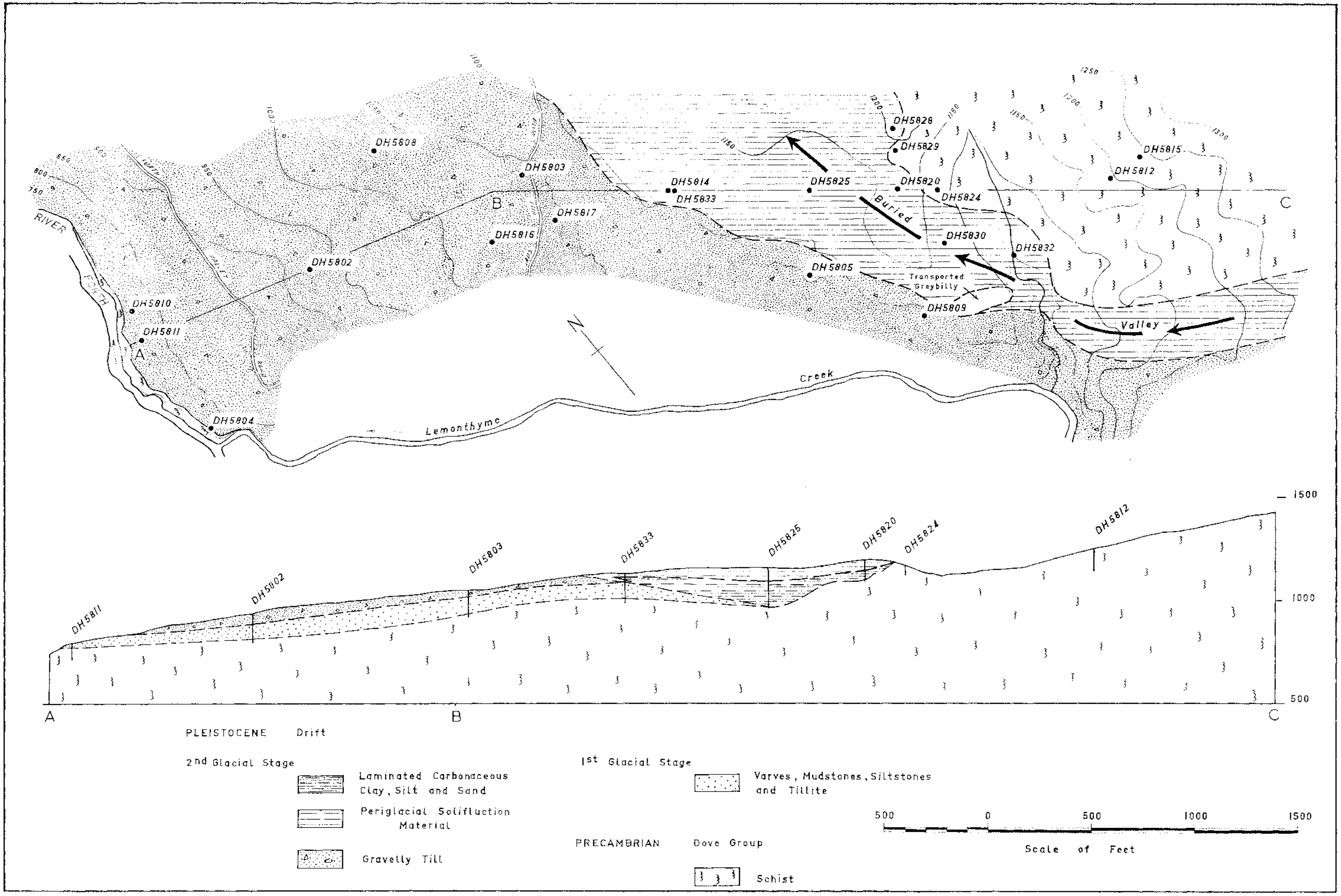


FIG. 5.—Lemonthyme Penstock Line.

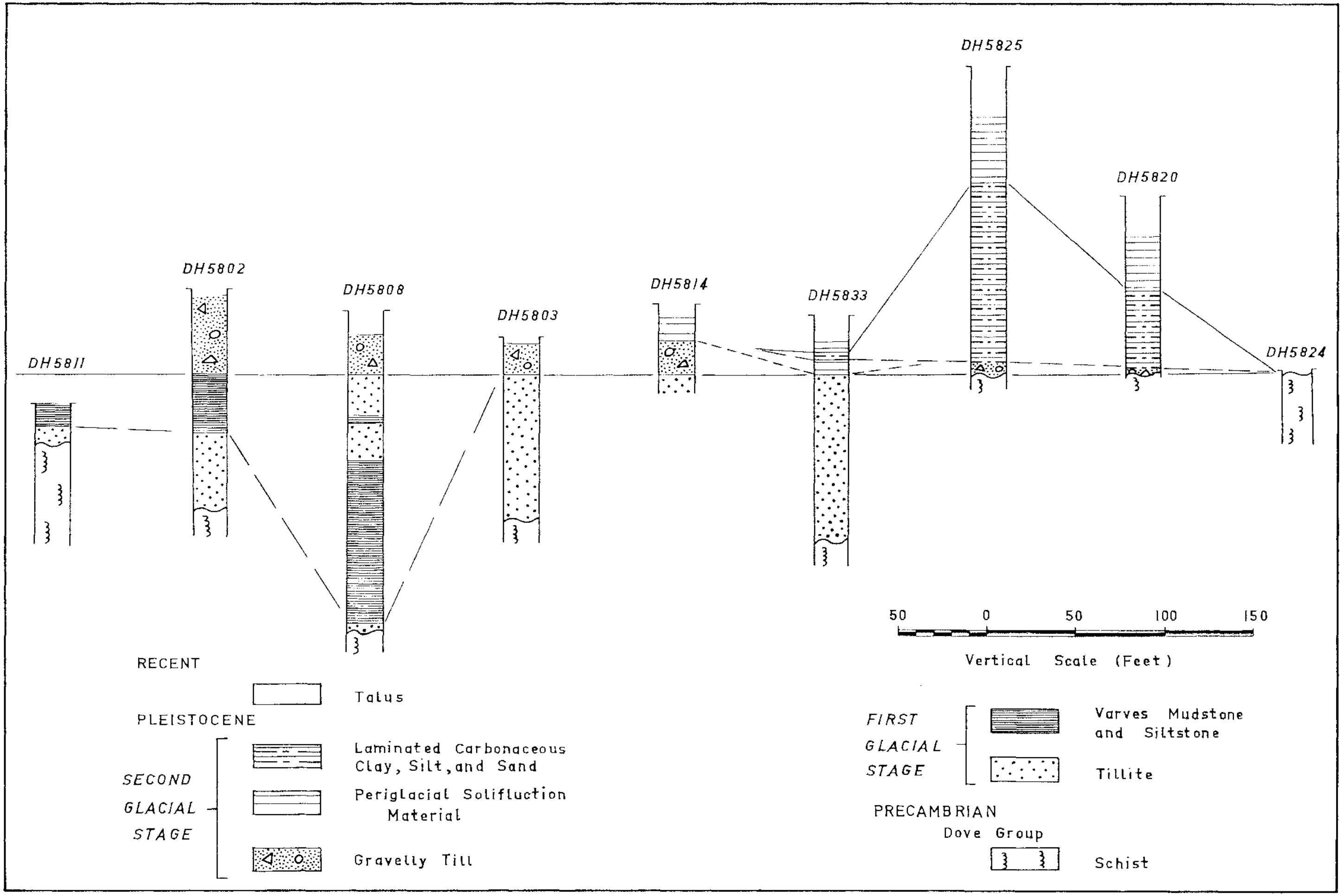


FIG. 6.—Stratigraphic Cross-sections along the Lemonthyme Penstock Line.

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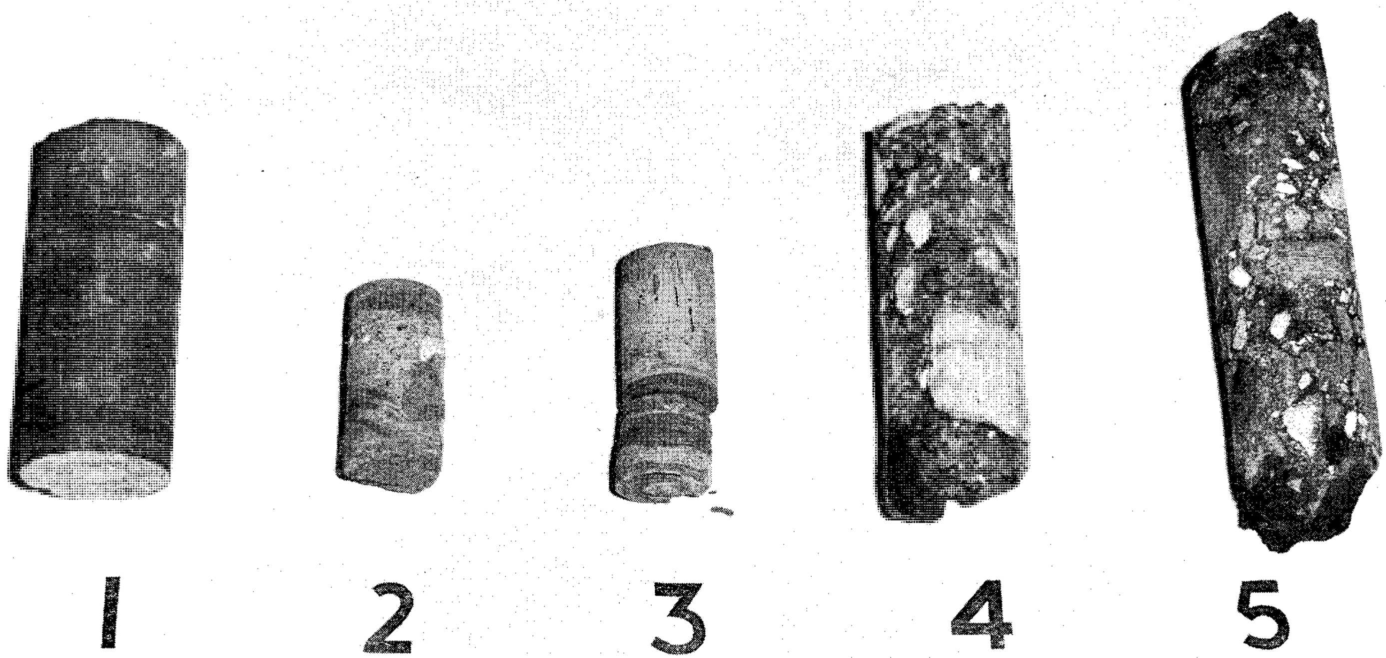
PLATE I.

FIG. 1.—Bedded sand and gravel adjacent to the Mersey-Little Fisher Road above Rowallan Damsite.

FIG. 2.—Bouldery till overlain by a basalt erratic in a cut on the Arm Valley Road.

PLATE II.






Cores from the Lemonthyme Penstock Line. 1. Interbedded carbonaceous clay, silt and sand. 2. Pebbly layer in interbedded mudstones and siltstones. 3. Interbedded varves, mudstones and siltstones. 4. and 5. Tillite. The numbers are 1 inch high.