https://doi.org/10.26749/rstpp.105.29

PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA, VOLUME 105

[*Manuscript received 3rd November, 1970*]

FOSSIL SHORELINES OF THE ULVERSTONE DISTRICT, TASMANIA

by

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ABSTRACT

The Ulverstone district covers part of the coastal lowlands of the North-West Coast district of Tasmania, centred upon the Leven River, some 12 miles west of the southernmost point on the Tasmanian shore of Bass Strait. A series of well marked older shorelines is found along and below the coastal escarpment. Included are shorelines at 110, 65, 45, 35, and 3 feet above mean higher high water mark, which, at Ulverstone, is 10 feet above State Datum. The highest shoreline is interpreted as representing a late high sea level of the Mindel-Riss Interglacial.

The 65 foot shoreline, the Ulverstone shoreline (45 feet) and the Glenhaven shoreline (35 feet) are interpreted as being Last Interglacial. The Glenhaven shoreline is associated with cobble material thought to be marine-redistributed glacifluvial material from the Forth river. It may constitute further evidence for two phases of Tasmanian glaciation.

The Brigadoon shoreline is thought not to require a rise in sea level to 3 feet to explain its morphology. Its age is interpreted as being Holocene. Benches on the sides of Buttons Creek and Claytons Rivulet are structural in origin, but fragments of valley fill terraces in the Leven valley are thought to be related to older shorelines. Parallels are drawn between landforms of the present coastline and landforms existing on fossil shorelines in the area and between fossil shorelines at Ulverstone and those elsewhere in Tasmania and King Island.

INTRODUCTION

The aim of this paper is to describe the form, and, where possible, the origin of the fossil shorelines in an area delimited by Claytons Bay in the east and the Three Sisters in the west. (See Figure 1). Detailed description of the morphology and sedimentology of the estuary and of the modern shoreline is reserved for future papers. Nomenclature used in this paper has the approval of the Nomenclature Board of Tasmania in part only. Reference to localities is made by the grid system of Zone Seven. Edwards (1941), Davies (1959) and Fish and Yaxley (1966) make passing reference to this district, and Davies (personal communication) has made a general reconnaissance of the area and a study of the Devonport Harbour to the east, but no significant work has yet been published on the geomorphology of the Ulverstone district.

Morphological Method

The writer accumulated hypsometric data from some 40 miles of levelling with dumpy level and theodolite and from published topographical maps. (Figure 3). All traverses were tied to bench marks based upon State Datum. Heights given in the text have been recalculated to height above mean higher high water mark at Ulverstone by subtracting 10 feet. The traverses were used to elucidate the system of marine terraces which exist below the old Pleistocene cliff line that truncates a dissected surface sloping from about 900 feet to about 250 feet. Far more traverses were completed than can possibly be included in the figures. However data derived from them are used to construct Figure 4.

Soil morphology

Careful observations were made of soil colours, textures and profile forms, using the key developed by Northcote (1965) in an attempt to differentiate between soils of the various terraces and slope deposits. 17 auger holes were put down to the depth of bedrock, cobble beds or the water table; 14 pits were dug and in addition to the recording of descriptive data in the field, 28 samples were collected for subsequent sedimentological analysis. Reference was also made to the diaries of the Municipal Clerk of Works which treat upon soil conditions relevant to the sewerage scheme. Since these data are very voluminous, reference will be made to them only where they appear to throw light on the age, morphology and/or genesis of the landform on which they are developed.

ABANDONED SEA CLIFFS

Location and Altitude

A scarp, generally in excess of 150 feet in height runs the full length of the study area at a distance between 50 yards and slightly over a mile from the modern coastline. Scarp slope elements vary between almost vertical and 9°30′, but are mostly less than 30°. The height of the base of the scarp is also variable between 3 feet above higher high water mark and about 55 feet, due to the truncation of parts of the fossil shorelines. Tests may also reveal strong positive correlations between increasing height of the base of the scarp and first, increasing thickness, age and degree of weathering of the wedge of detritus at the scarp foot, and secondly increasing distance from the coastline—that is, the width of the coastal terraces. Breaks in the cliff line occur only at the mouths of streams, where the scarp curves to follow the trend of the river course.

No clear distinctions between the morphology of valley sides and of abandoned marine cliffs were observed that could be ascribed to marine as opposed to fluvial agency. This may be due to the fact that, even as the sea has abandoned the cliff, the streams are aggrading their lower reaches so that the agents developing the slopes on valley sides and abandoned

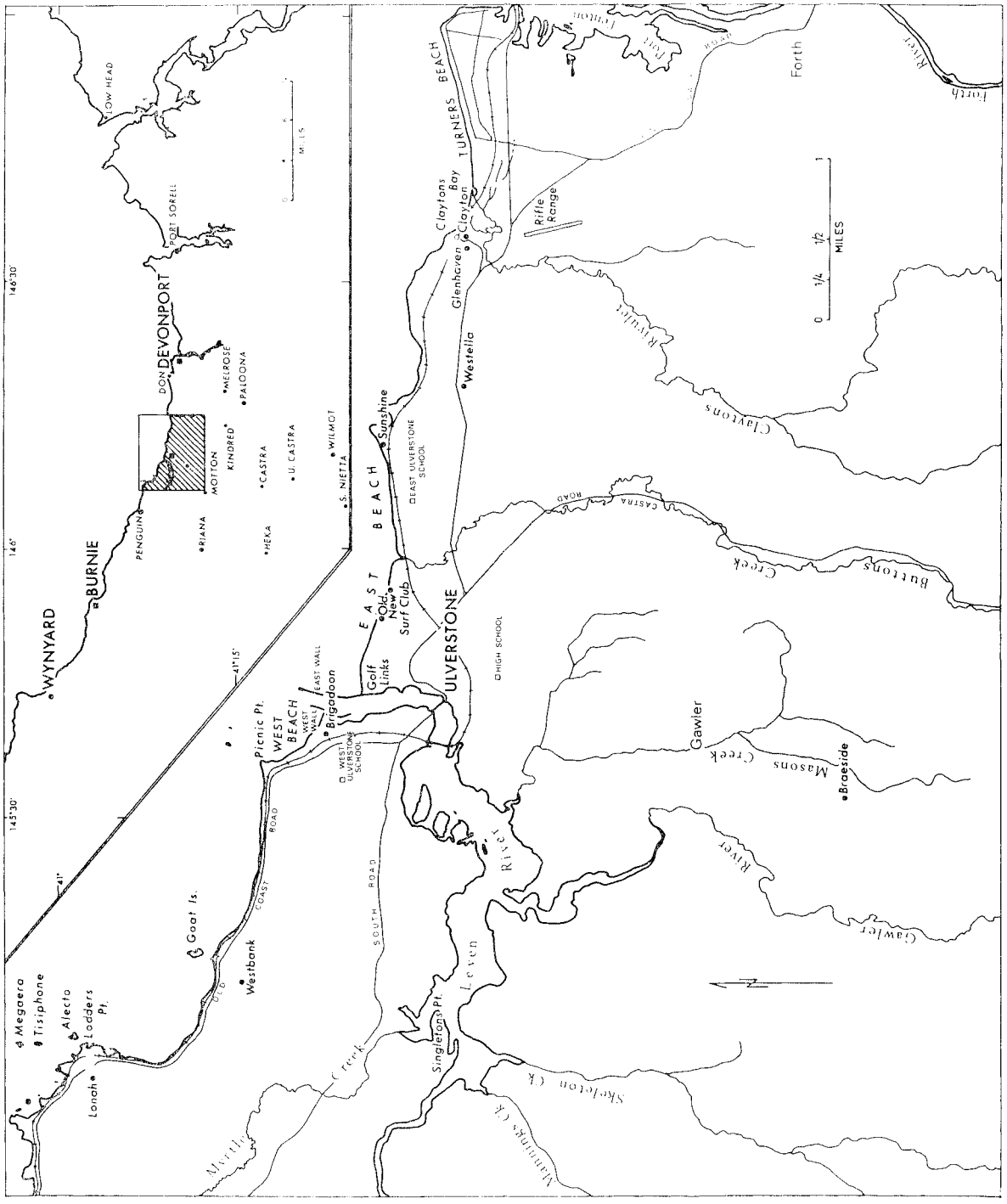

Fig. 1.—Location diagram.

marine cliffs have for some time been the same, viz. slope wash, surface creep, terracettes and slumping.

Mass movement

The efficacy of mass movement processes is due to the initial slope (variations in which are not ascertainable) and to the relative susceptibility of the rocks concerned. The more degraded scarps are found where the escarpment intersects a Tertiary deep lead such as that behind the old rifle range or just west of 'Westbank', where the heel of a landslip involving some 22 million cubic feet of material scallops the cliff line by some 200 yards. The bulbous toe spreads across the marine terraces below the cliff, to the sea's edge. The surface of the slide still preserves the reverse slopes diagnostic of rotational slip. This landslip clearly postdates recession of the sea from the cliff line. Other slides, such as that east of 'Westella', preserve scarce trace of such surface features and are clearly far older. Where man has sharpened the scarps, south of 'Lonah', and on Westbank Hill, rockfalls occur after heavy rain. Apart from very minor slumping on these landslips, there is very little evidence of active mass movement today.

The Clayton and Button Terraces

On the west bank of Claytons Rivulet at 198294 and on the east bank of Buttons Creek at 172275 are prominent valley side benches at 170 and 240 feet respectively. They are about 150 yards wide. There appears to be no clear evidence that these benches are matched by any other on the opposite bank of the streams, neither do they persist for more than about 3000 yards downstream, nor are their heights represented by any prominent level in the thalwegs of the streams, which are at or close to grade, or by any corresponding benches along the old marine cliffs. In each case, however, the bench represents a change in lithology from Tertiary rocks of the upper sequence of slope units to Precambrian garnet schist comprising the lower sequence. Similar arguments for lithological control may apply to a dissected bench at about 140 feet above the Gawler, southwest of 'Braeside', developed on Rocky Cape Group metasediments.

Narrow marine benches

The bench at about 110 feet along the side of the old marine cliff at West Ulverstone is developed across both basalt and (further west and rather less clearly) across Rocky Cape Group rocks. It is thought unlikely that a landslip could develop this bench, as it is far too long, narrow and uniform in height. Nor do slope angles on it seem typical of landslips on basalt. Landslips on basalt were observed to be either deeper and longer than their width or to consist of a confused, even chaotic, complex of movements along a broad hillslope zone. Landslips (as opposed to rock falls) were not noted at all in Precambrian rocks. No sediments were found on this bench other than a wedge of surface wash from the slope above.

The prominent bench at 55-65 feet in the township proper does have some sediments: grits, clays and silts, particularly towards Buttons Creek along the line of Castra Road. It is also represented at 'Lonah', perhaps by the summits of Goat Island, a ledge on Westbank Hill, and, rather more tentatively it is believed that South Road crosses a bench at the same height. Nowhere were the sediments found to bear much resemblance to marine sediments, though there is an unconfirmed report in the neighbourhood of shell beds at the east end of Leven Street.

The remaining surface features of the coastal zone consist of a flight of very gentle step-like features from 44 or 45 feet down to a pronounced scarp, the base of which is 3-4 feet and which varies from 3-8 feet in height. Three old shorelines can be distinguished within this altitudinal range on the bases of height, surface morphology and soil development.

THE ULVERSTONE SHORELINE

Even the existence of the sewerage scheme maps, contoured at 5 feet intervals and with tens of thousands of spot heights was of little use in distinguishing the fine detail of the surface morphology of the terrace system within the town area, particularly where home and street development are concentrated. Careful observation after heavy rain was more useful, enabling the writer to pick out the swales of lower relief and waterlogging from the intervening swells.

The Ulverstone terrace is defined to be the almost featureless surface below the Ulverstone shoreline which is at 45 feet. (See Figure 6). An almost imperceptible swale, parallel to the line of the hill behind runs towards Buttons Creek in the east and Masons Creek in the west, the latter section being better developed along Alexander Street. There are possibly two parallel swells. East of Buttons Creek the terrace continues as far as 'Westella' where it pinches out. The terrace is not entirely depositional in character as the house west of 'Westella' at 179309 is built on a basalt bench which stands at 40 feet, 1.5 feet above the sandy terrain. Trenching during the implementation of the sewerage scheme revealed a variable A horizon of bleached grey fine sand, underlain by a pronounced hardpan of coffee rock, up to 20 feet thick, which is so indurated that it required blasting in places. This is underlain by flowing sand, shell or shingle beds at depth, except near Buttons Creek where the proportion of clay increases markedly.

THE GLENHAVEN SHORELINE

The Glenhaven shoreline is at 35 feet. To seawards is a system of from 3-9 parallel to semi-parallel fossil dune ridges and intervening swales which lie below 35 feet in the main and terminate seawards at the scarp backing the Brigadoon beach ridge system. East of 'Westella', only a narrow strip of land lies above 35 feet between the Glenhaven fossil dunes and the old cliff line. It consists of a mixture of slope wash and marine terrace material, often with basalt floaters. Since it lacks both the soils and the morphology typical of the Ulverstone Terrace it is here considered to be associated with the Glenhaven Shoreline.

Post Glenhaven shoreline depositional landforms are narrowest southwest of Goat Island, where there is no fossil dune development, merely a narrow raised beach of coarse to medium texture grey sand. Between Westbank Hill and Picnic Point seawards of the Glenhaven shoreline are three sub-parallel fossil dune ridges with intervening raised beach sediments, lying thinly over reefs of Precambrian and Cambrian rocks at a higher

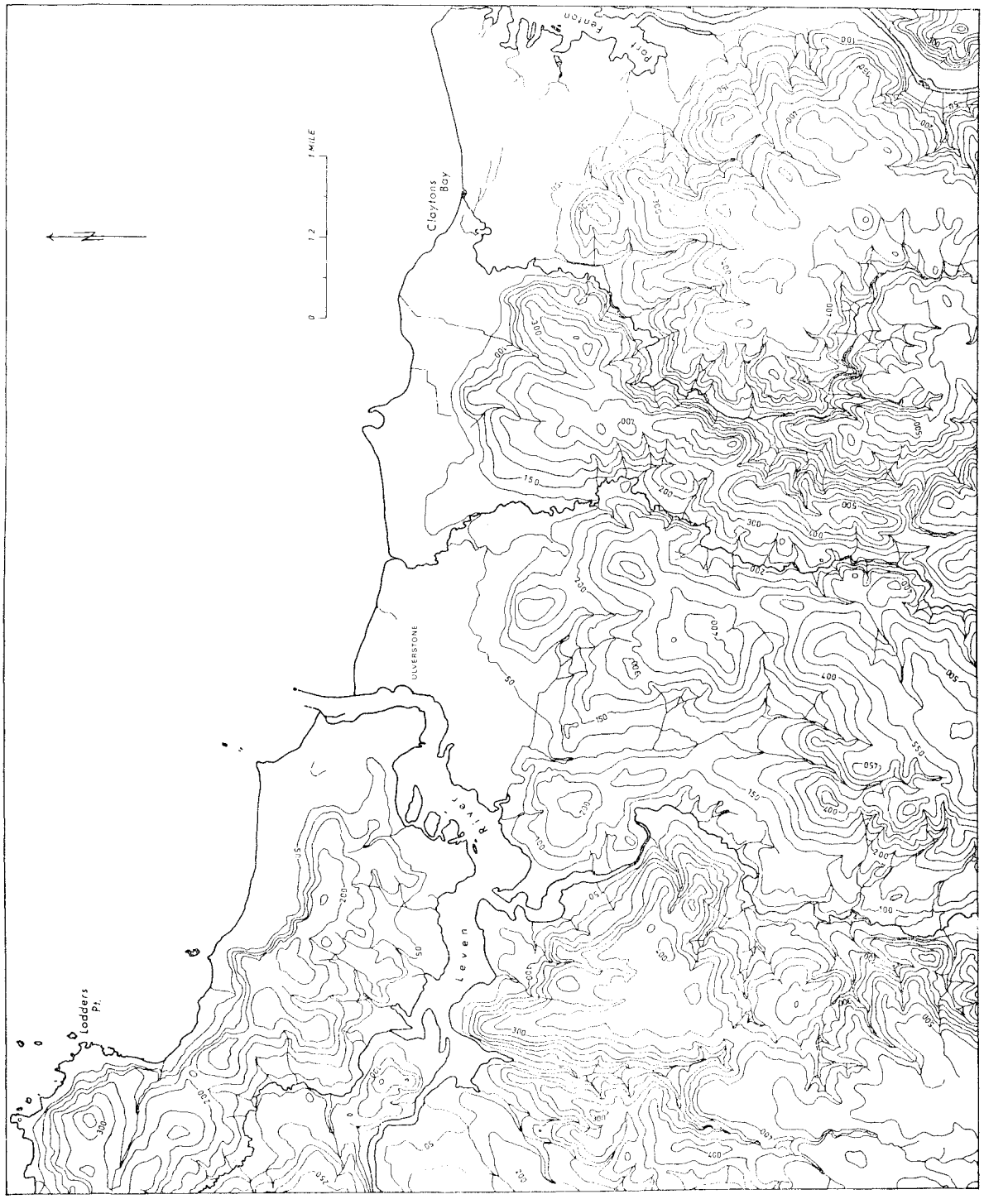

Fig. 2.—Contour map of the Ulverstone district, Contour interval = 50 feet. Datum = State Datum.

level than the reefs of the modern shoreline, but at approximately the same slope angle. In several places the reefs project through the dune and raised beach sediments, and there are numerous floaters of locally derived angular pebbles and boulders—features also typical of the beach immediately seawards. Towards Picnic Point the surface below the Glenhaven shoreline becomes more step-like, with raised basalt shore platforms at 25 feet.

The alignment of the fossil dunes between Westbank Hill and Picnic Point is sub-parallel to the cliff line. The dunes are closer together at the western end, where they consist largely of conglomerate pebbles of local origin, but become more widely spaced and sandier towards the east. This is the same disposition as the dunes of the modern coastline and of the fossil dunes in the type locality of the Glenhaven shoreline between 'Clayton' and 'Westella'. The basalt hill at 'Westella' acts as a fulcrum for the alignment of five of the fossil dunes. Figure 6 shows how the inner dune (30.58 feet) lies east-west, but that the fourth, which terminates at 'Glenhaven' and the fifth, which terminates at 'Clayton' have alignments parallel to the frontal dune of Turners Beach, and for the same reasons.

These five dunes are composed of sediments of two kinds. Surface layers are sandy, but at depth (surficial in the case of the inner dunes) there are cobbles. These are not of local origin. Their presence here and elsewhere along the coast constitutes a problem for which a solution is suggested at the conclusion of this paper.

With each successive dune, the height decreases coastwards, the length of the landform increases, alignment swings more towards facing the west and the proportion of sand to cobbles increases until the outer (cliffed) dune is composed almost entirely of sand with cobbles revealed only in trenches at 198309 and in pits dug along the line of the dune. The four remaining dunes of this system lie parallel to the fifth just described and are gentle swells abutting onto a stepped raised basalt shore platform at 15-25 feet northeast of 'Westella'. Their surface morphology is much disturbed by cultivation.

Within the built-up area of the town proper, between the Glenhaven shoreline and the Brigadoon shoreline is a maximum width of 600 yards. Between the Leven and 'Sunshine' the disposition of the Glenhaven shoreline fossil dunes is difficult to determine owing to human interference, but there appear to be five ridges west of Buttons Creek and three east of the creek, pivoting southeastwards from the raised basalt shore platform (30.88 feet) at 177314. The influence of Buttons Creek upon this flight of dunes can be seen in Figure 6 on which prior outfalls are marked. The composition of some of these dunes shows the possibility of Buttons Creek having once terminated in a barrier lagoon.

The age of the Ulverstone and Glenhaven shorelines

The Tertiary/Quaternary boundary is not ascertainable in the absence of datable deposits, but the dissection of the Lower Coastal Surface (Davies, 1959) appears to have been a Pleistocene event, initiated at least in part by changes in the level of the sea with respect to the land. The dissection involved the incision by streams to depths of several hundred feet below the level of the surface. (Figure 2). The present landscape may be described as one with gently rounded interfluves and V shaped valleys which for the most part are graded to the present sea level. Some sections of the valleys are alluviated and there are depositional terraces above the Leven which, in terms of height above the river, correspond to the Ulverstone and Glenhaven shorelines. This implies, but does not prove, that the rivers were earlier graded to these shorelines.

The work of Jennings (1959) on King Island has established a sequence of shorelines very comparable with those of this study area. He assigns those shorelines within the range of 20 to 65 feet above M.H.W. Springs to the Last Interglacial on the grounds of morphology and soil development and a comparison with coastal terraces in other parts of the world. The contrasts in morphology and soil development noted by him apply closely to the Ulverstone situation except for the absence in this study area of transgressive dunes. Gill and Banks (1956) provide Upper Pleistocene dates for deposits of comparable morphology and height in the Smithton area. In the absence of datable deposits from the Ulverstone area, if one accepts the interpretation of an Upper Pleistocene age for the Ulverstone strandlines within the range 20-65 feet above M.H.H.W., then the 110 feet shoreline may be older than Last Interglacial or may represent an early interstadial within the Last Interglacial. The former is much more likely.

Gill (1961 and 1964) and Ward and Jessup (1965) find shorelines at heights similar to those mentioned above in Victoria and South Australia, though there the picture is complicated by neotectonic activity. There are no known post-palaeozoic faults in the Ulverstone district west of the Don Heads (Burns, 1964). None of the shorelines at Ulverstone shows height variations other than those expectable in terms of variation in exposure to marine processes and subsequent erosion. In the absence of any positive evidence to the contrary, the Ulverstone coast is considered to have been tectonically stable with respect to east-west vertical movements. Movement normal to the coast cannot be discounted, but this is likely to have been downwarping towards the Bassian Depression rather than the repeated uplift indicated by the existence of raised lagoons, shore platforms and fossil dunes that repeat the alignment of the present coast. The sum of the evidence indicates that the old shorelines are Last Interglacial in age and older, and are due to Pleistocene glacio-eustatic changes in the level of the sea with respect to the land rather than due to tectonic changes in the level of the land with respect to the sea.

THE BRIGADOON SHORELINE

The mean of 32 measurements of the height of the base of the scarp falling from the Glenhaven terrace dunes at West Ulverstone is 3.23 feet, with a standard error of 0.09 feet. 18 measurements along the scarp base behind East Beach yield a mean of 3.93 feet with $SE_m = 0.06$ feet. The single reading of 4.50 feet for the back of the pebble beds at Lodders Point agrees with the mean of 13 measurements of the scarp foot between 'Sunshine' and 'Clayton', which is 4.53 feet, with $SE_m = 0.13$ feet. In terms of the standard Ulverstone datum, these values are between 3.23 and 4.53 feet above mean higher high water, and show an in-

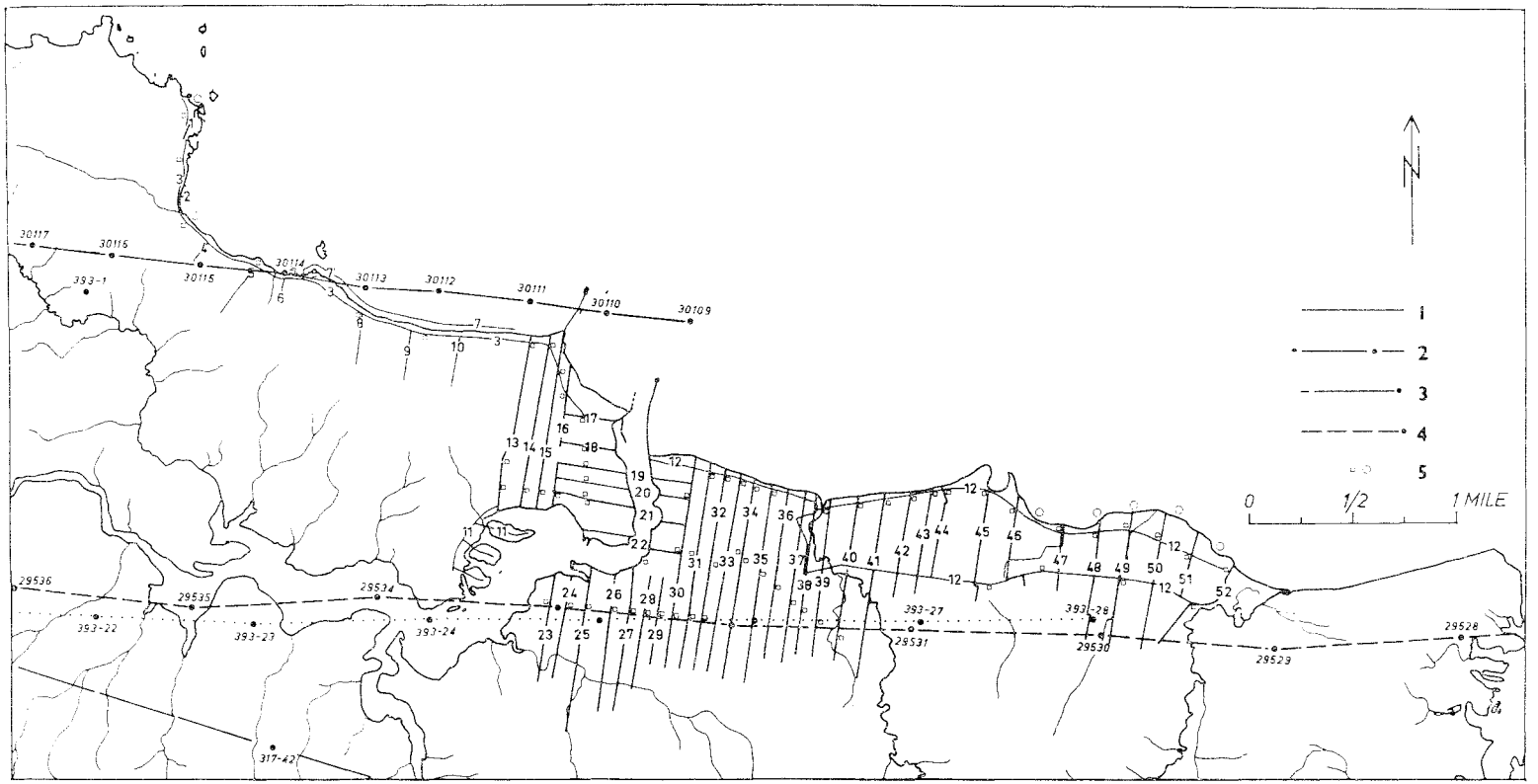

Fig. 3.—Ground survey lines and aerial photography.

1. Line of ground survey by level and theodolite.
2. Photo series of 1945: (6,750 feet) 20 chains to 1 inch.
3. Photo series of 1956: (20,000 feet) 40 chains to 1 inch.
4. Photo series of 1964: (7,500 feet) 20 chains to 1 inch.
5. Bench marks (Railways Department, State Permanent Marks, Ulverstone Municipality and temporary bench marks put in by the writer). Datum = State Datum. Circles show sample sites listed in the Table.

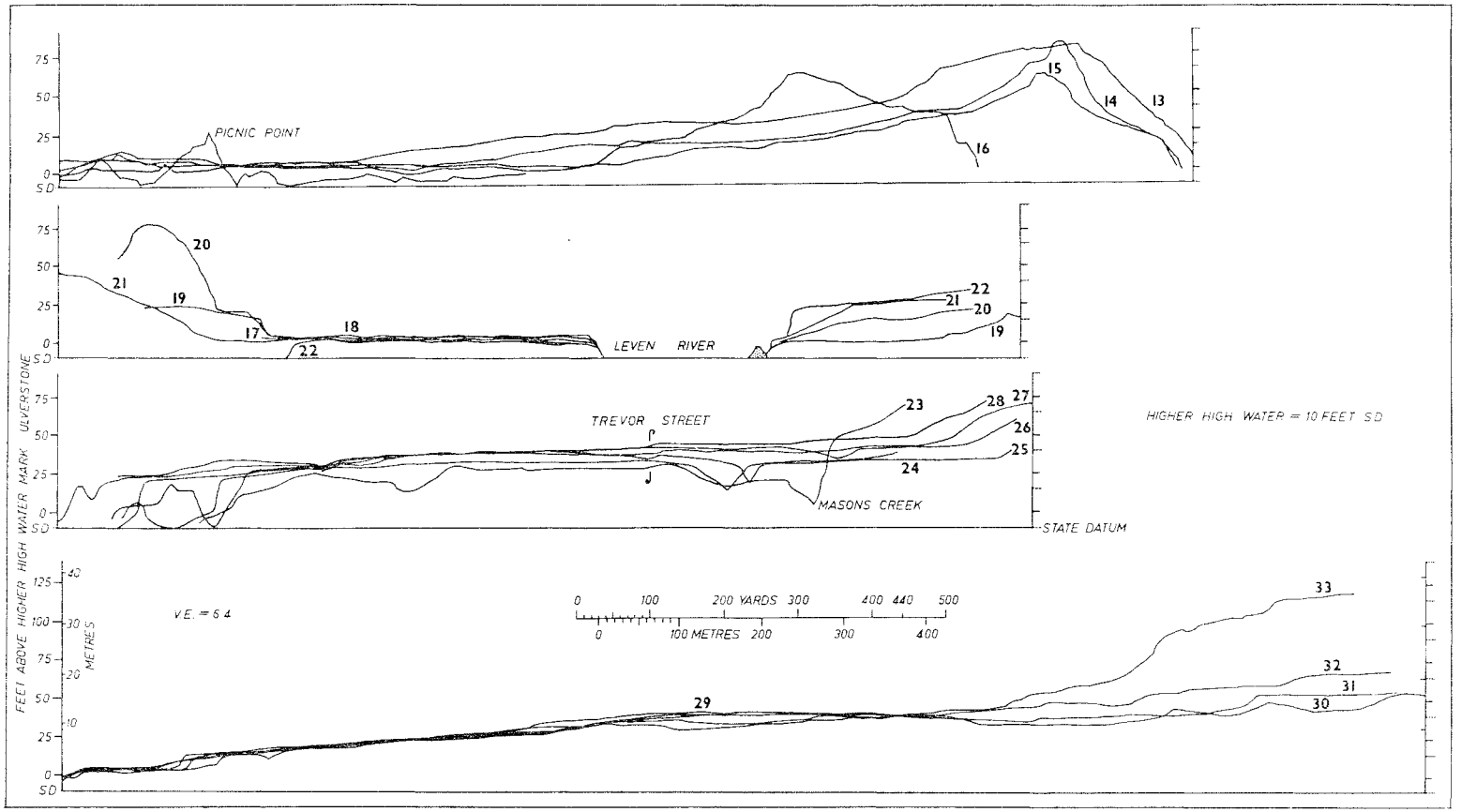

Fig. 4.—Survey traverses (see Figure 3 for location).

a. 13-16, West Ulverstone
b. 17-22, Leven River mouth
c. 23-28, aligned to Trevor Street
d. 29-33, centre of township

Heights are given in feet and metres above mean higher high water mark, and also in feet above State Datum.

crease of 1.3 feet from the sheltered parts of the coast between Picnic Point and the estuary and the more exposed environments. On taking these local variations in exposure into account, the Brigadoon shoreline can be considered to be about 3.25 feet above the present mean upper still water level.

At Lodders Point the sediments are being eroded at the back of the east facing storm beach, though the beach facing north appears to be either static or prograding. At the back of the main beach an auger hole was put down through the dune to the level of cobbles. The dune sediments were without any carbonate material even though the modern beach only a few feet lower was rather shelly. The material near 'Brigadoon' is also leached sand, boreholes having reached to —23 feet (14 feet below mean low water springs) in 1961, with sand all the way. The surface consists of a series of low ridges increasing in height towards West Beach. East of the Leven, the proportion of cobbles to sand increases until, east of 'Sunshine', post-Brigadoon deposition consists of a descending series of pebble ridges, though, at 194314, a sand dune behind a cobble beach which has no local source of sand is also carbonate free even though exhibiting scarcely any profile development. Dunes just behind the foredune at Picnic Point have a more developed soil profile.

The Brigadoon shoreline, at 3-5 feet above M.H.H.W.M. is regarded as Holocene in age and may mark the upper limit of the postglacial marine transgression. Davies (1959a and 1961) has identified a postglacial shoreline at 5-6 feet above H.W.M. along the North-West Coast of Tasmania which he correlated with a shoreline at 2-3 feet above H.W.M. in southeastern Tasmania. This is the Milford shoreline which he believed to relate to a postglacial higher sea level. The Brigadoon shoreline appears to be a correlate of the Milford shoreline. However, the present extreme upper limit of wave action at Lodders Point and on Alecto is 6 feet above M.H.H.W. Thus the status of the Brigadoon shoreline at Ulverstone as a raised shoreline in the sense of a fall in sea level since its formation is not unchallengeable. Davies (1961) claimed that Tasmanian beach ridge systems such as those at Ulverstone were built during a fall in sea level, but Hails (1965) is a critical review of eastern Australian (but not Tasmanian) evidence stated that much data, particularly that based on deposits, postulating postglacial higher sea levels, is equivocal. This appears true for Ulverstone.

Nowhere could the Brigadoon shoreline be seen to be strictly rock cut. On exposed parts of the coast between 'Sunshine' and 'Clayton' most of the Brigadoon shoreline is cut into post-Glenhaven shoreline dunes. Behind East Beach, raised lagoon deposits and dunes are cut back, while at 'Brigadoon' itself, the scarp is cut into Last Interglacial deposits with postglacial deposits at the scarp foot. The same is true east and west of Goat Island and at Lodders Point where the rock scarp foot is covered with cobbles. A large excavation would be needed to find the bedrock base.

Where the Brigadoon shoreline is highest above M.H.H.W.M., the shoreline is most exposed and there are wave-built ridges of cobbles and pebbles, materials which can be thrown above high water mark. (The windows of 'Clayton' have been shattered by storm-flung pebbles). At the more sheltered site at West Beach, the initial cutting of the scarp into the post-Glenhaven shoreline sediments is believed to have occurred prior to the establishment of the wave-built river-mouth bar.

The morphology of the post-Brigadoon shoreline deposits can be explained by initial rapid sedimentation followed by a gradual reduction in the rate of delivery of material to the coast, especially from offshore after a stable sea level had been reached. Differences in height between the Milford and Brigadoon shorelines are possibly a function of tidal range. It does not appear to be necessary to invoke sea level change to explain the morphology of the Brigadoon shoreline.

THE PROBLEM OF THE COBBLES

Cobble and pebble material is rare on Tasmanian beaches. Four possible origins may be suggested for it: it may be derived locally from rocks along the present coast; it may have been quarried from the sea floor or delivered to the coast by rivers and then redistributed by marine processes; or it may have been recycled following the erosion of prior marine terrace deposits.

Davies (1961 and 1965) suggested that the presence of cobbles and pebbles on the beaches associated with the mouths of the Forth and Mersey rivers is attributable to the function of these streams as glacial meltwater outlets in the late Pleistocene. The glacifluvial valley trains of these streams contain material of the same lithologies as are found as exotic pebbles on the Ulverstone coastline in pebble beaches and storm ridge systems between Lodders Point and Claytons Bay, and again eastwards to Pardoe Beach. The lithology of nine samples, each of over 300 beach pebbles, is given in the table below. Material not of immediately local origin is given in italics.

The cobbles found as raised storm ridges, capped by sand, associated with the Glenhaven shoreline, have already been mentioned. They too are not of local origin. The country rocks behind the site of the Glenhaven fossil dunes and ridges are Tertiary basalts above garnet schists and quartzites of the Precambrian Forth Metamorphics. The cobbles, however, include basal Ordovician greywackes and conglomerates, very variable Cambrian dacitic volcanics, gabbro, jasper and chert, and several types of Precambrian quartzites, none of which is found in the coastal bedrock nor in the catchment of Claytons Rivulet, but which do outcrop in the catchment of the Forth river. Cobbles of the same lithologies are also found across the Clayton on the old rifle range at 40 feet, and on parts of the higher terraces associated with the mouth of the Forth River. At shallow depth the sandy matrix is well cemented.

If one accepts a Last Interglacial age for the post-Glenhaven shoreline terrace sediments on the ground of comparability of altitude, morphology and soil development with those described by Gill and Banks (1956) and Jennings (1959), then the implication is that this material was delivered to the shore when the Forth was an outlet for glacial meltwater, and that it was redistributed when the sea level was at a height acknow-

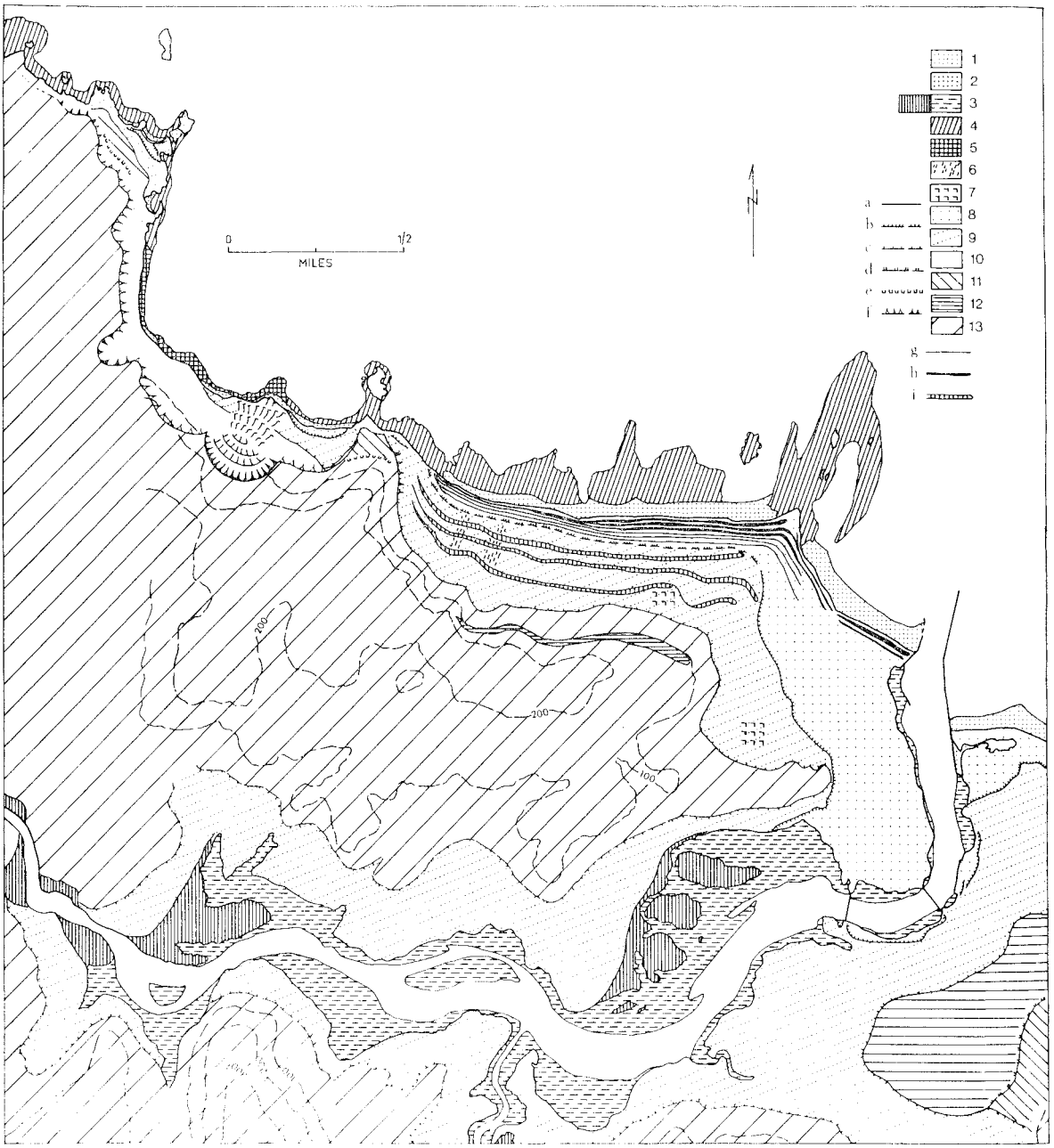

Fig. 5.—Landforms west of the Leven River mouth.

1. Sand beach sediments
2. Cobble beach sediments
3. Salt marshes; sand and mud flats
4. Reefs and platforms on Palaeozoic rocks
5. Platforms on Tertiary basalt
6. Raised platforms on Palaeozoic rocks
7. Post-Brigadoon shoreline surface (sandy)
8. Post-Brigadoon shoreline surface (cobbly)
9. Post-Glenhaven shoreline surface
10. Post-Ulverstone shoreline surface
11. Higher marine bench (55-65 feet)
12. Higher marine bench (110 feet)
13. Lower Coastal Surface and scarps
    a. Modern shoreline
    b. Brigadoon shoreline
    c. Glenhaven shoreline
    d. Ulverstone shoreline
    e. 55 feet to 65 feet shoreline
    f. Scarp; landslips
    g. Beach ridges
    h. Dune
    i. Fossil dune

ledged to be, for tectonically underformed areas of Southeastern Australia and Tasmania, of Last Interglacial age. Paterson (1965) and Paterson, Duigan and Joplin (1967) have suggested two glacial phases for the Forth River system on stratigraphic, petrological and palynological evidence from Lemonthyme Creek. Although categorical proof of this claim cannot be made from this coastal geomorphology, or even perhaps from a stratigraphy and palaeontology of the coastal deposits, the distribution and disposition of the cobbles do suggest two lines of thought. First that the raised cobble deposits are glacifluvial outwash from an earlier glacial phase, deposited in part as river mouth terraces and in part as storm ridges, and secondly that the cobbles of the modern shoreline are probably mostly marine redistributed glacifluvial material of the last glaciation. An unknown proportion of the postglacial deposits is thought to have been recycled from the raised deposits as evidenced by the incision of the Forth into its old river mouth terraces and the cliffing of the Glenhaven terrace deposits during the formation of the Brigadoon shoreline.

TABLE: PEBBLE LITHOLOGY (PERCENT)

	SAMPLE SITES								
	Lodders Point	½ mile west of Goat Island	220 yards west of Goat Island	220 yards east of Goat Island	Coast, north of 'Westella'	500 yards east of 'Westella'	Midway between 'Sunshine' & 'Clayton'	700 yards west of 'Clayton'	Coast, north of 'Glenhaven'
PRECAMBRIAN									
Ulverstone Conglomerate		0.8	0.6	42.1					
Quartzite	*19.1*	22.7	3.6		*70.2*	*57.5*	*36.3*	*14.9*	*17.9*
Rocky Cape Sandstone			8.4	50.0					
Garnet schist						0.6			6.0
Phyllite		0.8							
Purple Quartzite					*2.0*				
Aventurine					*0.5*				
CAMBRIAN									
Chert	47.5	9.2	18.0	*3.7*	*2.9*		*0.7*		
Chert breccia	5.7					*0.6*			
Greywacke		5.8							
Mudstone	14.9								
Spilite	8.5	2.5							
Dacite					*7.8*	*4.0*		*1.5*	*2.4*
Jasper	0.7						*0.7*		
Vein Quartz	0.7	0.8	3.6		*2.9*		*0.7*		
ORDOVICIAN									
Basal greywacke and conglomerate	*1.4*		*1.8*	*1.1*	*3.9*	*2.9*	*3.0*	*4.1*	*4.4*
TERTIARY									
Limonite	1.4		1.2						
Basalt		2.5	62.9	3.2	9.3	34.5	57.8	78.5	71.4
Amygdaloidal basalt		54.6			0.5	0.6		1.7	

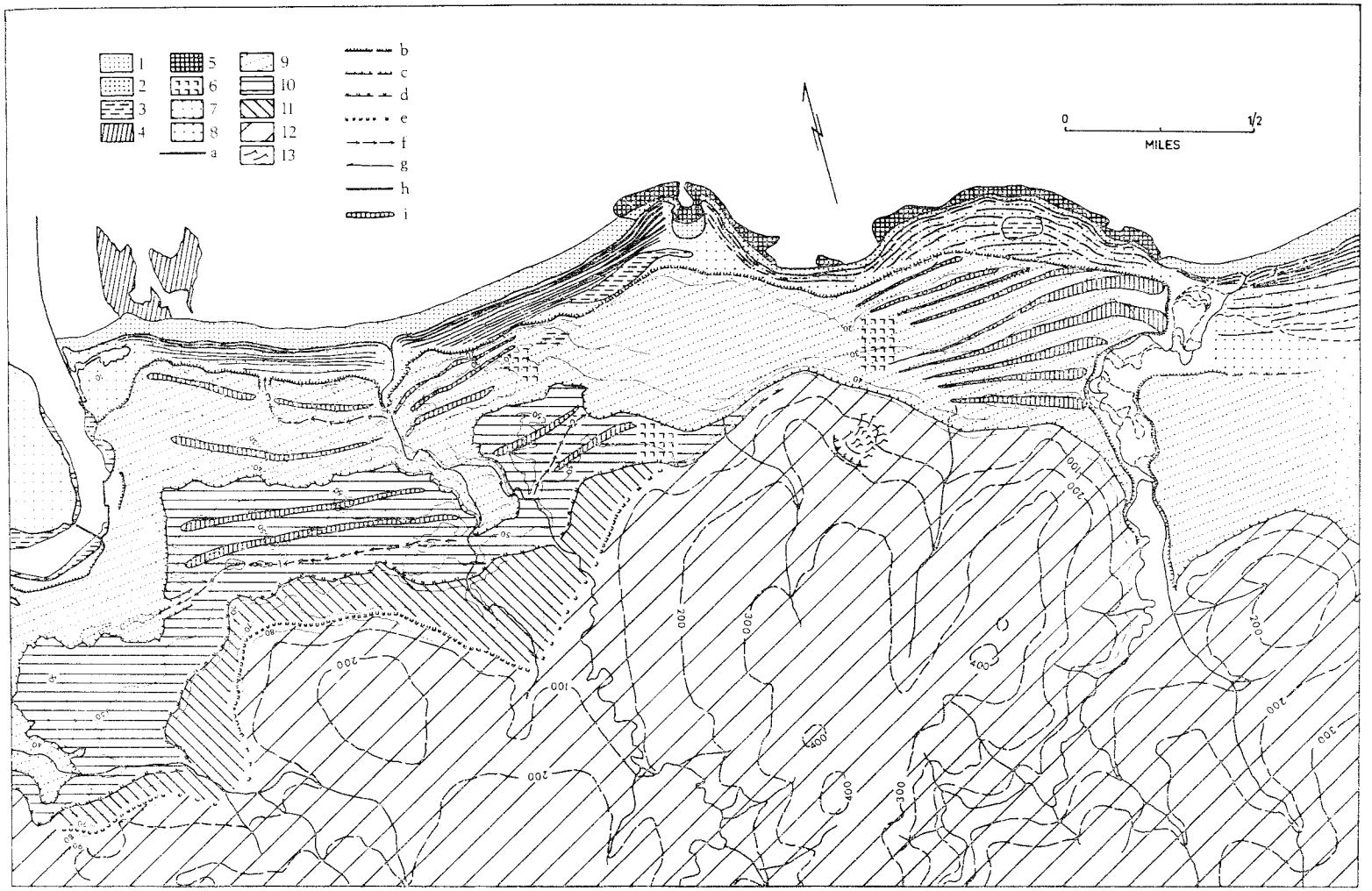

Fig. 6.—Landforms east of the Leven River mouth.

1. Sand beach sediments
2. Cobble beach sediments
3. Sand and mud flats, swampy.
4. Reefs and platforms on Palaeozoic rocks
5. Platforms on Tertiary basalt
6. Raised platforms on Tertiary basalt
7. Post-Brigadoon shoreline surface (sandy)
8. Post-Brigadoon shoreline surface (cobbly)
9. Post-Glenhaven shoreline surface
10. Post-Ulverstone shoreline surface
11. Higher marine bench (55 feet to 65 feet)
12. Lower Coastal Surface and scarps
13. Landslips
    a. Modern shoreline
    b. Brigadoon shoreline
    c. Glenhaven shoreline
    d. Ulverstone shoreline
    e. 55 feet to 65 feet shoreline
    f. Prior stream courses
    g. Beach ridges
    h. Dune
    i. Fossil dune

ACKNOWLEDGMENTS

I wish to express my gratitude to the many people without whose help and co-operation this study would never have materialized. Special thanks are due to Dr J. L. Davies, Reader in Geography, who provided financial security in the form of a part-time research assistantship, and gave so much helpful advice and criticism. There were many fruitful discussions with Mr A. Goede, Lecturer in Geography and Mr G. van de Geer, the department's cartographer. Mr M. R. Banks, Reader in Geology and Dr J. A. Beattie, Senior Lecturer in Soil Science excited the writers' interest in sedimentology and pedology respectively. I am very grateful to many friends in the Ulverstone district, particularly my uncle and aunt, Mr and Mrs T. K. Wilson of 'Clayton', and also my students: John Hensby, John French, John Eaton and Graeme Marshall, who gave happy and tireless help in the field.

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