Chapter 7 The strata underlying the Drift of the Northern Plain

Historical and general

The opinion had long been entertained by geologists that rocks of Carboniferous age were likely to exist beneath the drift-covered northern plain of the Island. Thus, in 1848 Cumming remarked, " it is very reasonable to conclude that the basset edge, both of it [*i.e.,* of the Peel Sandstone] and of the different beds of the superior limestone, curves round to the northwards and passes under the northern area of the Isle of Man "; and he even suggested that borings should be made to seek the limestone which he thought might occur at from 60 to 100 feet below the surface along the northern edge of the Curragh. To this suggestion he added the following foot-note: "In the year 1839 borings were made for coal at the Craig near St. Jude's Church; the following is stated to have been the result; 5 feet sand, 27 feet blue marl, 2 feet gravel, 27 feet blue marl, and then sand. The boring was not proceeded with any deeper".<ref>"Isle of Man", p. 210.</ref> Again, in an editorial note in the reprint for the Manx Society of Sacheverell's "Account of the Isle of Man " (Douglas, 1859), in discussing the probability of the occurrence of coal, Cumming stated that it was " just possible, though far from probable", that some of the higher portions of the Carboniferous series might underlie the northern plain: (p. 17 of reprint). The same conjecture was made by Mr. J. D. Kendall in 1883, in discussing the westward submarine extension of the Whitehaven Coalfield.<ref>"The Structure of the Cumb.lrland Coalfield", Trans. N. of Eng. Instit. of Min. Engineers, vol. xxxii., p. 356.</ref>

Besides the Craig boring mentioned by Cumming, other attempts to find coal seem to have been made in the plain about the middle of last century (see p. 558); and one of these, in the vicinity of Cranstal, is reported to have reached'the base of the drifts. But it was not until 1891, when Messrs. Craine Bros. of Liverpool commenced the systematic exploration of the northern extremity of the Island, that any definite information regarding the buried rock-platform was forthcoming. The first descriptions of their investigations were published by Prof. W. Boyd Dawkins in 1894 and 1895,<ref>Trans. Manchester Geol. Soc., vol. xxii., pt. xxi., and vol. xxiii., pt. vi.; also in Report British Assoc. for 1894, p. 662, and for 1896, p. 776; and in Colliery Guardian, vol. lxix., p. 414.</ref> who gave the record of three borings which had been carried down into the solid rocks; and the details of a fourth boring were made known in 1896, by Mr. John Todd, the engineer in charge of the operations.<ref>Yn Lioar Manninagh, vol. iii., pt. ii., pp. 65–72.</ref> Since that time two additional borings have been completed (Nos. 5 and 6); and through the courtesy of Messrs. Craine Bros., we are enabled to include a full description of these in the following pages<ref>Prof. Boyd Dawkins has included an account of the last two borings in his recent papers. (See postscript on p. 279.)</ref>. Besides confirming the forecast as to the Lower Carboniferous rocks, these borings have likewise proved the existence of Triassic and Permian strata, hitherto scarcely suspected, within the limits of the Island. (See also Postscript to last chapter, p. 279.)

The recent borings have all been made upon the extreme northern margin of the drift-covered plain; and there lies to the southward a space ranging in breadth from 4¾ miles on the west to 7 miles on the east, with a superficial area of over 40 square miles, in which no direct evidence as to the solid geology is at present forthcoming. On the geological map as published, a conjectural representation of the geology of this tract has been attempted, from general considerations, as subsequently explained (p. 294); but this can be, at the best, only approximately correct. The uncertainty . is rendered the greater since there is a possibility that Devonian and Silurian rocks as yet unknown in the Island, may crop out under the drift between the Lower Carboniferous beds of the borings and the hilly slope of the Manx Slates. This point will be further discussed in a later part of the present chapter.

Description of the deep borings

The sites of the six borings already sunk are shown on the ground-plan on p. 283, (Figure 79); all except No. 6 are also indicated on the published one-inch geological map.. The numeration is that adopted by the proprietors, and follows the order in which the borings were made. It will be more convenient, however, to describe them in their geographical sequence from west to east, as we shall then pursue the upward succession of the solid rocks, which were entered at higher stratigraphical horizons by each boring consecutively in this direction. Through the kindness of Messrs. Craine Bros., and of Mr. J. Todd, the resident engineer, the writer was enabled to examine, while the work was in progress, the

whole of the cores in their possession, and to select a typical series for the Survey Collection. The following descriptions of the sections are based on notes made during these examinations. The complete journals of the borings are printed in Appendix III., p. 578.

The glacial deposits passed through in the borings are more fully described in Chapter 9., p. 340 and XI., p. 418.

No. 3 — The Lhen Mooar Boring

[NX 38280 01885]. Summary of section (See also Appendix 3, p. 580)

	Feet	inches
Sand and Gravel, probably Raised Beach	12	0
Glacial drift; sand, gravel and silt	155	6
Carboniferous Limestone	66	10
Total depth	234	4

Further description — This, the most southerly as well as the most westerly of the borings, had its site on the Raised Beach only 10 or 15 feet above high-tide level, and 50 yards from high water-mark, on the north-western coast of the Island, 470 yards N.N.E. of the bridge at Lhen Mooar.

We have no definite information as to the character of the drifts, as the boring had been completed before our visit, and specimens of the drift-deposits had not been preserved. The apparent absence of boulder-clay is singular, though in all the borings the proportion of sand and gravel to boulder-clay is greater in the drifts of these sections than in the average cliff-sections.

The rock-floor was found at within a few feet of the same depth in this boring as in borings No. 2 and No. 4, but at a less depth than in those to the eastward of No. 4. That it represents a plane of marine denudation is clearly indicated by the regularity with which it cuts such diverse rocks *as the limestone of the present boring and the Triassic Sandstone of borings Nos. 2 and 4.

The Carboniferous Limestone, as shown by the cores, was throughout much crumpled and disturbed, dipping at an angle of 40° or more. It contained many calcite veins and cavities, and varied in colour from dark blue to palish grey. It abounded in fragments of encrinites, which were the only fossils recognised. It appeared to be more massive and less interrupted by shale partings than the Lower Limestone of the south of the Island, and less fossiliferous than the Poolvash Limestone.

No. 2 — The Ballawhane Boring

[NX 39284 02429]. Summary of section (See also Appendix 3, p. 579).

	Feet	Inches
Raised Beach; sand and gravel	16	0
Glacial Drift; sand, clay and silt (see p. 421).	155	0
St. Bees Sandstone (Triassic) passing downwards into	371	0
Lower Red Marls (Permian)	33	4
Lower Carboniferous Series, consisting of—		

Stained limestone with encrinites, much shattered at the top	3	6		
Hard mottled blue grit	0	9		
Limestone	2	0		
Purple sandstone and shale, more or less calcareous, with bands of stained encrinital limestone	98	10		
passing down into Thicker beds of pale encrinital limestone, with gritty and shaly partings in the upper part	37	11		
			143	0
Total depth			718	4

Further description — This bore-hole is on the narrow strip of Raised Beach on the western side of Blue Point, 70 yards from high-water mark and 1,300 yards to the north-eastward of No. 3, and at the same elevation above the sea as that boring.

The drift had been penetrated before my first visit and the material had not been kept (see p. 421). The St. Bees Sandstone resembles in all respects that of Cumberland, being a rather fine grained somewhat micaceous unfossiliferous sandstone, of brightish red colour mottled and streaked in places with greenish grey, interlaminated with thin partings of marl. These manly intercalations increase in thickness towards the base of the sandstone, thus giving a gradual passage into the Lower Marls, which again resemble those of the coast near Whitehaven except in the comparative rarity of gypsum, of which only a few thin streaks were encountered. These rocks possessed throughout a gentle dip of from 5 to 10 degrees, and showed no signs of disturbance except within a short distance of the base of the marls, where there was much slickensides, especially just above the sudden junction with the highly disturbed Carboniferous rocks.

The condition of the cores immediately at the base of the marl and at the top of the Carboniferous rocks indicated that the junction was almost certainly a line of fault. The effect of this fault is apparently to let down the Triassic and Permian rocks on the east against the Lower Carboniferous rocks on the west, thus causing the wide difference between the rocks of this boring and of the last. The fault appears to have been struck at such a level in the boring as to cut out the lowermost portion of the Permian strata from the section, so that the Brockram so well represented in borings farther eastward is not found here. The magnitude of the fault is probably considerable judging from the thickness of the Triassic Rocks at this place on the one hand, and from the absence of staining in the Carboniferous Limestone of No. 3 [NX 38280 01885]. Boring on the other hand, the latter fact indicating an uplift of the Carboniferous rocks to the westward sufficiently great to have carried the stained strata which must originally have underlain the Red Rocks (see p. 286) above the present plane of the denuded rock-surface. The direction of the fault can only be conjectured; on general considerations, it may be supposed to strike from some point between north and west to some point between south and east (see p. 294); and as no fault of magnitude has been detected in the Manx Slates anywhere to the southward a southeasterly course has been adopted for it on the map.

We have previously referred to the account of this boring published by Prof. Dawkins, in which the Red Marls for 33 ft. 4 in. above the fault and the Carboniferous rocks for 101 ft. 11 in. below it are combined under the heading of *"Permian Rocks of the Stack Series".*<ref>Trans. Manchester Geol. Soc., vol. xxiii., pt. vi.</ref> As already stated, Professor Dawkins has now abandoned this reading, and grants that Lower Carboniferous rocks set in immediately below the Red Marls at a depth of 575 feet below the surface and are continuous thence to the bottom, and that no rocks comparable to the Peel Series occur in the boring. The supposed conglomerates and breccias mentioned in his account are bands of Carboniferous limestone disturbed by Pre-Permian earth-movement and afterwards partly brecciated in the vicinity of the

fault: they are stained by the Red Rockg, partly dolomitised, and frequently veined with haematite. The Lower Carboniferous beds of which these bands form part include purple-stained sandstone and shale, alternating with limestone-bands generally full of encrinite-stems. The uppermost calcareous band occurs immediately below the Red Marls, with others at intervals throughout the next 100 feet of the section, finally giving place to the more massive limestone at thebottom of the boring; this series appears to be conformable throughout; its dips range from 40° in the upper portion to 60° in the lower part of the section, thus contrasting strongly with the gentle dips of the overlying Red Sandstone and Marls. A "conglomerate with pebble bed" 3 feet 9 inches thick is mentioned in the journal of the boring at a depth of 631 feet 2 inches; but I carefully examined the cores without finding any true conglomerate in the Carboniferous series, an3 suppose the entry to refer to one of the crushed Lmcstone bands. The beds were full of slickensides for 20 to 30 feet below the junction with the Red Marl, and there were again similar symptoms of disturbance at 678 feet; but in the intervening space the crumpling and pressure-structures were of older date than the Post-Trissaic fault, and were such as usually accompany the folding of rocks. The purple sandstones and shales accompanying the Carboniferous Limestone become still more abundant eastward in the next two borings, presumably indicating that we reach higher horizons in the Lower Carboniferous series in this direction.

No. 4 — Knock-e-Dooney Boring

[NX 40164 03040] Summary of section (see also Appendix 3. p. 581).

	Feet	inches
Raised Beach; sand with stones	16	0
Glacial Drift; sand, gravel, silt, clay, etc. (*see* p. 419)	157	0
St. Bees Sandstone (Triassic) passing down into	335	8
Lower Red Marls with intercalations of sandstone (Permian) passing down into	98	4
Brown coarse-grained sandstone with partings of marls, and fine "Brockram " (conglomerate) at base (Permian)	55	1

Carboniferous Rocks: Feet	inches
Stained reddish and purplish-grey sandstone with deeply stained shaly layers 62	2

Sandy shale with clay-ironstone nodules, starred dull red, passing down into dull purple and gradually into dark-grey and black shale with pyrites; slightly calcareous; containing a few crushed fossils (encrinites; *Spirifera, Productus,* etc., of small size)	220	2		
Bands of limestone and shale	17	6		
			299	10
Total depth			961	11

Further Description — This bore-hole is distant 1,500 yards N. 58 E. from No. 2, on the Raised Beach, 30 yards from high-water mark, on the western side of Rue Point, N. 20 W. of the farmstead of Knock-e-Dooney. It is noteworthy that at all the borings, in spite of the proximity of the sea and the very porous character of the superficial material to some depth below sea-level, a supply of fresh water was obtained by excavating the Raised-beach shingle to a depth below the level of high-tide. The fresh water in these excavations rose and fell with the tide, and only occasionally became slightly brackish.

I was able to make a careful examination of the material obtained from the drift deposits of this section, and have incorporated the results in a succeeding chapter (p. 420). These drifts extended downward to about the same depth as in the preceding bores; and the top of the St. Bees Sandstone immediately beneath them was soft and rubbly, being probably broken up by glacial agencies. The sandstone was identical in character with the corresponding rock of No. 2 Bore, and possessed the same low dip. In places it showed extremely well-marked cross-bedding. The marly intercalations gradually increased toward the base, until they predominated over the sandstone, and constituted the Lower Math. The lower portion of these marls was streaked with thin irregular dabs and patches of coarse sandstone or grit, and this material increased in quantity downwards until it replaced the math which thus formed a link between the overlying St. Bees Sandstone and an underlying sandstone of a different type.

It is now usual to consider the St. Bees Sandstone as the lowest division of the Trias in Cumberland, and to class the underlying strata as Permian. It seems necessary, therefore, that we should regard the Lower Marls and the underlying beds down to the base of the Red Rocks in these Manx sections as Permian; but this classification is purely artificial, since the so-called Permian strata are simply the basement beds of the overlying series, as indeed they are also on the Cumberland coast. These "Permian" rocks appear to have been faulted out in the boring last described, so that we have here for the first time an opportunity to examine them. Prof. Boyd Dawkins cla-uses their upper portion with the Triassic, but ascribes their lowest part, for a thickness of 28 feet 3 inehes, to "Permian rocks of the Stack Series"<ref>Rep. Brit. Assoc., Liverpool, 1896, p. 778.</ref>; they bear no resemblance, however, either to the Peel rocks or to the so-called "Stack Series" of the Ballawhane boring.

The peculiar coarse brown sandstone, into which the marls passed downward as above described, is characterised by the size and also by the roundness and polish of its quartz-grains, which are set in a more or less marly matrix and in some bands exceed ■ inch in diameter.

Toward the base it becomes streaked with a fine calcareous conglomerate or breccia, of which the more or less subangular fragments, up to ■ inch in diameter, seem to have been derived from the underlying Carboniferous floor, being chiefly composed of dolomitised and decayed fragments of limestone, with dull red grit, brick-red grit or sandstone, shale and quartz. In the No. 5 boring two miles farther eastward, the breccia found at the base of the Red Rocks, though

of similar composition, was much coarser and thicker, and apparently replaced the round-gramed sandstone. In both sections the fragments of limestone, which constitute the most abundant element of the breccia, have undergone a curious outer dolomitization and internal decomposition by which a hollow interior lined with dolomite or calcite crystals is frequently produced. This is also a characteristic feature in the Cumberland Brockram, but is not present in the fragments of limestone in the Peel Series.

For a few feet immediately below the Brockram the cores were much shattered, and it was states that at this point the water sank in the tubes and the boring-rods dropped as if they had broken into a small cavity. The dips, down to the base of the Brockram, had continued parallel to that of the St. Bees Sandstone, ranging between 5° and 8°; but the Carboniferous rocks were now entered and showed the usual steep inclination, — 30° to 40° or over. The highest of these Carboniferous rocks was a reddish and purplish grey sandstone, veined in places with gypsum and somewhat irregularly stained, the colour being deepest in the ahaly layers. That this staining was derived from the overlying Red Rocks was strikingly demonstrated by the manner in which the red coloration faded out downwards among the underlying shales, passing gradually through shades of dull red and brownish purple into the original dark grey and black. The staining had affected the laminae unequally, thus giving rise in places to strongly marked colour-banding. The shales were full of slickensides and puckering, and showed other indications of severe compression. In their lower portion they contained many small round pyritous concretions, sometimes marked with slickensides on the surface. Considering the abundance of fossils in the Lower Carboniferous rocks of the south of the Island, the dearth of organic remains in these shales was somewhat remarkable. Towards the base they contained a few badly preserved and scarcely identifiable shells of small size, referable to the genera *Productus* and *Spirifera,* together with scattered encrinite stems also unusually small. These beds became more calcareous downward, until bands of shaly limestone were reached, while the lowest rocks pierced (of which I saw only a few specimens and not the whole of the cores) included some thicker beds of greyish crystalline limestone. It is probable that these beds represent a higher horizon than the massive limestone of No. 3 Boring [NX 38280 01885]. Prof. Dawkins refers the sandstone and shales to the Yoredale Series, but it seems scarcely advisable to extend that ill-defined local term to a district so remote from the place of its origin on the scanty evidence we possess at present.

Allowing for the angle of dip, we may estimate the thickness of the Carboniferous rocks pierced in this boring at about 235 feet.

No. 5 — Ballagenney Boring

[NX 43503 03831] Summary of section. (See also Appendix 3., D. 583.)

	Feet	inches
Raised Beach; sand and stones	15	0
Glacial Drift; sand, gravel, clay, etc. (see p. 418)	197	4
St. Bees Sandstone (and Lower Marls, inseparable),	792	2
passing into Marl with coarse sandstone and fine "Brockram", passing into	17	6
Coarse "Brockram "-conglomerate	19	6
Carboniferous Rocks: Feet	inches	

Purple sandstone and sandy shale with casts of *Productus* (?) and other shells in a band 36½ feet from top	45	3		
Purplish, reddish and grey sandstone with shaly layers; containing obscure plant remains, including *Lepidodendiron* and *Stigmaria*	87	1		
Dark purple shale and impure limestone, with badly preserved marine fossils (see list, p. 288)	61	3		
Stained sandy limestone and calcareous sandstone, with shaly layers; much disturbed and partially brecciated in places; containing oadly preserved marine fossils (see list)	62	5		
			256	0
Total depth			1,297	6

Further description — This boring, which up to the present time is the deepest of the series, lies at a distance of two miles E. 14 N. from No. 4, and almost exactly half-way between No. 4 and No. 1 (Point of Ayre). Like the others, it is at the seaward edge of the Raised Beach, here three quarters of a mile broad, and is about 30 yards from high-water mark, and a few yards to the westward of the cart-track leading from Ballagenney farm to the shore.

An examination of the material obtained from the superficial deposits proved that, as in all the borings, in spite of the depth below sea-level, the Glacial beds extended down to the solid rock, and that no Pre-Glacial or Tertiary strata were present (see p. 420).

The St. Bees Sandstone agreed in all respects with the same rock in the former sections, except that it was much thicker, from this boring having entered it at a higher horizon, and in a minor degree from the Lower Marls being so much interstratified with the sandstone as to be no longer separable as an independent division. The deposit probably attains nearly its full thickness here, as calculation from the dip will show that the overlying Upper Saliferous Marls proved in the Point of Ayre Boring should extend nearly to this place.

Below the St. Bees Sandstone the succession differed from the last boring, not only in the less distinct development of the Lower Marls but also in that the brown sandstone with polished grains was represented only by thin streaks of coarse sand interstratified with marl. This gritty marl mingled gradually downward with conglomeratic "brockram" which was at first scanty and of fine texture; but increased rapidly in quantity and coarseness down to the base, wnere it contained blocks of dolomitised limestone, sandstone, etc, up to 6 inches or more in diameter. The "brockram" as developed in this section very closely resembled the corresponding rock of the Cumberland coast-section near Whitehaven.

A great unconformability was again found at the base of the Red Rocks, their low and regular dip of 5° to 10° giving place suddenly to tilted and disturbed strata of Lower Carboniferous age dipping at about 35°. These Carboniferous rocks differed widely from those in No. 4 boring [NX 40164 03040], and only in part resembled the series in No. 2. The stained

sandstone of the uppermost portion was strongly cross-bedded; it passed down into mottled green and purple shale, strongly slickensided along the bedding planes. A band of dark purple sandstone, 7 feet 3 inches in thickness, occurring at a depth of 36½ feet from the base of the brockram, must originally have been a fossiliferous calcareous grit; but the lime was leached out, leaving obscure casts of shells among which *Productus* and *Spirifera* were recognised.

Below the shelly seam was a band, 1½ feet thick, of very hard close-grained grit — almost a quartzite — not unlike certain thin bands passed through in the No. 2 Boring. In the succeeding 87 feet of stained sandstones and sandy shales no marine fossils were found, but some of the beds were full of obscure plant remains, among which *Lepidodendroa* and *Stigmaria* have been recognised. At a depth of 1,173 feet 10 inches from the surface there was a rather sudden change to calcareous shales full of marine fossils, encrinites predominating, and these shales, with intercalations of impure limestone and sandstone, continued to 1,235 feet; while below this, to the bottom of the boring, the rocks consisted chiefly of stained sandy limestone or calcareous grit, with numerous fossils, among which encrinites were not so conspicuously abundant as at the higher level. The list of the fossils of the boring given on the next page has been prepared by Messrs. Sharman and Newton from specimens preserved in the Survey Collection. The dips in the lower part of the Carboniferous rocks were somewhat steeper than in the higher part, ranging between 45° and 50°. The steady persistence of dips approximating to 45° in this series, extending to sections 3½ miles apart; when taken in connection with the disturbed character of the bedding, is a strong indication of the presence of systematic folding. In the present boring especially, most of the shales and thinner limestones were much crumpled and partially brecciated, showing fluxion structure' of the bedding planes and in some cases a fracture like incipient cleavage; slickensides and polished surfaces were also abundant throughout.

Some thin veins of gypsum cut across the bedding-planes in the lower part of the section. The staining of the rocks in different shades of red and purple was again a marked feature, and extended, in varying degrees, to the bottom at 1,197 feet from the surface, where a strong joint or fault accompanied by a brecciatien of the shale was passed through, the staining was accentuated.

In this section, as in No. 2 [NX 39284 02429] and No. 4 [NX 40164 03040], we find that the limestones are subordinate to beds composed of sandy and shaly material. These facts suggest that the Lower Carboniferous rocks of the north of the Island are likely to correspond more nearly to the strata of similar age in the southwest of Scotland than to those of any part of England, as indeed might be expected from their geographical position. The presence of sandstone with plant remains, intercalated with beds containing marine fossils, affords further evidence in this direction.

There were, again, no rocks in the boring that could be correlated with the Peel Sandstone notwithstanding that the base of the New Red series was again revealed; and, as stated in the previous chapter, this evidence tells strongly against the supposed Permian age of the Peel series.

List of fossils from the Carboniferous rocks in the Ballagenney (No. 5) Boring [NX 43503 03831].

At depth of 1,078 feet from surface:

<ref>The fossils marked thus were only seen by the writer in the cores at the boring; the remainder were determined by Messrs. Sharman and Newton.</ref>Casts of *Productus ?* and *Spirifera ?* At about 1,165 feet:

<ref>The fossils marked thus were only seen by the writer in the cores at the boring; the remainder were determined by Messrs. Sharman and Newton.</ref>Impressions of vegetable remains, including *Stigmaria* and *Lepidodendron* ?

At 1,176 feet:

Spirifera trigonalis ? and fragments of other shells.

At 1,182 to 1,189 feet:

(Sponge) *Hyalostelia sp.*

(Cnord) Encrinite stems.

(Polyzoa) *Fenestella* sp.

(*Polyzoa) Rhomhopora megastoma ?* McCoy

(Brachiopoda) *Chonetes laguessiana,* de Kon.

(*Brachiopoda) Productus scabriculus,* Mart.

(*Brachiopoda) Productus longispinus,* Sow.

At 1,200 feet:

(Annelid) *Spirorbis* sp.

At 1,208 to 1,210 feet:

Encrinite stems.

Fenestella sp.

Chonetes laguessiana t de Kon.

Fish tooth.

At 1,282 to 1,290 feet:

Encrinite stems.

Productus longispinus, Sow.

Productus punctatus, Mart.

Productus semireticulatus, Mart.

No. 1.—Point of Ayre First Boring

[NX 46479 05032] Summary of section.—(See also Appendix 3,p. 578.)

Raised Beach; shingle	23 feet
Glacial Drift; sand, gravel, silt, and clay	275 feet
Triassic Red Marls, with gypsum and rock-salt	332 feet
Total depth	680 feet

Further Description — This boring, commenced in 1891, was the first of the series. Its position, 2 miles distant E. 25 N. from No. 5, is on the Raised Beach, close to high-water mark, at the extreme northerly point of the Island.

It had been completed before I visited the place, and the drift material had not been preserved. Through the kindness of Mr. J. Todd, however, we have been supplied with a full set of specimens from the corresponding drifts of the later boring, No. 6, which lies only 335 yards south-eastward from No. 1, 9nd have been thus enabled to make a careful study of the exceptionally interesting glacial section at this place (see p. 340).

In the No. 6 boring the Glacial deposits appear to extend to the remarkable depth of at least 428 feet below the surface, the middle portion consisting mainly of sand and gravel, in places full of marine shells, and the lowest part, of re-arranged red marl with foreign stones. From the difficulty in distinguishing between the latter material and the Triassic marl in its

original state, it is possible that the drift in the present boring was thicker than statei; the diamond drill was not used until a depth of 452 feet was reached, and the difference between drift and solid of similar composition would be scarcely perceptible in the fragments broken up by the chisel. Otherwise the difference of over 100 feet between the thickness of the drift in these contiguous sections would denote a most uneven surface of the solid rocks in this quarter; and this, though not inherently improbable, is opposed to the evidence of the former borings, which indicated a regular plane of erosion beneath the drifts (see (Plate 5)) Nowhere in the British Islands, so far as I am aware, have the Glacial deposits been proved to so great a depth as in hese two borings (see p. 344).

The Triassic marls were red and brown in colour, mottled and streaked with greenish grey. They were thinly veined throughout with gypsum, and contained crystals and pseudomorphs of rock-salt. In the lower part of the section several bands of rock-salt were passed through, having an aggregate thickness of 33 feet, the thickest bed (20 feet) occurring at 635 feet 2 inches from the surface. A brine-run 2½ feet in depth was also intercepted, and preparations are now in progress for turning the discovery to economic account (see Appendix, p. 579, also Chapter 13., p. 559).

Prof. Dawkins has pointed out the great theoretical importance of this discovery, which "links on the salt-field at Carrickfergus with those of Barrow and of Cheshire, and shows that the Irish Sea is a basin in which the salt-bearing, Triassic marls were deposited. They have since been broken up and denuded, and it remains to be proved how far they are continuous under the sea, eastward to Barrow and to the north-west in the direction of Carrickfergus".<ref>Rep. British Assoc., Liverpool, 1896, p. 778: ahn Trans. Manch, Geol. Soc., vol. xxii., pt. xxi.</ref>

No. 6.—Point of Ayre Second Boring

[NX 46712 04835] Summary of section — (See also Appendix 3, p. 585.)

		Feet	inches
Raised Beach; shingle		16	0
Glacial Drift: consisting of:	Feet		
Sand and gravel with broken marine shells	97		
Stony clay with some sand	102		
Muddy sand and gravel with many shells	25		
Reddish sand and gravel apparently derived in great part from Triassic rocks; shell fragments very small and rare; a large boulder 9 feet above the base	123		
Local drift of reconstructed. Triassic marl with a few erratic pebbles	65	412	0
Disturbed Triassic Red Marl: probably partly reconstructed by glacial agency (containing a few foreign pebbles at 476 feet from surface) about		65	0
Triassic Red Marl (stratified), with gypsum and rock-salt		382	8
Triassic Red Marl with sandy bands		44	8
Total depth		920	4

Further Description — This boring is near the edge of the Raised Beach 262 yards east of the Point of Ayre Lighthouse, and, as already stated, only 335 yards south-east of No. 1 Boring. It was sunk in 1897–8 for the purpose of testing the extent of the Saliferous Marls. Our fieldwork in the Island had been completed before it was commenced, but through the kindness of Mr. J. Todd and Messrs. Craine Bros., we have been supplied with specimens of the cores at short intervals throughout the section; and the following notes, as well as the fuller details of the Glacial deposits given in the subsequent chapter (p. 340) have been based on our investigation of this material.

From the base of the Raised Beach at out 16 feet from the surface down to 363 feet the drift was compose (chiefly of stratified material, in the main resembling that of the other borings, but about midway containing a marine shell-bed different from any deposit known to exist elsewhere in the Manx drifts (see p. 342). Below the stratified drift we seemed to have a thick mass of local till consisting of reconstructed gypseous Red Marl sporadically mixed with a few pebbles of extraneous origin. These drift pebbles were present in all the samples examined by us down to 428 feet (see p. 343), but were absent from the lower material at 453 feet and at 462 feet, which consisted entirely of broken-up marl and gypsum, until the depth of 476 feet was reached, where in the specimen supplied to us, the foreign pebbles reappeared. If the depth was correctly marked on our specimen, this may indicate that large masses of the upper portion of the marl have here and there been displaced *en bloc* by glacial action, after the manner well known in the east of England. In the journal of the boring, however, no drift seems to have been recognised below 363 feet, and the classification in the summary given above rests on the evidence of our specimens (see p. 585).

Although no extraneous material was observed in the samples below 476 feet, the marl continued to present a reconstructed aspect, without original bedding, down to a depth of about 535 feet, where its stratification first became apparent. The dips were irregular and the material disturbed for some distance further; and, in fact, the cores throughout appear to show much irregularity in this respect, which may perhaps be explained by local subsidences of the marls into hollows left by the removal of the salt in solution.

The chief saliferous beds lay between the depths of 604 and 875 feet, the mineral occurring in numerous bands, either pure or mixed with varying proportions of marl (for full details see Appendix 3., p. 586). The ollowing statistics of the salt deposits of this boring have been placed at our disposal by Mr. Todd: Salt (cores obtained) 76 ft. 8 in.; Salt with about 20 per cent. of Marl 10 ft. 4 in.; Salt with about 25 per cent. of Marl 2 ft.; Salt with about 50 per cent. of Marl 8 ft. 3 in.; Marl with about 30 per cent. of Salt 11 ft. 6 in.; Marl with about 10 per cent. of Salt 2 ft. 10 in.

Below 875 feet, to the bottom of the boring, the marls were interstratified with thin bands of marly sandstone of the usual character of such intercalations in Keuper Marls.

General deductions from the foregoing evidence

The fine series of borings above described enable us to construct a section completely across the extreme north of the Island, from E.N.E. to W.S.W., as shown in (Plate 5). We will now proceed to discuss this section and the probable solid' stratigraphy of the low ground to the southward.

New Red Rocks

The Triassic and Permian strata of our section correspond closely to the rocks of similar age on the opposite Cumberland and North Lancashire coast, the chief difference being that the Magnesian Limestone, which is reduced to a thickness of about ten feet at Whitehaven, is altogether wanting in the Isle of Man. These Manx Red Rocks are even more strongly unconformable upon the underlying Carboniferous than on the mainland; and it is probable that they have once extended across the denuded edges of the Carboniferous strata up to and over the flanks of the Manx Slates of the central massif exposed by Pre-Permian erosion, exactly as they overlap upon the Skiddaw Slates on the western margin of the Lake District. Some traces of this overlap seem still to be preserved, in the occurrence of bodies of haematite and the prevalence of red staining in the lodes and faults in the slates in the north-eastern corner of the massif.

The gentle dip and undisturbed condition of the New Red Rocks throughout the borings, in strong variance with the steep dips and disturbed state of the underlying Carboniferous strata, prove that, as compared with the Pre-Permian

disturbances, the movements in this district since Triassic times have been relatively simple. As on all the opposite shores of the Irish Sea, these later movements of elevation and depression seem to have obtained relief through normal faulting only. That the northern part of this sea-basin was already troughed out in Permian times is indicated by the manner m which the New Red Rocks are distributed in depressions adjacent to its shores, in the northwest of Ireland and the south-west of Scotland, as well as in the north-west of England.

The direction of dip of the Red Rocks was not actually determined in the borings, but the incoming of the higher members of the series towards the north-east is sufficient to show that their general dip must be approximately in that direction The line of section shown in (Plate 5). is therefore somewhat oblique to the dip.

The strong probability that the neighbouring part of the Irish Sea is mainly underlain by the rocks of this age will deserve careful consideration in case the proposed scheme for a submarine tunnel between Scotland and Ireland should ever reach the practical stage.

Lower Carboniferous Series

The disturbed condition of the Carboniferous strata in the borings precludes any positive conclusion as to their sequence or direction of strike. They appear to have been more severely affected than the rocks of this age in the south of the Island. Judging from the analogy afforded by the Carboniferou's rocks of other districts, it seems likely that their general strike will run more or less iparalled to the nearest margin of the old slate-massif, and therefore approximately east and west, with a general northerly dip. This agrees with the conclusion reached on other grounds, that the newer members of the series occupy the more northerly positions, and that the line of the borings diverges north-eastward at a low angle from the strike of the strata. The fossil evidence is unfortunately too scanty to afford much assistance, as the species recorded are all common Lower Carboniferous forms. The absence of the corals found in the calcareous bands of the Peel Series is, however, noteworthy.

It seems probable, then, that the massive limestone of No. 3 Bore [NX 38280 01885] is the lowest stratigraphical horizon which has been reached. From the geological standpoint it is to be regretted that this boring was not carried deeper, though of course nothing of economic value was likely to be thereby attained. As the case stands, with allowance for the dip we find that about 45 feet of limestone was penetrated, which is the thickest mass of calcareous rock passed through in the borings.

In the next section north-eastward (No. 2 Bore) [NX 39284 02429], the Carboniferous rocks contained at first only thin bands of limestone, subordinate to calcareous sandstone and shale, but thicker limestones were reached at the bottom of the boring.

In the succeeding boring (No. 4) [NX 40164 03040] the first 282 ft.<ref>As measured in the borehole; not corrected for dip.</ref> of Lower Carboniferous rocks consisted of 62 ft. of sandstone, underlain by 220 ft. of dark sandy shale; and bands of limestone made their appearance only below that depth.

Finally in the boring (No. 5) [NX 43503 03831] farthest to the north and east which has hitherto reached the Carboniferous, it consisted for about 140 feet of sandstone and sandy shale only, containing plant-remains as well as marine shells, and below there were impure limestone bands among the shales.

Thus the last three sections all showed, though in varying degree, the same tendency towards a downward passage into limestone, the borings being suspended when the thicker bands of limestone were reached. This leads to the conclusion that the sequence consists of a series of sandstones and shales, with thin limestone bands in their lower part, overlying more massively-bedded limestone of unknown thickness.

It is noteworthy that no trace whatever was found of the Carboniferous Volcanic Series of the south of the Island.

As regards the hypothetical downward continuation of the section below the Carboniferous limestone touched in No. 3 Bore [NX 38280 01885], I think the most probable inference is that rocks equivalent in age and similar in character to the Peel Sandstone will occupy this position. Indeed the absence from all the borings of any rocks comparable to the Peel

Series seems necessarily to imply that if the series is represented at all in the north of the Island, it must lie below the Carboniferous Limestone found in the borings. If Cumming's suggestion be correct, that the Peel Rocks represent simply a belt of shore-deposits of the early Carboniferous sea, like the conglomerates of Lankness, it is possible that they may have passed laterally into Carboniferous Limestone (as similar beds are known to do at the western margin of the Carboniferous basin in Ireland) at a short distance from the flanks of the slate massif,<ref>For general discussion of the facts relating to Ireland see G. H. Kinahan's "Geology of Ireland", p. 64 *et seq.* (London, 8vo., 1878.)</ref> and may therefore have become attenuated and largely replaced by limestone before reaching the northern limits of the island. But in view of their considerable thickness north of Peel and the far-drifted and non-local aspect of many of their pebbles, it seems more probable that the sandstones have originally extended over a wide tract of sea-bottom, and therefore are likely to underlie the Carboniferous Limestone of the northern plain, and if fully developed, to represent, as in some parts of Scotland, the transition from Upper Devonian to Carboniferous times. The resemblance between the Peel Series and the Calciferous Sandstones which form the lower portion of the Carboniferous system in Kirkcudbrightshire, commented on in the preceding chapter (p. 265), suggests a common basin of deposition, that would probably include the north of the Island, which is over 12 miles nearer that coast than is the Peel outcrop. If, therefore, the beds underlying the Carboniferous Limestone had been penetrated in the borings, it is probable that they would have been found more to resemble the rocks of the same age in Scotland than those in Cumberland.

The most probable downward sequence of the concealed Lower Carboniferous strata of the north of the Island will therefore read as follows:

3. Sandstones and shales, with thin limestone bands in the lower part.

2. Limestones.

1 Sandstones and Conglomerates of the Peel Series.

The already proved extent and diversity of these rocks indicate that their aggregate thickness must be great, certainly far exceeding that of the Carboniferous strata of the south of the Island; it may reach some thousands of feet.

Probable stratigraphy of the low ground south of the borings

As mentioned at the commencement of the present chapter, between the borings and the nearest outcrop of the Manx Slates there is a space from 4¾ to 7 miles wide, stretching right acrossthe Island, in Which evidence as to the solid geology is lacking but for which it was imperative to prepare a conjectural reading, in order to complete the 'solid' edition of the geological map in accordance with the conventional system adopted by the Geological Survey of showing the solid colouring in all tracts not covered with alluvium. This area, of over 40 square miles, is, to all intents and purposes, geologically a portion of the bottom of the Irish Sea, which has been converted into dry land by the locally profuse deposition of Glacial drift. The 'solid' lines adopted for this tract are necessarily and essentially hypothetical; hence a brief statement of the considerations which have weighed with me in drawing them may be found useful.

Starting in the extreme north, at the Point of Ayre, we have to deal first with the Triassic Saliferous Marls revealed in Bores Nos. 1 and 6. We know that these rocks do not extend westward to Bore No. 5 [NX 43503 03831]; and concluding, for reasons already stated, that their dip is probably towards the north-east, we find, by calculation from their proved thickness that their line of outcrop is likely to be just covered by the tract of Raised Beach and Blown Sand forming the eastern part of The Ayre; and as these superficial deposits, being akin to Alluvium, are shown on the 'solid' map, we gladly evade the necessity for separately colour-in or drawing a boundary-line for the Marls.

The St. Bees Sandstone which directly underlies the drift in Bores Nos. 5, 4, and 2, is likely, from its thickness and gentle dip, to extend for some distance inland in the eastern portion of the tract, outcropping from beneath the Saliferous Marls near the southern margin of the Raised Beach, while westward it is probably faulted off against the Carboniferous Limestone of Bore No. 3 [NX 38280 01885]. as already described. The proved existence of this Post-Triassic fault, taken in conjunction with the known prevalence of faults in the Carboniferous rocks in other parts of the Island, and on the opposite Cumberland coast (where the Whitehaven coalfield is cut into strips by dislocations of two distinct ages, some

being Pre-Permian and others Post-Triassic), leaves no doubt that many other faults must exist in the area we are considering, and must profoundly modify its stratigraphy. But we are compelled to ignore this factor except in the one ease proven, and to calculate the inland extension of the St. Bees Sandstone from its known thickness and probable north-easterly dip.

The Permian Brockram and associated beds proved in Bores Nos. 4 and 5, are shown as a narrow belt outcropping along the southerly inargin of the St. Bees Sandstone, the breadth being somewhat exaggerated on the one-inch map for the sake of clearness. On the evidence of Bore No. 2 [NX 39284 02429], it is indicated that these rocks are cut off westward by the above-discussed fault.

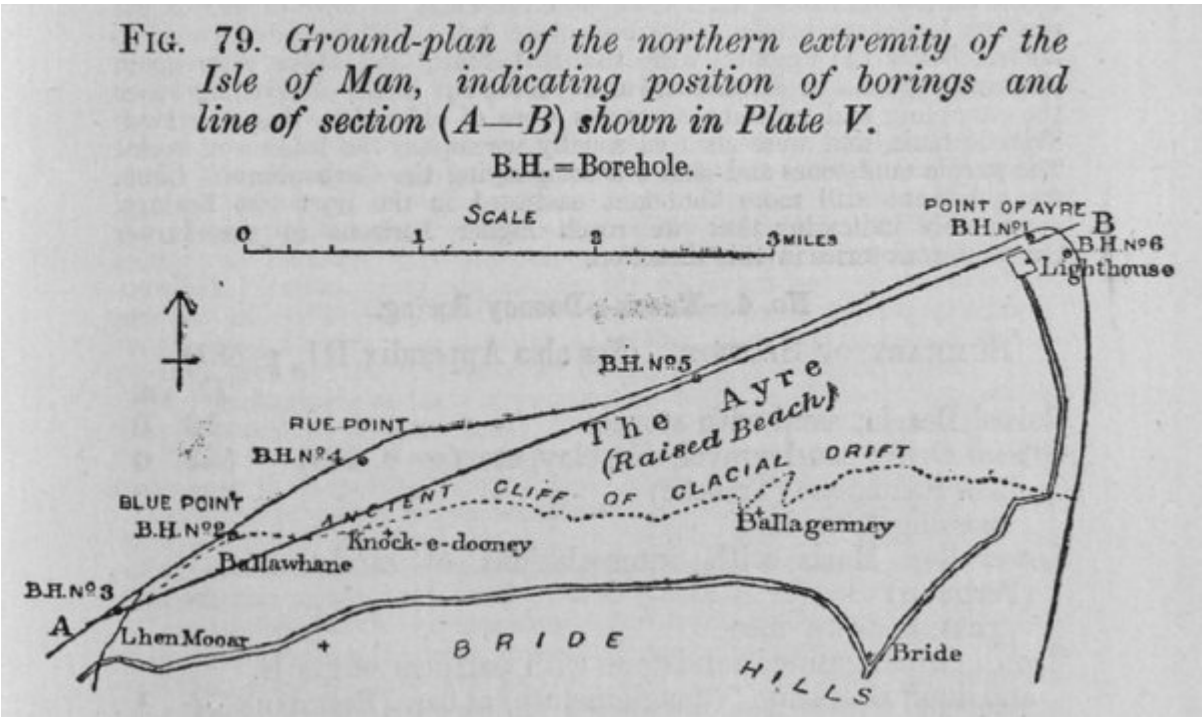
There is, however, some probability that the Permian and Triassic strata may stretch farther southward on the eastern side of the Island than we have ventured to extend them; they may, indeed, in this quarter entirely overlap the Carboniferous Limestone.

The Carboniferous Limestone Series, which was found to be covered by the New Red Rocks in all the borings except No. 3 [NX 38280 01885], is shown outcropping to the southward, in a broad belt on the west, narrowed eastward by the above-mentioned fault and by the unconformable overlap of the Permian and Trias. The southern boundary has been bravely drawn parallel to the northern termination of the slate massif, but can be justified only by the necessity of placing it somewhere between the Red Rocks and the mountains.

It is clear that the massif has been truncated at some period prior to the Glacial epoch by marine action. Hence we must presume that there exists at the foot of the old cliffs a platform of erosion in the Manx Slates, stretching northward and marking the extent to which the cliffs have been cut back. The greater part of this platform will lie beneath the alluvium of the Curragh, and in this tract we escape the responsibility for delineating it; but on both flanks of the Island the drift is heaped up on it above alluvium-level, and there it has been represented. Its breadth is a matter of pure surmise, and is likely to be less than we have allowed.

We have now to fill in the space, still far too wide, between the edge of this platform and the southern boundary of the Carboniferous Limestone Series; and the only rocks available for this purpose seem to be the hypothetical equivalents of the Peel Series. There is, indeed, a distinct probability that strips of Silurian and Devonian may lie hidden in this quarter, but it is out of the question to introduce rock-systems into the map without some kind of evidence for their existence. If a boring were sunk to the solid rocks in the middle of the plain in the neighbourhood of Andreas it could not fail to throw light upon these problems, but unfortunately there is no likelihood that it would yield results of economic value, and therefore little chance that it will ever be undertaken.

Hence, however disinclined we may feel to allow such broad outcrops to the Lower Carboniferous rocks and to their suppositious basement beds, especially when we bear in mind the high dips of the former in all the borings and of the latter at Peel, there seems at present to be no better alternative than that which has been adopted, given the necessity for producing a map of the area on the existing evidence.



(Figure 79) Ground-plan of the northern extremity of the Isle of Man, indicating position of borings and line of section (A—B) shown in (Plate 5).