Chapter 1 General description of the island

"Rising from the middle of the Irish Sea, within sight of each of the three Kingdoms, with a history and associations so distinct, yet so intimately linked with those of the rest of Britain, this interesting Island presents in its geological structure features that connect it alike with England, Scotland and Ireland, while at the same time it retains a marked individuality in regard to some of the rocks that form its framework". These words, with which Sir Arch. Geikie preludes his account of the volcanic rocks of the Isle of Man serve equally well as an introduction to its general geology.<ref>Ancient Volcanoes of Great Britain", vol. ii. p. 22.</ref>

The predominant feature in its stratigraphy is the central ridge of slate and greywacke, which seems to have constituted an insulated tract at as early a date as the beginning of the Carboniferous Period.<ref>See Rev. J. Cummings "Isle of Man", p. 239; Bev J. Clifton Ward Geol. Mag., dec. ii., vol. vii. (1860), p. 6</ref> This prototype of the present Island appears afterwards to have been enfolded and obliterated by the sediments of later times; but with the progress of denudation the old ridge has once more emerged from beneath this mantle.

Its insular character is as well maintained in its physical as in its geological features. The erosive agency of the simple drainage system, descending radially to the sea from the central hill-range, together with that of the waves which surround it, is adequate to explain all the contours of its present surface. It must indeed frequently during its history have been reunited to the mainland by a continuous land surface; but at such times it probably still retained in some degree its characteristic individuality, and arose above the surrounding plain as a hilly tract with a self-contained drainage, although its streams may then have been tributary to a larger river-system lying beyond its limits.

The sketch map, (Figure 1), will serve to recall the position of the Island as regards the neighbouring shores. Its northernmost point is 16 miles distant from the nearest headland of the Scottish coast, while its closest approach to the Cumberland shore is 31 miles, to that of Ireland, in Co. Down, 31 miles, and to the Welsh coast near Holyhead 45 miles. The same map shows roughly the contours of the surrounding sea-bottom. To the eastward of the Island the depth is nowhere more than 20 fathoms; to the northward it rarely roaches 30 fathoms; to the southward it usually ranges between 30 and 50 fathoms; while to the westward, midway to the Irish. Coast, there is a long narrow trough descending to over 70 fathoms.

As at present constituted, the Island, with the detached islet of The Calf [SC 155 655] off its south-western extremity, contains 227 sq. miles (145,325 acres), of which 170 sq. miles, or three-fourths of the whole, are occupied by the slate and greywacke rocks, probably of Upper Cambrian age, composing the hilly massif. Strata of the Lower Carboniferous age occur in a small basin of 7 or 8 sq. miles at a low elevation in the south of the Island; and a narrow strip of red sandstone, probably belonging to the same period, borders the coast for two miles about midway upon the western side. The northern extremity consists of a low-lying tract of about 45 sq. miles, which is an addition made to the Island in Glacial times by the deposition of great masses of Glacial Drift upon the Pre-glacial sea-floor. Deep borings through this drift have recently revealed a rock-floor of Triassic, Permian and Lower Carboniferous strata at a considerable depth below sea-level.

The Island is irregularly oblong in shape, with its longer axis running N.N.E. to S.S.W., which is the direction of strike of the slate-rocks. In this direction, from the Point of Ayre [SC 465 055] to Spanish Head [SC 185 655] the land has a length of 30 miles, while the breadth of its wider central portion varies from 8 to 12 miles. Excepting in the well-cultivated northern plain, there is little flat ground. In the interior the physical features bear much resemblance to the Southern Uplands of Scotland. The hills are steep, but not generally craggy, and are arranged in long grassy or heather-covered ridges running with the longer axis of the Island, with broad intervening valleys. The highest of these ridges commences in the vicinity of the eastern coast near Ramsey [SC 455 945], and is practically continuous to the south-western coast north of Port Erin, but is broken across in one place by a deep transverse valley, which intersects the Island between Peel [SC 245 845] and Douglas [SC 385 755]. North Barrule [SC 445 905], with an altitude of 1,840 feet, forms the northeastern extremity of this ridge, which culminates 3½ miles farther south-westward in Snaefell [SC 395 885], the highest point of the Island, with an elevation of 2,034 feet, while Cronk ny Arrey Lhaa [SC 22448 74675], over hanging

the south-western coast, is 1,449 feet height.

Most of the larger streams of the Island rise in the vicinity of Snaefell and fall outward in different directions to the sea, the Sulby River and Glen Auldyn water draining northward, the Cornah and the Laxey Rivers eastward, the Glass and the Baldwin south-eastward, and the Neb south-westward. The drainage of the smaller tract south of the transverse valley is radial from a separate centre in the south western portion of the hill-chain, whence flow the Glen Rushen waters north and northwestward, the Foxdale River northward, and the Santon, the Silverburn, and the Colby southward. Fuller details of the physiography are given in the small-typed portion of this chapter.

The Ordnance one-inch map of the Island, though numbered in the New Series as occupying sheets 35, 45, 46, 56 and 57, is published at present only in a single sheet (No. 100 of the Old Series).

The following Table of Strata shows the divisions which have been adopted for the one-inch map of the Geological Survey, published in 1898. The more southerly portion of the northern drift-plain may possibly be underlain by rocks intermediate in age between the Manx Slate Series (Upper Cambrian?) which bounds it on the south, and the Lower Carboniferous strata which have been proved in the borings at its northern margin.

	TABLE OF STRATA.
RECENT	Blown Sand
	Peat-Freshwater
	Alluvium-Freshwater
	Raised Beach - Marine
GLACIAL	Late-glacial Flood-gravels
	Sand and Gravel occurring as platforms
	Sand and Gravel occurring as mounds
	Boulder Clay or Loam, and Rubble Drift
	Great Unconformability
TRIASSIC	Red Marls (saliferous) — Proved in deep borings beneath the drift-plain
	St. Bees Sandstone — Proved in deep borings beneath the drift-plain
PERMIAN	Lower Marls and Brockram — Proved in deep borings beneath the drift-plain
	Great Unconformability
CA.RBONIFEROUS	Carboniferous Limestone Series
	Basement Sandstone and Conglomerate
	Great Unconformability
	Barrule Slate
	Manx Slate Series — Locally divided into: Barrule Slate.
UPPER CAMBRIAN?	"Crush Conglomerate". Agneash and other Grits. Lonan and Niarbyl Flags
IGNEOUS ROCKS	**Contemporaneous**
	Carboniferous — Tuff, Agglomerate, &c.
	Carboniferous — Basalt
	Manx Slate Series?— Tuff (small patch near Dalby only)
	Intrusive
	Olivine -Dolerite ((Tertiary ?) dykes
	Diabase, etc., ("Greenstone") dykes
	Diabase, Epidiorite, Chlorite schist,etc. ("Altered Greenstone") dykes
	Diorite and Camptonite dykes
	Mica-trap dykes
	Micro-granite dykes

Detailed description of the physical features of the island

The Raised Beach

Commencing our examination at the northern extremity we find first a barren strip of shingle, rising from 10 to 15 feet above high-water mark, covered in places with low dunes of drifting sand. This tract, known as The Ayre, has a width in its eastern portion, at the Point of Ayre [NX 49357 04290], of 1½ miles; but narrows gradually westward, until on the opposite side of the Island, in the vicinity of the Lhen, about 6 miles from the Point of Ayre, it has dwindled to a mere bank like a single storm beach. Throughout the greater part of its extent the inner margin of this old beach is sharply defined by an ancient cliff carved out of the drift deposits, the slope of which in many places is nearly as steep as that of recent cliffs of the same material. At Blue Point [NX 39288 02618], near the western termination of The Ayre, the summit of this old cliff is about 100 feet above Ordnance datum. The prevalent belief of the countryside (which has found its way into the topographical literature of the Island) based no doubt on the fresh aspect of the bare shingle-ridges, is that The Ayre is still growing by accretions to its seaward margin. The present investigation, however, has shown that this view is almost certainly erroneous. Not only has there been no addition to the land at the Point of Ayre during the last 83 years (see p. 417), nor in any part of the tract since the Ordnance Survey was made 30 years ago, but also in some places there are clear indications that encroachments have been made by the sea upon the raised beach since its accumulation, the old shingle-ridges near the Point of Ayre being broken off abruptly by the present shore and the recent storm-beach lying athwart them.

In many other places around the sea-margin of the Island less conspicuous indications of the same raised beach are found. Thus, the older portions of the towns of Ramsey [SC 455 945], Laxey [SC 435 845], Douglas [SC 385 755], Castletown [SC 26576 67468] and Peel [SC 24335 84219] stand on a corresponding marine terrace, slightly above present high-water mark; and elsewhere the innermost recesses of the bays, inlets and caves with which the rocky coast-line is abundantly indented are often above the reach of the highest waves of the present sea, so that their erosion is arrested. Even the outstanding headlands frequently still exhibit, above high-water mark the notch which was cut into them during the same period of depression. The persistence of this notch is a striking indication of the durability of the slate-rocks, as well as of the comparative recently of the re-elevation of the land. From evidence which will be given in a later chapter (see p. 403) it appears probable that this elevation was in progress during Neolithic times.

The Drift Plain of the North

To the southward of the Ayre the drift-plain is diversified by a crescentic chain of mounds composed of glacial deposits, known as the Bride Hills [NX 44669 01100], which in their higher eastern portion attain from 200 to 300 feet above sea-level, or about 150 feet above the general level of the plain. The western horn of the crescent, broken across by two wide drainage hollows, is traceable southward until it abuts upon the solid massif of the Island to the westward of Ballauh [SC 345 935]. The eastern horn was probably once similarly continuous up to the hills in the vicinity of Ramsey, but has been partially destroyed by the encroachment of the sea, which eats with great rapidity into the incoherent drift-material of the mounds. The origin of these mounds will be discussed in the later chapter dealing with the Glacial Deposits. On the inner or concave side of the crescent the ground falls away to lower levels in a series of sloping platforms with terrace-like edges until the boggy depression of the Curragh [SC 365 955] is reached, which lies immediately beneath the bold slopes in which the solid massif terminates northward.

The Curraghs

[SC 365 955]. Artificial drainage has rendered the greater part of this hollow cultivable, but it still contains some patches of bog and moist meadow-land hich are sometimes flooded. Old records and maps<ref>See Cumming's "Isle of Man", p. 215 et seq., & pl. iv., reproducing a map of 1595.</ref> prove the existence of small bodies of fresh water in this area within historic times. In its earliest stages, about the close of the Glacial Period, the whole depression was probably filled by one continuous lake, fed by the streams descending from the hills; but somewhat later the water-level was lowered by

the erosion of drainage-channels through the drift-barrier, and at least three separate basins at different levels were then revealed, falling towards the east, and more or less separated from each other by ridges of dry land. Hence we find that the height of the present surface of the most westerly portion of the Curragh, between Sulby and Ballaugh and to the north-eastward of Sulby, is from 36 to 40 feet, while that of the eastern portion, in the parish of Lezayre, is not more than from 18 to 25 feet, above ordnance datum. The presence of large trees embedded in the peat of the Curragh in several localities (see p. 439) affords further proof that the area has not been continuously flooded.

The high rim of drift around this depression caused the Post-Glacial drainage of the greater part of the northern plain to flow inland to the hollow, and the waters escaping thence to the sea have cut the above-mentioned gaps in the barrier. From the rapidity with which the drift-material could be eroded, some curious changes and reversals of drainage have been brought about in this area in Post-Glacial times. These will receive consideration on a later page. In many respects the district resembles the Holderness plain in East Yorkshire, which is similarly built up of drift-deposits piled upon a Pre-Glacial sea-floor.

The Northern Hills

The northern termination of the solid massif of the Island has evidently once formed a coast-line. The range of bold rocky bluffs overlooking the drift-plain, broken only by the embayments at the mouths of the mountain valleys, bears all the characteristics of an old sea-margin; and though in places degraded, its upper slopes are frequently as steep as the slopes overlooking the cliffs of the present coast. The bluffs truncate the strike of all the component members of the Manx Slate Series, and do not coincide with any known structural feature of the rocks. In short, their whole aspect suggests a cliff-line, rising above the platform of marine erosion now buried beneath the Glacial and Alluvial deposits &the plain.

This likeness to a coast is recognised in the Manx place-names, the more prominent bluffs, like the headlands of the existing sea-margin, being known as Gobs, thus—Gob y Volley [SC 37204 94104], etc. The feature is well expressed by the shading on the Ordnance one-inch Map, while on the Geological Map it is further accentuated by the ending off of the superficial deposits at the foot of the slope.

The upland ridges of which these bluffs are the termination attain an altitude of about 800 feet above sea-level and are continued backward at this elevation into the high moorlands which form the northern portion of the massif of the Island. From their flatness and coincidence in altitude, these ridges appear to be the remnants of an ancient peneplain out of which the existing valley system has been carved and the higher summits of the massif, which rise above them, appear to be the relics left from the destruction of a still older upland. The same 800-feet plateau seems also to have existed in the more southerly portion of the massif, though now almost obliterated. At any rate, in almost every part of the upland tract the surface-features of two distinct epochs of erosion may be recognised. During the earlier of these, the broad smooth outlines of the more elevated areas, with their wide but shallow drainage basins, were shaped out; while in the later, the excavating power of the streams was greatly increased, so that deep, steep-sided trenches were notched out in the lower portions of the old basins, and the gradients of the tributary brooks thereby sharply raised. As to the geological age of the earlier of these epochs it is not possible to speak with certainty; but from the manner in which the latest basaltic dykes of the Island, supposed to be of Mid-Tertiary age, are planed down along with the country-rock, a later Tertiary date seems to be indicated, at any rate for its final stages. The succeeding epoch of rapid denudation may be fixed with more confidence at the period immediately preceding the oncoming of Glacial conditions. The earliest drifts of the area have found lodgment within the trench-valleys, while from the sharpness of the contours, the interval between the erosion of the valleys and the deposition of the drift within them must have been comparatively short.

The drainage of the Northern Hills

Unlike the conditions on the northern plain, the drainage system of the hills has been scarcely at all modified by the Glacial Period. All the main valleys, and most of their branches, were already in existence in Pre-Glacial times; and though they must have been temporarily obliterated by the ice-sheet under which the Island was buried during the period of maximum glaciation and were in many casts made the receptacles of glacial deposits of considerable thickness, their general gradients were not materially affected. Hence upon the disappearance of the ice, the streams resumed their

previous courses and cut rapidly through the incoherent glacial detritus to the old rocky floor, leaving only terraces of drift in places to show the original extent of the infilling. There are, indeed, in a few localities rocky gullies within the main valleys where the Post-Glacial stream has temporarily lost its way in re-excavating its old channel, but these have not permanently affected the drainage. There are also a few channels cut into the slopes of the hills in places where there is little or no natural drainage under present conditions. These, as will be shown in a subsequent chapter, were probably excavated by streams flowing principally within or upon the ice-sheet, and are independent of the land drainage, either of Pre-Glacial or of Post-Glacial times.

In the northern part of the massif, as previously mentioned, the chief watershed is formed by the long ridge which culminates in Snaefell [SC 39775 88075]. The Sulby River [SC 38253 93676], the largest stream of the Island, flows northward from the north-western slopes until it reaches the foot of the hills, where, in Pre-Glacial times, before the northern plain was in existence, it no doubt discharged directly into the sea. Upon the recession of the great ice-sheet, it seems to have poured for some time into the western Curragh, and thence through the Lhen, a broad valley excavated through the drift-mounds (see p. 435), to the sea at the north-western angle of the Island. But at a later date it diminished in volume until no longer able to surmount its own flood-gravels, and by these has been deflected into its present easterly course under the range of bluffs. Here it is joined by the originally independent Glen Auldyn stream [SC 42571 92481] which flows northward from the more easterly part of the hills; and the combined waters now find their outlet on the east coast at Ramsey.

The opposite or south-eastern flank of the ridge is drained by the Cornah [SC 47269 88028] and Laxey [SC 44028 83878] rivers, which flow in deep Pre-Glacial glens, diverging respectively north-eastward and south-eastward, to the eastern coast. Before reaching the sea the Cornah stream turns sharply southward, and runs in a deep rocky glen of newer aspect than the upper portion of its valley, possibly indicating its "capture", during the Pre-Glacial elevation, by a small stream draining southward, with a very steep gradient, to the coast.

In the neighbourhood of Maughold Head [SC 49831 91357] we find a short segment, about 1½ mile in length, of a broad Pre-Glacial hollow, truncated by the present coastline at Port e Myllin [SC 47444 92735] on the north and at Port Mooar [SC 48754 90971] on the south, indicating that an old drainage system has here been broken up by the encroachment of the sea.

The southern prolongation of the Snaefell ridge forms the gathering ground for the Glass [SC 35931 82951] and the Baldwin [SC 36843 82372], which run southward in parallel valleys for 4 miles, and then uniting swerve south-eastward to their junction with the Dhoo in the central valley of the Island a mile to the westward of Douglas [SC 36661 75778].

In the south-western continuation of the ridge towards the central valley the chief summits south of Snaefell are Beinn y Phott (Pen-y-Pot) [SC 38109 86091], 1,772 ft.; Gwraghan [SC 36830 84891], about 1,600ft.; Colden [SC 34348 84357], 1,599 ft.; Slieau Ruy [SC 32854 82398], 1,570 ft., and Greeba [SC 31918 81659] 1,383 feet. The small streams flowing westward from Colden and Slieau Ruy unite to form the River Neb, which goes southward to the central valley at St. John's, and then westward and finally northward to the sea at Peel.

The north-western flank of the massif is occupied by an outer hilly ridge, parallel to but divided from the Snaefell chain by the broad basin of the Sulby River, having for its chief eminences Slieau Curn [SC 34190 90679], 1,153 ft., Slieau Freoaghane [SC 34062 88416], 1,602 ft.; and Sartfell [SC 33339 87176], 1,560 ft.<ref>Approximate only: height not stated on Ordnance map.</ref> The northern end of this ridge is cleft by Glen Dhoo, the short deep valley of a small stream which flows northward through the village of Ballaugh [SC 345 935] and the western edge of the Curragh. There is also a broad shallow depression on its western flank, continuing south of Kirk Michael [SC 31675 90703] for over three miles, which may possibly mark a once continuous line of drainage belonging to the older epoch of erosion, though its waters are now carried off by three separate streams, the most northerly flowing north and north-west to the sea at Kirk Michael through Glen Wyllin, the second running a parallel course to the sea at Glen Mooar (Michael) [SC 30531 89413], while the third goes southward to join the Neb below Glen Helen. The student of physiographical evolution will find in this portion of the Island some other features of peculiar interest, which will be discussed in the chapter on Glacial geology (see p. 363).

The Central Valley

The deep central valley which runs across the Island from Peel [SC 245 845] to Douglas [SC 385 755], since it affords an easy route bisecting the massif and separating the northern from the southern hills, has been noticed by all writers on the physical features of the country, and deserves our careful study. The first impression one receives upon examining it is that it is an antecedent feature, of high antiquity and independent of the general drainage system of the Island, due to conditions which may have prevailed at some period when the district has formed part of a larger land area. But this impression is dispelled by closer investigation, which reveals the probability that the gap has been caused by the breaking down of a ridge between two overlapping streams running respectively east and west from the central axis.<ref>We find that this explanation has been previously fuggested, in a single sentence in a paper by Mr. J. White; Remarks on the Geology of the Isle of Man. Trans. Geol Soc. of Glasgow, vol. vii. (1882), p. 84.</ref> The head of the ravine draining eastward is still intact at Cooillingill [SC 31432 79556] on the southern side of the valley west of Crosby; and the westward stream has probably had its source on the opposite side of the depression, in the coomb-like hollows on the eastern flank of Greeba mountain [SC 31977 81543], and has flowed round the southern end of that mountain, held in on the eastern side by a low ridge, since broken away, separating it from the former stream. Hence we may regard the gap which breaks the central ridge of the Island between Greeba and the craggy hill facing it on the south as principally the work of a westward-flowing stream now abolished. At present the main watershed of the Island lies about a mile to the westward of this gap, in the boggy bottom of the valley barely 160 feet above sea level: but this is clearly a case of captured drainage through the shifting back of the head-waters of the east-flowing stream. Close to this watershed two small streams discharge from the hills into the central valley from opposite sides—the Greeba River [SC 30930 80433] on the north and the Ballacurey or Glen Darfagh stream on the south; and in Pre-Glacial times these have both been branches of the westerly drainage-system. But at the present day, while the second stream still goes westward to Peel, the first turns eastward through the Greeba Gap and, joining the Cooillingill water, flows to the sea at Douglas. Their present channels in the valley near the watershed are, it is true, to some extent artificial; but the main came for their divergence in opposite directions is the position of the fans of flood-gravel which the swollen streams have spread out at their debouchure into the central valley in Late-Glacial or Post-Glacial times. Each diminished brook now turns aside from its former gravelly fan and continues along the trunk valley at right angles to its previous direction; and the accident therefore which has sent them in opposite directions to the sea is a slight difference of trend before leaving the hills, which has determined the situation of the bar at their mouths.

The central valley has, no doubt, been modified considerably during the Glacial Period, and especially during the closing stages, when it seems to have been occupied by temporary bodies of fresh water hemmed in by the waning ice-sheet; but that it was mainly excavated, in the manner above-described, previous to the Glacial Period is shown by its general characters. From both sides of the Island it narrows towards the centre, and has the sinuous course characteristic of fluviatile action. So far as can be observed, it cuts across the Slate Series without reference to their structure, like the other transverse streams of the Island. Its present floor rises gradually from sea-level at Peel and at Douglas to about 160 feet above sea-level at Greeba [SC 31169 80543]; and though the rock-floor is buried beneath drift and alluvium throughout its course, the general aspect of the rock-slopes of the valley suggests that the gradient of this floor corresponds in the main to that of the infilling material. Its erosion may indeed have been facilitated in one portion of its course westward of Greeba by certain peculiarities of rock-structure to be described in a later chapter (p. 52), which have tended to produce a somewhat more rapid weathering of the slates and therefore a general lowering of the surface; and its westerly termination nearly coincides with the faulted western margin of the Peel Sandstone; but, considered as a whole, in spite of its unique character among the valleys of the Island, we conclude that it may be explained as a combination of two simple valleys of erosion essentially similar in origin to the other valleys of the country.

The Southern Hills

On the southern side of the great valley both the central and western hill-chains are continued, though of less- elevation than in the northern area. Slieau Whuallian [SC 26477 80460], 1,054 ft., and Dalby Mountain [SC 24072 77951], about 950 ft., are the chief eminences of the western ridge, and South Barrule, 1585 feet, of the central; and the two converge southward and unite in Cronk ny Arrey Lhaa [SC 22443 74680], 1,449 feet, immediately overlooking the western coast. To the eastward, lower hills extend to the coast-line in the district occupied by the Manx Slates, but towards the south the

ground falls away into a drift covered lowland country of limited extent, which is underlain by the Carboniferous rocks. Southward from Cronk ny Arrey Lhaa, lower hills of slate form the western margin of this Carboniferous basin, and are prolonged into the Calf of Man [SC 15761 65728]. This islet is a little less than one square mile in extent, and its highest point is 421 feet above sea-level.

Excepting in the ground to the westward of the ridge of South Barrule [SC 25789 75939], the drainage of this area flows southward or south-eastward to the coast, in brooks of which the chief are the Santon River [SC 30730 74665], the Silverburn [SC 27536 69496], and the Colby River [SC 23051 71234]. These streams inn for the most art in shallow open valleys, and not in deep-walled glens like the majority of the Manx mountain streams. Their courses often present examples of local modification from the effect of the Glacial deposits with which the valleys are partly choked (see pp. 468–70).

The drainage of the depression between the South Barrule ridge and the Slieau Whuallian and Dalby Mtn. ridge is somewhat curious. Its higher southern portion, where the ridges unite, forms the gathering ground for a small river which flows north-north-eastward along it for two miles, occupying an inner hollow known as Glen Rushen. The stream then turns sharply at right angles to its former course, and goes west-north-westward, cutting through the Slieau Whuallian range in Glen Mooar, a deep Pre-glacial valley about a mile in length, and thence passes westward into Glen Meay, a smaller Post-glacial ravine, by which it reaches the western coast nearly 3 miles south of Peel. Between Glen Mooar and Glen Meay the stream captures a tributary from the south which seems once to have flowed northward to the Neb through a valley now dry, along which the high road goes from Dalby to Peel.<ref>Reference to the hill-shaded one-inch map will serve at a glance to elucidate this description, and also the previous account of the central valley.</ref>

The depression of which Glen Rushen forms the southern part is prolonged north-eastward from the point where the Glen Rushen stream escapes from it, a low watershed dividing its drainage between Glen Rushen [SC 24213 76931] and Foxdale [SC 28050 78183]. In this case the Foxdale drainage appears to be encroaching upon that of Glen Rushen. Foxdale is a deep Pre-glacial valley which carries the waters from the north-eastern slopes of South Barrule [SC 26896 76728] northward to the Neb at St. Johns [SC 27715 81653]. That it is an aggressive stream and is appropriating the drainage of its neighbours is further shown at its head, where its two branches have trenched respectively upon the sources of the Santon River and the Awin Ruy [SC 29006 73547], a tributary of the Silverburn; and it has moreover been artificially assisted in capturing drainage by a sluice which has been cut on the southern slope of South Barrule to bring more water to the reservoirs of the Foxdale Mines [SC 28331 78060].

The aggressiveness of this stream probably dates back to the elevation of the land in Pre-glacial times, its shorter course and consequently steeper gradient then giving it the advantage over its longer and more leisurely rivals. Other cases of the same kind may be studied in the central district north of the main valley, and the above descriptions may serve as generally typical for the stream-development of the billy part of the Island.

Present inactivity of the Manx streams

There is clear evidence in every part of the Island that the volume of the streams has greatly diminished during comparatively recent times, and that their present condition is one of relative inactivity as regards their erosive power.

The trenches cut into the drift deposits at the heads of the brooks, both in the mountains and on the lowland, are now usually dry and overgrown with grass, or are even becoming refilled with peaty growth, while lower down the valleys the stream-channels are often choked with coarse detritus beyond the power of the present waters to remove. The relative weakness of the existing Manx streams is also noticeable when they are compared with those of other areas of similar physical character, as, for example, with those of some parts of the English Lake District where the drainage, though shrunken from its former volume, is still doing vigorous erosive work.

These facts no doubt indicate changes of climate by which there has been a diminished and more evenly distributed rainfall, and less snow in the winter.

The total annual precipitation for the last twenty years varies from about 60 inches in the hills, to 25 to 30 inches on the plain,[1] which is less than the island might seem to claim from its geographical position and average altitude.

[1] Mr. A. W. Moore, Speaker of the House of Keys, to whom our knowledge of the meteorology of the Island is principally due, gives the following observed averages of rainfall for the twenty years 1878–1897:

Point of Ayre	24.6 inches.
Cronkbourne (near Douglas)	41.1 inches.
Calf of Man	24.6 inches.

He has also kindly furnished me with the following figures calculated for the same period at other localities where observations have been carried on for less than this time:

	Period of observation	*Actual fall*	*Calculated mean for 20 years.*
Druidale	2 years	61.1	60.6
Peel	5 years	35.5	38.1
L. Marks	6 years	5.5	39.5
Ballasalla ("Gauge probably in too sheltered a spot".)	7 years	30.3	27.5
Port Erin	3 years	31.7	33
Andreas Rectory	6 years	32.4	35.1
Langness	10 years	29.9	26.1

See also Mr. Moore's "Climate of the Isle of Man". (Douglas, Brown and Son. 1889.)

The force of the streams would probably be materially increased by a comparatively small additional rainfall, since the retentive power of the soil and vegetation on the valley slopes, though very effective up to a certain point, is lost when the saturation limit is reached; so that any excess of rainfall above the quantity requisite to produce this condition is shed at once into the streams and tends to produce powerful floods. But when, as at present in the Isle of Man, the precipitation is fairly evenly distributed throughout the year, and rarely sufficiently rapid to produce saturation, the water reaches the drainage channels so gradually that the streams, though constant, are persistently feeble. The great fans of flood-gravel which often mark the issue of the Manx hill-streams upon the plain betoken past conditions very different from those which now obtain (see p. 371).

The Coast-line

Not only from its extent but also from its wide diversity of character, the coast line is, as might be anticipated, of extreme interest to the physio-graphical student. The low Ayre beach along its northern margin has already been described. To the southward, fringing the drift-plain, are high cliffs composed entirely of Glacial clay sand and gravel, which crumble rapidly beneath the attack of the waves. So rapid is the encroachment of the sea upon these cliffs that the annual recession of the land in some parts of the parishes of Jurby and Michael, on the western coast, reaches an average of 4 feet (seep. 13). Where boulder clay enters largely into their composition these cliffs are occasionally precipitous; but more frequently they present long talus slopes, from the falling away of the loose stratified material which is generally their chief ingredient. On the eastern coast they stretch southward from the Ayre [NX 46474 05076] for 6 miles, usually between 50 and 90 feet in height, but rising to over 200 feet at Point Cranstal [SC 46091 99907] where they intersect the Bride Hills. On the western side of the Island they extend for eight miles, with an average altitude of about 80 feet, the solid rocks making their first appearance in the cliff 1½ miles to the southward of Kirk Michael [SC 31653 90673].

The tidal flat beneath these cliffs is everywhere broad and sandy, dotted here and there with large boulders derived from the wasting drifts and where the beach-material is locally stripped away by storms, a floor of red boulder-clay or pebbly loam is exposed.

The graceful contours and cheerful colouring of these cliffs render the natural scenery of this part of the coast very pleasing; while to the student of glacial geology these fine sections, by reason of their fossil contents as well as their exceptional height and extent, are of unusual interest.

To the southward of Ramsey [SC 45803 93518] on the east coast, and of Ballacarnane [SC 30091 88512] on the west, though the drifts still often form a thick capping to the solid rocks, the rugged dark-hued Manx Slates are the dominant factors of the scene:

These occur in jagged cliffs, whose outline varies according to the relation of the coast-line to the direction of dip of the slates. As the general strike of the strata is roughly parallel to the trend of the shores, and as the dominant structural dips are at high angles outward from an anticlinal axis in the interior toward the coasts, there is a prevalence of dip-slopes in the cliffs on both sides of the Island, which is, however, constantly interrupted by the coastal irregularities. The stratigraphical axis of the Slates is intercepted by the sea in the vicinity of Maughold Head [SC 49783 91386] in the north-east, and of Bradda Head [SC 18361 69914] in the south-west; and in the neighbourhood of these places the cliffs are characterized by rapid changes of lithological character, the various divisions of grit, greywacke and slate, which go to make up the Manx Slate Series, being contorted together and presented in swift succession; but in the middle portion of the Island the shores run principally amid the flaggy greywacke divisions—the Lonan Flagson the east, and the Niarbyl Flags on the west—so that the prevalent rocks of the cliff-sections are these alternately thick-bedded and thin-bedded gritty or slaty flags.

From the hilly character of the ground out of which they are carved, the cliffs vary greatly in altitude. They are not often precipitous from base to crest, their profile in most places exhibiting a long steep upper slope terminating in a shorter more nearly vertical wall below. The long slope appears to represent the degraded remains of the Pre-glacial coastal feature, while the shorter precipice at its foot marks the re-advance of the sea since Glacial times.

On the eastern side of the island, the boldest and most picturesque portions of the coast are Maughold Head [SC 49783 91386], about 250 feet; Bulgham Bay [SC 45751 85631], 600 feet; Clay Head [SC 44361 80547], 300 feet; Douglas Head [SC 39050 74759], 300 to 400 feet; and Spanish Head [SC 18256 65798] about 400 ft. in height. The Calf [SC 15841 65652] is surrounded by steep cliffs, and except in very calm weather there are only two places where it is possible to effect a landing upon it. The Chickens Rock [SC 14318 63929], on which stands a fine lighthouse, is an insulated low-water reef, composed of the Manx Slates (see p. 173), lying off three-quarters of a mile to the south-westward of the extremity of the Calf.

Where the Carboniferous rocks of the southern area occupy the coast, the shore is broad and shelving and the cliffs low; and there is an absence of the jagged outlines which characterize the sea-margins of the older formation.

On the western side of the Island, the cliffs in the slaty rocks to the southward of Kirk Michael are comparatively low, but full of picturesque detail from their irregular erosion. These extend southward for 2½ miles, and a fault [SC 29808 88868] then suddenly brings in the Peel Sandstones whose steep dip-slopes form a more regular sea-margin for the next two miles, up to the town of Peel. At Peel [SC 24046 84277] the slates reappear and are continuous thence throughout the western coast, forming bold cliffs, with scarcely any drift-capping excepting in the low tract between Glen Meay and Dray and in the coves of Fleshwick [SC 20336 71698] and Port Erin [SC 19567 69167]. Near Contrary Head [SC 22782 82836] the ground neighbouring the coast rises to 500 feet; while to the southward of Dolby, where the cliff-line intercepts the principal hilly axis, it presents a magnificent series of rudely terraced precipices plunging from the summit of Cronk ny Arrey Lhaa [SC 22435 74717], 1449 feet above Ordnance datum, down to the sea-Thence to Bradda Head [SC 19701 71513], a distance of 4 miles, the grandest cliff-scenery of the Manx coast is traversed, the crest of the declivity never sinking below about 650 feet except in the lovely recess of Fleshwick [SC 20174 71454]. The ground also falls away rapidly inland, so that the views from the summit over land' and sea are delightful, including in clear weather, down on the western horizon, a long stretch of the north-eastern coast of Ireland, with the Mourne Mountains in the background.

Coast erosion

The following notes were drawn up by the writer in 1897, at the request of the late Deemster Gill, to be laid before a Committee appointed by the House of Keys to inquire into the coast erosion of the Island:

"It was found during the course of the survey that the greatest loss had taken place in the parish of Jurby, where in some instances a span of 50 yards had disappeared since the Ordnance Map was made, 28 years before. Near Orrisdale the loss in the same period had been from 20 to 30 yards, and it had been about the same near Kirk Michael. Northward from Sartfield, in Jurby, there was practically no loss, as the cliff is protected by a low platform of shingle and blown sand continuous with the ancient sea-beach which forms The Ayre. This protecting platform evidently once extended farther southward, and is slowly yielding to the flank-attack of the sea. So long as it remains there can be no waste of the cliff behind it; and the idea prevalent in the north of the island, that the loss of land is greater now than formerly, probably has its basis in these conditions. The current impression, however, that The Ayre is still increasing is a mistaken one. (See pp. 402–3.)

"The removal of shingle is generally held to be detrimental to the preservation of the cliffs, but its effect must vary very much according to the local conditions. Where the cliffs are wasting rapidly the new material annually added to the beach must greatly exceed the quantity removed by human agency, and if the shore were left undisturbed it is probable that the shingle would still be carried down by tidal action. But where no new material is being added to the beach, the removal of the sand and gravel must be harmful by lowering the shore and increasing the power of the waves upon the cliff. In every case the larger boulders should be allowed to remain, as these are not readily washed away, and tend to accumulate at the foot of the cliff as a rude breakwater.

"The subject of Coast Erosion generally has been investigated by a committee of the British Association, and a large body of information from all parts of the kingdom has been collected and published in the annual reports of the Association, wherein many valuable hints as to the result of the removal of shingle and the effect of various kinds of protection-works may be gleaned.

"The district of Holderness in East Yorkshire furnishes a case exactly similar to that of the northern part of the Isle of Man. In both areas the land consists of loose deposits of sand, gravel and boulder clay, forming low tracts upon which the sea is steadily encroaching. In Holderness, along a coast line of about 35 miles the average loss is stated to be at the rate of 21 yards per annum, though in some places the loss is as high as 5 yards per annum. Defences have been erected to protect the towns of Bridlington Quay, Hornsea and Withernsea, but no attempt has been made to preserve the purely agricultural land as calculation has shown that the annual charge of any efficient scheme of defence would exceed the value of the land lost in the same period. This subject has been fully discussed from the standpoint of the engineer by Mr. R. Pickwell, C.E. In his paper on 'The Encroachments of the Sea from Spurn Point to Flamborough Head, and the Works executed to prevent the Loss of Land' (in Proc. Institute of Civil Engineers, vol. li., 1877–78), Mr. Pickwell considers that the coast might be efficiently protected by a system of timber groynes, 300 to 400 feet in length, and 300 to 400 yards apart of which the cost would be approximately (in 1877) £1 10s. per lineal yard of protected coast.

"He then states that 'taking a length of 1,200 yards of coast and the loss at 2½ yards per annum, there is an actual loss of land of from three-quarters of an acre to one acre per annum, equal to £35 to £50 per annum. The interest alone on the cost of protective works, as suggested, for the same length of frontage, would be equal to £90 to £100 per annum, at five per cent., so that to the landowners as a whole it is cheaper to lose the land than to protect it.'

"The Memoir of the Geological Survey on 'Holderness', by Mr. Clement Reid, contains full details of the loss of the land in Holderness".

Durability of the Manx Slate Series

From their tough and well-knit character all the members of the Slate Series are very enduring under the attack of the sea. The cliffs are moreover protected in most places by the presence of a bare rocky tidal-reef ending off in deepish water, and by the consequent scarcity of the beach-material which is so powerful an agent in erosion. Hence the waves break with so little effect against the rocks that even during storms the water remains unclouded, except in the vicinity of the shingly recesses where there is sometimes a little rock-flour in suspension. Indeed we find that in these old rocks the

coast-line of the Island, like the drainage system, has undergone only slight modification since Pre-glacial times. That is to say, the recession of the rocky part of the coast since Glacial times has not been sufficient to affect materially the outline of the old massif, and there are many indications that cliffs of the slate rocks were in existence in Pre-glacial times in approximately the same position as those of the present day. The rocky tidal shelf on the more exposed parts of the coast appears usually to represent the extent of Post-glacial erosion, while in some of the larger bays, *e.g.* those of Douglas, Port St. Mary and Port Erin, where the foreshore is broad and smooth there are patches of drift upon the rocky platform, apparently mdicating that even this feature may sometimes be Pre-glacial; and in a few sheltered recesses the ancient cliff-slope is still unbroken (see pp. 346, 446, 462).

The persistence in many.places of the little notch which was cut into the base of the cliffs during the Raised Beach stage, already commented on, affords another illustration of the slow progress of marine erosion. This quality of the mass of the strata serves to accentuate the effect of the sea upon every plane of weakness in the massif; and the coastline is therefore gashed by innumerable narrow gorges and partially roofed recesses, marking the lines along which the rock is dislocated and somewhat shattered (see p. 86). These in some parts of the Island are known as Gullets; in others as Ghaws— the latter a term of Norse derivation, in common use in Iceland for similar features. Where these channels intersect, rude rock pillars or Stacks are isolated, which stand like sentinels a little in advance of the main cliff-line. These are the favourite haunts of seabirds. Wider recesses named Purts or Ports occur at intervals; and in them, as in the more open bays, there is usually some accumulation of beach-material, which in Manx is called the Traie.

Other physical details regarding the coast will be mentioned in the account of the stratigraphy of the cliffs in succeeding chapters.

Sub-aerial weathering of the Manx Slates

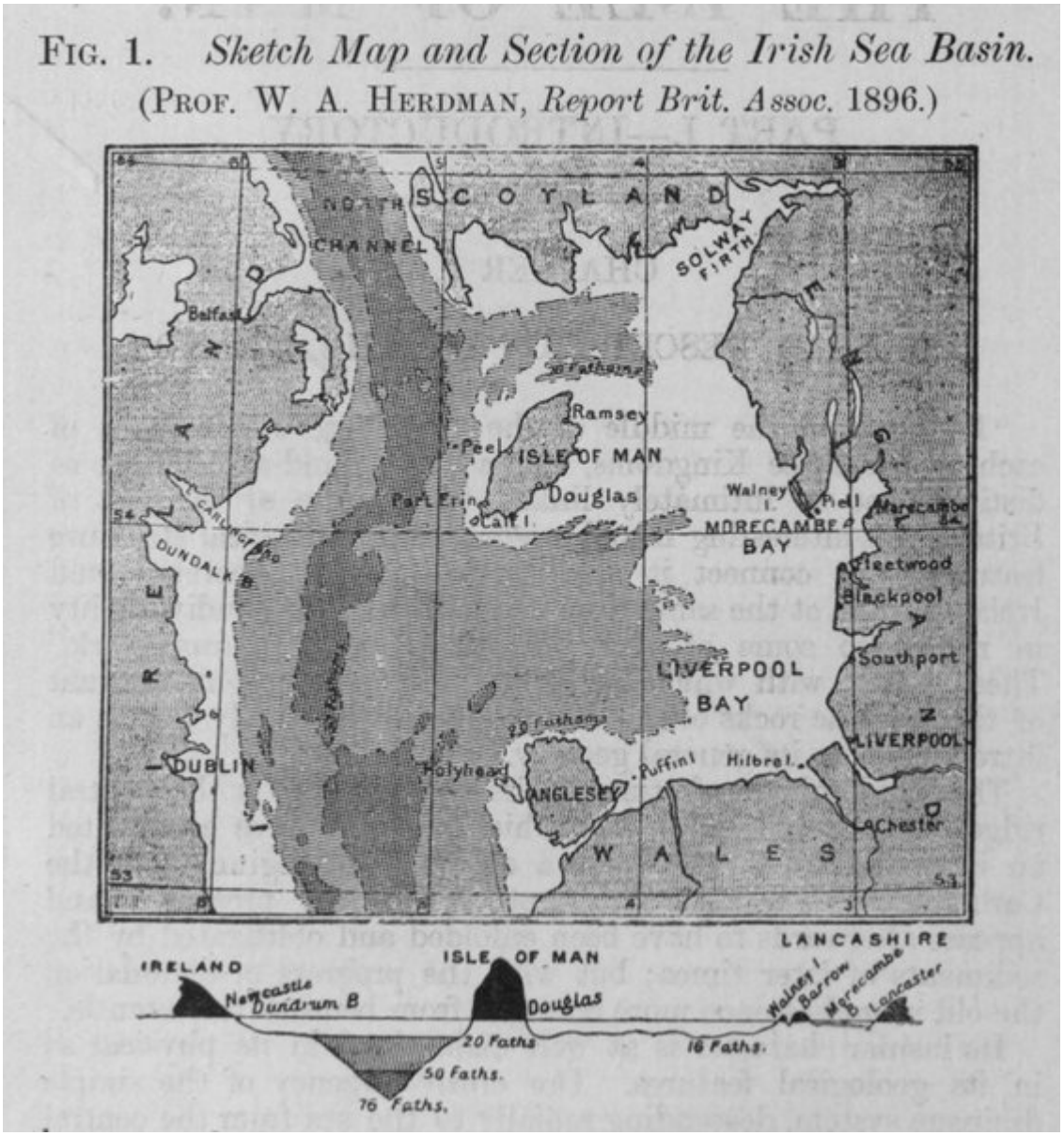
It sometimes happens that rocks which offer a firm resistance to the sea, are yet crumbled away readily by the less boisterous but more subtle sub-aerial agencies. This is not, however, the case with the Manx Slates, which appear to give way as slowly to the one attack as to the other. In no part of the series are the rocks in themselves permeable to water, so that it is only along the lines of jointing and faulting that underground percolation can take place in them, and the sparsity and insignificant size of the rock-springs show that the amount of water thus conveyed must be very limited. The structural changes; due to pressure and earth-movement, which the strata have undergone, while often obliterating the tendency to split along the bedding planes, have not usually developed a sufficiently definite cleavage to render the rock readily fissile in any other direction. The result is especially notable in the argillaceous portion of the series, which has been so toughened and welded into one mass that, though intrinsically much softer than the greywackes and grits, it is much less jointed and less liable to splinter, and has therefore resisted disintegration better. Hence we find that the higher ridges of the Island, with all its chief eminences, are principally composed of the comparatively soft argillaceous Barrule Slates, while the hard Agneash Grits, with the Lonan and Niarbyl Flags, for the most part occupy lower ground on their flanks.

The granitic bosses also form comparatively low ground in the massif, and the intrusive igneous dykes with which the sedimentary rocks are often riddled are rarely prominent at the surface.

The persistence of the old massif as a land area is evidently due to this enduring quality of its component strata.

As a general rule, it has not been found that the valleys of the Island bear any relation to the stratigraphy of the present surface; but there are certain exceptions in which, on a limited scale, some such relationship may exist, as, for example, where Sulby Glen follows for some distance the main belt of Crush-conglomerate, and where Glen Agneash coincides for a short space with the outcrop of the Laxey metalliferous lode.

FIG. 1. *Sketch Map and Section of the Irish Sea Basin.*
(PROF. W. A. HERDMAN, *Report Brit. Assoc.* 1896.)



(Figure 1) Sketch Map and Section of the Irish Sea Basin. (Prof. W. A. Herdman, Report Brit. Assoc. 1896.)