i
No. XXXIV.—NOTES ON THE GEOLOGY OF FIFE. By the Rev.
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THE county of Fife lies between the firths of Forth and Tay, and forms with Kinross a rectangle 36 miles in length by 14 in breadth. The total area of the two counties is about 600 square miles, and the coast-line extends to 85 miles. Through the middle of the county, for the greater part of its length, runs a hollow—the Howe of Fife, in the eastern half of which the river Eden flows, discharging itself into St. Andrews Bay. From Loch Leven the river of the same name issues, and after an easterly course of 12 miles falls into Largo Bay. Along the northern boundary to the west are the Ochil Hills, which are continued eastward as a ridge of moderate height between the Eden and the Tay, one of the peaks, Norman's Law, being 850 feet. North-east of Loch Leven are the Lomond Hills, 1713 feet; Largo Law, 1020 feet, is a conspicuous landmark on the bay of that name, and to the east of this Kelly Law rises to 800 feet. The Cullalo Hills, near Aberdour, attain a height of 750 feet, while the Cleish and Saline Hills, of similar height, are situated in the extreme west of the county. The surface of Fifeshire generally is undulating, exhibiting considerable variety, and the scenery in many parts is highly picturesque.

The geological map of Fife might be represented by a *tricolor* flag, the three horizontal bands corresponding to the three great formations of which the rock-strata of the county are built up. The northern strip is entirely occupied by great sheets of interbedded trap, variously designated whinstone, greenstone, felstone, and porphyrite. The middle belt of the county is formed of rocks belonging to the upper series of the Old Red Sandstone period. Loch Leven, Kinross, Strathmiglo, and Cupar are situated on this central area. The southern zone, which is the widest of the three, consists of strata belonging to the Carboniferous period, interrupted here and there by outbursts of igneous rock associated with patches of volcanic tuff and breccia. Taking them in order, we have the three bands running east and west :—

- I. The northern zone of Interbedded Trap or Porphyrite.
- II. The middle zone of Old Red Sandstone.
- III. The southern zone of Carboniferous strata.

I. The rocks of this northern zone are continuous with the traps composing the Ochil Hills, and form the eastern portion of the great belt of volcanic strata which stretches across Scotland from S.W. to N.E., through the counties of Renfrew, Dumbarton, and Stirling, into Fife. Known as the great trappean conglomerate, this belt includes rocks which belong to different ages. The trap rocks of Scotland have been formed at very different times—periods of intense volcanic activity alternating with long ages of inaction. During the early part of the Old Red Sandstone period the central district of Scotland was the scene of volcanic phenomena on the grandest scale. Miles on miles of country were deluged with fiery floods of molten lava, or buried under showers of scorïæ and volcanic dust—the Pentlands, the Ochils, and the Sidlaws being built up of successive sheets of consolidated lava erupted during this period. Then followed a long epoch of tranquillity, throughout which our Scottish volcanoes remained dormant, and the deposition of the stratified rocks of the Old Red Sandstone formation proceeded without interruption.

The succeeding age, to which belong the calciferous sandstones forming the base of the Carboniferous system, witnessed a renewal of volcanic activity. In this era the volcano of Arthur's Seat came into existence, throwing out the streams of basalt and porphyrite and showers of ashes which have formed the lower portion of that well-known hill. The traps of the Lennox and Kilpatrick ranges, the hills of Renfrewshire and North Ayrshire, the heights between Bathgate and the Forth, beds of tuff and porphyrite between Haddington and Dunbar, and possibly also similar accumulations near Burntisland, date from this time.

Above the calciferous sandstones lies the mountain limestone series. While the strata comprising this second division of the Carboniferous system were being laid down there existed numerous active volcanoes scattered over the central area of Scotland. During part of this period the greater portion of what is now Fife must have presented the appearance of an archipelago of volcanic islands, each fringed with its reef of coral, like groups of islands now existing in the Pacific Ocean. The eruptions became less frequent during the deposition of the millstone grit, and a period of comparative tranquillity succeeded, during which the true coal measures, forming the uppermost division of the Carboniferous system, were accumulated.

Along the coast of Fife there are numerous isolated bosses, necks, and veins of trap, indicating that some at least of the volcanic cones of the Carboniferous period continued to manifest activity down into Permian times. The troubled condition of the coal strata furnishes conclusive evidence on this point. At the historical and far-famed Hill of Beath the trap has burst up through the limestone series, and the coal seams through which it passed are burnt for some distance round. The structure of the hill is that characteristic of a volcano; there is the central vent, containing a plug of lava encircled by beds of tuff formed of débris expelled from the volcanic orifice. The Lomonds, Largo Law, Kelly Law, and many lesser hills throughout the county also date in all probability from the time of the mountain limestone.

Early in Permian times volcanic action all over Scotland subsided; the masses of rock and tuff which had been thrown up from the earth's interior began to be worn down by atmospheric denudation, and the softer parts were removed, exposing the harder central stumps of the extinct volcanoes. Of these, Arthur's Seat, a typical instance originating in the calciferous age, remained dormant, according to Sir A. Geikie, all through the remainder of the Carboniferous period. In early Permian times it broke out again, but from that period till now has remained inactive, though it would hardly surprise a geologist to learn any day that Arthur's Seat was once more in an active state of eruption.

There is no subsequent record of volcanic action in Scotland until we come down to Miocene times, and this represents an immense interval of time, for between the Permian and Miocene formations lie the whole of the Mesozoic strata, together with the Eocene beds. It may be accepted as certain, however, that during the protracted period in which the New Red Sandstone, the Jurassic Series, the Chalk, and the Eocene strata were in course of formation no active volcanoes existed in Scotland. In the meantime all the species of plants and animals had changed; the old forms had become extinct, and had been replaced by entirely new races. But the volcanic forces, though so long dormant, had not permanently ceased; in the Miocene age a fresh outburst on a grander scale than ever took place. This

time the greatest masses of lava were poured out on the western shores of Scotland. The basalts of the Giant's Causeway, Staffa, Skye, and the inner Hebrides are of Miocene age, these hardened lava floods attaining in Mull a thickness of over 3000 feet. Nor was the disturbance confined exclusively to the west, for all over Scotland there occur numerous trap dykes, generally running east and west. These have originally filled vertical fissures into which the melted lava was forced from below, passing up through the various horizontal beds. This lava solidified as it cooled, and long afterwards, in cases where the softer sedimentary strata, through which it rose, had been removed by atmospheric denudation, remained in the well-known form of a trap dyke. Such dykes of Miocene lava breaking through the sedimentary strata occur in all parts of the Fife coal-fields. A good example may be seen close to the shore, not far from St. David's.

The great belt of igneous rock which traverses the centre of Scotland from east to west, though continuous on the map, includes traps of various ages. The main masses west of Stirling, forming the Fintry, Campsie, and Kilpatrick ranges, and the traps of the Renfrewshire hills, belong to calciferous times; while the Ochils and the interbedded traps covering the northern zone of Fife, belong, on the other hand, to the earlier age of the Old Red Sandstone. From the circumstance that volcanic products are found interstratified with sedimentary rocks, we infer that the volcanic eruptions which threw up the former were contemporaneous with the deposition of the strata among which these volcanic products occur. These interbedded traps are well exposed in Glen Farg, through which runs the new railway route to Perth; they are also well seen near Newburgh station on the line to Ladybank.

Nearly all the hills of Fife are of trap, at least in their upper portions. This is apparent even from a distance, for the long level or slightly sloping lines and step-like terraced sides and ends outlined against the sky cannot be mistaken. But while the larger sheets are contemporaneous and interbedded, the smaller masses of later date are generally intrusive and break through, violently disrupting the subjacent rocks, which, from the effects of heat, are altered at the points where they come in contact with the trap. The older lavas differ in chemical composition from

the more recent; the former being acid and containing excess of silica, while the latter are basic. They differ also in their mode of weathering—Abbey Craig, Stirling Castle, and Craigforth furnishing examples of concentric greenstone. Of similar character is the intrusive dolerite at North Queensferry, which weathers into rounded masses, often forming almost perfect spheres. This rock is extensively quarried for causeway and kerb stones. Good examples of jointing and very marked lines of ex-filtration may be seen in some of the quarries. Cavities are occasionally found filled with crystals of calc spar, or sometimes with bituminous matter having a naphtha-like smell, derived doubtless from the beds of shale through which, in a fluid condition, the rock was ejected. The island of Inch Garvie, on which rests the central cantilever of the Forth Bridge, is a narrow ridge of the same dolerite, rising abruptly from the bed of the Forth, which at this point is of great depth. A mile or so westwards, opposite the anchorage of St. Margaret's Hope, the dolerite gives place to dark-coloured basalt having the characteristic conchoidal fracture. On the beach at Rosyth Castle the basalt may be seen, its surface showing innumerable lines of cross fracture.

As has been pointed out by Sir A. Geikie, the traps of Carboniferous age in Fife and the Lothians occur as small isolated masses, while those of corresponding age in the western counties form extensive beds. Such isolated bosses and necks are very numerous along the shore, particularly in the east of Fife. On the beach between Elie and St. Monance may be seen several instructive examples of volcanic necks or vents, filled with basalt, or in some cases with agglomerate. The space occupied by volcanic rocks in the middle and southern zones is, however, small relatively to the total area, but the northern belt, with the exception of a narrow fringe of Old Red Sandstone strata on the south-side of the Tay, is entirely taken up by the interbedded traps which, as we have seen, were poured out by volcanoes at the beginning of the Old Red Sandstone period.

II.—The middle zone is formed of rocks belonging to the upper series of the Old Red Sandstone, and, in the valley of the Eden, these beds are exposed at a number of places. Not far from Dairsie station there is a fine section of cliff composed of massive yellow sandstones. The road passes between the river and the

cliffs, which are about 60 or 70 feet high, while Dura Den, a beautiful spot and classic ground to geologists, is close by. These yellow sandstones have yielded numerous specimens of fossil fish, *Holoptychius*, *Glyptolepis*, *Pterichthys*, &c., and form the subject of a monograph by the late Rev. Dr. Anderson of Newburgh. The seam from which the fish were obtained lies along the bed of the stream. On the slabs preserved in the Edinburgh Industrial, in the Hunterian of Glasgow, and other museums, the fish occur in such numbers as to indicate that they perished suddenly. Exactly similar fossils have been obtained from the Heads of Ayr. During a recent visit to Dura Den the writer did not succeed in finding any ichthyolites but had the consolation of learning from a native that there were "plenty o' fine trout in the burn."

On the adjoining heights, from which one obtains a magnificent view of the Howe of Fife, are extensive freestone quarries where plant remains occur in great abundance. The thin uppermost seam is a veritable exhibition in black and white, but unfortunately the impressions soon fade when exposed to the action of the air. Casts of *Lepidodendron*, *Lepidostrobus*, *Calamites*, and others, possibly *Cordaites*, or perhaps the leaf stalk of a fern, are to be found in these quarries. *Stigmaria*, with the rootlets attached, is very frequent; these rootlets leave smooth grooves in the fine-grained sandstone which might easily be mistaken for worm-tracks.

The yellow sandstones of Dura Den correspond with the Elgin beds from which the remains of fish belonging to the same genera have been obtained. The occurrence of reptilian remains in the newer Elgin beds is, however, indicative of Triassic age, and there is reason to suspect that these latter lie unconformably upon the Old Red Sandstone group below. Fish remains are also not uncommon in the lower division of the Old Red series to which the flagstones of Forfarshire and Caithness belong; and from the Carmyle quarries the remarkable crustacean *Pterygotus* is obtained, of which a magnificent specimen is preserved in Arbroath museum. The Old Red strata seem to have been deposited in a great inland lake, or possibly series of lakes, formed by the gradual shallowing of the Silurian seas.

III.—All the four main divisions of the Carboniferous system

are represented in the southern zone of Fife. If a line be drawn from St. Andrews due south to Elie, all the triangular area to the east of this, as far as Fife Ness, consists of rocks of the calciferous sandstone group, with the exception of a small tract at St. Monance and Pittenweem. This small area is occupied by a part of the Carboniferous limestone series let down among the calciferous beds. In it there occur a number of coal seams, but of so poor a quality that they have been abandoned. Passing westwards along the coast, from Elie to Largo, we are on the mountain limestone series; from Largo to Pathhead we cross the Dysart coal basin, belonging to the upper coal measures. At Pathhead a narrow band of millstone grit is passed, and at Kirkcaldy we are again on the Carboniferous limestone. At Kinghorn and Burntisland there occur great masses of porphyrite with interstratified tuff, and between this and North Queensferry we return to the calciferous series. At the latter place, a great mass of intrusive dolerite has burst up through the calciferous shales and sandstones. The overflow has formed the massive beds of whinstone, 150 to 180 feet thick, which surround Inverkeithing Bay, and also the Ferry Hills which jut out into the Forth, contracting its channel by a half. On the outer edge of this mass of dolerite the northern piers of the Forth Bridge are built. When first seen by the writer the beach at this point vividly recalled a part of the shore at Catania on the coast of Sicily, where a lava stream from Mount Etna has entered the sea, the scenery of Fife generally, as viewed from the Forth, being Sicilian in character. West of the Forth Bridge the limestone group reappears and continues on to Culross; to the west of which, near Dunimarle, we get the Castlecary limestone and the millstone grit. Beyond Blair Castle the slaty-band ironstone comes in, and the Kincardine and Alloa coals, which belong to the upper or true coal measures.

We thus see that along the south coast section there are two principal areas of geological elevation, viz., in the extreme east of the county and on the portion between Burntisland and the Forth Bridge; on these areas the low-lying Calciferous series is thrown up to the surface. The general dip of the strata agrees with these main undulations, though there are frequent lesser foldings, and in many places, the strata are faulted and disrupted. Inland, the main faults run east and west; in the Dunfermline

district there are four principal faults, ranging from 10 to 100 fathoms, by which the strata are thrown up towards the north. In general, the strata dip to the north, and as a result of the step-like faulting we meet, in passing northward, the same seams cropping out again and again.

(1.)—The calciferous series consists largely of flaggy sandstones, varying in colour from white to purple, and usually bearing ripple marks, with occasionally, the impressions of raindrops. These sandstones are well seen on the shelving shores at St. Andrews, Aberdour, and Rosyth. The shales, which attain a thickness of more than 100 feet, correspond with the oil shales so largely developed across the Forth in Linlithgowshire. From the shale oil is extracted at Binnend Works near Burntisland. This shale crops out again at North Queensferry, where it is traversed by a seam of clay-band ironstone.

A cliff near Rosyth Castle, consisting of thin beds of shale and compact earthy limestones, strongly recalls the Ballagan beds of the Campsie district, which also belong to the horizon of the calciferous or cement-stone series. Thin limestones occur here and there; of these the most interesting is the Newbigging seam, between Burntisland and Aberdour. This limestone is the equivalent of the Burdiehouse seam, and consists entirely of ento-mostracan remains. It is clearly a fresh-water deposit, and, from the appearance presented by the myriads of little *Cypris* cases of which it is made up, gets the name of seed-cake limestone. At various points between Kinghorn and St. David's occur masses of a peculiar volcanic breccia containing plant remains. This rock has evidently been formed out of pieces wrenched from different strata as the result of numerous explosions, for it consists of angular fragments of sandstone, *cypris* limestone, shale, and coal, cemented into a kind of concrete, sometimes hard enough to be used for building purposes. It may be seen in the immediate vicinity of the new pier at Aberdour. From it have been obtained many specimens of petrified wood in which the minute structure is admirably preserved. Fossil stems (*Lepidophloios*, &c.) from the porphyrite tuff of Burntisland have been made the subject of several interesting papers by Professor Williamson of Manchester.

On the whole, organic remains are scanty in the calciferous series, though scales of ganoid fish, and those doubtful structures

known as conodonts, supposed to be the jaws of annelids, are found in some parts of the shale. The general character of the group points undoubtedly to a fresh-water origin; like the rocks of the Old Red Sandstone, the calciferous series must have been deposited either in an inland lake or in the estuary of some mighty river. The thickness of the series has been estimated at 2000 feet.

(2.)—The Carboniferous limestone series covers a larger proportion of Fife than any of the previously mentioned groups. It consists mainly of sandstones, coals, shales, and limestones, the limestone which forms its base being quarried in many places. There are large works at Charleston from which great quantities of lime are annually shipped to various markets. The rock is here over 50 feet thick; it contains 92 per cent. of calcic carbonate, and abounds in fossils, corals—*Cyathophyllum*, *Lithostrotion*, and *Zaphrentis* being among the number—and various species of *Productus* and *Crinoidea*. From the Calais Muir quarry, north of Inverkeithing, some species of *Orthoceras*, and heads of the crinoid *Poteriocrinus* have been obtained. In Roscobie quarries, north of Dunfermline, fossils representing a marine fauna of the most varied description abound, and of these a goodly collection is to be seen in the Smith Institute at Stirling. Very fine septaria, with pyrites containing traces of copper, are abundant in the marly shale at Calais Muir, and lead ore has been obtained in small quantity near Inverkeithing.

The Dunfermline coal-field, which extends from the Cullalo Hills on the east to the Saline Hills on the west, forms part of the mountain limestone series, and is thus equivalent to the Possil and Maryhill coals of the Glasgow area. It has been worked for over 600 years. In 1291, a charter was granted to the Abbot of Dunfermline by the proprietor of Pittencrieff, conferring the privilege of working a coal pit on that estate. About the middle of the fifteenth century an Italian, Æneas Sylvius, who afterwards became Pope Pius the Second, relates that when visiting Scotland he saw the poor people, who in rags begged at the churches, receiving for alms pieces of stone with which they went away contented, adding that they burn them instead of wood, of which their country is destitute. Boetius, referring to Scotland in an account written early in the sixteenth century, states that

there "black stones are dug out of the ground which are very "good for firing, and such is their intolerable heat that they melt "iron and are therefore very profitable for smiths and other "artificers in metals."—(Chalmers' "History of Dunfermline," vol. i. p. 20).

The principal seams are known as the Dunfermline Splint or 4-foot, the 5-foot, and the 8-foot seams. In the Wallsend basin a 7-foot seam comes in above these, while the Little Splint, No. 3, the Ironstone, and Parrot form a still higher group, occurring in various pits. At the Elgin Colliery, a shaft of 105 fathoms passes through nineteen workable seams of coal, making an aggregate of 50 feet. This section shows 111 seams of alternating shale, sandstone, and coal, including altogether twenty-seven coal seams with a total thickness of 57 feet. Eastward, at Lochgelly pits, there are found in descending order, a 14-foot coal, the Lochgelly Splint and Parrot, the Mynheer, and the Splint, while at Donibristle we have the same series, with the limestone and calciferous rocks, cropping out on the flanks of the Cullalo Hills. From the last-named colliery have been obtained specimens of coal which were found by the late Professor Balfour to consist entirely of the spores of plants belonging to *Lycopodiaceæ*. Teeth of *Megalichthys* have occasionally been found in the Elgin and Halbeath pits. Seams of blackband ironstone occur in Townhill, Cowdenbeath, and several other pits, and near Oakley, to the west of Dunfermline, there were formerly extensive iron-works, but the furnaces have not been in operation for over twenty years. The Kirkcaldy series, also belonging to the Carboniferous limestone period, includes—in descending order—the millstone grit, thin coals, limestone, coal, Rough coal, Splint, the Duddie Davie, Black, Parrot, Upper Smithy, and Lower Smithy coals. On the St. Monance and Pittenweem area there are seventeen thin coal seams and five limestones, the latter with an aggregate thickness of 37 feet. In the extreme west of the county at Torryburn and Preston Island there is the following series:—Blackband, Lowrie Graham's, 6-foot, 9-foot, 5-foot, and $2\frac{1}{2}$ -foot seams. Preston Island, with its ruined buildings, forms a picturesque landmark in this part of the Forth. The seams just mentioned are inclined at a very steep angle, recalling the edge coals of Portobello. There is an old shaft on the shore near

Torryburn which must formerly have communicated with the one on the island, for there is a well known story connected with it. King James VI. of Scotland was taken down on one occasion by his courtiers and when brought up to the daylight through the shaft on the island, seeing the water all around him, his suspicious nature gave vent to itself in the exclamation, "Treason! Treason!"

A little further west, in the flagstaff park at Low Valleyfield, we come on the outcrop of the Cowglen or "Index" limestone. West of this again, and still higher up in the series, are the outcrops of the Janet Peat coal and limestone. The latter is identified in the Survey with the calmy, Arden, or Hurlet seam. The strata at this point have been thrown into folds, and the dip changes rapidly; a trough is formed, and the Janet Peat limestone, which crops out just behind Culross Townhouse, is again encountered at Blair burn, further west. This seam occupies the same horizon as the Robroystone limestone which crops out in George Square, Glasgow. Beyond Dunimarle we get the Castlecary limestone and the millstone grit, west of which lies the Clackmannan and Alloa coal basin, where occur the Upper 5-foot, the 9-foot, the Cherry, and the Splint coals, all belonging to the true coal measures.

On comparing the Carboniferous limestone series of Dunfermline with the corresponding strata of the Edinburgh or Glasgow districts, one is struck with the paucity of limestone in the former. No limestones have yet been found in the upper coal measures of the Glasgow district, so in this respect the Dunfermline basin, though belonging to the lower, rather resembles the higher series. It would appear that during the latter part of the mountain limestone era the deeper water lay to the westward, and that the Dunfermline area was occupied by a shallow lake or estuary, on which the accumulation of river sediments took place, the conditions being unfavourable to the formation of calcareous strata.

(3) The millstone grit covers but a small part of Fife. West of Dysart is a narrow strip running north to a point west from Thornton, and we do not meet with it again till near Kincardine, where it occupies Culross Moor and Tulliallan forest. Its strata consist of the characteristic coarse-grained sandstones and fine quartz conglomerates.

(4) The upper or true coal measures in the Dysart basin include eighteen seams, known as Wemyss Castle; Wall; Barn Craig, 5' 6";

Upper Coxtool, 3' 6"; Lower Coxtool, 3'; Den, 2' 2"; Chemiss, 9'; Bush, 3' 6"; Parrot, 2' 3"; Wood Coal; Earl's Parrot, 2'; Bowhouse, 6' 6"; Brankston, 4'; Boreland; Shandwell; Dysart Main, 21'; Clayband ironstone, 2'; and the 7-foot coal. Inclusive of the lower seams of the limestone series, we have a theoretical aggregate thickness of 120 feet of coal on this area. When we compare the Dysart series with that of Dalkeith, the general correspondence points to both areas having once formed part of the same basin. The Dysart Main seam of 21 feet, for example, may very well correspond with the 15 feet seam at Portobello, while a 7 feet seam forms the base of both series. As a whole, however, the beds must have thinned out towards the north, for a section in one part of the Edinburgh field passing down through 3000 feet of strata reveals fifty-eight coal seams, with a total thickness of something like 150 feet. The equivalents of the Dysart series are to be found in the district east of Glasgow—*i.e.*, at Rutherglen, Shettleston, Bothwell, Coatbridge, and Airdrie, all situated on the upper coal measures; the Upper Soft, Ell, Main, Humph, Splint, and Virgin coals of the Bothwell pits, and the Blackband, Musselband, Virtuewell, and Drumgray seams of the Airdrie pits being their representatives in the western coal-field.

The number of these Dysart and Dalkeith coal seams, as well as their total thickness, may well induce us to pause and reflect on their geological significance. A coal seam approximately represents an old land surface, being composed for the most part of the remains of terrestrial plants, which cannot grow without air and light. When, then, a coal seam is discovered at a depth of 3000 feet, this affords conclusive evidence that the land has been depressed to something like this extent. But fifty or more coal seams may be superposed one above another, with beds between them of sandstone and shale which could only have accumulated under water. All this could, of course, be explained on the theory of alternate elevation and depression of the land level. Such oft-repeated alternations are not indeed impossible, but it is much simpler to suppose that it was brought about by the continuous sinking of the coal area. The formation of a coal basin may be accounted for in some such way as this—first, we may suppose that over a certain extent of land surface a quantity of vegetable matter sufficient to form a seam of coal had accumulated;

next, that by depression this area became submerged, and was buried under sand and mud brought down by river action from the neighbouring land; that this sediment continued to be deposited until the depressed area was completely silted up and the river confined to a narrow channel. In this way the level would be restored, and, vegetation again taking possession of the ground, material for the second coal seam would in course of time be formed. This process repeated time after time would ultimately, as the subsidence continued, give rise to a series of strata like those of which the Carboniferous system is built up. But the lapse of time, which a system many thousand feet in thickness, and formed in this way, must represent, transcends the powers of imagination to grasp.

The upper beds of the Carboniferous system consist of thick red sandstones, which are well developed at East Wemyss. These rocks are here, as the name of the place indicates, pierced by numerous caves hollowed out by the action of the sea. These are not so extensive as those of the Arbroath coast, nor does the sea reach them now, for they form part of a Raised-beach. These red sandstones are perhaps the youngest rocks in Fifeshire, for mesozoic strata are entirely absent. If they ever existed, they have long since been removed by denudation.

It only remains to mention the Boulder-clay, which attains in places a thickness of 90 feet, and the Post-tertiary beds with glacial shells, exposed at low water on various parts of the coast. During the Ice age the physical conditions all over Scotland were so uniform that these deposits offer no features of special interest.

Sub-aërial accumulations are represented by the sand dunes along the southern shores of the Tay and by the golf-links of Leven, Largo, and St. Andrews. There is a good example of a Raised-beach above the pier at Aberdour, where marine shells of existing species occur in beds at a level quite 40 feet above the present high-water mark.

In the west of Fife the old coast-line can be traced in some places fully a mile inland from the present beach, and here and there a second or intermediate coast-line can be made out. At Kincardine 360 acres have been reclaimed from the river by means of a sea-wall constructed after the Dutch fashion. Between this town and Stirling the numerous windings of the Forth and the

alluvial flats on either bank furnish convincing proofs of the power of a river to restore a depressed level. Many years ago the skeleton of a whale 70 feet in length was discovered north of Stirling at Airthrey, near the northern limit of the alluvium, at a level 22 feet above the highest spring tides of the present day; and the remains of seals have been dug out of the brick-clays of Strath Eden. The evidences of recent depression are not so obvious in Fife as those of elevation, but submerged forests are stated to occur on the coast near Largo and in the Tay. There are a number of dried-up lakes throughout Fife, one of which is situated to the north of Aberdour. In constructing the railway between the Forth Bridge and Inverkeithing, after tunnelling the whinstone, a small ravine had to be crossed. The embankment thrown over this space kept sinking for months, the adjoining high road was pressed up 25 feet above its former level, and a neighbouring field was converted into a series of hillocks by the displacement of the subsoil, which apparently consisted of fine laminated clay.

On the shore at Port Laing, which is in the immediate vicinity, some years ago two ancient canoes were discovered, and on the hillside near North Cliff a Roman road can still be traced. In the museum of the Society of Antiquaries, Edinburgh, may be seen a pair of Celtic urns found at Craig Dhu, North Queensferry, in 1859; and quite recently a series of similar urns were unearthed at Pitreavie, south from Dunfermline. Rough and polished stone hatchets have occasionally been picked up in the same neighbourhood.

Marvellous is the story furnished by these stony records of the past, marvellous what they tell, more marvellous what they leave untold, of long protracted ages and innumerable forms of life that have come and gone, leaving behind them no memorial of their existence. Neither the pterodactyl nor the deinosaur have left their footprints on the shores of Fife, for this reason, that of all the natural phenomena which occur in any locality, while some are duly recorded in earth's rock-leaved annals, others unchronicled, as in the case of that long geological drama of mesozoic times, are destined to dissolve,

“And, like this unsubstantial pageant faded,
Leave not a wrack behind.”