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2. *On FOSSIL SHELLS and STRIATED BOULDERS at HIGH LEVELS in SCOTLAND.* By THOMAS F. JAMIESON, Esq. In Letters addressed to Sir R. I. MURCHISON, V.P.G.S., &c.

[As the notices read before the Meeting from these letters are fully detailed by Mr. Jamieson in a Paper received shortly afterwards, the latter is here printed in full.]

On the PLEISTOCENE DEPOSITS of ABERDEENSHIRE. By T. F. JAMIESON, Esq. Communicated by JAMES SMITH, Esq., F.G.S.

In the lower districts of Aberdeenshire, all along the coast, we find the rocks almost entirely hidden by a clothing of superficial matter, varying in quality from fine clay to stony earth, loose shingly gravel, and sand. In some places this covering is of great depth, exceeding even 100 feet in thickness, and is most developed in wide basin-shaped tracts, where the rock sits low. Much of it seems to have been gradually accumulated under the waters of a former sea, and, when now exposed to the light of day, presents a series of stratified layers of silt, sand, and clay, occasionally disposed in laminæ as thin as paper.

A careful search now and then discloses traces of marine shells scantily dispersed, either in the shape of broken fragments or, more rarely, in a perfect condition—bivalves entire and shut, with the delicate skin or epidermis in complete preservation, apparently in the spot where the animals had lived and died. In other places, however, we find large boulders, and blocks sometimes of gigantic size, together with deposits the character of which cannot be accounted for by the causes at present operating on our coast.

Commencing at the southern boundary of the shire, I shall proceed north, sketching the features of the coast as I go along.

At the mouth of the River Dee the denuded remains of these beds are found on both sides of the stream; and at the Torry brickwork on the southern side, the succession of strata is as follows:—

1. Shingle, or coarse water-worn gravel, irregularly bedded 7 feet.
2. Finely-laminated clay, varying in colour from yellowish-brown to red and bluish-grey. Contains some thin seams of fine sand 22 feet.
3. Gravel; depth unascertained.

No organic remains appear to have been got in this excavation, the base of which is probably rather below the present sea-level. At the bottom of the uppermost gravel-bed, and resting between it and the subjacent clay, I saw an angular boulder of quartzose gneiss, between two and three feet in length. None were seen by me in the clay itself; but the manager of the work told me that they are occasionally found in all the beds. I suspect they must be of small size, for I saw no large blocks lying about the place.

At another brickwork, on the opposite side of the river, the series of beds, commencing also at the surface, is—

	Feet.
1. Water-worn gravel and sand, stratified	12
2. Alternating seams of fine sand and brownish clay, the layers very numerous and somewhat undulating	20
The clay gets redder towards the lower part, and passes down into	
3. A mass of fine brick-red clay	17
4. Fine light-greyish clay, with thin seams of sand	10
5. Sand and gravel irregularly disposed	10
6. Strata of fine pale-greyish clay, laminated and containing seams of small sand	20
7. Fine sand; depth unascertained.	

In the mass of red clay the skeleton of a bird was obtained about twelve years ago. It is now in the museum of the Marischal College, Aberdeen, where it is ticketed as the bones of a duck. I have not seen any shells or other organic remains from this excavation; but the workmen told me that, a few years ago, they had found in the lowermost clay-strata the remains or impression of what they thought were fossils, but nothing that would bear removal. No boulders or large stones were seen by me in any part of this excavation; the clay-strata are, indeed, remarkably devoid of stones and pebbles of every kind.

The bottom of the cutting is a little below the present high-water mark.

The greater part of the city of Aberdeen appears to stand on this gravel-covered clay; and some borings for Artesian wells, attempted in different parts of the town, reveal its connection with the sub jacent rock.

Fig. 1.—Section along the Coast of Aberdeenshire. Length about 35 miles.

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I have obtained the following account of the most interesting of these bores. One sunk at the Woolman Hill pierced through—

	Feet.
1. Vegetable mould	6
2. Grey or bluish clay	18
3. Sand and shingle	20
4. Light blue clay.....	6
5. Rough sand and shingle	3
6. Old Red Sandstone conglomerate	115
7. Alternating strata of compact red sandstone and clay	74
8. Mica slate.....	9

Another, executed by Messrs. Richards and Co., disclosed the following beds:—

	Feet.
1. Moss and black earth	18
2. Gravel and small stones	14
3. Reddish clay.....	5
4. Loose sand and clay.....	6
5. Rock, mostly granitic	132

To the north of Aberdeen the coast is low, with a sandy beach all the way to the River Ythan.

Between the mouths of the Dee and Don the surface is generally occupied by coarse water-rolled gravel and shingle, which frequently assumes the form of large irregular mounds and hillocks, such as the Broad Hill, the Powder-magazine Hill, and others. This gravel, so far as my observation goes, is found to rest upon fine strata of clay and sand, occasionally exposed in cuttings at the outskirts of the town. For instance, at the Seaton Brickwork, near the River Don, the following section is got:—

	Feet.
Gravel	3
Fine clay of a yellowish-brown or bluish-brown hue; contains some thin seams of sand	16
Sand and gravel; depth unascertained.	

The bottom of this section is also about the sea-level. No shells appear to have been found here. These brickworks are generally established at a spot where the gravel-covering is thin, in order to avoid the expense of reaching the clay.

Keeping still close to the sea, we find another excavation for clay about $2\frac{1}{2}$ miles to the north of the River Don, at a place known by the name of the Black Dog. Here the cutting discloses—

	Feet.
Coarse gravel and shingle, water-rolled	4
Fine strata of clay and sand, disposed in undulating layers; contain broken shells	11
Sand; depth unknown.	

The clay varies in colour from brick-red to a dull-greenish tint, and predominates over the sand, which is of fine quality and brownish colour. The shells that occur in some of the seams, although apparently all in a broken or comminuted state, yet often retain their glossy surface. Those which I found were in very small fragments; amongst them, however, I could recognize the *Cyprina Islandica*, *Tellina solidula*, *Saxicava rugosa*, *Cardium echinatum*, and a species of *Astarte*; and doubtless others occur. No boulders were seen in these beds of sand and clay. The meeting of the upper bed of gravel with the clay forms a distinct horizontal line, the two masses not mingling where they join. The section here is also not much above the sea-level, although somewhat higher than the last.

Large irregular mounds and straggling narrow ridges of coarse gravel abound in this locality, known by the name of the Hills of Fife. I have not met with any shells in this gravel, the base of which seems to rest on the stratified beds.

A little further on, and we come to the Burn of Millden, along the banks of which we again find the stratified clay and sand cropping out. A section, the base of which is probably not more than three feet above high-water mark, shows some 16 feet of alternating layers of pure red clay and fine greyish sand, quite devoid of all stones. These strata are arranged horizontally, and terminate somewhat abruptly towards the sea. Their surface indicates considerable denudation; and on the top of one of the banks, lodged amongst the bent-covered sand which drifts off the adjoining beach, I found two or three boulders of gneiss, granite, and syenitic greenstone,—the largest not exceeding $3\frac{1}{2}$ feet in diameter. Some boulders of granite and trap occur also in the bed of the stream. These may have been left by the agency which denuded the clay.

A short distance further up the stream, and at a height of probably not more than nine or ten feet above the sea, there is a very small patch of what appears to be the Old Red Sandstone conglomerate, but quite smothered beneath a heavy mass of the stratified sand and clay.

Mounds and ridges of coarse ferruginous shingle and gravel, all water-rolled, come nearly close up to the top of these banks, as if superimposed abruptly on the stratified beds,—while, a little further north, some small cuttings occasionally show the gravel overlying fine red clay.

The great mass of shingle, however, retreats inland a short distance here, returning towards the beach at Menie, from whence it may be traced, with hardly any interruption, to the mouth of the Ythan.

In the neighbourhood of Hopeshill the fields abound with large boulders, mostly of syenitic greenstone and other varieties of trap, similar in quality to rock *in situ* a few miles to the west. Near the Menie Coast-guard Station I found these large boulders of trap, granite, and gneiss resting on the top and surface of the gravel-ridges (fig. 2), some of them measuring six feet in length, and more or less rounded in form: I traced them also amongst the low

hillocks of blown sand overgrown with bents, which margin the beach, occurring sometimes singly, sometimes in clusters, and of various sizes up to 11 or 12 feet in length. Their surfaces are either rounded or rugged, scarcely ever angular, while in mineral character they are generally of greenstone and syenite.

Fig. 2.—Diagram showing the position of the Boulders at the top and on the surface of the Gravel-mounds at Menie Coast-guard Station.

In a field on the farm of Drums a gigantic boulder of granite occurs, known as "the Grey Stane." I found it to measure 54 feet in circumference, with a height of about 7 feet above the ground. It has no sharp angles, and most of its exterior is rounded. Another immense block, also apparently a transported mass, is seen lodged in the surface of a field near Menie. I found it to be 78 feet in circumference, and projecting 6 feet out of the ground. It is a coarse-grained greenstone.

Drums seems to take its name from these tumuli and hillocks of gravel,—*Druim* in the Celtic language meaning a ridge or little hill, and being of frequent application in the names of places.

I found these ridges to consist of highly-rolled fragments of rock of all sizes, from coarse gravel up to boulders 2 feet in diameter. Those of gneiss are perhaps most numerous, often of a hard, tough, crystalline nature, yet much worn and rounded, showing the great attrition which they have undergone. Granite, both grey and red, is also plentiful, and lumps of serpentine occasionally occur, with other varieties of trap; but, besides these, there are a good many rounded fragments of red sandstone in several places, both at Drums and near Menie. On the top of one of these gravel-ridges, a little to the north of Drums, I found a boulder of coarse crystalline rock, of a greenish tint, measuring 8 feet in length by 5 in breadth. No sharp angles occur on its surface. A layer of red clay, about 9 inches thick, overlies the gravel at this spot; and I found traces of a similar clay covering the gravel at Drums. This boulder rested immediately upon the gravel; but the clay encircled its base. Another large boulder of greenstone lay beside it; and many other blocks were observed in the adjoining fields.

Here, then, are clear instances of large transported boulders sitting on the top of these abrupt ridges of water-worn shingle. It seemed

rather remarkable to me that I had never met with any of these larger blocks imbedded in the gravel itself; nothing larger than 2 or $2\frac{1}{2}$ feet in diameter has occurred to me. I have, however, been informed by workmen that they do occasionally find boulders even of very large size in the interior of these gravel-mounds.

Reaching the estuary of the Ythan, we find the coast much encumbered by great heaps of drifted sand; and tradition relates that a small parish, called Forvie, was here suddenly overwhelmed by the sandy drift. Coarse gravel and stony earth generally cover the surface, on piercing through which, however, the stratified beds are often exposed at the lower levels. For instance, on the north side of the estuary, at Westfield of Auchmacoy, the following section has been laid open:—

	Feet.
1. Gravel and coarse water-worn shingle	3
2. Strata of fine clay, varying from red to pale grey, with occasional seams of fine sand	7
3. A layer of gravel	$0\frac{1}{2}$
4. Pure red clay	2
5. Gravel; depth unascertained.	

The bottom of this section is rather below high-water mark. Fragments of shells occur occasionally in the sandy seams, chiefly in No. 3.* Up beside the dwelling-house, at a level of probably 50 feet higher, in sinking a well, the layers passed through were—

	Feet.
1. Shingle and coarse gravel	3
2. Coarse red clay, containing small fragments of stone	9
3. Fine brownish sand, quite devoid of all stones or gravel	26

The bottom of this sand was not reached; and no water was got.

Finely-laminated clay, I find, occurs up the valley of the Ythan for some miles, but is seldom exposed to view. In sinking a well in the village of Ellon, $4\frac{1}{2}$ miles inland, the beds exposed were—

	Feet.
Coarse water-worn gravel	11
Fine laminated clay, varying in colour from brick-red to pale-greenish grey	33

This clay was not passed through, so that its depth was not ascertained; and the bottom of the bore here would also be about as low as the sea-level.

Along the south bank of the Ythan, below Ellon, the same fine stratified clay occurs, covered by masses of water-worn gravel, and sometimes by a stratum of stony earth, full of boulders of all sizes,

* Since the above was written, I have obtained the fragments of what seems to be the skull of a Common Seal (*Phoca Vitulina*, Linn.), from the layer of red clay No. 4.—October, 1858. T. F. J.

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up to a weight of about a ton and a half, and of a mineral character similar to rocks which occur further up the valley.

Fig. 3.—*Section at Collieston Coast-guard Station.*

About a couple of miles to the north of the River Ythan the sandy beach gives way to a rocky coast of gneiss and mica-schist, which continues without interruption to the Bay of Cruden, a distance of more than five miles. These cliffs very commonly present a face from 60 to 100 feet high towards the sea: where the rock itself attains this elevation it is generally destitute of superficial covering, or has sometimes a thin layer of coarse clay; where, however, the rock sits low, the additional height is made up of grassy banks, which appear to be composed of red clay and sand, stratified, frequently in an undulating manner. Owing to the grassy surface, the interior of these banks is seldom disclosed by any good section. At the Collieston Coast-guard Station (fig. 3), however, a slip has laid the mass open from top to bottom, showing—

	Feet.
1. Red clay, devoid of stones, but without any stratification-lines apparent	17
2. Strata of the finest sand, varying in colour from pale brownish-grey to reddish	56
3. Gneiss-rock, covered by a foot or so of its own debris	30

The sandy strata lie horizontally with some gentle undulations: they are quite devoid of all stones, pebbles, or coarse gravel. In some small seams of coarser sand, near the bottom of the mass, I found traces of broken shells, but so comminuted as to render any knowledge of the species unattainable. The junction of the clay and sand forms a line nearly horizontal; and the sea-waves wash the foot of the rock.

At a cliff, a mile or so to the north of Collieston, some slips show that the gneiss is covered by 30 or 40 feet thick of strata, composed almost entirely of fine sand varying in hue from red to grey. Some

seams of pebbly gravel occur in several places, interstratified with the fine sand in undulating layers. These gravelly seams contain fragments of broken shells, amongst which I could distinguish the hinge of the *Cyprina Islandica*, also bits of smaller Pectens and pieces of a bivalve shell, ornamented with fine radiating striæ between the growth-lines. Along with these shells there occur also many small bits of grey and yellow limestone, which appear to have been derived from secondary formations.

All along the coast of Slains, the mass of sandy strata seems to rest directly upon the gneiss-rock, without the intervention of any other deposit. Sometimes the top of the bank consists partly of fine red clay, occasionally interstratified with the sand.

No large boulders are seen in these strata; but large boulders occur in the fields immediately back from the brink of the cliffs, as if resting on the surface of the deposit. These blocks are of greenstone, gneiss, and granite.

Further north, towards the Bay of Cruden, the rocks get higher, and the Pleistocene deposits retire from the cliffs, which are generally bare. The gneiss is thrown into long undulations, and gets more contorted and altered in texture as it approaches the granite, which first shows itself at the southern side of the Bay of Cruden. At the bay itself the rocks disappear, and a low expanse of drifted sand is backed by steep grassy banks, which appear to be composed almost entirely of Pleistocene beds. These banks attain a height of about 120 feet above high-water mark, presenting a steep front to the sea. Their base is perhaps 10 or 12 feet above the sea-level. No good section reveals the structure of these slopes; but near the top of one of them, about 5 feet of coarse red clay is seen resting on fine soft sand, of a reddish-brown tint, indistinctly stratified, and quite free from stones. The clay shows no stratification-lines, and contains pebbles of greenstone, granite, quartz, &c., more or less rounded. I picked out one fragment about 5 inches long, smoothed on one side, and covered with many striæ in different directions. Towards the northern side of the bay these banks appear to have suffered denudation, and are much lower and more undulating. A section, 18 feet deep, shows fine, soft, reddish sand, containing several thin seams of red clay. Following up the Burn of Cruden, deep masses of fine sand and clay appear to occupy the ground on both sides; and at Ardifferry we find the stream flowing along the foot of steep banks about 130 feet high, and the ground slopes up behind perhaps 20 feet higher, making a total height of 150 feet. These banks appear to be composed, to their very base, of sand and clay. The stream here cannot be many feet above high-water mark—perhaps 15 feet. No deep extensive section occurs; but slips in various places reveal the structure of the mass almost from the top to the bottom. The lower part of the bank, to the height of about 20 feet above the stream, is concealed by the low slope of the ground, beyond which several small sections disclose regular horizontal strata of very fine sand, mostly of a pale-grey tint, but occasionally reddish. Amongst this sand there occur a few thin

layers of fine brick-red clay. The appearance of these sandy strata, deep down in this bank, very closely resembles the lower part of the cliff at Collieston; and in like manner I found them to contain minute fragments of shells. A shell, said to have been obtained in these banks, is in my possession, which I received from Mr. Dawson of Cruden. It appears to be the *Mangelia turricola* of Forbes and Hanley, and is somewhat water-worn, although almost entire. The only stone of any kind which I found in these sandy layers was a small pebble of flint. The strata here are horizontal, not undulated, but often finely rippled.

Higher up, the sandy strata seem to be of a more reddish hue, containing seams of red clay; and some coarser stuff, with boulders, appears to occur occasionally, as if it had slipped down in some places. The upper part of the bank is not exposed by any good section, but seems still sandy; while higher up still, where the ground slopes back, there is some coarse gravel or stony stuff exposed at the side of the adjacent fields.

These Pleistocene deposits, although still of great depth in this locality, have no doubt been worn down and washed away to some extent during the course of events which intervened betwixt the period of their deposition and the last movement of elevation. This denuding agency, in cutting down the stratified beds, must have thrown their materials, together with other debris, into positions which are now difficult to be explained. It will be safest, therefore, to rest any theories upon good, clear, extensive sections, where this disturbing element can work no mistake.

To the north of Cruden Bay the coast is composed of red granite all the way to Peterhead, forming cliffs from 70 to 150 feet high, and upwards. The top of these rocks is more or less bare, and destitute of any considerable covering of loose matter. In some places a depth of 3 to 4 feet of clay and stony rubbish occurs; and it is worthy of note that the stony debris is not made up of granite, but of the detritus of slaty gneiss, with varieties of porphyry and quartz: sometimes a few bits of red sandstone may be found. Some slight difference may be occasionally remarked in this superficial mass, the upper part being less stony, and of a red colour, more of the nature of red clay, while the lower portion next the granite is little else than a mass of small stony debris, the fragments mostly angular or little worn, although there are also many rounded pebbles. One large boulder of red granite, perhaps 6 feet in diameter, I noticed amongst this stony stuff, resting on the top of a narrow precipitous ridge jutting out into the sea, immediately south of the Bulls of Buchan.

To the north of the Buchan Ness the rocks sink down to a low height, and in some places disappear, and the Pleistocene deposits again show themselves. No good section is seen, however, except at Invernettie, where a brick- and tile-work has long been established. The excavations are made in the face of a bank, which rises up from the sea-beach to a height of nearly 50 feet. I found its structure to be as follows:—

	Feet.
1. Blackish loamy earth	1
2. Reddish-brown clay, apparently devoid of stratification or lamination, and containing stones of various kinds, and of all sizes up to $4\frac{1}{2}$ feet in diameter; often striated and grooved on the surface	30 to 40
3. Clay of a brick-red colour and finer nature, and apparently free from boulders	1 to 2
4. Very fine, laminated, dark-brownish clay, quite free from stones	2 to 4
5. Fine brownish-grey sand, devoid of all stones or pebbles of any kind: the bottom of it has not been reached; but it has been penetrated to a depth of	20

The foreman of the work told me that this finely-stratified clay and sand had occurred regularly at the base of the bank all along, covered deeply by the coarser clay with boulders. The fine sand at the base of the bank must extend beneath the sea-level. The stones which I found in the deep mass of boulder-clay were of granite—both red and grey, crystalline schist of different varieties, greenstone and other kinds of trap, sandstone, and flints. The largest block was of a fine-grained, tough, greenish rock, $4\frac{1}{2}$ feet long by $2\frac{1}{2}$ feet broad and $1\frac{1}{2}$ thick. It was rough and angular on all sides but one, which was smooth and worn, as if it had been rubbed strongly over some hard surface. There were several sets of scratches, grooves, and furrows, mostly short, and tending in one general direction, viz. parallel to the longest diameter of the block. The granite-blocks were generally more rounded, and occasionally grooved, but much less distinctly; those of greenstone are also occasionally smoothed and scratched. The largest piece of sandstone was greyish, moderately fine-grained, measuring in feet $3 \times 2 \times 1$, angular and rough on the surface.

Many of the boulders are striated on all their sides. The stones in this upper bed of clay do not bear a very large proportion to the whole mass; so that the clay is used for making bricks and tiles after the stones are extracted. In this boulder-clay I found also traces of broken shells, occurring in films of coarse reddish sand in various parts of the deposit. I also picked a broken fragment of shell out of the finely-laminated clay No. 4.

Several years ago, the skeleton of a bird was found in this bank, at a depth, it is said, of 25 feet from the surface, and about 15 or 20 feet above the level of the sea. I have not hitherto discovered what became of this skeleton. When in search of it, in the Arbuthnot Museum, Peterhead, I found an organic remain with the following label:—"Fossil vertebra found in excavating clay at the Brickwork, Peterhead, August 1825, 38 feet below the surface, *placed on what has been the sea-beach.*" The words in italics were somewhat indistinct, the ink being much faded. This fossil

I found to be $6\frac{1}{2}$ inches in diameter and $4\frac{1}{2}$ inches thick, and of a general roundish aspect. What animal it had belonged to, I cannot say—probably some large fish. There are no spinous processes or bony projections from it. From the depth at which it was found, it would seem to have been about the top of the mass of fine sand.

No rock is exposed at the bottom of this section; but it protrudes in the beach at a short distance on both sides.

Here, then, at Invernettie is a very good instance of a clay, containing numerous boulders, overlying stratified clay. I found the same thing at a place called Downiehills, nearly three miles to the west of Peterhead, and at a higher elevation. At this spot there is also a brickwork, and the brickmaker informed me that he had sunk a well 40 feet deep, and bored 12 feet further, without reaching the bottom of the clay, and that the section was—

	Feet.
Unstratified stony clay, of a reddish-brown colour, containing some large boulders and stones of many varieties, which are occasionally striated.	20
Stratified clay, containing layers of different colours, but no stones	32

This uppermost boulder-clay is also fine enough for making bricks and tiles, after extracting the stones. He told me that he had got one block of granite in it about 3 tons in weight, some of the fragments of which he showed me, built into some adjoining masonry. It was of the red Peterhead granite, and showed the traces of the boring-iron upon it. No others had occurred nearly so large as this; but boulders are often found from 2 to 3 feet in diameter, and indeed I saw some of this size in the clay myself. In a heap of smaller stones which had come out of the same mass of clay, I observed fragments of granite of different varieties, also gneiss, trap, porphyry, and a few of red sandstone and flint, and one bit of limestone 4 inches long and striated on the surface, apparently belonging to secondary strata: it was fine-grained, but of impure quality. Two or three scratched and striated stones were observed by me; but they were far from numerous.

This boulder-clay, according to my informant, also contains shells, generally broken, but sometimes whole. They are, for the most part, so decayed that they cannot be preserved; but some of them appear to have been thick and strong. I have not ascertained the elevation of this spot, but should think it to be somewhere between 150 and 200 feet above the sea-level, or perhaps scarcely so much.

At the north side of the town of Peterhead some low granite-rocks, the base of which is washed by the sea, are seen to be covered by a mass of coarse gritty earth or mud, of a dirty-grey hue, full of small stones, some of which I found to be striated or scratched on the surface. They are of trap, quartz, and granite. This mass of stuff is about 8 feet deep, and rests immediately upon the solid granite-rock, without the intervention of any other layer whatever. Some indistinct undulations seem to occur in this deposit; but otherwise it is unstratified. No high banks occur here.

A little beyond this, the Ugie flows into the sea, draining a low basin of ground. I have found fine laminated clay composing the ground along its banks in many places, for several miles up its course, but frequently concealed by a deep covering of coarse gravel. At Ednie this fine stratified clay rests upon a mass of coarse stony stuff, which, however, is not clearly exposed. In sinking a well there was found, I am told—

	Feet.
Fine stratified clay	13
Coarse stony clay, dark-coloured, and apparently devoid of stratification	20

I found some traces of broken shells in the stratified clay here also. I am not aware that any large boulders occur in the lower mass. In the part of it which I saw, the stones were not of large size. This section, although little more than two miles distant from the sea in a straight line, is yet much more following the course of the Ugie. It is at no great height above the sea.

The coast to the north of the Ugie for many miles presents a broad sandy beach, backed by undulating banks of various height, but seldom, if ever, exceeding 100 feet. The drifting sand which blows off the coast hides everything, so that the interior of these masses is rarely to be seen. In some places, however, their structure is indicated, and seems to be a fine tenacious clay of a bluish tint.

About five miles to the north of Peterhead is the Annochie Brickwork, close upon the sea-beach. Here the excavations are made into the heart of these sand-covered banks, and disclose a fine, blackish-blue, sandy clay, quite unmixed with stones or pebbles of any kind. This clay has been penetrated to a depth of 25 feet, and found to pass into fine sand of a similar hue; but it is not known what lies beneath.

Deeply imbedded, then, in this fine bluish clay-mud, I found perfect shells occurring, in some places rather abundantly. The species were—

<i>Nucula tenuis.</i>	<i>Leda pygmæa.</i>	<i>Lucina ferruginosa.</i>
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The last-mentioned is a very minute shell, and seems to be much less numerous than the two others. All the three are very delicate thin-shelled bivalves; but their preservation is so perfect that the greenish-yellow epidermis, or skin-like pellicle that covers them, is quite uninjured. They are, however, so friable, that the slightest touch converts them into powder; and on exposure to the air for some time, the epidermis loses its lustre, and sometimes shrivels up. Sometimes both the valves are in conjunction and shut; but more frequently, I think, they occur as single valves. It is also worthy of notice, that no broken or comminuted shell-fragments were observed occurring in this clay*.

* At a subsequent visit to Annochie, in company with Mr. Winter, the manager of the work, who most kindly gave me all the assistance in his power, I succeeded in finding nearly a dozen other fossils. Amongst these were several

Here, then, we seem to have the remains of the animals imbedded in their native mud. The assemblage and the deposit itself both indicate deep water; and these same species have been found congregating at a depth of from 30 to 100 fathoms on the western coast of Scotland, where they have all been dredged alive by Mr. MacAndrew. They are species, however, which are characteristic of a more northern region at the present day: in fact, until within these few years, the *Leda pygmæa* was not known to occur so far south as Britain, being principally developed in the Arctic seas; and even now it is known in only one locality, namely the neighbourhood of Skye.

This clay-bed appears to have suffered much denudation, and has an irregular undulating surface. No considerable section is exposed; and, as far as I could see, it appeared to be of a very uniform texture, without any distinct stratification-lines. The position of the shells is little above the present high-water mark; and the clay-bed appears to pass in below the beach.

We have here a great change indicated, from this old muddy seabottom to the present sand-encumbered coast, which abounds at this place in broken shells. In the course of a short search along the beach, I picked up specimens of the following species, mostly in broken fragments:—

Purpura lapillus.	Tapes pullastra.
Littorina littoralis.	Donax anatinus,
Patella vulgata.	Pecten pusio.
— pellucida.	— opercularis.
Cyprina Islandica.	Nassa incrassata.
Cypræa Europæa.	Buccinum undatum.
Trochus cinerarius.	Mytilus edulis.
— zizyphinus.	Solen ensis.
? Astarte sulcata.	Venus striatula.
Mactra solida.	

In some of the banks in the neighbourhood I found fine blue clay, of a similar appearance to that in the brickwork, but containing numerous minute regular crystals of sulphate of lime.

I have now sketched the greater part of the eastern coast of Aberdeenshire, and have shown that a deposit of stratified sand and clay, often of great thickness, appears to occur with considerable

specimens of Foraminifera. Of Mollusca there were two or three species of *Cylichna* (one of which seems to be *C. cylindrica*, the others resembling *C. obtusa* or *C. mammillata*),—a single valve of *Kellia*, apparently *K. suborbicularis*,—decayed specimens of *Panopæa Norvegica* and *Mya truncata*, variety *pullus* of Wood's 'Mollusca of the Crag.' These shells, however, were so decayed and friable as to render their determination difficult and doubtful. They did not occur in broken fragments, but were perfect in form, although the shelly substance was gone. I was told also that the skeleton of a fish had been found some years ago, but had not been preserved. Messrs. W. K. Parker and Rupert Jones have kindly examined microscopically some of the Annochie deposit, and they inform me that in about two thimblefuls of the dark-slate-coloured, fine, sandy clay, with roundish quartz-grains and some brownish mica, they have found several fine specimens of the *Polystomella crispa*, var. *striatopunctata*, two large specimens of *Cornuspira foliacea*, and a few little fragments (plates) of *Echinus*.—October, 1858. T. F. J.

regularity wherever the rock sits low, and that these fine strata are covered in some places by extensive masses of coarse gravel and shingle, and in others by a clay or earth full of boulders of many kinds, often of large size, and sometimes striated and grooved in a singular manner. It has also been shown that great boulders occur on the surface of the gravel-ridges, and, according to the accounts of workmen, occasionally imbedded in their interior, although I have not observed this latter fact myself*.

These stratified masses have been found resting on Old Red Sandstone conglomerate at Millden, and on gneiss and mica-slate along the sea-margin of Slains; and no clear instance along the coast has occurred to me of any mass of coarse stuff, containing large boulders, lying beneath them; nor have any large blocks been seen by me imbedded in the fine strata themselves. These are evidently the remains of an old sea-bottom of the later Tertiary period,—the laminated clay and sand having accumulated in the deeper troughs of the ancient coast, where they were beyond reach of the surface-agitation produced by the winds.

In the parishes of Slains and Cruden there are many knolls and ridges of water-worn shingle and gravel, which I have found in various places to contain broken marine shells. Perhaps the most remarkable of these are the gravel-ridges beside the Loch of Slains, locally known by the name of the Kippit Hills. They vary in form and size, but generally rise to the height of about 30 or 40 feet above their base. The sides are commonly steep, and their summit or ridge often so narrow that two carts could scarcely pass each other on them, while their breadth is such that a person standing on one side can easily pitch a pebble quite over them. In these features they would seem to resemble the Eskars of Ireland, the Kaims of the south of Scotland, and the Osar of Sweden, concerning the origin of all which there has been some discussion.

Our Kippit Hills can be traced, with hardly any interruption, for a distance of beyond two miles, in a tortuous, curving, or zigzag line without any definite direction. They are connected also with other gravel-deposits in the district; and their extent and relations are obscured to some degree by a deposit of red clay which covers them in many places.

Fig. 4.—*Diagram showing the Red Clay covering, and filling up the hollows of the Gravel-ridges at the Kippit Hills.*

* I am inclined to think that the gravel on the top of which these erratic blocks lie is of older date than the gravel covering the stratified beds at Aberdeen and elsewhere. It may belong to the same period as the gravel of the Kippit Hills.

As to the composition of these ridges, I have found them to consist of sand, gravel, and water-worn pebbles. In some places the mass is very coarse, showing no regular arrangement, but abounding in rolled stones of all sizes up to a diameter of $2\frac{1}{2}$ feet; few, however, exceed 1 foot in length. In other places the materials are much finer, passing from coarse pebbly gravel into undulating sandy layers. Broken shells occur in both sorts. The pebbles are of many different kinds; the most abundant seems to be micaceous schist, similar in character to what occurs along the adjoining coast, while gneiss, quartzose schist, granite, and greenstone are also plentiful. A bit of felspar and a flint or two may be occasionally found; and upon one occasion I picked up two small pieces of serpentine. But, besides all these, there are in many places a great abundance of red and grey sandstone, together with a multitude of limestone fragments, which vary in character and hue. They are always more or less water-worn; some are of a yellowish tint, and of a soft, tough nature, effervescing strongly with acids, while others are finely laminated, varying in colour from greyish-white to dull grey and yellow: these are generally of a fine earthy texture, and effervesce more feebly on being treated with nitric acid. The limestone fragments occasionally, though rarely, contain fossils. I have found a bit or two containing traces of small shells, and have seen one fragment of laminated grey limestone with the impression of a small fish: both the head and tail were wanting, owing to the wearing of the fragment; but when complete, it might have been about 6 inches long. According to the reverend author of the statistical account of the parish, these limestones were formerly sought out by the farmers, and burned for lime, being found "generally from 1 to 16 lbs. in weight."

I may mention that I have found similar bits of limestone in various parts of Cruden and Slains, and also more rarely in Logie-Buchan and Foveran; they are, however, more plentiful in these Kippit Hills than anywhere else. I have never found them either scratched or striated in these gravel-ridges, but have occasionally found them so in other places, where they occurred in clay or stony earth. No rock of the same nature is known to me in this part of Aberdeenshire; but, from the abundance of the fragments, confined as they are to a limited tract near the coast, I am inclined to think that the source from whence they came must be within the district, and that patches of similar strata probably occur deeply buried beneath the Pleistocene deposits which drape the whole country hereabouts.

With regard to the broken shells which are mixed up with this gravel, they are generally in very small pieces, and much worn. I can distinguish at least eight different kinds, and probably more. The hinge of the *Cyprina Islandica* is of frequent occurrence, its massy thickness having stood the wear and tear better than most others. I have found also some almost complete valves of a *Tellina*, which seems to differ from the *T. solidula* only in being thicker and stouter. It is a strong opaque shell, very tumid in the valves. Is this the *Tellina Groenlandica*? Another is a shell of larger size, also a bivalve,

and strong and thick, but very compressed in form. A fourth (of which, however, I have got nothing but small fragments) is a bivalve with strong concentric growth-lines, having the interstices ornamented with peculiar radiating striæ. It is also crenated along the ventral margin similar to the *Venus Casina*. Some of the bits have evidently belonged to a good-sized shell, and are thickened along the edge, while others are the remains of individuals of smaller size, or perhaps of a different species. I have found it in many different places. Fragments of *Astarte* and *Pecten* are also not uncommon.

I have stated (p. 516) that, in a cliff on the coast of Slains, and immediately opposite these gravel-ridges, I found in the sandy strata seams of gravel containing similar fragments of shells along with pieces of the same kind of limestone. It would therefore appear that these mounds are formed out of the same materials, and may, perhaps, be a development of those gravelly layers which are interstratified with the fine sand. They may be old submarine banks of gravel, which have subsequently been moulded into the form of ridges by denudation.

Their base is at about the same elevation as the top of the coast-cliffs, or perhaps a little lower, and they can be traced almost close to the cliffs, while it is also found that a stratum of red clay overlies both them and the stratified sand at Collieston; and further, in some places the gravel of these ridges appears to pass into fine sandy layers, similar to the masses along the coast.

The district in which these shelly gravels occur lies between the estuary of the Ythan and the Burn of Cruden, comprising an area of about 15 square-miles. This tract of ground culminates, with gentle slopes, in an eminence called Highlaw, whose height I found to be 299 feet above the mean level of the sea. The summit consists of a mound of gravel, while banks and knolls of coarse water-worn shingle form the most of the adjoining ground. In some places these masses of gravel show many undulating layers and seams of sand, while in others the disposition of the materials is more irregular. No broken shells nor fragments of sandstone or limestone occurred to me here. The materials were of gneiss, granite, quartzose rock, felspar, porphyry, and other kinds of trap, sometimes not much rounded. It appears then that, while fine sand and mud were accumulating in the deeper recesses of the ancient sea, here, on the shoals and higher portions, under some 40 fathoms less water, the soundings would have shown coarse gravel, sand, and shingle.

I remarked, however, that a deposit of red clay in many places overlies this gravel, filling up the irregularities and hollows of its surface. It is never of great thickness, and is generally absent on the higher mounds, or forms but a very thin layer over them.

A similar clay was found in many places overlying the gravel of the Kippit Hills (p. 522); and a thick mass of it covers the stratified sand in the cliff at Collieston. Do not all these instances point to a depression of the sea-bottom, converting its shoals into sunken banks, and its deeper hollows into yet profounder depths?

I did not observe any large boulders beside Highlaw itself, but

some distance to the north, between it and the Episcopal chapel of Cruden, I found several occurring on the surface of the land, especially beside some small croft-houses. The largest were from 5 to 6 feet in diameter, but many were from 2 to 3 feet; and they consisted of red granite, gneiss, and trap. One of these blocks I observed to be much smoothed or ground down, and covered with striæ and scratches on part of its surface; and this occurred in a fragment of hard crystalline quality. On drawing the attention of one of the crofters to this circumstance, he said that he had noticed the fact, and that these markings were confined to the lower surface or *bed* of the stone. It had been a large block, some 6 feet in diameter, and had been blown to pieces by gunpowder when I saw it. Much of the ground here (which is at an elevation of probably 200 feet or upwards) seems to consist at the surface of coarse stony earth, varying in colour from reddish to a dirty bluish-grey, and contains many small stones of gneiss, granite, trap, micaceous schist, compact felspar, and quartzose rock. I picked up also two or three small bits of limestone of different colours, and similar in quality to those which occur in the gravel of the Kippit Hills. One of these limestone-bits was covered with striæ and scratches on both sides. I noticed also some nodules of flint, and a rounded pebble of red sandstone. Several striated fragments were observed by me in this coarse earth, the stones of which are seldom sharply angular.

In the Rev. Mr. Pratt's entertaining volume upon the district of Buchan, I find it stated that the outer walls of the parish-kirk of Cruden, erected in 1777, are said to have been all built "from the greystone of Ardendraught, a huge boulder of granite on the Old-toun Farm, upon which, from time immemorial, *Hallow fires* had had been lighted."

I have pointed out that the stratified sand and clay can be traced for some distance up the rivers which fall into the sea along the eastern coast. The same is the case along the Moray Firth.

The Kinedart Water, a tributary of the Deveron, flows through a Pleistocene deposit of considerable thickness; and deep down in the high banks along which it runs, I found specimens of the following shells imbedded in a fine, dark, sandy mud:—

<i>Tellina proxima</i> .	<i>Leda pernula</i> .	<i>Nucula tenuis</i> .
? <i>Tellina solidula</i> .	? <i>Dentalium</i> .	

The most plentiful was *T. proxima*, always complete, with the two valves in connexion and shut, the dark-brownish epidermis remaining. What is, however, remarkable, the valves were always more or less cracked, especially the upper one, which was often quite *squashed* into the lower. It looks as if the shell had been crushed with the animal in it, as it is generally filled with a dark powder, and a blackish stain frequently extends to the sand around it. The specimens were often of large size, measuring $1\frac{1}{2}$ to $1\frac{3}{4}$ inch across. Pressure from above, and suddenly applied, seems necessary to account for the condition of these shells: the crushed fragments were never shifted *sideways* out of their position.

A thick mass of gravel and sand, forming the upper part of the bank, appears to have been thrown down upon this fine sandy mud; but there is no good section, at the place, to show their connexion. I found this sand and gravel in some places containing a great abundance of broken shells. There were many entire single valves of *Tellina solidula*, and fragments of *Astarte arctica*. Pieces of the *Cyprina Islandica* were also numerous.

The *Tellina proxima* is characterized by MacAndrew as the *Tellina* of Arctic seas, and is not now found alive on the British coasts. He gives its principal development at a depth of from 4 to 10 fathoms, but ranging down to 40. The *Leda pernula* is also now extinct in our seas, but is found from Drontheim to the North Cape, having a great vertical range of from 35 to 160 fathoms. The *Tellina solidula* is still found from Britain to Finmark, in more shallow water.

Here then, again, are the remains of the animals apparently where they had lived and died. The prevalence of *Tellina proxima* marks shallower water than the assemblage at Annochie does, as might have been expected; for this Kinedart deposit must be at an elevation perhaps 150 feet higher, situated in a sheltered ravine. Of the other shells I found but one specimen each; and these were single valves although uninjured, with the epidermis in fine preservation.

The evidence still points to a chilly climate, and a sea undisturbed enough for mollusca to flourish at least for a certain lapse of time.

In the valley of the Deveron itself, as far up as Huntly, I found finely laminated silt and loam exposed on its banks, at the height of 360 feet above the sea-level, and perhaps 50 or 60 feet above the river. No organic remains, however, occurred to me. Passing over to the valley of Spey I there discovered finely laminated silt, capped by sand and gravel, lining the base of the hills to a great height. On the east side of the stream, from Cairnty to Ben Aigan, it may be traced with little interruption, running up the Burn of Mulbain at a corresponding elevation; and I found it also on the west side. Having borrowed a spirit-level from one of the gentlemen engaged with the railway now in process of construction across the Spey, I proceeded to measure the height of these terrace-like banks on Eastertown of Cairnty, and found them to reach an elevation of 247 feet above the river, and 375 feet above the sea, at high-water-mark, ordinary spring-tides of the Moray Firth.

Fixing the instrument on the summit, I took a sight across the Spey to the flat-topped fragment of a similar terrace on the west side, and found it to be at the same level. Turning my view up the river to a similar bank opposite Rothes, I ascertained that it was several yards higher, after allowing for curvature. I then swept the view towards the Moray Firth, and found, what was very apparent even to the naked eye, that I quite overlooked everything between me and its waters.

It thus became evident that here was no freshwater deposit accumulated in the depths of some dammed-up lake, but an indubitable portion of the ancient sea-bottom, when salt-water lochs stretched their arms far inland. No remnant of any barrier appeared, that

could account for a lake at such a height ; no glacier descending from Ben Aigan or any hill on the east side could have barred the valley down here ; for there is no height on the opposite side that the icy avalanche could have rested on.

Thinking that the spirit-level I had used might be out of adjustment, and consequently not trustworthy for a long sight, I procured the loan of another good instrument made by Troughton and Simms, which had been adjusted but a few days previously, and with it also I found the Rothés bank to be considerably higher than Cairnty, and also that terrace-like deposits, equal in height to that of Rothés, occurred for some distance up the glen on the opposite side of the Spey. Whether, therefore, the elevating power had increased towards the interior, or whether it is that the strata in the lower part of the valley have suffered more denudation, may be questioned ; yet the fact remains, that these banks rise in height as we ascend the valley. Those at Rothés are higher than those at Cairnty ; and similar terraces which I observed above Aberlour, and also opposite Ballindalloch, seemed to me higher still ; but want of time compelled me to leave their measurement unascertained.

The best section of these masses is at Rothés, where the bank that looks down upon the village, from an altitude of about 190 feet above the stream, presents the following section at its highest part :—

	Feet.
1. Loose gravel, sand, and shingle, stratified	30
2. Fine stratified sand and sandy mud, of a pale grey tint, containing no stones of any kind	45
3. Gravel and fine sand interstratified	15
4. Unstratified pebbly clay, some bands indistinctly seen here and there, colour dirty grey, somewhat reddish, no large boulders	15
5. Fine stratified sand and sandy mud, often rippled and waved, some seams containing a considerable proportion of clay, colour pale-grey, occasionally reddish. It contains no gravel, stones, nor pebbles of any kind	35
6. Base of the bank descending to the edge of the river, concealed by loose debris	50

In some parts of the bank the unstratified stony earth attains a considerably greater thickness ; but at the time of my visit there was a very clear section at the point described. The arrangement of the beds was nearly horizontal. The stones and pebbles were of gneiss, granite, quartz, and similar crystalline rocks. No large boulders were seen ; and I was disappointed to find no fossil remains in these beds, although a longer search might have been more successful.

Standing on the top of these high banks, and looking down upon the fertile lowlands of Moray, dotted with farms and thriving villages, I could not but picture to myself a time when the ocean rolled over its plains, and threw its breakers ashore even at my feet ; here,

far up on these hillsides, must once have been the old high-water-mark.

I shall now mention some other circumstances that tend to throw light upon the depth of the sea during a part at least of the Pleistocene epoch. The evidence of the Mollusca, so far as it goes, indicates that, at the period of their existence, the depth of the sea was not beyond a few hundred feet, even over the lowest part of the present land; and it is important to bear in mind that their remains have not been found anywhere in this part of the country at an elevation exceeding 250 feet. What I am now going to allude to, however, is the occurrence of beds of gravel and water-worn pebbles on the summits of some of the hills in this eastern part of Aberdeenshire.

I have shown that the top of the ridge about Highlaw, at an elevation close upon 300 feet, is occupied by gravel; there is also a ridge in the neighbourhood of Ellon, called Cross-stone, the top of which consists of great masses of water-worn pebbles and gravel at an elevation of 226 feet. The Hill of Auchleuchries, in the parish of Cruden, has also a crest of gravel, reaching a height of 356 feet.

Again, there is a ridge of hills which, commencing at the Buchan Ness, runs inland for seven or eight miles, rising gradually till it culminates, near its western extremity, in the Hill of Smallburn, at an elevation of 464 feet above the mean level of the sea. This ridge is remarkable for an abundance of flints, which are found along its summit from one end to the other. They are always water-worn, and sometimes contain chalk-fossils. Associated with them is a similar abundance of quartzose pebbles, which are also finely rounded and water-rolled.

Both the flints and quartz-pebbles extend a little further west, to the hills of Skelmuir and Dudwick; but towards the western extremity of the latter the flints gradually die away, and finally cease.

These chalk-flints appear to have been first brought under notice by Dr. Knight of Marischal College, Aberdeen, who read a paper upon them to the meeting of the British Association, at Edinburgh, in 1834, and exhibited a series of specimens; and they have since then been commented upon by various observers*. Their abundance is in many places surprising; but they are often hidden by a covering of peat-moss. In some places the flints predominate, in others the quartz; but they are both highly water-worn, the hard quartz pebbles being often as smooth as an egg, with a clean washed aspect, like the pebbles on the beach. I found that both kinds occur in a thin stratum of reddish or yellowish-brown earth or earthy clay; and in some places the pebbles form almost the entire mass, as is very observable in several pits at the side of a road which crosses the ridge between Tarhenry and Smallburn (fig. 5). This earthy clay appears to repose immediately upon the subjacent rock. I have seen it covering the granite at the Blackhill, and gneiss at Smallburn, and

* See a Memoir by Messrs. Salter and Ferguson on this subject, *Quart. Journ. Geol. Soc.* vol. xiii. pp. 83, &c.—EDIT.

rock of doubtful character in other spots. It is also not without interest to observe that a stratum of coarse reddish clay, containing pebbles of granite, quartz, and flint, covers the greensand-deposit at Moreseat*.

Fig. 5.—Outline-section along the hilly ridge from the Buchan Ness to Dudwick. Length about 12 miles.

In addition to the water-worn pebbles, a few larger stones occur, with a rougher exterior and shapeless form. Some of them occasionally reach from two to three feet in length; and I believe they are sometimes found still bigger. They are granite of different varieties, and compounds of quartz and felspar varying in quality.

Now, upon the top of the adjacent Hill of Dudwick, which reaches a height of 562 feet, I found the quartz-rock covered by its own debris, but the fragments *all quite angular and unworn*; and on a lower projection of the hill at an elevation of 480 or 500 feet the same thing occurred. But, searching along the eastern flank of the ridge, I found, to the north of a croft called Backhill of Dudwick, the water-worn pebbles of quartz and flint occurring with considerable regularity to a height of about 450 to 470 feet, beyond which they appeared to cease. It seemed, however, as if some agency had disturbed them since they were rounded, and had washed them up at certain points to a higher level; and a small flint or two may be picked up even on the very summit of the hill.

Whatever may be thought of this, I would at least draw attention to the great extent of water-worn pebbles that clothe the long ridge before mentioned, with great regularity, up to a height which I have measured and ascertained to be 464 feet above the mean level of the sea. They seem to attain their greatest development along a zone from 350 to 450 feet high. They are strikingly displayed over the Hill of Kinknockie, and also at Hillhead of Auquharney, where there is a croft or cottage, whose foundation I ascertained to be 398 feet above the sea-level. The flints are also particularly abundant on the top of Cruden-hill, which is the point where the three parishes of Cruden, Longside and Peterhead meet; they cover the ground there with a uniform close stratum; but over a great part of the ridge the peat lies so thick as to hide everything.

I shall now describe a great accumulation of highly water-worn shingle covering the top of a ridge in the parish of Fyvie, about twenty miles inland.

* See the Memoir above referred to.—EDIT.

The tract is known by the name of the Windy hills, and is situated close beside the hamlet of Woodhead, in the neighbourhood of the River Ythan. The whole crest of the ridge is thickly covered with great sheets of quartz-pebbles, mixed with a fine whitish sand derived from the grinding down of the fragments. These pebbles are of all sizes below that of an egg, for the most part a good deal smaller. It is true that bigger pieces occur; but there are no large boulders. Several holes or excavations show the mass to be very homogeneous and remarkably devoid of any foreign fragments. A few coarse water-worn flints occur, generally of large size—often nearly six inches in diameter, and frequently with a white chalk-like exterior. I did not find any trace of shells or other fossils in those I picked up. They are for the most part of a very coarse quartz character, and are whitish, blackish-blue, or yellowish in colour, and are generally unlike the flints of the ridge previously described.

The peculiar significance of this gravel (which covers a tract about two miles long and a mile broad) lies in the fact that it is not a drift-gravel, but an accumulation of local origin, derived from the quartz-beds of the clay-slate strata on which it rests. The pebbles are not pure quartz, but contain a considerable proportion of felspar, whose decay gives to the mass a particularly white aspect.

Thinking it of some importance to determine the precise height of this ridge, I levelled it from a point of known elevation in the immediate neighbourhood, and found the summit to be 412 feet above the mean level of the sea.

No clay was found overlapping this deposit; nothing covers it but some peat-moss. I should say that it had formed a shoal or bank covered by very shallow water, the lashing of which had ground down the quartz into the shingle that we now see. Had the water been of any depth, there would have occasionally occurred seams of clay or fine sand interstratified with the pebbles; but such is not the case.

No transitory flood can account for these extensive shingle-banks; a lengthened period of time is demanded for grinding down the hard quartz fragments into their present smoothly-rounded form. The thick accumulations of finely-laminated silt which line the lower part of the Spey valley and margin the surrounding coast, the evidence of the molluscs found imbedded in their native mud, together with the silent testimony of these gravelly shoals, all converge to prove that the sea-waters had long stood over this part of Scotland some 450 feet higher than the present coast-line.

On the emergence of the land from the waters of this Pleistocene sea, I find evidence that the country had attained a greater elevation than it does at present. This is shown by superficial beds of peat passing down below the present sea-margin.

In the links, or low sandy flats, adjoining the beach at Aberdeen, I have seen peat beneath the surface of the sea-sand; and at the mouth of a small rivulet, which divides the parishes of Belhelvie and Foveran, I have observed a formation of peat passing directly under the sea-beach.

Again, in the statistical account of Belhelvie, by the minister of the parish, the late Rev. Dr. Forsyth, the following interesting passage occurs:—"There is a great quantity of peat-moss in the parish. Some of it near the coast is considerably under the level of the sea, and is covered to the depth of 10 or 12 feet by sea-sand. It is probable that this moss extends a considerable length out to sea, and that there is a submarine forest in this bay at no great distance. For on Christmas 1799, when there was perhaps the most dreadful tempest that any person remembered to have seen on this part of the coast, several cubical blocks of peat-moss were cast by the sea upon the sandy beach, some of them containing upwards of 1700 cubic feet. Pieces of wood, like branches of oak-trees, apparently converted to a consistence like moss, passed through these blocks in every direction. Both moss and wood were perforated by a number of auger-worms of a large size; and most of them were alive in their holes. The moss was of a much harder consistence than any found in this part of the country. Such large blocks could not have been carried to the sea by any of the neighbouring rivers; for they were not swelled at that time, but were all firmly bound up with ice. In general, when anything like a tempest occurs at sea, a considerable quantity of peat-moss of the same kind is cast upon this sandy beach; but no person remembers to have seen it in so large masses as at Christmas 1799." The late Prof. MacGillivray, in his account of the Mollusca of this part of Scotland (p. 306.), also states, "Dr. Fleming informs me that he has seen *Pholas candida*, as well as *Pholas crispata*, in masses of peat cast on the beach near Donmouth."

I have further been told that, in the Bay of Peterhead, peat is occasionally brought up by the anchors of vessels; and in the Statistical Account of Fraserburgh I find it stated that "many of the benty hillocks which skirt the bay stand upon moss or clay; and in 1760, a tree with roots and branches and a stem 20 feet long was found entire under the sand within high-water mark."

In the Moray Firth a submarine forest is known to exist between Burghead and Nairn.

The occurrence of extensive fields of peat, abounding in remains of trees such as the Birch, Fir, Oak, and Hazel, and situated on exposed tracts close to the sea, where trees can hardly be got to grow at the present day, also renders it probable that the coast was further off when these woods flourished.

Horns of large extinct species of oxen have been found in the surface-beds of peat, but are very rare. A specimen got in Belhelvie is now in Marischal College Museum; another found at a place called Tuchin, in the parish of Cruden, is in Slains Castle*.

I have also in my possession the root-fragment of a stag's horn found in a bed of peat overlying the clay at Annochie in St. Fergus. For this specimen, as also some other interesting fossils, I am indebted to Dr. Gordon, R.N., St. Fergus.

Into the subject of the transport of boulders, and other phænomena

* Both of these specimens I have seen, and find them to be remains of the *Bos primigenius*.—October, 1858. T. F. J.

of the drift, I do not now enter, merely remarking that blocks from a distance and striated fragments are found at elevations far above what I have mentioned regarding the stratified deposits and water-worn gravels.

In this paper I have chiefly sought to point out two distinct periods, or resting-points, in the Pleistocene history of this part of Scotland:—one when, under a climate much colder than what we now enjoy, the land sat some 450 feet lower than at present; and a subsequent period when it stood higher than it does now, and when deer and great wild oxen roamed amongst its woods.

Note.—Mr. S. P. Woodward, F.G.S., author of the well-known ‘Manual of the Mollusca,’ has favoured me with his opinion on some of the shells from the Pleistocene beds described in the foregoing paper, and remarks as follows:—

“Most of the shells from the Annochie clay at St. Fergus are examples of *Nucula tenuis* and *Leda pygmæa*. All the largest shells from the same spot are *Saxicava arctica*. The *Lucina ferruginosa* appears to be rightly named. One shell is a *Cryptodon*, apparently, but quite new to us. The *Cylichna* is like *C. obtusa*.

“Of the broken shells from the Kippit Hills, beside the Loch of Slains, are—

“*Cyprina Islandica*, *Astarte borealis*, *Fusus carinatus*, *Tellina solidula*, and *Cardium Norvegicum*.

“There are two specimens of the *Tellina* of unusual thickness; but they are like no other species.

“Those from Cruden include—

“*Pecten opercularis*, *Cardium Norvegicum*, and *Trichotropis borealis*.”—October, 1858.

3. Mr. KENNEDY MACNAB, of Inverness, communicated, in a letter to the Secretaries, the fact of flint arrow-heads and whelk-shells having been found at the depth of about 3 ft. 6 in. beneath the surface of a moss, covered with wood, in the parish of Abernethy (Inverness and Elgin).

4. Mr. RICHARD MASON, of Tenby, in a communication to the Secretaries, offered a *résumé* of the evidences, traditionary, historical, and physical, of—1st, the probable depression at some pre-historic period of an extensive tract of country, covering the site of the Bristol Channel and Cardigan Bay; and 2ndly, of the more recent elevation of the land in the neighbourhood of Tenby, South Wales; the elevated district being apparently confined to that lying on the Carboniferous Limestone. Evidences of a comparatively recent depression of the Cardiff area were also alluded to.