they may be of some use to future investigators who may attempt to account for the formation of these peculiar markings.

5. *Black shale bed*.—This bed is not seen in the quarry, but in the same bed, half a mile distant, I got part of a tree, three feet long by five inches diameter, composed of white sandstone, which could not have been formed in black shale, but must have been brought from a distance,—that is, if fossil remains are generally converted into the same substance as the rock in which they are embedded.

From the facts above related, I conclude that the beds under consideration were formed at the mouth of a river flowing from east to west, at a period posterior to the formation of the Virtue Well coal; and taking as granted that the underclay was the soil on which the vegetation grew to form the coal bed, the conclusion is that dry land existed during the growth and decay of the coal-forming plants, and that the land afterward sank sufficiently to form the bed of a river, carrying in its flood the worn materials of older strata, which now form the roof, shale and sandstone, of the coal bed.

XII.—NOTES *on a RAISED BEACH at CUMBRAE*. By Mr DAVID ROBERTSON, F.L.S., F.G.S.

[Read 20th May, 1875.]

THE late James Smith of Jordanhill was the first to point out a difference between the molluscan fauna of the post-glacial deposits and that of the raised beaches; also, that the fauna of the raised beaches was identical with that living in neighbouring seas, and that both of these deposits are anterior to the recent or historical period.

He says, "On one of my cruises* I had the good fortune to be accompanied by my lamented friend Edward Forbes. . . . After visiting the Clyde deposits, we proceeded to Port Rush, on the Irish coast, where I had discovered a peculiarly rich deposit, collecting nearly 100 species in its raised beach, about 15 feet above the level of the sea. At the first glance, he exclaimed, 'Here is an end of your Arctic climate; these

* "Researches in Newer Pliocene Geology," 1862, pp. 76, 77.

shells indicate a warmer climate.' Next morning he told me that he had been thinking over the climatal conditions of the Port Rush shells; that we were further out at sea than in the Clyde beds; the shells were, therefore, more pelagic in their character, and had a wider range. He would not, therefore, say that they indicated a warmer climate; but he could see no reason to suppose that they indicated a colder one. This was rather perplexing, as some of the shells were unknown to me; but upon the discovery of the last of these shells by Captain, now General Portlock, I became satisfied that there were two distinct formations."

No further search appears to have been gone into in regard to the fauna of these old beaches of Scotland. But be their age what it may, a decided break is established between them and the post-tertiary deposits, which contain Arctic shells not now living—or, at least, not now known—in our neighbouring seas.

Whatever variations of climate obtained during the whole deposition of the post-tertiary deposits, they do not appear to have left any decided impress of change on the molluscan fauna, no break that may not be satisfactorily accounted for by existing conditions. It is true that in some districts the post-tertiary fauna differs from that of another, at no great distance, in its apparently more northerly or southerly aspects, which unquestionably might arise from local causes, independently of climatal changes. The same thing holds good at the present time. For instance, *Fusus Tartoni* (Bean), *Fusus Norvegicus* (Chemn.), *Fusus Berniciensis* (King), and *Saxicava* (*Panopcea*) *Norvegica* (Spengler), all northern species, have been taken living on the coasts of Durham and Northumberland, while no trace of them has been found on the western coasts of Scotland. We may reasonably infer that similar variations occurred in the seas of ancient times, yet no one would ascribe them to change of climate.

Perhaps nowhere is the old twenty-five feet raised beach seen with more advantage than round the shores of the island of Cumbrae. Millport is built upon it, or, at least, upon a plateau regarded as belonging to it, though the greater portion is not half so high. From Kames Bay along to the south-west end of the island, a length of about one and a half miles, marine debris is seen lying in the greatest abundance. Elsewhere all round the shore it is generally comparatively bare, with only a little soil

covering the rock, except a few gravelly patches here and there, and at two or three places clay with Arctic shells.

One of these shell beds crops up on the north-east side of Kames Bay; it is composed of hard reddish clay, and, from its dip, apparently passes under the sea. It lies between tide marks, but is seldom seen except when laid bare by storms. There is another Arctic shell bed lying at a higher level (32 feet above high water) on the west side of the College, where the shells are imbedded in sand.* It may be worth notice, in passing, that the shell sand of this bed was only reached, but not passed through. A short time ago, a well put down about twenty yards to the west of the old cutting, passed through the deposit, which proved to be only about a foot thick, and much more hard and compact than the over-lying sands. Under this firm shell-bearing sand, grey laminated clay, two feet thick, was cut into, and also contained Arctic shells; but, as it was not pierced through, its depth is therefore at present unknown. There is every reason to believe that this is the same bed which crops out in Kames Bay. Moreover, Arctic shells, such as the valves of *Saxicava Norvegica* and *Pecten Islandicus*, are often thrown up on the shore in Balloch Bay, opposite Fairlie, and at the west end of Fintry Bay. There can, therefore, be no doubt that all these patches of post-tertiary clays around the island are, or were, connected with the clays on the opposite shores, and those again with all others in the Clyde valley containing Arctic shells.

The area referred to of the Cumbræ raised beach is chiefly covered by the calcareous sea plant (*Melobesia calcarea*), locally known as "Marl."

The principal exception is the beach in Kames Bay, which consists of sand and gravel. In the sinking of a well there, about seventy yards inland from high water mark, six feet of fine sand were passed through, next one foot of peat, then seven feet of gravelly sand; a few hundred yards further back the sand thinned out on the peat, showing conclusively that all the sand over the peat in this place has been wind-drifted. The peat proves the existence of a fresh-water morass, which overlaid the gravel perhaps at no very distant date.

The portion of the beach to which I shall more particularly refer in this paper is that at the south-west end of the island,

* Trans. Geol. Soc. Glas., Vol. III., p. 118.

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exposed in a cutting for a new road near the battery, where many acres of the flat land consist chiefly of shell "marl."

The shells are mostly littoral, many more or less broken and water-worn. One moderately common is *Trochus lineatus* (Da Costa), and is of considerable interest, in so far as it is not known to be now living on the neighbouring shores. Its habitat is on stones near high water mark. Jeffreys records it from Dorset, Devon, Cornwall, Swansea, Anglesea, Channel Isles, Ireland as far north as Donegal Bay, and Spain. The following Scottish habitats are also given:—Dunbar (one specimen in deep water (Laskey)); Peterhead (Macgillivray); Cumbrae (Smith); but Jeffreys thinks that these Scottish localities require confirmation. In reference to Mr Smith's find, there is now much reason to believe that he was right, from the fact that opposite this old beach has long been a favourite dredging ground of marine Zoologists; and as portions of this old beach are carried away by every storm into the sea, there is nothing more likely than that Mr Smith might dredge up one of these washed out shells.

As raised beaches occur near Dunbar, and probably at Peterhead, the above is a reasonable explanation of the finds at both these places.

The range of *Trochus lineatus* being confined to stones and rocks near high water, it could not be affected in any way by the shifting or transition of banks of one character into that of another, or other disturbances at the sea bottom, or by the changes in the depth of water. If due to change of circumstances at all, we cannot well suppose any other than atmospheric influences; and the fact that it is now more a southern than a northern species, favours the idea that a lower temperature prevails now than was the case when the shells of the old sea beach lived.

Tapes decussatus is another shell moderately common in the same beach, and not now found, so far as I know, round the shores of the island, though abundant on other shores at no great distance.

From the quantity of shells in the beach burrowed into by the sponge *Cliona celata* (Grant), it would appear to have been much more plentiful at one time than it is now, as recent examples of those species which suffered most from its attacks in these old beaches, are now rarely to be seen touched by it.

A land shell, *Helix nemoralis*, is not uncommon amongst the

debris of this raised beach, and might have got there readily enough by being carried into the sea by rivers or streamlets, and again thrown up on the beach.

Another of these stragglers is a fragment of bone sent me by my friend Mr Levach, which he found in the same beach at a depth of six feet, and which was submitted to Professor J. Young, who pronounced it to belong to the right lower jaw of a young cow. Had the whole skeleton been found, it would be natural to suppose that the animal had been buried there purposely; but, as there was only a portion of a bone, it is more likely that it was deposited there along with the material in which it was found.

It may be remarked that *Melobesia polymorpha* (Linn.) is common in the post-tertiary clays of the West of Scotland, associated with Arctic shells, and is still more common, living all round our coast; but no trace of *M. calcarea* has been met with in these beds, although present in our old sea beaches, and abundant in our present seas.

It might be expected that the fauna of the old raised sea beaches would be exceedingly rich, where so much has been washed up by tides and storms,—where mollusca, polyzoa, ostracoda, and foraminifera have been floated up on the roots and stems of the large sea-weeds, and left on the shore to be disengaged as the plants decayed. But such accumulations of the remains of these ancient life forms do not seem to have taken place; so far as these old sea beaches have come under my notice, they are generally poor in variety, although occasionally one or two species may be very abundant. The scarcity of ostracoda and foraminifera, compared with the quantity obtained from an equal amount of material taken from the neighbouring sea-bottom, is particularly noticeable.

In regard to the age of these old sea beaches, although from the date of their formation till the present time there may be no change in their fauna sufficient to characterize a geological epoch, such as we have between the post-tertiary and raised beach deposits, yet the disappearance of the species above referred to is an inducement to extended research in the same direction for other facts that may lead to some satisfactory conclusion as to whether these variations are merely local, or brought about by more widely supervening influences.

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That some sub-aërial change has taken place at no very distant time, geologically speaking, we may infer from the fact that the remains of large trees are found in the peat of the Shetland Isles, where no trees will now grow. Sir Charles Lyell, in his "Antiquity of Man," refers to a deposit of peat in Denmark varying from 10 to 30 feet in depth, where remains of *Pinus sylvestris*, 3 feet in diameter, are found near the bottom; next is a layer containing the sessile variety of oak; next follows the pedunculated oak, and overlying that is the beech, a common tree in Denmark, but flourishing in places where the pine will not now grow. Whatever variations may have taken place in the temperature of our country, and whatever its effects on animal and vegetable life on land, since the formation of our raised beaches, such effects do not appear to have obtained appreciably at the bottom of the sea; one reason probably being that the range of temperature is vastly greater on land than in the sea. For the examination of doubtful species of the mollusca, I have to acknowledge my obligations to Mr Gwyn Jeffreys, F.G.S.

The list of species met with is as follows:—

Mollusca	66 species.
Crustacea	24 "
Annelida	2 "
Echinodermata	2 "
Foraminifera	17 "
Porifera	1 "
Alga	1 "
<hr/>	
Total,	113

MOLLUSCA.

CONCHIFERA.

<i>Ostrea edulis</i> (Linn.)	Common; moderately large.
<i>Pecten maximus</i> (Linn.)	Rather rare; large.
— <i>opercularis</i> (Linn.)	Small and fragmentary.
<i>Lima hiems</i> (Gmel.)	Rare; rather small.
<i>Mytilus edulis</i> (Linn.)	Moderately rare.
— <i>modiolus</i> (Linn.)	Moderately rare.
<i>Lucina borealis</i> (Linn.)	Moderately common.
<i>Cardium edule</i> (Linn.)	Common.
— <i>Norvegicum</i> (Spengl.)	Common.
<i>Cyprina Islandica</i> (Linn.)	One fragment.
<i>Venus casina</i> (Linn.)	Moderately common.

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Venus fasciata (Da Costa).

— *gallina* (Linn.)

— *ovata* (Penn.)

— *exoleta* (Linn.)

Tapes pullastra (Mont.)

— *decussatus* (Linn.)

— *virgineus* (Linn.)

— *aureus* (Gmel.)

Tellina crassa (Gmel.)

— *Balthica* (Linn.)

Macra subtruncata (Da Costa).

Solen ensis (Linn.)

Pholas crispata (Linn.)

Common.

Moderately rare.

Rare.

Moderately common.

Common.

Moderately common.

Very common.

Rare.

Rare.

Moderately rare.

Moderately rare.

A few fragments.

Rare.

GASTEROPODA.

Patella vulgata (Linn.)

Helcion pellucidum (Linn.)

Tectura virginea (Müll.)

Emarginula fissura (Linn.)

Trochus magus (Linn.)

— *lineatus* (Da Costa).

— *cinerarius* (Linn.)

— *umbilicatus* (Mont.)

Lacuna divaricata (Fabr.)

— *pallidula* (Da Costa).

Littorina littorea (Linn.)

— *rudis* (Maton.)

— *obtusata* (Linn.)

Rissoa parva (Da Costa)

— *costata* (Adams).

— *striata* (Adams).

— *cingillus* (Mont.)

— *reticulata* (Mont.)

— *violacea* (Desm.)

Hydrobia ulva (Penn.)

Skenea planorbis (Fabr.)

Cæcum trachea (Mont.)

Turritella terebra (Linn.)

Scalaria communis (Lam.)

Odostomia spiralis (Mont.)

Natica catena (Da Costa).

— *Alder* (Forbes).

Aporrhais pes-pellicani (Linn.)

Cerithium reticulatum (Da Costa).

— *perversum* (Linn.)

Purpura lapillus (Linn.)

Buccinum undatum (Linn.)

Fusus gracilis (Da Costa).

Common.

Rare.

Moderately common.

Rare.

Very common and large.

Moderately common.

Common.

Common.

Rare.

Moderately rare.

Very common.

Moderately common.

Common.

Moderately common.

Rare.

Moderately common.

Common.

Moderately common.

Common.

Rare.

Moderately rare.

Moderately rare.

Rare.

Rare.

Rare.

Rare.

Rare.

Rare.

Very common.

Rare.

Very common.

Common.

Moderately rare.

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<i>Fusus antiquus</i> (Linn.)	Rare.
<i>Nassa reticulata</i> (Linn.)	Moderately rare.
—— <i>incrassata</i> (Ström.)	Rare.
<i>Pleurotoma rufa</i> (Mont.)	Rare.
—— <i>costata</i> (Don.)	Rare.
—— <i>septangularis</i> (Mont.)	Rare.
—— <i>striolata</i> (Phil.)	Rare.
—— <i>Trevelyana</i> (Turt.)	Rare.
<i>Cypræa Europæa</i> (Mont.)	Moderately common.

CRUSTACEA.

CIRRIPEDIA.

<i>Balanus porcatus</i> (Da Costa).	Rare.
—— <i>balanoides</i> (Linn.)	Rare.
—— <i>crenatus</i> (Brug.)	Rare.
<i>Verruca Strömia</i> (Müll.)	Rare.

ANOMOURA.

Claw of Crab. *Sp.*?

OSTRACODA.

<i>Pontocypris mytiloides</i> (Norman).	Rare.
<i>Cythere convexa</i> (Baird).	Moderately common.
—— <i>villosa</i> (Sars).	Common.
—— <i>lutea</i> (Müll.)	Moderately rare.
—— <i>albo-maculata</i> (Baird).	Moderately common.
—— <i>angulata</i> (Sars).	Rare.
—— <i>pulchella</i> (Brady).	Moderately rare.
—— <i>pellucida</i> (Baird).	
—— <i>tenera</i> (Brady).	Rare.
—— <i>viridis</i> (Müll.)	Moderately common.
<i>Cytheridea papillosa</i> (Bosq.)	Rare.
<i>Loxoconcha impressa</i> (Baird).	Moderately common.
<i>Xestoleberis aurantia</i> (Baird).	Moderately common.
<i>Cytherura nigrescens</i> (Baird).	Common.
—— <i>angulata</i> (Brady).	Rare.
—— <i>flavescens</i> (Brady).	Rare.
—— <i>cellulosa</i> (Norman).	Rare.
—— <i>acuticostata</i> (Sars).	Rare.
<i>Paradoxostoma ensiforme</i> (Brady).	Rare.

ANNELIDA.

<i>Serpula vermicularis</i> (Ellis).	Common.
<i>Spirobis communis</i> (Flem.)	Very common.

ECHINODERMATA.

<i>Echinus sphæra</i> (Müll.), Plates of
<i>Amphidotus</i> , Spine of

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FORAMINIFERA.

<i>Biloculina ringens</i> (Lam.)	Rare.
<i>Triloculina trigonula</i> (Lam.)	Rare.
<i>Quinqueloculina seminulum</i> (Linn.)	Common.
———— <i>bicornis</i> (W. & J.)	Moderately common.
———— <i>secans</i> (D'Orb.)	Common.
———— <i>subrotunda</i> (Mont.)	Moderately common.
<i>Spiroloculina planulata</i> (Lam.)	Rare.
<i>Lagena sulcata</i> (W. & J.)	Rare.
<i>Polymorphina gibba</i> (D'Orb.)	Common.
———— <i>compressa</i> (D'Orb.)	Moderately rare.
———— <i>tubulosa</i> (D'Orb.)	Moderately rare.
<i>Textularia sagittula</i> (DeFrance).	Moderately rare.
<i>Truncatulina lobatula</i> (Walker).	Moderately common.
<i>Rotalia Beccarii</i> (Linn.)	Common.
<i>Polystomella crispa</i> (Linn.)	Common.
———— <i>striato-punctata</i> (F. & M.)	Common.
<i>Nonionina depressula</i> (W. & J.)	Rare.

PORIFERA.

<i>Oliona celata</i> (Grant), burrows of	Common.
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ALGA.

<i>Melobesia calcarea</i> (Ellis & Sol.)	Common.
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XIII.—On the GEOLOGY of the ISLAND OF ISLAY.* By JAMES THOMSON, F.G.S., corresponding member of the Royal Science Society of Liège, Belgium. With a Map.

[Read 13th May, 1875.]

THERE are few parts of Scotland of which we know so little of the geological features as of those of the Island of Islay. The only information we have on the subject is to be found in Dr M'Culloch's "Highlands and Western Isles of Scotland," vol. ii., page 249; and by Prof. Nicol, in his "Geology of the North of Scotland."

Dr M'Culloch deals principally with the topographical aspect of the island, of which he gives a map and several sections. He describes the rocks in the central valley as being made up of

* The substance of this Paper was read at the meeting of the British Association in Edinburgh.