THE

GEOLOGY OF PORTLAND:

TWO LECTURES

DELIVERED IN PORTLAND,

Feb. 10*th and* 13*th* 1865,

BY

REV. J. E. TENISON WOODS, F.R.G.S.,F.L.S.,F.G.S., &c.

Primus ego aspiciam notum de littore pinum. *Ovid.*

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LECTURE II.

GEOLOGY OF PORTLAND.

THE MARINE FORMATION.

THE subject for our consideration this night, is a little more tranquil in its associations than the products of those fiery disturbances, which have ushered in the early history of this continent, and which occupied our attention on a former occasion. We must entirely as it were change the scene. Instead of burning mountains, flaming craters, earthquakes and terrific explosions, we have the quiet bed of the ocean to deal with, and many a hundred fathom of silent dark blue water heaving above it. And yet, if the scene is different, it is none the less in remarkable contrast with what we see around us at the present day. I mean, that if it excites our astonishment to fancy what are now the quiet streets of Portland, affording a bed to a glowing lava stream, it is quite as surprising to think of them as the bed of the ocean. To remember that where we see our houses now, there were formerly fishes; that above our quiet streets, great whales may have plashed and floundered; where fires glow up from our chimneys, salt water surged and fretted; and where the little children peacefully play, grim and voracious sharks may have found their prey. And yet it has been so, not only before the volcanoes poured out their fires, but even afterwards. Let us therefore trace the history which the rocks give us, of how it all happened.

When I mentioned the other evening, that volcanic rocks were found upon the surface, I did not mean you to understand that they were the most recent formation, but I treated of them first because they came first to the surface, and were most likely to attract the attention of those who wanted to know the history of the rocks of Portland. They are not the newest, neither are they the oldest. We will begin with the latter to-night. Every one who hears me has, I presume, noticed the white cliffs, which underlie the red clay and the trap rock of our shores. They are objects which might attract the attention of any observer, because they offer so strong a contrast to the dark strata above them. They are limestone, but I don't mean the term as chemically accurate, because they contain a great many other substances besides carbonate of lime, especially silica and magnesia; but I mean the term, as it is generally employed, to signify a rock which contains more lime than anything else. A great many of you have examined these rocks pretty closely, and no doubt have observed that the stone runs in strata, in horizontal lines not always parallel with each other. These strata are often divided by layers of shells, or rather fragments of shells, for they are all more or less broken. Between the layers the stone is a very soft substance, which crumbles easily between the fingers, and is not as far as one can see with the naked eye, composed of shells, and is not like sea sand. The shells or fragments are very different from what are found upon the beach now. It is not alone that they are all white, and the beach shells are more or less

coloured, because that effect might have been produced by exposure alone, but they are of different shape and appearance, in fact, I am sure that the most persevering shell collector upon the coast here, has never, in all his experience, found anything closely resembling the shells embedded in the cliffs. One which is very common in the strata, and which, being very small, is frequently found unbroken, is a very peculiar little shell, and I am sure none of you have ever picked up a living specimen from the pretty coloured fragments which so plentifully strew our shores. It is something like an ancient lamp; indeed, for want of a better name, it received from earlier naturalists a distinction in accordance with this resemblance. There is a little orifice from the end of the ventral valve, through which a ligament was passed, and by means of which the animal used to attach itself either to a rock or some floating object. I am almost tempted to stray away from the immediate object of my lecture, to tell you more about these kinds of shells. They seem to be favourite forms of nature, because in one way or another they appear in every succession of life, from the oldest rocks to those of our own times. It would be impossible to give you any idea of what a period, what a vast stretch of time, this implies. An instance will perhaps be better. Close to Melbourne there are some very old looking slates, so old and mossy looking that you would almost laugh at the idea of any person expecting to find shells in them. Yet shells there are, and in great quantity. It is not my purpose now to tell you how they came there, or how they have been altered from their primitive forms into the odd looking reddish masses in which they are found. You might not recognize them at once as the relics of shells, but no sooner had you done so, than you would also recognize their strong resemblance to the forms so common in the Portland Cliffs. There is the same type evidently. The same large valve overlapping the smaller one; the same kind of orifice in the hinge, by which the animal attached itself. But it is not by that character alone you will recognize the identity. If you open one of the valves of the shell you find in Portland, you will perceive inside a kind of shelly framework. These are the supports for the breathing appendages of the mollusc, and it is upon the peculiar shape of these, that some of the genera are distinguished in nature. And on these little bony frameworks, it is wonderful how many changes have been rung by nature in the past history of this earth. It would be impossible for me to attempt giving you any idea of their beauty or variety. Sometimes they take the form of huge bosses, or again of delicate spindles; but in one genus, the branchial appendages of the animal could never have been retracted comfortably into the shell, and to leave them lolling outside, would be to ensure their destruction by some predaceous fish. Nature, however, had provided a beautiful resource. Each side of the internal skeleton, was lengthened out into a beautiful tapering spiral coil on each side, something like a watch spring, and so the animal was able to wind his arms around them and secure them from danger. These are the *Spirifera* of the primary and secondary formations, though none of them have survived into our own times. It was in such forms as these that our Portland shell, which we call *Terebratella compta*,* was represented in former ages, so that you see it comes of noble ancestry, and the beauty of its relatives will, I hope, pardon the digression it has caused me. Next in interest to the *Terebratella*, comes that pretty looking heart shaped shell, so very common in the limestone. This is the *Hemiptagus*. Only the small ones are found perfect. The larger ones are broken and scarcely recognizable, except from the porcellanous character of their shiny fragments. The specimen before you,† has been variously named by different naturalists, and, unfortunately, I could tell you more about the name than about the habits of the animal itself. A kindred species is

* Called Terebratula by Sowerby, but its internal skeleton shows it to be a Terebratella. See appendix.

† Hemiptagus Forbesi.—Woods and Duncan.

very common at the present day, upon the coast of Scotland. It appears to live upon sand, a diet which no one will envy it; but there is a good deal of organic matter in the sand of this coast, or rather in the microscopic shells which compose it, and it is by digesting the various pieces of this that the animal picks up a living. Like the *Terebratella*, these animals seem to have been more common in the earth's former history than they are now. The variety of their forms, in what is called the secondary period, is astonishing. I can best give you an idea of what they are like, by referring to a very common shell upon our coast. You all know what is called the sea egg or *Echinus orum*. That little kind of marine porcupine, which children are so fond of collecting, in order to sow sand broadcast over the furniture of their houses. Scientific men call them a species of *Echinus*, a name applied to them even by the Romans, and meaning prickly. Well, the *Hemiptagus* is a kind of *Echinus*, and those little dots or markings which cover the surface, are the places occupied by the spines. I dare say you have found the spines too, for they are common enough in the cliffs and look like ivory pegs. Now, when we have mentioned these two fossils, the *Terebratella* and the *Hemiptagus*, we have exhausted the list of all that are common in the cliffs. I might specify other shells which occur occasionally, but the limits of my time will not allow me to speak of more than those which are common. Now, what evidence do these two shells afford? In the first place, I need hardly tell you that neither of the specimens I have referred to exist at present. They have all died out, and living species of the same kind are nowhere to be found. Secondly, you will remark that the general character of the formation is very different from our beach. This deposit could never have existed near the shore, not because the two shells would not have lived in shallow water, for probably they would, but because there would have been a great many others along with them, which in effect we do not find. For instance, take a walk along the coast and try to count the number of different species you will discover in an hour's ramble. Thirty or forty different kinds will reward your labours in a very short space of time. There will be, to use the common name for them, limpets, cockles, muscles, perriwinkles, oysters, scallops, mutton fish, &c., &c., all of such different shapes that there will be no fear of even the most inexperienced mistaking one for the other; and what is more, you will often find the fish inside the shells either living or dead, showing that the animal which occupies the shell can evidently find a livelihood at no great distance. What is seen in Portland is also seen elsewhere, modified of course by various circumstances. Wherever you find a beach you find also what are called littoral shells or mollusca, which love the shallow water and the food, animal or vegetable, which is always found upon the rocks. I have seen a great portion of the coast of Australia. From Wilson's Promontory round to the head of Spencer's Gulf, has been visited by me at different intervals, and I have always found littoral shells on every part. Yes, even on those very terrible ridges of sand which lie along the Coorong, and seem too desolate and too arid to afford a respectable livelihood even to a perriwinkle, I have found the usual abundance of littoral shells, but of course of different kinds. Now as we do not find littoral shells on the cliffs in Portland, it could not have been a littoral or a coast deposit. And we can go further than this. Littoral shells extend to a great distance from the coast, at any rate as far from the land as a depth of 100 fathoms. Sixty fathoms would carry us right across Bass's Straits to Tasmania, a distance of nearly 150 miles, and in effect I am sure we could count upon finding littoral shells right thro' the sea bottom of Bass's Straits. At any rate we might look for them in some quantity at least 100 miles from land. What therefore is to be our conclusion with regard to the Portland rocks? why that they were formed at some distance out at sea. Certainly not near any land, at least within a hundred miles and probably, for reasons which I shall now give, for a much greater distance, many hundred in fact. The reasons for the latter opinion are easily

given. When I said there were no shells in the cliff, I did not mean to exclude the *Foraminifera* or microscopic shells, which any ordinary magnifying glass will show, and are too beautiful and various for me to attempt to describe. Well these *Foraminifera* or chambered shells, are found to be a clue to the depth of the ocean. One kind is found at a certain depth, and another at another, so that if you find in any rocks a peculiar kind of shell and no other, and are aware at the same time of the depth at which that animal lives, then you form a good estimate of the depth of the sea, at the time the shell became entombed. Now the fine dust of the cliffs of Portland is one mass of two kinds of shell, *Globigerina bulloides* and *Orbulina universa*, both of which affect great depths of the ocean, certainly not less than 300 fathoms. In order to find such a depth, we should have to sail at least 150 miles away from Australia, and I doubt whether we should even find it then. So that we have here in the cliffs, a section of that mysterious place which we call the depths of the vast and mighty ocean, as it stood before mankind appeared upon the earth, and as it is in those watery wildernesses which roll away in blue waves as the Atlantic and Pacific Oceans. It is only lately we have been able to form any notion of what is the nature of the floor of those great seas. When soundings were taken for the Atlantic Cable, tidings reached us, both new and strange, of what the bottom of the sea was like. It was thought at one time, that no sounding line could reach it, but by ingenious contrivances it was made to give up its secrets. Awful depths they were too. A thousand fathoms, two thousand and even three, were run out in places before the bottom was reached, and when, after tedious labour, the lead came up again, as if in mockery of tho-e great measurements and mighty abysses, the only living organisms obtained were slender and delicate, so small and fragile that their beautiful intricacies and fairy like carving could only be made visible by the aid of the microscope. However, what was only obtained by hard labour and tedious experiments by the sounding apparatus of the Atlantic, is here unveiled before your eyes in the cliffs of Portland. You have only to imagine about six thousand feet of water above your head, and then you can make yourself quite at home fancying that you are exploring the floor of the ocean. We can see that it is level enough, and we can see too that there must lie some mistake in the imaginings of those who state that the telegraph cable had failed because of the inequalities of the sea bottom. What was the floor here was smooth enough. But we must change the subject, only asking who is there that would peer enough into futurity, to be able to prophesy that any portion of the present Atlantic sea bottom, will eventually have a town like Portland upon it.

But how do we account for the *Hemiptagus* and the *Terebratella*? This enquiry will tell us something more about the sea which rolled over our town. In the first place you will remark, as I have already said, that none of the larger specimens of *Hemiptagus* are found whole. All but the smaller ones are broken, and this leads to the presumption that they must have been brought from a distance. Still I will not give this explanation as at all a certain one. We all know that sea eggs are extremely brittle, the larger ones especially, so that the specimens in question might easily have become damaged without travelling very far. But could they have lived upon a sea bottom, with such a depth of water over it as this must have had? I think they could. And here I must tell you that the opinion of scientific men upon these matters, has undergone a considerable modification of late years. It used to be held that no molluscous animal, could exist at a greater depth than about 100 fathoms. The pressure of the water and various other circumstances, were deemed incompatible with the enjoyment of life. But one fact is worth a thousand theories. About three years ago, in the course of some sounding operations in connexion with the Atlantic Cable, a live star fish was brought up from a depth of, I think, 1,200 fathoms. Since that period other facts have come to light, which show that life is not incompatible with very great depths. It must, you will admit, be a very uncomfortable place to live in according to

our notions, and I suppose our view of the subject is shared by a large majority of the marine mollusca, for they are rarely found there. Such unnatural members of the animal kingdom as star fishes and *Echinidæ*, must be allowed a little latitude, especially as they look for no better diet than sand. Between the star fishes and *Hemiptagi* there is a close family resemblance, so that, after all the pretty heart-shaped stones which are so plentiful in our cliffs, may have lived and died on the spots where we find their shells. But with the *Terebratelia* the case is different. They, as I have already said, used to attach themselves to some foreign object, by the ligament which protruded thro' the orifice in their lower valves, and there was surely nothing to which they would fasten in the soft mud we find about here. My opinion is therefore, that they were attached to floating bodies, such as sea-weed and sponges, and when they died they dropped off and found a sepulchre in the depths of the ocean; though I should state, also, that they may have lived at such depths, for it is a truly deep sea mollusc. *Terebratella* are found, at the present day, at depths where no other shell fish could live.

I have now nearly done with the fossils, but I have to notice one more. I dare say many of you have remarked in certain places on the cliff, seams of white fragments which are about an inch thick, and which follow the sinuous lines of stratification. If you will examine these fragments closely, you will find that they are like the small spines of *Echini* or fossil ivory pegs, of which I have spoken already. Yet there is a difference between them. These pegs are hollow and open at the end; in fact, they are little tubes, which once contained mollusca. What are they, and why are they found in such quantities in regular strata in the sea bed, as if they appeared and disappeared at regular intervals? The answer is not hard to find. I dare say you have read in the journals of Arctic voyagers, how sometimes they have come to places in the ocean where the surface seemed covered with a small mollusc, sailing along and darkening the ocean in its multitude. Sailors call them whales' food, and no doubt they form a large ingredient in that fish's diet. They occur, it appears, in patches of many hundred square miles in extent, and have great facilities for changing their localities. If they fall victims to the appetite of the whale, they in turn prey upon the microscopic *Foraminifera*, of which I have already spoken, showing upon what small things the large body of the whale eventually depends. The *Pteropods*, for that is their name, have a small shell which varies for the different species, one of which is very like the tubes we are now considering. It is easy therefore to understand how these fossils come to be disposed in lines, about half-an-inch or so in thickness. While Portland was an open ocean, its dark blue waves would be sometimes visited by these little voyagers. A shoal of them might stay in the neighbourhood for weeks, and while they did so would cover the sea bottom with the shells of the dead members, which they would leave behind. I cannot say whether there were whales to prey upon them then as now. We find no bones of any, but they may have existed for all that. There certainly were sharks, for their teeth occur in abundance, but their bones are cartilaginous, and therefore would not be preserved in the limestone.

And now I have done with the fossils, which, in order to make as little tedious as possible, I have passed over quickly. I might have noticed other shells, such as pectens, scallops, oysters, &c. No particular interest is attached to them however, and we can pass from their consideration to something which I shall try to make of equal interest. Let me first tell you that these rocks are tertiary, that is to say containing a portion of shells or marine remains, which now exist upon the coast. For you must know that rocks are sometimes found, which, tho' full of shells, have not only no species, but very few genera similar to those we find now upon the shores of existing seas. Such rocks occur in what are called the earliest and secondary periods, and when you come to strata which possess some shells

similar to those now living, they are called Tertiary; a fact which is known, I am sure, to the majority of those who hear me now. Well, these tertiary rocks are distinguished from each other, according as they contain a larger or smaller proportion of existing species in them. Now, there are two important reasons for this distinction. In the first place, it enables us to tell which of two deposits is the most ancient; and secondly, whether two deposits, which are too widely separated from each other to contain the same shells, are not, in spite of that difference, contemporaneous. I will illustrate these two cases by an example. Near Hamilton we find a deposit which is very rich in shells, and which, at a glance, any one would see to be totally different from the deposit we have at Portland. They both, however, lie under the volcanic rock, and both are sufficiently near the surface to be seen at any moderately deep section. Now, which is the older? They cannot, as I have already remarked, be mistaken for each other. One is a mass of shells of all sorts in pretty fair condition, only so soft and brittle that it requires the utmost care to extricate them; the other is, as I have described, and as you know it, in Portland. It would be very difficult to describe which is the older, were we not to take the proportion of recent species as our guide. There are few recent species, or indeed species of any kind in the Portland rocks, but the formation occurs in other places, and a very small acquaintance with it enables one to pronounce that the Hamilton beds are the older of the two. They contain a far smaller per centage of recent species, and that is not all, but they have evidently a much more ancient character, although, from their mode of preservation, they would seem to an inexperienced person to be more recent.

This is one reason why tertiary rocks are divided into periods, according to the modern character of their contents. The earliest rocks are called eocene, and these are represented, according to Professor M'Coy, at Schnapper Point, Port Phillip; the next, in point of time, are the miocene, and these, he says, are found at Hamilton;* last of all come the pliocene formations, and these are the rocks of Portland with which I have been dealing this evening. Another illustration of the way in which these subdivisions become useful, is in comparing them with deposits which occur in Europe. The three deposits I have mentioned occur here. Europe has its Tertiary rocks, but not one single shell of Australia has a representative in England, nor even on the continent of Europe. How can we tell which of our deposits was in course of formation at the same time that the European miocene beds were accumulating? Why, by the proportion of existing shells in both. And thus, when I visit the Hamilton tertiary clays and look upon their curious richness in fossils, tho' not one single shell is like any fossil I have seen before, I can say that those shells were deposited here at a time when a great part of the North of France, when Vienna, and a portion of the Rhine, a great portion of India and Africa were under water.

Just, pause, however for one moment to consider the wonderful lapse of time which we include in the period between the rock formations of Hamilton and Portland. It is not only that they are different seas but they are different creations. In Hamilton we have fossil beds, some fourteen or fifteen feet in thickness and probably more, which are entirely composed of shells or marine remains. Large shell-fish have lived and died and their remains have taken so long a time to have become buried, that they are often encrusted with the shells of other adhering mollusca, which have found a temporary home upon them. But neither are their lives or the lives of their parasitic successors, nor the lives of the thousands of both which lie buried above them, the measure of the time which has elapsed. They have been succeeded by an almost totally different creation. Their places are taken by animals of different structure, and

* I would prefer regarding the Hamilton beds as Upper Eocene and the Schnapper Point beds as Lower Eocene.

frequenting different physical climates. If any of you were to go to India for instance, taking with you a collection of the shells from this coast, you would find in a very short time, that they differed completely from those of the land to which you had come. And if you went inland you would find that the trees and plants differed quite as much from those of Australia as the shells. You can easily see therefore that immense changes must take place before a new animal and vegetable world could take the place of the one we see around us in our home. And yet such changes have taken place. There is not more difference between our present fauna and flora and that of India, than there is between it and that of the cliffs at Whaler's Bluff. How long a time it has taken to work out such a change, is a matter of which we are utterly ignorant, except that we understand it to be a manifestation of a mysterious and grand sequence of events, which differ so completely from anything our earthly experience teaches us, that all efforts at comprehension are perfectly baffled.

I have yet two or three interesting questions to deal with, which I regret to find that time will not permit me to discuss fully. It may be asked first, how is it that the Portland rocks lie above those at Hamilton, and yet the latter have nothing above them even though they are scarcely fifty miles away? Could they have been dry land when the coralline rocks were accumulating? The depth of the Portland sea then precludes such a supposition. We must suppose that they have been there, but have been afterwards worn away, either by the action of the sea, or by subsequent weathering. It should be remembered that marine formations, especially the more recent ones are rapidly destroyed once they have been lifted from the water, and we only find them subsequently in patches when very favourable circumstances have contributed to their preservation. Thus the beds at Hamilton are only preserved through their being covered by a layer of trap rock. If you want to see how these formations become obliterated you have only to look at the break in the cliffs at Portland, and ask yourselves what has become of those portions which have been cut away to form the precipices.

Our next question is, to what causes are we to attribute upheaval? Let me in the first place beg of you to dismiss from your minds the idea that we have here any enormous result to deal with, at least as regards the whole earth, and even supposing the whole continent to have been uplifted together. The altitude of the highest mountains in the world added to the depth of the Pacific Ocean, would make nothing more than the merest scratching with reference to the whole diameter of the earth. Now supposing the depth of the sea when the Portland beds were accumulating to have been 1,000 fathoms, we have scarcely more to account for than the upraising of a portion of the surface of the earth, equal to about one four thousandth part of its radius. This quantity is so small that very trifling causes will explain it: either the expansion of rocks by heat, the percolation of water, or a difference in the magnetic state. The slightest alteration of the position of the earth in its orbit would give rise to the first and last causes, and there are not wanting in our present age scientific men who contend that the phenomena manifested at the close of the Tertiary period, can only be accounted for by supposing some such catastrophe as a change in the earth's axis of rotation. At any rate, a change in the specific heat of the earth even caused by slight variations in the sun's light, would cause changes of level on the world's surface more than sufficient to raise twenty continents like Australia.

The last question I shall deal with is this. What are the signs by which we know that the Hamilton and Portland beds are really distinct? The following is a brief description of the characters of both:—The Hamilton beds are rich in corals; the Portland beds contain none. The latter however, are very rich in Bryozoa, which are not numerous in Hamilton, and nearly all of different species. The characteristic fossils of Portland are *Terebratella compta*, *Pecten Cambierensis*, *Hemiptagus Forbesii* and *Hemiaster Archeri*. Of these the *Pecten* alone is found at Hamilton, and that rarely. The

characteristic fossils of Hamilton are *Natica Hamiltonensis*, *Pectunculus laticostatus*, *Pecten tenuistriatus*, *Cerithium Duncani*, *Flabellum Victoriæ*, and *Placotrochus deltoideus*. The two latter are corals. None of these are found at Portland, and the *Pectunculus* exists at the present day—but, singularly enough, at New Zealand and not in Australia; a *Flabellum* too, which is not common, is found alive at present in the Chinese Seas. This is the *F. Candianum*, so that, since the beds of Hamilton were deposited, there appears to have been a migration north and south of the few species which have survived to our day. The last difference between the beds is, that the Hamilton deposits are always highly ferruginous, the Portland beds perfectly free from iron; and this is a character which is maintained in both formations, for hundreds of miles.

And now I have finished all I have to say about one portion of the marine rocks. At some future time I might return to some other consideration in connexion with the same subject. At present I have not exhausted it, but I have probably passed the limits of what you can patiently hear. I am more than repaid, however, by the interest you have evinced; and my success is beyond my most sanguine expectations, if I can induce any of you to take an interest in the romantic history of the stone beneath your feet. It is the story of your hearths and homes, which should more than interest you, if they are as dear to you as they have become to me.

APPENDIX.

Terebratella compta appears in Strezelecki's Physical Description of N.S. Wales, p. 297, as a Terebratula. Sowerby however wrote in 1845, long before D'Orbigny had separated the genus into one or two divisions. It is rather singular however how this well established genus is ignored by some authors. In the Rev. J. G. Wood's Natural History, he gives at p. 417, vol. 3, a figure of the internal skeleton of some species of *Terebratella*, probably *T. dorsata*, Lamarck, as *Terebratula flavescens*, when the smallest attention to the classification must have pointed out the mistake. No true *Terebratella* are found near Portland, though a ribbed shell with a perforation (Waldheimia Australis, an allied genus), is not uncommon.

Hemiptagus Forbesii, Woods and Duncan, is more common at Portland than anywhere else. The genus was established by Desor, and is distinguished from *Spatangus* by the defective fasciole, or band without spines, surrounding the petals, and by the larger tubercles being confined to the anterior half on the upper surface. This peculiarity it shares with *Euptagus*, from which, however, it is distinguished by the fasciole being very clearly defined. The species in question, was described by me as *Spatangus Forbesii*.

The fossils named from the Muddy Creek, have not been described by me, because, I believe, they have for some time engaged the attention of Professor McCoy, who will probably publish them in his forthcoming "Decades." As it has been some years in preparation, the work will probably soon be in the hands of the Australian public. The names I have applied to the Hamilton fossils, have been for the sake of convenience, with the exception of the corals which have been published by Dr. Duncan, in the September No. of the Annals of Natural History for last year. To his list I may add the following, which are being described by Dr. Duncan and myself:—

Sphenotrochus Australis.
Balanophyllia seminuda.
Flabellum quasillum.
Cyclolites caduca.

The *Bryozoa* of both Portland and Hamilton will be described shortly being in the Transactions of the Adelaide Philosophical Society.