# On the Clifton Rocks.

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OF the many thousands who annually visit the Clifton Downs, probably few, if any, go away without admiration of the scenery. The foliage of the Leigh Woods, whether green with the youth of spring, or tinted with the varied hues of autumn, always forms such a combination of colour, that the eye is relieved and the mind of the visitor pleased.

Then again, what painter could equal the rich colouring of the massive cliffs, which from their angles of inclination expose immense slabs of the purest limestone. Every time we turn a corner, a varied scene presents itself, and to the thoughtful mind is a studio in which the natural historian may follow his favourite pursuit with pleasure and delight.

It is perhaps to the geologist that the deepest interest is afforded; to him questions occur in our earth's history of the most thrilling interest.

Standing on the edge of the old camp on Clifton Down, he sees the spot where the terrific power of the earth's interior had once been displayed, rending asunder the rocks and coal measures to the depth of nearly a quar-

ter of a mile. In another place he sees the memorials of a coral reef, where hundreds may now be found in all stages of growth, or of a sea bottom over which extended the slimy pseudopodia of myriads of foraminifera, burying with their tiny shells multitudes of little univalves whose bodies very likely were once their food. The busy steamers, the invention of the present century, claim his attention, ploughing their way over beds that once held waters which were the home of hideous and immense sharks, whose mouths were paved with crushing teeth, and which now enrich the cabinets of nearly every museum in Europe.

Here too, many hundreds of feet of limestone are literally made up of exquisitely formed sea lilies, whose nature has been so carefully studied and illustrated by our friend Major Austen.

I should detain you far too long were I to tell you of half the treasures in which the geologist might revel. With your permission I will now proceed to describe the section forming the Clifton Gorge, dividing my paper for the sake of regularity, into six heads, viz. :—

1.—The Physical Features.
2.—The Old Red Junction.
3.—The Lower Limestone Shales.
4.—Massive Mountain Limestone.
5.—Upper Limestone Shales.
6.—Millstone Grit.

1. Physical Features.—So interesting is the district in which we now are, and so rich and varied are its objects, that one is almost tempted to extend the subject, as announced in one of our notices, "the Geology of the Bristol District," but as I have no time to write a good sized book, nor wish to fatigue you by reading one, I will confine my paper to the Clifton Rocks.

The city of Bristol is placed on the confluence of two streams, the Avon and the Frome, not more than twenty feet above the mean sea level. This circumstance it is which causes the tides of this port to rise so high, being, with one or two exceptions, the highest in the kingdom. This flat portion of the country was formerly marsh land, the remains of which may now be seen at Baptist Mills, Bedminster, and Horfield. On both sides this marsh land, are high lands separated by valleys through which the before-named streams run ; after meeting, the river passes through the Clifton Gorge into the Severn. On the north and west sides, the Bristol district is bounded by palæozoic formations ; on the east and south by triassic and jurassic. Notwithstanding the low level on which Bristol is built, there are several hills having a considerable elevation, *e.g.*

| | FEET. |
|---|---|
| Dundry Hill (an oolitic outlier of the Cotswolds) | 700 |
| Ashton Hill .. .. .. .. .. | 270 |
| Troopers Hill .. .. .. .. .. | 230 |
| St. Vincent's Rock .. .. .. .. | 315 |

These elevations give the geologist a most valuable key to a knowledge of his position.

No neighbourhood of equal area can vie with that of Clifton and Bristol in geological interest whether considered lithologically or palæontologically.

When it is taken into consideration that within a radius of six miles no less than five complete geological systems are very fairly developed, it will be at once understood how good a field it is for the student of the natural sciences. The most complete of these without doubt is the carboniferous formation to which entirely Clifton is indebted for its grand and picturesque scenery.

The Clifton section is an epitome of this formation,

offering unequalled facilities for observation and study. The lowest level, namely that on which the city of Bristol lies, consists of alluvial soil and Keuper deposits, which fill up all the irregularities of the pennant and carboniferous rocks.

On the east, the coal measures come to the surface, which probably were once continuous with the Welsh coal fields, but now severed by denudation, except it may be at great depths north and south.

At earlier periods of the earth's history, very strong currents passed over the district from north east to south west, at all events there exists very strong evidence that such was the case during the time that the Cotswold and Dundry Hills were forming.

At that time how different must have been the scene, the bold escarpments and cliffs running south of where Gloucester now is, with their gulfs and bays and small islets, surrounded by a rough sea, separating England and Wales, like the Irish Sea now separates Wales from Ireland.

(Geologically speaking) just before this, occurred that convulsion of nature which formed the great fault running from Leigh Woods across the Coalfields to Mangotsfield and Will's Bridge. The fault is splendidly seen just beyond the station of the Port and Pier Railway, where the massive limestone abruptly terminates and is succeeded by broken ground, consisting of heaps of millstone grit, coal, and limestone, all crushed and forced up together giving evidence of irresistible power. Singularly enough this great break in the continuity of the rocks gives rise in this place to a repetition in the series. This is better explained by the diagram before you. The strata have sunk into the earth 800 feet.

The Clifton limestone series is part of the great basin connecting the Mendip and Cheddar Cliffs on the south, with the Shropshire and Staffordshire beds on the north. The whole of the limestone beds commence and end with their argillaceous and sandy beds termed "shales," and occupy a position between the old red beds at the bottom of Cooksfolly and the coal measures at Brandon Hill, where the lowest member is seen attaining a thickness of 950 feet.

The section now to be described begins a little below Cooksfolly and terminates at Brandon Hill. The angle at which the beds dip to the S.S.E. varies with the locality. At the Hotwells the strata dip at an angle of 40° which gradually decreases to 13°, then quickly rises to 70°; the curved nature of the strata denoting great pressure. There are about 800 to 1000 separate beds of limestone between the old red, before mentioned, and Brandon Hill, having altogether a thickness of about 3000 feet.

Before going into detail I would mention a curious deposit that is found filling up the cavities of the limestone almost everywhere, and we frequently hear it called permian. This we believe to be an error, from the extensive investigations of Mr. Sanders, who for more than thirty years has been mapping the district. The deposit is a conglomerate, composed of fragments of the older rocks, Devonian, carboniferous, millstone grit, and coal, all mixed and cemented together by magnesian limestone. It is nothing more than the basement bed of the trias or new red, with which it is perfectly conformable and horizontal. The triassic sea washing against the older rocks, broke them up, the heaviest pieces collecting against the foot of the cliffs. It is exactly so that we now find them either as a bank or heap, at the foot of a limestone or sandstone

cliff, or filling up a crevice. Sections of this remarkable conglomerate may be seen at the drawbridge and still better on the new rail to Portishead. In it we find the beautiful geodes or as they are commonly called "potato stones," they are hollow balls of quartz crystals, chalcedony or calc spar. The crystals are often pierced by multitudes of minute spicules of manganese and peroxide of iron. In other places the finest known crystals of celestine or sulphate of strontia have been collected together with galena and calamine. It was in this also that Messrs. Riley and Stutchbury found the thecodontosaurus and palæosaurus, distinguished from other saurians by having their teeth implanted in distinct sockets.

2. The Lower Limestone Shales rest immediately upon the old red sandstone and are about 500 feet thick comprising one hundred and forty-seven beds. The actual junction lies 35 feet above a well-known conglomerate of quartz pebbles, below this we find nothing but sandstones, but above it lime gradually creeps in till the beds become argillaceous limestone. Nearly the whole of the lower shales are covered by Cooksfolly Wood, but now that the Port and Pier Railway is finished a good section is obtainable, and also a little lower down on the opposite side of the river. They are extremely rich in fossils, especially encrinites, trilobites, and brachiopods, comprising nearly ninety species.

About 72 feet from the bottom of the shales are two green and red marly beds of considerable interest at the present time. They contain the same fossils that occur in the Coomhola grits of Ireland, and the Pilton and Marwood groups in Devonshire, where they were always considered as old red, but the present section goes to shew that really they belong to the carboniferous. They abound

with Modiola Macadami Avicula Damnoniensis, and multitudes of the little entomostraca. *(Leperditia and Cythere.)*

About 10 feet above these is a most singular fossil bank that once formed an inclined and sandy sea shore. It is so completely made up of minute fossils that a pound of the stone actually yields more than 1,600,000 organisms, principally consisting of encrinital joints, univalves, and entomostraca. Above this again is a rich palate bed, quite full of the the teeth, spines, and coprolites of fishes ; from it besides these, the collector will find many of the rarer shells as lingula, conularia, &c.

The remaining beds are equally rich, whole slabs being covered with the exquisite little polyzoon, Ceriopora rhombifera, and arms, heads, and stems of encrinites.

3. Mountain Limestone succeeds the shales and forms the principal part of the Clifton gorge, it comprises five hundred and twenty-five beds having a total thickness of 2000 feet.

The colour varies, being white, black, and many shades of red. The dark colour of the lower beds gives the local name to the quarry, "Black Rock." This black colour is probably owing to the presence of bituminous matter, some portions smelling very strongly. Frequently the workmen come upon a small cavity full of rock oil which is in great repute for rheumatism. In the Black Rock quarry are found some of the finest specimens of the remains of placoid fishes which in that age were of tremendous size and power. The dorsal fin spines are very large and perfect. A fine collection of these and other local fossils is open to all in the museum of the Bristol Institution. The next, or Great Quarry, exhibits a section of the highest beds of the mountain limestone. Not so many fossils occur here, although some very fine corals and

palates are sometimes found in the upper part. Between the beds of limestone are often seen small cubes of fluor spar. In this quarry the lime is so pure that 99 per cent. of carbonate of lime is often present.

A most remarkable example of the effect of pressure may be observed in the lower part of the Great Quarry and is considered well worth a visit of the physical geologist. Some of the bottom beds have given way, while the upper ones have been actually forced in by the superincumbent strata. At the top of this quarry it is that the great fault previously mentioned occurs, and causes a repetition of the limestone series.

During our excursion on Friday, you will easily see now that you have an explanation of the fault, that St. Vincent's Rocks are merely a continuation of those in the Great Quarry. At the top of the cliff, near the north buttress of the suspension bridge, a dyke of the conglomerate may be well seen.

On approaching the zigzag, several very thick beds of limestone project, cropping out at an angle of 30° to 35° over the pump room. From these beds it is that the Hotwell water springs at the rate of sixty gallons per minute, at the temperature of 76°. Each gallon contains 15·3 C.I. of carbonic acid and nitrogen gases. The amount of salines is only 44 grs. per gallon; not so much as is usual in mineral waters, for instance the Bath waters contain 120 grs. to the gallon.

The Hotwell salts consists of the chloride, nitrate, salphate, and carbonate of magnesia, with the usual lime salts, a little carbonate of iron and organic matter, and about 6 grs. of chloride of sodium. From the small amount of salts, arises the curious fact, that the Hotwell water actually is a better tea maker than that from the Clifton wells.

Dr. Grenville, in his work on the Spas of England, speaks of this water as containing 26° of volcanic heat, but I think this expression must be an error. The chemical evidence points to its origin being in the conglomerate beds, and its heat being attributable to chemical and not volcanic agency. Above this series of mountain limestone we arrive at

4. The Upper Limestone Shales which differ altogether in lithological character from the lower shales; they are very sandy and gritty, instead of argillaceous as in the latter. These beds are exceedingly rich in corals, and no doubt are the site of an ancient coral reef that existed in the carboniferous seas. This opinion is strengthened by the occurrence of oolitic beds underneath, in which we now find small shell and foraminifera just as in the present day.

In these beds more than twenty species of corals are found from a few lines to a foot in diameter. The upper shales comprise about 209 beds having a total thickness of 500 feet. They are best studied at the present time in a cutting for the Portishead Railway.

5. The Millstone Grit is the last formation to be mentioned, as it closes the Clifton series. It is the floor of the coal measures, the lowest portion of which rest upon it. This grit is usually very ferruginous, hard, and compact, so much so, that it is preferable to granite for pitching and paving. It may be well studied at Brandon Hill, from whence it passes under Park Street, St. Michael's Hill, Kingsdown, Stoke's Croft, and on to Easton. In many parts of its course good iron ore has been obtained. The beautiful crystals of peroxide of iron and göthite are obtained between the millstone grit and the upper shales.

The millstone grit has a thickness of 950 feet. Major

Austen has found and described a large number of fossils in it, to whose work on the subject I must beg to refer you.

This, then, closes my necessarily very brief description of the Clifton Rocks, alike magnificent for scenery and interest to the natural historian.

To give some idea of the store of geological treasures, I may mention that I have collected 255 species of fossils from the Clifton section alone; many of them of great beauty and rarity. Our visitors will find them all exhibited in the Park Street Museum.

I will remind the botanists that St. Vincent's Rock is the habitat for some scarce and local plants, such as St. Vincent's Rock Cress, *(Arabis Stricta)* St. Vincent's Stone Crop, *(Sedum rupestre)* Rock Hutchinsia, *(H. petræa)*. The Wallflower, *(Cheiranthus Cheiri)* here grows in a truly wild state.