The Avon Gorge.[1]

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IN the lower part of its course from the uplands near Sodbury to the Severn flats near Shirehampton the valley of the Avon is characterised by scenery of great and varied beauty. Above Bath the richly wooded slopes which sweep down to the winding river's edge have a charm for the eye greater perhaps than that which is afforded by the Avon Gorge. But few can deny that the view of that Gorge from the Suspension Bridge or from Observatory Hill is at any rate the most remarkable and striking feature of the scenery of the Avon. And for those whose interests are scientific it is here that one is brought into closest touch with the most varied episodes in the history of the district which the Avon drains. Of these episodes an attempt is made in the following pages to give an account in language as free as possible from technicalities.

(1) We may take first the scenic features.

Between Bath and Bristol the Avon runs in a wide open valley, which extends westwards to the Severn, and forms the gently undulating and low-lying country stretching from Long Ashton to Tickenham and Nailsea, and thence on to the mouth of the river. The Avon, however, instead of following what seems to be its natural course through this low-lying country, bends sharply to the north and runs through the narrow and deep gorge between the Downs and Leigh Woods, once more

1. This account of the Avon Gorge was written for the Handbook to the Weston-super-Mare district prepared for the meeting of the National Union of Teachers in 1913. In it an attempt is made to describe the subject in simple language, and geological terms are as far as possible omitted.

entering low-lying country near Sea Mills. How did this gorge come into existence, and why does the Avon follow such a peculiar course ?[1]

(*a*) The first explanation that would occur to most people is that the gorge was produced by the splitting action of some mighty earthquake. If this were the cause the rocks seen in the quarries on one side of the gorge ought to slope away from those on the other side, or at any rate give evidence of dislocation ; but on both sides the rocks slope in precisely the same way, *i.e.* up the river, and there is no sign of dislocation.

(*b*) The second view regards the Avon Gorge as having been cut by the overflow channel of a glacier lake which it is suggested may during the Glacial Period have occupied the low country between Bristol and Bath. According to this view the Avon valley had its original outlet, *via* the Long Ashton and Nailsea valley, blocked by a mass of ice, which formed a barrier behind which the waters of a lake gradually accumulated till they overtopped the Downs. An overflow channel then began to form which eventually as it deepened gave rise to the Avon Gorge. In support of this view there is little or no evidence ; neither the ice barrier, nor the supposed lake have left any distinct or recognisable traces of their existence.

(*c*) The third explanation is that the Gorge marks the original course of the river,—that it is the work of running water and was in fact produced by the Avon itself. It is not however implied that the Avon which produced the gorge was the sluggish tidal river of the present day ; as will be pointed out in the sequel, the Avon was probably once a swift stream draining an area standing at a far higher level than its present basin.

The formation of a river valley is a two-fold process : in the first place there is the downward-cutting action of the main stream which tends to *deepen* the valley, and in the second place there is the work of rain, frost and the tributary streamlets which tend to cut back the sides and *widen* the valley.

In the case of the Avon Gorge the former of these processes

1. This subject has been fully discussed by Prof. C. Lloyd Morgan, *Proc. Bristol Nat. Soc.*, n.s., Vol. IV (1883-4), p. 171 *et seq.*

has predominated ; in the case of the Avon valley between Bristol and Bath the second process has been equally efficient. The reason for this difference is probably that the rocks of the Avon Gorge consist in the main of hard limestone traversed by well-marked divisional planes,—a type of rock that does not readily yield to frost and rain, and therefore does not crumble away to form a wide, open valley. The rocks on the other hand between Bristol and Bath are in the main relatively soft sandstones and marls, easily eroded, and similar rocks extend on past Long Ashton to the Nailsea neighbourhood. Why then did the river not follow the soft rocks throughout and avoid the hard rocks of the Downs altogether ?

To understand its present course, one must realise that when the Avon began to flow its direction was determined not by the rocks now forming the surface of the ground, but probably by a westward extension of the Oolitic rocks, now seen near Bath, and of the Chalk of Salisbury Plain, both of which rocks undoubtedly once extended far to the west of their present limits. After its first emergence from beneath the sea, a river system was established on the plain formed of these rocks, which completely smothered those now visible at the surface, the direction of the streams being determined solely by the slope of the ground, and having no relation to the lie of the older rocks buried far beneath. In course of time the old rocks of the Downs, etc., were laid bare owing to the removal by the action of rain and streams of the Chalk and Oolite which covered them, but the rivers continued to follow in the older rocks the same courses that they had originally established in the covering of newer rocks. It is a generally recognised geological principle that when once the course of a river has been established, it is only under very exceptional circumstances that that course is deserted.

(2) While to most people the Avon Gorge is most interesting from the scenic aspect, to the geologist it is at least equally interesting because it provides such a magnificent section of the Carboniferous Limestone rocks. The river cuts these rocks nearly at right angles, and as they are tilted up so as to slope at an angle of about 40° to the south, the whole thickness of some 3,000 feet is passed over in a distance of about $1\frac{1}{2}$ miles.

The points of interest are essentially geological, and it is somewhat difficult to deal with them without pre-supposing some geological knowledge.

It must be remembered that in the Avon quarries we have not only a sequence of rocks, and a suite of fossils, but also in part a geological history of the district. Hence, it seems best to describe in chronological order the events of which these rocks form a record.

Reference to Fig. 2 shows that the strata of the Avon Gorge succeed one another in a regular series, the lowest and therefore oldest, being at the north-western end, and successively higher and newer beds succeeding one another till Observatory Hill is reached. Here a great fault or dislocation traverses the rocks, as will be described in the sequel, and part of the sequence is repeated.

The oldest and lowest rocks are those known as the Old Red Sandstone, and are seen in several of the cuttings between Sea Mills station and the tunnel through Durdham Down, and also on the opposite side of the river. They consist of red sandstones, pebble beds and shales, and, except for a few scales of fish, have yielded no fossils. They are undoubtedly deposits laid down in shallow water, and the lack of the remains of any purely marine forms of life has led to the belief that the rocks were laid down, not in the open sea, but in a lake or land-locked gulf. The cutting immediately north of the mouth of the tunnel through the Downs on the Avonmouth line and the roadside exposures as far as the Black Rock quarry (*see* Fig. 1) are in the strata which immediately overlie the Old Red Sandstone and consist of shale with thin bands of limestone, these strata indicating a deepening of the water as compared with that in which the Old Red Sandstone was deposited, while the abundance of marine fossils shows that depression of the area had allowed fairly open sea to overflow into, and thus to replace, the lake or land-locked gulf in which the Old Red Sandstone accumulated. These beds are in the main soft and not suitable for quarrying, and where they occur the sides of the Avon valley are relatively low and gently sloping.

Attention may here be drawn to a thick band of red limestone which, owing to its superior hardness, makes a prominent

feature a few yards to the north of the mouth of the tunnel

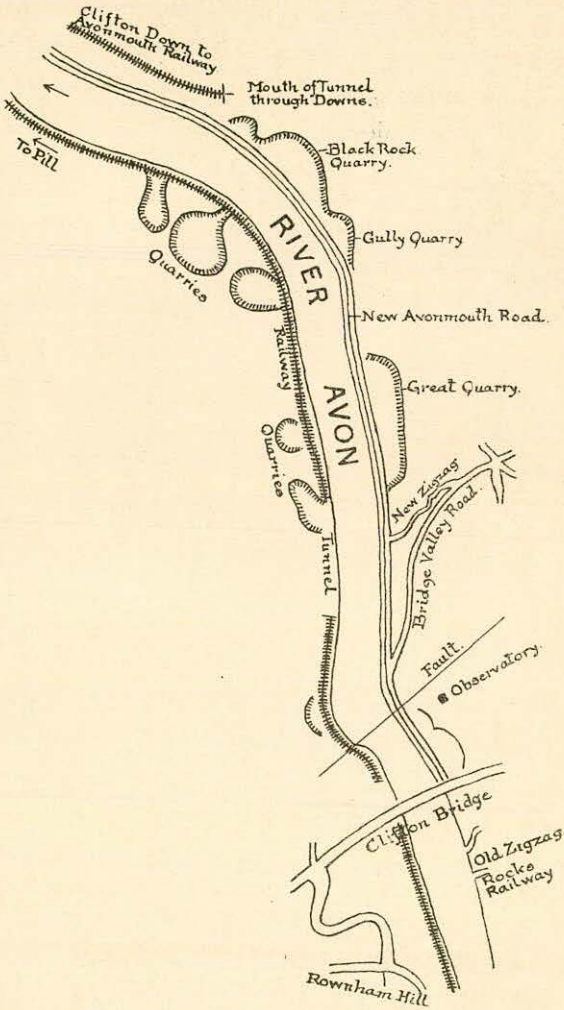


FIG. 1.—Sketch Map of the Avon Gorge. Scale 4 inches = 1 mile.

through the Downs, and is seen also by the river-side. Examination shows that this rock is mainly made up of the ossicles

or bits of the jointed stem of crinoids or sea-lilies—a group of animals, which while nearly extinct at the present day, flourished in immense numbers in former geological times, so that their hard parts are the main constituents of thick beds of limestone.

As one passes up the river towards Bristol the strata just described will be found to be soon succeeded by beds of massive limestone exposed in quarries on both sides of the Avon; and at once, owing to the superior hardness of the rock, the sides of the valley increase in height and it takes on the character of a gorge.

Massive limestones, with occasional interruptions of greater or less importance now commence, and prevail throughout the whole extent of the Avon Gorge, and indicate that our area for an immensely long period formed part of an open sea of considerable depth, and sufficiently far removed from land for little or no mud to reach it, so that the corals and other lime-secreting animals, which are very intolerant of mud, could flourish. There are many groups of organisms all of which have the power of abstracting carbonate of lime from sea-water and using it for the building up of their shells or other hard parts, and of these the corals, crinoids, brachiopod-shells and the microscopical foraminifera all played an important part in the formation of the limestones of the Avon Section.

In these lower limestones seen in the Black Rock quarry below Sea Walls, crinoids and brachiopod-shells are the most important limestone builders. The latter are abundant on some of the rock-faces near the northern end of the quarry, the former are better seen on the weathered surfaces of the rocks by the river-side than in the quarry itself. The fossils characteristic of this level of the limestone, however, may be better collected in the quarries on the left or Somerset bank of the Avon than on the right or Gloucestershire bank. Numbers of teeth of sharks or rays have been found at certain levels in the upper beds of the Black Rock quarry.

Beyond the Black Rock quarry a dry valley, the Gully, leads down to the Avon, and at the mouth of this valley is a second quarry, to which the Gully gives its name. Two kinds of

rock, contrasting rather strongly with one another, are seen in this quarry, the contrast being still more marked in the corresponding quarry on the left bank of the Avon. The lower beds occupying the main part of the quarry are formed of a very compact white rock, the upper beds consist of yellower rock much divided up by bedding planes which are conspicuous by their absence in the lower rock. Close examination of the lower rock show that it is oolitic, *i.e.* rock composed of immense numbers of little rounded particles of carbonate of lime, which, as is seen under the microscope, commonly consist of a series of layers arranged concentrically round some centre. The name oolite alludes to the resemblance which the weathered surface of the rock bears to the roe of a fish. This peculiar deposit may be taken to indicate that the water had shallowed since the deposition of the limestones of the Black Rock quarry, as at the present day similar deposits are being formed in the shallow water near coral reefs, where there is so much carbonate of lime in solution that it becomes readily deposited round any little nucleus as a centre. Such a limestone is an example of one formed chemically, as compared with one organically formed, such as a crinoidal limestone.

It will be noted that for some distance to the south of the Gully the side of the Gorge is unquarried ; this is because the strata here consist not of massive limestone, but of thin, calcareous beds alternating with shales. The limestone bands, too, have been in a great measure dolomitized, *i.e.* the carbonate of lime has been by the addition of carbonate of magnesia converted into dolomite. This again is a process which indicates shallow water conditions.

The succeeding Great quarry is in massive limestone, which affords evidence that relatively deep and clear water conditions were once more established. The limestones here are to a considerable extent formed of the remains of a coral *Lithostrotion*, many large masses of which may be seen in the rocks towards the northern end of the quarry. Much of the limestone, however, is found, when examined microscopically, to be largely composed of foraminifera, and a second thick band of oolite occurs in the southern part of the quarry.

From the southern part of the Great quarry to the bottom

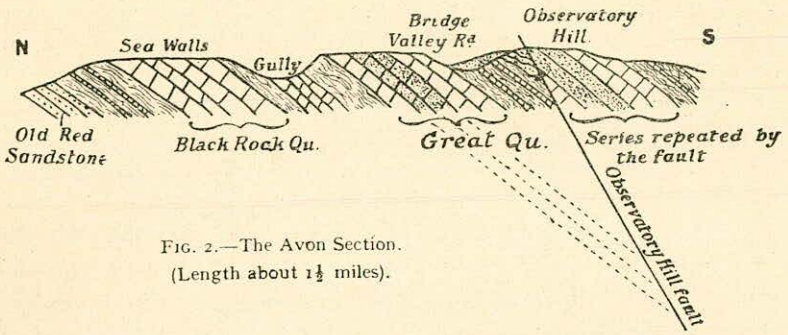


FIG. 2.—The Avon Section.
(Length about 1½ miles).

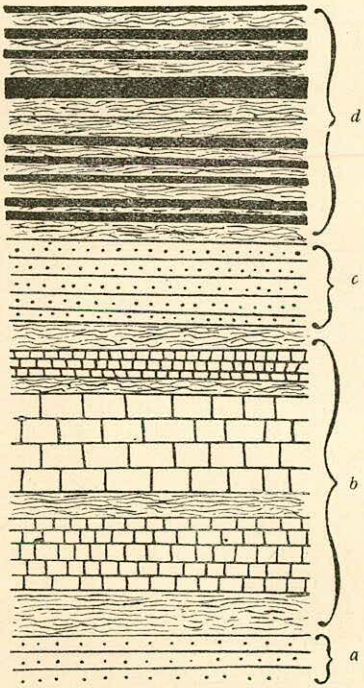
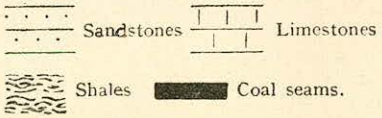


FIG. 3.—Diagrammatic representation of the older strata seen in the neighbourhood of the Avon Gorge.

d. Lower Coal Measures.
c. Millstone Grit.
b. Carboniferous Limestone series.
a. Old Red Sandstone.



of Bridge Valley Road the rocks are variable in character consisting of limestones (some of them oolitic, others full of corals) alternating with shales and bands of hard sandstone. The numerous corals can be readily seen in riverside exposures on the left bank.

The highest and newest strata are hard red sandstones and shales, seen near the mouth of the now disused tunnel below Observatory Hill. The section does not, nevertheless, end here, since resting on these red beds are the massive limestones of Observatory Hill The succession is not, however, a normal one—the rocks of Observatory Hill are in reality the same strata as those occurring in the southern part of the Great quarry, which after passing for a distance of about 1,000 feet underground have been brought again to the surface by a 'great fault' or dislocation (*see* Fig. 2). This fault is very well seen in the exposure, alluded to above, near the mouth of the disused tunnel. The red sandstones and shales are seen here to be sharply folded by the grinding of the massive limestone over their surface. The base of the limestone mass, too, is smoothed and polished by the friction as it moved over the beds below. The strata repeated by the fault extend on till the section of Carboniferous Limestone ends near the Rocks Railway entrance.

Upon the highest beds of the Carboniferous Limestone series were deposited the hard sandstones (Millstone Grit) which are well seen at Brandon Hill, and following them the Coal Measures. There are no good exposures of these strata in the neighbourhood of the Avon Gorge, but the Coal Measures lie beneath much of the city of Bristol.

The whole series of beds from the Old Red Sandstone to the top of the Coal Measures reaches a thickness of some 12,000 feet and represents a period of geological time of very great length. With the deposition of the Coal Measures the first and by far the longest chapter in the history of the Avon Gorge came to an end. Figure 3 shows the succession of strata from the Old Red Sandstone to the Coal Measures, the beds being represented in their original horizontal position.

If, standing on the right bank, one looks across the Avon at the quarry lying almost opposite the New Zigzag path, a few

feet of strata will be seen at the top, lying horizontally on the upturned edges of the Carboniferous Limestone. An immense period is represented by the gap between these horizontal Triassic strata and the upturned Carboniferous Limestone on which they lie, and during this period great physical changes took place, not only in the Bristol area, but throughout north-western Europe. Tremendous earth stresses gradually folded the rocks of north-western Europe into a series of ridges with alternating troughs, some of these trending east and west such as the Mendips, others north and south such as the Pennine Chain. The Observatory Hill ' fault ' was also a product of these earth stresses. The rocks of which these ridges are composed had been accumulating under the sea in the manner described above, to a thickness of many thousand feet, and as they were ridged up and brought within reach of wave action thousands of feet of the newer strata were stripped off the arches of the folds. In the troughs, however, they were left and still remain. Thus the Carboniferous Limestone and Old Red Sandstone rocks of the Avon Gorge were laid bare by the removal of the thousands of feet of Millstone Grit and Coal Measures which once covered them, while in the Mendips erosion went on to such an extent that the Silurian rocks which underlie the Old Red Sandstone were exposed. It is not, however, implied that the whole of this erosion was the work of the sea—the earth stresses raised the ridges, and finally the whole area above sea-level, and it became part of a continent, and was subjected for a long period to the atmospheric agents such as rain, frost and rivers whose effect is to wear away the rocks and sculpture the surface. In this way were formed hills with intervening valleys, many of which, such as that between Durdham Down and Kingsweston Hill and that in which Bristol lies, are important features at the present day. Figure 4 (A) represents diagrammatically the rocks of the Avon Gorge after the prolonged period of atmospheric erosion.

While erosion was carving these valleys in the Bristol area the districts to the north and south were occupied by Salt Lakes. But as time went on the Bristol area became gradually further depressed, the salt lakes extended into it, and as they

crept up the hill-sides and their waters occupied the valleys in the district which now forms the Downs, the rock-fragments lying about were cemented together forming a characteristic local deposit, the Dolomitic Conglomerate, which occupies much of the valley between the Downs and Kingsweston Hill, and is the stratum already alluded to as lying horizontally on the upturned edge of the limestone in the quarry on the left bank opposite the New Zigzag.

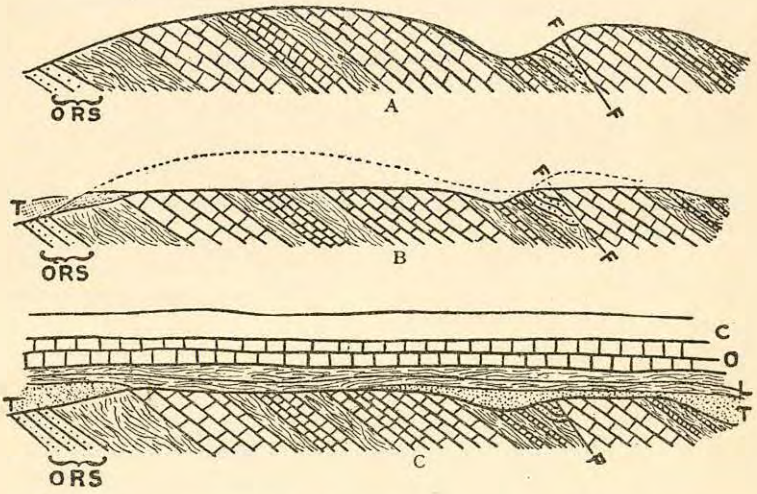


FIG. 4.—Rocks of the Avon Gorge at successive periods.

A. After the post-Coal Measures upheaval and atmospheric erosion.
B. After submergence and the planing-down of the surface of the older rocks.
C. After the deposition of the newer rocks.

O.R.S. = Old Red Sandstone. F = Fault. T = Trias. L = Lias.
O = Oolite. C = Cretaceous.

Depression and submergence still continued, and eventually our area was once more completely submerged beneath the waters of the open sea. When standing upon Observatory Hill one can scarcely fail to notice the fact that Clifton and Durdham Down, Leigh Woods and the neighbouring hills all form parts of a plateau with a singularly level surface best

seen at Sea Walls, *see* Fig. 4 (B). This level surface is in all probability the work of the waves of this ancient sea, is in fact part of a 'plain of marine erosion.' The Avon Gorge, the Gully, and certain other valleys which now dissect this old plain were, it will be remembered, at this time non-existent. The neighbourhood of the Avon Gorge illustrates well the contrasting action of marine erosion, which tends to produce a level surface, and 'subaerial' erosion, which tends to produce a diversified surface.

Following on the formation of the plain of marine erosion, the strata known as the Lias, Oolite and Cretaceous were doubtless deposited in our area, burying the Downs under, perhaps, some 2,000 feet of strata which are shown diagrammatically in Fig. 4 (C). Of these beds no trace remains in the immediate neighbourhood of the Avon Gorge. They have been completely removed by erosion during a second great continental period which set in after the deposition of the Chalk. During this continental period which continues to the present day, our area was uplifted, perhaps to considerably above its present level, and the now existing river system began to develop, being established, as has been already pointed out, not on the rocks now forming the surface of the ground, but on some of the now vanished horizontal strata shown in Fig. 4 (C). The shore line probably lay far to the west of its present position, and the Avon, with a length and descent far greater than at the present day, was capable of erosion vastly in excess of anything that can be performed by the sluggish stream of modern times.