A Visit to a Quarry
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Science for All
R. Brown, ed.
Cassell, Petter, Galpin & Co.
London, Paris, & New York
1881

OUR knowledge concerning the various rocks which compose the crust of the earth, has been derived from a careful study of the different beds exposed in the many sections, both natural and artificial, that are more or less abundant in all countries. The cliffs that fringe the sea-shore, or overhang the banks of some rivers, and the inland cliffs or “escarpments” that form such prominent features in many of our landscapes, are examples of natural sections; whilst among the artificial we may enumerate quarries, railway-cuttings, deep well-borings, &c. All the beds shown in such a section as that figured in the Frontispiece are not found at one place. Some are sure to be absent; but all bear the same relative position to the others, no matter how few or how many are found. In our own country a greater number of different beds, or sets of beds, occur than are, probably, to be met with in any other tract of similar extent, and a fair knowledge of their nature and fossil contents may be derived from the various rocks exposed in the faces of cliffs on our coasts; but the closest inspection of these sections would not enable one to trace out the direction and extent of the beds inland, which can only be correctly ascertained by consulting numerous quarry and other artificial sections, aided by a careful study of the physical features of the country. Then, again, beds of the same age may, in different localities, consist of entirely different materials, such as limestone in one place, clay in another, and perhaps sandstone in a third.

Fig. 1.

An observer going from one to the other would be most likely to set them down as altogether distinct deposits; whereas an examination of the intermediate rocks exposed artificially in quarries, and their fossil contents, would enable him to trace the connection which really exists between them, and to demonstrate the identity of their age. Besides, however, conveying especial information of this description, each quarry has its own version to give of the chapter of geological history that it illustrates; just as each copy of an ancient work will have its different readings and renderings of certain passages, whilst they all agree in the main facts stated. How the geologists manage to coax-or rather to hammer-sermons out of stones, is to some a profound mystery; whilst others treat the whole matter with the most supreme contempt, for to them a stone is merely a stone, and a quarry a pit in which men are at work cutting out and carting off the rocks for various purposes. Passing by these latter, we will ask our mystified friends to accompany us by that safest and most easy method of transit, a flight of imagination, to the nearest quarry, of which a detailed view is here given (Fig. 1.), where we will endeavour to initiate them into the secret of "how to read the great stone book of nature." The same means that conveyed us to the quarry has also furnished us with the requisite apparatus for pursuing our investigations -namely, a hammer, with one end of the head flat and square, and the other produced into a pick; a cold chisel, a pocket lens, a compass, a bottle containing acid, and a bag in which to put any specimens that we may wish to carry away with us. As we stand thus equipped looking at the wall of the quarry which faces us, the first thing we notice is, that it is built up of a series of beds or "strata" resting one on the top of the other. Of these, the two uppermost are nearly horizontal, and for the present may be left out of the question. The rest are inclined at a considerable angle, and slope down to the left. Consulting the compass, we find that we are looking almost due west, consequently the beds slope down -or, to speak geologically, dip to the south. The necessary result of this dip in the strata will be to cause the beds which are at the bottom here to come to the surface a little further north; and, on the other hand, to the south we should expect to find other and newer beds coming in and resting on the top of these. Originally, of course, they were all horizontal, that being the position in which they were deposited; but afterwards, owing to movements taking place in the crust of the earth, were tilted up as we now see them. Had it not been, therefore, for disturbances of this kind bringing the underlying rocks to the surface, none but the newest would be within our reach; whilst of the oldest -as, for instance, the Silurian and Cambrian (vide Frontispiece to this volume) -we should have known absolutely nothing whatever. The next thing in the "section" that strikes the eye, is a large crack running down in a vertical direction through these inclined beds, which at first sight appear to terminate abruptly on reaching it, for they have evidently no connection whatever with those immediately opposed to them on the other side of the fissure. A second glance, however, shows us that the same series of deposits occurs on either side of it, but that the relative level of the beds differs, those on the northern side of the fissure being some feet lower than the corresponding ones on the southern side. It is perfectly clear that they must formerly have been continuous, and that subsequently they were fractured at this point, and the northern set let down some eight or ten feet, bringing with it a portion of a higher bed (h), of which we should otherwise have had no trace in his section. Dislocations of this kind are termed "faults;" they are of common occurrence, and in some cases the vertical displacement of the beds can be measured by as many yards as inches in the present instance. They often give rise to striking physical features, as they afford lines of weakness along which the rains and frosts can act and cut out valleys for rivers to run in. But we have been stopping long enough at the entrance. Let us now make our way down to the section and see what all these different beds are made of, and what is the history that each has to tell us. The bottom bed (a) you will recognise at once. A pure white limestone, with layers of flint nodules at tolerably regular intervals, it can only be the well-known chalk. Microscopic examination has shown that the chalk is almost entirely composed of myriads of minute shells belonging to small beings, low down in the scale of life, known as rhizopoda or foraminifera. Now, these same little rhizopods swarm in the Atlantic Ocean at the present day, and their dead shells are forming at the bottom of that ocean a deposit precisely similar to the chalk, to which we are, therefore, perfectly justified in ascribing a like origin. The way in which the flints were formed is still a moot point; but the most probable explanation appears to be that the water of the chalk sea every now and again accumulated more flinty matter in solution than it could hold, and was therefore compelled to part with it, which it did by precipitating it to the bottom, where, when there was sufficient, it spread out in vast sheets; more generally, however, the flinty material collected in nodules around any decomposing organic matter that lay half-buried in the soft sediment, to-wards which it was attracted by certain chemical laws. And this is the reason that fossils are so often found imbedded in flint. Numerous fossils also occur scattered throughout the chalk-lamp-shells, sea- urchins, star-fishes, sharks teeth, &c. One of the quarry-men is coming to-wards us with a hat full of these fossils; they pick out those they come across in the course of their work, and take the earliest opportunity of selling them. Here are two kinds of the echinoderms or sea-urchins and here is a shark’s tooth.

Fig. 2.,

Fig. 3.

The fossil you hold in your hand is a "belemnite"; it is part of the internal bone, or pen, of a species of cuttle-fish that lived in the chalk sea.

Fig. 4.

The country people call them "thunder-picks," or "thunderbolts." Having picked out what we want of these, together with some specimens of the lamp-shells, we will wrap them carefully in paper to prevent their rubbing together them in the bag and then continue our exploration of the section.

Fig. 5.

The upper surface of the chalk, we find, is not perfectly even, but is worn into slight hollows; and resting on this slightly uneven surface is a bed of flints (b), about one foot thick. You can see that they have been washed out of the chalk; still, they do not seem to have been much rubbed, and therefore cannot have been carried far; but they nevertheless represent several feet of chalk entirely removed, so that a kind of gap exists between the chalk and the overlying deposits. It is not so great a break as one we shall come to presently, but still, there it is, indicating that some disturbance or other took place in the physical conditions at this point, the results of which will be shown in the changed nature of the overlying beds. Trifling as it appears to the eye, this break is one of great importance; for if you will consult the table strata in the frontispiece, you will find that with the chalk the "secondary" rocks end; so that at this point we pass from one great division of the earth's strata to another, and at the same time from one great group of fossils to another, in which the forms of life are much nearer to those of the present day. Resting on this bed of flints is a deposit of fine light-coloured sand (c), It affords no trace of a fossil, and if any shells ever were buried in it, they probably disappeared long ago, as beds of this sort allow the rain-water to percolate through them. Now, as rain-water generally contains acid, it dissolves the shells, so that unless the sand is pretty firm, not even a cast of them is left. Yet, from the appearance of the sand itself, we can tell that it is a marine deposit formed at no great distance from land. The next bed (d) we find to consist of rounded black flint-pebbles, packed closely together, the interstices being filled with sand. These pebbles have a rough bedding or "stratification" of their own, which runs at all angles to the direction of the bed itself, crossing it sometimes in one direction and sometimes in another, and giving rise to the appearance known as "false-bedding." Now, in a sea-beach the stones are of all sizes and shapes. Some are freshly broken, others are slightly rolled, the sharp edges being just worn off, and so on down to those that are quite smooth and perfectly rounded. But in this deposit all have been reduced to the kidney-bean shape, so that this is not It mere beach deposit, but must have formed a shingle-bank a little way out to sea, in reaching which all the pebbles would get thus rounded and ground down. The appearance of "false-bedding" is due to the action of the waves and currents that piled them up. See, here is a shark's tooth amongst them, so those voracious creatures could not have been far off at the time! You will, however, be hardly likely to find much else there, so we will proceed without further delay to the next bed. This is a mass of black clay (e). On the outer surface it has, by exposure to the weather, become hard and dry, but remains quite moist and plastic beneath. From top to bottom it is full of shells, arranged in layers. As the clay is impervious to the passage of water, they are capitally preserved, except on the outer surface of the bed, where they have been subjected to the destroying action of rains and frosts. Some good specimens are easily procurable, and by packing them in a box with some dry sand we can convey them home in safety. The shells shown in Fig. 6 belong to the class of molluscs that love to dwell in the mud at the mouths of large rivers, where the water is brackish. The clay, too, is exactly such as would be formed from the fine sediment brought down by some large river to the sea, and there deposited on the bottom. Hence we infer that this bed of clay is nothing more than the dried and pressed-down mud of some ancient estuary, whose turbid waters flowed over this spot in bygone ages. Before passing on, however, we must pause a minute to notice a ridge that juts out about the middle of this deposit, and is continued along its entire length. A tap of the hammer soon reveals its nature. Packed as closely as possible, and dovetailing, so to speak, into each other so as to form a hard band, are countless shells of oysters, often with both valves united just as they grew on the spot. As they prefer saltier water than the other shells, they point to a slight change in the physical conditions at this stage, whereby the sea was enabled to gain slightly over the river, driving the estuarine shells back, and allowing the oysters to settle here, till a return of the previous conditions re-established the former occupants in their old quarters. A somewhat different state of affairs is denoted by the succeeding formation (f). It is also a clay- very sandy, with thin seams or "partings" of pure clay. Its general colour is light-brown, and no shells are visible in it. By breaking off masses, and splitting them along the seams, the surfaces thus opened display a number of darker brown marks, which, when examined with the pocket lens, prove to be vegetable matter. Small sterns and the seeds of water-plants are abundant, whilst careful search is rewarded by the discovery of the perfect leaves of trees, which, if not identical with, are closely allied to some existing forms. The sandy nature of the deposit, and the presence of these vegetable remains, lead us to sup- pose that it accumulated nearer to the shore than the last, in quiet and tolerably shallow waters, out of the main current of some river. This stream was probably the same which furnished the black mud for the underlying bed, and which by this time had, owing to the seaward advance of the land, to carry its finer sediments further down, and only left here the heavier particles of mud and sand, and the waterlogged twigs and leaves of trees. At one period, however, the waters must have receded, leaving a swamp or marsh, in which various kinds of plants grew in abundance; for near the bottom of this bed appears a dark seam of "lignite," as it is called. If you examine a piece of this lignite under the lens, you will find that, like coal, it is entirely made up of vegetable remains pressed close together. Now, when vegetable matter buried in the earth is kept moist, and the air excluded, it commences to decompose slowly, and gives off carbonic-acid gas, thereby parting with a portion of its oxygen. By this means, it becomes gradually converted into lignite, and when this process of decomposition continues, the lignite is changed by degrees into common coal So that the lignite is merely coal in an early stage of its formation. Succeeding this sandy clay with plant-remains, is another pebble-bed (g), similar to the one we passed a little lower down, only the pebbles are much larger and more oval in shape, showing that this shingle-bank was nearer the shore than the other. Here, too, amongst the stones at the bottom, are some shells of the same type as those in the black clay. A fresh inroad of the sea must, therefore, have taken place, and a shingle-bank been formed off the mouth of the river. Above this, again, is the formation (h), which, as we had occasion to observe, was preserved to us through the occurrence of the fault at this spot. It is a dark-brown clay, dry and crumbly on the outside, becoming darker in colour, and stiffer, as you dig into it. That whitish, translucent substance that you have just picked out of it is the mineral called "selenite." A navvy would tell you that it was water "congealed by the moon;" it really is the crystalline form of sulphate of lime, and the crystals occur in clusters, radiating from a centre, falling apart when you attempt to excavate them. These clusters are all that remain of the fossil shells, once imbedded in the clay, that have undergone chemical change, and passed into this new form. You can readily split it with a knife, in one direction, into slices as thin as paper; but try and cut it in a direction perpendicular to this "cleavage-plane," as it is termed, and you will not be able to force the blade through it. Only the two topmost layers now remain to be considered. These, as we saw before, are not affected by the "fault," nor do they dip to the south like the underlying strata, but rest in an almost horizontal position on the upturned edges of the latter, which in places are worn into great hollows. A considerable period of time must therefore have elapsed between the deposition of the underlying beds and these two upper ones: a period sufficient to allow of the former being tilted up and "faulted," and the surface of the ground levelled before the latter were thrown down on them, all of which movements were effected by slow degrees, and not by any violent convulsions of nature. In order to get some idea of the length of time thus consumed, it will be necessary to ascertain in the first place the geological age of the underlying inclined beds, and then that of the two horizontal ones. Now, the sands, gravels, and clays which we have just been examining overlie the chalk, and are therefore newer than it. The chalk, we learnt, was the uppermost bed of the "secondary" series, so that these sands, &c., must be of "tertiary" age. The fossils they contain inform us that they belong to the lower portion of the lowest division of the tertiary series; a conclusion which we might have expected, though it did not of necessity follow, from their position with regard to the chalk. So much, then, for our first point. Now for the second -the age of the topmost beds. To solve this, we must ascertain what they are, and inquire somewhat into their history. The lower of the two (i) is clearly a gravel, and the upper (k) a clay full of big stones. The gravel is very different from the pebble-beds we saw just now. Instead of rounded flint-pebbles, it consists, mainly of angular stones, and, while most of them are flints, there are also a great number of other stones derived from rocks of altogether a different sort to those found round about here. Furthermore, they exhibit no sign of being spread out by water action; there is no trace of any stratification whatever; they lie all jumbled together "anyhow" with here and there a mass of sand let in bodily. A similar want of arrangement characterises the clay; there are no layers in it; it is one uniform mass from top to bottom; the big stones aloe scattered promiscuously throughout it in all sorts of I positions; and it is so full of pieces of chalk, from the size of a hen's egg down to the smallest imaginable grains, that it has a whitish tinge. Break open some of these big stones or "boulders," and you will find that they are fragments of many different rocks. There are granites, basalts, and limestones of all ages. You can tell the limestones in a minute, for they can be scratched with a knife, and a drop of acid put on them begins immediately to “fizz.” Many of these boulders are flattened and smoothed on one side, and covered over with long parallel scratches. What then, can have produced all these several results And how were all these various stones brought together there is only one agent known that could have performed al this work; that agent is -ice. The sand and gravel was floated hither from some sea-beach, frozen in blocks of coast-ice, which stranding and melting deposited them at this spot; the boulders, detached by frosts and snows from their parent rocks, were smoothed and scratched by being fixed in masses of ice and ground against other rocks: ultimately they were floated down here on icebergs and dropped into the glacial mud, which itself was formed by the wearing action of divers forms of ice upon the land. To geologists these beds are known as "drift," and, with the exception of the valley-gravels and alluvium, they are the most recent of the sedimentary rocks, as you will see by referring once more to the table of strata shown in the Frontispiece. We have thus solved our second problem, and are now in a position to gain some notion of the immense break in time between these glacial drifts and the strata they rest on in this quarry. It can not be estimated in years, or even hundreds of years, for it is impossible to form any accurate conception of the rate at which any given deposit accumulates; but we may be able to form some faint idea of its vastness when we realise the fact that this gap is elsewhere filled by beds some hundreds of feet in thickness, belonging to the Miocene and Pliocene epochs; that the great mountain-ranges of Europe attained their present elevations, by receiving an additional upheaval of several hundred feet; and, finally, that all the main physical features of the country were marked out in this interval, during the greater part of which this spot was, perhaps, dry land. Here the record of the rocks in this quarry terminates. The neighbouring river takes it up and carries it on down to the present date; it could tell of the rude savages who dwelt on its banks in prehistoric times, and fashioned weapons of flint and stone, with which they fought or hunted the huge wild animals that roamed about. With these, however, we have on the present occasion nothing to do, and so turn homewards, laden, it is to be hoped, with some additional weight of knowledge, as well as the more tangible burden of fossils for the cabinet; reflecting by the way on the things we have learnt from this visit to a quarry :-How that the past history of our earth, as related by geologists, so far from being a mere baseless myth, is a true account, founded on sound reasoning, and only to be learned by a diligent study of the phenomena in constant operation around us, and a careful application of the knowledge thus derived to the facts furnished by the various deposits -a process not more mysterious than the train of arithmetical reasoning by which we ascertain that two and two make four. We learn that the ground beneath us must have been formed at the bottom of sea, lake, and river, the particles of which it is composed being the results of the wearing away of some still older land-surface by the agencies of rain, frost, wind, &c., and the transporting powers of running water and floating ice. And now, when we next chance to light on a quarry of any description, instead of simply speculating as to the origin of the rocks we see in it, we may be able to set practically to work to obtain the information we desire concerning them.