

and Cheshire that our great stores of salt are found, but they are attained at one quarter of the above-named depth.

THE LIAS.—This is the geological name for a great series of bluish shales and clays which have harder beds of iron-stone in their central portion. The whole series is of great thickness in north-east Yorkshire. Mr. Blake gives Lower Lias 378 feet, Middle Lias 470 feet, and Upper Lias 280 feet, making a total of 1,128 feet. These beds form the easterly part of the vales of York and Cleveland. They form too the slopes of the moorland hills which are capped by the Oolitic beds, and are exposed along the sides of many inland valleys as in Eskdale, Rosedale, Bransdale &c. The whole series extends from the Derwent Valley between Kirkham and Howsham in a north-westerly direction, past Craike to Dalton and Thormanby, then it runs due north to Osmotherly, but turning to the north-east passes through Stokesley and Guisborough to the coast between Redcar and Staithes. The beds have a gentle south-easterly dip of about 3 degrees, and can be traced southwards along the coast, forming the lower portion of the cliffs as far as Robin Hood's Bay, where owing to an east and west fault they extend inland for some distance.

The *Lower Lias* is composed of blue clays with thin bands of impure shelly limestone. In the *Middle Lias* we get a great development of iron ore. One bed known as the "Bottom Seam" is characterized by the fossil *Ammonites margaritatus*, but the famous "Cleveland Main Seam" is situated from 7 to 20 feet above this and is characterized by the presence of *Ammonites spinatus*. These beds are the equivalents of the marlstone series of the middle and south of England. In the year 1877 the quantity of ore (argillaceous carbonate) raised in north Yorkshire (Cleveland district) amounted to 6,284,545 tons, valued at four shillings per ton net at the mines. (See Government publication, "Mineral Statistics of the United Kingdom," by R. Hunt.) The main seam is thickest and most valuable at its northerly outcrop at Eston Nab, where the workable part is from 10 to 12 feet thick, and it decreases in value as we follow it south-east to Whitby and south-west to Thirsk. On an average the rock contains 30 per cent of metallic iron. This seam may be said to have been first worked by Messrs. Roseby at Skinningrove in 1848, but it is to the firm of Bolckow and Vaughan, who opened the main seam at Eston in 1850, that the chief share of credit is due for the immense energy and vigour with which they laid the foundations of the vast industry now centred at Middlesbrough.

The *Upper Lias* is shaly and contains the jet-rock series near its base. The substance known as jet appears to be formed by the segregation of the bitumen with which the shales are charged. It is not fossil wood, though pieces of wood are often found which have been converted into jet. The manufacture of jet ornaments gives employment to about 1,500 persons, and is chiefly carried on in Whitby: the value of the trade in 1872 amounted to £88,000.

Above these jet-beds we get the *alum-shales*, marked by the shell called *Leda ovum*. They are about 110 feet thick, and in former times the shale of Whitby was our only natural source of potash-alum. The shale having been dug was calcined by means of burning brushwood: it was then washed in large cisterns to obtain the aluminium sulphate, and after evaporation either sulphate or chloride of potash was added, which precipitated the alum in the form of flour. About 25 years ago a Mr. Spence, of Manchester, invented an improved process by which alum could be more cheaply obtained from the shales of the coal measures, and the Yorkshire product has, in consequence, been driven out of the field.

The Yorkshire Lias furnishes a rich collecting ground to the fossil-hunter. No fewer than fourteen distinct zones characterized by different species of ammonites have been made out, whilst of other shells there is also a great profusion. Bones of large reptiles characterize the upper portion, where (especially in the jet-beds) remains of fishes are also common.

THE OOLITE.—The oolite of north-eastern Yorkshire presents many striking differences when compared with those of the typical region of the Cotteswold Hills. Instead of the thick beds of limestone which there constitute the main feature of the formation, we find in Yorkshire a great development of sandstones and shales full of plant-remains, and containing many shells resembling those which now inhabit estuarine or brackish waters. Even thin seams of coal occur, and altogether it is easy to see that the Yorkshire oolites were mainly formed in shallow seas near to the coast line, while those of the south-western counties were accumulated in a deeper and more tranquil sea.

In the cliffs of the Yorkshire coast between Staithes and Filey, we get a magnificent section of these beds cutting right across their strike, so that after examining the lowest

and oldest beds in the northern part, say between Staithes and Robin Hood's Bay, we find as we walk southwards along the beach higher and higher beds continually coming on, for the beds have a steady southerly dip or slant until at last they pass underneath the chalk at Speeton Cliffs. At Blea Wyke (or Blue Wick), near the Peak, about 60 feet of sandy beds occur above the Lias. These are true passage beds connecting the Lias with the Oolite: they represent the Midford Sands. *Lingula Beanii* is a characteristic fossil. When we attempt to follow the different oolitic beds inland, we find them change very rapidly, becoming much thinner and losing the arenaceous and argillaceous character as we follow them towards the south-west. Three main divisions are clearly traceable. The *Lower Oolites* form what Prof. Phillips called the Moorland Range of hills, which extends from Scarborough and Whitby westwards to the Hambleton Hills. The chief height attained is at Burton Head, 1,489 feet, but Hambleton End is 1,300 feet, and the cliffs at the Peak 605 feet above sea-level. Rosebury Topping (1,057 feet) and Eston Nab (800 feet), are detached hills capped by the Lower Oolites. The Howardian Hills are also formed of the Lower Oolite. The bottom bed is called the "Dogger," and contains a seam of ironstone: it has been largely worked in Rosedale, where it swells out so as to form an enormous boss of iron-ore. Mr. Hudleston writes "On the testimony of the foreman of the miners it exists as a sort of hump or saddle, 600 yards long by 150 yards wide, and 80 feet high. It has been 'drifted' in all directions during the last 14 years for the purpose of extracting the ore, and is now pretty well riddled. There is nothing like it in all this district, and it may fairly be described as the richest ore in North Yorkshire, a perfect nugget of ironstone on a bare hill side, 700 feet above the level of the sea. Before it was so much quarried and drifted, it used to stand out as a conspicuous cliff, and men hunted foxes into its holes and recesses. There is a tradition that during thunderstorms the lightning frequently struck that cliff of iron; and the country-folk said that treasure must be concealed there, which was true enough, whilst others more superstitious thought that the devil lay buried beneath. It is a fact, however, that the magnetic iron ore was used as a road-stone for years by people who took it to be a kind of whinstone or basalt." It contains nearly one-half its weight of pure iron. These Moorland Hills are heathy and barren, and the scenery much resembles that of the Millstone Grit region.

The *Middle Oolites* form the hills which Prof. Phillips called the Tabular Range, because of their flat tops. They extend from the coast between Scarborough and Filey westwards across Troutsdale and Newtondale to Kirby Moorside, and the Hambleton Hills west of Helmsley. Here they curve round and extend by Hovingham to Malton. The beds dip south and south-east: they have a steep but short escarpment on the north, but slope more gently southwards until they pass under the clays of the Vale of Pickering. At their base we can distinguish the *Kelloway Rock* 80 feet thick at Scarbro', but thinning southwards to 5 feet in Gristhorpe Bay. Then comes the *Oxford Clay* 130 feet, capped by the *Coral Rag* 200 feet thick, which from its hardness forms the upper stratum of the flat-topped hills. All these beds are well seen in Newtondale and in the steep sides of the other dales, formed by streams running from the Moorland Range on the north into the Vale of Pickering, and cutting through the Tabular Hills on their way.

The *Upper Oolite* is represented by the *Kimmeridge Clay*, which forms the greater part of the Vale of Pickering; whose surface is from 70 to 100 feet above the sea-level. This clay is of considerable but unknown thickness, and is only exposed at a few points on the north side of the vale near Helmsley, Kirby Moorside &c.: it yields *Ostrea deltoidea*, everywhere common in beds of this age.

BASALTIC DYKES.—In Teesdale, from Caldron Snout, to near Middleton, a great intrusive sheet of basalt forms the boundary line between the Scar limestone and the Tyne bottom limestone (the lowest member of the Yoredale series). From this region the famous dyke of igneous rock known as the Whin Sill runs northward through Durham and Northumberland. Two dykes also run eastward: one of these, passing by Cockfield in Durham, crosses the Tees midway between Yarm and Stockton, and can be traced by Stainton, Langbargh and Castleton to near the Peak on the coast.

THE DRIFT.—The surface accumulations of the North Riding do not offer so complete a history of the Glacial Period as may be obtained in Holderness, Lincolnshire &c. The reason of this is that, lying farther north and on higher ground, it was repeatedly swept over by ice-sheets descending from the north, each one pushing before it and destroying the accumulations left by the preceding glacier. Excavations made almost anywhere in the Vale of York reveal