I.—*On the Geology of the Neighbourhood of Weymouth and the adjacent Parts of the Coast of Dorset.*

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FEW parts of the world present in a small compass so instructive a series of geological phænomena as those which are displayed in the vertical cliffs of the south coast of England. An important portion of this coast, including the Isle of Wight and the Isle of Purbeck, has been well described by Mr. Webster*, and subsequently illustrated by Dr. Fitton†. In the Second Series of the Geological Transactions‡, Mr. De la Beche has published sections of the coast from Bridport Harbour to Sidmouth; and in the same volume Dr. Buckland has given drawings of the cliffs from Sidmouth to Beer Head, and from Lyme Regis to the Isle of Portland§. The geological history of the neighbourhood of Weymouth has been partially illustrated by Prof. Sedgwick in the Annals of Philosophy ||; and it will be the object of this paper to supply its full details, illustrated by a map and sections; beginning our observations at the point where Mr. Webster's sections end, viz., at the Promontory of White Nore, about eight miles E.N.E. of the town of Weymouth, and continuing them to Weymouth and Portland, and thence westward along the Chesil Bank to the cliffs west of Lyme Regis.

To our representations of the coast we shall add many inland sections of the adjacent district, including all the strata which occupy that portion of the south frontier of the county of Dorset which lies between the great south

* See Sir H. Englefield's History of the Isle of Wight; the Geological Transactions, First Series, vol. ii. p. 161—254; and Second Series, vol. ii. Part I. p. 37—44: also Annals of Philosophy, vol. xxv. p. 33—51.

† Annals of Philosophy, Nov. 1824, vol. lxiv. p. 376.

‡ Geological Transactions, Second Series, vol. i. Part I. Pl. VIII.

§ Ibid. Plate XIV.

|| Annals of Philosophy, 1826, vol. xxvii. p. 346.

escarpment of the chalk downs and the sea. We shall designate this tract by the general appellation of the Weymouth District: it is a tract of no small importance in the geological history of England:—

1. From its position near the south-western termination of several principal formations of this island, including tertiary strata, chalk, greensand, Purbeck and Portland beds, several members of the oolite formation, and lias.

2. As exhibiting a coast section which forms an interesting object of comparison with the north-eastern terminations of the same strata on the coast of Yorkshire, which have recently been so well described by Mr. Phillips*, and with their appearance across the Channel on the coast of Normandy, the details of which have been described by Mr. De la Beche in the Geological Transactions†, and subsequently by M. de Caumont in his Essay on the Department of Calvados‡.

3. As affording remarkable examples of violent disturbances which have affected all these strata since the period of their consolidation; producing elevations, depressions, fractures, and denudations, connected and continuous with those which have operated so extensively in Purbeck and the Isle of Wight, and through the wealds of Sussex and Kent.

We shall take a short review of the general physical features of this district before we enter upon geological details. It will be seen by reference to our map§, which is on the same scale as the Ordnance Survey, that the physical features of the coast are:—1. On the east a range of high cliffs extending from the chalk of White Nore to the flat marsh lands of Lodmore near Weymouth. 2. The marsh lands of Lodmore, divided only by a bank of pebbles from the waters of Weymouth Bay. 3. A low range of cliffs, extending from Weymouth Harbour to Portland Ferry. 4. The remarkable accumulation of pebbles called the Chesil Bank, extending from the northern extremity of Portland about sixteen miles north-westward to Burton Castle, and causing the sea to be separated from the main land along nearly half this district by a backwater called the Fleet. 5. A succession of cliffs rising gradually from Burton towards the west till they attain their highest elevation of about 600 feet in the summit of the Golden Cap Hill, between Bridport and Charmouth.

The physical features of the interior divide it into two distinct compartments, which we shall call the Vale of Weymouth and the Vale of Bredy.

The Vale of Bredy is bounded on the north and east by lofty escarpments of

* Illustrations of the Geology of Yorkshire, by John Phillips, Esq. F.G.S. York, 1829.

† Geological Transactions, Second Series, vol. i. Part I. p. 40—47.

‡ *Essai sur la Topographie Géognostique du Département du Calvados*, par M. de Caumont. Caen, 1828.

§ Plate I.

the chalk downs; on the south by Abbotsbury Castle, and a lower range which slopes from thence continuously to Burton Castle; on the west it is separated by some hills of moderate elevation from the valley of Bridport.

Of the Vale of Weymouth the following are the three most prominent features:—

1st, The lofty escarpment of the Ridgeway which bounds it on the north, running nearly in a straight line about twelve miles from east to west.

2nd, The elevated and inclined plane of limestone which constitutes the Isle of Portland, and terminates this district towards the south.

3rd, Between this elevated Ridgeway and Portland is a space somewhat triangular, composed of an alternation of low and nearly parallel, narrow ridges and narrow valleys, which are terminated successively on the west by the Chesil Bank, and on the east by Portland Road and Weymouth Bay; these all diminish in length successively, as their position is nearer to the south, until the most southerly of them terminates in the sea at Portland Ferry.

These ridges and valleys constitute a series of narrow belts, which are crossed nearly at right angles by the road from Dorchester to Weymouth; we shall therefore designate these belts by the names of the villages that stand upon or nearest to them: thus the names of Upway, Upway Street, Broadway, Nottington, and Radipole, will indicate five successive belts, composed of five distinct and successive formations; namely, Portland stone, Kimmeridge clay, Oxford oolite, Oxford clay, and forest marble,—all dipping north towards the base of the escarpment of the Ridgeway chalk: nearly in the centre of this belt of forest marble the dip changes suddenly towards the south; and the same succession of strata is repeated, dipping in an opposite direction southwards, and disposed in corresponding belts, which may be designated by the names of Melcombe, Wyke Regis, Portland Ferry, and Portland Island. The formations superior to the Portland beds, if they exist south of the island, are covered by the sea exterior to the Bill of Portland. At the Race of Portland the agitation of the water is caused by the obstruction which the subjacent mass of Portland stone offers to the tidal currents. The line of section fig. 1,* exhibits the general structure of this district.

The forest marble†, with its clays and cornbrash, constituting the lowest strata which rise to the surface, forms a double, central belt, elevated, as Mr.

* Plate II.

† The forest marble and cornbrash are so closely united throughout this district, that, except in cases of minute local description, it will be most convenient to include them and their subordinate clays under the common appellation of forest marble.

Conybeare has stated*, into the form of an arch or saddle, on each side of which the superior strata repose in corresponding order of succession, having their dips respectively conformable to the north and south dips of the sides of the arch, whilst their direction or line of bearing is nearly east and west, and parallel to the axis of this central arch. Thus, on each side of our axis or anticlinal line of forest marble, the Oxford clay reposes conformably, and constitutes two parallel valleys, which extend from the sea in Weymouth Bay to the Chesil Bank. To these succeed two similar parallel ridges of the Oxford oolite formation, which are again overlaid by two parallel belts of Kimmeridge clay, on which are still further superimposed two distinctly characterized deposits of Portland stone; and on the north side only, above the Portland stone we find strata belonging to the Purbeck series, to the green sand, the chalk, and plastic clay.

The superficial breadth of the belts on each side of the anticlinal line is in the inverse ratio of their dip; and as this dip is most rapid on the north side, the surface of the northern belts is less broad than that of the corresponding belts on the south side.

Having taken this general view of the structure of the coast of Dorset, we will again examine its component parts in a descending order, and point out in regular succession the history and peculiar circumstances of each formation of which it is composed, beginning from the eastern extremity at White Nore, and thus connecting it immediately with the observations of Mr. Webster.

Tertiary Deposits.—Plastic Clay, &c.

It is well known from the maps of Mr. Webster† and Mr. Greenough‡, that the tertiary strata which fill the chalk basin of Hants and Dorset find their western termination about three miles east of Dorchester. Between this termination and the great south-western escarpment of the chalk, there occur insulated patches of the same tertiary deposits, and many large blocks of pudding-stone and of gray-wether sandstone, which show that the original limits of the tertiary formations extended far beyond their present outlines, and were probably almost coextensive with the chalk. Thus near Came Down on the Ridgeway about four miles south of Dorchester, we have a deposit of rounded chalk-flint pebbles, resembling the round tertiary gravel of Blackheath, near Lon-

* Outlines of the Geology of England and Wales, by the Rev. W. D. Conybeare, F.G.S. &c., and William Phillips, F.G.S. &c., pp. 182, 192.

† Geological Transactions, First Series, vol. ii. Plate IX.

‡ Geological Map of England and Wales, by G. B. Greenough, Esq. P.G.S. 1819.

don: and at the summit of Black Down, six miles south-west of Dorchester, which forms the highest hill within our district, we have a considerable series of beds of similar pebbles, sand, brick earth, and plastic clay*, analogous to the outlying fragments of the plastic clay formation which crown many of the highest summits of the downs of Wiltshire and Hampshire, and are described in Dr. Buckland's paper on Valleys of Elevation†.

Upon the high table land of chalk, also, on which this plastic clay of Black Down rests, we have numerous blocks of siliceous pudding-stone, scattered over the surface of the fields, and composed, like that of Hertfordshire, of a congeries of chalk flints imbedded in highly indurated siliceous sand: these blocks also contain occasionally, though rarely, a few angular fragments of chert from the greensand formation, and a few small pebbles of white quartz. The chalk flints which make up the greatest part of their substance are not all rounded, as in the Hertfordshire pudding-stone, but for the most part are angular, as in the case of similar insulated blocks which occur on the hills of greensand near Sidmouth; and this angular condition deserves peculiar notice, as it seems to connect them with the next deposits we are about to mention, some of which may possibly be referred to the era of the plastic clay formation. In two deep and steep combs excavated in chalk on the west and south of Black Down Hill, viz. at Bride Bottom on the west, and at Portisham on the south, these blocks of angular breccia are accumulated as thickly as the gray-wethers in Clatford Bottom, near Kennet, on the Marlborough downs: their abundance in Bride Bottom has caused it to be called the Valley of Stones. This bottom forms the upper extremity of the Vale of Bredy, where it contracts into a deep and narrow comb, at the head of which the blocks are spread over a space of several acres, like a flock of sheep, often so close together that a man may leap successively from one to another of them.

On the south side of the plain of Black Down we have another collection of huge blocks of the same breccia in the steep comb which descends the chalk escarpment into the village of Portisham: they are most abundant in the village itself, where they lie so thick that they partly obstruct the street, and when they occur in the line of the houses the walls are built upon them: their extreme hardness and bulk have hitherto prevented their removal or destruction by the hand of man. In the street at West Lulworth, also, similar

* These strata supply materials to a manufactory of bricks, tiles, and coarse pottery that is established on this hill. The clay exhibits the same varieties of colour, viz. blood-red, yellow, white, and black, which are so characteristic of the plastic clay formation, and are so well shown in Alum Bay and at Reading.

† Geological Transactions, Second Series, vol. ii. Part I., p. 119—130.

blocks of the same stone lie in the line of the front of some cottages, and are built into the walls. In Dr. Kidd's Geological Essay, p. 177, a similar collection of siliceous boulders is described as scattered over a dry valley, high up on the chalk downs of Berkshire, near Ashdown Park, on the south of Swindon, so thickly as to render the road inconvenient, even to a foot traveller. Although these blocks have been entirely separated from the matrix in which they were formed, they are very slightly rolled, and have been drifted but to a small distance from their native place.

We think it right to refer to the action of water, probably in more than one period of the tertiary formations, certain deposits of angular gravel which occur on the summits of many hills within our district. A remarkable example of this kind, composed of an admixture of unrolled chalk flints with yellow clay and sand, is seen in the upper margin of the cliffs at White Nore, where it forms a continuous bed, varying in thickness from two to twenty feet, level at its upper surface, but extremely irregular below, and filling up deep holes and furrows (*puits naturelles*), which pervade the entire surface of the subjacent chalk.

These deposits seem due to the effect of water dissolving the chalky matrix of the flints, but not sufficiently agitated to roll them into pebbles, nor to move them from the spot on which the dissolution of the chalk had taken place. The most instructive example we know of the effects of this dissolving operation is at Dunscombe Hill, on the east of Sidmouth, where, on the summit of a ridge of chalk, of which the surface is furrowed with pits and hollows that are evidently due to the action of water, we find an unstratified mass of chalk flints, which have not undergone the slightest rolling, piled on each other, and intermixed with loose sand and clay; the outer portions of this mass, from which the rain has washed away the sand and clay, lie loose and hollow, like stones in an artificial barrow, or in a wall constructed without mortar. It is scarcely possible to explain the actual state and position of these flints but by supposing that the chalk in which they were formed has been gradually dissolved in a quiet sea. To the same operation of quiet solution we must also refer analogous deposits of angular chalk flints and yellow clay which fill the irregular and deep troughs and hollows that fringe the upper margin of the chalk in the cliffs from Lyme to Axmouth, in a manner similar to that we have described at White Nore.

Cavities and projections of this kind appear to be universal on the surface of the chalk wherever it is covered up with any kind of tertiary strata, and has been protected by them from the levelling effects of atmospheric agents; in all these cases the actual surface of the land affords no indications of the irregularities which exist below: but however rugged be the subjacent surface of the chalk, its irregularities are all obliterated and filled up with breccias and gravel beds, presenting on their upper surface a smooth and continuous outline, whilst their lower surface is curved and dentated downwards, conformably to the furrowed curvatures, and ridges and pinnacles that fringe the upper surface of the chalk on which they rest; the existence of these pits and cavities shows, that the chalk had not been exposed to the levelling effects of atmospheric agents before the deposition of these breccias and gravel beds.

The water which formed these breccias must have been subject to very irregular currents and agitations; for whilst in many places (such as those last mentioned) the solution has been conducted in perfect tranquillity, in other spots it has been attended or followed by agitations which have reduced the flints to perfect roundness, as in the Hertfordshire pudding-stone and Blackheath gravel; and again, in other cases, there is evidence of an intermediate state of action, where only a partial rounding of the fragments has taken place, as in the partly rounded and partly angular chalk flints which form a thick bed reposing on strata of greensand on the summit of Haldon, on the west of Exeter.

Another variety of angular gravel occurs in many beds of shivered chert of the greensand formation, which seem to have undergone a certain degree of decomposition, causing them entirely to break to pieces and crack into angular fragments, and become converted into strata of loose and shivered gravel, on which no mechanical attrition seems to have been produced by the operation of water, but the fractures have resulted from the splitting to pieces of the beds of chert still resting in their natural position. A remarkable example of this kind may be seen in the cliffs that overhang the new road between Lyme and Charmouth, and also on the summit of Abbotsbury Castle. In the oolite formation also, about two miles west of Bridport, a similar dislocation and splitting of the stone has converted to loose breccia the upper beds of inferior oolite on part of the summit of Chideock Hill. This is the only case we have noticed of such an occurrence in the oolite of the coast of Dorset.

It is not easy to distinguish between these undisturbed beds of shivered chert, and accumulations of the same chert which have been very slightly agitated by water, except in cases where the admixture of miscellaneous fragments of other strata shows that moving water has operated in bringing these fragments to their present position amongst the chert. There is also a difficulty in distinguishing the deposits of angular breccia, both of this chert and of the chalk formation, from deposits of diluvial gravel which have been removed to a small distance only from their native place. The cliffs at Axmouth and near Sidmouth exhibit deposits of such miscellaneous diluvial gravel, resting on red marl, and adjacent to beds of uniform and angular chalk-flint breccia that rest on the chalk.

These deposits of breccia on the coast of Dorset seem analogous to those which are found in Normandy, reposing on the similarly corroded surfaces of the chalk, and which occur also on the surface of other formations in that part of France, each formation respectively being often covered with a capping of loose angular fragments composed of the hardest materials of the subjacent strata. According to M. de Caumont, a breccia allied to the plastic clay formation, and composed of angular chalk flints imbedded in red clay, occasionally attaining the thickness of 80 and 100 feet, occurs in the valley of the Rille, and various adjacent parts of Normandy*. M. de Caumont speaks of all these breccias under the head of Diluvium,—falling into the same common error with many other Continental geologists, of including under the term Diluvium many pebble beds and breccias which belong to the tertiary, and to older formations.

Chalk.

The lofty escarpment of chalk which bounds our field of observation on the north, forms the margin of the chalk downs of the southern part of Dorsetshire, and is the direct continuation of the south frontier of the great chalk basin of Dorset and Hants. Along great part of this south frontier, from the east extremity of the Isle of Wight to the west extremity of Purbeck, and thence to the cliffs of White Nore, where we enter on its history, Mr. Webster has shown its position to be sometimes absolutely vertical, but for the most part dipping at a very high angle northwards towards the interior of the basin †. This high inclination ceases a little east of the promontory of White Nore, where the chalk suddenly sweeps round, and dips at an angle of a few degrees only to the north-east. Along the range of its escarpment westward, for nearly twenty miles from White Nore to its termination at Chilcomb Hill, on the east of Bridport, the dip is almost constantly towards the north, at angles varying from 10° to 40°. Its mean elevation along all this range may be taken at about 500 feet. The base of this escarpment appears throughout to be

* See sections and description in M. de Caumont's *Essai sur la Topographie Géognostique du Calvados;* and De la Beche on the Geology of the North Coast of France, from Fecamp to St. Vaast, in Geol. Trans. Second Series, vol. i. Part I. p. 73—89.

† See Sir Henry Englefield's History of the Isle of Wight, Plate 50; and the Geological Transactions, First Series, vol. ii. Plate XI.

composed of beds of the greensand formation; but these are rendered invisible in the greater part of the Weymouth district, in consequence of a fault which runs along the escarpment for nearly ten miles, from Poxwell to Abbotsbury, and brings up strata, subjacent to the greensand, into immediate contact with the chalk: this fault we shall hereafter describe.

The promontory of White Nore is the last point in the South-west of England at which the great body of the chalk touches the sea; those insulated portions of this formation which occur in the cliffs between Lyme and Sidmouth being only detached outlying masses, separated, by denudations of many miles in width, from the south-west termination of the great chalk basin of Dorsetshire*.

The mineralogical character and organic remains of the chalk in this district present nothing unusual: the lower strata of the chalk pass into hard chalk, devoid of flints, and interspersed irregularly with green grains of silicate of iron.

Greensand.

The strata of the greensand formation, which at White Nore emerge from beneath the lowest chalk, dip conformably with it to the north-east, and attain a thickness of about 100 feet: their succession in a descending order is:—1. Chalky glauconite, composed of greensand interspersed with calcareous cement. 2. Green, yellow, and brown sand, alternating with irregular calcareous concretions, and with thick beds of chert. 3. Dark argillaceous greensand, with large nodular concretions, equivalent to the sandy concretions called cow-stone, at Lyme Regis: the upper subdivisions of this section also closely resemble some of those exhibited by the greensand formation near Lyme.

We are unable to recognise distinctly in this district, or in any part of the coast west of Weymouth, those regular and extensive threefold subdivisions of fire-stone, gault, and lower greensand, which are so obvious in Hants, Sussex, and Kent; although an approximation to the character of fire-stone may be traced at White Nore, and still more decidedly in Devonshire, in the cliff and quarries of Beer already described by Mr. De la Beche†.

For a considerable distance near White Nore and Osmington the greensand is visible at the base of the chalk escarpments, dipping always conformably to the chalk; but along the great escarpment from Poxwell to Abbotsbury it is seen only in two places, namely, near Sutton Pointz, and at Bincombe, being elsewhere masked by the Portland stone, which the great fault that

* See Map, Plate I.

† Geological Transactions, Second Series, vol. ii. p. 109.

runs along this escarpment brings up into absolute contact with the chalk. At these two places, however, its thickness is so great as to leave little doubt that it continues in its proper place beneath the chalk, to the west extremity of the fault near Abbotsbury, where it is again exposed, and forms a considerable feature in the escarpment of White Hill, overhanging the village of Abbotsbury, and projecting thence nearly two miles westward into the summit of the long and elevated ridge of Abbotsbury Castle. From Abbotsbury Castle it turns northward, still forming the sub-escarpment of the chalk, along the entire east and north frontier of the Vale of Bredy. It appears also on the summit of Swyre Knoll, Hammerdon Hill, and Shipton Beacon, which form three remarkable outlying hills on the flanks of the Vale of Bredy, and in much greater force on the summits of the insulated hills of Golden Cap, Hadden Hill, Stonebarrow Hill, Coneygore, and Conig Castle near Charmouth; and further north, on the lofty tops of Lewsdon Hill, Pillesdon Hill, and Black Down near Broadwindsor*. In the escarpment on the north of Abbotsbury we have a distinct section, displaying ledges of hard coarse limestone, loaded with grains of quartz and silicate of iron, and alternating with thick strata of chert; a little further west, at Abbotsbury Castle, the calcareous matter ceases, and is replaced by strata of chert. These calcareous and cherty strata of the greensand at Abbotsbury, afford an interesting object of comparison with those in the neighbourhood of Lyme Regis, described by Mr. De la Beche†, as well as with those at White Nore. The occasional presence of so much calcareous matter in the greensand, seems to justify the appellation of *craie chloritée,* given by the French to the uppermost strata of the greensand formation.

The greensand in our Weymouth district is found to overlie and repose successively on formations of different ages; thus, in the valley of Upton on the east of Osmington it rests on the Purbeck beds‡; in the south escarpment of Upton Hill towards Ringstead Bay, on Portland stone§; on the west of Osmington Mill, on Kimmeridge clay||; at Abbotsbury Common, on a clay which is probably the Oxford clay¶; at Golden Cap Hill, on inferior oolite**; near Lyme Regis, upon lias††; and at Axmouth and Beer, upon red marl‡‡. The same overlapping disposition of the greensand has been ob-

* See Map, Plate I.

† Geological Transactions, Second Series, vol. ii. pp. 109, &c.

‡ See Plate II. fig. 2 & 3.

§ See Plate II. fig. 2.

|| See Plate II. fig. 9.

¶ See Plate II. fig. 6 & 7.

** Geological Transactions, Second Series, vol. i. Part I. Plate VIII. and Plate XIV. No. 1. In these sections the inferior oolite was omitted by mistake, but is inserted in a section of the same coast, in Pl. III. of Mr. De la Beche's Sections and Views Illustrative of Geological Phænomena.

†† Ibid. Plate VIII.

‡‡ Ibid. Plate XIV. No. 2.

served by Mr. De la Beche* and M. de Caumont in Normandy†, where it overlaps successively the formations of Kimmeridge clay, coral rag, and Oxford clay. This circumstance derives an additional importance, at the present time, from the recent paper of M. Elie de Beaumont‡, in which he observes that a connexion exists between the elevation of mountains and succeeding deposits of extensive overlapping strata, e. g. the greensand and chalk in the Jura mountains, filling the longitudinal valleys produced by the elevation of the oolites. On the coast of Dorsetshire no elevation of the strata appears to have taken place between the deposition of the lias and the plastic clay.

Hastings Sand, and Purbeck Beds.

Although the Wealden or Hastings sands do not enter the area of our actual observation, they approach very near to its eastern extremity, becoming gradually thinner in their progress westward through the Isle of Purbeck, until they terminate a little west of Lulworth: this has been already pointed out by Dr. Fitton and Mr. Webster§.

The identity of this Hastings sand with that of Swanwich Bay, at the east extremity of Purbeck, has recently been further confirmed by the Rev. T. O. Bartlett's discovery of the remains of the Iguanodon and other reptiles in the iron sandstone at Swanwich. Bones of this animal have also been recognised by Prof. Buckland and by Mr. Vine in the same sandstone at Sandown Fort, and other places on the south coast of the Isle of Wight.

The Purbeck beds enter our district on the north-west of White Nore, but are seen only in two small insulated patches near the villages of Osmington and Upway. The details of the beds composing the Purbeck series are so fully given by Mr. Webster‖, that it is here superfluous for us to say anything respecting them, further than that several of their most remarkable varieties are recognised and wrought even to their final termination on the west of Upway. We trace also throughout this district the remarkable beds of fibrous carbonate of lime that pervade the clay which alternates with the beds of limestone throughout the Isle of Purbeck. The fibres of this limestone, like those of satin spar, are at right angles to the planes of the beds which they compose, and which vary from two to six inches in thickness. From the resemblance of its small and parallel fibres to the fibres of animal muscle, this limestone is known among the workmen by the name of "Beef": it

* Geol. Trans. Second Series, vol. i. Part I. Pl. X.

† *Essai sur le Top. Geog.* Pl. VI.

‡ *Ann. des Sciences Nat.* vol. xvii. Sept. 1829.

§ Annals of Philosophy, 1824, New Series, vol. viii. p. 382: also Sir H. Englefield's History of the Isle of Wight, p. 194.

‖ Geological Transactions, Second Series, vol. ii. p. 36.

sometimes entirely occupies the place of the clay between the limestone beds of this formation. One of the most important points in the geological history of the Purbeck series, is the occurrence of a bed of oyster-shells called the "cinder bed," often many feet in thickness, and almost wholly composed of dark-coloured, small oyster-shells in the midst of a series of strata, some of which contain exclusively shells of freshwater formation, and others an admixture of freshwater shells with those which are marine: this circumstance has been duly noticed by Mr. Webster and Dr. Fitton; and although we cannot infer from it the return of the sea for any long period in the middle of the Purbeck formation, yet it shows that the district it occupies could not have been a lake of pure fresh water, but was probably an estuary at the time when these oysters occupied its bottom, and were accumulated to the thickness of many feet over a distance of many miles*.

We are disposed to agree with Mr. Webster, and to adopt more confidently than he has done the opinion he advances with respect to the propriety of referring to the lower region of the Purbeck series the beds of white calcareous slate, usually destitute of organic remains, which occur between the undoubted Purbeck beds and the Portland stone; these beds resemble the compact varieties of Purbeck stone, which are devoid of shells, and which near Lulworth attain a thickness of from 60 to 100 feet. In Portland the

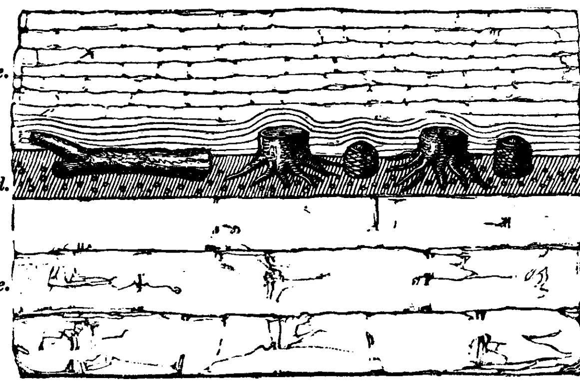
* The following description of the actual state of the lake Menzalé at the mouth of the Nile, by a modern traveller, is highly illustrative of the mode in which living animals of a mixed character are associated together near the confluence of great rivers with the sea.

"The *lake Menzalé* is only five miles distant from Damietta. I should judge it to be sixty-five miles long, and fifteen broad: it is not, properly speaking, a maritime lake, but formed by the increase of the Damietta branch of the Nile; the depth is from three to five feet, and on pushing an oar to the bottom I have observed it coated with the common mud of the Nile for about twenty inches deep. Along all the length of the lake a narrow tongue of land separates it from the sea, but not wholly: there are four passages through which it is possible for barks to sail; through two of them I passed with a good deal of difficulty. At the mouth of each there is a bar of sand, which makes the passage perilous from the sea. No sea or lake in the world can perhaps boast of the same quantity of fish in a given space as the lake of Menzalé.

"The principal sorts of fish caught here are the *Perca Luth*, or Lot's perch; another species called *kescher;* the *charamoot* or *Silurus anguillaris*,—the fin is said to be poisonous; the *burra*, or red mullet; the *kelp el bahr*, or sea-dog; the *casheff*, or *Mormyrus anguilloides* of Linnæus; this I have seen weighing thirty pounds. The salmon of the Nile is found in the upper part of *Menzalé* weighing from 80 to 100 pounds. The mixture of sea and river water in the lake causes it to be neither salt nor sweet; so that both river and sea fish are to be found here in equal quantity: but both, in my opinion, of an inferior quality. The quantity of birds which cover the lake is prodigious. Pelicans, cormorants, cranes, and herons live only on the fish."—*Madden's Travels in Egypt, &c.* vol. ii. p. 171—175.

lowest of them form the surface of the island, and cover the true Portland stone with a deposit of freshwater formation. This formation presents beds of chert containing freshwater shells, near the Ridgeway fault, on the west side of the road from Weymouth to Dorchester; and also beds of chert containing chalcedonic casts of minute freshwater shells, at the water's edge, on the east side of Lulworth Cove.

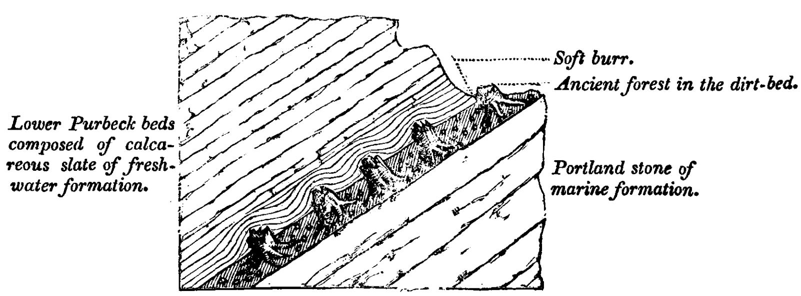
Section of the Dirt-bed in the Isle of Portland.



We consider a small stratum, called by the workmen "Dirt-bed," to be by far the most interesting and remarkable deposit in this district. It seems to be made up of black loam, mixed with the exuviæ of tropical plants, accumulated on the spot on which they grew, and preserved during a series of years, in which the surface of the Portland stone had for a time become dry land, and accumulated a soil of about a foot in thickness, composed of an admixture of earth and black vegetable matter, interspersed with slightly rounded fragments of stone, which Mr. Webster ascertained to be from the lower part of the Portland series. These fragments are found to be almost coextensive with the dirt-bed, and the fact that we have yet found with them no admixture of pebbles derived from the subjacent oolites, or from any other more ancient rocks, shows that no violent rush of water from any distant region took place during the period in which these pebbles of Portland stone were under the process of becoming slightly rounded.

This dirt-bed, as Mr. Webster has stated, forms the matrix of the silicified trunks of very large coniferous trees, which are so abundant in the Isle of Portland, and are found there coextensive with the upper surface of the Portland stone. Wherever the dirt-bed is laid open to extract the subjacent building-stone, it is found to contain these silicified trees laid prostrate, partly sunk into the black earth, and partly covered by the superjacent calcareo-siliceous slate: from this slate the silex, to which the trees are now converted, must have been derived. A bed of snow falling on a modern peat-bog, and covering the upper portion of prostrate trees, whose lower portion has been sunk by their weight into the substance of the peat, would represent the position of the calcareous slate which immediately covers these fossil trees in Portland: some of them extend to a length exceeding thirty feet, and bifurcate at their upper end; but the branches are not continuous to their extremities, and we find no traces of leaves. The leaves and small branches, and exterior parts of the trunks, had probably decayed, whilst they lay exposed to air on the surface of the peat. Amid these prostrate trees, many of which attain three and four feet in diameter, we find silicified stems of plants closely resembling the modern Cycas and Zamia: these have been described by Prof. Buckland under the name of Cycadeoideæ*, and are important, as indicating that the temperature in which they grew was much higher than that of our present climate. We find also, at nearly the same intervals at which trees are found growing in a modern forest, an assemblage of silicified stumps or stools of large trees, with their roots attached to the earth in which they grew. These stumps are from one to three feet long: they are mostly erect, whilst a few are slightly inclined. The black earth which contains their roots seldom exceeds one foot in thickness; the upper portions of the stumps, as represented by Mr. Webster†, project upwards into the substance of the superjacent stone (called "soft Burr" and "Aish"), which gives indication of their presence by hemispherical concretions accumulated around the top of each stump of wood‡.

Section of the Cliff east of Lulworth Cove.



In the highly inclined strata of the cliff, about a furlong east of Lulworth Cove, and represented in the above sketch, we find a considerable number of these silicified stumps, some entirely laid bare by the washing of the sea, others partly exposed and partly covered, and others still wholly encased with

* Geological Transactions, Second Series, vol. ii. Part III. p. 395.

† Ibid. vol. ii. Part I. Pl. 6. fig. 3, 4.

‡ See wood-cut at p. 13.

concretions of soft burr, and all having their roots fixed in the dirt-bed, which occurs here also of the same thickness, and in precisely the same relative place, and interspersed with the same rounded fragments of limestone which it contains in the Isle of Portland: the position of these stumps, at an angle nearly of 45° to the horizon, affords a striking proof of the elevation which the strata have undergone. We find the dirt-bed also on the top of the Portland stone, in the sections of some quarries along the Ridgeway, e. g. near Upway, on the north of Weymouth, and at the western termination of the Portland stone near Portisham, at the distance of twenty miles west from Lulworth. Dr. Buckland has found slight traces of this dirt-bed on the upper surface of a stratum of Portland stone in the quarries about two miles north of Thame, in Oxfordshire: it is here covered by a few feet of clay, in which he found no other animal remains than fragments of some Testudo, too small to point out the genus to which they belong. The recognition of this very remarkable bed in a locality so distant from Portland seems to indicate that it may be found to be nearly coextensive with the Portland formation throughout England; and it well merits the attention of future observers to search for it in the Vale of Aylesbury, and in the two localities of the Portland stone intermediate between Oxford and Dorsetshire, namely, at Swindon and Tisbury. The probability of its occurrence at Tisbury is increased by the recent recognition of the Cycadeoideæ at this place by Miss Benett*. We consider this dirt-bed as quite decisive in forming the barrier between the Portland and Purbeck formations: its deposition must have proceeded during a considerable period of time, antecedently to which the districts it occupies were entirely submerged beneath the sea, and subsequently to which the waters again returned to overwhelm them, first with a deposit of about 1000 feet of the semi-lacustrine sediments of a great estuary (including the united thickness of the Purbeck series and the Wealden sands

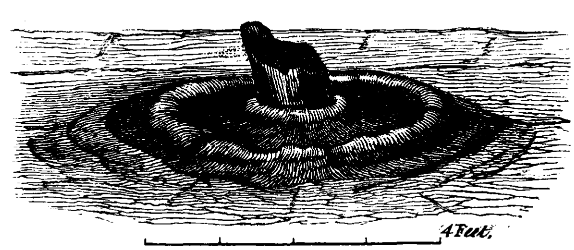
* Dr. Fitton has discovered this deposit on the opposite side of the Channel in the Boulonnois, and has thus described it in the Annals of Philosophy, December, 1826. "Some traces of the lowest members of the group to which these two strata (Weald clay and Hastings sand) belong, and which is remarkable from its containing throughout the remains of freshwater shells, are visible on the summit of the cliffs between Gris-nez and Equinen, where a thin bed occurs of somewhat bituminous clay, abounding in silicified wood, the cavities of which are coated with minute crystals of quartz. This bed corresponds precisely to that which exists on the top of the Isle of Portland, bearing there the name of 'Dirt,' and abounding in similar wood; and on the French coast it is associated with beds of limestone, different from the stone beneath, and containing shells in great numbers, apparently of the genera Cyclas and Ampullaria." Dr. Fitton has also recognised thin fissile beds of Purbeck stone containing freshwater shells, e. g. Cyclas and Cypris, at Whitchurch in Bucks.

and clays), and afterwards with a series of marine deposits amounting to much more than 1000 feet of greensand and chalk.

Throughout the entire succession of all these changes there is no evidence of any sudden and violent disturbance causing either elevation or depression of the Portland stone, or of the subjacent oolites. The present high inclination of all these beds is uniformly parallel to that of the beds of Purbeck stone, greensand, and chalk; and these all seem to have been raised simultaneously by the same convulsion which elevated the axis of the Weymouth district, together with all the inclined strata in Purbeck and the Isle of Wight.

We have a measure of the duration of the period during which the surface of the Portland stone continued in the state of dry land, covered with forest, in the thickness of the "Dirt Bed," which has accumulated more than a foot of black earth, loaded with the wreck of its vegetation. The regular and uniform preservation of this thin bed of black earth over a distance of so many miles, shows that the change from dry land to the state of a freshwater lake or estuary was not accompanied by any violent denudation or rush of water, since the loose black earth, together with the trees which lay prostrate on its surface, must inevitably have been swept away had any such violent catastrophe then taken place*.

* Prof. Henslow in the summer of 1832 found in the top cap of the Portland stone, immediately beneath the dirt-bed, root-shaped cavities descending from the bottom of the dirt-bed into the subjacent solid stone; this top cap should seem, therefore, to have been occupied by the roots of the trees which grew in the dirt-bed, and penetrated the Portland stone whilst it was yet soft and unconsolidated. He also noticed in Portland two partial and very thin seams of black earth; the uppermost at the distance of five feet, and the lowermost of seven feet, below the dirt-bed: these seams of black earth are important, as they mark two short intervals during which vegetable matter had begun to accumulate on the surface of the soft and gradually increasing materials of the uppermost beds of the Portland stone, whilst they were just rising above the level of the sea. The incipient bed of vegetable matter was thus twice interrupted in its progress, and buried beneath an influx, first of two feet, and next of five feet, of earthy sediment, before the general surface on which the true dirt-bed rests had been raised entirely above the water.



The above cut represents an example which in the summer of 1832 occurred to Prof. Henslow in the Isle of Portland, in a quarry where the surface of the burr had been laid bare,

Portland Stone.

As the details of the component beds and fossils of the Portland series have been sufficiently described by Mr. Webster and Mr. Conybeare, we shall

of an erect stump protruding through the burr stone into the superior stratum called Aish, analogous to that represented by Mr. Webster in his section of the Portland beds (Geol. Trans. Second Series, vol. ii. p. 1. Plate VI. fig. 3 and 4.), and which the workmen stated to be of rare occurrence; this superior stratum exhibited to Prof. Henslow two or three of those conical and dome-shaped protuberances which so generally indicate the presence of stumps of trees immediately beneath them. In the case represented, the protruding stump being longer than the rest, the burr stone was not deposited in sufficient thickness to cover it, but was heaped around it in two circular ridges, with intermediate circular depressions. From these appearances we may infer that a state of great tranquillity attended the deposition of the calcareous sediment of which the dome-shaped caps that cover the shorter stumps were formed (See Section of the Dirt-bed, page 13.) The circular ridges and depressions which surround the taller stumps (see page 16,) seem to have been produced by an interruption of the undulations on the surface of water so shallow that the waves were caught and broken by a stump but four feet high, whilst they passed over the shorter stools immediately adjacent to them; these interrupted undulations being propagated first downwards and then outwards along and around the stump whose top was high enough to obstruct the ripple on the surface of the shallow lake, by which the dirt-bed was gradually inundated.

Here, then, we have proofs of a tranquil state and gentle action of water in the period immediately succeeding, as well as in that which preceded, the formation of the dirt-bed, upon a surface that became dry land during a short time intermediate between the transition of the district which it covers from a submarine state to that of a freshwater lake. The rapid possession which in our modern tropics is taken by the Pandanus or Screw Pine and Cocoa-nut Palm of the first banks and reefs of coral islands that emerge above the level of the sea, affords an example of the luxuriant growth of vegetables on the margin of land just rising above the water, analogous to the ancient juxtamarine forest the remains of which contributed to the formation of the dirt-bed, in the region which has now become the southern coast of Dorsetshire.

With respect to the silicified trees Prof. Henslow makes the following observations:—

"From what I saw I should think that all the erect stumps must have suffered considerable decay before they had become imbedded, or at least fossilized, in the burr. They consisted of no more than the central portion of the wood just above and below the neck of the trees, which had every appearance of having grown in the places which they still occupy.

"In a quarry of very white and chalk-like Portland stone, at the base of Chalbury Hill, near Preston, I found a cylindrical mass of flint ten inches in diameter, reposing upon a soot-like mass of carbonaceous matter, probably resulting from the decomposition of leaves and bark, and forming an envelope to the lower part of the cylinder, but not extending beyond it. Upon cracking off as much of this cylinder as protruded from the side of the quarry, I perceived the central portions, of three inches in diameter, to consist of fossilized wood. It appears to me most probable that the whole cylinder had occupied the space originally filled by the trunk or branch of a tree; but that during the process of its becoming silicified, the organic structure of the outer portions had not been impressed upon the flint. In the Isle of Portland the quarry-men collect a similar black vegetable substance, which they use for blacking."

only refer to their account of them*, and to our own detailed section of Black Nore on the west cliff of the Isle of Portland†. We have little to add to what these authors have published, except the occurrence of bones of Saurians which we discovered in the cliff of Black Nore, imbedded in compact Portland stone.

We have stated in our introduction that this district contains two distinct ranges of Portland stone; one constituting the table-land of the Isle of Portland, dipping southwards beneath the sea, and rising with an elevated escarpment northwards towards the bay and valley of Weymouth; the other constituting a long and narrow line of elevated hills, parallel, and immediately subjacent, to the chalk escarpment of the Ridgeway, and presenting a continuous and lofty escarpment towards the south. In fact, these hills occupy the position which in districts that have been less disturbed is usually held by the sub-escarpments of the greensand formation, where it emerges regularly from beneath the chalk: such are the escarpments of greensand which in Kent and Sussex extend from Folkstone, by Coxheath, Nutfield, and Leith Hill, to Godalming. A glance at our map will show that along the northern frontier of the Vale of Weymouth this ridge of Portland stone forms a continuous band from the east extremity of our district near White Nore to Portisham, where it suddenly terminates in the great fault, and is found nowhere further west in England. Along nearly the whole of this tract it attains a high elevation, rising near the central part at least 500 feet into the lofty eminences of Preston Hill, Charlbury, and Bincombe Hill: at these three places its elevation is little less than that of the chalk itself. On the west of Upway it forms a narrow ridge or hog's back from Upway to Portisham, known by the name of Corton Hill and Waddon, dipping at an angle of about 45° to the north. Although these Portland beds dip thus rapidly to the north, through great part of the range now under consideration, yet such is the dislocation and elevation they have suffered along the line of the great fault, that their northern margin is seldom brought into contact with any other strata than the chalk. On the west of Upway this line of contact is marked by a longitudinal valley, flanked on its north side by the chalk escarpment, and on its south side by the upper Portland strata of Corton Hill‡: thus, the Portland beds dipping to the north in Corton Hill, and south along the fault, form a trough in which reposes a long and narrow strip of Purbeck strata, extending more than a mile both on the east and west of Upway, and dipping conformably to the double dip of the subjacent Portland

* Geological Transactions, Second Series, vol. ii. p. 37, &c. Outlines of the Geology of England and Wales, p. 172.

† Plate III. fig. 3.

‡ See Map, Plate I.

stone. The sudden and total disappearance and termination of the Portland formation at Portisham, seems not to result from its accidental intersection at that place by the great Ridgeway fault; but rather from the tendency which is common to this, with most other great formations, to terminate abruptly where they are accumulated to their fullest thickness; thus we find the full thickness of the chalk and oolite formations exhibited for many hundred miles along the line of their great escarpments throughout England, and in like manner the full Portland strata terminate abruptly in the Vale of Weymouth: they reappear and again terminate with equal abruptness in the Vale of Tisbury, and exhibit nearly the same features of sudden termination in the hills near Brill and Thame in Oxfordshire, and near Aylesbury and Whitchurch in Bucks.

The fact of the interrupted deposition of the Portland formation in England, occurring as it does only in the limited districts just mentioned, and in one other small spot at Swindon, is analogous to the interrupted deposits of other strata, particularly the most recent members of the oolite formation. We know not the cause of these irregularities; the fact may be illustrated by the case of the Kimmeridge clay, which attains at Kimmeridge a thickness of 600 feet, is reduced to 70 feet near Oxford, disappears entirely in some places along its line of bearing, and again resumes its strength in the Vale of Pickering, and near the coast of Yorkshire. The Portland stone has not yet been identified on the opposite coast of Normandy, but M. E'lie de Beaumont states that he has discovered it in Burgundy*, and M. Dufrénoy says that it occurs largely in the vicinity of Angoulesme†. We think it probable that it will soon be recognised among the great calcareous formations of the Alps and Apennines.

Portland Sand‡.

The consolidated and calcareous beds of the Portland stone are separated from the Kimmeridge clay by the interposition of a deposit of sand and marly sandstone at least eighty feet thick, exceeding the total thickness of the Portland stone itself. This deposit is coextensive with the Portland stone throughout nearly the whole of the coast of Dorset, and is well exhibited by a vertical section near Black Nore, on the west cliff of the Isle of Portland, and along the west shore from Black Nore to the village of Chesilton. Its prevailing character is a siliceous sand, so abundantly mixed with grains of green earth, as to be scarcely distinguishable from the lower strata of the greensand formation near Lyme and Seaton: it also contains large semicalcareous

* *Ann. des Sciences Nat.*, July 1829.

† *Annales des Mines*, 1829, vol. ii. p. 434.

‡ See Pl. III. fig. 1. *n. o.* and fig. 3.

concretions resembling the cow-stones in the lower greensand at these two places; its fossils, however, are different, and more allied to those of the oolite; and its position beneath the Portland stone is decisive in separating it totally from the greensand formation. We have adopted for this stratum the name of Portland Sand, being that suggested by Dr. Fitton, who had ascertained its relation in the Boulonnais and in Buckinghamshire*.

This Portland sand is of sufficient importance to be marked on our map by a distinct colour along nearly the whole extent of the base of all the escarpments of Portland stone; its mineralogical resemblance to the greensand of Lyme may be best seen at Corton, about two miles west of Upway, where nearly one half of its substance is made up of grains of green earth.

The following list of fossils from the Portland sand has been prepared by Mr. James Sowerby, from specimens we collected at Black Nore and Chesilton, in the Isle of Portland, and at Corton.

Black Nore.

Serpula plexus, M. C. 598. f. 1.
Mya? (Pullastra of Phillips), only a cast.
Trigonia clavellata, M. C. 87.
Plicatula, a new species, occurs at Weymouth.
Pecten, with concentric laminæ.
Exogyra (*Gryphæa*) *nana*, M. C. 383. f. 3.
Ammonites triplex. M. C. 292, 293.

Chesilton.

Mya? same as at Black Nore.
Venus, only a cast.
Ostrea Hemicyclus, new species.
Exogyra nana.
Ammonites giganteus? young, M. C. 126.

Corton.

Lucina? a fragment.
Cardium, small fragment.
Avicula concentrica, new species, very abundant.
Pinna viminea, new species; found also at Down Cliff, Bridport, in inferior oolite.
Pecten, with concentric laminæ.
Plagiostoma rusticum? M. C. 381.
Ostrea, new?
Anomia? one valve imperfect.
Belemnites, fragment.
Ammonites giganteus? Young, or possibly *A. Vernoni* of Phillips: it is much crushed.
Echinus spines.

The prevailing character of this stratum, along the whole line coloured on the north side of our map, is a bed of siliceous sand and green earth. It is also sandy and full of green earth at the village of Chesil; but at the base of the high west cliff of Portland, under the promontory of Black Nore, where it attains a thickness of eighty feet†, it is mixed with marl, and exhibits subordinate concretions, and beds of sandy marl and sandstone, both containing the same fossils that are found at Chesilton and Corton. Its lowest beds become more argillaceous as they approach nearer to the subjacent Kim-

* See Phil. Mag. and Ann., May 1827, vol. i. p. 139.

† See Pl. III. fig. 1 & 3.

meridge clay; it seems to form a connecting link between the Portland stone and Kimmeridge clay; and, as has been observed by Mr. Conybeare*, is probably identical with the beds of sand and green earth, full of large boulder-shaped semi-calcareous concretions, that occur in Shotover Hill, near Oxford, between Kimmeridge clay and the imperfect upper calcareous Portland beds, which extend from Shotover to Brill and Thame and Aylesbury, and which also are occasionally much loaded with grains of green earth. Dr. Fitton has recognised this sand beneath the calcareous Portland beds at Whitchurch in Bucks: it occurs also in the same position in the Quainton Hills; and Mr. Lonsdale considers the sand which forms the escarpment close on the north and west of the town of Swindon to be also identical with this Portland sand; the calcareous or upper Portland beds occur also beneath and a little to the east of that town. In the Boulonnois, Dr. Fitton describes this formation as consisting of calcareous concretions of great size, as in Oxfordshire and Bucks, abounding in petrifactions, and imbedded in yellowish somewhat ferruginous sand; between Gris-nez and Audreselles the shore is covered with these enormous masses fallen from the sand†.

Kimmeridge Clay.

The general character and fossils of this formation have been already described by Conybeare and Phillips. It is chiefly composed of beds of slaty bituminous clay, interspersed with Septaria and beds of bituminous marlstone. Near its middle region, in Ringstead Bay, it contains thin beds of marly sandstone, full of well preserved organic remains, and through its whole extent it is loaded with deltoid oysters, which are well known to be its most characteristic shell in England; it contains also the *Gryphæa Virgula,* which is considered characteristic of this formation in France, and abounds in it at Shotover near Oxford.

Mr. James Sowerby has prepared the following list of fossils from this marly sandstone in Ringstead Bay.

A carinated Serpula.
Mya depressa, M. C. 418.
Pholadomya, near *Ph. obtusa.*
Venus?
Cardium?
Trigonia elongata, M. C. 431.
Modiola bipartita, M. C. 210. f. 3, 4.
———, a small boring species.
Pinna granulata? a small fragment, M. C. 347.
Ostrea deltoidea, M. C. 148.
Terebratula inconstans, M. C. 277. f. 3, 4.
Pleurotomaria reticulata (Trochus), M. C. 272. f. 2.
Ammonites, species between *A. decipiens* and *A. mutabilis.*
Ammonites rotundus, M. C. 293. f. 3.

* Outlines of the Geology of England and Wales, pp. 166, 173, &c.

† Philosophical Magazine, 1827, New Series, vol. i. p. 139.

On the opposite side of the Channel the Kimmeridge clay occupies the cliffs of Havre and Honfleur, where it lies next beneath the greensand, and it has been further identified by M. Elie de Beaumont, and by M. de Dufrénoy in the South of France. This formation exhibits its best sections and highest elevation near the east extremity of our district in the cliffs of Ringstead Bay and Osmington, where it attains a thickness of about 300 feet.

From Osmington Cliff it continues westward, without interruption, through Preston and Upway Street to Abbotsbury, forming the narrow north belt of clay which we have named from the village of Upway Street. Great part of this belt is marked by a valley parallel and subjacent to the ridge of Portland stone above described, and dividing it from the ridge of Oxford oolite which forms its southern frontier: this belt of clay terminates suddenly about one mile west of Abbotsbury. In the Vale of Bredy, the covered state of the country renders it almost impossible to distinguish the Kimmeridge clay among the different clay beds that occupy a large part of its surface; but we have identified it at Litton Cheney, immediately on the south of that village, containing the *Gryphæa Virgula*.

The southern belt of Kimmeridge clay near Weymouth, occupies a very small portion of the surface, constituting a triangular area, the base of which extends about a mile from Sandsfoot Castle westward, to the Chesil Bank, whilst its apex is at Portland Ferry: but although so small a portion of this belt of clay is here visible on the surface, we have evidence of its submarine continuation from hence to Portland Island, in the clay bottom of the excellent anchorage of Portland Road, beyond which also it appears above the level of the sea in the base of the escarpment at the north extremity of the Isle of Portland, and along its west shore also immediately south of the village of Chesilton. Hence it is clear that the Kimmeridge clay forms the fundamental stratum of the whole island, separated, as we have shown, from the Portland stone by the Portland sand and sandstone last described. The rapid dip of all these strata towards the south, causes the Kimmeridge formations to sink below the level of the sea in the southern portion of the island; whilst that part of its western coast, whose base is composed of these perishable sands and clays, is defended from the tremendous south-western waves by a natural breakwater of enormous masses of Portland stone that have fallen from the summit, and form a barrier against any further encroachments*.

At a point near Portland Ferry, extending over many yards of the shore, Dr. Buckland remembers to have seen, several years ago, a portion of Kim-

* See Plate III. fig. 3.

meridge clay, which is now covered up with sand, and which at that time presented the appearance of slate burnt to the condition of red tiles; we have now strong reason to presume that such combustion may have taken place, since we have at this moment before our eyes the pseudovolcanic phenomena that are exhibiting themselves in the same stratum of Kimmeridge clay near the east extremity of Ringstead Bay, at Holworth Cliff, adjacent to the promontory of White Nore. This pseudovolcanic combustion began in September 1826, and during a period of many months emitted considerable volumes of flame, probably originating in the heat produced by the decomposition of the iron pyrites with which this shale occasionally abounds; in the same manner as in the year 1755, a spontaneous combustion arose and continued during several years in the bituminous shale-beds of the lias in the cliffs at Charmouth;—we have a description of this circumstance in the Chemical Essays of Bishop Watson: it is probable that in each case rain-water acting on iron pyrites has set fire to the bituminous shale; thus ignited, it has gone on burning at Holworth unto the present hour, and may still continue smouldering for a long series of years, the bitumen being here so abundant in some strata of the shale, that it is burnt as fuel in the adjoining cottages; the same bituminous shale is used as fuel in the village of Kimmeridge, and is there called Kimmeridge coal.

This pseudovolcano at Holworth commenced in the face of the cliffs about twenty feet above the sea; its combustion was proceeding feebly when we saw it in September 1829, and it emitted no flame; there was no appearance of any crater, nor has there ever been any kind of explosion. The extent of the surface of clay which has been burnt does not exceed fifty feet square. Within this space are many small fumaroles that exhale bituminous and sulphureous vapours, and some of which are lined with a thin sublimation of sulphur; much of the shale near the central parts has undergone a perfect fusion, and is converted to a cellular slag. In the parts adjacent to this ignited portion of the cliff, where the effect of fire has been less intense, the shale is simply baked and reduced to the condition of red tiles, like that on the shore near Portland Ferry. Should a similar ignition ever take place in the cliffs at Kimmeridge, which are so much more abundantly impregnated with bitumen, the fire may be propagated there for centuries, until the whole of the bitumen is consumed.

Coralline or Oxford Oolite, and Calcareous Grit.

The general thickness of this formation near Weymouth is about 150 feet. It contains beds of oolitic limestone resembling the oolite of Heddington, Calne, and Scarborough, and in the sandy beds of its lower region, the same huge semi-calcareous concretions that occur in the calcareous grit of Wilts and Oxon. The corals which abound in this formation, in the two last-named counties, and which there give it the name of Coral Rag, are rare on the coast of Dorsetshire, just as reefs of modern corals occur at unconnected intervals in our modern tropical seas. In the Annals of Philosophy * Prof. Sedgwick has published a list of the beds composing the cliffs between Portland Ferry and Weymouth Harbour, and of the principal organic remains which they contain: he divides the whole series into nine groups, which, in the following section, we have subdivided further into thirty-one beds, included between the Kimmeridge clay at the top, and the Oxford clay at the bottom, of the whole series.

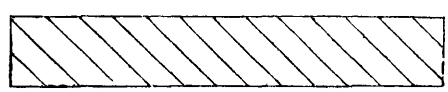
Section between Portland Ferry and Weymouth.—(Order descending.)

1. Considerable thickness of Kimmeridge clay, containing an abundance of the *Ostrea deltoidea*. At about fifteen feet above No. 2, clay iron-stone two feet thick—partly in nodules.
2. Brownish red bed, about six feet—limestone with small vesicles at top, gritty at bottom—cylindrical and round concretions of iron—contains deltoid oysters, Serpulæ, Pectines, Belemnites, and lignite.
3. Grey grit, full of concretions resembling the stalks of Alcyonia, and crossing one another horizontally like a mass of entangled and inosculating roots; the exposed surface is ferruginous.
4. Grey marl-clay.
5. Ferruginous bed, with eagle-stones: at first about one foot thick, afterwards swells out considerably under Sandsfoot Castle. *Lima rudis?* abundant.
6. Sandy grey and green marl—contains a continuous bed of deltoid oysters—also lignite.
7. Grit bed,—brown grey, Alcyonium-shaped concretions—Trigoniæ abundant—one foot. Clay parting.
8. Grit bed,—Trigoniæ abundant; clay parting.
9. Grit bed,—Trigoniæ and *Melania Heddingtoniensis* abundant.
10. Grit bed,—Trigoniæ abundant: the Trigoniæ fill more than half of the beds Nos. 7, 8, 9, & 10.
11. Grey marl.
12. More compact grit—few shells.
13. Same as No. 10.
14. Grit.
15. Grit, with Melaniæ.
16. Grey marl, about four feet.
17. Sandy bed.
18. Limestone full of broken shells.
19. Grit.
20. Dark grey sandy clay, four or five feet.
21. Light brown oolite,—jointed Ammonite—joints filled by hornstone. *Amm. vertebralis?*
22. Grey marl, five feet.
23. Oolite, three feet—marl parting.
24. Oolite, one foot.
25. Gritty marlstone.
26. Grey marlstone and marl, tending to concretions, twenty-five feet.
27. Fox-coloured sands, twelve feet.
28. Grey marl, twenty feet.
29. Alternations of calcareous grit and marls, eighteen feet;—Pectines, oysters, Nautili, Trigoniæ, Serpulæ.

* Annals of Philosophy, May 1826, p. 346.

30. Oolitic grit,—Trochus, Pecten—three beds alternating with marl.
31. Brown, reddish grit—oysters abundant,—Pectines, Ammonites, *Gryphæa dilatata*, *G. bullata*? Trigoniæ.
32. Yellow brown sandy grit, forty feet,—*Gryphæa dilatata*, oysters, sharp-keeled Ammonite, other Ammonites, Pectines, Nautili: the hard beds contain concretions resembling a mass of entangled stems of Alcyonia. Prof. Sedgwick has shown the resemblance of these beds to those of the same formation near Filey Bridge and Scarborough Castle, where the sandstone is similarly aggregated into irregularly branching cylindrical concretions.
33. Oxford clay, abounding in *Gryphæa dilatata*.

It appears from this section, that the Oxford oolite formation is composed of alternations of imperfectly oolitic limestone and calcareous grit, with numerous partings of clay. The superior beds are loose and sandy, and may be considered analogous to the upper calcareous grit in Yorkshire, described by Mr. Phillips; they are best seen near Sandsfoot Castle, where the uppermost of them contain deltoid oysters, and become gradually more argillaceous until they pass into Kimmeridge clay: the central beds are the most oolitic, sometimes loose and sandy, and at other times compact and in continuous beds: they are most oolitic at the village of Wyke Regis and in the cliffs near Osmington, at both which places they afford a light-coloured building-stone, which, but for the vicinity of Portland, might have been applied to purposes of architecture. In the cliffs west of Wyke Regis, they show the same oblique cleavage which is so common in oolitic strata. Thus M. Boblaye, in his paper on the Jura Formation in the North of France*, notices that in the great oolitic quarries of Ballon near Stenay, lines of false division cross the true stratification at angles of 45° or 50°. Examples of the same kind are seen in the Oxford oolite quarries at Heddington, and in the forest marble and great oolite along the road from Cirencester to Bath; similar partings occur also in the new red sandstone at Bridgenorth, but in a manner much more complicated, and crossing the true strata in all possible directions.



Beneath these central oolitic beds, strata of semi-calcareous sand and calcareous grit prevail, and display alternations of sand and sandy loam, with continuous beds of calcareous grit and beds of large concretions lodged in strata of sand. The entire thickness of these calcareous grit beds with their largest concretions, is best exhibited in Ham Cliff, about three miles north-east of Weymouth†. In the hill immediately on the west of Weymouth, the

* *Ann. des Scien. Nat.*, Mai 1829.

† See Plate II. fig. 8.

sandy loam beds of this formation afford an useful brick earth. The passage of the lowest strata into Oxford clay is indicated by the presence of the *Gryphæa dilatata* in the beds of grit, and this passage is analogous to that which occurs at Heddington Hill near Oxford; but the presence of an upper calcareous grit and gradual passage of the superior strata at Weymouth into Kimmeridge clay, show a more perfect development of this part of the oolite formation in Dorset than in Oxfordshire. In the sections at Heddington the upper grit is wanting, and the Kimmeridge clay reposes immediately on the oolitic building-stone: the surface of this stone is also guttered over and furrowed with water-worn cavities and small rock-basins, marking a destructive action of the sea before the deposition of the Kimmeridge clay: this water-worn surface of the oolite is also decomposed and become rusty to the depth of about a foot, in a manner unusual where the series of depositions has been regularly continuous, and its decomposition seems to have resulted from long exposure to water before the laying on of the Kimmeridge clay. These circumstances are duly noticed by Conybeare and Phillips*.

All the beds of the Oxford oolite formation near Weymouth are loaded with shells similar to those found in the same formation in Wiltshire, Oxford-

* Outlines of the Geology of England and Wales, p. 189, note.

Prof. Sedgwick, in his comparison of the appearance of the coral rag formation near Scarborough and Weymouth with that of Oxford (Ann. of Phil., May 1826), conjectures that the upper portions of the Scarborough and Weymouth sections may be wanting near Oxford, and that the coral rag and freestone of Heddington together, represent the central group of the Weymouth and Steeple Ashton sections: thus, at its two extremities in the coast of Dorset and Yorkshire, the superior members of this formation are most fully developed, whilst they are wanting, and have been apparently removed from the central part of their range near Oxford. We entirely agree with Prof. Sedgwick in these remarks, and in the consequences which he draws as to the imperfection of the type of this formation near Oxford: the whole of this subject has been fully illustrated by Mr. Phillips in his excellent work on the Coast of Yorkshire, and still more recently by Mr. Lonsdale in his valuable paper on the Oolite District near Bath (Geol. Trans. vol. iii. Part II. p. 262), in which he gives a section of the Oxford oolite formation at Highworth, where the upper members are represented by about seven feet of alternating beds of sand and rubbly oolite, or oolitic calcareous grit: he also shows that near Steeple Ashton the superior beds appear under the form of ten feet of sand, resting on ten feet of ferruginous clay interspersed with oolitic grains of hydrate of iron. Some bones of a Plesiosaurus have been found in this clay by Mr. Mead.

According to M. de Caumont, a similar alternation of strata of sand and calcareous sandstone, with beds of clay and of imperfect oolitic limestone, affords, on the coast of Normandy, a group corresponding with the upper calcareous grits of Weymouth and the coast of Yorkshire, interposed between the Kimmeridge clay and the coral rag. (See M. de Caumont's Sectional Lists of the Cliff at Hennequeville; of the Hill of Glos near Lisieux; and of St. Julien-sur-Calone near Pont l'Evêque. pp. 113, 114, 115.)

shire, and Yorkshire. The *Trigonia clavellata* and *Melania Heddingtoniensis* are among the most abundant.

Another feature which is wanting in Oxfordshire, is the highly ferruginous character which this oolitic formation assumes near Weymouth, particularly in its upper beds immediately below the Kimmeridge clay; the same ferruginous character prevails also in other parts of its course through this district, and very remarkably in the hills near Abbotsbury. In a ravine called the Red Lane, immediately north of that village, the oolitic grains are composed of a rich hydrate of iron, which, if the country afforded fuel, might be wrought as an ore of the same quality with that which supplies so many iron-foundries in France, from a similar granular ore in the oolite formation.

The extent of surface occupied by the Oxford oolite and its subordinate grits in the valley of Weymouth, will best be seen on the Map; it forms two parallel belts of unequal breadth and length, subjacent to the two beds of Kimmeridge clay before described, and reposing on two other parallel belts of Oxford clay; these oolitic belts terminate in two ridges, overhanging the Oxford clay, with two escarpments that face towards each other; the most southerly of them extends nearly two miles west, from the town of Weymouth to the Fleet at Linch, and is about one mile broad; the northern ridge and its escarpment occupies a length of twelve miles, from the cliffs of Osmington to the sea at Abbotsbury, terminating in an escarpment towards the south, which presents its highest inland elevation in Linton Hill near Abbotsbury. In no part of its course does it much exceed half a mile in breadth, excepting at its western termination near Abbotsbury, where it widens to about a mile, from the effect of the great fault hereafter to be described; here also it changes its dip from north, first to east, and then to south, bending round and enlarging itself like the bowl of a spoon, whose handle is represented by the long ridge of Linton Hill, just mentioned. The towers of St. Catherine's Chapel at Abbotsbury, and of Wyke Regis Church, are two remarkable landmarks, placed respectively near the western termination of the northern and southern belts of oolite just described, and serve as points by which their course may be recognised from the Dorchester road and hills adjacent to it near Weymouth. In the Vale of Bredy, the oolite occurs only in a very narrow band, extending about a mile from east to west, from Kingston House to the village of Litton Cheney; it is seen only in a few old quarries near these two places, and in a hollow way at Litton Cheney, where it appears much disturbed by a fault, and brought, as at Abbotsbury, almost into close contact with the base of the escarpment of the chalk.

Oxford Clay.

The Oxford clay in this district attains a thickness of about 300 feet, and reposes immediately, and with conformable dip, on the central arch of cornbrash and forest marble; on the south side of this arch it forms a belt of low ground about a mile broad, extending from Melcombe Regis and Weymouth Bay to East Fleet. It winds round the eastern extremity of the forest marble at the Barracks, and the marsh of Lodmoor, and thence extends westward along the north side of the central arch, forming a valley of less than half a mile in width, to the Decoy and Swanery at Abbotsbury, where it terminates in the Chesil Bank. Its eastern termination is seen in the lowest strata at the base of Jordon Hill and Ham Cliff, about three miles north-east of Weymouth*.

A distinct section of this stratum occurs in a low cliff under the Barracks at Radipole, where it dips south at about 20°, and where, till lately, it presented, at low water, a pavement of large and beautiful Septaria, known provincially by the name of Turtle Stones. The veins of these Septaria are filled with yellow semi-transparent calcareous spar, often passing into a rich deep brown colour: their beauty, when polished, has, within these few years, caused the greater part of them to be taken up and manufactured into slabs and tables.

In this same section at Radipole Barracks large Ammonites and other shells abound. The most characteristic shell is the *Gryphæa dilatata,* which is as universally abundant in the Oxford clay throughout this district, as the deltoid oyster is in the Kimmeridge clay. In consequence of the want of sections, we have not attempted to trace the minute details of this clay in its windings through the Vale of Bredy, in which it forms a marginal band round the eastern and northern frontier of the forest marble. On the opposite coast of Normandy this same Oxford clay occurs at Vaches Noires, and abounds with the *Gryphæa dilatata,* and many other fossil shells.

Forest Marble.

The formations, which, for convenience of description we have united under the name of Forest marble, and which are the lowest that occur in the Vale of Weymouth, admit of a three-fold division ;—1. Cornbrash; 2. Forest marble ; 3. Clay, and marlstone.

1. The uppermost region, or cornbrash, is composed of a loose rubbly limestone, alternating with thin beds of clay and marl, and is so absolutely

* See Plate II. fig. 8.

identical, both in its mineral characters and abundant organic remains, with the cornbrash of Wiltshire, that no further description need be given of it than may be found in Conybeare and Phillips's account of Cornbrash*.

2. The middle region, consisting of the usual well-known varieties of forest marble, sometimes constituting thick beds of stone composed of comminuted shells, at other times passing into oolitic and sandy slate. The most perfect condition of this forest marble is exhibited in the quarries of Bothenhampton, one mile south of Bridport, where it contains that remarkable fossil the Bradford Encrinite, *Apiocrinites rotundus*, together with fragments of Pentacrinite, palates of fish, and fragments of lignite, all imbedded in indurated masses of broken shells; it contains also the same Apiocrinite in the under-cliff between Abbotsbury Castle and the sea, and in the cliffs immediately west of Bridport Harbour.

3. The lower region is composed principally of strata of blue clay and grey marl and marlstone, containing subordinate beds of imperfect stone.

The best section of this grey marl is seen in the cliff at Watton Hill, close on the west of Bridport Harbour, attaining a thickness of about 150 feet; it is here capped by an outlying summit of forest marble, being the extreme south-western termination of this rock on the coast of England†. The base of this marl reposes on the sands of the inferior oolite. This grey marl also forms a cap on the summit of the inferior oolite in Burton Cliff, on the east of Bridport Harbour: it may probably be the equivalent of the Fuller's earth in the vicinity of Bath. The predominating character of these three deposits, which we have grouped together as forest marble, is clay; the amount of their united thickness may be about 400 feet.

The extent of this forest marble formation in the Vale of Weymouth is considerable; it occupies a tract near six miles long, and from two to three miles broad, constituting the lowest strata and central belt of that district. This central belt emerges at Radipole from beneath the Oxford clay, and is less elevated than the parallel belts of Oxford oolite and Portland stone, whose escarpments overhang it on the north and south, rising towards each other as if they once had been continuous, and had been separated by the elevation of the central axis of forest marble, over which, if reunited, they would form a continuous ridge. It is not of sufficient importance to trace separately the extent of the individual beds of cornbrash and forest marble throughout this central belt. The cornbrash occupies the uppermost place along the lines of its junction with the Oxford clay, and occurs also on many summits and minor

* Outlines of the Geology of England, p. 202.

† See Plate II. fig. 13 and 14.

hills within its area. The valleys are usually cut down to the slaty forest marble beds and their associated clays.

On the north, and east, and south, it is entirely surrounded by, and dips beneath, the Oxford clay; on the west it is terminated by the back-water of the Fleet, cutting it in an oblique line for about four miles, from the village of East Fleet to the Swanery of Abbotsbury. It has been already stated, that it constitutes the axis or central arch of the Weymouth district, upon each side of which, as on a saddle, all the more recent formations successively repose.

After a slight depression beneath the surface at Abbotsbury, the forest marble and its clays, or in most cases the clays without the marble, reappear in strength in the Vale of Bredy, occupying an extent of surface about eight miles long and four miles broad; bounded on the east and north by the overhanging escarpments of chalk and greensand; on the south by the sea and Chesil Bank, and on the west by the subjacent strata of inferior oolite near Burton Bradstock and Bridport. Throughout all this Vale of Bredy, the main dip of this strata is towards the north.

Inferior Oolite.

Along the whole coast of Dorset, and indeed the whole south coast of England, there is a total absence of Bath oolite; but the inferior oolite occurs in the vicinity of Bridport, attaining a thickness of about 300 feet, and occupying the cliffs for two miles east, and three miles west, of Bridport Harbour. The summits of the highest hills around the town are composed of the superior strata of this formation, consisting of coarsely oolitic yellow limestone, resembling that of Dundry Hill near Bristol, irregularly interspersed with oolitic grains of hydrate of iron, as at Bayeux in Normandy: the most extensive quarries in these upper strata of the inferior oolite, are at the summit of Chideock Hill, on the west of Bridport; these are wrought in a light brown limestone full of large and small ferruginous grains; a few beds also abound in minute veins and cells lined with hydrate of iron. One stratum on this hill is in great measure composed of fragments of Pentacrinite, others contain a variety of organic remains,—Ammonites, Nautili, Belemnites, several Pectens, a large Lima, Cucullæa, Plagiostoma, Modiola, several species of Terebratula, and fossil wood*.

Beneath this coarse limestone is a series of brown and yellow loam and sands, highly micaceous, and containing, in their upper region, strata of cal-

* The oolite of Chideock Hill contains caverns, but no bones have yet been noticed in them; in the same oolite beds at Burton Cliff, there are inaccessible fissures filled with diluvium.

careo-siliceous sandstone, and in the lower region interrupted strata of large concretions of coarse sandstone; the lowest strata of this formation become gradually more blue and marly, and at length pass insensibly into the upper marl beds of the lias.

We observed a remarkable fact in some stony masses from the middle region of the inferior oolite at Down Cliff on the west of Bridport, namely, that some of these masses contained an oolitic breccia or conglomerate of rolled fragments of coarse oolite, not differing in character from the strata of which they form a part. The fragments in this breccia are not concretions, but afford unequivocal evidence of having been rolled by water, in the fact that many of them are perforated on all sides by the holes of small Lithodomi, of which holes the lower extremities alone remain, their tops having been worn away by the attrition which has reduced the fragments in which they occur to the state of large subangular pebbles; these fragments must have lain loose in the sea at the time when the Lithodomi perforated their surface, for one side only could have been perforated before they were detached from their native rock; and the perforation of the lower side at least, if not of the other sides, must have taken place in a period intermediate between such separation and the completion of that moderate degree of rounding which they have since undergone. We see at this time on the ledges of the shore at Lyme, between high and low water mark, loose angular slabs of lias recently torn from the subjacent strata, and perforated on all sides by boring Molluscæ, after the manner of the fragments in our oolitic breccia. This perforated breccia at Down Cliff shows a lapse of time to have intervened, in which there was apparently a suspension of the deposition of the inferior oolite; a time in which fragments were torn by the waters from the earlier beds and became inhabited by Lithodomi, and subsequently rolled on the shores, or at the bottom of the then existing seas; they further show that the lower strata of the inferior oolite were at once consolidated to the condition of stone, hard enough to protect Lithodomi and to be rolled to pebbles, before the upper strata of this same inferior oolite formation had been laid over them.

Lias.

The western extremity of our Map includes the upper marl beds only of the lias formation; these are exposed at the bottom of the valleys of denudation round Golden Cap Hill, and on the sea-shore along its base: they are characterized by enormous deposits of Belemnites, and correspond with the *Calcaire à Belemnite* of the French geologists, as the lower and more stony beds of lias at Lyme agree with the French *Calcaire à Gryphite*. One bed at the base of Golden Cap presents an almost continuous pavement of Belemnites, running for some distance along the shore; these marl beds also contain the remains of Saurians. A detailed description of this lias formation at Lyme having been published by Mr. De la Beche*, we deem it sufficient to refer our readers to that paper.

VALE OF BREDY.

We have already pointed out details of the leading formations of the Vale of Bredy in our description of the westward terminations of the strata that occur in the Vale of Weymouth; we here sum them up in a few words. The structure of the Vale of Bredy is much less complicated than that of the Vale of Weymouth; its strata do not, as there, dip in opposite directions from an anticlinal line, but emerge regularly from beneath the chalk and greensand escarpments of its eastern and northern frontiers, rising to the west and south, until at their western termination they rest on the inferior oolite of Burton Cliff and the hills near Bridport.

Around the eastern and northern frontiers, the greensand constitutes a sub-escarpment to the chalk, and also forms the outlying summits of Abbotsbury Castle, Swyre Knoll, Shipton Beacon, and Hammerdon Hill already mentioned: its southern frontier next the sea, is composed of forest marble and thick beds of clay connected with it; its middle region also (constituting the bed of the river Bredy,) is made up of these same clays, interspersed occasionally with thin stony beds of forest marble. The entire face of this Vale of Bredy is so destitute of roads and sections, and so covered up with grass from the bottom of the valley to the escarpment of the hills, that it is extremely difficult to trace the separation between these extensive clay beds of the forest marble formation, and those which may be made up of the continuations of Kimmeridge and Oxford clays, interposed between the forest marble and the greensand.

EFFECTS OF DISTURBING FORCES.

Having thus far considered the character and extent of each formation which occurs on the coast of Dorset, it remains only to examine the effects that have been produced on them by disturbing forces: these may be divided into five heads; namely,—1. Elevation;—2. Depression;—3. Contortion;—4. Faults;—5. Denudation.

I. ELEVATION.

The most important feature which pervades the whole Vale of Weymouth

* Geol. Trans. Second Series, vol. ii. Part I. p. 21. Plate III.

is, the arch-like disposition of all the formations it contains ; the axis of this arch passes east and west from Weymouth Bay to the Chesil Bank, forming an anticlinal line, on each side of which all the successive strata dip respectively to the north and south. This dip of the strata in opposite directions from the anticlinal line, is represented in the general section, Plate II. fig. 1. It affords, on a larger scale, an example of the same kind of valleys of elevation with those which have been described by Professor Buckland*. The details of these arched strata in the Vale of Weymouth have already been sufficiently set forth. We think there is evidence enough to show that the strata were once nearly continuous and horizontal, and have been elevated to their present position by a force acting from beneath in a line nearly east and west, forming a continuation of the same line of elevation that extends through Purbeck and the Isle of Wight, and parallel to that of the axis of elevation of the Weald of Sussex and Kent. The period of elevation in all these cases was apparently the same, viz. subsequent to the deposition of the London clay, if not of the most recent tertiary strata in the Isle of Wight.

With respect to the analogous axis of elevation, which extends with certain interruptions from the eastern extremity of the Mendip Hills along the coast of South Wales to Milford Haven, it has been shown by Dr. Buckland and Mr. Conybeare that this elevation took place before the deposition of the new red sandstone formation †; the direction of this line deviates from east and west several points towards the north-west.

In these comparatively small instances, as in the elevation of the highest mountains in the world, noticed by M. Elie de Beaumont‡, it seems that the operating forces have been exerted usually in straight lines, and that these straight lines were often parallel to one another; and the fact that the greatest mountain chains are for the most part thus disposed, more especially those which are volcanic, as in the case of the Andes, leads us to refer the elevation of them all to one and the same common cause,—namely, the expansion of elastic vapours bursting upwards in longitudinal cracks along the lines where the least resistance was presented by the incumbent strata§. The comparative insignificance of the elevations we are considering in the South of England, makes no difference in the principles we would apply to explain their origin ; they appear to us to be faithful models, representing on a smaller

* Geol. Trans. Second Series, vol. ii. Part I. p. 119.

† Ibid. vol. i. p. 210, et seq.

‡ *Annales des Sciences Naturelles*, 1829—1830.

§ The movement of modern earthquakes along straight lines, added to the frequent rectilinear position of volcanic chains, adds still further probability to these conjectures.—See Hall's South America.

scale, the self-same phenomena, which, in more gigantic magnitude, pervade the highest Alps.

In the eastern part of our Weymouth district, we have examples of valleys of elevation, on a small scale, in the three little circus-shaped valleys of Moignes Down, Poxwell, and Sutton Pointz*. All these three valleys are of an elongated oval shape, and so nearly resemble the interior of a Roman circus, that if the basset ends of the strata were cut into benches, the central area would be visible to persons seated on every part of them.

These three small valleys of elevation are on the same straight line, running east and west, parallel to the grand axis of the Weymouth district, and also parallel to two great faults adjacent to them, and immediately to be described†. The western extremity of the first valley touches the eastern extremity of the second, and the second is separated from the third, only for a small space, by a ridge of Portland stone: each of these valleys has only one small lateral outlet for the discharge of its waters; the area of the Moignes Down Circus scarcely descends below the Portland stone: those of the Poxwell Circus and Sutton Pointz Circus descend into the Portland sand and Kimmeridge clay.

In the circus of Moignes Down and of Poxwell, the circumference is chiefly composed of the basset edges of strata of Portland stone dipping outwards in every direction; but the circus of Sutton Pointz, which is much longer and wider than the other two, is surrounded by Portland stone on three sides only, the remaining north side being partially occupied by greensand and chalk, in consequence of its being intersected by the great Ridgeway fault‡. Although the elevation of these circus-shaped valleys must have produced vast piles of fractured strata on the line of elevation, there is no accumulation of such fragments, nor any perceptible quantity of gravel of any kind within their area; the clearing out of all the rubbish which must have encumbered them at the time of their elevation, can only be referred to the contemporaneous or subsequent operations of very powerful denudation.

II. DEPRESSION.

Elevations of strata, such as we have been tracing, can scarcely have arisen without simultaneous depressions in the spaces intermediate between

* See Plate II. fig. 2, 3, 4. † See Map, Plate I.

‡ The circus-like inclosure of the Valley of Sutton Pointz is best seen from its eastern extremity at the top of Osmington Hill, at a point on the old road near the western extremity of the Poxwell Circus; the new turnpike road from Poxwell to Osmington, enters the Poxwell Circus by the outlet on its north side, and crossing its shorter diameter, cuts through the Portland stone on its south side, and there enters upon the Purbeck beds, reposing on the back of the Portland stone, and dipping towards Upton. See Plate II. fig. 3.

the lines of elevation; and accordingly our district affords examples of troughs and depressions thus produced in the case of the Purbeck beds lying upon a trough of Portland stone at Upway, and of Kimmeridge clay in a trough of Oxford oolite at Abbotsbury*.

III. Contortion.

At Upway in the quarries west of the Church, we have examples of contortion produced by the elevation of the strata, similar to those represented by Mr. Webster in his drawings of Lulworth Cove and the coves adjacent to it, in the Isle of Purbeck. Throughout the whole Weymouth district, and particularly along the lines of fault, which we shall next describe, contortions of greater or less amount are too numerous to require individual specification.

IV. Faults.

In a district which has been so much dislocated, the elevations and depressions just described lead us to expect still further disturbances in the occurrence of faults; and accordingly we find two very extensive faults on the northern and north-eastern frontier of the Vale of Weymouth, and also two others on the north-west of the Vale of Bredy and near Bridport, besides many minor local fractures.

The two great faults in the Vale of Weymouth, run nearly in a straight line from east to west, parallel to the general axis of elevation of the whole district, and were probably produced by the same forces and at the same time with this general elevation.

We shall call the most northerly of them the great Ridgeway Fault, the other the Osmington Fault. Wherever we examine these faults, we find double evidence of the movement that has taken place; 1st, In the non-accordance of the strata that form the opposite sides of the faults; 2ndly, In the fine parallel lines and vertical furrows resembling the lines and grooves on Slikensides, and often also in the highly polished surfaces of the materials that form the side walls of the fault, showing that these ponderous masses have ground each other with prodigious violence in the act of separation and movement from their original position. The great Ridgeway fault is an upcast fault, elevating, on its south side, into contact with the escarpment of the chalk, strata that would otherwise have dipped beneath it, particularly the Portland stone, nearly along the whole line which this fault traverses. The Osmington fault is a downcast fault, throwing down, on its south side, strata

* See Plate II. fig. 1, 6.

of chalk, greensand, and Portland stone, to a position lower than the strata from whose extremities they have been snapped off*.

1. *Great Ridgeway Fault.*

The most important of these, the great Ridgeway fault, extends, without interruption, nearly fifteen miles, from the eastern extremity of our district at Moignes Down, to the sea near Abbotsbury, passing along the great escarpment of the chalk at various elevations, from the top to the bottom of it; the Osmington fault we could trace only about three miles, from South Holworth near White Nore, to Ham Cliff on the north-east of Weymouth.

The first or great Ridgeway fault is one of the most curious and important we have ever seen, in consequence of the variety of instructive sections afforded along its course; these sections we shall describe in the order of their occurrence, beginning at the eastern extremity †. The fault emerges from the chalk formation at Moignes Down Farm, on the north side of the circus of Moignes Down, and brings the truncated lower ends of strata of Portland stone into contact with the truncated upper ends of strata of chalk, both dipping to the north ‡. Here a valley of denudation runs exactly along the line of fault, having its north side composed of chalk, and its south side entirely of Portland stone. The strata have been raised on both sides of this fault, but raised unequally; whence it results, that on the north side the chalk rises towards the fault, whilst on the south side the Portland stone dips towards it, as if plunging beneath the chalk; whereas the Portland stone has been elevated from its original position, relatively, though not absolutely, much higher than the chalk: yet, notwithstanding this fracture of the strata and dissimilarity of substances on the two sides of the valley, the effect of denudation has been so equable, and the removal of the fractured materials so total, that no other features are presented by the surface than those of an ordinary valley of denudation on horizontal chalk.

Our next section § is taken at Poxwell Hill, less than one mile west of Moignes Down Farm. Here the circumstances of the fault on the north of Poxwell Circus are similar to those at Moignes Down Farm, excepting that at Poxwell there has been no denudation on the line of fault. Two miles west of Poxwell in the valley of Sutton Pointz ||, the exact line of the fault is scarcely to be recognised, from the circumstance of the strata on both sides of it being perpendicular. At fig. 5. in Sutton Valley, one mile west of

* See Plate II. fig. 2, 3.
† See Plate II. fig. 1, 2, 3, 4, 5, 6, 7, 12.
‡ See Plate II. fig. 2.
§ Plate II. fig. 3.
|| Plate II. fig. 4.

fig. 4, the Portland stone forms the south side of the fault; and greensand, surmounted by chalk, the north side,—both dipping rapidly to the north.

The theoretical figure (Plate II. No. 12.) is intended to represent by the dotted lines *aa. bb. cc.*, effects that would be produced by denudation extended to different depths along the line of a fault, traversing such strata as occur along this part of the Ridgeway; thus a denudation descending to *aa.* would leave chalk and greensand on the north side of the valley so denuded, and Portland stone on the south; a denudation to *bb.* would give the same section on the north side of the valley, and Portland sand on the south; and in this case it would be difficult to distinguish between these two sands, without the aid of organic remains. A denudation to *cc.* would give again the same beds on the north side, and Kimmeridge clay on the south: examples of all these three theoretical representations are visible in the course of the Ridgeway fault; e. g. On the high crest which separates the valley of Bincombe from that of Sutton Pointz, the Portland stone touches the chalk; the surfaces of both rocks at the line of fault presenting a uniform appearance, and uniformly level line, like the surface of fig. 12. Plate II. Near the north-western extremity of Sutton Valley, a denudation, analogous to that represented by *aa.* fig. 12. Plate II., shows the Portland stone touching greensand; a lower point of the same denudation exhibits the Portland sand in contact with the greensand, as represented at *bb.* in the same figure; and on the north of Sutton village the Kimmeridge clay also is brought into contact with the greensand, as represented at *cc.*

At Upway, on the northern extremity of the general section, and near the summit of the hill*, the Portland stone, covered by Purbeck beds, occupies the south side of the fault, and nearly horizontal chalk its north side, the Purbeck and Portland beds rising at a high angle northwards towards the fault. From Upway, for four miles westward, to the final termination of the Portland stone at Portisham, the Portland stone is continued on the south side, and the chalk on the north side of this fault; it is exposed by no section, but the junction can be traced on the surface of the fields.

Near the village of Portisham, precisely at the western termination of the Portland stone, the fault deviates to a south-western direction for about a quarter of a mile, traversing the bottom of a deep and narrow dry valley or comb, by which the road from Portisham leads up to Black Down; the east side of this valley is composed of Portland stone, and the west side of chalk, both attaining a considerable elevation above the bottom of the valley. In the village of

* Plate II. fig. 1.

Portisham, the fault again resumes its westerly direction, and at the same time brings up the Kimmeridge clay into immediate contact with the base of the escarpment of the chalk; this contact continues for some distance towards Abbotsbury. At Abbotsbury*, the Oxford oolite occupies the south side of the fault; and greensand, resting upon clay, the north side; the two latter are nearly horizontal, whilst the oolite rises to the north.

The irregularities of structure occasioned by this fault on the west of Abbotsbury are considerable, and not totally made out by us. A compound disturbance, similar to that which has produced the trough-shaped disposition of the Purbeck and Portland stone at Upway, has caused an analogous derangement near Abbotsbury, along a tract of about a mile in length, from east to west, and nearly a mile in breadth†. This tract occupies the slope and under-terrace, between the summit of Abbotsbury Common and the sea, and is composed chiefly of ferruginous Oxford oolite, dipping regularly towards the north, on that side of Abbotsbury which is nearest to the sea, until it terminates abruptly in a hill called Zoles (immediately above the mansion of the Countess of Ilchester). In this hill it suddenly trends round, changing its dip towards the east, and rising with an escarpment to the west, for a short distance, until the dip again turns suddenly to the south, and so continues along the line of fault, running east and west more than a mile from Zoles to the town of Abbotsbury. By these three dips, the oolite is thrown, at its termination, into the form of a spoon, rising outwards in three directions from the lowest central line of depression, and terminated by high escarpments on the south and west, and on the north partly by a false escarpment‡, and partly by abutting against the fault§.

The existence of this false escarpment (fig. 7.) is due to the agency of the upcast fault, which has elevated, not only these Oxford oolite beds, but even the subjacent beds of Oxford clay and forest marble irregularly along the under-terrace, between the false escarpment of oolite, and the true south escarpment of the lofty ridge of greensand and chalk composing Abbotsbury Common; so that beneath and parallel to this true escarpment, at a distance varying from one to two furlongs, the false escarpment forms a broken under-terrace|| facing the true escarpment, with opposite dip; and between these two escarpments a narrow band of forest marble is thrown up in great confusion for about a mile, from the town of Abbotsbury west to Zoles. The confusion is increased by land slips, which have brought down heaps of rubbish from the greensand escarpment of Abbotsbury Common and Abbots-

* Plate II. fig. 6.
† See Plate II. fig. 6 & 7.
‡ Plate II. fig. 7.
§ Plate II. fig. 6.
|| See Plate II. fig. 7.

bury Castle Hill, and spread them over the various broken beds of the oolite formation, along the under-terrace and line of fault; and have also so completely masked and covered up all the lower beds of the true escarpment below the greensand, that not one of them can be distinctly seen: and although this great escarpment is at least 400 feet above the sea, none of its lower strata are exposed to view, except a bed of clay, which, by casting out a line of springs along its junction with the incumbent greensand, affords a perpetual cause of the land slips which obscure the entire base of this escarpment, and prevent our tracing distinctly the great Ridgeway fault at its western termination into the sea*.

The depth of the dislocations occasioned by this great Ridgeway fault along the escarpment of the chalk appears to vary to the amount of several hundred feet.

2. *Osmington Fault.*

The range of the Osmington fault is east and west, and parallel to the great Ridgeway fault we have just described, at the distance of about one mile and a half to the south: its eastern extremity is lost in the chalk downs near South Holworth, and its western termination is seen in Ham Cliff, three miles north-east of Weymouth. Plate II. fig. 2. exhibits its most eastern section at Upton Hill, in which horizontal chalk beds form the north side of the fault, and subsided chalk, greensand, and Portland stone, the south side: a lime-kiln excavated exactly on the line of fracture, exhibits the disposition here represented. In a section of the hill and water-course, one mile further west, at Osmington Mill†, the south side of this fault is formed of subsided chalk and greensand, dipping north; and the north side formed of chalk, resting on greensand, both inclined slightly to the south. Plate II. fig. 8. shows the western extremity of this fault at Ham Cliff, where the Oxford oolite on its south side has subsided to the level of the Oxford clay on its north side.

3. *Ringstead Bay Fault.*

Plate II. fig. 11. represents a third and very local small fault, produced apparently by a fracture in the cliffs, and bringing a subsided mass of Portland stone and Portland sand into contact with Kimmeridge clay. This fault is more oblique than any part of the two great faults we have been describing; like them it ranges east and west, but can be traced only to a

* On the north side of Abbotsbury Common, immediately below the Castle, a series of land slips, similar to those on the south side, is indicated by a long range of narrow ponds, supported by the bed of clay, across which the land slips have taken place.

† Plate II. fig. 3.

very short distance: the pseudovolcano we have described is in the Kimmeridge clay which forms the base of this subsided mass.

Another minor fault is seen at Boat Cove, on the west of Osmington Mill*, where an apparently false dip of the Oxford oolite has been produced by a recent slip of the cliffs; it is so small and partial that it would be unworthy of notice were it not that it is prominently exposed in the profile of the coast, and gives an erroneous impression of the position of the strata in the cliff from which it has fallen. Near this spot, also, at the cascade of Osmington Mill, we have another small fault, exposed on the shore traversing the Oxford oolite, and running outwards into the sea, just along the anticlinal line, where the strata turn at this part of the coast†.

4. *Bothenhampton Fault.*

Pl. II. fig. 14. represents a downcast fault at Bothenhampton, one mile south-east of Bridport. We believe that this fault was first noticed by Prof. Sedgwick: it is of considerable depth, bringing the forest marble on its south side into contact with inferior oolite on the north side, the forest marble dipping at a considerable angle towards the fault; its general range, like that of the rest, is nearly east and west, and although, from the similarity of the clays which it intersects, we have not traced its uninterrupted connexion, we think it continues eastward to Shipton Gorge, Litton Cheney, and Long Bredy. At each of these three places, lying as they do nearly on a straight line, there has been much dislocation and disturbance.

5. *Bridport Harbour Fault.*

At Pl. II. figures 13 and 14 represent the western termination of another downcast fault in the cliffs about a mile west of Bridport Harbour, being the last we have to mention. Its amount is considerable: on its north side are beds of inferior oolite based on lias; on its south side are beds of forest marble based on more than 150 feet of grey clay, and these are suddenly and violently turned up when they come into immediate contact with the fault. We believe this clay to be the same that occurs in such thickness in the Vale of Bredy; and although we have there considered it as subordinate to the forest marble formation, we have no evidence to show that it may not also represent the Fuller's earth beds that occur between the great oolite and inferior oolite of the neighbourhood of Bath. The eastern extremity of this fault‡ presents a complicated double fracture, causing the lower beds of the

* See Plate II. fig. 9. † See Plate II. fig. 9. ‡ Plate II. fig. 13. *a.*

grey marl and marlstone to assume a position partly vertical and partly tortuous, between horizontal beds of grey marlstone on the one side, and of inferior oolite on the other. These appearances may in part be due to subsidence superadded to the fault; the point of the cliff in which they occur is so much exposed to the action of the waves, that it may ere long be totally removed, and the appearances represented in our section be entirely changed.

It should be observed that not one of all these faults appears to have been produced during the formation of the strata: not one is covered at its summit by any overlying substance except diluvium; and that those in the eastern part of our district were evidently not produced until the time at which the chalk and all the strata subjacent to it, in this district, underwent a simultaneous elevation.

V. Denudation producing Valleys.

In a country that has been the scene of such tremendous convulsions and subterranean disturbances, it was probable that we should find on the surface abundant ruins, and dislocated fragments of the rocks that have been submitted to such violence; we should expect to discover masses of rubbish such as we see in the wreck of modern land slips, and which cannot but have been created in prodigious quantity along the line of the elevations and fractures we have been tracing: but on examination we find that all this wreck has vanished, and been so totally swept away, that scarce a trace of it can be recognised throughout the whole district which it must once have covered.

It is obvious, from a mere glance at the Map, that the strata originally occupied larger areas than they cover at present; and that if no further operations had taken place in the Vale of Weymouth beyond the elevation and fractures we have described, we should have had little more than a series of arches piled successively on one another, and extending over a large portion of the whole district; the angle at which the strata rise being in many parts so small that no very distant separation of the fractured parts could have attended their elevation; and thus the central cornbrash of the Vale of Weymouth would have been arched over with bending strata of Oxford clay, coral rag, Kimmeridge clay, and Portland stone; and the Vale of Bredy and the Bridport district would have been covered by nearly horizontal beds of greensand and chalk, connecting the great greensand escarpment of the north and east of the Vale of Bredy and Abbotsbury Castle with the outlying summits of Swyre Knoll, Shipton Beacon, Eype Down, Golden Cap Hill, Lewsdon Hill, Lambert's Castle, and the entire group of insulated caps and ridges of greensand and chalk near Charmouth, Lyme, and Axminster. But as no such arches exist in the Vale of Weymouth, nor any such continuity of the greensand strata in the vales of Bredy and Bridport, we cannot but infer that some adequate cause has produced the removal of the vast masses of materials which apparently must once have filled the spaces that are now left void; and we see no cause adequate to the production of such an effect, except the denuding power of a mass of moving waters; a power which has removed more than it has left of the entire bulk of nearly all the strata that appear on the surface of this district, excepting the chalk.

Again, if we look for traces of ruin and violence on the surface along the lines of fault, we find no such indications presented to us; but however great may have been the dislocation and subterraneous changes of level, the outlines of the surface are little affected by these changes: thus, our sections Pl. II. fig. 1, 2, 3, 4, 5, and 6, afford examples of the summits and sides of hills where we should be utterly unconscious, from the external form of the land, that the least derangement or fracture has ever affected the subjacent strata; the general outlines are regular and rounded, as if no violent movements had ever occurred below, and all the ruins and piles of rubbish that must have been produced along the lines of elevation and fracture are swept clean, clear, and smooth away.

If we traverse the great Ridgeway fault for fifteen miles, from one extremity to the other, we see along the whole surface scarcely an indication of its existence. Near Upway we have an obvious example of this fact, at the point where the road from Bridport passes down the chalky escarpment of the Ridgeway through one of those broad and sweeping dry combs which are so common in escarpments of chalk: having descended nearly to the bottom of the hill, where we should expect the outcrop of inferior chalk or greensand, we are surprised to find Portland stone rising to the north, and abutting against the chalk; yet we see not the slightest change in the outline of the surface on either side of this line of fault, nor is there upon its south side a single remaining fragment of all the masses of greensand and chalk that must have been elevated into a new and high position on that side of the fault when the fracture took place; all traces of the enormous ruins that attended this great convulsion have utterly vanished and been swept away; so that scarcely the residuum of an outlying fragment remains to attest the catastrophe that has taken place: the sloping sides of the combs glide regularly and gently down, as if they had been excavated in one undisturbed and uniform mass of continuous chalk. Nor is this outclearing and total removal of the broken fragments peculiar to this comb on the north-west of Upway; it is equally apparent in many others along the whole extent of the fault, particularly in the deep combs of Elwell, Bincombe, and Sutton Pointz, that lie successively adjacent to Upway on the east.

The deep and numerous dry valleys on the surface of the chalk hills that bound our district partake of the general character of such valleys on the surface of the chalk formation throughout England; and have no peculiar features beyond those which they have derived from enormous volumes of water, retiring in all directions from the higher to the lower levels, and acting at all elevations and on all points to modify the previous forms of the surface of the earth.

If we look for the cause of all this removal in any natural operations now proceeding within the district, we find not the shadow of any satisfactory explanation of that vast destruction of which it has been the scene. It is vain to appeal to the action of rivers, for in many parts where the denudation has been greatest, there is not even a streamlet, or a single spring. The greatest streams we have in the district are the two insignificant rivulets of the Wey and Bredy*. It is equally vain to appeal to meteoric agents, for we have a measure of the total amount of their effects in the fragments accumulated in the form of talus and land slips at the bottom of certain slopes and precipices, and in a few small accumulations of mud and sand in the low grounds.

The only satisfactory solution we can find is in the waters of a violent inundation, and in these we think we see a cause that bears a due ratio to the effects that have been produced.

* The only river in the Vale of Weymouth is the small stream of the Wey, which, rising suddenly at Upway, from a cross fracture in the Portland beds, runs about five miles from north to south, into the sea at Weymouth, crossing nearly at right angles all the different formations, as well as the hills and valleys that occur along its course, and receiving only a few tributary confluents from the west. The Vale of Bredy is traversed by the small river of that name, running west from the village of Little Bredy to the sea at Burton Bradstock. It is impossible to refer the excavation of these deeply denuded valleys and the removal of the broken strata to the flood waters of such streamlets, or to the agency of their waters accumulated into lakes by any imaginable series of barriers, which the bursting of such lakes may be supposed to have removed. The east and west portions of the elliptical valley of Sutton Pointz offer a good example of denudation, independent of rivers. The only stream within this valley rises on its northern side, upon the line of the great fault at the base of the chalk escarpment, and running direct across the shorter diameter of the valley, escapes through a broad denudation, which intersects the Portland stone that forms the south side of the ellipse. (See Map, and Pl. II. fig. 4. 5.) We have a measure of the small amount of the excavating power of this streamlet cooperating with meteoric agents in a ravine five or six feet deep, and a few yards long, which the water has cut in a talus of chalk rubble, in which it begins its course. A similar ravine of much greater length, and about twenty feet deep, which occurs at the base of the chalk escarpment, on the south of Wantage, is there cut through

How far the causes of this inundation may be connected with the elevation of the strata in the immediate neighbourhood or in distant regions, is a subject which at present we conceive it premature to enter into, further than to suggest that the relation of the one to the other may possibly be nearer than has been hitherto apprehended.

DILUVIUM.

Although the excavation of valleys of denudation, and removal of broken strata has been so considerable in all this district, we have no proportionate accumulation of extensive and continuous beds of gravel. The power and rapidity of the currents which could excavate the materials that filled such enormous spaces must have been too great to allow these materials to subside so near the spots from which they have been torn away, and must have drifted them far forwards into the prolongation of these valleys in the bottom of the English Channel, whence perhaps many of them may have been cast up again, and have contributed to form the Chesil Bank. The largest deposit of diluvium we have noticed is at Upway Street, four miles north of Weymouth; but in smaller quantities and irregular patches it is disposed over the whole surface of the country, on the summits and slopes of the hills as well as in the valleys.

We have not heard of many organic remains in the diluvium of this district, but the following are sufficient to show their identity with those found in diluvial gravel in other parts of England. A few years ago a large rolled molar tooth of an elephant was cast upon the Chesil Bank, from the diluvium

the chalk-marl with such regularity as to present the uniform width and uniform grassy slopes of the deep foss of a military fortification, and affords a similar measure of the amount of the power of existing agents on a substance of such uniform and perishable materials as soft chalk-marl.

The following list of the temperature of springs in the neighbourhood of Weymouth was taken by Professor Henslow, with a good thermometer, in the year 1832:—

20th August. Well at Chesilton, in Portland stone, near the middle of the ascent in the yard of the Portland Arms. A pump was used .... 54° 0′

24th August. Spring at Preston, by the road side, in the Portland sand .... 53° 0′

28th September. Large spring at Upway, the source of the river Wey, rising suddenly in great force from a cross fracture of the Portland rock .... 51° 0′

20th Septemper. Pump at Corfe Castle .... 52° 5′

20th September. Hill side (vertical strata), half way between Corfe and Worbarrow Bay, junction of chalk and sands .... 52° 0′

4th September. Top of Headon Hill, Isle of Wight: spring from the upper freshwater formation, a few feet from the summit .... 50° 0′

5th September. Spring issuing from the sand rock under the fire-stone at Knighton.... 51° 0′

Where the temperature was taken in pump-water, it was not done until all the water that had filled the pipes was removed by long pumping.

beneath the sea, and is preserved at Abbotsbury by the Countess of Ilchester. Near Bridport also, at the villages of Burton Bradstock and Loders, the gravel has afforded the remains of elephants and other terrestrial quadrupeds. In the gravel that crowns the cliffs of lias, near the church of Lyme Regis, many teeth of rhinoceros have been found, and portions of the tusks of elephants; and lastly, the cliff at the south termination of the valley of Charmouth, where, as at Lyme, the lias is covered with a cap of diluvium, has afforded several nearly perfect tusks of elephants which tumble from the summit and get mixed with the debris of lias, when masses of the cliff are undermined, and fall down on the sea shore. A tusk nine feet eight inches long, from the gravel of this cliff, was some years ago in the collection of Mr. De la Beche, and is now in the Museum of the Geological Society*. Two molar teeth of elephant, one weighing twelve the other thirteen pounds, were found in this same cliff, in December 1832.

Conclusion.

We shall conclude with pointing out the following general results that appear deducible from the facts we have been considering. We conceive that we have before us sufficient evidence of the following succession of changes in the state of that small portion of England which occupies the coast of Dorsetshire. They are analogous to those deduced by Mr. Mantell from the phenomena he has described in the weald of Sussex.

1st, We have a succession of marine deposits, continuous from the lias upwards through the oolites, and terminating in the deposition of the Portland stone; during the period of all these formations our district must have been the bottom of an ancient sea: the presence of the remains of trees in the oolite and lias shows that land existed probably at no great distance from this sea; it is also probable that the waters were not very deep, in which Plesiosauri were so abundant as they must have been, to supply such numerous remains as we find imbedded in the lias at Lyme.

2ndly, The bottom of this sea appears for a certain time to have become dry land, and whilst in this state, to have been covered with a forest of large coniferous trees, and of Cycadeoideous plants that indicate a warm climate. We have a measure of the duration of this forest, in the thickness of decayed vegetable matter and soil, which has accumulated more than a foot of black earth around the roots of these trees. The regular and uniform preservation of this thin bed of black earth over a distance of so many miles, shows that

* See Geological Transactions, Second Series, vol. i. p. 421—422.

the change to the next state of things was quiet and gradual; since the trees that lie prostrate on this black earth would have been swept away had there been any violent agitation, or sudden irruption of water.

3rdly, The dry land on which this forest grew became converted to something like an estuary, in which the lowest deposits contain freshwater shells; these are succeeded by a thick bed of oyster shells, and above the oyster bed are strata containing an admixture of freshwater shells with shells that are marine.

We have evidence that this formation extended eastward from what is now the coast of Dorset, through the Isle of Wight to the eastern extremity of the weald of Kent; but of the boundaries of this supposed estuary we have not the slightest indication beyond that which is afforded by the existing deposits of Purbeck and Wealden freshwater formations.

The occurrence of the Purbeck strata reposing on the Portland stone at Lady Down near Tisbury, on the west of Salisbury, in a position directly north of the Isle of Purbeck, at the distance of about thirty miles, renders it probable that the breadth of the estuary in this part extended over the intermediate portions of Dorset and Wilts, which are now covered up with chalk.

4thly, We have a return of the sea over our estuary; and in this sea an accumulation of the successive and thick marine deposits which constitute the greensand and chalk formations.

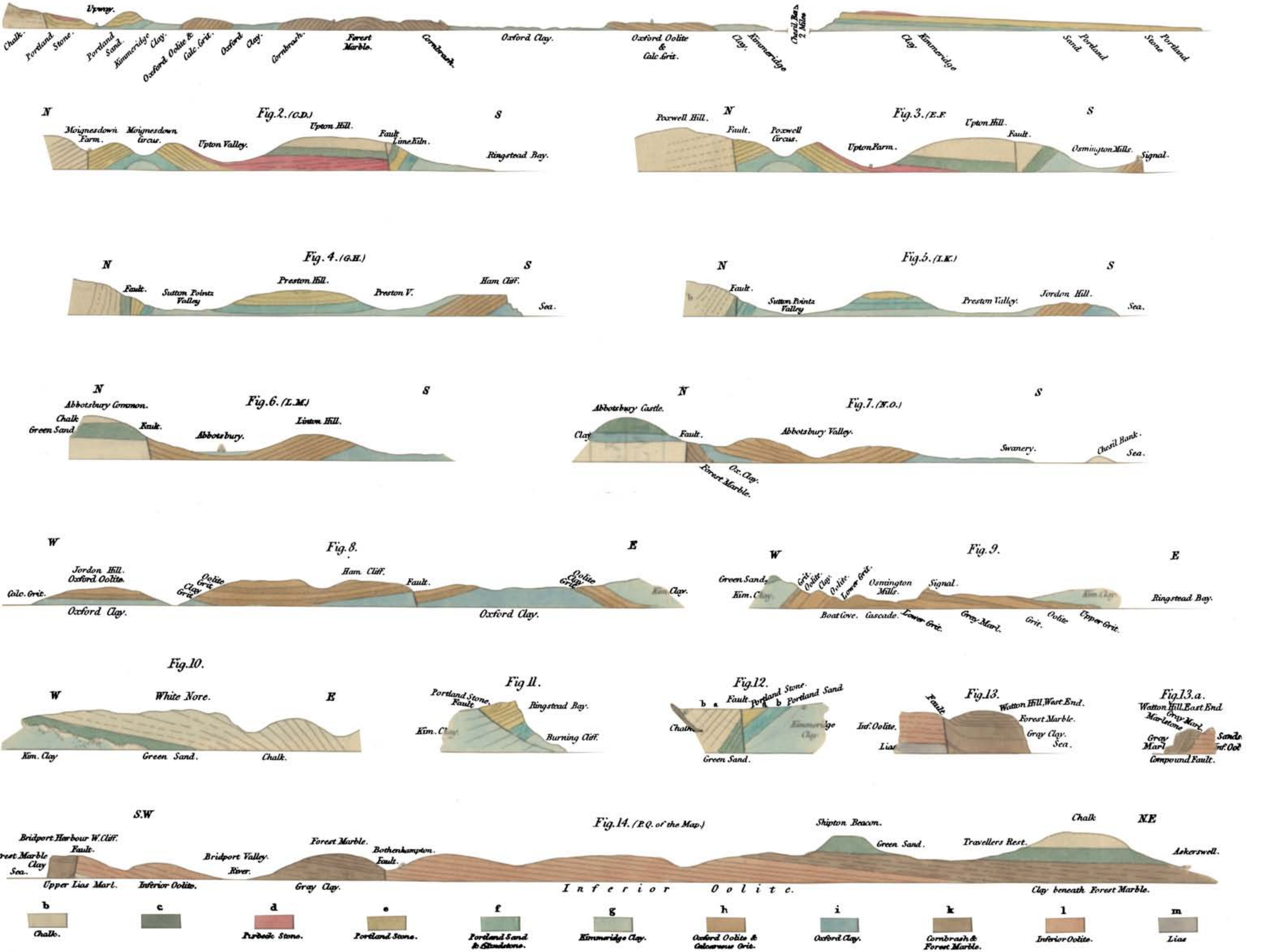
5thly, We have in the Isle of Wight a reappearance of freshwater deposits mixed and alternating with others that are marine, through the next great periods of the tertiary formations.

6thly, All these deposits appear to have been succeeded by a tremendous catastrophe, producing elevations, depressions, and contortions of the strata; and intersecting them with enormous faults.

7thly, These movements of the land have been succeeded by inundations, competent to excavate the valleys of denudation, and partially to overspread the country with diluvial gravel.

8thly, This denudation has been followed by a state of tranquillity, which has remained undisturbed to the present hour.

J. Briggs Lithog



Upway.
Chalk. Portland Stone. Portland Sand. Kimmeridge Clay. Oxford Oolite & Calc. Grit. Oxford Clay. Cornbrash. Forest Marble. Cornbrash. Oxford Clay. Oxford Oolite & Calc. Grit. Clay. Kimmeridge
Chesil Bay 2 Miles
Clay. Kimmeridge Sand. Portland Stone. Portland
Fig. 2. (C.D.)
N S
Moignesdown Farm. Moignesdown Circus. Upton Valley. Upton Hill. Fault. Lime Kiln. Ringstead Bay.
Fig. 3. (E.F.)
Poxwell Hill. N Fault. Poxwell Circus. Upton Farm. Upton Hill. Fault. S Osmington Mills. Signal.
Fig. 4. (G.H.)
N S
Fault. Sutton Pointz Valley. Preston Hill. Preston V. Ham Cliff. Sea.
Fig. 5. (I.K.)
N S
b Fault. Sutton Pointz Valley. Preston Valley. Jordon Hill. Sea.
Fig. 6. (L.M.)
N S
Abbotsbury Common. Chalk Green Sand. Fault. Abbotsbury. Linton Hill.
Fig. 7. (N.O.)
N S
Abbotsbury Castle. Clay. Fault. Abbotsbury Valley. Swanery. Chesil Bank. Sea. Forest Marble. Ox. Clay.
Fig. 8.
W E
Jordon Hill. Oxford Oolite. Calc. Grit. Oolite Grit Clay Grit. Ham Cliff. Fault. Oolite Clay Grit. Kim. Clay. Oxford Clay. Oxford Clay.
Fig. 9.
W E
Green Sand. Kim. Clay. Grit. Oolite. Clay. Oolite. Lower Grit. Osmington Mills. Signal. Kim. Clay. Ringstead Bay. Boat Cove. Cascade. Lower Grit. Gray Marl. Grit. Oolite. Upper Grit.
Fig. 10.
W White Nore. E
Kim. Clay. Green Sand. Chalk.
Fig. 11.
Portland Stone. Fault. Ringstead Bay. Kim. Clay. Burning Cliff.
Fig. 12.
b a Fault. Portland Stone. a b Portland Sand. Chalk. Kimmeridge Clay. Green Sand.
Fig. 13.
Fault. Watton Hill, West End. Forest Marble. Inf. Oolite. Gray Clay. Lias. Sea.
Fig. 13. a.
Watton Hill, East End. Gray Marl. Marlstone. Gray Marl. Sands. Inf. Ool. Compound Fault.
Fig. 14. (P.Q. of the Map.)
S.W N.E
Bridport Harbour W. Cliff. Fault. rest Marble Clay Sea. Bridport Valley. River. Forest Marble. Bothenhampton. Fault. Shipton Beacon. Green Sand. Chalk. Travellers Rest. Askerswell. Upper Lias Marl. Inferior Oolite. Gray Clay. Inferior Oolite. Clay beneath Forest Marble.
b Chalk.
c
d Purbeck Stone.
e Portland Stone.
f Portland Sand & Sandstone.
g Kimmeridge Clay.
h Oxford Oolite & Calcareous Grit.
i Oxford Clay.
k Cornbrash & Forest Marble.
l Inferior Oolite.
m Lias

Fig. 1.

General Section of the Strata in the Weymouth District.

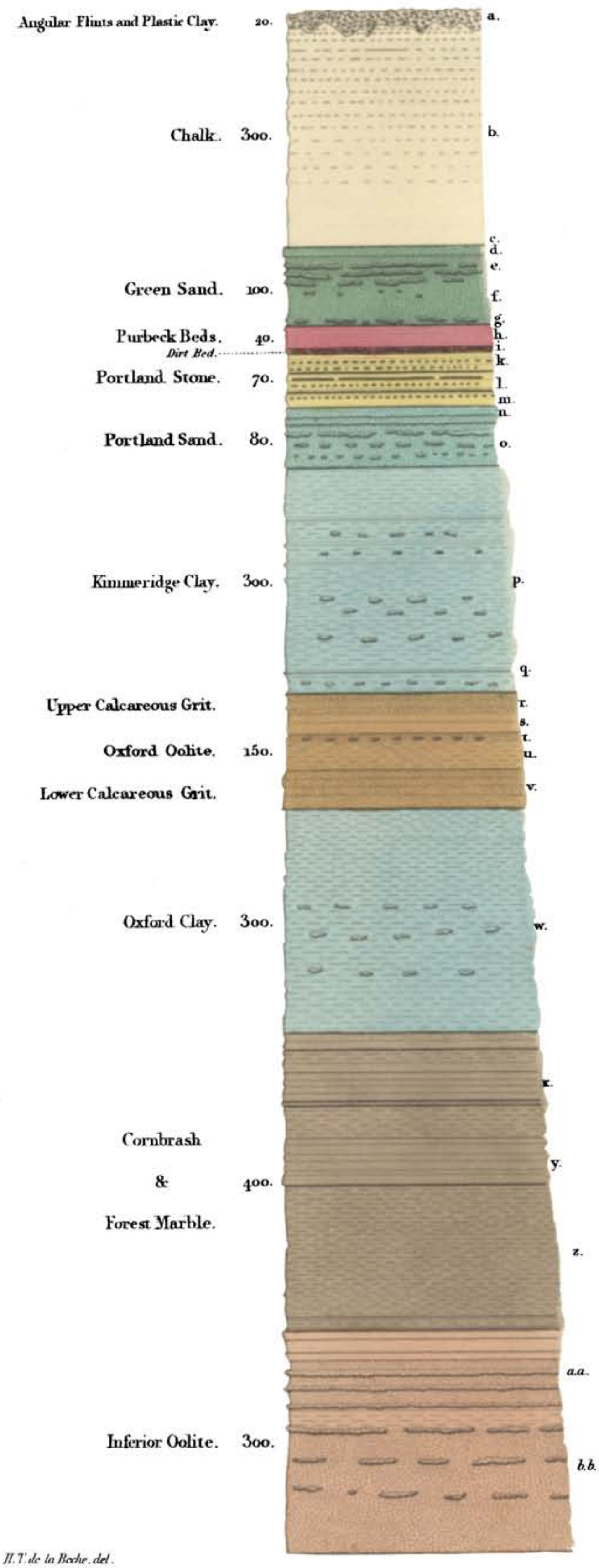


Fig. 2.

Section between Ringstead Bay & Osmington Mills.

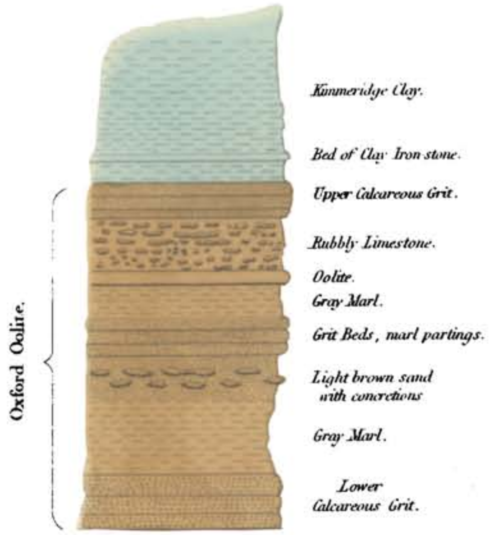
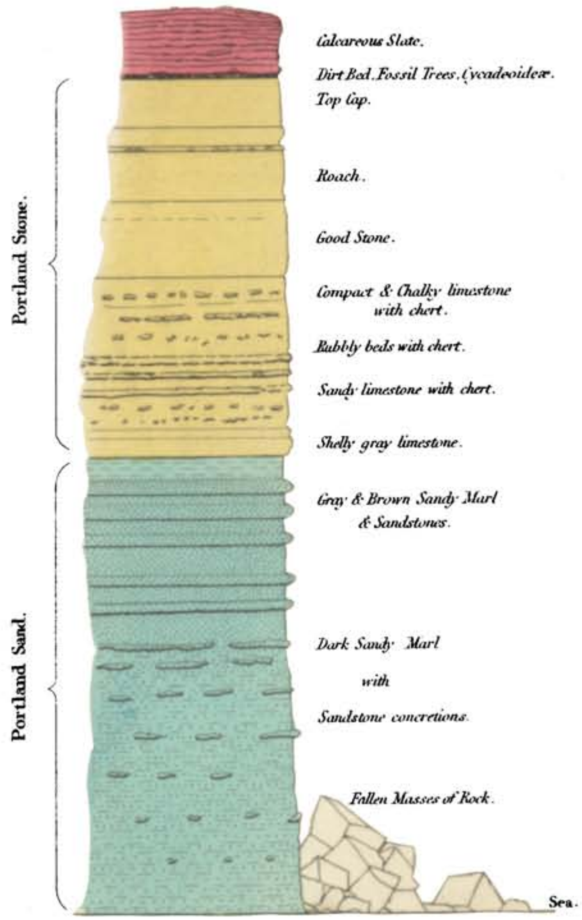


Fig. 3.

Section of the Cliff of Black Nore, W. side of Portland.



H. T. de la Beche. del.