



## XXXVI. Geological and mineralogical survey of part of the Yorkshire coast

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To cite this article: Rev. Geo. Young & Mr. J. Bird (1818) XXXVI. Geological and mineralogical survey of part of the Yorkshire coast, Philosophical Magazine Series 1, 51:239, 206-214, DOI: [10.1080/14786441808637535](https://doi.org/10.1080/14786441808637535)

To link to this article: <http://dx.doi.org/10.1080/14786441808637535>



Published online: 27 Jul 2009.



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May I request the correction of the underwritten *errata*:—those in figures with one exception may be my own.

Page 112, for Crichman, read *Crickmore*: page 113, line 2, read at  $4\frac{1}{2}^{\circ}$  at  $2\frac{1}{4}^{\circ}$  instead of and. In the plate for 140,000, read 130,000: and in the other numbers 156, 182, 208, 234,000: and for 922, read 322,000.

XXXVI. *Geological and Mineralogical Survey of Part of the Yorkshire Coast. Drawn up by the Rev. GEO. YOUNG from Materials chiefly furnished by Mr. J. BIRD\*.*

THE mountainous tract, bounded by the plain of Cleveland on the north and west, and the vale of Pickering on the south, may be distinguished into four parallel ridges of hills, running from east to west. The first commences with the lofty cliffs at Boulby, and terminates at the western extremity of Barnaby moor. The highest parts of this ridge are Easington heights, Huntcliff, Burleigh moor, and Eston Nabb, which rise from 600 to 800 feet above the level of the sea. The second ridge, which comprehends the moors of Aislaby and Danby, and extends to High Cliff Nabb and Rosebury, is considerably more elevated; Danby beacon being 966 feet high, and Rosebury Topping 1022 feet. This ridge is separated from the former by the vales of Guisborough, Skelton, Lofthouse, and Dalehouse. On the south, the vales of Kildale, Common Dale, and the Esk, part it from the third ridge which is much more extensive, and forms the central and most elevated part of our moors; beginning at Peak and the Fyling hills, and proceeding westward by Lilla cross, Silhoue, Cock Heads, and Ralph cross, to Burton Head, Cold moor, and Cranimoor. The western part of this ridge is by far the most lofty, the heights at Cock Heads and Ralph cross being 1400 feet above the level of the sea, Burton Head † 1485, and Cranimoor upwards of 1500. A spectator on Cranimoor can observe the sea over the summit of Rosebury. This ridge is of great breadth, especially in the middle, where it reaches from Danby dale to the valley at Lestingham and Hutton. Immediately beyond the latter valley we find some of the hills of the fourth ridge, which takes its rise near Scarborough, and includes the hills of Seamer, Silphoue, Langdale, Crosscliff, Saltergate, Cawthorn, Spaunton, Gillimoor, &c. extending to the vale of the Rye. In point of

\* From the History of Whitby and Statistical Survey of its Vicinity. By the Rev. Geo. Young.

† This hill is erroneously called Botton Head by Colonel Mudge. The Colonel has committed an error in regard to the angle taken at Burleigh moor formed between Barnaby moor and Rosebury Topping; he makes it  $42^{\circ} 59' 56'' 5$ , whereas it is only about  $38\frac{1}{2}$  degrees.

height,

height, these hills correspond nearly with the second range; but they are of a different character from all the rest, being distinguished by the striking similarity of their abrupt northern fronts, forming the same angle with the horizon, and having the same smooth appearance, wearing a covering of short ling and moss, and rarely presenting any broken ground or naked rocks.

In all these four ridges, as in many other mountainous tracts of Britain, the hills generally rise with a gentle slope from the south, and fall abruptly in steep cliffs towards the north. A few of the smaller hills are nearly round, so that they appear like works of art; as Freeburgh hill, Oliver's mount, Blakey Topping, and some hills on the west of Langdale; most of which have tabular summits. Freeburgh and Blakey have indeed been pronounced artificial, by authors who had never examined their structure.

II. *Nature and Order of the Strata.*—None of our hills belong to the primitive class; they are all of the secondary formation, composed of strata, or beds, of various descriptions. There are few places where the stratification can be examined with equal facility; for, besides the opportunities for such investigations afforded by our inland cliffs, and by cuts or deep channels worn by rivers and mountain streams, our bold and lofty shores present complete sections of the strata along the coast. The strata, as in most other hills, are seldom parallel to the horizon, but generally dip towards the south, their inclination corresponding with that of the hills themselves, as above described: and they often assume an undulating form, the undulations bearing some proportion to those of the surface, rising in the heights, and falling in the valleys; the strata being thickest and highest in the most elevated situations.

The great bed of aluminous schistus, or alum-rock, as it is commonly termed, first demands our attention. At Boulby cliffs this immense stratum rises about 450 feet above the level of the sea. In the upper part of the bed, the rock is of a dark slate colour, feels soft and unctuous, like indurated clay; the laminated fracture is smooth and shining, the transverse fracture dull and earthy; it divides horizontally into thin laminae, and, where exposed to the effects of the atmosphere, splits into shiver or shale, which is blown about by the winds. The natural seams, or partings, are in an inclined direction, dividing the rock into regular rhomboidal sections, the size of which increases in every successive course from the top downwards, the texture of the rock becoming harder and firmer as we descend. At the depth of about 250 feet from the top of the bed, the schistus loses its smooth unctuous feel, and becomes mixed with a large portion of sand and mica in shining scales. In this part of the bed, about 60 feet

60 feet in thickness, the colour changes to a light yellowish gray; and we find here some bands of iron-stone, alternating with the schistus. Below this part, the rock recovers its softness and smoothness; and at the depth of 140 feet more, the schistus sinks below the level of the sea, and how far it descends has not hitherto been ascertained.

From the experiments made by Mr. Winter\*, the schistus is found to contain alumine, silix, magnesia, lime, oxide of iron, bitumen, sulphur, and water; the proportions of which vary considerably in different parts of the bed. The upper part abounds most with sulphur, and therefore yields the greatest quantity of alum; a cubic yard at the top being as valuable as five cubic yards at the depth of 100 feet. Of course the specific gravity of the schistus is not uniform: Mr. Winter states it at 2.48.—Calc spar often occurs in the veins of the rock.

The aluminous schistus abounds with pyrites, which makes it subject to spontaneous combustion, when great quantities of that substance become suddenly exposed to moisture and the effects of the atmosphere. Some years ago, a considerable part of the cliff between Sandsend and Kettleness fell down and took fire, and continued to burn for two or three years.

In this bed, that curious stone, called conical coralloid, occurs in abundance. It is found adhering, like a shell or crust, to large oval or lenticular blocks of hard calcareous stone, from which it is not easily separated. It is composed of an immense number of cones, from an inch to six inches in height, with all their apices pointing towards the central block, and the interstices between them filled with calcareous matter. The cones are variously aggregated; the larger containing several concentric cones within them, and one cluster often encroaching on another, or reclining on the side of another, so as almost to make their apices meet. When the stone is broken, the cones are very discernible in the fracture, and may often be taken out singly, or in clusters: they are transversely marked with undulating striæ, and their structure appears lamellated. In colour and feel, the stone resembles the alum-rock; but it properly belongs to the calcareous tribe, and bears some analogy to the stink stone.—The lenticular masses, incrustated by this fossil, are from a foot to six feet in diameter. In some of them are cavities, lined with crystals of calc spar, and filled with petroleum in a very fluid state. From the fragments of these stones exudes a kind of pitch, or indurated petroleum, which readily melts with heat, and when ignited burns with a crackling noise, and emits a strong bituminous smell.

\* See his Essay in Nicholson's Philosophical Journal, for April, 1810, p. 247.

The same bed contains numerous nodules of what we may call cement stone, being the stone from which Roman cement is manufactured. The nodules vary in their form and size: they are often globular, and sometimes two are joined by a slender bar, so as to resemble a double shot. Many of them are coated with a shell of pyrites, a quarter of an inch thick, and of a bright metallic lustre: they often contain extraneous fossils. These stones appear to be principally composed of argillaceous and calcareous earth, with oxide of iron, so mixed by nature as to form the proper composition for *terras*, or Roman cement.

On the top of the aluminous schistus rests a stratum of hard compact stone, from six to twelve feet in thickness. The workmen call it *dogger*, a name which they also give to the cement stone; and indeed its component parts seem to be nearly the same, but with a greater mixture of iron. The colour of the recent fracture is blueish gray, but, when exposed to the atmosphere, it changes to a deep purple brown. The transverse partings divide the stone into large blocks, nearly cubical; each parting contains thin plates, resembling rusted iron, and between the plates a soft ferruginous earth, apparently the result of decomposition. This bed of stone always covers the aluminous schistus where the strata are entire.

The superincumbent strata consist of alternate beds of indurated clay, iron-stone, coal, bituminous shale, and granulated sandstone; varying in number and thickness, according to the height of the hills in which they occur. The indurated clay always rests on the *dogger*. It is of a light ochrey colour, is soft and gritty, and divided into thin laminae. Alternating with the strata of clay are several thin beds of iron-stone, and generally one or more seams of coal. Where the surface is low, the coal is seldom more than an inch or two in thickness; but where the hills are highest, the principal seam is from six to eighteen inches.

A little above the coal seam, there usually occurs a bed of siliceous sandstone, 20, 30, or even 40 feet in thickness. Over this stratum, bituminous shale and sandstone rise, in alternate beds, to the tops of the hills, in the first three ranges formerly described. Nodules of rich iron-stone abound in the shale: some of them are of the granulated kind, in which the green specks that often occur seem to indicate the presence of copper.

In the upper end of *Tripsdale*, a branch of *Bilsdale*, is a bed of bituminous schistus, of a dark brown colour, and soapy feel. It is easily divided into thin plates, which are used by the inhabitants of the neighbouring vales for baking cakes. The slates are soft and elastic when first dug out; but are prepared by roasting them in hot turf ashes, after which they will bear the heat of a common fire for several years.

A stratum of limestone, but too much contaminated with iron to be used for agricultural purposes, crops out on the east side of Cold moor. It is about eight or ten feet thick: and in the transverse veins are observed stalactites, curiously formed, some of them studded with pyramidal crystals of calc spar, commonly called dog's tooth spar.

In the front of some of the Cleveland hills, where the beds of indurated clay crop out, are seams of a fine yellow ochre, similar to the Oxford stone ochre. The same hills contain, in the bituminous shale, balls of a rich yellowish brown ochre, perfectly free from grittiness; perhaps produced by decomposed pyrites.—In the upper end of Greenhoue Burton, is a rock called the Rudd scar, from a seam of ruddle, or red ochre, which it contains, with which the farmers mark their sheep.

The sandstone beds which lie above the aluminous schistus are all siliceous; but differ greatly in their texture and hardness, some being soft and friable, while others are well adapted for building. On the tops of some of the moors a very hard siliceous stone, called crow stone, occurs. Near Hunt-house, in Godeland, is a large bed of stone, composed of fine white crystals, having so little cohesion, that the stone is easily crumbled to pieces between the fingers: the powder is used by farmers for sharpening their scythes.—Most of the sandstone contains mica; which occurs in a schistose state between the strata of sandstone, and is also found in fissures, in loose scales, which from their bright lustre have been sometimes taken for metallic ores.

Such is the stratification of the first three ranges of hills, which we may call the alum hills. In the southern slope of the third line, the aluminous bed sinks below the level of the sea, and rises no more. Its descent is rather rapid; for though it appears at a great height at Stoupe Brow, it sinks about a mile to the south of Peak; and the descent takes place in a similar form, throughout the whole of this range of hills, from Peak to Osmotherley, the place where it disappears on the Cleveland side. The superincumbent strata sink at a proportionate distance to the south, and then commences a new series of stratification, composing the fourth, or southern, line of hills. These we may term the limestone hills, as they consist of alternate strata of limestone, marl, and sandstone, resting on a bed of clay slate, of a coarse granular texture, and a light gray colour. This slate lies over the upper strata of the former series, that sinks beneath this; for this series has the same inclination as the former, dipping gradually towards the south, till it sinks in the vale of Pickering, or of the Derwent; beyond which another series appears in the chalky strata of the wolds.

The limestone is chiefly of the oolite or roe-stone species; and contains

contains in its fissures great quantities of calc spar, in beautiful lenticular crystals, about an inch in diameter, adhering to the rock by their edges. Fine specimens of this kind of spar may be seen in the rock on the north side of Scarborough castle.

In the limestone hills are numerous subterraneous fissures and chasms. There are no apertures to admit our entrance into them, as in the Craven lime rocks; but their existence is demonstrated by their effects, particularly in the absorption of water. In these hills it is rare to meet with a spring, till we come down to where their bases join the plain on the south; their dales and deep cuts are streamless and dry, except where rivulets flow through them from the hills of the third range: the waters are wholly absorbed by the fissures of the strata, and running down in these subterraneous channels at last burst out at the foot of the hills in springs of immense size, or rather in whole rivers. At Keldhead, near Pickering, the Costa rises from the earth in one vast volume of waters: at Brompton, a river bursts at once from the caverns of the limestone, and is collected at its very source into a large mill-pond, so that it drives a mill in descending from the ledge of rocks out of which it issues: and similar phenomena are observed at Ebberston, and other places along the foot of this range.—Nor do these cavernous hills absorb their own waters only, they also swallow up the rivers and streams which pass through their dales from the hills beyond them; for these streams, on their arrival at the limestone beds, suddenly disappear, and afterwards rise again on the south side of the hills, in a line with the springs which issue from their bases: at the same time a channel is left above ground, in which a portion of the water flows during winter, or in occasional floods, when the subterraneous channel is insufficient to admit the whole. The Rye sinks a little above Helmsley, and rises at a small distance from its proper channel, about a mile below: the Riccal disappears about a mile above the new bridge on the Helmsley and Kirkby Moorside road, and rises at Haram, a mile below, a few yards from its channel: Hodge beck descends into the rock a few paces below Holme Caldron mill, near Kirkdale church, and bursts up again at Howkeld-head \*, on the south side of the road, a mile west of Kirkby Moorside, and about a quarter of a mile east of its channel: the Dove, or Dow, sinks about twenty yards below Yawdwath mill, and after running near half a mile under ground, resumes its old channel about a furlong above Keldholm bridge; Hutton beck, or Catter beck, disappears about a mile north of Catter bridge, on the Kirkby Moorside and Pickering road, and starts up

\* Keld-head means Spring-head; How-keld-head is Deep-spring-head, a name fitly given to that frightful basin from whence this river boils up.

again about half a mile below: and lastly, the Seven is swallowed up a little above Sinnington, and appears again in its own channel, not all at once, but by successive risings, between Sinnington and Normanby. Thus, in skirting the foot of these hills, the traveller crosses a succession of subterraneous rivers.

Caverns are also formed in beds of sandstone, not only by currents of water, but by the action of the atmosphere and the rains, washing away the loose sands or soft strata below, and leaving the harder strata above, in the form of a roof. In some instances, insulated fragments of the hard strata are left standing on a kind of pillars, like monuments of art. The rocks called the *Bride-stones*, running along the margin of a deep ravine, in the moors near Saltergate, about two miles south of Blakey Topping, furnish curious examples both of caves and insulated rocks. Some of the latter appear like mushrooms, supported on a narrow stalk; particularly one which is about thirty feet high, and in one direction near the top about twenty feet broad, while the stalk or pillar, which supports it, is only three feet across in one direction, and about seven feet in the other.

In the cliffs along the coast, the strata are not only liable to be decomposed by the atmosphere, but undermined and wasted away by the tides, especially in storms. The ratio in which this decay proceeds is not easily ascertained; but it does not appear on an average to exceed a yard in ten years, or ten yards in 100 years; for though in some spots the decay is much greater, in others it is much less. The notion that our abbey was a mile from the sea at its first erection is a groundless fancy: the port of Whitby always was where it now is: the cliffs might project 100 or 150 yards further in Hilda's time than at present, but that is the utmost extent that can reasonably be allowed. For the sake of future investigations on this subject, I would here state, that the distance from the outer edge of the north buttresses of the transept of the abbey, measured in a line with the middle of the transept, to the edge of a hole that seems to be an old quarry on the margin of a cliff, was found in 1816 to be exactly 634 feet, and the distance across that hole to the verge of the precipice, 46 feet more; making in all 680 feet from the edge of the cliff to the nearest part of the abbey, in the line of the transept. I may add, that the distance from the middle of the outer court gate in front of Mrs. Cholmley's hall, to the verge of the cliff, taken in a line with the cross, is 238 yards, or 714 feet: and, that the distance from the north-west angle of the tower of Whitby church to the nearest edge of the precipice behind Henrietta-street, is 70 feet.

Besides the numerous veins and vertical fissures that cross the strata



strata in our hills, and the frequent undulations of the strata already noticed, some remarkable interruptions occur which demand observation. At the mouth of the Esk, a slip or down-cast has taken place on the north side, the whole mass of the strata on that side being 80 or 100 feet lower than the corresponding strata on the south side; and this interruption seems to be continued throughout the whole vale of the Esk. A similar break is seen about two miles to the south of Carleton alum-works, where the north part of a hill has sunk wholly down about ten feet, exposing the section of a bed of sandstone, which, when viewed from the north, appears exactly like a stone wall running across the whole ridge from Bilsdale to Scugdale.

But the most singular interruption of the strata is that produced by the whinstone dyke, or basaltic ridge, which traverses our hills, like a vast vein. This is perhaps the most remarkable ridge of the kind in Britain, being 40 feet thick and often more, and being traced on the surface to the extent of 60 or 70 miles, in a straight line. It runs from Cockfield Fell in the county of Durham to the river Tees near Preston; and then, entering Cleveland, it crosses our district in the line laid down on the map, but has not been traced quite to the coast, the last discernible portion being at Blea hill, near the upper end of Harewood dale. The ridge rises perpendicular to the strata, and consequently inclines towards the south, the dip of the strata being in that direction: it proceeds nearly from W.N.W. to E.S.E. and seldom deviates from the straight line. In many places it does not reach the surface; in some, the top of it is on a level with the surface, or protrudes only a foot or two above it, as on the moor between Maybecks and Silhoun\*, and in the descent from Silhoun towards the Mirk Esk; in other places it rises to a great height above the surface, as at Parker's house near Lealholm Bridge, and especially in the long and lofty ridges which it forms in Cleveland. In these prominent parts of the whinstone dyke, it occupies a much wider space than the breadth of the vein; for there the higher portions of the ridge, having nothing to support them, have fallen down on both sides, especially on the south side to which it inclines: and hence such protuberances assume the form of oblong hills. The most remarkable hill of this description is on the south and west of Rosebury Topping: it is

\* Here the moor road that runs contiguous to it is called the High-street, probably from the resemblance which the ridge bears to a paved road; though it is possible, that a Roman vicinary way may have passed in this direction, from the camp on Lease-rigg to the fort at Peak. I might have noticed, in speaking of the Roman roads, that some houses near Loftus are called Street-houses, which favours the idea that a Roman road might run that way from Dunsley to the mouth of the Tees.

named Langbargh, from its form, a name which it has imparted to the whole wapentake\*.

This singular ridge is composed of blocks or masses, generally oblong, and lying across the vein, parallel to one another, in a form approaching to that of basaltic pillars, yet without any regularity of shape or size. The interstices are filled with a kind of ferruginous earth, or decayed whinstone, and the blocks are coated with a crust of the same colour: the recent fracture, which is rough and granular, presents a dark blue colour, with a number of small shining crystals. The stone is exceeding hard, and is excellent metal for making roads. Mr. Bailey, in his Survey of Durham, (p. 32.) justly remarks, that it “seems to have been in a state of fusion when it filled up the fracture, as the seam of coal, for some feet distance on each side, is turned into a sooty substance, which becomes a cinder as the distance from the whinstone increases, and by degrees assumes the natural appearance of coal with all its properties: which takes place about 50 yards from the whinstone.” What impression it has made on the aluminous schistus, which it traverses in our alum hills, has not been ascertained: but in Langbargh quarry we see the south side of its bed, against which it has leaned, appearing smooth and firm, as though it had been baked.

### XXXVII. On the transverse Strength and Resilience of Timber.

By Mr. THOMAS TREDGOLD.

To Mr. Tilloch.

SIR, — THE growth of our own *ship-timber* has always been considered to be of great importance to this country; but on account of the slow growth of the oak, the demand, it is probable, will soon far exceed the produce of the British Islands: therefore, the introduction of the *larch*, which has been very extensively planted by a few patriotic individuals, is very justly esteemed an object of national importance, as the rapid growth of the larch far exceeds that of most of our native trees, and “it is remarked,” says Dr. Hunter, “that those trees which have been planted in the worst soils, and most exposed situations, have thriven the best†.”

The timber of the larch is durable; it does not burn readily,

\* The original name Langberg signifies Long-hill: the ancient name of Rosebury was Ohtneberg or Hogtenberg = High-hill. The wapentake courts were formerly held at Langbargh, and the steward still holds his court, *pro forma*, beside Langbargh quarry.

† Notes on Evelyn's Silva, i. 280.