

ALUMINA, MAGNESIA, & IRON .	34. <i>Ripidolite</i> .
	35. <i>Chlorite</i> .
ALUMINA, MAGNESIA, IRON, AND	36. <i>Biotite</i> or <i>Magnesia-Mica</i> .
POTASH	37. <i>Pinite</i> . Altered <i>Cordierite</i> , some Mg replaced by K.
	38. <i>Tourmaline</i> . A mineral of various and complicated chemical constitution. Contains Na with K, also about 9 per cent. of Boracic acid, and 3 per cent. of Fluorine.
ALUMINA, IRON, AND POTASH .	39. <i>Potash-Mica</i> . Has sometimes Mn.
ALUMINA, IRON, POTASH,	40. <i>Lepidolite</i> , or <i>Lithia-Mica</i> . Also Hydrofluoric acid.
LITHIA, AND MANGANESE .	
MAGNESIA, LIME, AND PROT-OXIDE IRON	41. <i>Hornblende</i> . Often some Al.
	42. <i>Augite</i> . ditto.
	43. <i>Diallage</i> . Generally some Al, also H and Mn.
	44. <i>Hypersthene</i> . Generally Al and Mn.
MAGNESIA AND IRON	45. <i>Olivine</i> .
	46. <i>Bronzite</i> . Some H.

THE GEOLOGY OF BEADNELL, IN THE COUNTY OF NORTHUMBERLAND, WITH A DESCRIPTION OF SOME ANNELIDS OF THE CARBONIFEROUS FORMATION.

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Read before the Berwickshire Naturalists' Club, at Beadnell, in May, 1858.

A SECTION along the coast from Ebbs Nook to Annstead Bay, of nearly one and a half miles in length, exhibits a fine series of rocks belonging to the Mountain Limestone Formation. Thick sandstones and limestones, shales with ironstone, and coal-seams are intercalated with each other; and these strata are traversed by a lead-vein and a basaltic dyke. As we wander along the shore, we meet with evidences of sea-deposits in the limestones and calcareous shales, wherein are embedded many corals and mollusks; the sandstones, shales, and coal afford relics of the vegetation of the Carboniferous Era; some slaty sandstones give distinct indications of ancient shallow seas and coast-lines, whereon the waves broke gently and over which worms crawled; while the basaltic dyke tells of the play of internal forces, rending asunder the vast mass of stratified rocks, and pouring molten lava into the fissures.

The general dip of the strata, about 15° , is south-east, and as we proceed northward we pass over the lower beds in succession. There are a few dislocations and faults, and in some parts the limestones are thrown into wave-like ridges and hollows; but the contortions are not so remarkable as at Howick, Holy Island, and Scremerston. As the greater proportion of the middle group of the mountain-limestone rocks is seen here, the following section will be instructive, giving, as it does, the strata in detail from the highest at Ebbs Nook, down to the lowest which have been reached by pit-sinkings in the neighbourhood. It has been made out by repeated examinations of the coast, collated with information derived from pit-sinkings, which has been kindly supplied to me by my friend, Mr. William Wilson, the intelligent manager of the Shilbottle Colliery. The lower strata from No. 68 downward are taken entirely from pit-sections.

SECTION.

	ft. in.		
1. Ebbs Nook Magnesian limestone, containing <i>Productus giganteus</i> , <i>Spirifer lineatus</i> , <i>Chonetes septosus</i> , <i>Lithostro- tion basaltiforme</i> , <i>Syringopora ramulosa</i> , &c.	30 0	beds, annelids in flaggy beds	24 0
2. Red, flaggy sandstone, ripple-marked	4 0	14. Shale with ironstone-nodules	15 0
3. Shale, reddish at top, darker and carbonaceous in lower beds	20 0	15. Limestone, generally blue: —the basaltic dyke cuts through these beds near the shore	18 0
4. Coal	1 2	16. Coal	0 6
5. Fire-clay and shale	7 0	17. Grey shales with ironstone-nodules	10 0
6. Flaggy sandstones, micaceous along the laminae; with borings of annelids	30 0	18. Blue shales	15 0
7. Shale	5 0	19. Grey slaty sandstone	5 0
8. Sandstones with ripple-marks, false-bedding, and worm-casts and trails	40 0	20. Coal (<i>stony coal</i>)—this is very nearly in the same position in the series as the fine "Shilbottle-seam"	1 0
9. Shales	27 0	21. Slaty sandstones	8 0
10. Limestones, generally blue; some beds dun, weathering buff; a calcareous shale, 2 ft. 6 in. is interstratified: — <i>Productus giganteus</i> , <i>Aulophyllum fungites</i> , &c.	28 0	22. Blue slates	7 0
11. Coal mixed with shale	0 6	23. Slaty sandstones and shales —some beds are ripple-marked, and the vein of Galena is seen crossing the sandstone	37 0
12. Arenaceous shale	1 0	24. Shales	10 0
13. Sandstones, some blotched and red, others flaggy; <i>Stigmaria ficoides</i> in upper		25. Limestone, dark	6 0
		26. Grey slaty sandstones and shales	27 0
		27. Calcareous shale; with many fossils	3 0
		28. Limestones much contorted; the upper beds impure, but the middle and lower make good lime. These beds were	

worked here until lately ; and also at North Sunder- land, where they are brought in through the undulations and faults of the strata. They are very fossiliferous.		24	0	54. Grey sandstones and slaty sandstones	9	0
29. Coal	0	8		55. Limestone	5	0
30. Fire-clay and shales	10	0		56. Coal ("Swinhoe coal")	1	4
31. Sandstone, upper beds slaty.	30	0		57. Sandstones	27	0
32. Carbonaceous shales with ironstone-nodules	10	0		58. Grey shale	9	0
33. Limestone, dun and impure — <i>Productus giganteus</i>	4	0		59. White sandstone	12	0
34. Carbonaceous shales	12	0		60. Blue shale	36	0
35. Coal ("Beadnell-coal"). Va- ries in thickness from 2 ft. 6 in. to 6 ft. ; the average about	3	0		61. Limestone, impure	6	0
36. Sandstones and slaty sand- stones with <i>Sigillaria orga-</i> <i>nica</i>	17	0		62. Coal	0	9
37. Coal	1	5		63. Fire-clay and shales	24	0
38. Grey slaty and flaggy sand- stones	45	0		64. Coal ("Fleetham coal," of good quality)	1	6
39. Shales	8	0		65. Sandstones	132	0
40. Grey slaty sandstone	6	0		66. Blue shales	33	0
41. Shales	10	0		67. Sandstone	21	0
42. Sandstones, some of the beds red	38	0		68. Limestone	21	0
43. Grey shales	22	0		69. Coal	0	4
44. Limestone	2	6		70. Slaty sandstones and shales.	60	0
45. Grey slaty sandstones	6	0		71. Coal	0	10
46. Fire-clay and shales	30	0		72. Fire-clay	48	0
47. Coal (<i>stone-close-coal</i>)	1	4		73. Limestone, light-coloured	6	0
48. Grey slaty sandstone	10	0		74. Coal, mixed with sandstone.	2	0
49. Dark shale	5	0		75. Shales and slaty sandstone	15	0
50. Slaty sandstone	10	0		76. Limestone, impure	2	0
51. Dark shale	18	0		77. Coal	2	0
52. Limestone	14	0		78. Sandstones	150	0
53. Coal	0	4		79. Slaty sandstone	30	0
				80. Blue shale	6	0
				81. Hard stone	4	0
				82. Sandstone, coarse, white	15	0
				83. Blue shale	12	0
				84. Coal, good	1	8
				85. Slaty sandstones	27	0
				86. Coal ("main coal")	4	0
				87. Fire-clay	5	0
				88. Blue shale	42	0
				89. Limestone	4	0
				Total	1,493	10

There are in this section fourteen different limestones, varying in thickness from 2 to 30 feet, and having an aggregate thickness of 171 feet. Most of them are of a bluish colour and yield good lime ; many fossils characteristic of the mountain-limestone formation occur, especially in the thicker sills and in the calcareous shales connected with them. The main limestone, No. 28, is the most fossiliferous ; and the following list, though far from complete, will show how rich it is in organic remains :—

FISH.

A few remains of fish appear, viz—
Megalichthys Hibberti, Ag. (scales, of a
quadrate form, one inch across.)

Cladodus mirabilis, Ag. (teeth).
Cochliodus magnus, Ag. (teeth).

CRUSTACEA.

Griffithides Farnensis, Tate.

MOLLUSCA.

Orthoceras sulcatum, Flem.
 ——— *Goldfussianum*, Kon.
Naticopsis plicistria, Phil.
Loxonema rugifera, Phil.
Euomphalus carbonarius, Sow.
Pleurotomaria decipiens, McCoy.
 ——— *atomaria*, Phil.
Platyschisma helicoides, Sow.
Bellerophon Urii, Flem.
Orthis resupinata, Mart.
 ——— *Michelini*, Kon.
Strophomena crenistria, Phil.
Productus Martini, Sow.
 ——— *punctatus*, Mart.
 ——— *scabriculus*, Mart.
 ——— *spinulosus*, Sow.
 ——— *imbriatus*, Sow.
 ——— *latissimus*, Sow.
 ——— *Flemingii*, Sow.
 ——— *semireticulatus*, Mart.
Chonetes sordida, Sow.
 ——— *Dalmaniana*, Kon.
 ——— *gibberula*, McCoy.

Spirifer trigonalis, Mart.
 ——— *glaber*, Mart.
 ——— *lineatus*, Mart.
 ——— *octoplicatus*, Sow.
Edmondia sulcata, Phil.
Sanguinolites iridinoides, McCoy.
 ——— *transversa*, Port.
 ——— *variabilis*, McCoy.
Ariculo-pectendocens, McCoy.

BRYOZOA.

Fenestella plebeia, McCoy.
 ——— *crassa*, McCoy.
 ——— *undulata*, Phil.
Glaucanome pluma, Phil.
Sulcoretepora parallela, Phil.

CORALS.

Aulophyllum fungites, Flem.
Lithodendron irregulare, Phil.
Stenopora tumida, Phil.
Favosites parasitica, Phil.
 ——— *serialis*, Port.

The calcareous shale is remarkably full of fossils ; indeed it is almost entirely formed of *Productus Flemingii* and *Spirifer trigonalis*. Being exposed to the weathering influence of the tide, which washes away the softer matrix, the fossils stand out in bold relief, and fine specimens of the *Productus* can be obtained, showing beautifully the curious internal structure of the shell.

The limestone which forms the bold headland of Ebbs Nook is, however, the most interesting of the group, from its peculiar organisms, its mineral composition, and picturesque appearance. It is 30 feet in thickness ; and, being very hard, resists more effectively than the other rocks the destructive action of the sea. Resting, however, on a soft shale which is easily broken up and washed away by the tides, this superincumbent limestone is deprived of support, and from time to time large masses tumble down from the cliff. It now forms a narrow point running out into the sea for about one quarter of a mile ; but the tides and high seas are still working away the lower and softer beds which connect this promontory with the land, and in the course of a few centuries it will become an island on the flow of every tide. This limestone is of a buff colour and generally of a crystalline structure. It is a magnesian limestone, being composed of carbonate of magnesia and carbonate of lime. Besides containing

Productus giganteus and other commoner mountain-limestone fossils, it abounds with large masses of the corals *Lithostrotion basaltiforme* and *Chaetetes septosus*; and occasionally we find *Syringopora ramulosa*, which is a rare coral in the Northumberland beds. These distinctive organisms are excellent guides in tracing the range of this "sill." Northward I have found it at Holy Island, and southward I have traced it to Spittleford, near Embleton, and to Dunstan, Craster, and Shilbottle; thence in a south-west direction to Whittle, Newton-on-the-Moor, Framlington, and across the Coquet to Ward's Hill and Rothley. It should be noticed that the magnesian character of this limestone is a local phenomenon, seemingly in some way arising from the proximity of basalt; in several parts of its range, as at Shilbottle and Framlington, it is a comparatively pure carbonate of lime.

There are eighteen different coal-seams in the section; most of them thin and of an inferior quality; only two exceeding 2 feet in thickness; their aggregate thickness being only 24 feet 4 inches. That which is called the "Beadnell-coal" (No. 35) has been worked both for domestic use and for lime-burning. It is of variable thickness, seldom less than 2 feet 6 inches, and generally about 3 feet; but on Mrs. Taylor's estate it has been found as much as 6 feet thick, and of a better quality than in other localities. It lies there, however, below the sea-level; and as the sea some time ago broke into a neighbouring colliery, due precautions would be necessary to prevent a similar irruption, in the event of this more valuable portion being worked for the use of the district.

The sandstones and shales associated with the coal-seams contain relics of the vegetation of the Carboniferous Era; *Stigmaria ficoides* appear abundantly in these beds, with a few *Sigillariae*. One interesting specimen of *Sigillaria*, laid bare in quarrying the sandstone in 1853, deserves a more particular notice; although but a fragment, it was six feet in height, two feet two inches in diameter at the lower end, and one foot nine inches at the higher. It stood perpendicular to the strata, which dip 15° south-east, and its inclination to the horizon was 75°. The lower extremity terminated abruptly on the surface of slaty sandstone beds, but the outcrop of the rock in which it was embedded prevented our knowing how far upward it extended. Over its surface was a thin carbonaceous coating, being the bark converted into coal;

but the interior was replaced with sandstone, retaining no structure, but bearing, however, the rude flutings which distinguish the casts of *Sigillariæ*: it appeared to belong to the species *Sigillaria organum*. The sandstone in which it stood consists of several beds; the lines of stratification distinctly passing through the fossil, and curving more or less downward on all sides towards it. No roots could be observed attached to this tree; yet from its position at right angles to the strata, and the peculiarity of the stratification, I think it originally grew on the spot. Indeed, there seems to me little doubt that most of the coal-seams, even in northern Northumberland, have been formed of plants and trees which grew, during the Carboniferous Era, in the district now occupied by the coal-beds; the under-clay usually beneath each coal-seam having been the surface-soil on which they grew, it is now found more or less traversed by the *Stigmaria ficoides*,—the roots of *Sigillariæ*,—the trunks of which have largely contributed to the formation of the coal. As this fossil tree is frequently to be seen in Northumberland, it may add to the interest of these notes to give the following description from my "Fossil Flora of the Eastern Borders." "The structure of the *Sigillariæ* differs widely from that of any living plant; it is, however, essentially acrogenous; and the nearest analogue to those majestic trees of other times is the Lycopod or lowly-creeping club-moss; yet the radial arrangement of the woody tissue and the presence of medullary rays and a sheath bring them into a distant relationship to exogenous vegetation. Brongniart considers them allied both to the Lycopod and to the *Cycas*; they form, therefore, a connecting link between orders which stand far apart in existing nature. Composed chiefly of cellular tissue, the *Sigillariæ* were extremely succulent; they grew in swamps and marshes, their long and numerous roots and rootlets (*Stigmaria*) forming an entangled mass and permeating the mud in all directions, in a manner similar to that of the living water-lily in shallow lakes and pools. The roots sometimes exhibited a crucial arrangement, uniting into four main portions, separated from each other by deep channels and forming a dome, from the summit of which the furrowed and scarred stems, clothed in the upper parts with a long, narrow, and pendent foliage, rose to the height of nearly 100 feet." *

* Tate's "Fossil Flora of the Mountain Limestone Formation," in Dr. Johnston's "Botany of the Eastern Borders," p. 299.

Other conditions of the Carboniferous Era are made known by several of the sandstones, which present ripple-marks, oblique lamination, and fossil worms and worm-tracks, indicating ancient beaches and the action of waves and currents. When deposits are made in comparatively tranquil water, the planes of the several beds are pretty nearly parallel to each other ; but some sandstones exhibiting in mass this ordinary stratification have also included in them thin layers or stratula, which are inclined sometimes highly to the plane of the principal bed ; of this oblique lamination, or, as it is frequently called, *false-bedding*, there are many examples in the "Beadnell-sandstones." Both ripple-marks and false-bedding result from the action of waves and currents ; the former being produced by the gentle motion of waves, and the latter by stronger currents. After the recession of the tide, furrows and ridges may be seen on sandy and muddy coasts ; these are similar in form and arrangement to those left impressed by ancient waves on the "Beadnell-sandstones," in which they are beautifully distinct ; some of them are large, measuring six inches from one ridge to the other, and they usually trend from east by south to west by north. As the line in which a current moves is at right angles to the direction of such marks, the ancient currents which rolled over the Beadnell coast must have come either from the north or the south.

Mr. H. C. Sorby has attempted to determine the direction whence currents came by observations on the dip of the stratula, as he considers the direction to be the opposite to this dip in relation to the plane of true bedding ; and he concludes from a series of observations, that the drifting current which formed the carboniferous sandstone-beds of the southern part of the coast of Northumberland came from north 9° east.* The "Beadnell-beds," however, do not lead to any such general conclusion, for I found in the same stratum, and within a distance of not many yards, that the stratula in one place dipped from 40° to 70° to the north, and in another place at similar angles to the south-west by south. Probably this bed had been formed by the action of strong eddies and counter currents, which piled up the drifted sand with considerable irregularity.

Most curious and instructive are the fossil worms and their tracks which occur in several layers of flaggy and ripple-marked sandstones

* Proceedings of the Yorkshire Geological Society for 1852, p. 232.

a little northward of Ebbs Nook. They are seen also in other sandstone beds of the section, as well as in other localities in Northumberland. Though similar annelids are not unfrequent in Palæozoic rocks, they have been but seldom noticed. Species from the Silurian rocks have been described by Sir R. Murchison in his great work the "Silurian System," by Professor McCoy in Sedgwick's "Synopsis of the Classification of British Palæozoic Rocks," and by Mr. J. W. Salter in the Quarterly Journal of the Geological Society. Few distinct descriptions have been given of such forms in the Carboniferous formation; the only notices I know of are contained in a paper by Mr. E. W. Binney, "On some Trails and Holes formed in rocks of the Carboniferous Strata;"* and in an excellent popular "Account of a large fossil, marine worm, occurring in the Mountain-limestone district in Wensleydale, Yorkshire," by Mr. Edw. Wood, F.G.S.† Mr. W. Lee also refers to annelid-borings, in a paper on what he calls "Fossil Footprints in the Carboniferous system."‡ Having carefully examined the annelids in the Mountain-limestone formation of Northumberland, I am able to distinguish four distinct forms; two of them are referable to *Crassopodia* (McCoy), a genus which has been found in Silurian beds, and which may be thus defined:—Body long; formed of excessively short, numerous, wide segments, from which arise very long, delicate, crowded cirri forming a broad dense fringe on each side, completely concealing the feet. These annelids appear to belong to the order Dorsibranchiata of Cuvier, and are allied to the nereides which now inhabit our coast. These latter are marine worms which creep in a serpentine manner, and even swim by successive undulations of their bodies or by agitating their appendages.

CRASSOPODIA EMBLETONIA § (Tate). Plate II. figs. 1, 2.

Length unknown (upwards of two feet); width one inch; thickness not exceeding four lines; width of body five lines; articulations three lines apart; cirri about four lines long, crowded, there being twenty-four in the space of one inch. There is no appearance of a head; the

* Memoirs of the Manchester Philosophical Society, vol. x. p. 181.

† The Naturalist, Nos. I. and II. pp. 14 and 41.

‡ Proceedings of the Yorkshire Geological Society, vol. ix. p. 409.

§ I have named this after my esteemed friend, Mr. R. C. Embleton, the accomplished Secretary of our Club.



width and characters are the same throughout the entire length ; it occurs in large rounded loops from half an inch to more than three inches apart.

Having found sections showing the interior of this curious fossil, I have been able to determine the width of the body, and the distance of the articulations from each other.

This is the most widely distributed of the carboniferous annelids ; it occurs in sandstones of the mountain-limestone at Beadnell, Scremerston, Howick, Haltwhistle,* and also in flaggy beds of the millstone-grit at Berlin Carr, between Alnmouth and the Coquet.

Fig. 1.—Upper surface ; the keel-like centre is that portion of the body not covered with cirri.

Fig. 2.—Section showing the articulations of the body ; a, intestinal canal ; b, muscular layer and articulations ; c, space occupied by cirri.

CRASSOPODIA MEDIA (TATE). Plate II. figs. 3, 4.

Length considerable (upwards of three feet, nine inches) ; usual width about four lines ; some specimens are only three lines, others as much as six lines wide ; thickness three lines ; width of body two lines ; length of cirri one line and a half, twenty of them in the space of one inch ; the width and thickness continue the same throughout the entire length.

It occurs in irregular loops and long undulations which occasionally cross each other, and is quite distinct from the *C. Embletonia*, being much smaller and much thicker in proportion to its size ; the cirri are less crowded and the foldings are more tortuous and irregular.

It occurs in sandstone at Beadnell, abundantly at North Sunderland, at Newton-on-the-Moor, and at Howick.

Fig. 3.—Upper surface.

Fig. 4.—Section showing the cirri and a cast of the body.

NEMERTITES (McLEAY).—A Genus which has been described from the Silurian formation ; it is thus defined :—Body very long, linear, slender, of nearly uniform thickness throughout, without distinct articulations.

* On the Irthing, near Combe Crag.

NEMERTITES UNDULATA (TATE). Plate II. fig. 5.

Length unknown (upwards of nine inches), body round, half a line in diameter, usually in loop-folds from a quarter to half an inch apart; neither articulations nor cirri are observable.

This species is generally found where fossil worms appear; it occurs in sandstone at Beadnell, North Sunderland, Howick, and Haltwhistle.

Fig. 5.—*Nemertites undulata*, accompanied with borings of other annelids; this species also is figured on the slab, fig. 6.

EIONE (TATE).—This annelid, very different from every other, occurs in considerable abundance at Howick, in a thick flaggy sandstone which holds a similar relative position in the mountain-limestone series to some of the sandstone-beds at Beadnell. This fossil, too, is associated with the same species of worms as are found at Beadnell. It has characters so remarkably distinct that I have provisionally given it a generic as well as a specific name.

EIONE MONILIFORMIS (TATE). Plate II. fig. 6.

Length unknown (upwards of three feet); body rounded, lower surface and sides moderately convex, smooth, upper annulated, diameter six lines; articulations consisting of bead-shaped rings on the upper surface, distinctly separated from each other by a deep sulcation, the length of each articulation being five lines; it occurs in long undulations. Some individuals are a little larger and others a little smaller than the size stated; but each preserves the size and character throughout the entire length. I have been unable to detect any internal structure, or to observe setæ, cirri, or appendages.

This very peculiar fossil worm may be referred to Cuvier's order *Abranchiata*. Destitute of setæ and cirri, it resembles the *Hirudo* or leech, and probably, like the *Lumbricus* or earth-worm, it respired by the entire surface of the skin and not by special organs; it would progress by the contraction and extension of the subcutaneous muscular stratum.

It is found at Howick, Scremerston, and Haltwhistle in Northumberland, and I believe also in Yorkshire.

Besides the forms now described, there are other casts and trails at

Beadnell. Some seem to be the burrows or casts of annelids, passing either perpendicularly or obliquely through several layers of rock, the upper surface of the layers being pitted and the under projecting. These casts or burrows are about two lines in diameter, and are so crowded together in some rocks both at Beadnell and Kirkwhelpington, as to give the stone a pock-marked appearance. Meandering furrows about one line in width, with a ridge in the centre, are probably the trails of an annelid: they occur also at Howick, North Sunderland, and Haltwhistle. It has been suggested that these were tracks made by small crustaceans, but the absence of all remains of the hard shell renders this opinion doubtful, and more extended observations on these borings and trails, and on the other markings associated with them, are required before the true characters can be distinctly determined.

As confirmatory of the marine conditions of the rocks in which the ripple-marks and annelids are found, I may add, that the flaggy sandstone containing annelids at Howick has in some of the layers *Bellerophon*, *Euomphalus*, *Murchisonia*, and *Pleurotomaria*, shells undoubtedly of marine origin.

The group of facts now noticed gives us a partial glimpse into a far distant era. The Beadnell flaggy beds expose to our view an ancient coast-line: we hear the waves breaking on the shore; we perceive currents rolling along masses of sand; the tide recedes, and ripple-marks, long ridges and furrows, sharp and distinct, appear; there, too, are seen worms, some of large size, crawling over the surface or burrowing in the sand. Marks left by the sea are often fugitive,—the impressions made by one tide are obliterated by another; but here they are preserved; the sand and mud are hardened, it may be, by a warm sun breaking forth and baking the surface before the return of the tide; other deposits have covered over the markings, and buried up and preserved the organic forms; and now, when these rocks are laid bare and examined, they reveal to us that the same physical laws operated during the Carboniferous Era as at the present time, and that, though the aspects of vegetation were wonderfully different, and organic life specifically distinct, yet the animals of the period were formed according to the same types, and were subject to like conditions as those now existing.

Before leaving the stratified rocks, allusion may be made to the illustration they afford of changes of physical condition and of oscillations of level. Taking the coal in connexion with the limestone, there is evidence of not less than fourteen changes of level ; as many times, during the period when these rocks were being deposited, the district was clothed with an abundant and marvellous vegetation, —as many times were there alternations of swamps and lakes, of estuaries and lagoons, and of seas sometimes profound, though generally of moderate depth.

A little northward of the basaltic dyke, a narrow crack or fissure of the sandstone contains galena or sulphuret of lead. It runs across the strata from south by east to north by west ; and a branch from it forks off to the north-north-west. The vein seems too small to be worked with advantage. Its position gives probability to the theory that the igneous agency which forced upward the basalt produced also, by sublimation, the ore which is found in the vein.

When viewed from the shore near to Dunstan Square, this basaltic dyke, even to one unacquainted with geological principles, is a striking and interesting object. It rises perpendicularly through the stratified rocks, and runs in a direct line from west 85° south to east 85° north. Its width is twenty-five feet, contracting seaward to twenty feet. It stands in some parts ten feet above the strata, and appears like a wall rudely piled up by Cyclopean builders ; and, although in other parts it is broken down by the waves, its course can be distinctly traced for a considerable distance into the sea. The basalt is of the usual composition, augite and felspar ; but it is finer grained than the larger masses at Ratcheugh and the Farne Islands. The adjacent strata are very slightly altered in position ; but their structural characters are changed. Coal for some distance from it is valueless ; limestone near it will not burn into lime ; and shale and sandstone are indurated. At the point of contact, sandstones, shales, and limestones are much jointed and fissured, and assume the external form of basalt ; on the other hand, the basalt itself becomes calcareous and siliceous. This transference of qualities and the structural changes superinduced are the results of the igneous agency which, by its upward pressure, rent asunder the vast mass of stratified rocks, and then poured the molten basalt into the fissures.