AMENDED SKETCH-MAP OF THE COUNTRY SURROUNDING THE VALE OF PICKERING.

ORDINARY MEETING, MAY 3RD, 1878.

Professor J. MORRIS, F.G.S., President, in the Chair.

The following Donations were announced :—

“Journal of the Society of Arts,” Nos. 1325, 27, 28 ; from that Society.

“Abstract of Proceedings of the Geological Society of London,” Nos. 351-352 ; from that Society.

“Transactions of the Watford Natural History Society,” Vol. i. pt. 9 ; from that Society.

“Annual Report of the Royal Cornwall Polytechnic Society, 1877 ;” from that Society.

“Description de quelques espèces nouvelles de la Craie de l'est du Bassin de Paris,” by Dr. Chas. Barrois ; from the Author.

“Les Sables de Sistenne,” &c., by Dr. Chas. Barrois ; from the Author.

“Note sur les traces de l'époque glaciaire en Bretagne,” by Dr. Chas. Barrois ; from the Author.

The following were elected Members of the Association :—

John Eunson, Esq., F.G.S., F.M.S., &c. ; R. Nuttall, jun., Esq. ; Charles Edward Paget, Esq. ; Philip Edward Vizard, Esq.

The following Paper was read :—

THE YORKSHIRE OOLITES—PART II., SECTION 2. THE CORALLINE OOLITES, CORAL RAG, AND SUPRACORALLINE BEDS.

BY WILFRID H. HUDLESTON, Esq., M.A., F.G.S., &c.

TABLE OF CONTENTS.

Preliminary.	Rag of Langton Wold.
Generalized Scheme.	Fossils.
The Lower Limestones.	Lithology and Silicification.
Extent.	The Supracoralline Beds.
Development.	Physiography, &c.
Lower division.	Lagoon theory.
Upper division.	Faults and Springs of Tabular
Fossils.	Range
The Coralline Oolite Group.	Ditto near Malton.
Middle Calc Grit.	Borings, &c., in Kimmeridge Clay
Coralline Oolite.	Summary (stratigraphical).
“ of Scarborough District.	Palæontology.
“ of Pickering, &c.	Explanation of Table.
“ of the Howardian Hills.	Synonymy.
Fossils.	Cephalopoda.
Lithology.	Gasteropoda.
The Coral Rag.	Conchifera.
General considerations.	Echinodermata, &c.
Rag of the Scarborough District.	Notes on the Fossils figured.
“ of the West.	Table of Fossils.

The introduction to Part ii. of the Yorkshire Oolites,* deals briefly with the whole of the Middle Oolites, including beds of every description, which occur between the top of the Cornbrash and the base of the Kimmeridge Clay. In Part ii. Section 1, a full description of each formation is given, as far as the top of the Lower Calcareous Grit, including the coast exposures at Scar borough and Filey, where the Lower Calcareous Grit is seen to be passing upwards into a group of limestones more or less oolitic.

The present paper, which concludes the series written upon the Yorkshire Oolites, is intended to deal with the subject of these limestones, which everywhere within the area have for their base the Lower Calcareous Grit proper. Barely seen on the coast, they have an extensive development inland, where they are variously known as Coralline Oolite and Coral Rag, and are covered in many places by a series of subcalcareous shales, grits, &c., which are interposed between the top of the Coral Rag and the base of the Kimmeridge Clay.†

Where there exists a series of beds having considerable variety within certain limits, the question of names is always a difficult one. In Yorkshire the Corallian Limestones have usually been called Coralline Oolite, whilst in the South of England Coral Rag is the more frequent term. If we select for the group a petrological distinction of this sort, naming the entire formation after one of its subdivisions, there is always the danger of confounding the part with the whole, to say nothing of the erroneous notions arising from affixing a definite petrological character to beds of considerable variety. Thus an idea has prevailed amongst some that there was no Coral Rag in Yorkshire, although there are far finer displays of this class of rock there than in any part of the South of England. Again, in the North, there are found two very distinct Oolites, forming portions of the Upper and Lower Limestones of Mr. Fox Strangways respectively. We might, it is true,

* Proc. Geol. Assoc., Vol. iv., p. 353.

† It should be borne in mind that the Corallian Limestones as a group, along with their associated underlying and overlying Grits and Shales, are by no means continuously developed throughout England. They may be regarded as the result of a peculiar phase of conditions obtaining locally towards the middle of the Oxford-Kimmeridge stage. It is probable, however, that these conditions would not be without their effects on the contemporaneous clays, as has been pointed out by Professor Seeley.

call the whole "Coralline Oolite," or "Coral Rag," as suits the fancy, and indicate the several subdivisions by letters simply. But for most people this is too abstract a way of dealing with the question, and therefore, even at the risk of some misunderstanding, it is best to make use of names already existing as far as this is practicable, and indicate, in a tabular form, their more exact geological value.

As regards the period assigned to the deposits in question, we are again met by the difficulty of names. I have already expressed the opinion that "the name Corallian must be deemed a mere matter of convenience, not representing a formation in time."* It does, in point of fact, represent somewhat different periods in different districts throughout Europe, and there are fair reasons for presuming that the more northerly Corallian Deposits are the oldest. Such being the case, their chronological import is more than doubtful—it is misleading—and for this reason De Loriol and Pellat† propose to suppress altogether the term "étage corallien." We are thus left with the major divisions, Oxfordian and Kimmeridgian, out of which to construct the geological clock of the White Jura, and we must regard Corallian deposits as pointing to slightly different figures in different places. These are generally in the centre, but with a tendency to advance the lower the latitude. If, therefore, we get rid of the element of time, and view the Corallian Limestones simply as an important, but yet sporadic manifestation of the existence of reef-building corals in the Oxford-Kimmeridge sea, we may use the old names with safety. Moreover, if we construct our geological clock of reliable materials, it will be possible ultimately to assign to each Corallian Deposit of the White Jura throughout Europe its proper position in the chronology of the entire system. Approximately we may regard the lower portions of our area as Oxfordian, whilst the upper portion, representing the sub-zone of *Cidaris florigemma*,‡ and yet higher beds, prefigures to a certain extent the Kimmeridgian fauna as known to us in the South.

* "Proc. Geol. Assoc.," Vol. iv., p. 334.

† "Monog. des ét. sup. de la form. Jur. de Boulogne," Part ii., p. 320.

‡ Mons. Rigaux, of Boulogne-sur-Mer, has expressed his surprise to Mr. Blake that so much importance should be attached to the presence or absence of this fossil. Since this paper was read I have had the good fortune to make Mons. Rigaux' acquaintance during the recent Excursion of the Association, and to hear his views upon the subject. It must be admitted that *Cidaris florigemma* appears to range lower in the Corallian Limestones

With a view of affording at the outset a fair idea of the average development and character of the great belt of Corallian Limestones which partially encircles the Vale of Pickering, a generalized section has been constructed from data obtained chiefly in the interior, as the higher beds are not to be seen upon the coast. It will be perceived in the sequel that the variations are so considerable as to preclude us from doing more than loosely to fit each group into its appropriate place. Treating the subject in this way, we may preserve for each series of Shelly Limestones, Oolites, and Rag-beds their separate individuality, and yet feel sure that we are right in correlating them within certain limits. The varying details of this old sea-bottom, as obtained in the numerous quarries and natural sections, may thus be presented to us with a fidelity which it is impossible to attain in respect of deposits now in course of formation.

The deposits which underlie the Kimmeridge Clay in Yorkshire, may be grouped in descending order as follows :—

Red Grits, Shales, and Argillaceous Limestones, THE SUPRA-CORALLINE BEDS.

Flaggy Shelly Beds, Hard Crystalline Limestones with Corals, and soft Intercoralline Brash, often very fossiliferous, sub-zone of *Cidaris florigemma*, THE CORAL RAG.

Oolites and pasty Limestones, with or without Shell-beds, characterized by multitudes of *Chemnitzia* and *Nerinæa*, Corals rare, THE CORALLINE OOLITE.

A Middle Calcareous Grit in the Tabular Range, included palæontologically with the Coralline Oolite.

Thick masses of Oolite poor in fossils, but with shelly beds sometimes at top, but more especially towards the base, which is an impure limestone, Corals locally, THE LOWER LIMESTONES AND PASSAGE BEDS.

The further subdivisions may be studied in the accompanying Table :—

The two first groups belong, in a certain sense, to the Kimmeridge of the Boulonnais than we have any proof of its doing in this country. In Yorkshire, however, its almost total absence from the Lower Limestones and from the lower division of the Upper Limestones (Coralline Oolite), when contrasted with its abundance in the Coral Rag, makes it a very reliable "leit-fossil" throughout the region described in the present paper.

GENERALIZED SCHEME OF CORALLIAN LIMESTONES AND ASSOCIATED BEDS.

FORMATION.	TOPOGRAPHICAL DIVISIONS AND VARIETIES.	LOCALITIES.	LITHOLOGY—REMARKS.	SOME OF THE CHARACTERISTIC FOSSILS.
A. SUPRACORALLINE 15-40 ft., wanting in places.	1. Upper Calcareous Grit flanking the western part of the Vale of Pickering. 2. Argillo - calcareous beds (Throstler) of the same locality. 3. Argillo - calcareous beds (Cement stones) of the Howardian Hills.	Pickering, Kirkby Moorside, Helmsley, Oswaldkirk. Pickering, Appleton Common, near Kirkby Moorside Hildenley, Burdale, Langton.	Reddish Calc Grits, often cherty, with sometimes marly shales. Dirty earthy Limestones, very unfossiliferous. Hard calcareous bands and soft sub-calcareous Shales.	<i>Belemnites nitidus</i> , Dollf. <i>Am. varicosatus</i> , Buckl. <i>A. alternans</i> , Von Buch. <i>Ostrea bullata</i> , Sow. <i>Gryphaea subgibbosa</i> , Bl. & H. <i>Pecten Midas</i> , D'Orb. <i>Modiola cancellata</i> , Röm. <i>Lucina aspera</i> , Buvig. <i>L. substriata</i> , Röm. <i>Thracia depressa</i> , Phil. <i>Goniomya</i> , <i>Pleuromya</i> , &c.
B. CORAL RAG, sub-zone of <i>Cidaris florigemma</i> . 12-40 ft.	1. Rag of the Scarborough district, without <i>Cidaris florigemma</i> . 2. <i>Florigemma</i> -Rag flanking the western part of the Vale of Pickering, on both sides. 3. <i>Florigemma</i> -Rag of Langton Wold.	Ayton, Brompton, Hackness. Sinnington, near Kirkby Moorside, Helmsley, Oswaldkirk, Slingsby. Hildenley, Langton Wold, North Grimston.	Boulders of <i>Thamnastræa concinna</i> , and branches of <i>Rhabdophyllia</i> in an intercoralline brash. Variety of Corals; often massive, sometimes compact and cherty, rarely oolitic. Compact Limestones; massive Coral Bands, shelly brash, rarely oolitic.	<i>Am. varicosatus</i> (Buckl.) var. of <i>A. plicatilis</i> . <i>Purpurioidea nodulata</i> , Y. & B. <i>Natica globosa</i> , Röm. <i>Cerithium limæforme</i> , Röm. <i>Nerinea Ræmeri</i> , Goldf. <i>Littorina muricata</i> , Sow. <i>Turbo funiculatus</i> , Phil. <i>Ostrea duriuscula</i> , Phil. <i>Pecten vimineus</i> , Sow. <i>Lima pecteniformis</i> , Schlot. <i>Arca quadrisulcata</i> , Sow. <i>Astarte rhomboidalis</i> , Phil. <i>Opis viridunensis</i> , Buvig. <i>Terebratula insignis</i> , Schübl. <i>Cidaris Smithii</i> , Wr. <i>C. florigemma</i> , Phil. <i>Hemicidaris intermedia</i> , Flem. <i>Pseudodiadema hemisphericum</i> , Ag.—CORAL RAG.
C. CORALLINE OOLITE. 20-35 ft.	1. Oolites underlying the Rag of the Scarborough district. 2. <i>Chemnitzia</i> -limestones, compact or suboolitic; impure earthy limestones. <i>Trigonia</i> -beds at base. 3. Oolites of the Howardian Hills in part.	Seamer, Forge Valley, Brompton Keld. Pickering, Kirkdale, Sproxtun, Ampleforth Beacon. Malton, Settrington.	Fine white Oolites, with Coral-shell Beds in the upper part. Usually compact creamy Limestones with sparry Shells, calcareous Pastes with Oolitic granules Clean white Oolites, sometimes a little marly, burnt for lime.	<i>Belemnites abbreviatus</i> , Mill. <i>A. plicatilis</i> , Sow. <i>A. cordatus</i> , Sow. <i>Chemnitzia heddingtonensis</i> , Sow. <i>Nerinea visurgis</i> , auct. <i>Cerithium muricatum</i> , Sow. <i>Pecten intertextus</i> , Röm. <i>Cucullæa corallina</i> , Damon. <i>Trigonia Meriani</i> , Ag. <i>T. perlata</i> , Ag. <i>Lucina aliena</i> , Phil. <i>Astarte Duboisiana</i> , d'Orb. <i>Pygurus Hausmanni</i> , K. & D.—CORALLINE OOLITE.
C ¹ . MIDDLE CALCAREOUS GRIT. 10-45 ft.	The <i>Trigonia</i> -beds at the top of this series in the Pickering district are referred palæontologically to the Coralline Oolite.	Filey Brigg, Pickering, Duncombe Park, Wass Moor. Not proved in the Howardian Hills.	An Arenaceous Calc Grit, sometimes with Shell-beds, where it graduates into the overlying series. Building.	N.B.—The top shell-bed of the Lower Limestones is included with the Coralline Oolite palæontologically.
D. LOWER LIMESTONES. 20-120 ft.	<i>Upper Division</i> . 1. Oolites underlying the M. C. G. of the Tabular Hills. 2. Oolites, sometimes split by a fourth grit, of the Hambleton Hills. 3. Oolites of the Howardian Hills in part. <i>Lower Division</i> . 1. Passage-Beds at base of the Lower Oolite in the eastern districts. 2. Cherty Limestones of the Western districts. 3. Basement Limestones above the L. C. G. of the Howardian Hills.	Scarborough Castle, Lime quarries of Silpho and Suffield, Forge Valley, Thornton, Cropton. Hawby Hill top, Kewick, Cold Kirkby, above Rievaulx. Broughton, Swinton. Scarborough Castle, Hackness (Lower Coral Rag), Filey Brigg, Wydale. Appleton. Brows quarry (Malton).	Small-grained Oolites, frequently rather gritty, much used for lime. Gritty small-grained Oolites, often very impure, quarried for lime and roadstone. Thick-bedded Oolites, formerly much burnt for lime. Coarse gritty Limestones, often ferruginous. The basement beds not well distinguished here. Fig-seedy Limestones, with much grit—building, road stones.	<i>Belemnites abbreviatus</i> , Mill. <i>A. perarmatus</i> , Sow. <i>A. cordatus</i> , Sow. (<i>caecatus</i> .) <i>A. goliathus</i> , d'Orb. <i>Cylindrites elongatus</i> , Phil. <i>Avicula ovalis</i> , Phil. <i>A. expansa</i> , Phil. <i>Pecten fibrosus</i> , Sow. <i>Gervillia aviculoides</i> , Sow. <i>Myacites</i> , <i>Pholadomya</i> . <i>Echinobissus scutatus</i> , Lam. <i>Holætypus</i> . <i>Ammonites Williamsoni</i> , Phil. <i>A. goliathus</i> , d'Orb. <i>Avicula ovalis</i> , Phil. and <i>expansa</i> , Phil. <i>Gervillia aviculoides</i> , Sow. <i>Trigonia clavellata</i> ? Sow. <i>T. triquetra</i> , Von Seeb. <i>T. Snaintonensis</i> , Lyc. <i>Sowerbya triangularis</i> , Phil. <i>Waldheimia buculenta</i> , Sow. <i>W. Hudlestoni</i> , Walk. <i>Terebratula fileyensis</i> , Walk. <i>Rhynch. Thurmanni</i> , Voltz. <i>Glyphea rostrata</i> , Phil. <i>Millerocrinus echinatus</i> , Goldf. <i>Spongia floriceps</i> , Phil.
E. LOWER CALCAREOUS GRIT proper.				

meridgian* subdivision: of these the Coral Rag is richly fossiliferous, and has many features of its own. The Coralline Oolite, or third group has a still more special character, but with a leaning towards the Oxfordian fauna. To this group are assigned the few fossils of the Middle Calc Grit, and for the most part the top shell beds of the Lower Oolite. The fossiliferous beds at the base of the Lower Limestones may be referred, along with the whole of the Lower Calcareous Grit, to the Oxfordian division.

The Lower Calcareous Grit proper has already been fully dealt with in Section 1, together with such portions of the Lower Limestones as may be seen on the coast at Filey and Scarborough. The mass of these Lower Limestones, however, in the Tabular Range, is so important, that I propose to commence with a description of them, adding at the same time such references as may be necessary for the explanation of those portions already described in Part ii., Section 1.

I. THE LOWER LIMESTONES AND PASSAGE BEDS (D).

This group may be defined as a mass of calcareous rock, oolitic in part, of an elliptical shape, the longer axis running E. and W., or in the same direction as the Tabular Hills, where, from the Vale of Thirsk to the German Ocean, the group is largely developed, its eastern termination being on the coast.

The whole of the Limestones of Scarborough Castle Hill above the Ball-beds belong here, as likewise that portion of the Filey section which underlies the Filey Brigg Calcareous Grit (Middle Calc Grit).† At the latter place its altering character and diminishing thickness lead us to suppose that, as an oolitic limestone, it must have had its original termination not far to the S.E. of where that promontory now is. Its *southern* limits are for the most part unknown, as usually where we meet with the Lower Limestones on the slopes of the Tabular Hills, they are seen to be passing underneath higher beds, and are thus lost to sight; and

* It is true that there is not much analogy between the fauna of the Coral Rag and that of the Yorkshire Kimmeridge Clay, but the basement beds of this latter are very little known.

† Cf. Proc. Geol. Assoc., Vol. iv., pp. 396 and 400, and Quart. Jour. Geol. Soc., Vol. xxxiii., pp. 318 and 324. It will be understood, therefore, that the Oolite of Scarborough Castle is the Oolite of the Lower Limestones.

even if this was not the case, they must be cut off, as they are seen to be at Wydale by the great fault which runs at the foot of the Tabular Range. Their possible re-appearance on the opposite side of the Vale of Pickering (Howardian Hills), will be considered subsequently. The *western* limits of the group must be sought in the Hambleton escarpment, overhanging the Vale of Thirsk (without the limits of the sketch-map, Plate iii). On the brow of this escarpment, at a place called Kepwick, 1,000 feet above the level of the sea, a mass of small-grained gritty Oolite, 50ft. thick, and remarkably unfossiliferous, is extensively quarried for lime. The series is here split by a (fourth) grit, for the flaggy oolites on the top of Hambleton Moor (Cold Kirkby, &c.), are somewhat higher in the series than those of Kepwick, which are dying out as we follow them to the south. That the Hambleton Oolite itself also thins rapidly to the south, may be proved.* Therefore there seems reason to suppose that the original limits of this mass of limestone on the S.W. are capable of approximate definition. The *northern* limits of the Lower Limestones are to be sought at varying distances from the edge of the northern escarpment of the Tabular Range.

At Cropton, where this range is much indented and depressed, they appear in full force on the face of the escarpment itself, and thus some of the finest inland sections are obtained. Hence it is evident that we are not anywhere near its original limits at this point; but if we trace the northern boundary still further to the east, there are said to be indications of this limestone thinning out to a feather edge, and this would seem to tally with its known diminution from Forge Valley (Ayton) to Hackness. Its original limits, therefore, on the N.E. are also capable of approximate definition.

The line of maximum thickness along the major axis is not very easy to ascertain, for the same reasons that obscure the southern margin of this group; but it is not improbable that this may be found not far from the roots of the Tabular Hills, though, as we travel from E. to W., the position of this line seems to recede rather further from the edge of the vale. Mr. Fox Strangways considers that the maximum thickness along the N. and S. or shorter

* Quart. Jour. Geol. Soc., Vol. xxxiii., p. 356.

axis of the ellipse, occurs about Kirkby Moorside, where he estimates it at 150ft., nearly all oolite, without much Passage-bed rock. It is on this meridian, therefore, that we might expect to find the oolite of the Lower Limestones again on the opposite or Howardian side of the vale, after suffering the eclipse which all these Corallian beds undergo beneath its enshrouding clays. The usual thickness in the oolite quarries of this formation is about 40ft., often less, seldom more; but it is evident that, where well developed, it attains a greater thickness than any portion of the Upper Limestones (Coralline Oolite and Coral Rag) of the Tabular Range.

On reviewing the evidence as to its extent and development, the body of the Lower Limestones, apart from its interest as a local feature amongst the Corallian Rocks of Yorkshire, seems to afford a good instance of an ovately lenticular mass, principally oolitic, occurring as a sort of swelling in the midst of a great formation of Calcareous Grit. The actual proof, however, of its original shape can only be inferred at present, in consequence of our inability to trace its southern boundary.

Divisions.—A considerable variety of beds have been grouped under the general term Lower Limestones. The basal portions are very gritty, and afford examples of a lithological passage between Calc Grits and Oolites. This is better seen in the Scarborough district, and especially in the two coast sections, than elsewhere; for in the western portion of the Tabular Range, and in the Hambleton escarpment, the type of these basal beds changes, and they, at the same time, become less fossiliferous. Following out the plan adopted in the Generalized Scheme, it will be convenient to place these basal beds by themselves.*

LOWER DIVISION.—1. *Passage-beds at the base of the Lower Oolite in the eastern district.* The details of these beds, as seen on the coast, have been very fully given already in a previous communication (Part ii., Sec. 1.) The ferruginous character of the lower part of the Passage-beds throughout the Scarborough district is a distinguishing feature, and may be noted at Hackness, where there is a very interesting development, including a Lower Coral Rag.

* In the subsequent pages these are spoken of sometimes as the Lower Passage-beds, to distinguish them from the Upper Passage-beds at the base of the Coralline Oolite of Pickering.

SECTION OF CORALLIAN ROCKS AT HACKNESS.

FT. IN.

Upper Limestones.	1. Upper Calcareous Grit, partly <i>in situ</i> , and partly occurring as a fragmentary wash covering the fields to the north of Loffeyhead Heights.		
	2. Upper or true Coral Rag—a crystalline limestone made up of roundheads of <i>Thamnastræa concinna</i>	12	0
	3. The Bell-heads Limestone, or equivalent of the Coralline Oolite, made up of large oolitic granules in a dense greyish paste, and containing towards the centre a strong band of <i>Thecosmilia</i> -rag full of fossils.	18	0
	5. Thin bands of gritty limestones and sandy beds—Middle Calcareous Grit.		
	4. The Lower Oolitic Series. Small-grained oolites towards the centre of the mass with flaggy limestones towards the top and thick-bedded fossiliferous limestones towards the base—the rock of the lime-quarries of Silpho and Suffield.	18	0
LOWER LIMESTONES.	6. Lower Coral Rag: a brown ferruginous coral limestone, with brashy partings and interspaces, having a peculiar set of fossils.	8	0
	7. Basement- or passage-beds: a series of impure, gritty, and rather flaggy limestones, in some places made up of comminuted shelly matter, and generally very ferruginous; quarried for walling and road-mending.	24	0

The fossils of the Lower Coral Rag are numerous and interesting. There are some peculiar forms of *Ostrea*. The list includes *Ostrea*, sp., *O. gregaria*, *O. solitaria*, *Exogyra nana*, *Gryphæa chamaeformis*? *Pecten fibrosus*, *P. articulatus* (dwarf), *Hinnites velatus*, *Lima rudis*, *Lima*, sp., *Trichites*, *Cypricardia* (small), *Astarte rhomboidalis* (small), *Waldheimia Hudlestoni*, *Cidaris Smithii*, *Spongia floriceps*, *Serpula squamosa*. The corals present more variety than might be found in an equal amount of the Upper (true) Coral Rag of the district. *Isastræa explanata*, *Thamnastræa concinna*, *Thecosmilia annularis*, and *Rhabdophyllia Phillipsi*, with the inevitable *Modiola inclusa*, may be seen. The "sandstone" quarry on Suffield Heights is the best place for collecting.

The horizon of this Lower Coral Rag, distinctly traceable both at Scarborough and Filey, though without the corals, is generally marked by *Spongia floriceps*, and numerous small Brachiopods, and, indeed, throughout the eastern districts the shell-beds seem generally to be near this horizon. Hence it is interesting to note how this vertically limited group holds true for some horizontal distance, though a growth of coral in any quantity on this horizon

is now preserved to us at Hackness only. In Forge Valley, which also yields an admirable section of the entire Corallian series, the equivalents of the Scarborough Castle *Gervillia*-beds are poor, but the iron series (Red-beds) tolerably fossiliferous. Proceeding westwards the types begin to change, but we meet with a very rich shell-bed in a quarry at Wydale, about one mile west of Brompton, evidently in the Passage-beds.

* FIG. 14.—QUARRY AT WYDALE—WEST END.

One inch to 25ft. vertical.

- A. Flaggy, suboolitic limestone, sometimes merely a rubble.
- B. Shell-bed, a sandy limestone with very fine-grained oolite.
- C. Block gritty limestones, blue centred. c. soft sands.

Immense quantities of *Gervillia* project from the shell-bed, and with these are associated an interesting group of small *Trigonia* (two species being new), three species of *Astarte*, and all the Brachio-poda found on this horizon. For the list of those actually collected consult the table.

Westwards from this quarry no good places for collecting are known to me in these Passage-beds, though at Cropton they have yielded immense specimens of *Gervillia*.

2. *Cherty Limestones of the western districts.* The eastern type of Passage-beds seems to have died out in this direction, or at least to have become so cherty and unfossiliferous as not to be recognised; and in the Hambleton escarpment no shell-beds of any consequence are seen to mark the series between the Calc Grits and the Oolites. An uninviting formation, as far as my limited acquaintance with it extends.

3. *Passage-beds in the Howardian Hills.* The basement Limestones, which rest immediately upon the Lower Calcareous Grit at Appleton, are good examples of a fossiliferous phase. The stone resembles that in the analogous position at Filey, rather than the

* N.B.—The figures in this paper are numbered according to their order in the entire series of "The Yorkshire Oolites."

Scarborough or northern type, consisting of sandy speckled limestones of considerable hardness, varying from buff to blue. Sometimes the stone looks as if it were partly made up of fig-seeds. The following fossils may be deemed characteristic :—

<i>Ammonites cordatus</i> (excavatus), <i>Sow.</i>	<i>Waldheimia bucculenta</i> , <i>Sow.</i>
<i>A. goliathus</i> , <i>d' Orb.</i>	<i>Rhynchonella Thurmanni</i> , <i>Voltz.</i>
<i>A. perarmatus</i> , <i>Sow.</i>	<i>Glyphea rostrata</i> , <i>Phil.</i>
<i>Pecten fibrosus</i> , <i>Sow.</i>	<i>G. scabrosa</i> , <i>Phil.</i>
<i>Avicula ovalis</i> , <i>Phil.</i>	<i>Echinobrissus scutatus</i> , <i>Lam.</i>
<i>A. expansa</i> , <i>Phil.</i>	<i>Millericrinus echinatus</i> , <i>Goldf.</i>
<i>Trigonia snaintonensis</i> , <i>Lyc.</i>	

UPPER DIVISION.—1. *Oolites* underlying the Middle Calcareous Grit of the Tabular Range. This division constitutes the great bulk of the formation. The Oolite on the summit of Scarborough Castle Hill belongs here, and it may be traced in the numerous natural sections and quarries throughout the Tabular Range, generally at some distance from the edge of the vale. There are but few fossils as a rule, hence the exposures are lacking in interest. *Cylindrites elongata*, *Rhynchonella Thurmanni*, *Gervillia*, and some of the species of the Passage-beds may be noticed sparingly in the eastern divisions. A line of coral growth may also be noted in some of the quarries in the region east of Pickering, whilst, in the western part of the range, the silicification of the lower beds presents us with some interesting examples of oolite turned into flint.

2. In the Hambleton Hills (beyond the sketch map) this oolite of the Lower Limestones is, if possible, still less fossiliferous, as may be gathered from previous remarks with reference to the quarries at Kepwick and on Hambleton Moor, though a closer search might yield more satisfactory results.

3. The possible representatives of the oolite of the Lower Limestones in the Howardian Hills will be treated under the head of Coralline Oolite.

The fauna of the Lower Limestones generally, including, of course, the Passage-beds, is very much that of the Lower Calcareous Grit, making allowance for change of conditions. But it must be admitted that the mass of the rock has been very little searched, and that our knowledge is, in a great measure, limited to those beds which are situated in the eastern portion of the Tabular Range. The central mass contains no shell-beds of consequence in

any portion of the area under description, but towards the middle of the Tabular Range there is a shell-bed of considerable horizontal extent at the top of the series. This is chiefly interesting from the very great change in the fauna, which may be said to prefigure the Coralline Oolite to a certain degree, and for that reason, in the Tables, is included, though not without doubt, in that subdivision. The following fossils have been found in this top bed at three different points, viz., Thornton West, Newtendale, and Sinnington—

Belemnites abbreviatus, *Ammonites cordatus*, *Chemnitzia heddingtonensis*, *Exogyra nana*, *Anomia radiata*, *Pecten lens*, *P. fibrosus*, *Avicula pteropernoides*, *Avicula* cf. *Struckmanni*, *Perna* (large species), *Gervillia aviculoides*, *Trigonia* (clavellate sp.), *Opis Phillipsi*, *Lucina globosa*, *Astarte depressa*, *Homomya tremula*, and *Myacites* sp.

Subjoined is a list of the more common or characteristic fossils of the Lower Limestones, excluding the above-mentioned top-bed :—

<i>Ammonites Williamsoni</i> , <i>Phil.</i>	v. c. <i>Pecten</i> sub-fibrosus, <i>d'Orb.</i>
„ <i>goliathus</i> , <i>d'Orb.</i>	v. c. <i>Exogyra nana</i> , <i>Sow.</i> , includes <i>E. spiralis</i> , <i>Goldf.</i>
„ <i>cordatus</i> , <i>Sow.</i>	<i>Ostrea flabelloides</i> , <i>Lam.</i> (var.)
„ <i>vertebralis</i> , <i>Sow.</i>	<i>Terebratula fileyensis</i> , <i>Walk.</i>
<i>Alaria bispinosa</i> , <i>Phil.</i>	<i>Waldheimia Hudlestoni</i> , <i>Walk.</i>
<i>Pleurotomaria Münsteri</i> , <i>Goldf.</i>	v. c. <i>Rhynchonella Thurmanni</i> , <i>Voltz.</i>
v. c. <i>Cylindrites elongata</i> , <i>Phil.</i>	<i>Cidaris Smithii</i> , <i>Wr.</i> (small).
<i>Goniomya litterata</i> , <i>Sow.</i>	<i>Acrosalenia decorata</i> , <i>Haime.</i>
<i>Myacites</i> , &c., several forms.	<i>Collyrites bicordata</i> , <i>Leske.</i>
c. <i>Astarte extensa</i> , <i>Phil.</i>	(small.)
c. <i>Trigonia clavellata</i> , <i>Sow.</i>	<i>Echinobrissus</i> cf. <i>clunicularis</i>
„ <i>triquetra</i> , <i>Von Seeb.</i>	<i>Lhwyd.</i>
„ <i>snaintonensis</i> , <i>Lyc.</i>	v. c. <i>Echinobrissus scutatus</i> , <i>Lam.</i>
<i>Arca æmula</i> , <i>Phil.</i>	<i>Pygurus pentagonalis</i> , <i>Phil.</i>
v. c. <i>Gervillia aviculoides</i> , <i>Sow.</i>	(small.)
c. <i>Avicula expansa</i> , <i>Phil.</i>	c. <i>Millericrinus echinatus</i> , <i>Goldf.</i>
c. „ <i>ovalis</i> , <i>Sow.</i>	<i>Spongia floriceps</i> , <i>Phil.</i>
<i>Lima læviuscula</i> , <i>Sow.</i> var. c.	
„ <i>gibbosa</i> , <i>Sow.</i>	

The following Corals occur at Hackness in this series :—

<i>Thecosmilia annularis</i> , <i>Flem.</i>	<i>Isastræa explanata</i> , <i>Goldf.</i>
<i>Rhabdophyllia Phillipsi</i> , <i>E. & H.</i>	<i>Thamnastræa concinna</i> , <i>Goldf.</i>

II. GROUP OF THE CORALLINE OOLITE, C¹ & C.

As the Middle Calcareous grit (C¹) is a deposit of very irregular development, consisting for the most part of mechanically derived sediment with but few included fossils, except where it approaches the overlying limestones, it is treated palæontologically as part of the Coralline Oolite (Column ii. of the Table of Fossils). Indeed, as the top bed of the Lower Limestones is included in this subdivision, the Middle Calcareous Grit which separates them must, of necessity, be included also. *A. plicatilis*, along with some of the Cordati, is the prevailing ammonite, nor have I ever seen *A. Williamsoni* or *A. perarmatus*.

Briefly, then, the MIDDLE CALC GRIT (C¹) is a calcareous grit, usually very poor in lime, which, throughout the Tabular Range separates the Lower Limestones (D) from the Upper Limestones (C & B). At Filey, as we have seen, it forms the Brigg itself, still dividing the two shrunken representatives of the calcareous series, but elsewhere, east of the Derwent Gorge (Ayton), its presence is not particularly obvious. Towards the middle of the Tabular Range its thickness reaches from 40-45ft., inclusive of the *Trigonia*-beds. In this region, extending from Thornton, a few miles east of Pickering, to Sinnington, a few miles west of that town, the following relations between this sandy bed and the underlying and overlying limestones were made out approximately by Mr. Blake and myself from three different points, as follows:—

		Impure suboolitic limestones with corals at the base of the Coralline Oolite of Pickering.
MIDDLE CALC GRIT.	{	<i>Trigonia</i> -beds and building stones of the Pickering quarries.
		Building stones—few shells: base of the Pickering quarries.
		Lower part of the Middle Calc Grit seen at Highfields.
		Flaggy calcareous sandstone and hard blue rock slightly oolitic, with <i>A. plicatilis</i> . Highfields
LOWER LIMESTONES.	{	Shell-bed atop of L. L., Highfields—(also at Sinnington, D, Fig. 16).
		Ammonite bed at Whitethorn quarry, near Cropton. <i>A. perarmatus</i> , plentiful. <i>A. cordatus</i> , com. <i>A. goliathus</i> , com. <i>A. plicatilis</i> , rarer.
		Oolite of the Lower Limestones, Cropton.

It would, of course, be more satisfactory to trace a complete sequence in each of the deep valleys which intersect the Tabular Range instead of constructing a sectional sequence from three

different points. But we are not altogether without evidence in this respect, for a complete sequence, as far as the relations of the Middle Calc Grit are concerned, may be seen in the gorge of the Seven between Pickering and Kirkby Moorside. See *postea*, p. 424. It is probable, however, that the thickness of the Middle Calc Grit in Newtondale (Pickering) considerably exceeds that shown in the Seven Valley, where the Lower Limestones, on the other hand, are fully 100ft. thick.

In Duncombe Park, just west of Helmsley, there is a copious development of these Middle Calc Grits. They form the base of the cliff supporting the terrace on which the magnificent residence of the Earls of Feversham is built, and have been quarried to some extent. Here the formation consists of strong blocks, doggers, and soft sands with spongy and fucoidal reliefs. The lower beds are of a soft brownish yellow stone, without a fossil visible; the upper beds are thinner and harder. These same beds in their extension westwards, appear as the loose reddish sands of Wass Moor, which probably have a thickness of 60ft. In the Howardian Hills the equivalents of the Middle Calcareous Grit are not yet determined, if indeed they exist.

We now come to deal with the CORALLINE OOLITE (C) itself. This constitutes the lower subdivision of the Upper Limestones, and is, in fact, the base on which the great mass of coral limestone has been built. In describing its existing extent, it cannot well be separated from the overlying Rag. These two, then, forming the mass of the Upper Limestones, occupy the innermost portion of the belt of rocks which surrounds the Vale of Pickering for three-fourths of its circuit. This fixes the general position of the formation; the topographical details must be sought under the several subdivisions. The same remarks apply to this group as to that of the Lower Limestones, with reference to their disappearance beneath the clays of the Vale of Pickering; only that, in this case, the reappearance of the Coralline Oolite on the opposite or Howardian side, is undoubted, though with considerable change of type.

Both lithologically and palæontologically the Coralline Oolite presents a very great contrast to the Coral Rag. Yet there is no reason to suppose that the two were separated by any very great interval of time, the differences being due principally to physical conditions of deposit: still as the Coralline Oolite almost invariably underlies the Coral Rag, and is not merely intercalated with it, as

oolitic beds and coral beds might be in a large calcareous series, it is evident that the one preceded the other in time, and that each, therefore, is entitled to rank as a sub-formation in the Corallian system of Yorkshire. It should also be observed, in support of the above view, that, although a slight development of coral does take place towards the top of the Pickering *Trigonia*-beds, yet this is for the most part devoid of that peculiar fauna so characteristic of the larger aggregate of corals and coral *débris* called the Rag.

There is no positive evidence that all the beds within the area classed as Coralline Oolite are quite on the same geological horizon.

Whether the differences in the Coralline Oolite are the result of purely lateral variations, or are due to the deposits having been formed at slightly different periods, is a question not easily answered. We may feel pretty certain that every bed of oolite represents the destruction of a bed of coral somewhere in the vicinity. If the bed of coral has been totally destroyed, as seems generally to have been the case, we can merely infer its existence; but sometimes we have a fragment preserved, as already noted in the Lower Coral Rag of Hackness, whose lateral equivalents may be sought in the oolitic shell-beds of Wydale and other places. It so happens that the Upper Limestones are discontinuous in the tract between Brompton and a point about two miles east of Pickering, owing to a slight anticlinal at right angles to the general strike of the beds. The types on either side, both as regards Rag and Oolite, are materially altered. It has sometimes occurred to me that the whole of the Upper Limestones, Oolite and Rag, of the district between Seamer and Brompton, are older than much of the Coralline Oolite of Pickering.

SUBDIVISIONS OF THE CORALLINE OOLITE.—1. *Oolites underlying the Rag of the Scarborough District (Seamer to Brompton)*. The character of these in their fullest extent is best gathered in the gorge at the mouth of Forge Valley (Ayton), where a complete sequence of all the Corallian Rocks can be traced.* The base just above the uncertain representative of the Middle Calc Grit consists of shelly and gritty limestones, with very large *Chemnitzia*, *Astarte Duboisiana*, &c., and to these suc-

* Quart Journ. Geol. Soc., Vol. xxxiii., p. 320.

ceed rather gritty oolites. The upper portion of the series is best judged of in Seamer parish, where the following section may be noted, although the thicknesses vary within short distances.

SECTION OF THE CROSSGATES QUARRY, SEAMER.

		FT. IN.
Coral Rag.	Soil, broken rock, and boulders of <i>Thamnastræa concinna</i> (roundheads)	2 0
	Oolite in a buff pasty matrix, with a bed of <i>Rhabdophyllia</i> at the base	3 0
Oolites and Corals.	Oolite in a buff pasty matrix, with a shell-bed at the base. <i>Nerinea visurgis</i> , <i>Trigonia</i> (costate sp.), <i>Lucina</i> , sp., <i>Astarte Duboisiana</i> , spines of <i>Cidaris Smithii</i> , and a few delicate fingers of <i>Rhabdophyllia</i>	2 8
	Thin clay parting	0 1
	Shelly bed, partially oolitic. <i>Ammonites plicatilis</i> , <i>Nerinea</i> , <i>Lucina</i> , <i>Astarte Duboisiana</i> , many <i>Rhabdophyllia</i> and stray fragments of <i>Thamnastræa</i> . "Snake-bed"	1 4
	Indurated, cemented, large-sized pisolite, with an occasional coral. "The Top Hard."	1 0
The Coral shell-bed.	The Coral shell-bed. A pale grey oolite, rather pasty; shells and corals very sparry. Fragments of <i>Thecosmilia</i> , often prostrate, and principally in the upper portion; <i>Rhabdophyllia</i> ; a few lenticular masses of <i>Thamnastræa</i> towards the base; <i>Pecten fibrosus</i> , <i>Lima rigida</i> , <i>L. densepunctata</i> , <i>L. pectiniformis</i> , <i>Perna rugosa</i> , <i>Trichites</i> , <i>Arca pectinata</i> , spines of <i>Cidaris Smithii</i> , very large; megalomorphic fauna. There is much comminuted shell in this bed. "The Bottom Hard."	2 0
	Rubby pisolite, full of small <i>Exogyra</i>	0 2
Oolites.	Oolitic series, poor in shells, with an occasional brashy parting; excellent lime	6 6
	Rubby pisolite, full of small <i>Exogyra</i> ; contains <i>Echinobrissus scutatus</i> , <i>Phasianella striata</i> , &c., a constant parting	0 6
	Fine-grained oolites, making excellent lime; some of the upper portions of the beds are rather lumpy, owing to casts of <i>Phasianella striata</i> , and to nodules which may represent sponges. There is one moderately shelly bed. <i>Exogyra nana</i> , <i>Pecten fibrosus</i> , <i>Gervillia aviculoides</i> , <i>Trigonia</i> , <i>Lucina</i> , &c., to base of quarry	6 0
		25 3

We here perceive a mere fragment of the Coral Rag of the district which is gradually lost on the rise. The upper part of this section is instructive, as showing an intermediate character. It is, in fact, a Coralline Oolite with Corals, principally the branching species, and contains a series of fossils, such as *Nerinea visurgis*

and *Astarte Duboisiana*, which are so characteristic of the base of the Coralline Oolite at Pickering, whilst here they occur towards the top of the Oolite. The equivalent bed at the Ayton lime-quarry also contains these fossils, but I have never found them in the overlying Rag. The last glimpse of this Oolite is obtained at Brompton Keld, where a little cliff above the spring, surmounted by a grassy slope, discloses about 22 feet of this class of rock.

FIG. 15.—CORALLINE OOLITE AT BROMPTON KELD.

B. Coral Rag (out of sight from the point of view).

C. CORALLINE OOLITE of the Scarborough district.

a. Foundations of Brompton Castle in the Coral Rag at the top of the hill (out of sight).

b. Wall enclosing the Castle garth.

c. Road into the village.

d. The highest spring. e. Pool forming the head of Brompton beck.

The three lowest beds forming the little cliff, are strong blocks of Oolite in paste, one of the beds being slightly fucoidal and sandy. Above these is a *Thecosmilia*-band, which projects in relief from the grassy slope: it may correspond in part to the Coral Shell-bed of the Crossgates Section.

2. *Chemnitzia-Limestones, Oolites, and Trigonia beds of the Pickering and Hambleton Districts.* By far the best exposures of this group occur at Pickering itself. The following generalized section is taken from the Paper by Blake and Hudleston on the Corallian Rocks of England:—*

* Quart. Journal Geol. Soc. Vol. xxii., p. 335, which consult for further details.

*Generalized Section—Pickering (Newtondale).**Upper Division (supracoralline).—Grits, Shales, &c.*

		FT. IN.
A.	a. An Upper Calcareous Grit with abundance of tuberous and ramifying forms and many fossils in bad preservation.	7 0
	b. Sandy and marly shales resting upon a thin bed full of <i>Ostrea</i>	10 0
	c. Bed of argillo-calcareous stone, locally termed "Throstler," wanting in places, or represented by a flaggy parting of a few inches	3 0
		<hr/> 20 0

Middle Division.—Upper Limestones.

B.	d. Top-stone—a grey ferruginous limestone, generally false-bedded. The equivalent of the Coral Rag ...	5 0
		<hr/>
C. and C.	e. Impure earthy limestones, known as "black posts," poor in fossils, but containing <i>Belemnites abbreviatus</i> , and towards the base <i>Ammonites varicosatus</i>	10 0
	f. <i>Chemnitzia</i> -limestones, compact and suboolitic. Shell-beds, at intervals full of <i>Chemnitzia</i> and <i>Nerinea</i> ; <i>Astarte ovata</i> and other bivalves less numerous... ..	20 0
	g. Variable limestones and pisolites, with shell-beds and nests of <i>Thamnastræa arachnoides</i> in the lower part; indications of Calc-Grit towards the base. Roadstones, walling, &c.... ..	13 0
		<hr/>
	CORALLINE OOLITE... ..	43 0
	<i>Lower Division.</i> —Shell-beds and Grits (Middle Calc Grit in part).	
	h. The upper part of this division contains the principal <i>Trigonia</i> -beds, full of fossils alternating with Calc Grits, <i>Ammonites plicatilis</i> abundant. Building stones, walling	17 0
	i. Calc Grits begin to predominate, base not seen. <i>Nautilus hexagonus</i> , <i>Ammonites-cordatus</i> group numerous, &c.	11 0
		<hr/> 28 0

Reference should here be made to the sectional sequence on either side of Newtondale (p. 418), in order to fit this section to the beds below.

Throughout the whole series, from the *Trigonia*-beds well into the Coralline Oolite, ammonites generally referable to *A. plicatilis* are obtained; these sometimes attain enormous dimensions. Attention should be drawn to the abundance of corals in the base of

group *g*, unassociated with the Rag-urchins, which, with the *Mya*-*cidæ* and *Anatinadæ* seem, throughout the section, to be wanting.

Proceeding westwards along the margin of the Vale we obtain an excellent section in the Gorge of the Seveñ at Sinnington, which affords a good opportunity for comparison with that at Pickering, and is also useful as showing the exact relations of the Middle Calc Grit to the underlying and overlying limestones.

FIG. 16.—SINNINGTON SECTION.

Length 230 yards—actual dip about 5°.

Details of the beds.

	FT. IN.	FT. IN.
α. Soil, rainwash, and clay at the fault ...		4 0
A. Upper Calcareous Grit, consisting of (1) "Red beds" (<i>a</i> of the Pickering Section), (2) a band of hard blue rock, and (3) shaly sands, base not seen ... about		18 0
B. 1. Coral Rag, with plenty of <i>Cidaris florigemma</i> in the lower block, at the fault	13 0	
2. <i>Rhabdophyllia</i> -bed. The upper part is very full of small branches. This is the equivalent of the Coral shell-beds of other places... ..	2 3	15 3
C. CORALLINE OOLITE.		
a. Comparatively unfossiliferous lime- stone, the lower portion impure and dirty (<i>e</i> of the Pickering section) ...	11 0	
b. <i>Chemnitzia</i> -limestones. The great shell-bed at the top is charged with <i>Chemnitzia heddingtonensis</i> , <i>Nerinea</i> sp., <i>Astarte ovata</i> , <i>Lucina globosa</i> , &c. Noted also <i>Ech. scutatus</i> . (<i>f</i> and part of <i>g</i> of Pickering section) ...	17 9	
c. Impure bluish limestones, with a line of scattered pisolite. (remainder of <i>g</i> of Pickering section)	6 0	34 9
C1. <i>Trigonia</i> -beds and Middle Grit (<i>h</i> and <i>i</i> of Pickering section plus the remainder of the Middle Calcareous Grit)... ..		34 0
D. Top of the Lower Limestone series ...		5 0
		<hr/> 111 0

Upper Limestones, Middle Division
of Pickering

As the quarried face is an old one, there are not those opportunities for obtaining fossils which the immense works at Pickering present. Other difficulties also exist in the way of a thorough investigation, such as the chance of breaking one's neck in endeavouring to examine the tempting arabesques presented by the weathered surface of the *Trigonia*-beds. Enough, however, may be seen to render it probable that they are extremely rich, whilst the upper portions of the Coralline Oolite appear less so. It is a circumstance worthy of note, that a spine of *Cidaris florigemma* was found in one of these *Trigonia*-beds, born, as it were, before its time.

Still continuing along the margin of the Vale, the next gorge is at the mouth of Hodgebeck, between Kirkby Moorside and Helmsley. At the ford on the old road, the *Trigonia*-beds form the floor of the river, which is generally dry except in rainy weather. The general sequence is not so well seen as at Sinnington and Pickering, and it is probable that the minor subdivisions are beginning to vary. The "black posts" for instance (*e* of the Pickering Section, *C a* of the Sinnington Section), are assuming greater importance. The base bed of this group, called by the workmen at Pickering "hilly and holey," is the cave line throughout the district, and it is on this line, about 35ft. above the ford, that the celebrated Kirkdale Cave occurs. It is well known that most of the rivers hereabouts "swallow," *i.e.*, run underground at certain points, as their predecessors seem to have done at a higher level, of which this cave now presents an example. The explanation is that such beds present a hummocky surface of hard impure limestone difficult of solution, with interspaces filled in by a soft limestone brash, which is readily disintegrated both chemically and mechanically by the action of running water. The origin of the peculiar rock called "black posts," as also of "throstler," though in some way connected with Coral, is not quite clear, the fossil evidence having been more or less melted up by some powerful action; but this subject is connected with the general lithology of the Coral Rag.

These types of the Coralline Oolite of the Tabular range may be traced to some extent into the neighbourhood of Helmsley, but before they reach the southern flank of the Hambleton massive, at Oswaldkirk, they are already changed; the *Trigonia*-beds have entirely disappeared, there is no Middle Grit, and no Lower Limestones as in any way separated from the Upper Limestones.

3. *Oolites of the Howardian Hills.* A portion of these may

belong to the Lower Limestones, but in the absence of absolute proof, they naturally fall into this subdivision. As the Oolites of Malton and the adjacent villages are largely developed, and have at times been extensively wrought, they may be taken as typical of the group. A little attention to topography is necessary, and the requisite information may be derived from an inspection of the accompanying Map.

FIG. 17.—CONTOUR MAP OF THE COUNTRY ROUND MALTON.

Scale 1 inch to a mile.

- A. Limekiln Tavern quarry—Oolite,
- BB. Quarries on the high side of the "Street"—Oolite.
- C. Disused quarry—Gritty Limestones betwixt two oolites.
- D. Cross-roads quarry, Peasy Hills—Oolite with capping of Rag.
- E. Highfield Road, or Old Malton quarry—Oolite with capping of Rag.
- F. Pye-pits quarry—Oolite with capping of Rag.
- G. Whitewall quarry—Oolite and Rag.
- H. Brows quarry—L. C. G. and Passage-beds.
- I. Lyon's pit—L. C. G. and Passage-beds.
- J. Quarry on Hildenley Heights—Coral Rag.
- K. Hildenley brickyard—Kimmeridge Clay.

} according to the
general belief.

N.B.—The 100ft. contour line which encloses the quarries D and F, does not cross the Middle Fault as shown above, see pp. 450 and 451.

The terminal promontory of the Howardians west of the river Derwent, is a mass of Corallian rock, chiefly Oolite, flanked on either side by Kimmeridge Clay. Along the northern escarpment the rock generally makes its appearance about the 100ft contour; but in the town of Malton, just opposite the most easterly of the two bridges, the rock comes down in a steep face almost to the level of the river, here about 50 ft. above the sea. The principal Oolite quarries are, firstly, in the neighbourhood of Swinton—A, BB; secondly, in the peninsula between Malton and the village of Old Malton, D, E, F. Upon these latter there is a thin capping of Rag, so that the surface is formed by this class of rock, but the mass of the elevation consists of oolite, as is very plainly shown in the railway cutting and the three last-mentioned quarries. In the southern escarpment what is generally believed to be the Lower Calcareous Grit is worked at the Brows quarry H on the northern side of the Middle Fault.

In the neighbourhood of Swinton, the northern escarpment shows at least 60ft. of Oolite, and though the Passage-beds are not actually exposed in any section on this side within the limits of the Map, we may be certain that they underlie this Oolite. The sequence upwards is not so easy to trace, but there is no Coral Rag at the top. On the other hand, the Oolite in the eastern peninsula, between Malton and Old Malton, is clearly seen to immediately underlie the Coral Rag, whilst the descending sequence is more or less a matter for conjecture.

There are, therefore, two Oolites in the neighbourhood of Malton, occurring under different circumstances, and it is just possible that the one resting on the Passage-beds in the neighbourhood of Swinton may represent, to a certain extent, the Oolite of the Lower Limestones. Hitherto I have been unable to trace the stratigraphical relations of the two Oolites with certainty, but when they are closely examined a considerable difference is observed in their form and general character. Whether this is due to slight difference in age, or merely to lateral variation, remains yet to be proved. As the fossils of both have been long ago hopelessly mingled in collections, they are all placed in Column II. of the Table of Fossils, under the heading of Coralline Oolite. A comparison of the two following sections, one from each group of Oolite, may afford some insight into the nature of the differences :—

SECTION AT THE LIMEKILN TAVERN QUARRIES (A & B), SWINTON,							FT. IN.
Highside of road—							
Small-grained rubbly oolites in beds of 18-24 in., with brashy partings. <i>Ech. scutatus</i> , <i>P. fibrosus</i> , <i>Avicula ovalis</i> , <i>Myacites</i> in bad preservation							14 0
Lowside of road—							
Oolite and brash, sometimes false-bedded, with a few shells ...							8 0
Oolite very full of fossils, mostly small; <i>Cerithium muricatum</i> , c., <i>C. limaforme</i> , r., <i>Nerinea Rameri</i> , c., <i>Cylindrites</i> , r., <i>P. fibrosus</i> , <i>P. lens</i> , <i>Lima gibbosa</i> (juv.), <i>Avicula ovalis</i> (fine), <i>Lucina globosa</i> , c., <i>Astarte depressa</i> , <i>Opis corallina</i> or <i>Phillipsi</i> , c., <i>Sowerbya triangularis</i> , c.							2 6
Oolites and brash, with beds of small shells; fauna nearly as above, but more scanty... ..							17 0
Hard oolitic limestones and brash with <i>Ech. scutatus</i> and <i>Cylindrites</i> numerous							5 6
Paste with Oolite in thick blocks, and wider brash partings, few fossils							9 0
							<hr/> 56 0

The beds dip about 5° at the low end of the bottom quarry, away from the great fault near the base of the escarpment, recover to about 2° nearer the road, and are nearly level in the top quarry. South of this the ground continues to rise, but affords little opportunity for estimating the further development of this series.

The numerous quarries, B, B, B, exhibit a class of rock similar to the upper beds of this quarry.

For the purpose of comparing the oolite east of Malton with the above, the quarry at D is selected.

SECTION AT THE CROSS-ROADS QUARRY, PEASY HILLS.										FT. IN.
CORALLINE CORAL OOLITE.	{	a. Soil. Brash, which is coralline, and contains spines of <i>Cidaris florigemma</i>								7 0
		b. White oolite, not very fossiliferous								13 0
		c. { Shelly oolites... ..								9 0
		{ Compact fine-grained oolites... ..								2 6
		In an adjoining quarry								6 6
										<hr/> 38 0

b. A clean white oolite, with very little paste. The ova are of medium size, regular, distinct, and usually free from shell-fragments; not many shells are to be seen. These oolites have a fauna somewhat approaching that of the Rag; and this may partly serve to account for the very mixed character of the fossils which come from the Malton district in an undoubtedly oolite matrix. *Phasianella striata* is plentiful towards the bottom. In an adjoining quarry this group has yielded some remarkable coniferous fruits.

c. These are the regular *Chemnitzia*-beds of the Coralline Oolite, and, in this quarry at least, contain the bulk of the fossils. The uppermost bed is a regular "rabbit-eye," i.e., a mass of *Chemnitzia heddingtonensis* in transverse section—along with other shells. The principal shell-bed is thus at the top of the series, as seems frequently to be the case throughout the oolitic formations. This group is less oolitic than the overlying one; and the sedimentary impurities appear to be rather greater. The fossils most obvious on the weathered surfaces are *Chemnitzia heddingtonensis*, *Nerinea Ræmeri*, *Astarte ovata*, *Lucina aliena*, *L. oculus*, Bl. & H.; the less frequent are *Ammonites plicatilis*, *Cerithium muricatum*, *Phasianella striata*, *Pecten lens*, *Lima læviuscula* (type form), *Cucullæa* (small sp.), *Cyprina corallina*, &c.

This quarry and the two adjoining ones have furnished a large proportion of the genuine Malton fossils. Their fauna is obviously different from that of the Swinton oolites, but resembles, in many respects, that of the Coralline Oolite of Pickering above the *Trigonia*-beds. If geologists should consider these differences to be due to mere lateral variations, no further explanation is required; but if the differences are allowed to be connected with the age of the beds, one might be disposed to refer the Swinton oolites to the Lower Limestones, those of East Malton to the Upper Limestones. Still some further confirmation of this view might be desirable, where no stratigraphical sequence has yet been traced.

The disused quarry (C) below Middlecave, where we have a series of "Passage-beds" sandwiched betwixt two oolites, seems to supply us with a clue.

FIG. 18.—PROFILE OF OLD QUARRY NEAR MIDDLECAVE.

a. Oolite, rubbly and fragmentary, but increasing on the dip. ? Upper Oolite.

b. Alternations of hard bands of oolitic Calc-Grit, with large-grained softish Oolites. *Ech. scutatus*.

c. Two hard bands of gritty large-grained Oolite, separated by a red sand of variable thickness. The lower portion of the second block is a mass of shells, often of large size, in a sort of Passage-bed matrix. A splendid list is made from here, including *A. plicatilis*, *Chemnitzia heddingtonensis*, *Lima læviuscula*, *Pecten intertextus*, *Avicula ovalis*, *Gervillia aviculoides*, *Trigonia Meriani*, *Trigonia* (clavellate), *Cypricardia isocardina*, and fragments of *Thamnastræa*, *Rhabdophyllia*, and numerous *Pholadomya*.

d. Brashy Line.

e. Oolite, at base of quarry, without fossils. ? Lower Oolite.

If we could persuade ourselves that these really are the oolites of the Upper and Lower Limestones respectively,* and that we have a faint repetition of the Middle Calc Grit in this section, it would be gratifying to such of us as may be desirous of establishing some correlation between the Corallian rocks of the Tabular and Howardian Hills. Unfortunately, in this case, the shell-bed, with *Trigonia*, is at the bottom instead of the top of the gritty series, and with some resemblance there is also considerable difference between this fauna and that of the Pickering *Trigonia*-beds. That the Oolite, *e*, has suffered some denudation previous to the deposition of the overlying beds, is almost certain, as a thorough change of conditions must have ensued before a rich shell-bed could be laid down on the top of an unfossiliferous oolite. True, it may be a purely local bed which is thus seen for a limited space to divide the Coralline Oolites of Malton, but this point, along with many others, must be left for the present.

Fossil Contents. The full fauna of the Coralline Oolite must be gathered from Column II. of the Table, but the following short list shows the common, or characteristic species. The quarries at Malton and Pickering have yielded the bulk of the fossils:—

CORALLINE OOLITE—COMMON OR CHARACTERISTIC FOSSILS.

Belemnites abbreviatus, <i>Mill.</i>	Cucullæa corallina, <i>Damon.</i>
Ammonites plicatilis, <i>Sow.</i>	Modiola subæquiplicata, <i>Goldf.</i>
v.c. Chemnitzia heddingtonensis, <i>Sow.</i>	Trichites Plotii, <i>Lhwyd.</i>
Cerithium muricatum, <i>Sow.</i>	Gervillia aviculoides, <i>Sow.</i>
Nerinaa visurgis, <i>Auct.</i>	Lima læviuscula, <i>Sow.</i> (type.)
„ Rømeri, <i>Goldf.</i>	„ rigida, <i>Sow.</i>
Myacites decurtatus, <i>Phil.</i>	„ elliptica, <i>Whiteaves.</i>
„ recurvus, <i>Phil.</i>	Pecten lens, <i>Sow.</i>
Pholadomya decemcostata, <i>Ræm.</i>	„ vimineus, <i>Sow.</i>
„ parvicosta, <i>Ag.</i>	„ intertextus, <i>Ræm.</i>
Quenstedtia lævigata, <i>Phil.</i>	„ fibrosus, <i>Sow.</i>
Astarte ovata, <i>Smith.</i>	„ inæquicostatus, <i>Phil.</i>
„ Duboisiana, <i>d'Orb.</i>	Anomia radiata, <i>Phil.</i>
v.c. Lucina aliena, <i>Phil.</i>	Exogyra nana, <i>Sow.</i>
„ ampliata, <i>Phil.</i>	Pygurus pentagonalis, <i>Phil.</i>
Corbis lævis, <i>Sow.</i>	„ Hausmanni, <i>K. & D.</i>
„ Buvignieri, <i>Desh.</i>	Pygaster umbrella, <i>Ag.</i>
Trigonia Meriani, <i>Ag.</i>	Carpolithes conicus, <i>L. & H.</i>
v.c. „ perlata, <i>Ag.</i>	

* This view was adopted with reservation in constructing Column XI. of the Table of Comparative Sections in the "Corallian Rocks of England:" it is certain that the thickness of the lower of the two Oolites was under-estimated on that occasion.—W. H. H.

Lithology. If we exclude such exceptional beds as the "black posts" of Pickering, the Coralline Oolite may be said to have two petrological types, the oolitic and the pasty, and its rocks are, for the most part, mixtures of these in varying proportions. Corals are usually rare. The oolitic granule is, as a rule, larger than that of the Lower Limestones. The pasty variety sometimes becomes very hard, and, in fact, appears as a dense creamy limestone, like that of group *f* at Pickering. This seems to have been the result of finely-ground coral mud, which has produced these calcareous pastes with oolitic grains, in some cases so closely cementing the shells and other organic fragments as to form rocks with a fracture almost like flint. The physical history of such beds seems to have been this:—The coral is being perpetually ground down to the finest powder, which is held suspended in the sea like ordinary sediment; but as it falls towards the bottom, it encounters an acid stratum of water, due to the quantity of carbonic acid generated by the decomposition of organic matter and the respiration of animals. This slightly attacks the calcareous sediment and forms the usual soluble bicarbonate, which is again precipitated as calcic carbonate amongst the interspaces of the slowly settling mud, thus cementing the whole into a mass of most compact rock, and gluing up all the shells.

From this type of rock, to a regular oolite with very little paste, there is every gradation. The Malton rocks, on the whole, contain the greater proportion of oolite.

It is difficult to avoid speculating upon the causes which have produced these granular rocks, so characteristic in this country of the Jurassic formations above the Lias. The evidence appears pretty conclusive that the structure is the result of original deposit, and that the subsequent modifications, though important, are yet of a subordinate character, being, in fact, nothing more than a sort of alteration, such as goes on in nearly all limestones. The connection of oolite with corals has long been noted, and since the physical features which accompany the modern formation of coral have been so elaborately described by Dana and others, we arrive at the conclusion that oolite is, for the most part, *granulated coral mud*.* The finely-ground pulp, such as that producing the rock previously described, is associated with larger particles, which are

* Dana, on "Corals and Coral Islands," p. 152 *et seq.* There are, of course, other causes, unconnected with coral, which have produced an oolitic structure in rocks, though not perhaps on so extensive a scale.

the result of cementation through the alternate moistening and drying of the mud, assisted by the small quantity of soluble lime carbonate in the slightly acidulated fluid. This alternate wetting and drying between wind and water, adds a new layer to the surface of each grain, so that the process is one of granulation and concretion going on almost simultaneously. This takes place at the edge of the parent reef, and sometimes the reef itself is covered by similar drift accumulations which are cemented into a solid rock having an oolitic structure.

Some of the intercoralline beds of the Rag most probably represent these shore and drift accumulations, which have been preserved along with the coral whose partial destruction produced them. But the origin of the Coralline Oolite must have been different. This in Yorkshire always forms the basement rock, and therefore could never have been derived from the Coral, now forming the Rag, which grew upon it. There may be some plausibility in the view that Oolite and Rag were forming simultaneously in different localities, and that the oolite of one district is the *débris* of part of the Rag of another. Thus arises the question—Do any of the reefs which contributed to the formation of the Coralline Oolite of one part of the Yorkshire area exist as Coral Rag in another part?

The annexed hypothetical sketch is intended to show the probable action which went on at the time :—

FIG. 19.—FORMATION OF OOLITE.

A is a reef sufficiently high to be ground by the waves, and where coral mud and sand, *a*, are forming. Part of this is retained about the reef as beach and wind drift accumulation. But a portion is carried away just as sand or mud of any other kind, and is distributed over an area of deposit, *a*¹, which may be taken to represent a bank or lenticular mass in the course of formation. This would consist of just such a varying aggregate of paste and oolite as we have in the Coralline Oolite of Yorkshire. When the

bathymetrical and other conditions became suitable, a fresh reef representing the Coral Rag, *B*, grew upon the platform thus produced, and would in its turn be attacked by the waves. An indefinite distance separates *A* from *B*.

That something of this kind took place can hardly be doubted, and thus we arrive at the original proposition that a bed of oolite is the result of a pre-existing coral bank; but whether such coral bank was contemporary with any portion of the existing Coral Rag, or formed part of a slightly antecedent series, now wholly destroyed, is a question not easily answered. It seems to me that the several beds of which the Coralline Oolite itself is composed were laid down, and had in many cases been partly denuded before the Coral Rag, as now preserved to us, was commenced. The sudden change in the character of the rock, as shown in the quarries at Malton* and elsewhere, proves this.

Although it may be deduced from the above considerations that oolitic structure is largely due, in the first instance, to the formation of coral sand, the subsequent alteration of the oolitic granules is no doubt considerable. Some oolitic rocks are too soft for making thin sections; but, not to multiply examples, let us take a sound oolitic freestone as the type. This is one where the paste has become calcitic, and therefore each section of a granule stands out as a partially opaque disc in a crystalline ground mass. It is easy to perceive that there is much variety, but setting aside such interior fragments as sponge spicules, ground urchin spines, &c., which have formed centres, the bulk of the discs are without foreign matter as nuclei. They are of several shapes, but oval may be taken as the average. The interior consists of an inner circle of very fine granular matter, and an outer circle of concentric rings, having a radial or fibrous structure, and consisting partly of calcitic and partly of granular matter. Sometimes a granule has been made up by the coalescing of two or more, and sometimes, perhaps, this appearance is due to the primary nucleus having been a tri-radiate spicule. Very fine fragments of quartzose sand are also noticeable, usually outside the granule. Moreover, there are a number of discs, which either never had or have lost their outer rings. On the whole, there is

* See Section at the Cross-roads Quarry (D) p. 423.

nothing which militates against the view previously expressed as to the primary cause of the granulation, but, on the contrary, the changes are just what one would expect to take place in a rock whose chemical composition causes it to be so assailable by acids, and whose structure is expressly calculated to promote the circulation of fluids.

III. THE CORAL RAG (B).

The petrological contrast between the Coral Rag and the Coralline Oolite is more marked, perhaps, in some districts than in others, but in most cases an observer could hardly fail to be struck with it. Instead of the monotonous appearance of the oolite in those quarries where the shell-beds are poor, there is generally something very fascinating in a weathered face of Coral Rag, especially if it be formed of branching coral, loaded with shells, and spines of urchins, such as may be seen to perfection about Oswaldkirk, Slingsby, and other localities in the west. And even the more massive Thamnastræan Rag, with its undulating layers and bluff terminations, has its picturesque characters, though usually very barren ground for the fossil hunter. But the Rag is not made up entirely of coral: much is composed of fine coral mud, rarely oolitic, forming an intercoralline mixture, sometimes soft and slightly chalky,* sometimes hard and calcitic. This holds the bulk of the shells, which are often in a highly crystalline condition, and make splendid cabinet specimens, when they can be extracted without fracture—a rare occurrence. When oolitic structure is developed in this group of beds, the granules are usually large, irregularly pisolitic and lumpy. Great quantities of such rock, associated with masses of oysters, serve to swell out the bulk of the Coral Rag on Langton Wold and elsewhere, and in these higher beds *Cidaris florigemma* becomes much scarcer. It is probable, therefore, that the extra thickness of this subformation on Langton Wold is due to the preservation of beds which may have been denuded off in other districts.

The fauna differs materially from that of the Coralline Oolite, and this, no doubt, is partly due to difference in the conditions of deposit, but yet not wholly so. It should be remembered that

* The coral mud never forms "chalk."

there are in the Tabular Range three horizons where corals may be noted, viz:—

Limited Coral
growths in
lower forma-
tions, | { | 1. THE CORAL RAG, or subzone of <i>Cidaris florigemma</i> .
2. The Coral band in the base of the Coralline Oolite at Pickering.
3. The Coral band at Hackness. Towards the base of the Lower Limestones—of some extent. |
|---|---|---|

The first contains a rich and characteristic fauna, and is remarkable for the profusion of mammilated urchins, especially of *Cidaris florigemma*, and is of great extent: the two latter do not contain that fauna, and are destitute of the characteristic urchin.

Hence we are justified, to a certain extent, in assuming that the difference between the Coral Rag and these limited Coral growths of the underlying formations is due to the lapse of time, and to the changes wrought within the area by the accumulation of so much calcareous matter and its concomitants, and that the differences, therefore, between the Coral Rag and the Coralline Oolite are not due to the difference of a *facies* merely, but are also partly the results of a more advanced age. We can imagine that the fauna of the true *florigemma*-Rag was being slightly modified from the Upper Oxfordian forms in those very reefs whose destruction produced the bulk of the Coralline Oolite.

One difficulty remains to be encountered—*Cidaris florigemma* is made the “leit-fossil” of the Coral Rag, and yet it is not found in the Seamer-Brompton division of it. *Cidaris Smithii*, which appears to have a greater range in time, occurs together with many of the beautiful univalves characteristic of the *florigemma*-Rag elsewhere. For these reasons it is not separated, but there is just the possibility that this Rag of the Scarborough district should be placed in alignment with the Coral band in the base of the Coralline Oolite at Pickering.

TOPOGRAPHICAL DIVISIONS OF THE CORAL RAG.—1. *Rag without Cidaris florigemma of the Scarborough District.*—About $1\frac{1}{2}$ mile N.W. of the quarry at Seamer, already described, are the Ayton quarries, which, being within an easy walk from Scarborough, have yielded collectors some very fine fossils. The junction of the Rag with the underlying oolite is well shown here. See sketch annexed.

Fig. 20.—AYTON QUARRY (SCARBOROUGH ROAD.)

A. Loose Doggers and masses of *Thamnastræa concinna* in an ochreous marl; occasional branches of *Rhabdophyllia*.

B. The hard undulating masses of A seem to cushion themselves in the soft yielding brash of B, which is a very variable bed, being sometimes a hard flaggy shell limestone, as in the left of the section, and sometimes a soft brash, full of large *Phasianellæ* along with coral doggers and many other fossils, as may be gathered from the annexed sketch (Fig. 21), which was drawn strictly from nature. This bed is intercoralline in its character,

Fig. 21.—PORTION OF B. ENLARGED.

and belongs to the Rag, though the division between it and C is not always clear.

(A and B, constituting the CORAL RAG, have a thickness of 8 or 9ft.)

C. Oolite with two shell-beds. *Nerinea visurgis* and *Astarte Duboisiana* (fine). *Gervillia aviculoides*.

D. Oolites forming the base of the quarry. N.B.—As no more than 9 or 10 feet of oolite is visible in this quarry we may suppose, judging from its thickness in the Seamer Quarry (page 421), that only the uppermost beds are here exposed.

The working face of this group of quarries changes from year to year; the beds dip in rolls at a considerable angle towards the south, in which direction there were some very large pits, now filled in, where the Rag is much thicker than it is in the present quarry.

There are some good exposures in Ayton village, and at several points between that village and Brompton. At the latter, the old castle above the Keld (see Fig. 15, p. 422), had its foundations in this Rag, which, in this division, is nowhere capped by Upper Calcareous Grit, except in the outlier at Hackness. The actual continuity of this Rag at all points along the edge of the vale, cannot be proved. But it has been felt beneath the drift at the Cayton Waterworks, some distance to the east of Seamer, and it is at least probable that there is a continuous* belt as far west as Brompton.

2. *Florigemma-Rag of the Western Half of the Vale.* This topographical section of the Coral Rag is observed to extend along the inner rim, in a sweep from the quarry at Hagg House— $1\frac{1}{2}$ mile east of Pickering—to the neighbourhood of Slingsby—two miles east of Hovingham. There is, in this long semi-ellipse of beds, great variety, both as to development and thickness. The following is the section in the quarry above-mentioned where the Upper Limestones are again picked up after their loss near Brompton:—

QUARRY NEAR HAGG HOUSE, IN THE UPPER LIMESTONES.

Corresponding in Pickering Section.		FT. IN.
a.	1. Upper Calcareous Grit, fossiliferous ...	6 0
b.	2. Argillaceous marly layers	2 0
d.	3. Dense ferruginous limestone in irregular lumps—the equivalent of the CORAL RAG	0 6
	4. Oolite—few fossils	6 6
e.	5. Dense and sometimes earthy limestones, with some oolitic granules—few fossils...	12 0
f.	6. <i>Chemnitzia</i> -limestones to base of quarry.	
		<hr/> 27 0

The equivalent of the Rag here contains a mass of fossils glued together in a dense ferruginous limestone with hard cores, indicative of its coral origin. The following, in very bad condition, were

* *i.e.* Continuous, except for the breaks produced by more recent denudation, such as the present river gorges.

noted—*Natica*, *Nerinea*, *Chemnitzia*, *Phasianella striata*, *Lima pectiniformis*, *Perna mytiloides*, *Arca quadrisulcata*, *Exogyra nana*, *Cidaris florigemma* (spines).

Here we seem to catch a glimpse of the edge of an original basin of deposit, and have, in bed 3, the thin end of a coral conglomerate, contemporary with the fine masses of coral observed *in situ* to the westward. In the principal quarries at Pickering, the Coral Rag makes a poor show (see Section p. 423), but on reaching the Gorge of the Seven we observe the more typical development (Section Fig. 16). Further west, in the neighbourhood of Kirkby Moorside, there is again some change in the type, and there are evidences of its blending, to a certain extent, with the dirty argillaceous limestones, known at Pickering as "Throstler," which there are sharply separated from the equivalents of the Coral Rag, and form part of the Supracoralline beds. On both sides of the synclinal at Helmsley, good exposures are to be obtained, but the upper part of the series there is frequently poor in coral, presenting the appearance of fine-grained siliceous limestones, such as may be seen in the quarry on the York Road.

At Oswaldkirk the Coral Rag attains its maximum thickness hereabouts towards the east end of the village, where there is a face of probably not less than 22 feet. In the Birch-House quarry it forms a bold precipice, weathering in large, swelling, rounded masses, which exhibit much *Thamnastræa* and *Thecosmilia*, with profusion of spines of *Cidaris florigemma*, plenty of *Ostrea nana*, *Pecten vimineus*, &c. Throughout the village, wherever there is an exposure, we note the usual intercoralline beds, which tend to swell out the Rag. In the softer portions of such beds *Terebratula insignis* is not unfrequent. In some places the upper surface is so extremely uneven as to suggest the idea of unconformability with the succeeding formation; but this is no doubt due to the fissuring and shifting of a more recent date, as we find the hollows filled in with Upper Calcareous Grit in a tumbled and fragmentary condition, showing that it too was deposited and consolidated before such fissures were formed. In the Nunnington cutting, $1\frac{1}{2}$ mile to the east, the Coral Rag, even including the Coral Shell-bed at the base, is barely 12 feet thick, but affords a good opportunity for collecting. On the whole, the Coral Rag of the Oswaldkirk district, especially about Nunnington, is rendered very interesting by

the quantity of *Thecosmilia* which it contains, and also by the profusion of spines of *Cidaris florigemma*. The varieties of Coral are perhaps more considerable than is generally the case in Yorkshire, as we frequently meet with *Montlivaltia dispar* and *Stylina tubulifera*, besides the more common reef-building forms: in these respects it differs much from the *Cidaris-Smithii* Rag of Seamer-Brompton, chiefly remarkable for *Thamnastræa concinna* and *Rhabdophyllia*.

A similar type for the most part prevails on the opposite side of the Gilling valley, as far as Slingsby, a village between Hovingham and Appleton. Thence, with the exception of a peculiar phase of Coral Rag at Hildenley, and a very thin cap on the promontory on the east side of Malton, there is no further exposure of this class of rock in the Howardian Hills west of the Derwent.

3. *Florigemma-Rag of Langton Wold*. The northern slope of this well-marked ridge, facing the Coralline peninsula of Malton (see Map, Fig. 17), contains several quarries, mostly in softish oolite, with sometimes a moderate development of Rag at the top. The quarry at Whitewall—*G* of the Map—is of this character. The Rag there is tolerably fossiliferous, and is noted for fine specimens of *Terebratula insignis*. The crest of the hill is kept entirely by Coral Rag, which falls over to the southward with a sharp dip, forming a ridge, including the outlier of North Grimston, of nearly five miles in length. The thickness varies, but where the dip and slope are to the south, the Rag seems to pass under the supracoralline formations, without loss of its upper beds. At North Grimston, the hard Rag and underlying urchin series are at least 60 ft. thick, and it is not improbable that something like this development may obtain throughout a considerable part of the southern slope of Langton Wold. The quarries on the north side show nothing like this thickness of Rag, nor is there anything which could represent the marly paste with oolite so full of mamillated urchins. It is evident, therefore, that there is much to clear up before we can arrive at a correct understanding of the puzzling geology of the Langton-Grimston ridge.

At the village of North Grimston this ridge is cut through by a transverse valley, thus forming, in conjunction with the escarpment here facing the north, that remarkable salient, North-Grimston Hill. In this way, starting from the village itself, we may

trace a continuous sequence from a low position in the Lower Calcareous Grit up into the Kimmeridge Clay of Burdale, as follows:—

NORTH GRIMSTON TO BURDALE.						FT. IN.
Supra-coraline.	{	1. Cement-stone, or "Lias," maximum proved (at quarry)	...	...	...	36 0
CORAL RAG.	{	2. Coral Rag, "North-Grimston limestone," about	...	...	...	40 0
		3. Marly Oolites, with an occasional coral band or hard limestone, the mamillated-Urchin series, say... ..	...	...	...	25 0
Coralline Oolite and Passage-beds.	{	4. Drab-coloured marly oolites, becoming very earthy towards the base: full of <i>Echino-brissus scutatus</i> , the equivalent of the Coral-line Oolite of other districts, say	...	...	...	30 0
		41. Passage beds about	...	...	...	6 0
L.C.G.		5. Lower Calcareous Grit down to bed of beck... ..	...	...	...	62 0
Total thickness of beds in the escarpment						163 0

The best place for studying the development of the Urchin-beds is at the west end of the lower quarry on the south side of the Wharram road, where the lime kilns are built in some soft drab-coloured marly oolites, said to be very full of *Echinobrissus scutatus*. The latter probably represent the upper portion of group 4. But between these and the limestone No. 2 are some 20-25 feet of beds the representatives of group 3. They are seen to consist of flattened buff-coloured granules in a buff or drab-coloured marl; and sometimes the marl or paste is devoid, or nearly so, of any granules. They are divided occasionally by beds of hard compact limestone, having partially the features of the Rag, and containing a few corals, many spines of *Cidaris florigemma*, and small muricated univalves: one of these hard bands, towards the top of the series, has a thickness of 2ft. 6in., and exhibits a fine arabesque of shells such as are usually associated with a Rag-fauna. Throughout the series, and especially towards the upper part, a profusion of the spines of urchins may be noted, and the tests of many are from time to time discovered. *Pseudodiadema hemisphærica* is especially abundant, and may be called the North-Grimston Urchin *par excellence*. *Cidaris Smithii*, *Cid. florigemma*, *Hemicidaris intermedia* also occur, the latter frequently. *Collyrites bicordatus* and *Pygaster umbrella* are also quoted from here; and *Echinobrissus*

scutatus, which swarms in the lower beds, cannot fail to put in an appearance.

In the quarries the hard Rag (2 of the above section), presents two phases. Without detailing the beds, the following is a description, taken principally from the upper quarry, in descending order :—

	FT. IN.
a. Buff-coloured limestones with yellowish markings; beds of white stone, seldom hard and crystalline like the series below. Indications of corals moderate: flints rare. Spines of <i>Cidaris florigemma</i> less plentiful. <i>C. Smithii</i> and <i>Hemicidaris intermedia</i> numerous. Beds less shelly than lower series, but contain a fair assemblage of some of the Rag-fossils, <i>Nerinea</i> , <i>Littorina pulcherrima</i> , <i>Opis</i> , &c., along with <i>Pentacrinites</i> and <i>Apiocrinus</i> ...	about 20 0
b. Soft yellowish brash, with <i>Ammonites varicostatus</i> ...	0 4
c. White sparry and compact limestones in strong blocks, which become largely charged with flint, especially about 6 ft. above the base of the series. Beds full of fossils: fauna megalomorphic ...	17 0
d. Urchin series.	

37 4

Some of the beds are very rich in shells; but these are frequently so glued into the general mass of the limestone as to be difficult of extraction. Nevertheless a fine body of fossils, without enumerating the teeth of Reptilia, have been proved here. The lowest portion of c consists of alternations of hard and soft Rag and has a thickness of about 6ft.: this is moderately shelly, and contains numerous spines of *Cidaris florigemma*. Above this occurs the great shell-bed, about 3ft. thick; it is a mass of the most splendid fossils, all of them the finest and largest of their kind. The small univalves so frequent in other parts of the Rag are not common here, the fauna being essentially megalomorphic. *Lima læviuscula* (var.) is the prevailing shell. The species of corals are those found elsewhere in Yorkshire; but *Thecosmilia* and *Rhabdophyllia* are most frequent.

The section at North Grimston represents the fullest phase of the Rag or Upper Corallian, just as the section at Pickering represents the finest development of the Coralline Oolite of the Tabular Range. The contrast between the two sub-formations may be said to reach its maximum at these two points respectively. The fauna of the Oolite of Malton seems to be intermediate between the two.

Subjoined is a restricted list of the fossils of the Coral Rag, or Upper Corallian of the Langton-Grimston district :—

<i>Ammonites varicostatus</i> , <i>Buckl.</i>	<i>c.</i> <i>Lima rigida</i> , <i>Sow.</i>
(var. of <i>A. plicatilis</i> .)	<i>v. c.</i> " { <i>pectiniformis</i> , <i>Schlot.</i>
<i>Ammonites vertebralis</i> , <i>Sow.</i> (var. <i>cawtonensis</i> .)	{ <i>rudis</i> , <i>Sow.</i>
	" <i>sp.</i> (<i>cf. elliptica</i> , <i>Whit.</i>)
<i>Purpuroidea nodulata</i> , <i>Y. & B.</i>	<i>c.</i> <i>Trichites Plotii</i> , <i>Lhwgd.</i>
<i>Natica globosa</i> , <i>Röm.</i>	<i>Mytilus unguatus</i> , <i>Y. & B.</i>
" <i>clytia</i> , <i>d'Orb.</i>	<i>c.</i> <i>Arca quadrisulcata</i> , <i>Sow.</i>
<i>c.</i> <i>Chemnitzia</i> , var. of <i>heddingtonensis</i> , <i>Sow.</i>	" <i>pectinata</i> , <i>Phil.</i>
<i>Nerinaea Römeri</i> , <i>Goldf.</i>	<i>Cucullæa elongata</i> , <i>Phil.</i>
<i>Littorina pulcherrima</i> , <i>Dollf.</i>	<i>v. c.</i> <i>Astarte ovata</i> , <i>Smith</i> (attaining a great size.)
<i>c.</i> " <i>muricata</i> , <i>Sow.</i>	<i>c.</i> " <i>rhomboidalis</i> , <i>Phil.</i>
<i>Neritopsis Guerrei</i> , <i>Héb. & Desl.</i>	<i>Opis viridunensis</i> , <i>Buvig.</i>
<i>Pleurotomaria reticulata</i> , <i>Sow.</i>	" <i>lunulata</i> , <i>Röm.</i>
<i>Trochotoma tornata</i> , <i>Phil.</i> (<i>T. discoidea</i> , <i>Buvig.</i>)	" <i>Phillipsi</i> , <i>Morr.</i> , or <i>corallina</i> , <i>Damon.</i>
<i>v. c.</i> <i>Ostrea duriuscula</i> , <i>Phil.</i>	<i>Terebratula insignis</i> , <i>Schüh.</i>
<i>v. c.</i> <i>Exogyra nana</i> , <i>Sow.</i>	<i>c.</i> <i>Cidaris florigemma</i> , <i>Phil.</i>
" <i>sp.</i>	<i>c.</i> " <i>Smithii</i> , <i>Wright.</i>
<i>Ostrea gregaria</i> , <i>Sow.</i>	<i>c.</i> <i>Hemicidaris intermedia</i> , <i>Flem.</i>
<i>c.</i> <i>Anomia radiata</i> , <i>Phil.</i>	<i>v. c.</i> <i>Pseudodiadema hemisphærica</i> , <i>Ag.</i>
<i>v. c.</i> <i>Pecten vimineus</i> , <i>Sow.</i>	<i>c.</i> <i>Pygaster umbrella</i> , <i>Ag.</i>
" <i>inæquicostatus</i> , <i>Phil.</i>	<i>Echinobrissus scutatus</i> , <i>Lamk.</i>
" <i>intertextus</i> , <i>Röm.</i>	<i>Pentacrinites</i> , <i>sp.</i>
<i>Pecten lens</i> , <i>Sow.</i>	<i>Apiocrinus</i> , <i>sp.</i>
<i>c.</i> <i>Hinnites corallina</i> , <i>sp. n.</i>	
<i>v. c.</i> <i>Lima læviuscula</i> , <i>Sow.</i> (<i>N.-Grimston variety</i> .)	

The Lithology of this group is more varied than that of the preceding ones. Much depends upon the nature of the coral; whether it is branching, like *Thecosmilia* and *Rhabdophyllia*, or compact like *Thamnastræa* or *Isastræa*. Great changes have taken place during the process of mineralization: much of what was once coral is now calcareous spar, partly replacing the original structure, and partly filling large cavities with calcite. The upper beds in many places are also greatly silicified, and this silicification occurs in many ways, not being confined to the purely coralline portions of the Rag, but extending to the compact limestones and intercoralline beds which tend to swell it out.

In close proximity to the clays and grits of the Supracoralline beds, as at Pickering, the Coral Rag contains bunches of crystal-

line quartz (rock crystal), which have been deposited in cavities of the limestone. There is a tendency, however, in many parts of the Rag to various forms of silicification, altogether irrespective of proximity to the overlying beds, as may be well studied in the Langton-Grimston Rag. The first thing noticeable is the tendency to "beekization" in the oyster shells. A specimen of *Ostrea duriuscula* is exhibited, showing the external layer "beekized": the middle layer of the shell has been eaten away, leaving a number of siliceous pillars supporting the outer layer like the roof of a cavern. The small *Exogyra* which swarms here, and the Oysters generally are more or less silicified.

The hard Rag of this district is usually very siliceous. A fragment from one of the North Grimston shell-beds shows it very clearly. The fragments of the little *Exogyra* are seen to be developing specs of botryoidal chalcedony. A thin section placed under the microscope reveals some very interesting phenomena, which may afford a clue to the source of so much silica. Besides a number of spicular forms of various shapes, the slice is observed to be crowded with a quantity of renuline bodies, nearly all of the same shape and size. These are much smaller than the ordinary oolitic granules, and much more uniform in their appearance, otherwise their oval shape might lead to their being confounded with very fine grained oolite. If a portion of the rock is treated with very dilute acid, many of these renuline bodies, being siliceous, can be detached from the matrix. Similar bodies have been noticed and described by Mr. Sorby, and more recently by Mr. Blake, who was disposed to refer them to Foraminifera. But Mr. Sollas' view seems the most in accordance with the facts as here observed, viz., that they are the globo-stellate spicules of a lithistid sponge.* If, then, these renuline bodies really were in the first instance ovate spicules, such as those which form the interlayer of a species like the existing *Geodia arabica*, the acerate and anchoring spicules and other parts must have been equally abundant, affording a copious supply of organic silica, which has been one source of the chalcedonic matter so largely pervading portions of the North Grimston hard Rag. *Cliona* also may have contributed to swell the amount of silica secreted

* For an account of "globo-stellates," and of the changes they undergo through the action of caustic potash, cf. Sollas, in the *Ann. and Mag. of Nat. Hist.*, 1877, p. 292.

and left behind by spongy organisms, and which has run about the rock, just in proportion as the original organic silica yielded to the action of solvents. It is interesting, for instance, to notice how completely the phragmacone of the large Belemnite in this specimen of hard Rag is chalcedonized at the tip, whilst the central portion consists of calcite crystals surrounding a conical cavity. It is not very difficult, in this case, to perceive how the silica got at the tip, for a thin layer of chalcedony lines the interior cavity all the way down, partly occupying the position of the "pen" of the original shell. Thus, we again see that decay of organic matter, and facility of infiltration, tend to determine a deposit of chalcedony.

Another specimen from North Grimston shows how chalcedony, in large mamillary masses, occurs in connection with coral. It is taken from a junction of *Thamnastræa* with indurated intercoralline matter. A slice cut at the junction in the neighbourhood of a bore-hole serves to show the stars of the *Astræa*, which are becoming faint, except at the edge, and disappear entirely where the chalcedony becomes opaque and milky; showing that the inner portion was, in all probability, deposited in a cavity, whilst the outer and more flinty looking portion is the result of displacement.*

Finally, we pass to flint, and of this there are great masses both parallel with the bedding, and lining the diagonal fissures. This may be seen in those quarries where there is a sharp dip to the south, which has caused a fracture of the beds and consequent gaping; whilst, singularly enough, it does not seem to be produced in that portion of North Grimston Hill where the beds are level. Flint can only be viewed as chalcedony of a peculiar character, but of infinite variety, according to the bed in which it occurs. The original character and markings of the limestone seem to be fairly preserved in these flints, as may be seen by comparing the specimen containing a section of an urchin with the ordinary hard intercoralline portions of the Rag. The shell fragments, spines, test, matrix, and everything are silicified. The spines of urchins generally hold out to the last. There seems,

* There is a peculiar structure observable inside this coral, something like the *Aulopera dichotoma*, Goldf. (Tab. 65, figs. 1 and 2), *Alecto coralina*, d'Orb.; see also *Talpina*—Morris' Catalogue.

therefore, no reason for doubting that these flints are the result of the silicification of the intercoralline portions of the Coral Rag, though what determined the action in this particular case is not very obvious.

IV. THE SUPRACORALLINE BEDS (A).

Reference should be made to the sections at Pickering and North Grimston (pp. 423, 440), in order to understand the development of this group, which, on the whole, is not a satisfactory one. The beds are there, and often of considerable thickness, but they are not good historians of the period, which was revolutionary, and one of decadence. Hence the fossils are few, and badly preserved. Passing over the Scarborough district, where there is but a trace at Hackness, we first meet with beds of this group in the Hagg House quarry (p. 437). The Coral Rag is there overlaid by an argillaceous marl, 2 ft. thick, on which rests the Upper Calcareous Grit. At Pickering 17 ft. of these kind of beds intervene between the Rag and the Upper Calcareous Grit. The "Throstler" is a peculiar argillo-calcareous stone, of very unequal development, which first appears at Pickering, and assumes considerable importance towards Kirkby Moorside, where it seems to contain occasionally a sort of revival of Coral Rag. Certainly, in this region, there is a considerable mass of argillo-calcareous rock, which has hardly yielded a recognisable fossil, interposed between the Coral Rag and Upper Calcareous Grit. From Kirkby, westwards, all the way round by Helmsley to Oswaldkirk, the Supracoralline Beds are not less than 30 ft. thick, and form an important feature in the country; the lower portions are still argillaceous, but reddish cherty grits prevail towards the top. These are sufficiently fossiliferous in places, especially at Pickering, but the forms are difficult to determine. In the Kirkdale cutting, south-west of Kirkby Moorside, there is a section, now grassed over, about 16 ft. deep. Towards the top occur red sandy clays, with calcareous discs and nodules. Ammonites, some in a tilted position, were found at the base of this. The remainder of the cutting was seen to consist of hard blue rock, and buff-coloured calc grits, full of dichotomizing forms. Several ammonites of considerable size were found during the progress of

the railway (see Table), the forms having a strong Lower Kimmeridge aspect. All about Helmsley there is a great quantity of Upper Calcareous Grit, and in the valley of the Rye below the town, it forms a little cliff of extremely red cherty rock, on which Rye House is built. In the Nunnington cutting again, east of Oswaldkirk, there is a section of these beds 30 ft. thick, dipping about 5° N.N.E., and apparently right under the Kimmeridge Clay, which succeeds on the dip slope.

Not a trace of Upper Calcareous Grit is to be seen in the Howardian Hills, west of the Derwent, but the "Throstler" has been proved on the dip slope at Hildenley, and is succeeded by the Kimmeridge Clay of Sir Charles Strickland's brickyard,* whence a fine series of Lower Kimmeridge fossils have been obtained. East of the Derwent, the Supracoralline beds are very copiously developed on the south side of the Langton-Grimston ridge, usually in the argillo-calcareous form. Hence it is probable that the Cement-stone of the North Grimston "lias" quarry represents the Throstler rather than the Upper Calcareous Grit of Pickering. The fossils, however, are pretty much the same in both. These beds dip south towards the Chalk escarpment, in the direction of Lord Middleton's brickyard (Kimmeridge Clay), but their full thickness (36 ft., proved in the quarry) is unknown. A large portion of the country between the Langton-Grimston slope and the Chalk escarpment (see explanation to sketch map, Plate iii.) is occupied by these Supracoralline Beds, and in some places their boundary is not easy to trace, so that I cannot well say how far they extend, though at Rowmire Spring beds of this character may be seen faulted against the Lower Calcareous Grit.

Between the village of Langton and the Grand Stand, are some speckled grits—like the Passage-bed stone—which contain a few phantom fossils. If the determination of such wretched specimens can be relied upon, we have *Belemnites nitidus* and *Ammonites serratus*, pointing to the Upper Calcareous Grit, which, in certain places, south of the Coral Rag ridge, probably overlies the more argillaceous portion of supracoralline rock, some of which might possibly be mistaken for Kimmeridge Clay.†

* See introduction to part ii., p. 360.

† Since the above account of the Supracoralline Beds in Yorkshire was written, my attention has been called by Mr. Fox Strangways to a singular fragment of Cement-stone rock of very considerable thickness beyond the

Subjoined is a list of some of the common or characteristic fossils of the Supracoralline Beds :—

<i>Belemnites nitidus</i> , <i>Dollf.</i>	<i>Gryphæa subgibbosa</i> , <i>Bl. & H.</i>
„ <i>abbreviatus</i> , <i>Mill.</i> var. <i>c.</i>	<i>Avicula ovalis</i> , <i>Phil.</i> , var. <i>obliqua</i> .
<i>Ammonites alternans</i> , <i>V. Buch.</i>	<i>Pecten Midas</i> , <i>d'Orb.</i>
„ <i>biplex-varicostatus</i> }	<i>Lucina aspera</i> , <i>Buvig.</i>
„ <i>decipiens</i> , <i>Sow.</i> } *	„ <i>substriata</i> , <i>Rœm.</i>
„ <i>Berryeri</i> , <i>Leseur.</i>	<i>Thracia depressa</i> , <i>Sow.</i>
<i>Ostrea bullata</i> , <i>Sow.</i>	<i>Pleuromya</i> , <i>Myacites</i> , <i>Goniomya</i> , numerous.

V. STRATIGRAPHY AND PHYSIOGRAPHY.

Before proceeding to a general summary founded upon the previous details, a brief notice of the peculiar stratigraphical features of the country surrounding the Vale of Pickering is absolutely necessary. Until the mysteries which lie beneath that Kimmeridgian gulf are solved, it cannot be said that we have at all a full knowledge of the development of Corallian rocks in Yorkshire. These, as will be remembered, form three-fourths of the circuit round the Vale (see sketch map, Plate iii) and, as the cretaceous escarpment constitutes the fourth part, at a higher level it might be supposed that a sort of continuation of the Howardian Hills existed under a wreath of chalk, though, in point of fact, such is not the case, as the Corallian rocks of North Grim-

limits of the sketch map, containing the characteristic Cephalopoda. This has been let down by the great double fault, which produces the Gilling-Coxwold gap, and thus divides the Hambleton from the Howardian Hills. The most curious fact is that, instead of resembling the Upper Calcareous Grit of Oswaldkirk, only a few miles to the eastward, it has many of the features of the North Grimston Cement-stone, quite at the other end of the Howardian Hills. This fragment is seen to rest upon Coral Rag at Snape Hill, and is there faulted against the Lias; it is probably the rock referred to by Phillips, when he speaks of the Upper Calcareous Grit being found in the neighbourhood of Kilburn.

* Such names are admittedly only makeshifts, in order to register the occurrence of numerous ammonites, belonging to the group *Perisphinctes* which are too badly preserved to admit of very close definition. Many of these ill-preserved forms and fragments have a strange resemblance to some of the figures of *Perisphinctes* in the “Mémoires de la Société Paléontologique Suisse,” from the zone of *Ammonites tenuilobatus* in Argau, and from the zone of *A. acanthicus* in Switzerland and Savoy. A trifurcation of the rib across the back is not an uncommon feature. The zone of *A. acanthicus* in the Alps is deemed the base of the Kimmeridgian of that region.—Cf. Morris, in “Geological Magazine,” 1878 (Aug.), p. 354.

ston are faulted out of sight in Nine-spring Dale just before the Chalk escarpment is reached.

This very singular resemblance to an atoll has given rise to the idea that the girdle of Corallian Rocks might possibly be the remains of an elliptical coral reef, with a central hollow, representing the lagoon, now filled in with Kimmeridge Clay. In that most delightful of geological works, "The Primæval World of Switzerland," Professor Heer, after pointing out the fringing reefs that cling to the west side of the Black Forest shore, proceeds to show us the lagoons and atolls of the Jurassic period in northern Switzerland.* One of these atolls has a length of 24 miles, and its lagoon has the form of a long, narrow ellipse. The great coral banks of Mont Terrible, the classic ground of the Lethæa Bruntutana, form the N.W. part of the rim of this old Swiss lagoon. It is not easy to gather from Professor Heer's statements, what is the nature of the deposits within the lagoon, and details both stratigraphical and otherwise, are altogether wanting.

Hence, even if we had no other indications, it would be dangerous to infer merely from Swiss analogies that the Vale of Pickering represented a lagoon of the Jurassic sea; but when we come to stratigraphical considerations, an explanation of existing phenomena, more in accordance with the accepted geological views is presented to us. We are, in fact, tempted towards the conclusion that this apparent elliptical arrangement is due to a series of faults and folds, whose extreme synclinal depression may be traced in the rocks at Helmsley. The mean strike on either side of this synclinal meets at an angle towards the west, and the result is a deep inlet or bay, the mouth of which is closed by the Chalk escarpment, and in a less degree by the Drift of the coast.

As the Vale of Pickering is much covered by superficial deposits attaining a depth, in some places, of 70 ft., it is not easy to ascertain the position of all the faults which may lie concealed beneath its surface; but there is one longitudinal fault of great importance which inclines to the northern side, and probably passes out to sea not far South of Filey Point. The Upper Limestones of the Tabular Hills are seen to be cut off suddenly by this fault at Brompton, and the apposition of these porous rocks with the Kimmeridge Clay at the edge of the vale is there marked by the series

* Heer's "Primæval World of Switzerland," (Heywood), Vol. i., p. 121.

of springs which form the Keld, or headwater of Brompton Beck. (see Fig. 15, p. 422). At Wydale quarry, a mile further west, many feet above the edge of the Vale, the same fault brings the Kimmeridge Clay in juxtaposition with the Lower Limestones. Thence it has been traced for a considerable distance to the westwards. The disappearance of the Limestones at Pickering is probably due to the same or a parallel fault. A little west of the town and about the 100ft. contour, at the junction of the last slopes of the Tabular Hills with the vale, the Costa flows, a ready-made river of some magnitude, from the pool at Keld Head. Again, we seem to perceive the effects of the juxtaposition of a wall of Kimmeridge, or valley Clay, against the porous Corallian Beds, whose waters, instead of filling Newtondale Beck, leak through a hundred crevices, and thus form an underground stream, which is unearthed at this spot. On the whole, the stratigraphy of the Tabular Hills is simple; the general dip of the rocks is to the south, and, as previously explained, at an angle which causes the beds which are highest in a geological sense, to occupy the most depressed positions at the edge of the vale. These are suddenly snapped off, and the whole system jammed against a mass of clay, as indicated below.

FIG. 22.—RELATION OF THE TABULAR HILLS TO THE VALE OF PICKERING.

a. Kimmeridge Clay.	f. Lower Calc Grit.
b. Upper Calcareous Grit, sometimes	g. Oxford Clay.
with a cap of Kimmeridge Clay, &c. x. Superficial Deposits of the Vale of	
c. Upper Limestones.	Pickering—chiefly clays.
d. Middle Calc Grit.	y. Keld Head—Source of the river
e. Lower Limestones.	Costa.

All attempts to reach the rock by boring have failed; and this

should be borne in mind, as it shows that the hade of the fault must be very steep, or that there is something unusual in the sudden and total disappearance of the rock at the edge of the vale.

The stratigraphy of the Howardians, though a smaller mass, is far more complex. This range forms the opposite flank of the Vale,* and the normal dip of the beds being N.N.E., we should expect that this dip would prevail at the junction of the rock with the clays, as the opposite or southerly dip does generally throughout the Tabular Range. Such, however, is not always the case, and it is evident that the area is one whose stratigraphy is extremely complicated. Some clue to the working out of the problem may perhaps be furnished by a study of the system of faults at Malton.

The natural positions in the vicinity of this town (see Contour Map, Fig. 17, p. 426†), due entirely to geological, or rather to stratigraphical causes, have long marked it out as a place of importance. The western Howardians may be said to terminate here in a tongue of limestone rock, which projects into a level expanse of Kimmeridge Clay. The tip of this promontory is cut through by the Derwent below Old Malton, and a little further back by a dry valley, possibly some previous waterway, so that a section of the Corallian area is completely insulated, and has the river Derwent as a natural ditch on the south-east. The Romans were not long in finding out the advantages of such a position as the partially preserved Roman Camp will testify, and although archæologists are not absolutely agreed that the name of the station was *Camulodunum*, it is evident from the immense quantities of Roman coins found here, that the locality was much frequented by them.

These peculiarities are due to the extensive system of faults prevailing here, and in order to show this more clearly, a section across the Coralline peninsula is appended. (*See opposite page*).

* See Proc. Geol. Assoc., Vol. iii., p. 285, "Yorkshire Oolites," Part 1.

† The following additional explanations are necessary:—

x. Line of section from Malton Fields to Whitewall (Fig. 23).

y. Portion of section passing through Hildenley Heights (Fig. 25).

N.B.—The western prolongations of the Middle and Southern Faults are only laid down approximately. The extent of the tongue of Kimmeridge Clay in this direction is likewise at present undefined.

FIG. 23.—OLD MALTON FIELDS TO HIGHBECK SPRING, NEAR WHITEWALL.
Distance—Two miles one furlong. Horizontal scale, 3 in. to 1 mile; vertical scale, 6 in. to 1 mile.

A, Old Malton, or north fault.

B, Norton, or middle fault.

C, Whitewall, or south fault.

a. Position of the river Derwent at Malton; bank 50ft. above O. D. at railway bridge.

b. Boring in Old Malton fields through Superficial Beds and Blue Clay to a depth of 468ft. 70ft. above O. D. at surface.

c. Well in Westgate lane, Old Malton (1,000 ft. south of b), reaches oolite rock at 28ft.

d. Highfield-road quarry (100ft. contour passes over the top) in oolite and Rag—E. of map, fig. 17. Beds dip slightly to the N.E.

e. The Lady's Spring: on the line of fault proved at Russell's brewery—Malton water supply.

f. Unsuccessful boring through about 400ft. of Superficial Beds and Blue Clay, near St. Nicholas Church, Norton.

g. Base of escarpment near Whitewall-corner, about the 100 feet contour. Line of fault indicated by Highbeck Spring.

h. Limestone quarries—Coral Rag upon Coralline Oolite: dip northerly—up to the 150ft. contour in Langton Wold ridge.

It must be admitted that the thickness of the superficial deposits in the lower, or vale portions of this section tend to obscure its reading, the more so that they consist partly of clays themselves; still there is difficulty in avoiding the conclusion that along this line we cross three faults, or folds so sharp as

to have the effect of faults. At the north end the fault, or whatever it may be, can clearly be fixed between *b* and *c*, a distance of 1,000 feet. The rods, after passing through 17 feet of surface matter, continued in "hard dry clay with white specs" to 150 feet, and thence through variable clays with hard bands to a depth of 468 feet, without ever touching the Oolite Rock, which was the object of the search, though this was found within 28 feet at *c*. Here we enter the Coralline peninsula, rather under a mile in width on this line. On the plateau the beds are nearly level, with slight north-easterly dips on the north side, and east south-easterly dips on the south side. The Oolite Rock comes to a sudden termination at the Lady's Spring, where a copious supply of pure water oozes up on a level with the river. The evidence as to the rock being really lost, and not merely covered up by superficial clay, may be found in numerous borings in or near Norton, one of which is said to have gone through 400 feet of Blue Clay without touching the rock, although they started close to it. Between *f* and *g* the surface is pretty level, but with a gradual rise towards the foot of Langton Wold ridge, where, in the sharp rise at Whitewall-corner, we once more find the Corallian limestones. That we are fully justified in placing a fault at the foot of this escarpment, may be gathered from an actual exposure two or three miles to the eastward, where, at the lime-quarry near Settrington, the following section may be observed :—

FIG. 24.—LIME QUARRY, SETTRINGTON.

Owing to the removal of the soil and clay at the point where the railway to Driffield first strikes the Langton ridge, a state of things was disclosed which was of material benefit to the contractor, viz., that the hard rock which was supposed to pass under the clay of the vale broke off short, as indicated in Fig. 24. It will be observed that the portion of rock which has fallen over into the fault or unconformity, can be defined with absolute certainty, as it happens to be that piece which forms the junction between the Coral Rag and Coralline Oolite. This curious wall of rock may now be traced for some distance westwards from the quarry face; whilst in the opposite direction, where the line ultimately begins to cut through the Corallian rocks, this piece, which is very hard and much discoloured from contact with the clay, may actually be seen to stand out like a trap dyke in those portions of the cutting which are not ballasted. Ammonites and oysters are said to have been found in the Clay, which is blue and does not appear remanié.*

The evidence as to the Blue Clay of Section, Fig. 23, being Kimmeridge Clay, is briefly as follows†:—

PARTICULARS OF THE BORING AT OLD MALTON (b Fig. 23).

FEET.

1— 17.	Superficial Beds; sand, clay, gravel.	
17—150.	Hard dry clay, with white specs: at 60 feet 12 inches of Septarian stone occurs. The cores where tried, effervesce freely.	
150—165.	Clay becomes black and more plastic; core at 158 feet no effervescence, no white specs.	
165—175.	Water rises to surface, clay hardens	} usually white
specs; generally
effervesces freely.
175—195.	Clay softer and paler	
195—231.	Clay darker, then lighter; 12in. stone	
At 232.	Band of red sandy matter, a few inches.	
233—321.	Clays sometimes plastic, generally pale and crumbly, with white specs, strong effervescence.	

* During the discussion on the Paper, Mr. Blake alluded to a third mode of endeavouring to explain the relations of the Vale of Pickering to the encircling Corallian rocks, viz., that these dislocations had partly occurred before the deposition of the Kimmeridge Clay, which was thus laid down in a sort of trough against a cliff line of rocks already formed. This view also has formerly found favour with Sir Charles Strickland.

† For these particulars, and for much information on the stratigraphy of the neighbourhood, I am greatly indebted to Mr. Henry Hurtley, of Malton, a member of the Association.

FEET.

- 322—377. Pale-coloured crumbly shales, sometimes nearly half soluble in acid—hard and “jetty” at 348 feet—thin bands of stone—at 353 feet “hard clay, with large white patches size of a pigeon’s egg, and like salt, but tasteless” (? gypsum).
- 378—430. Mostly as above, but rather less friable ; at 430 feet heavy blue shale, with streaks of decomposed shell.
- At 447. “Black clay with small pebble”
 At 460. “Clear spar and pyrites”
 At 468. “Another hard stone : rods broke”
- } clays with less
 } effervescence.

From a superficial inspection of these cores, it is evident that marly shales and clays constitute the formation of this part of the Vale of Pickering for a depth of 450 feet. Not a recognisable fossil was obtained. Specs and flakes of rotten shell fragments occur in many of the cores, though less so about 300 feet, where the calcareous matter seems to have been broken up finer. These presumed shell fragments lie at all angles to the axis of the bore, but mostly horizontally. No trace of bedding can be made out in the clays. Below 400 feet there is greater density, and rather less lime than immediately above. A sort of lustre may be noticed at the broken edges of some of the cores, which answers, I presume, to the “jetty” of the Report. On the whole, if we except the varying colour and plasticity of the clayey matter, there is considerable uniformity throughout ; the most important exceptions are at 158 feet, where there is hardly any lime in the clay ; and at 230 feet, where the red sandy bed occurs. About eight or nine bands of stony substance, showing an aggregate of some 5 feet of stone, were encountered, and these seem to have been of the nature of concretionary matter, such as occurs in clay. No sand other than the thin streak at 232 feet was found, and the clays are remarkably free from grit.

All the above facts are very much against the theory of this part of the Vale of Pickering consisting of Oxford Clay, which in this district (Hutton Banks, three miles west of Malton, is the nearest good section) is only 70 feet thick and rather sandy. But if we now turn to the Blue Clay on the opposite side of the Coralline peninsula, still more conclusive evidence is obtained. There are at least three points on this side where borings have been executed within a few hundred feet of the oolite rock ; the one at *f* (Fig. 23) is the middle of these. A depth of 400 feet was attained in one case, still ending in this everlasting Blue Clay. Nothing shows the excessive steepness of the hade of the fault *B* so clearly as these futile attempts to touch the rock. This is the middle fault which cuts off the Coralline Oolite, and so forms the well-known escarpment at the south-west corner of the Roman camp above Castlegate. The rock has been worn back a little, and the actual fault runs between Castlegate and the river, being 40 feet from the centre of the street at Russell’s brewery. A very short distance further down the river itself flows

along the line of fault at the new bridge, opposite the station (see Contour Map, Fig. 17). The north pier of this bridge rests in valley deposit and oolite rubble, whilst the south pier stands in "clay with ammonites and oysters." Mr. Hurtle, Mr. Mortimer, and others all concur in saying that the clay exposed was very like Kimmeridge Clay, and that the fossils were such as characterise that formation. But if any doubt should remain, an inspection of the New Cut, about one mile W.S.W. of the station will remove it. Here is an exposure, fortunately free from Superficial Beds, showing stratified blue clay with septaria of the regular Kimmeridge kind, where, in the summer of 1877, Mr. J. R. Mortimer and myself found *Ostrea deltoidea* and *Belemnites nitidus*.

Such being an outline of the leading stratigraphical features in the immediate vicinity of the capital of the Howardians, the disappearance of the Corallian rocks would seem to be best accounted for on the supposition of a great undulating synclinal which has largely determined the physiography of this region. This system of flexures is partly preserved in the present contours of the hills, the actual *fractures* being more frequent in the Howardians than in the Tabular Range. Fig. 25 (p. 456) is a measured section (in part shown by the line, *y*, on the Contour-Map, Fig. 17) across a portion of the former range of hills parallel to, and three miles to the westward of the measured section, Fig. 23.

It is not at all claimed that this section is an absolutely correct reading of the difficult bit of country between the Derwent and the Rye, but it is sufficiently accurate to show the system of flexures and fractures. The fault which forms the northern termination of the Howardians for many miles (in this section shown a little south of Amotherby Station) is undoubtedly the Malton North-fault, which is one of the master faults of the whole country. The very puzzling relations of the Kimmeridge Clay of the Hildenley Brickfield to the Middle Oolites on the south are masked by a mass of Boulder Clay; it is difficult, therefore, to say what connection this rapid change of beds has with the Middle or Norton fault. Further south there is a fault of moderate throw (York Road) which also must have some connection with the Middle or with the South fault.

Putting aside such questions as these, which can only be decided by a systematic survey, we may gather quite sufficient from a study of the above section as to the up and down character, both geologically and topographically, of this part of the Howardians, although the actual throw of the faults is perhaps less here than at Malton.

FIG. 25.—SECTION THROUGH HILDENLEY.

Having now got some insight into the structure of the encircling ranges, and having obtained clear evidence as to the relations of both of them to the great mass of Blue Clay filling up the Vale, we are entitled to ask—

Are the Corallian rocks continuous beneath the Vale of Pickering, as they should be if the ideal diagram, Fig. 26, is an approximate representation of the facts?

Or does this faulted synclinal correspond with an original lagoon-like gulf, destitute of Coral-bearing rocks?

Or, thirdly, was the depression commenced during the Kimmeridge period, and thus filled to a greater extent than the surrounding area with argillaceous sediment?

None of these questions can be answered with certainty until the boring rod has actually passed through the Kimmeridge Clay of the vale and shown us on what it really rests.

FIG. 26.—HYPOTHETICAL SECTION ACROSS THE VALE OF PICKERING.

A. Position of the Malton North fault. *B.* Position of the Middle or Norton fault. *C.* Position of the Whitewall, or South fault.

D. Probably easterly continuation of the fault on the north side of the Gap leading up to Oswaldkirk. N.B.—The clays of this remarkable gap (through which the railway from Malton to Thirsk finds a passage between the Howardian and Hambleton Hills) have always been regarded as Oxford Clay till very recently. Mr. Fox Strangways has shown, however, that this gap is a “let in” of Kimmeridge Clay which completely severs the two ranges, and the effects of which may be traced far beyond Coxwold. It is thus analogous to the “let in” of Kimmeridge Clay at Malton between *B* and *C*, the westerly termination of which, beyond Hildenley, has not yet been made out.

E. Position of the fault, or faults, at the base of the Tabular Range.

F. Position of the fault between Birdsall and Langton. N.B.—It may be doubted whether the Clay here shown is true Kimmeridge Clay or only an expansion of the Cement-stone (Supracoralline.)

It must be distinctly understood that Fig. 26 is only a very generalized section, which may be taken as approximately true of a line passing by Langton, Malton, and Pickering. In this section the faults or fractures are represented as folds, and the difference between the vertical and horizontal scale produces an amount of distortion, which the reader must bear in mind. There can be little doubt that at Malton, hundreds of feet below the surface, the Kimmeridge Clay must be faulted against the Lias. There is, therefore, a certain distance from the edge of the rock, whence a bore-hole, after passing through 400 or 500 feet of Kimmeridge Clay might cross the fault into the Lias unobserved if there were no fossils, and thus miss the Corallian Rocks altogether.

In the foregoing maps and sections no notice has been taken of minor or cross faults running N. and S. The principal lines of disturbance have an E. and W. or perhaps W.N.W. direction, and may belong to the Post-jurassic system of disturbance, which Hull (Quar. Journ. Geol. Soc., Vol. xxiv., p. 332) has noted in the Carboniferous rocks of Lancashire and Yorkshire, though he states the direction of this system to run N.N.W. in that region.

VI.—PALÆONTOLOGY.

The arrangement adopted in the accompanying Table may be explained as follows. Column A indicates whether or no the species has been found on a *lower* horizon in Yorkshire.

Column I.—LOWER CALCAREOUS GRIT AND PASSAGE-BEDS include most of the fossils of the Lower Calcareous Grit proper; of the Lower Passage-beds, *i.e.*, at Filey, Scarborough, Wydale, Appleton, &c., as well as the Lower Coral Rag of Hackness; also those of the mass of the Lower Limestones generally as far as their contents are known. The great change, however, from the fauna associated with the Lower Calcareous Grit to that which is characteristic of the Coralline Oolite may be said to occur somewhere within the mass of the Lower Limestones, as the top shell-bed of that group, wherever it has been discovered, contains an assemblage whose general facies though possessed of certain characters of its own has more affinity with the Coralline Oolite than with the lower beds. The change resulting from those causes which produced this remarkable mass of oolitic limestone could not fail to make itself felt upon the life within the area and for some distance around. The effects thus brought

about seem to have been of so permanent a character, that, although arenaceous deposits (Middle Calc Grit) again prevailed for a time in some quarters, the old Brachiopodous life of the Lower Calcareous Grit, with many of its associated forms, never seems to have regained its sway in these regions.

Column II.—CORALLINE OOLITE includes all the fossils known to occur between the top shell-bed of the Lower Limestones in the Tabular Hills (including that bed), and the base of the Coral Rag, *i.e.*, to say, the Coralline Oolite of Seamer, Brompton, &c., the Bellheads Oolite at Hackness, the Upper Passage-beds (containing the *Trigonia*-beds), the *Chemnitzia*-limestones, and indeed everything in the Pickering section beneath the equivalent of the Coral Rag (see Section, p. 423): also the whole of the limestones west of Pickering, between the Middle Calc Grit and the Coral Rag. In the Howardian Hills it embraces the majority of the oolites underlying the Rag, and especially the oolites in the immediate neighbourhood of Malton, which have yielded so many fossils from time to time. It is a very comprehensive division, and certainly includes several sub-faunas, due probably to local rather than important physical differences. The oolites between New and Old Malton have more affinities with the Rag than have those of Swinton, &c. Taken as a whole, the fauna of the Coralline Oolite of Yorkshire is a sort of mixture of Oxfordian and Corallian forms. *The almost total absence of Brachiopoda is most remarkable.*

Column III.—THE CORAL RAG. This, of course, is the backbone of the Corallian system. Whilst in the underlying oolites we see a *débris* derived in no small degree from pre-existing coral growth; here we see the Coral banks themselves, and what is still better for the collector, great accumulations of intercoralline brash where the shells are preserved. The extent and subdivisions of the Coral Rag have already been indicated.

Column IV.—THE SUPRACORALLINE BEDS include all the Fossils found in the "Throstler," "Cement stone," and Upper Calcareous Grit at Pickering, Helmsley, North Grimston and elsewhere between the top of the Coral Rag and the base of the Kimmeridge Clay.

Column B indicates whether or no the species has been found on a *higher* horizon in Yorkshire.

Columns A and B are, unfortunately, of but little use in our present state of knowledge. As regards species occurring on lower

horizons the practical continuity of the lower part of the Lower Calcareous Grit with the upper part of the Oxford Clay tends to blend the faunas somewhat. There are also several forms, if not actually identical, at least similar to those in some of the limestones of the Lower Oolites. On the other hand, the tremendous break which seems to exist between the highest Corallian beds and the Kimmeridge Clay may be partly due to our very limited acquaintance with the basal beds of the Kimmeridge Clay in Yorkshire.

It must be admitted that a Table is but an inadequate method of conveying a really comprehensive view of the life of a period in a given district. There is something so alarming in the phalanx of hard names drawn up, as it were, in battle array that readers may well be excused if they are somewhat repelled by the sight of it. And when one further reflects that in making choice of each of these names the palæontologist is afflicted by a synonymy which is yearly growing more oppressive, it is not to be wondered at if some people are inclined to despair of ever bringing order out of this terrible chaos. Perhaps when we have seen the "Stratigraphical Catalogue of British Fossils" so long promised by Mr. Etheridge, "We may for the first time expect that the complex subject of synonymy—at present the curse and opprobrium of Palæontology—will be brought within a manageable compass."* But there are other matters to be taken into consideration before we can hope to arrive at the Golden Age. It cannot be doubted that fossils have different names in different countries; one can hardly look through an illustrated work on Palæontology without being convinced of the fact that we see many an old friend under a new title. This arises from two principal causes. *Firstly*, the imperfect figure, and inadequate description (sometimes wanting entirely) of the older and frequently foreign author; and *secondly*, the existence in a fossil of some trifling difference of form, which difference is in itself well worthy of conscientious record, but affords no valid excuse for putting a totally different ticket upon its possessor. So long as the bulk of naturalists really believed in the immutability of species there was something dangerously fascinating in the prospect of finding out and describing a *form-group*, which was destined to endure no change, which might indeed be destroyed or die

* Inaugural Address before the Edinburgh Geological Society by Prof. H. Alleyne Nicholson, Nov., 1877.

out, but could never be altered. The maker of a new species would thus come to look upon his offspring with almost parental solicitude, and having stood godfather to his own child, would attach to the name given by him a peculiar interest.

In what way, then, it may well be asked, are the leading features of a geological formation to be brought synoptically before those who are desirous of becoming acquainted with its contents? Certainly a table is a comprehensive method of doing this; but in the present case I would not have any one attach too much importance to the specific names of which that table must necessarily in a great measure be composed. Setting aside cases of mistaken identification, of which there may be some in so long a list, the following points should be kept in view by way of caution.

1. The absence of a fossil from any of the columns I, II, III, IV, merely implies that it has never been found, to my knowledge, in the corresponding group of beds.

2. A more extended and systematic search would considerably increase the list, especially as regards the smaller and less obvious forms.

3. The specific names adopted only give an inadequate representation of the numerous forms or varieties which are met with.

4. On the other hand some specific names are given to forms which are clearly the representatives, one might almost say the descendants of species occurring in lower beds, *e.g.*, *Pecten Midas* in the Upper Calcareous Grit, replacing *P. fibrosus*.

We must now take a rapid survey of the principal genera which the Table contains. The Reptiles, Fishes and Crustacea are not sufficiently important or novel to call for any special remark; it is the Mollusca therefore with which principally we have to deal.

The Cephalopoda are moderately plentiful. One type of belemnite runs through the entire formation, coming into the Lower Calcareous Grit as the short thick *B. abbreviatus*, Mill., passing through the Coralline Oolite in a modified but distinctly recognisable form, and finally emerging in the higher beds as the exceptional variety so common in the cement-stone at North Grimston (in the Table referred to *B. abbreviatus*, var. *c*). In the Upper Calcareous Grit, and again in the Kimmeridge Clay, we seem to recognise in *B. nitidus* the attenuated representative of this latter. Of course it may be pure imagination on the part of a palæontologist to attempt to establish a connection between

any of these forms. On the other hand some might take the bolder view that they were all varieties of one great group to which one specific name should be applied. But whether, as regards nomenclature, we adopt the connective or disconnective method, the fact remains the same as above stated. This serves to illustrate what the careful watching of fossil forms on gradually ascending horizons must often have impressed upon the observer, viz., the modifications introduced by time in some, though not perhaps in all, cases. When we meet a friend, after an interval of many years, the changes in his visage are manifest, but if we see him every day, although conscious of that change, it is less striking.* So it is with a fossil. If we can trace the successive changes in a series of forms through a group of beds which do not present us with a total change of conditions, we seem to see the missing links, and get accustomed to the alteration. An admirable instance of this has lately been adduced by Mr. Meyer with reference to the *Micrasters* of the Chalk.† But if on the other hand an important physical change, bringing about a stratigraphical hiatus, and in some cases even an unconformity, has occurred in our area, when the old state of things is restored, we immediately describe the modified form which occupies the analogous position as a totally distinct species. For purposes of constructing a table this simplifies matters very much, whilst it is the perpetual recurrence of these missing links which constitutes one of our difficulties.

Another type of *Belemnite* tolerably plentiful in the lower beds is *B. hastatus*, Blainv., a specimen not to be easily separated from this

* As the actual question is one of races and not of individuals, this comparison is only just up to a certain point, viz., as illustrating how we may become familiarised with changes of form, and how on the other hand such changes may produce a far stronger impression. Neither must it be inferred from previous or subsequent remarks that palæontologists are not justified in recording these differences of form by *some* change of title. If, however, palæontology aspires to the rank of a science, it will be necessary to systematise these efforts at discrimination. Otherwise each country will have totally distinct names for fossils either identical or closely allied, thus producing different languages as it were—rebuilding, in fact, the Tower of Babel with all its concomitant confusion.

† "Geol. Mag." for 1878 (March), p. 115, where the author shows that there is a sort of regular gradation in the variation between the relative positions of the mouth and apical disc of *Micraster cor-anguinum*, and that such systematic changes are coincident with slight differences of Geological horizon. When it is possible to calculate the vertical position of a given bed of chalk by means of the angle thus obtained, Palæontology may take rank with the exact sciences!

occurs as high as the Cement-stone. A third type includes certain long narrow forms of considerable size, which in appearance are not unlike *B. Owenii*, Pratt, though it is by no means sure that this identification is correct.

As regards the ammonites of the lower beds, I must refer to a previous paper.* The Coral Rag is not remarkable for the abundance of its ammonites: such as occur in the soft beds associated with that formation cannot be quoted as carrying out the view of descent with modification, since the state of preservation is usually too indifferent for the establishment of niceties of form and ornamentation. The *varicostatus* var. of *A. plicatilis* seems to be the most common form, but when the inner whorls only are found it is difficult to make out much difference. There occurs, however, a very interesting modification of *A. vertebralis* at Sike Gate on Cawton Heights, leading on from the older form to the newer *A. alternans*. See figure and description of *A. Cawtonensis*, Bl. & H. in the "Corallian Rocks of England."† Whilst, then, the *Cordatus* group may be said to occur throughout, though in forms which seem partly to replace each other, it is very curious to note how *A. perarmatus* of the lower beds is superseded by the *A. plicatilis*-group in the Coralline Oolite and Rag. These two forms seem hardly ever to meet, as though they were mutually repulsive to each other. In the Passage-beds of the Scarborough district a compromise seems to have been effected, resulting in *A. Williamsoni*. This splendid ammonite has not yet, to my knowledge, been found in Yorkshire out of the Scarborough district, nor do I know how far it ranges downwards into the Lower Calcareous Grit proper.

In the Cement-stone of North Grimston there are many ammonites, but usually their state of preservation is far from satisfactory. Well-marked biciplicated forms are seen in the fragments of stone obtained from the quarrymen, and there are other fragments showing very large ribs, this evidence leading to the inference that a kind of *A. varicostatus* still prevailed: specimens of *A. alternans* are also obtained. The Upper Calcareous Grit at Pickering has yielded many fragmentary forms. These may be referred to *A. varicostatus* or to *A. Achilles* (much the same thing perhaps) and to *A. decipiens*? whilst some rather

* "Yorkshire Oolites," Part ii, sect. 1. Proc. Geol. Assoc., Vol. iv, p. 390.

† Quar. Journ. Geol. Soc., Vol. xxxiii, p. 392, pl. xiii, fig. 2.

fine specimens from the railway cutting at Kirkdale are quite Kimmeridgian in their character. All these forms, with the exception of *A. alternans*, seem modifications of the old plicatiloid type (See also *ante*, p. 447).

Both Coralline Oolite and Coral Rag contain the remains of numerous Gasteropoda, and in this respect present a strong contrast to the formations immediately above and below. The Lower Coral Rag and Lower Passage-beds, so rich in many of the Mollusca, are almost destitute of Univalves, whilst nothing beyond squeezed specimens of *Chemnitzia* and one doubtful *Patella* have as yet been found in any of the Supracoralline beds. It has long been a subject of reproach to the Corallian formation of this country that it is not rich in species, and the late Professor Phillips had even a worse opinion of it, when he described it as being a "pauperized" fauna.* Although the Professor spoke more especially of the neighbourhood of Oxford, he must also have had the Yorkshire deposits in his mind. As regards mere number of species there may be some truth in this, but certainly not as regards individuals. So far from the Corallian of Yorkshire showing a "pauperized" fauna, it exhibits the flowering of Jurassic life within the area as regards the Gasteropoda, as regards many of the Conchifera, and as regards the Echinodermata. This rule holds good both as to the number of individuals and as to the size attained. But considering the extent of the formation in Yorkshire and the numerous shell-beds it contains, the list of species seems only moderate. This arises partly from the excessive difficulty of extracting the shells from the matrix, and the still greater difficulty of developing them so as to show specific characters.

There are enormous masses of *Chemnitzia* in various parts of the Coralline Oolite, so hopelessly sealed up that tons of them are fractured by the quarrymen. Every one of these, so far as is known at present, are referred to *Ch. heddingtonensis*, which sometimes attains a length of 8 or 10 inches. This shell, when well preserved, as in the "small shell-bed" at Pickering, has a very strong resemblance to *Ch. vittata* of the Cornbrash, and has indeed a very long pedigree, for it is distinctly identified by Deslongchamps as occurring in the Inferior Oolite of Normandy. This

* "It is perhaps safe to view it as a 'pauperized' fauna, indicating the approaching extinction of physical conditions which marked the Oolitic ages and influenced the life of the period." Phillips "On the Geology of Oxford," p. 304.

means nothing more than that the great genus *Chemnitzia*,* which culminated in the Jurassic period, then included a form limited in numbers, but ultimately preponderating in Corallian times above all others of the genus. This shell, along with certain species of *Nerinea* and others less plentifully distributed, is the principal constituent of shell-beds which may be traced for great distances, especially in the Tabular Hills and also in the Malton Oolite. Reference will be made to this when we come to consider *Nerinea*. In the Coral Rag, which is the principal museum for the rarer univalves, besides doubtful varieties, three very well-marked species have been found, though at present their identification rests upon very few specimens. One of these, *Ch. langtonensis*, figured and described in the "Corallian Rocks of England,"† is at present unknown elsewhere, and is altogether so remarkable a shell that its relationships are not quite clear.

There is a small univalve bed in the Coralline Oolite of Pickering, and a somewhat similar bed has been found in a quarry near Ness (Cawklass), which is full of *Cerithia*, and probably of *Nerinea*, yet the number of determined species is very small, and one is apt to look with envy upon the wonderful list of this genus, which has been put together by Buvignier, from the Corallian of the Department of the Meuse. Again, the terrible difficulty of extracting from the rock impedes us. *C. muricatum* (out of which perhaps one or two varieties might be carved), is plentiful in some of the shell-beds of the Coralline Oolite; but its place seems to be taken by *C. limæforme* in the Coral Rag. At least, I don't remember ever to have found *C. muricatum* in any of the Rags. In the Howardian Coral Rag, especially in the Langton Wold and Grimston quarries, this genus does not seem well represented.

Nerinea, next to *Chemnitzia*, are the most abundant of all the Univalves. Individually they are, perhaps, more numerous in the Coralline Oolite, but the Coral Rag contains possibly a greater number of species. There is a variety of this peculiar and extinct genus, which at once arrests our attention. Biologically it forms a connecting link between the *Nerineas* and the *Actæons*, and seems peculiar to the Corallian formation. Several "species" are recorded by d'Orbigny from the Corallian of France, and amongst

* De Loriol separates these from *Chemnitzia* and unites them with the "*Phasianella*" of the Oolites to form a genus *Pseudomelania*.

† Quar. Journ. Geol. Soc., Vol. xxxiii, p. 393, pl. xiii, fig. 3.

others *N. fusiformis*, which is excessively plentiful in the intercoralline chalky mud of the Rag at Brompton. A larger form, almost answering to his *N. clymene*, is also met with on the same horizon in the Rag pit at Ruston.

The elongated, or more typical forms of *Nerinea*, are met with sparingly in the oolite of the Lower Limestones, but never in a condition where it would be safe to attempt a specific name. Throughout the Coralline Oolite, especially at Pickering, the various shelly horizons, even as low down as the *Trigonia*-beds abound with *Nerinea*, usually referred to *visurgis*, Rœm.; but there is more than one form, and it may be doubted if the real *visurgis* be amongst them. Out of the unapproachable figures of *Nerinea*, which d'Orbigny's skilful artist has presented to us, there are some to which our rolled and battered Yorkshire specimens bear a faint resemblance. In the Rag again, where this group of univalves is not quite so plentiful, there is an immensely long, narrow species, well described by Bean's term *allongiuscula*, whatever may be its more correct identification. The most common species throughout is *N. Rameri*, and there may be others besides the three to which the majority of the specimens are referred.

If we were disposed to describe a portion of the Coralline Oolite as a *Nerinea* or *Chemnitzia* Limestone, it would be quite in accordance with the facts, and yet in Yorkshire this subformation lies *below* the zone of *Cidaris florigemma*, or Coral Rag; whereas, in Eastern France, the so-called Nerinean zone is within the Epicorallien of Thurmann, and therefore *above* the great bulk of madreporic limestone of that region. Hence the inapplicability of such terms as Nerinean* zone is most obvious, except for purposes of local description; hence, also, the impossibility of a too rigid correlation being attempted between areas widely separated.

The smaller univalves are principally confined to the Coral Rag, which contains species of *Littorina*, *Nerita*, *Neritopsis*, *Turbo*, *Trochus* and *Delphinula*. With the exception of *L. muricata*, and its very near relative, the *L. pulcherrima* as identified, none of these are very plentiful. We have a poor list to exhibit in comparison with that of Buvignier from the Coral Rag of the Meuse,

* Since De Loriol has proposed that the term Etage Corallien should be altogether suppressed, as only leading to confusion, *a fortiori*, therefore, such terms as Nerinean-zone.

and it also compares disadvantageously with the Inferior Oolite of Bradford Abbas, and the Great Oolite of Minchinhampton. The fact is that, in this formation, a small shell has a poor chance of being detected unless it is developed by weathering, and too often the process has gone too far. Still the shells are there, and it may well be doubted if this apparent poverty is the result of such a very restricted fauna as Prof. Phillips supposed. The chalky Coral Rag of Upware contains numerous casts of small univalves, and there is considerable analogy between its fauna and that of the Coral Rag of the Howardian Hills, east of the Derwent; hence we may hope to find more in course of time.

The genus *Pleurotomaria* was evidently on the decline; besides the species, or varieties quoted, there is a very fine *Pleurotomaria* in the Rag of North Grimston, but I have not been able to extract it and therefore it is unnoticed in the Table. The remainder of the Gasteropoda in the list call for no special remark. It may, however, be noted that *Cylindrites elongata*, Phil., so characteristic of parts of the Lower Limestones, has been most inadequately figured by that author; his representation (Pl. iv., fig. 7), merely shows the interior of the whorl. The shell most probably appears in some other work, and of course under another name.

The Anatinidæ and Myacidæ are not particularly numerous in the Coralline Oolite or Coral Rag generally; not nearly so abundant, for instance, as they are in the Cornbrash and other members of the Lower Oolites. In most parts of the Rag and in the *Trigonia*-beds of Pickering, these two families are poorly represented, but some of the oolites about Malton contain several fossils belonging to them. Their state of preservation is usually so indifferent that determinations are not very satisfactory. Such being the case, the differences between the common forms of *Goniomya*, for instance, and those which occur in the Kelloway Rock do not seem to be very great. This subgenus is extremely plentiful in the Upper Calcareous Grit of Pickering, and the Cement-stone of North Grimston, where specimens attain an unusual size, becoming complete megalomorphs in fact, but yet not differing very much from the regulation *G. litterata*, or *G. v-scripta* of our English palæontologists. It would not be difficult, perhaps, to increase the number of species of *Myacites* recorded in the Table, if one were disposed to match every variety of form with the figures in Agassiz' work. Some of these forms, such as that referred to *M. jurassi*,

Brogn., appear to run through nearly all the Oolites, though with such a number of aliases, that their identity seems lost. The *Pholadomyæ* present more salient features for specific identification, and, as usual, there is an infinite choice of names. The forms identified with *P. decemcostata*, Roem., and *P. æqualis*, Sow., will include most of the more or less elongated varieties, whilst the large deltoid *Pholadomyæ* are placed under the head of *P. parvicosta*, Ag.* These shells are ventricose, truncated in front, and ornamented with salient ribs, few in number, sometimes no more than one. The Malton collectors obtain them, but I have never been able to ascertain the precise horizon on which they occur. This may be the same shell as the *P. paucicosta* of Roemer, and the *P. ventricosa* of Goldfuss, the former being said to occur in the "Upper Coral Rag" of Hildesheim.

The genus *Astarte* is very well represented, both as to individuals and species. The forms in the lower beds are *A. Duboisiana*, and *A. extensa*, and more rarely the great species found at Wydale. *A. Duboisiana* is extremely characteristic of the Coralline Oolite of Seamer, Ayton, &c., and occurs as a megalomorph in the equivalent Bellheads oolite at Hackness. It is also very common in the base of the Coralline Oolite of Pickering along with *Nerinaæ* and some corals. The most frequent *Astarte* of the higher part of the Coralline Oolite is *A. ovata*, and this attains a large size, being frequently found with both valves in the Coral Rag of North Grimston. This species is particularly plentiful in the shell-beds of the *Chemnitzia*-limestones and oolites. It usually occurs in the oolites with a perfectly smooth exterior, the whole of the surface markings having been removed by attrition, or by that peculiar process of "sweating," which is so destructive of many of the shells. But if preserved under favourable conditions, as, for instance, in the great shell-bed of the North Grimston Rag, where the fossils have not been rolled, and where the slightest trace of marking on the surface has been most faithfully copied in the calcitic replacement of the original shell, the delicate concentric lines of growth which form its only ornament, are very distinct. This is a very common form throughout the Oolitic System; but little real differ-

* "C'est une des espèces les plus communes du Jura Suisse; elle est surtout caractéristique pour les strates de calcaire vaseux, alternant avec les marnes subsablenses du groupe Oxfordien des régions littorales."—Agassiz, Moll. Foss., p. 99.

ence seems to exist between our shell and *Astarte modiolaris* (? = *obliqua*) of the Inferior Oolite. We can also trace the form in some of the plates of foreign palæontologists, though of course under a different name. As an extremely common species it would naturally throw off a certain number of varieties, and some of these might "take," or be perpetuated, but yet the type form seems to have been recurrent, with very slight modifications indeed, at periods sufficiently remote. A case like this affords an illustration of the extreme difficulty of giving an adequate idea of the fossil conchology of a formation through the agency of "specific" nomenclature as at present adopted; hence the necessity, as I previously pointed out, of taking our Tables *cum grano salis*. In this particular instance, one cannot help wondering whence came this *Astarte ovata* into the Coralline Oolite, since we fail to find it in the shell-beds at the base of the Lower Limestone. On the other hand what was the fate of the descendants of *Astarte producta*, that very common little shell of the Lower Passage-beds?

Astarte rhomboidalis, which externally is very like a *Hippopodium*, first enters an appearance as a micromorph in the Lower Coral Rag of Hackness, and has never, to my knowledge, been found in the Coralline Oolite, but is plentiful in the Howardian Rag. This shell seems identical with the one occurring in the Inferior Oolite of Bradford Albas and the Great Oolite of Minchinhampton.

The genus *Opis* is one of such marked outline, and such pronounced ornamentation, that its various forms are more easily caught and differentiated. Hitherto, in the Yorkshire list, *Opis Phillipsi* has usually included *O. corallina*, and all the small varieties, but these are subject to great differences throughout the entire series. The Coral Rag of Langton-Grimston has yielded us a few specimens of two far larger species, viz., *Opis viridunensis*, and *O. lunulata*.* The seeming connection between the fauna of this Rag of the Eastern Howards and the small but very rich exposure at Upware is curious. In Yorkshire we get the shells, in Cambridgeshire the casts, but the former are rare, the latter plentiful.

The Lucinidæ are amongst the more numerous bivalves of the Coralline Oolite, and they constitute the bulk of the shells as yet

* These occur, the former abundantly, in the Coral Rag of Upware, along with *Opis paradoxa*, and *O. arduennensis*, d'Orb., in addition to the *Phillipsi-corallina* group.

recognised in the Supracoralline beds. The physical conditions of the Coral Rag seem to have been less favourable for them. The genus *Lucina* itself, is most fully represented by unornamented forms of moderate dimensions, such as those referred to *L. aliena*, and *L. globosa*, which, along with *Ch. heddingtonensis* and *Nerinea*, make up the bulk of the shell-beds in the *Chemnitzia*-limestones and oolites (Coralline Oolite); these two are closely allied, and perhaps pass into each other. The less common forms require to be well preserved in order to admit of identification. As regards those species which are so common in the Upper Calcareous Grit, it has been thought advisable to adopt the named form which most resembles them, but the identifications must be received with caution. I have not yet succeeded in finding the foreign synonym for the large and handsome *Lucina ampliata*, if the shell really is a *Lucina*. "Malton" alone yields it, but whether it comes from the Upper Oolites of Malton, &c., or the presumed Lower Oolites of Swinton, &c., is unknown to me; and the same remark is applicable to the fine series of *Corbis* or *Corbicella*,* which serves to connect our Yorkshire Corallian with those districts, whence Buvignier's fine shells were obtained. *Tancredia* and *Unicardium* are found sparingly, though these and many other shells, such as *Myacites*, &c., were possibly the originals of the half-dissolved casts so often met with in the upper part of the Swinton Oolites.

The *Trigonia* have been so exhaustively treated in Dr. Lycett's admirable monograph, that it is not necessary to say much in explanation of this portion of the Table. The specimen from the Upper Calcareous Grit referred to *T. Voltzii* might perhaps be open to doubt. When one looks over a large series of clavellate forms from the *Trigonia*-beds (Upper Passage-beds) of Pickering, it would not be difficult to pick one out that would match it. The discovery of a well-marked and very handsome species, belonging to the group *Scaphoidea*, in the Lower Passage-beds, is one of considerable interest. This species, called by Dr. Lycett *T. snaintonensis*, follows the type of *T. recticosta*, so characteristic of the *Millepore*-bed of the Inferior Oolite, but there are very obvious differences of ornamentation, and as the missing links which must have existed somewhere during the long time which elapsed between the two formations, are not forthcoming at present within the Yorkshire

* Mr. Blake obtained a specimen from one of the quarries at Malton.

area, the claim of this form to specific distinction is a very good one.

It is difficult to avoid remarking that the coarse gritty limestones and marly sands of the "Yorkshire Oolites" generally, have been prolific of small and curiously-marked *Trigonia* belonging to the so-called Scaphoideæ and Undulatæ; and it may be a question for subsequent investigation how far these local and vertically limited forms are due to mere variations in larger, and more widely distributed species superinduced by the coming on of "estuarine" conditions; or, on the other hand, whether each sandy "estuary" was not provided with varieties of race especial to itself—*T. snaintonensis*, however, has a considerable horizontal range, as Dr. Barrois has sent it to me from the Upper Oxfordian of the Ardennes, where it is associated with a fauna not on the whole dissimilar from that of the Passage-beds.

The *Arcadæ* are both numerous and conspicuous, especially in the upper beds; *Arca* and *Cucullæa* seem to have affected the neighbourhood of Coral Reefs. The two commonest forms in the Rag are *A. pectinata* and *A. quadrisulcata*, but along with these occurs a large *Arca* or *Cucullæa*, also found in the Malton oolite, which seems to replace *C. corallina*, the species so plentiful in the *Trigonia*-beds at Pickering, and elsewhere in England. Some of the smaller species of *Arca*, especially from the lower beds, may turn out to be micromorphs of forms attaining greater dimensions in the Rag.

Of the aviculoid Monomyaria, *Gervillia* is by far the most abundant, so much so that the shell-beds of the Lower Limestones generally may be called *Gervillia*-beds, just as those of the Coralline Oolite are called *Chemnitzia*-beds. The genus *Avicula* is very well represented both in species and individuals in the lowest beds, but is rare in the Coralline Oolite, and almost unknown in the Coral Rag. The most characteristic species, and one peculiarly Corallian, is *A. ovalis*, which here performs the part of *Avicula echinata* in the Cornbrash. It makes its appearance probably somewhere in the Lower Calcareous Grit, and attains its maximum size, and abundance in the lower Passage-beds, especially at Appleton. This variety is also found in the Swinton Oolite, which contributes to strengthen the view that that rock is related to the Lower Limestones. Tracing it upwards through the Coralline Oolite, its form changes, whilst its size is reduced, and

finally, in the Upper Calcareous Grit, there is a form so different as almost to merit another name. Here the curtain drops, and when next we obtain a glimpse of another act in the Jurassic drama of Yorkshire *Avicula ædiligensis*, so common in the lower Kimmeridge of Hildenley and Burdale, has possession of the stage: this species, however, is allied to *A. inæquivalvis*, and not to *A. ovalis*.

The Ostræidæ are well represented. *Lima* is very abundant and varied, the shells of the different species attaining a great size, especially in the Rag. Again we seem to have some Lower Oolite forms. *L. pecteniformis*, so common in the Inferior Oolite of Cheltenham and Cornbrash of Yorkshire, is one of the leading fossils of our Coral Rag, and it would be difficult to separate the *L. gibbosa* of the Lower Passage-beds from the well-known species which first appears in the *Spinosa*-stage of the Inferior Oolite of the Cotteswolds.* Some of the other forms are similar rather than identical with those of preceding formations. The true *Lima læviuscula* (var. b.) and *L. rigida*, neither of which I have as yet found of any size in the Lower Limestones, are amongst the most characteristic fossils of the Coralline Oolite and Coral Rag in the Howardian Hills, and also at Oxford. The two splendid fossils figured in Pl. vi. are portraits of individuals rather than of species. In the Table they are referred provisionally to known species, in order to obviate the necessity of giving new names. These identifications might not perhaps suit every palæontologist. In the Ayton-Brompton Rag a smaller species with finer lines is very numerous.

The Pectens also are very numerous and attain magnificent proportions in the Malton oolite, as an inspection of the Museums at Cambridge, York, and Scarborough will prove. In this genus we see no signs of a pauperised fauna, but each form-group culminates in size and beauty, having passed on from the older Jurassic beds, where, as in the Cornbrash, the ancestors of *Pecten lens*, *P. vimineus*, *P. fibrosus*, and *P. inæquicostatus*, amongst others, are not difficult to recognise—nay, we can trace their likeness in still older beds. Yet in the lower Corallian of Yorkshire—on the horizon, for instance, of the Hackness lower Coral Rag, often so very fossiliferous, and generally, in fact, until towards the top of

* It is more like *L. gibbosa*, Sow., than it is like *L. lepida*, Dollf.

the Lower Limestone—the genus is represented by small forms, amongst which *P. vagans-fibrosus* is by far the most numerous. To what cause, then, are we to attribute this increase in the size of the individual, and the complexity of the forms? Is it that the finer species kept out of the area during those periods of adversity when the Oxford Clay and Lower Calcareous Grit were being deposited; or are these results due to the effect of favourable conditions stimulating into activity capacities otherwise dormant? Closely associated with *Pecten* is the sub-genus *Hinnites*, and in no section of the Mollusca do we seem to see greater variation according to conditions, yet with an approximate retention of original form. There is, however, in the Coral Rag throughout England a most characteristic representative of *Hinnites*, which attains an immense size at North Grimston, and is well worthy of specific designation. This is also true of the so-called *Anomia radiata*.

The Oysters proper are, of course, the most numerous of all the Mollusca. The sandy and clayey beds above and below contain the large Gryphæas, which disappear or are modified in the more calcareous parts. Some of the intercoralline portions of the Rag are a mass of oysters, especially on Langton Wold about the Grand Stand. These are generally called *Ostrea duriuscula*, which is the name of a flat valve of no very marked characters, figured by Phillips. As this Rag is high, and probably above the *florigemma*-zone in places, one might expect to find some of the figured forms of continental authors. The innumerable small oysters which occur from the base to the summit of the formation are conveniently lumped under the general heading of *Exogyra nana*. The plaited or coxcomb oysters offer more interesting forms, and in the lower beds on the coast modifications of the old *Ostrea flabelloides* are often seen, whilst the *Ost. gregaria*, also an older form, swarms in parts of the Rag.

Allusion has been made to the Brachiopoda of the lower beds in a previous paper.* Above the basement beds of the Lower Limestone they seem to be scarce, and in the Coralline Oolite are almost absent. One bad specimen of *Rhynchonella* and a still more dubious *Terebratula* are all I have ever seen. A similar scarcity was noted at Oxford by Whiteaves, and obtains through-

* Proc. Geol. Soc., Vol. iv., pp. 394 and 403.

out England. *T. insignis* (var. *Maltonensis*) occurs in the Coral Rag, being found at the Whitewall quarry on the northern face of the Langton Wold ridge.* The Echinoidea of the lower beds† have already been alluded to in the above-quoted paper. For further information I must refer to the Table of fossils, merely remarking that the rule as to increase of size in the higher beds is especially true of the Exocyclic urchins, where the same species ranges throughout. This is especially noteworthy in *Collyrites bicordatus*, *Echinobrissus scutatus*, and *Pygurus pentagonalis*. A specimen of the latter found by me during the autumn of 1877 in the Grimston Field Rag-quarry is very much larger than the biggest specimen figured by Dr. Wright.

There are not more than ten species of Corals at the utmost enumerated from the Corallian of Yorkshire, and of these *Isastræa explanata* and the two species of *Thamnastræa*, together with *Thecosmilia annularis*, make up the bulk of the reefs. The lower Jurassic beds show a greater variety in this respect, though not perhaps in Yorkshire. Many species have lately been described from the Lias of the West Midlands, where they seem to occur in isolated patches of small extent, but highly prolific in variety of form. The Coral reefs of the Inferior Oolite in the Cotteswolds, occurring on three distinct horizons, are also richer in species than the far more bulky Coral Rag. We must regard the whole Jurassic period, therefore, as one where reef building conditions prevailed when the opportunity was suitable, and this is generally admitted to afford evidence that the isocryme of 68°F. then prevailed at least as far as the latitude of North Yorkshire.

The Coral Rag and its accompanying *débris* are the remains of the last great effort of the reef building species in our islands, and nowhere else in Britain has the *Astræa* tribe left such a monument of its energies as in East Yorkshire. To the geologist, who is above all things the historian of the earth's progress in time, the remains of these latest reef building Corals that ever grew in the British area must present features of considerable interest. Compared with the stupendous masses in existing æquatorial seas, the accumulations which have been described in this Paper may seem scanty even in the region of their greatest development.

* Cf. Hudleston and Walker—"Oolitic Brachiopoda of Yorkshire," Proc. York. Phil. Soc.

† *Loc. cit.*, p. 394.

Doubtless they must be looked upon as shallow water deposits supported on sand banks and shell beds, rather than on submerged peaks such as those of the Indian and Pacific Oceans, whose rapid declivity and continuous descent have afforded opportunities for such enormous thicknesses of Coral rock to be built in recent times.

There is no evidence of the formation of Coral reefs in the British seas during the Cretaceous period ; yet they are met with in the contemporaneous deposits of central and southern Europe. The last traces of reef building Corals had not been extinguished from southern Europe even in Miocene times, but since then all parts of Europe have become too cold for them. When we couple these facts with a study of the development of reef building Corals in times anterior to the Jurassic, we seem to obtain important evidence as to the climatal history of our planet which physicists and speculative mathematicians, ignorant of or indifferent to geological history, can alone afford to ignore.

NOTES ON THE FOSSILS FIGURED.

NERINÆA VISURGIS, Auctorum, non Rœmer. Pl. iv, figs. 1*a* and 1*b*.
—This species is locally abundant, especially in the Coralline Oolite of Seamer and Ayton, and at the base of the Coralline Oolite, Pickering. 1*a* is an unusually good specimen for Yorkshire, yet the shell is so worn that the ornaments are more or less obliterated, especially towards the apex. I have never seen a specimen of the real *N. visurgis*, Rœm., but if it is anything like the figure (Nordd. Ool. Geb., t. xi., fig. 28), it is much more obtuse-angled than our species. In the small shell-bed at the base of the Coralline Oolite, Pickering, are many specimens of *Nerinæa*, of which 1*b* has been selected for figuring. It probably represents a younger stage of this species.

NERINÆA RœMERI, Phillipi, in Goldfuss. Pl. iv, figs. 2*a*, 2*b*, 2*c*.
—This species is by far the most abundant and widely distributed, both vertically and horizontally, but usually so disfigured that the ornamentation is lost. The figure in Goldfuss (Petref., t. 176, fig. 5*b*) is very like the majority of those Yorkshire specimens, whose ornaments have to any extent been preserved. Ours is certainly not the *N. fasciata*, Rœm. (Nordd. Ool. Geb., t. xi., fig. 31) ; neither is it the *N. fasciata*, Voltz (N. Jahrb., 1836, t. vi., fig. 21), which may or may not be the same species. In *N. Rœmeri* the apical angle is more obtuse than in either of these, and the

shell is altogether shorter and stouter. 2a is a full-sized specimen from a very rich block of the Ayton or Seamer Coral Rag. The artist has a little overdone the restoration of the ornaments, especially at the sutures, but the figure may be taken as a fair representation of one of the best preserved specimens I have been able to procure. The others are fragments of probably the same species in different conditions of preservation, which may account for the somewhat different character of the surface.

NERINÆA, cylindrical species. Pl. iv., fig. 3.—This is probably the *N. allongiuscula* of Bean. The angle of this shell corresponds pretty nearly to that of *N. fasciata* according to Rømer's figure, but the ornaments, as far as these can be made out, do not seem to correspond. It has been confounded with the far commoner *N. Rømeri* under the general term *N. fasciata*. I have seen very long individuals, probably belonging to this species with every trace of ornament destroyed. The specimen figured is merely a fragment; the apical angle at once shows it to be different to either of the other species. Cf. *N. sexcostata*, d'Orb.

PSEUDOMELANIA, species. Pl. iv., fig. 4.—This has far too blunt a cone to be the well-known *Ps. heddingtonensis*; *Ps. collisa*, de Lor., is something like, yet hardly the same. Should further search disclose better specimens this form may be worthy of specific description.

TROCHUS, cf. *ACUTICARINA*, Buvignier; *TROCHUS INORNATUS*, Buvignier; *TURBO LÆVIS*, Buvignier; *TURBO CORALLENIS*, Buvignier.—Pl. iv, Figs. 5, 7, 6, 8.—These are all specimens from the Corallian of Yorkshire, and with the exception of the last (often mistaken for a *Nerita*) have as yet been very rarely found.

QUENSTEDTIA LÆVIGATA, Phillips. Pl. iv, figs. 9, 10, 11.—The specimen figured by Phillips ("Geol. Yorks.," vol. i, Pl. iv, fig. 5) is much smaller than fig. 9, but the general character is the same, with its round anterior margin, and the produced and sub-quadrate character of the posterior margin. The generic characters are given in Morris and Lycett, "Bivalvia," p. 96. Distinguished from *Psammobia* by the position of the ligament which is placed in a narrow fossa, this feature is common to all the three shells figured, and may serve to distinguish them from *Panopæa*, *Arcomya*, &c., to the latter of which Fig. 11 has a strong external resemblance. The dentition is obscured more or less in all the specimens by wear, or by the adhesion of fragments of oyster shells. The group

appears moderately plentiful in the Malton Oolites. Whether the forms figured have any claim to specific distinction, or are simply varieties of over growth (megalomorphs), it is impossible to say.

CUCULLÆA CORALLINA, Damon. Pl. v, fig. 12.—Damon's figure ("Geology of Weymouth, Supplement, Pl. iv, fig. 8) gives the character of this species fairly, but there is no description. Phillips' *C. oblonga* ("Geology of Yorkshire," Vol. i, Pl. iii, fig. 34) is probably intended for this species. Lycett, in the "Supplement to the Great Oolite Mollusca," figures a shell from the Cornbrash of Scarborough, which he refers to this species ("Supplement" t. xxxix, 3). The figure is certainly not characteristic of the Corallian form, though, no doubt, the two are closely related.

This species, as found in the *Trigonia*-beds at Pickering—its head-quarters in Yorkshire—is short, tumid, and abruptly truncated, but is especially characterised by the ornamentation on the anterior side. This consists of a few well-defined but distant radiating lines decussating with the densely arranged longitudinal lines which pervade the entire surface. This seems more conspicuous on the left valve than on the right one. The radiating lines on the posterior surface are only just visible and appear to have been wanting in the centre. It is probable that *C. contracta*, Phil. ("Geology of Yorkshire," Vol. i, Pl. iii, fig. 30) may be intended for a small and very truncated form of this species.

CUCULLÆA ELONGATA, Phillips, non Sowerby. Not figured.—It was originally intended to give a figure of this large form, as the *C. elongata* in the "Geology of Yorkshire" (Pl. iii, Fig. 33) is a very inadequate representative of our shell, if, indeed, it be really meant for it. The *C. elongata* of Sowerby is totally different, but *C. oblonga*, Sow., from the Inferior Oolite not unlike; hence probably the mistake. Some of the foreign names—such as *Arca Laura*—would almost do. In comparison with *C. corallina* this shell is more produced in proportion to its height, and has less angularity and abrupt truncation. All the specimens seen by me are destitute of ornament, but this may be due to attrition. Mr. Reed has a fine example $3\frac{1}{2}$ inches long, from the Coralline Oolite of Malton. We may regard this shell as taking the place of *C. corallina* in the upper part of the Coralline Oolite and in the Coral Rag. Doubtless, intermediate forms must occur.

TRIGONIA BLAKEI, Lycett; and *TRIGONIA SNAINTONENSIS*, Lycett. Pl. v, figs. 13 and 14.—Named by Dr. Lycett from

specimens obtained by me at Wydale. *T. snaintonensis*, which is a very well-characterised species, locally rather abundant, is described in the "British Fossil Trigonæ," p. 198. It is believed that *T. Blakei* will shortly be described and figured by Dr. Lycett.

AVICULA OVALIS, Phillips. Pl. v, figs. 15*a* and 15*b*.—Figure 15*a* shows the variety characteristic of the Passage-beds just above the Lower Calcareous Grit at Appleton: Fig. 15*b*, represents the variety which occurs sparingly in the Coralline Oolite of Malton. It might almost be taken for the young of *Hinnites*.

PECTEN INÆQUICOSTATUS, Phillips, Pl. v, fig. 16.—The right valve (16*a*) is the form usually known under this title, and the left valve (16*b*) not seldom goes by some other name. These are opposite valves of the same individual shell fitting without the least displacement. The specimen, which belongs to Mr. Reed of York, has been kindly lent for the purpose of illustration; it is probably the finest of its kind in any collection. The ears are drawn from other specimens.

LIMA SUBANTIQUATA, Rømer. Pl. v, fig. 17.—This well-marked species of *Lima* is figured from a Yorkshire specimen, not quite well enough preserved to show the true character. Its outline seems different to that of any other species of *Lima*.

LIMA, species. Pl. vi, fig. 18.—This magnificent specimen, the property of the Yorkshire Philosophical Society, has been kindly lent for illustration. In the table of fossils it is provisionally referred to *L. læviuscula*, var. *c*.

In English works dealing with palæontology the large Corallian forms have hitherto been referred either to *L. læviuscula*, Sow., or to *L. rigida*, Sow. But shells extremely different to these well-known types are not unfrequent. In Rømer's work (Nordd. Ool. Geb.), we find two large Corallian Limas described and figured; viz., *Lima tumida*, Røem. (Pl. xiv., fig. 1) from the Upper Coral Rag of Hildesheim, and *Lima grandis*, Røem. (Pl. xiii., fig. 10), from the Lower Coral Rag of Heersum.

The shell now figured has been occasionally identified with *Lima tumida*, no doubt on account of its suborbicular figure, and to a certain extent similarity of ornament. This may be near the mark. In order, however, to avoid the risk of a wrong identification, and also to obviate the necessity for making a new species, I have concluded to place this shell with the *læviuscula* group provisionally. Inferior specimens of probably the same variety are met

with chiefly in the lower beds, and have already been placed by Blake and Hudleston, provisionally, in the same category.

The specimen figured is the largest and best preserved of any known to me. It is plano-convex (scarcely tumid), suborbicular, and nearly equilateral, with broad, radiating costulæ, smooth above, but rougher, and with more tendency to rise into ridges below. The interstitial sulci, narrow above, but widening out towards the lower margin, are transversely punctato-striate to about the middle of the shell, below which these markings disappear—perhaps owing to an imperfection of fossilization. Being somewhat obscure, they are not shown in the figure.

LIMA cf. *GRANDIS*, Rømer. Pl. vi, fig. 19.—The markings on the sulci would seem to connect our shell with *L. rigida*, Sow., but its ribbing and mode of growth are altogether so different that we must either find another name for it, or give it a new one. Rømer's description of *L. grandis* suits our shell better than his figure does, the chief difficulty being as to the markings of the sulci.

The specimen figured is a very fine one, but I have seen some others nearly as good. It is plano-convex, obliquely semicircular, shortened anteriorly; with flattened, closely set, narrow costulæ, separated towards the lower margin by wider sulci. In the anterior portion of the shell the sulci are always wider, and the intervening costulæ by consequence thinner and sharper. The transverse striations of the sulci, where visible, are fine and numerous.

EXPLANATION OF PLATES.

PLATE IV.

- 1a *Nerinaea visurgis*, auct, non Røem. C.O., Seamer; Reed Coll.
- 1b *Nerinaea visurgis*, young specimen, C.O., Pickering; my Coll.
- 2a *Nerinaea Rømeri*, Goldf. C.R., Ayton; Leck Coll.
- 2b *Nerinaea Rømeri*, Goldf. C.O., Ayton; Leck Coll.
- 2c *Nerinaea Rømeri*, Goldf. C.R., Langton Wold; my Coll.
- 3 *Nerinaea* (cylindrical species). C.R., Langton Wold; my Coll.
- 4a *Pseudomelania* sp. C.R., Brompton; my Coll.
- 4b *Pseudomelania* sp., reverse.
- 5 *Trochus*, cf *aoticarina*, Buvig. C.R., Howardian district; Leck Coll.
- 6 *Turbo lævis*, Buvig. C.R., Ayton; Leck Coll.
- 7 *Trochus inornatus*, Buvig. Passage-beds, Wydale; my Coll.
- 8 *Turbo corallensis*, Buvig. C.R., Ayton; my Coll.
- 9a *Quenstedtia lævigata*, Phil., right valve. C.O., Malton; York Coll.
- 9b Hinge of ditto.
- 10a *Q. lævigata*, var *gibbosa*, right valve. C.O., Malton; York Coll.
- 10b Hinge of ditto.

11a *Q. lævigata*, var. *elongata*, left valve. C.O., Malton; Leck Coll.

11b Hinge of ditto.

PLATE V.

12 *Cucullæa corallina*, Damon. C.O., Pickering; my Coll.

13 *Trigonia Blakei*, Lycett. Passage-beds, Wydale; my Coll.

14a *Trigonia snaintonensis*, Lyc. Passage-beds, Wydale; my Coll.

14b *Trigonia snaintonensis*, from the Upper Oxfordian of the Ardennes; my Coll.

15a *Avicula ovalis*, Phil. Passage-beds, Appleton; my Coll.

15b *Avicula ovalis*, variety from the C.O., Malton; my Coll.

16a *Pecten inæquicostatus*, Phil., right valve. Corallian, Malton; Reed Coll.

16b Opposite valve of same specimen.

17 *Lima subantiquata*, Rœm. C.R., Settrington; my Coll.

PLATE VI.

18 *Lima*, species, left valve. C.O., Malton; York Coll.

19 *Lima*, cf. *grandis*, Rœm., left valve. Coral Shell-bed, Seamer; my Coll.

POSTSCRIPT.—The following notes were hastily put together during a recent inspection of Bean's collection at the British Museum:—

Astarte, species: possibly different to any in the Table.—*Cyprina corallina*, d'Orb.=*Cytheræa maltonensis*, Bean.—*Astarte aytonensis*, Lyc. The specimens in Bean's cabinet were found, according to Dr. Lycett, in the "Calcareous Grit of Ayton." The matrix is sub-oolitic. He compares this shell to *A. compressiuscula* of the Inferior Oolite of the Cotteswolds. Judging from the exterior only, some persons might doubt whether the shell should be referred to this genus.—*Cypricardia corallina*, sp. n. very like the shell so named from the Leck. Coll.—*Corbicella lævis*, Sow.=*C. lucida*, Bean.—*Anomia radiata*, Phil.=*A. inæqualis*, Bean.

A few doubtful points might be cleared up, and one or two additional species noted, from a more careful inspection of Sir Charles Strickland's collection, in some respects the best Corallian collection in this country. The opportunity thus afforded would furnish material for a short palæontological paper, in which the new species of Invertebrata enumerated in the Table—ten in number—could be described and figured.

When studying the Table attention should be drawn to the great abundance of Univalves in Column iii. (Coral Rag), pp. 483, 484, and to the poverty of this sub-formation in the genera and species enumerated at base of Page 485 and on Page 486. Note also the abundance of *Arca* and the absence of *Avicula*.

TABLE OF FOSSILS AT PRESENT KNOWN TO OCCUR IN THE CORALLIAN ROCKS OF YORKSHIRE.

For further explanation see PALÆONTOLOGY, page 458.

Explanation.—Column A denotes beds older than the Corallian in Yorkshire.

B. beds newer than the Corallian in Yorkshire, *e.g.*, Kimmeridge Clay.

I. Lower Calcareous Grit in part, and lower Limestones excepting top shell-bed.

II. Coralline Oolite Group.

III. Coral Rag.

IV. Supracoralline.

v. c. Very common. c. common. m. moderately plentiful. l. locally abundant. r. rare. v. r., very rare.

<i>Genus—Species.</i>				A.	I.	II.	III.	IV.	B	<i>Localities and Remarks.</i>
Pleiosaurus	teretidens,	Owen MS.	...	—	r	r	*	—	—	1. cf. <i>P. brachydeirus</i> , Owen—Teeth in C. R. of Grimston; rarer in Malton Oolite.
Teleosaurus	sp. (<i>probably undescribed</i>)		...	—	*	*	—	—	—	r. Lower jaw in York Mus.—Teeth found sparingly.
Dakosaurus	sp. (<i>probably undescribed</i>)		...	—	*	*	?	—	—	r. Teeth found sparingly.
* Megalosaurus	? Bucklandi,	Meyer	...	—	—	*	—	—	—	v. r. Specimen of tooth in white oolite, York Museum.
Sphærodus	sp. (<i>probably undescribed</i>)		...	—	—	*	—	—	—	1. "eyes" of the Malton quarrymen.
Pycnodus	cf. umbonatus,	Ag.	} p	—	—	*	—	—	—	v. r. British Museum, Bean Coll.
Gyrodus	sp.		...	—	—	?	—	—	—	v. r. One palate in Leck. Coll.—apparently in Malton Oolite.
Hybodus	cf. grossiconus,	Ag.	...	—	—	*	r	?	—	1. Chiefly from calc grits of Appleton, and Birdsall.
"	obtusus,	Ag.	...	—	—	—	*	—	—	r. C. R. of Grimston—Found at Wheatley, near Oxford.
Asteracanthus	ornatissimus,	? Ag.	...	—	?	—	—	—	—	v. r. One spine in my Coll.—locality unknown.
Belemnites	abbreviatus,	Mill. var. a.	...	—	r	*	r	—	—	c. Chiefly in the L. C. G., very stout short form.
"	"	var. b.	...	—	—	*	?	—	—	c. A modification of the above, chiefly in the C. O.
"	"	var. c.	...	—	—	—	?	*	?	1. A very marked form occurring in the supracoralline.
"	nitidus,	Dollf.	...	—	—	—	—	*	*	r. In the U. C. G., but characteristic of the lower K. C., = <i>B. explanatus</i> , Phil.
"	cf. Owenii,	Pratt	...	—	—	*	—	—	—	r. These narrow forms occur in C. O., at Malton and Settrington.

* N.P. The Museum of the Yorkshire Philosophical Society contains the bones of a very large Saurian from the Corallian of Slingsby; also fragments of bone referred to *Ganodus*.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
Belemnites hastatus, Mont.	...	...	...	*	*	?	—	—	—	m. Small forms referred here occur chiefly in the lower beds.
„ ? semisulcatus, Münst.	...	...	...	—	—	—	—	*	—	v.r. One specimen from the Cement-stone, N. Grimston.
Nautilus hexagonus, Sow.	...	...	...	*	*	*	—	—	—	m. Chiefly in the gritty Passage-beds. Attains a great size.
„ aganiticus, Schlot.	...	...	...	—	—	—	*	—	—	v.r. One specimen found in the top of the C. R., Grimston Field.
Ammonites (Aspidoceras) perarmatus, Sow.										
var. a. ...	...	...	...	*	*	—	—	—	—	m. Rounded thick-whorled form with large spikes, L. C. G. of coast.
„ var. b.	...	...	...	—	*	?	—	—	—	m. Sides more compressed; spikes less prominent (type). Lower Limestones.
„ var. c.	...	...	...	—	—	—	*	—	?	v.r. Single specimen from Sike-Gate, showing connection with <i>A. longispinus</i> , Sow.
„ (Perisphinctes) Williamsoni, Phil.				?	*	—	—	—	—	r. Passage-beds of Scarborough district: near to <i>A. arduennensis</i> , d'Orb.
„ „ convolutus, Quens.	...	...	...	*	*	—	—	—	—	m. The representative of <i>A. plicatilis</i> in the lower beds.
„ „ plicatilis, Sow.				—	—	*	—	—	—	c. Upper Passage-beds, Pickering, and C. O. generally.
„ „ varicostatus, Buckl.				—	—	—	*	*	?	m. Chiefly C. R. at Hildenley and N. Grimston.
„ „ cf. Achilles, d'Orb.				—	—	—	—	*	—	m. A compressed “biplex” form, chiefly in the U. C. G.
„ „ cf. decipiens, Sow.				—	—	—	—	*	*	l. A triplicate form from the U. C. G. of Kirkdale cutting.
pl. 294.										
„ Berryeri, Leseur.	...	...	...	—	—	—	—	*	*	l. Allied to <i>A. cymodoce</i> , d'Orb., U. C. G. Kirkdale.
„ (Amaltheus) cordatus, Sow.	...	...	...	*	*	*	—	—	—	v.c. <i>A. excavatus</i> , Sow., in the adult stage.
„ „ vertebralis, Sow.	...	...	...	*	*	*	—	—	—	v.c. Perhaps <i>A. goliathus</i> , d'Orb., in the adult stage.
„ vertebralis, var. Cawtonensis, Bl. & H.	...	...	...	—	—	—	*	—	—	l. A variety found in the C. R., Sike-Gate, and urchin beds, Grimston.
„ „ alternans, Von Buch.	...	...	...	—	—	—	—	*	?	m. The representative of the Cordati in the Supracoralline Beds. Pickering, &c.
„ (?) Sutherlandiæ, Sow.	...	...	...	*	*	—	—	—	—	r. A name doubtfully applied to a distinct form in the lower beds.
Purpuroidea nodulata, Y. & B.	...	...	...	—	—	—	*	—	—	m. C. R. of the Howardians. Near to <i>P. Lapiérrea</i> , Buvig.; differs from any of the Minchinhampton sp.
„ sp. ?	...	...	...	—	—	—	*	—	—	r. C. R. of Howardians.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
<i>Natica globosa</i> , Roem.	...	...	...	—	—	—	*	—	—	m. C. R. of the Howardians. Cf. also <i>N. grandis</i> , Münster, (d'Orb., pl. 295).
„ <i>clytia</i> , d'Orb.	...	...	...	—	—	—	*	—	—	c. C. R. of the Howardians. ? Ayton } These forms seem to run into each other. m. In situations similar to the preceding.
„ <i>Clymenia</i> , d'Orb.	...	...	...	—	—	—	*	—	—	
„ ? <i>arguta</i> , Phil.	...	...	...	—	—	—	*	—	—	r. Fine specimen from Slingsby in the Leck Coll.
<i>Chemnitzia heddingtonensis</i> , Sow.	...	...	...	—	?	*	*	r	—	.c. C. O. everywhere, less common in C. R., where the form is rather different.
„ <i>Pollux</i> , d'Orb.	...	...	...	—	—	—	*	—	—	v.r. C. R. of Langton Wold, and ? Helmsley.
„ <i>langtonensis</i> , Bl. & H.	...	...	...	—	—	—	*	—	—	v.r. Single specimen from the C. R. of Langton Wold.
<i>Pseudomelania striata</i> , Sow.	...	...	...	?	—	*	*	—	—	v.c. Frequent in C. R. of Ayton, &c., and in C. O. of Pickering and Malton.
„ <i>Buvignieri</i> , d'Orb.	...	...	...	—	—	*	*	—	—	r. C. R. of Ayton, C. O. of Nawton. The <i>Phasianella elegans</i> of some collections.
„ species.	...	...	...	—	—	—	*	—	—	v.r. C. R. of Brompton. A short form with rounded whorls. Pl. iv., fig. 4.
„ <i>calypsoides</i> , Thurm.	...	...	...	—	—	—	*	—	—	v.r. ? C. R. of Ayton—Scarborough Museum—as a <i>Nerinæa</i> in Thurm. & Etallon. (Pl. vi., fig. 20.)
„ sp.	...	...	...	—	*	—	—	—	—	v.r. A small form from the shell-bed at Wydale.
<i>Cerithium muricatum</i> , Sow.	...	...	...	*	*	*	—	—	—	c. Chiefly the shell-beds of C. O., rare in L. C. G., not found in C. R.
„ <i>limæforme</i> , Roem.	...	...	...	—	—	r	*	—	—	m. Chiefly in the C. R. of Ayton, &c., Sparingly in the Oolites.
„ <i>inornatum</i> , Buvig.	...	...	...	—	—	r	*	—	—	l. Plentiful in the C. R. of Ayton, &c.
„ cf. <i>Humbertinum</i> , Buvig.	...	...	...	—	—	—	*	—	—	v.r. C. R. of Ayton and the neighbourhood—Scarborough Museum.
„ cf. <i>viridunense</i> , Buvig.	...	...	...	—	—	*	—	—	—	r. From a shell-bed containing small univalves at Ness—doubtful identification.
„ <i>Michaelense</i> , Buvig.	...	...	...	—	—	—	*	—	—	v.r. Single specimen, C. R., Sproxtton, Blake Coll.
„ sp. n. (<i>bicinctum</i>)	...	...	...	—	—	—	†	—	—	v.r. Single specimen in Leck. Coll., “Malton.”
<i>Nerinæa fusiformis</i> , d'Orb.	...	...	...	—	—	r	*	—	—	l. Very abundant in C. R., Brompton. ? C. O., Pickering.
„ <i>Clymene</i> , d'Orb.	...	...	...	—	—	—	*	—	—	r. A stouter variety of this peculiar group of <i>Nerinæa</i> , C. R., Ruston.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
<i>Nerinea visurgis</i> , Auct., non Rœm.	...	...	...	—	—	*	—	—	—	1. <i>N. visurgis</i> of most collections. C. O. Ayton, &c. Base of C. O. Pickering. Pl. iv., fig. 1.
„ <i>Rœmeri</i> , Philippi, (Goldf.)	...	...	...	—	?	*	*	—	—	c. <i>N. fasciata</i> of some collections. C. R. Ayton. C. O. Malton, &c. Pl. iv., fig. 2.
„ „allongiuscula,” Bean.	...	...	...	—	—	—	*	—	—	r. C. R. Langton Wold. Pl. iv., fig. 3.
<i>Alaria bispinosa</i> , Phil.	...	...	...	*	*	—	—	—	—	m. Found chiefly in the L. C. G. of the coast.
„ cf. <i>tridactyla</i> , Buvig. (De Lor.)	...	...	...	—	—	—	*	—	—	v.r. Noticed by Mr. Blake in the urchin beds of N. Grimston.
„ sp.	...	...	...	—	—	—	*	—	—	v.r. One specimen, C. R. Hovingham.
<i>Pteroceras</i> ? sp.	...	...	...	—	—	—	*	—	—	v.r. One specimen (cast), urchin beds, N. Grimston.
<i>Littorina Meriani</i> , Goldf.	}	...	...	?	*	*	—	—	—	r. } The difference between these three forms is slight, yet fairly recognisable. <i>L. muricata</i> is a little beehive form; v.c. } the others are larger, but not nearly so fine as the figured c. } specimens.
„ <i>muricata</i> , Sow.		...	...	—	—	r	*	—	—	
„ ? <i>pulcherrima</i> , Dollf.		...	...	—	—	—	*	—	—	
„ (<i>Eucyclus</i>) Buvignieri, d'Orb.	...	...	...	?	—	—	*	—	—	r. C. R. of Ayton and Langton Wold.
„ „ <i>princeps</i> , Rœm.	...	...	...	—	—	—	*	—	—	v.r. C. R. of the Howardians, e.g. Hildenley—Colls. Strickl. and Reed.
<i>Nerita</i> , sp.	...	...	...	—	—	—	*	—	—	r. Casts from C. R., N. Grimston.
<i>Neritopsis Guerrei</i> , Héb. & Desl.	...	...	...	—	—	—	*	—	—	v.r. C. R. of the Howardians—Colls. Strickl. & Leck.
„ ? sp.	...	...	...	—	—	—	*	—	—	v.r. Possibly another species of <i>Neritopsis</i> . Strickl. Coll.
<i>Turbo funiculatus</i> , Phil.	...	...	...	—	—	r	*	—	—	m. Most frequent in the C. R., Ayton, Brompton, and Langton Wold; rare in C. O.
„ <i>corallensis</i> , Buvig.	...	...	...	—	—	—	*	—	—	m. The <i>Nerita levigata</i> of Bean's identification. Ayton, &c. Grimston.—Pl. iv., fig. 8.
„ <i>lævis</i> , Buvig. (? = <i>T. Erinus</i> , d'Orb., Prod. ii., 9.)	...	...	...	—	—	—	*	—	—	v.r. Single specimen in Leck. Coll. C. R. of Ayton, &c. (i.e. of Scarborough district).—Pl. iv., fig. 6.
<i>Trochus aytonensis</i> , Bl. & H.	...	...	...	—	—	*	*	—	—	r. C. R. of Ayton, &c.; Shell-bed at base of C. O. Pickering.
„ cf. <i>Michaelensis</i> , Buvig.	...	...	...	—	—	—	*	—	—	v.r. Single specimen from C. R. Brompton.
„ cf. <i>acuticarina</i> , Buvig.	...	...	...	—	—	—	*	—	—	v.r. C. R. of Howardian district; Leck. Coll.—Pl. iv., fig. 5.
„ sp. n. (<i>granularis</i>)	...	...	...	—	—	*	—	—	—	v.r. Single specimen; shell-bed at base of C. O., Pickering; Leck. Coll.
„ <i>inornatus</i> , Buvig.	...	...	...	—	*	—	—	—	—	v.r. Shell-bed in Lower Limestones, Wydale.—Pl. iv., fig. 7.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
Delphinula	Pellati, deLor.	...	...	—	—	—	*	—	—	v.r. Single specimen from quarry on top of Langton Wold; described from "Sequânien" of Boulogne.
"	muricata, Buvig.	...	...	—	—	—	*	—	—	r. C. R. of Ayton—Brompton. Strickl. Coll.
Pleurotomaria	Münsteri, Goldf.	...	...	*	*	*	—	—	—	m. Base of the whorl less bicarinated than in succeeding species.
"	reticulata, Sow.	...	...	—	—	—	*	—	—	r. C. R. of the Howardians. Originally described from K. C.
"	Agassizi, Münst.	...	...	—	—	—	*	—	—	v.r. Single specimen in Leck. Coll., from C. R. of the Howardians.
Trochotoma	tornata, Phil.	...	...	—	—	—	*	—	—	c. ? = <i>T. discoidea</i> , Buvig. Characteristic of C. R. throughout.
Patella, cf.	Mosensis, Buvig.	...	...	—	—	—	—	*	—	v.r. Single specimen from U. C. G., Pickering.
Dentalium	entaloideum, Desh.	...	...	*	*	—	—	—	—	c. L. C. G., and Lower Passage-beds of coast.
Bulla	Beaugrandi, de Lor.	...	...	—	—	—	*	—	—	v.r. Single specimen from the quarry east of Ayton.
Cylindrites	elongata, Phil.	...	...	—	*	?	—	—	—	v.c. Characteristic of the Lower Limestones, especially of the Scarborough district.
"	(Acteonina) retusa, Phil.	...	...	—	r	—	*	—	—	r. C. R. both of Scarborough and Howardian districts.
"	" ? Lhuidii, Whit.	...	...	—	—	—	*	—	—	? L. C. G.—specimen in York Mus.
Gastrochæna	Moreana, Buvig.	...	...	—	—	—	*	—	—	r. C. R., Ruston.
										c. C. R., especially at Brompton. ? = <i>Pholas recondita</i> , Phil.
										A coral borer.
Gresslya	peregrina Phil.	...	...	*	*	—	—	—	—	r. Passage-beds. Scarborough Castle.
Goniomya	litterata, Sow.	...	...	*	*	*	—	*	—	m. L. C. G., Oliver's Mount. Upper Limestones of Filey, and many other places.
"	v.—scripta, Sow.	...	...	*	—	—	*	—	—	m. C. R. of N. Grimston and elsewhere.
"	marginata, Ag.	...	...	—	—	—	—	*	—	1. Perhaps some of the Supracoralline specimens may be referred here.
Myacites (Pleuromya)	tellina, Ag.	...	...	—	—	—	—	*	—	1. } The numerous Myacites of the U. C. G., Pickering, are
"	" Voltzii, Ag.	...	...	—	—	—	—	*	—	1. } referred here.
"	" jurassi, Brong.	...	...	*	*	*	—	—	—	c. Not far from <i>M. decurtatus</i> , Phil.
"	" recurvus, Phil.	...	...	*	*	*	—	—	—	c. Near to <i>M. obliatus</i> , Sow.
Pholadomya	decemcostata, Rœm.	...	...	—	—	*	—	—	—	Several obscure and ill-preserved forms are included here.
										m. Upper Limestones of Filey point, and elsewhere.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
Pholadomya	æqualis, Sow.	...	...	—	—	?	—	—	—	m. Oolites and Limestones of uncertain position.
"	cf. concentrica, Rœm.	...	...	—	—	—	—	*	—	r. The Cement-stone of N. Grimston.
"	parcicosta, Ag.	...	...	—	*	*	—	—	—	m. Oolitic Limestones of Malton district; exact position unknown.
Homomya	tremula, Buvig.	...	...	—	—	*	*	—	—	r. Large casts occur at Malton in white oolite, and in soft rag at Grimston.
"	sp. n. (<i>grimstonensis</i>)	...	...	—	—	—	*	—	—	v.r. One specimen, C. R., North Grimston.
Thracia	incerta, Thurm., or depressa, Sow.	...	...	—	*	—	—	*	?	m. Uncertain if specimens from L. C. G. of coast are same as those from Cement-stone.
Solemya	sp.	...	...	—	?	—	—	—	—	v.r. Fine specimen, probably from Appleton, in Bowerbank Coll.
Anatina	undulata, Sow.	...	...	...	*	*	*	—	—	r. Lower Passage-beds, Appleton. Upper P. B. Pickering, Bowerbank Coll.
Quenstedtia	lævigata, Phil.	...	...	...	*	—	*	—	—	m. Type form: chiefly Malton Oolites—Pl. iv., fig. 9.
"	" var. elongata.	...	...	...	—	—	*	—	—	r. C. O. Malton. Leck. and Reed. Colls.—Pl. iv., fig. 11.
"	" var. gibbosa.	...	...	...	—	—	*	—	—	v.r. York Museum.—Pl. iv., fig. 10.
Sowerbya	(Isodonta) triangularis, Phil....	...	...	...	—	*	*	—	—	c. Specially abundant in the small Shell-bed, Pickering.
"	" Deshayesea, Buvig.	...	...	...	*	*	—	—	—	r. Occurs in Shell-bed, Wydale. N.B. Whiteaves' figure does not represent Buvignier's species.
Cyprina	corallina, d'Orb....	...	...	...	—	—	*	—	—	r. Trigonia-beds, Pickering. C. O., Malton.
Astarte	ovata, Smith.	...	...	...	—	—	*	—	—	v.c. Chiefly upper part of C. O. and C. R. of the Howardians.
"	" var. cf. Michaudiana, Dollf.	...	...	...	—	—	—	?	—	r. Specimen in York Museum.
"	Duboisiana, d'Orb.	...	...	...	—	*	*	—	—	l. Small in the L. L. Larger and more abundant in C. O. at Ayton, &c. Representative of <i>A. elegans</i> .
"	" sp. n. (<i>æquilatera</i>)	...	...	...	—	—	*	—	—	v.r. Malton Oolite. York Museum.
"	depressa, Münster.	...	...	...	—	—	*	—	—	r. Top bed of L. L., Newtondale, and Oolite of Swinton.
"	sp. n. (<i>megalomorpha</i>)	...	...	...	—	*	—	—	—	l. Passage-beds of Scarborough district. Immense specimens at Wydale.
"	extensa, Phil.	...	...	...	—	*	r	—	—	c. Lower beds of Scarborough district. Abundant at Wydale. ? <i>A. percrassa</i> , Et,

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
†	<i>Astarte</i>	<i>aytonensis</i> , Lyc.	...	—	—	—	?	—	—	v.r. A form similar to that figured by Lycett occurs in the C. R. Upware, Cambs.
"	"	<i>rhomboidalis</i> , Phil.	...	—	*	—	*	—	—	c. Chiefly C. R. of the Howardians; a dwarf variety in the L. C. R., Hackness.
	<i>Isocardia</i>	<i>tenera</i> , Sow. (<i>tumida</i> , Phil.)	...	...	*	*	—	—	—	c. More abundant in the L. C. G. than in the Passage-beds.
	<i>Cypriocardia</i>	<i>glabra</i> , Bl. & H.	...	...	—	*	—	—	—	r. Shell-bed, Nawton; small shell-bed, Pickering.
"	"	<i>isocardina</i> , Buvig.	...	...	—	—	*	*	—	m. Probably the <i>Cardium lobatum</i> , Phil.; chiefly C. R. of the Howardians.
"	"	sp. n. (<i>corallina</i>)	...	...	—	—	*	—	—	v.l. Single specimen, Leck. Coll. <i>Trigonia</i> -beds, Pickering.
"	"	? sp.	...	...	—	*	—	—	—	l. Casts of a small <i>Cypriocardia</i> occur in the L. C. R. of Hackness.
	<i>Opis</i>	<i>Phillipsi</i> , Morr.	...	...	—	?	*	*	—	m. } Small species having intermediate forms which seem to
"	"	<i>corallina</i> , Damon.	...	...	—	—	*	*	—	m. } connect them.
"	"	<i>verdunensis</i> , Buvig.	...	...	—	—	—	*	—	r. C. R. of Langton—Grimston (Howardians). Very abundant at Upware, Cambs.
"	"	<i>lunulata</i> , Roem.	...	...	—	—	—	*	—	v.r. C. R. of Grimston, Strickl. Coll.
	<i>Myoconcha</i>	<i>texta</i> , Buvig.	...	...	—	—	—	*	—	r. C. R. of Ayton, Brompton, &c. Figured by Buvignier as a <i>Mytilus</i> .
"	"	<i>Sæmanni</i> , Dollf.	...	...	—	—	*	—	—	v.r. Specimen in Reed Coll. from Malton Oolite may be referred here.
	<i>Lucina</i>	<i>aliena</i> , Phil.	...	...	—	—	*	—	—	v.c. Coralline Oolite generally, especially about Malton.
"	"	<i>globosa</i> , (Beanii) Buvig.	...	...	...	*	—	*	—	v.c. Nearly allied to the preceding; abundant rather lower down.
"	"	<i>oculus</i> , Bl. & H.	...	...	—	—	*	r	—	r. Chiefly in C. O., Malton, Nawton, Ampleforth. One specimen C. R. Ruston.
"	"	<i>Moreana</i> , Buvig.	...	...	—	—	*	—	—	r. Near to the preceding species, Nawton, Ampleforth, &c.
"	"	<i>substriata</i> , Roem.	...	...	—	—	*	—	*	m. Occurs in the C. O. at Nawton, but more frequently in U. C. G., Pickering.
"	"	<i>cf. aspera</i> , Buvig.	...	...	—	—	—	*	*	c. Very characteristic of the U. C. G., Pickering, and Cement-stone, N. Grimston.
"	"	<i>lirata</i> , Phil.	...	...	...	*	*	*	—	m. Chiefly in the calc grits, Passage-beds and limestones of the coast.

<i>Genus—Species.</i>			A.	I.	II.	III.	IV.	B.	<i>Localities and Remarks.</i>
<i>Lucina ampliata</i> , Phil. ...	...	...	—	—	*	—	—	—	1. Oolites of the Malton district only.
<i>Corbicella Buvignieri</i> , Desh. ...	...	...	—	—	*	—	—	—	r. } Fine large shells, found sparingly in the Malton Oolites. r. } York Mus. and Leck. Coll. m. }
„ <i>decussata</i> , Buvig. ...	...	...	—	—	*	—	—	—	
„ <i>lævis</i> , Sow. ...	...	...	—	—	*	—	—	—	
„ sp., with mesial umbones. ...	...	...	—	—	—	*	—	—	r. Clearly different to any of the others. York Mus.
<i>Tancredia curtansata</i> , Phil. ...	...	...	*	?	*	—	—	—	r. Originally figured by Phillips, from C. O. of Malton district.
„ cf. <i>planata</i> , M. & L. ...	...	...	—	—	*	—	—	—	r. Oolite of Settingington; "small shell-bed," Pickering.
<i>Unicardium (Sphæra) depressum</i> , Auct. ...	...	...	—	—	*	—	—	—	r. "Rabbit-eye," Malton; "small shell-bed," Pickering; C. O., Ampleforth.
„ „ <i>plenum</i> , Bl. & H. ...	...	...	—	—	*	—	—	—	r. Leck. Coll. Malton Oolite.
„ „ sp. ...	...	...	—	—	*	—	—	—	v.r. Single specimen from the C. O. of Ness.
<i>Cardium cyreniforme</i> , Buvig ...	...	...	—	—	*	—	—	—	r. "Small shell-bed," Pickering.
„ cf. <i>delibatum</i> , de Lor. ...	...	...	—	—	—	*	—	—	r. A distinctly marked <i>Protocardium</i> , U. C. G., Pickering.
<i>Trigonia Meriani</i> , Ag. ...	...	...	?	—	*	—	—	—	r. Fine specimens obtained from C. O., Malton, v.r. in <i>Trigonia</i> -beds, Pickering.
„ (<i>costate</i>) sp. ...	...	...	—	—	—	*	—	—	r. C. R. of Sike Gate, and sparingly elsewhere.
„ <i>clavellata</i> , Sow. ...	...	...	—	*	—	—	—	—	m. Specimens from L. C. G., and Passage-beds referred here by Dr. Lycett.
„ ? <i>Bronnii</i> , Ag. ...	...	...	—	*	—	—	—	—	v.r. One specimen from Oliver's Mount; not the <i>T. Bronnii</i> of Glos near Lisieux in France.
„ <i>perlata</i> , Ag. (as identified by Lycett) ...	...	...	—	—	*	—	—	—	v.c. <i>Trigonia</i> -beds (Upper Passage-beds), Pickering. C. O. generally.
„ ? <i>Voltzii</i> , Ag. ...	...	...	—	—	—	—	*	—	v.r. One specimen, U. C. G., Pickering.
„ <i>triquetra</i> , von Seeb. ...	...	...	—	*	—	—	—	—	r. In the lower beds at Filey, and ? Scarborough.
„ <i>snaintonensis</i> , Lyc. ...	...	...	—	*	—	—	—	—	1. Plentiful in the shell-bed at Wydale. Appleton. Pl. iv, fig. 14.
„ <i>Blakei</i> , Lyc., sp. n. ...	...	...	—	*	—	—	—	—	v.r. Single specimen. shell-bed, Wydale. Pl. v, fig. 13.
<i>Nucula</i> , sp. ...	...	...	—	—	—	—	*	—	r. Cement-stone, N. Grimston
<i>Arca pectinata</i> , Phil. ...	...	...	?	—	?	*	—	—	c. C. R. throughout; also in the Coral Shell-beds.
„ <i>quadrisulcata</i> , Sow. ...	...	...	—	—	—	*	—	—	c. C. R. throughout.
„ <i>æmula</i> , Phil. (? <i>Mosensis</i> , Buvig.) ...	...	...	—	*	—	*	—	—	r. Shell-bed, Wydale (if same). C. R. of the Howardians.
„ cf. <i>Langei</i> , Thurm. ...	...	...	—	—	—	*	—	—	r. A doubtful form occurring in C. R. of Ayton.
„ <i>lanthanon</i> , Bl & H. ...	...	...	—	—	—	*	—	—	v.r. Single specimen, C. R., Slingsby. Blake Coll.

Genus—Species.			A.	I.	II.	III.	IV.	B.	Localities and Remarks
Cucullæa	corallina, Damon.	...	—	r	*	—	—	—	m. Mostly in <i>Trigonia</i> -beds, Pickering. Pl. v, fig. 12.
"	elongata, Phil., non Sow.	...	—	—	*	*	—	—	m. Resembles <i>C. oblonga</i> , Sow. Seems to replace <i>C. corallina</i> in the higher beds.
Limopsis	corallensis, Buvig.	...	—	—	*	—	—	—	r. "Small shell-bed," Pickering. Blake Coll.
Mytilus	ungulatus, Y. & B.	...	—	—	*	*	—	—	m. <i>Trigonia</i> -beds, Pickering, and C. R. of the Howardians.
"	? jurensis, Merian.	...	—	*	—	—	—	—	r. L. C. G., and Passage-beds, Filey.
"	pectinatus, Sow.	...	—	—	*	—	—	—	v.r. Single specimen, Westendarp Coll., obtained at Malton.
Modiola	bipartita, Sow.	...	*	*	—	—	—	—	c. Characteristic of the L. C. G., but scarcely ascends into L. L.
"	subæquiplicata, Goldf.	...	—	—	*	*	—	—	r. Occurs in C. O.; and in soft parts of C. R., Syke Gate—variety of the preceding.
"	cancellata, Rœm.	...	?	—	—	*	*	—	r. Found in C. R. at Grimston and Hildenley—U. C. G., Nunnington cutting.
"	inclusa, Phil.	} Coral Borers.	—	*	*	*	—	—	v.c. Wherever there is coral. Especially common in C. R.
"	Iycetti, Whit.		—	—	—	*	—	—	r. C. R. of Ayton, Brompton, &c.
"	sp. n. (<i>gibbosa</i>).		—	—	—	*	—	—	v.r. Single specimen, Leck Coll., probably C. R. of Howardians.
Pinna	lanceolata, Sow.	...	*	*	r	—	r	—	c. Chiefly in the L. C. G. proper. <i>Pinnæ</i> of the Supracoralline-beds may be different.
Trichites.	? Plottii, Lhwyd.	...	—	*	*	*	—	—	m. L. L. Cropton. C. O. Malton. C. R. North Grimston.
Gervillia	aviculoides, Sow.	...	*	*	*	—	—	—	v.c. Passage-beds and L. L., Cropton and elsewhere; Upper Limestones, Filey, Pickering, &c.
"	angustata, Rœm.	...	—	—	*	—	*	—	r. "Small shell-bed," Pickering, U. C. G., Kirkdale cutting.
Perna	mytiloides, Lam.	...	—	*	*	r	—	—	m. When very large, as in the Malton oolite, resembles <i>P. rugosa</i> , Goldf.
"	subplana, Ét.	...	—	—	—	*	—	—	r. Found in the great Shell-bed of the C. R., North Grimston.
"	sp. n. (<i>inoceramoides</i>)	...	—	—	*	—	—	—	v.r. Single specimen in Malton oolite; York Museum.
Avicula	pteroperonoides, Bl. & H.	...	—	—	*	—	—	—	v.r. Top of the L. L., Thornton.—A specimen in Bowerbank Coll. possibly from L. C. G.
"	Struckmanni, de Lor.	...	—	—	*	—	—	—	v.r. Single specimen (cast): top of L. L., Newtondale.
"	Breamburiensis, Phil.	...	*	*	—	—	—	—	l. L. C. G. of Oliver's Mount.
"	expansa, Phil.	...	*	*	*	—	—	—	c. A megalomorph of a very persistent Jurassic form. Appleton and elsewhere.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
<i>Avicula inæquivalvis</i> , Sow.	...	...	...	*	—	*	?	—	—	m. Generally associated with, and nearly the same as the preceding.
„ <i>ovalis</i> , Phil.	...	...	...	?	*	*	—	—	—	c. The finest shells occur in the P. B., Appleton; a different type in the C. O.—Pl. v, fig. 15.
„ „ var. <i>obliqua</i> , Bl. & H.	...	...	...	—	—	—	—	*	—	r. U. C. G., Pickering—diverges still further from the large forms at Appleton.
„ <i>lævis</i> , Bl. & H.	...	...	...	—	*	—	—	—	—	r. L. L. Kepwick and Cropton.
„ <i>elegantissima</i> , Bean.	?	Corallian.	...	—	?	—	—	—	—	v.r. Single specimen in York Mus. Matrix might be Passage-bed rock.
„ <i>ædilignensis</i> , Bl.	...	...	...	—	—	—	?	—	*	v.r. A doubtful specimen, C. R. Grimston; v.c. in K. C., Hildenley.
<i>Lima læviuscula</i> , Sow., var. <i>a</i> .	...	...	...	—	—	*	—	—	—	1. Sowerby's type; principally Malton Oolites.
„ „ „ <i>b</i> .	...	...	...	—	—	—	*	—	—	1. A smoother form, characteristic of the great shell-bed, C. R., North Grimston.
„ „ „ <i>c</i> .	...	...	...	—	*	*	—	—	—	m. Belongs to the <i>læviuscula</i> group, but is far coarser in the ribbing. Pl. vi, fig. 18.
<i>Lima</i> cf. <i>grandis</i> , Rœm.	...	...	...	?	—	*	*	—	—	r. Coral Shell-bed, Seamer. Malton Oolite. Pl. vi, fig. 19.
„ <i>rigida</i> , Sow.	...	...	...	—	—	*	*	—	—	c. Principally C. O. and C. R. of the Howardian district.
„ ? <i>densepunctata</i> , Rœm.	...	...	...	—	—	—	*	—	—	1. Species with very fine lines. C. R. of Ayton, &c.
„ <i>subantiquata</i> , Rœm.	...	...	...	—	—	*	*	—	—	r. C. O. of Malton. C. R. Settrington Grange. Pl. v, fig. 17.
„ { <i>pecteniformis</i> , Schlot.	...	...	...	*	—	—	*	—	—	v.c. } Throughout the C. R. generally. Has a wide range
„ { <i>rudis</i> , Sow., dwarf var.	...	...	...	—	*	—	*	—	—	c } throughout the oolites.
„ <i>gibbosa</i> , Sow.	...	...	...	?	*	—	—	—	—	r. “Red beds” of the Scarborough district. Like the Inferior Oolite form.
„ <i>elliptica</i> , Whit.	...	...	...	—	*	*	—	—	—	m. L. L., Kepwick, C. O. Pickering, Malton.
„ sp. near to <i>elliptica</i>	...	...	...	—	—	—	*	—	—	r. C. R., Langton Wold and North Grimston.
<i>Pecten lens</i> , Sow.	...	...	...	*	?	*	*	—	—	c. Left valves of this sp. named <i>P. arcuatus</i> in some collections.
„ ? <i>comatus</i> , Münst.	...	...	...	?	—	—	*	—	—	r. C. R., Ayton; in Jermyn St. Mus. N.B. <i>P. comatus</i> was described from the black “Jurakalk.”
„ <i>vimineus</i> , Sow. (near <i>articulatus</i> , Schlot.)	?	*	*	*	*	*	*	—	—	v.c. Always abundant in the C. R. Fine specimens from C. O., of Malton.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
Pecten demissus, Phil.	...	...	...	*	—	*	*	—	—	r. Malton, Settrington. <i>P. climatus</i> , Bean—B. Mus.
„ intertextus, Rœm.	...	...	...	*	—	*	*	—	—	m. Magnificent specimens from C. O., Malton, &c., and C. R., Langton. <i>P. cancellatus</i> of Bean.
„ fibrosus, Sow.	...	...	...	*	*	*	—	—	—	v.c. includes <i>P. subfibrosus</i> , d'Orb.; and <i>P. vagans</i> , Sow., in part.
„ inæquicostatus, Phil.	...	...	...	*	—	*	*	—	—	m. C. O. of Malton, Settrington, C. R., Langton Wold. Pl. v, fig. 16.
„ qualicosta, Ét.	...	...	...	—	—	*	—	—	—	r. C. O. of Settrington.
„ Midas, d'Orb.	...	...	...	—	—	—	—	*	—	m. The representative of the <i>P. fibrosus</i> group in the higher beds.
Hinnites cf. velatus, Goldf.	...	...	...	—	—	*	*	—	—	m. C. R. of Ayton, Brompton, &c. “Small shell-bed,” Pickering.
„ sp. n. (<i>corallina</i>)*	...	...	...	—	—	—	*	—	—	c. Characteristic of the C. R. throughout England; common at Grimston.
Plicatula fistulosa, M. & L.	...	...	...	—	—	—	*	—	—	r. C. R., Brompton, Seamer, Ayton.
„ sp. n. (<i>subinflata</i>)	...	...	...	—	—	—	*	—	—	v.r. C. R. Brompton.
„ or Spondylus, sp.	...	...	...	—	—	*	*	—	—	r. C. R., Ayton, &c.; base of C. O., Pickering.
Anomia radiata, Phil.	...	...	...	*	—	*	*	—	—	c. Attains a great size in the C. R., N. Grimston.
Ostrea duriuscula, Phil.	...	...	...	—	—	*	*	—	—	v.c. Principally in the C. R. A comprehensive species.
„ Moreana, Buvig.	...	...	...	—	—	—	*	—	—	r. C. R. Nunnington cutting and elsewhere.
„ bullata, Sow.	...	...	...	—	—	*	—	*	—	l. Large variety, Filey Brigg Calc Grit; smaller ditto, Supracoralline beds.
„ (<i>Gryphæa</i>) dilatata, Sow.	...	...	...	*	*	?	—	—	—	c. L. C. G. and Lower Passage-beds; type form, rare in C. O.
„ subgibbosa, Bl. & H.	...	...	...	—	—	—	—	*	—	l. Cement-stone, N. Grimston; closely allied to the preceding.
„ (<i>Exogyra</i>) nana, Sow.	...	...	...	*	*	*	*	*	*	v.c. Includes the <i>Ex. mima</i> , Phil.
„ „ cf. <i>spiralis</i> , Goldf.	...	...	...	*	*	—	—	—	—	r. Some of the forms in the lower beds, e.g. L. C. R., Hackness.
Ostrea, var. of <i>flabelloides</i> , Lam.	...	...	...	*	*	—	—	—	—	m. Lower Passage-beds at Scarborough and Filey.
„ gregaria, Sow.	...	...	...	—	—	—	*	—	—	c. C. R. everywhere. L. C. R., Hackness.
„ ? <i>solitaria</i> .	...	...	...	—	?	*	*	—	—	r. C. R., Ayton, <i>Trigonia</i> -beds, Pickering.
Terebratula fileyensis, Walk	...	...	...	—	*	—	—	—	—	l. L. C. G., Scarborough; but most plentiful in P. B., Wydale, Filey, &c.

* The nearest figured form is *Hinnites fallax*, Dollf.

Genus—Species.			A.	I.	II.	III.	IV.	B.	Localities and Remarks.
<i>Terebratula insignis</i> , Schübl.	}	...	—	—	—	*	—	—	r. C. R. of Howardians, Oswaldkirk, Helmsley; var. <i>Maltonensis</i> , Oppel.
<i>Boloniensis</i> , R. & S.		...	—	—	—	*	—	—	v.r. Single specimen in Leek. Coll. C. R. of the Howardians.
<i>Waldheimia bucculenta</i> , Sow.	...	...	?	*	—	—	—	—	v.r. Passage-beds, Appleton.
<i>Hudlestoni</i> , Walk.	...	...	—	*	—	—	—	—	l. Abundant in the L. C. R., Hackness; Lower P. B., Filey; Wydale.
<i>margarita</i> , Opp.	...	...	—	—	—	*	—	—	l. Not rare in the C. R., Ayton. Previously quoted as <i>T. insignis</i> (juv.)
<i>Rhynchonella lacunosa</i> , Schlot.	...	...	—	*	?	—	—	—	v.r. L. C. G., Oliver's Mount, "Red beds," Beedale. ? Pickering.
<i>Thurmanni</i> , Voltz.	...	...	?	*	—	—	—	—	v.c. L. C. G. throughout, and base of L. L., <i>i.e.</i> , the Passage-beds
<i>Diastopora</i> ? <i>diluviana</i> , Edw.	...	...	*	*	—	—	—	—	v.r. One specimen on <i>Astarte</i> , Wydale.
<i>Cidaris Smithii</i> , Wright.	...	...	—	*	r	*	—	—	v.c. <i>i.e.</i> The spines. Has a wider range than <i>C. florigemma</i> .
<i>sp.</i>	...	...	—	—	—	*	—	—	v.r. A very long spine in the Leek. Coll. may belong to another species.
<i>florigemma</i> .	...	...	—	—	r	*	—	—	v.c. <i>i.e.</i> The spines. Characteristic of the C. R., except of the Scarborough District.
<i>Hemicidaris intermedia</i> , Flem.	...	...	—	—	—	*	—	—	c. C. R. everywhere, test and spines.
<i>Pseudodiadema versipora</i> , Phil	...	...	—	*	—	*	—	—	c. Abundant in the C. R. of Ayton, &c.
<i>hemisphaericum</i> , Ag.	...	...	—	—	—	*	—	—	l. C. R. of Howardian Hills only, most abundant at N. Grimston.
* <i>Hemipedina corallina</i> , Wright	...	...	—	—	—	?	—	—	v.r. A single fragment obtained by Bean from Malton.
<i>Glypticus hieroglyphicus</i> , Goldf.	...	...	—	—	—	*	—	—	r. C. R., Nunnington and Hovingham.
<i>Stomechinus gyrtatus</i> , Ag.	...	...	—	—	—	*	—	—	r. C. R., Nunnington, North Grimston.
<i>Acosalenia decorata</i> , Haime	...	...	—	*	—	—	—	—	l. The specimens known to me are from the Passage-beds (L. L.) of the coast.
<i>Holectypus depressus</i> , Leske	...	...	*	*	*	?	—	—	} Usually too defaced for specific determination.
<i>sp.</i> (? <i>oblonga</i> , Wr.)	...	...	—	—	—	*	—	—	
<i>Pygaster umbrella</i> , Ag.	...	...	—	—	*	*	—	—	m. Chiefly in the Howardians.

* This species is inserted entirely on the authority of Dr. Wright in the Palæontographical.

Genus—Species.				A.	I.	II.	III.	IV.	B.	Localities and Remarks.
Collyrites bicordata, Leske	...	...	...	—	*	—	*	—	—	m. Small in the L. C. G., Castle Howard; large in C. R., Hildenley, and Sike Gate.
Echinobrissus, sp.	...	...	...	*	*	—	—	—	—	r. Some forms in the lower beds resemble <i>Ech. clunicularis</i> . Scarborough Castle.
„ scutatus, Lam.	...	...	...	*	*	*	*	—	—	v.c. Especially in the L.L. Specimens from C. R., rare, and far larger.
Clypeus subulatus, Y. & B.	...	...	...	—	—	*	—	—	—	v.r. "Usually imbedded in a white oolitic limestone," Wright, page 385.
Pygurus pentagonalis, Phil.	...	...	...	?	*	*	*	—	—	m. Specimens from the L. L. Scarborough smaller than those from C. R. of Hildenley.
„ Hausmanni, K. & D.	...	...	...	—	—	*	—	—	—	m. Chiefly from C. O. of the Malton district.
Millericrinus echinatus, Goldf.	...	...	...	?	*	—	—	—	—	c. Passage-beds, Filey, Appleton, and many other localities.
„ ? sp.	...	...	...	—	—	—	*	—	—	r. May be a different portion of stem of preceding. Kirkby Moorside, Whitewall.
Apiocrinus polycyphus, Merian	...	...	...	—	—	?	*	—	—	r. C. R., North Grimston; fine specimen in oolite matrix, York Museum.
Pentacrinus, sp.	...	...	...	—	*	—	—	—	—	r. Passage-beds, Scarborough, Wydale.
„ sp.	...	...	...	—	—	—	*	—	—	r. Highest C. R. of N. Grimston, along with <i>Apiocrinus polycyphus</i> .
Astropecten rectus, M'Coy	...	...	...	—	*	—	—	—	—	m. L. C. G. of coast. Plates of this or an allied species occur in the lower shell-beds.
Glyphea rostrata, Phil.	...	...	...	—	*	r	—	—	—	l. Plentiful in the L. C. G. and Passage-beds, Appleton, &c.
„ scabrosa, Phil.	...	...	...	?	*	—	—	—	—	r. York Museum.
Serpula squamosa, Phil.	...	...	...	—	*	—	*	—	—	c. P. B., Scarborough Castle; C. R., Langton Wold; ? <i>S. sulcata</i> , Sow.
„ tetragona, Sow.	...	...	...	*	*	—	—	—	*	v.r. P. B., Scarborough Castle; similar to form in K. C.—York Museum.
„ deplexa, Phil.	...	...	...	*	—	—	*	—	—	r. C. R. of Ayton. Similar form occurs in the Dogger.
„ sp.	...	...	...	—	—	?	—	—	—	r. Smooth species in coils. York Museum.
Vermicularia compressa, Y. & B.	...	...	...	*	*	—	—	—	—	m. P. B. Scarborough Castle. Similar form occurs in the Dogger.
Stylina tubulifera, Phil.	...	...	...	—	—	—	*	—	—	m. C. R., Grimston, Oswaldkirk, &c.

<i>Genus—Species.</i>	A.	I.	II.	III.	IV.	B.	<i>Localities and Remarks.</i>
<i>Montivaltia</i> dispar, Phil. ...	—	—	—	*	—	—	c. C. R., Cawton, Oswaldkirk, Langton Wold.
<i>Thecosmilia</i> annularis, Flem. ...	—	*	—	*	—	—	v.c. L. C. R., Hackness. <i>Florigemma</i> -Rag generally.
<i>Rhabdophyllia</i> Phillipsii, Ed. & H. ...	—	*	*	*	—	—	v.c. L. C. R., Hackness; C. O., Pickering; C. R. generally.
<i>Cladophyllia</i> cæspitosa, Con. & Phil. ...	—	—	?	—	—	—	r. Base of C. O., Pickering. ?
<i>Goniocora</i> socialis, Roem. ...	—	—	—	*	—	—	v.r. Single specimen, C. R., Langton Wold.
<i>Isastræa</i> explanata, Phil. ...	—	*	—	*	—	—	c. L. C. R., Hackness; C. R. generally.
<i>Thamnastræa</i> arachnoides, Park. ...	—	—	*	*	—	—	c. Base of C. O., Pickering; C. R. generally.
" concinna, Goldf. ...	—	*	—	*	—	—	v.c. L. C. R., Hackness. C. R. generally.
<i>Comoseris</i> irradians, Ed. & H. ...	—	—	—	*	—	—	r. C. R., Langton Wold; Coneysthorpe.
<i>Manon</i> , ? foliaceum, M'Coy ...	—	*	—	—	—	—	l. L. L. Scarborough Castle.
"Sponge," silicified fragments ...	—	*	—	—	—	—	Passage-beds, Filey and Scarborough.
"Sponge," sp. sp., &c. ...	—	*	*	*	—	—	Forms due probably to sponges occur throughout.
<i>Spongia</i> floriceps, Phil. ...	—	*	—	—	—	—	l. L. C. R. Hackness, and throughout Scarborough district on that horizon.
<i>Araucarites</i> Hudlestoni, Carr. ...	—	—	*	—	—	—	v.r. Two cones from the C. O. of the Old Malton quarry.
<i>Carpolithes</i> conicus, L. & H. ...	—	*	*	—	—	—	c. Known chiefly from P. B., Appleton, and C. O., Malton.
<i>Coniferus</i> wood ...	—	*	*	?	—	—	Chiefly in the L. C. G.

18.

19.