SYNOPSIS. Rocks of Lower Liassic (Sinemurian and Lower Pliensbachian) age exposed in Robin Hood’s Bay, near Whitby, north Yorkshire, are described from the mapping, stratigraphical descriptions and ammonite collections made by Mr Leslie Bairstow in the years 1927–1970, and preserved in the Palaeontology Department, The Natural History Museum, London. His large-scale map of the geology of the foreshore is published on five sheets at a scale of approximately 1:5000. The stratigraphical sequence from bed 418 at the base up to bed 600.5 at the top of the Lower Pliensbachian is 163.74 m thick, and consists of the Redcar Mudstone Formation, for which four members are formally defined – the Calcareous Shale (at the base), Siliceous Shale, Pyritous Shale and Ironstone Shale Members – overlain by the lower part of the Staithes Sandstone Formation. The lowest beds exposed by the lowest spring tides are Sauzeanum Subzone, Semicostatum Zone, in age; ammonites occur in all subzones, and the only uncertain boundary is that between the Masseanum and Valdani Subzones (Ibex Zone), where there are few characteristic ammonites. Bairstow’s ammonite collection consists of more than 2360 specimens, all from recorded horizons, and is notably rich in Promicroceras, Asteroceras, Epiparietes and Oxynoticeras from the Obtusum and Oxynotum Zones, Echioceratids, Eoderoceras and Apoderoceras from the Oxynotum, Raricostatum and Jamesoni Zones, and Liparoceratids from the Davoei Zone, making it a primary source for Sinemurian and Lower Pliensbachian ammonite biostratigraphy. The recently proposed selection of Wine...
INTRODUCTION

The geology of Robin Hood's Bay (Fig. 1) has received the attention of many geologists since the 1820s. One such geologist was Leslie Bairstow, who decided to make the description of the outcrops of the Lower Lias on the foreshore of the bay (Fig. 2) the main scientific work of his life. He started serious investigations in 1928 and worked in the bay for the next 50 years. Dr L.F. Spath, a colleague at the British Museum (Natural History) (now the Natural History Museum, London), identified the many ammonites that he collected and brought to the Museum. As long ago as 1956 Spath (1956: 147) referred to 'the (still undescribed) collections made by Mr L. Bairstow in Robin Hood's Bay', but Bairstow was never able to finish a detailed account for publication, and finally he left his work for me to complete. That completion has involved more fundamental work than mere editing: complete rewriting of the stratigraphical section, revision of the maps, preparation of many tables and diagrams not envisaged by Bairstow, and revision of the determinations in order to produce an up-to-date account of the ammonites and the biostratigraphy, were all found to be necessary. The final result is eminently worth publishing, if only because it would be very difficult to duplicate the ammonite collection, which is the core of the paper and the biostratigraphy, at the present time. I had many conversations with Bairstow during the period 1956 to 1965, and less frequently up to the early 1980s, and quotations from a few of them are given here. This paper is not the same as Bairstow would have written – his account would have had more local details of the outcrops in the bay as they were in the 1920s and 1930s, while the paper now presented is more orientated towards correlation by ammonites, for which his accurately documented sequence in the bay is of major international importance. The comparison that it will afford with rocks of the same age and the sequence of zones and subzones on the Dorset coast is long overdue. Such comparison is too lengthy to be included here – it would involve much collation and reidentification of the many separate collections of Dorset ammonites that now exist, in order to produce a consistent set of determinations, and hence biostratigraphy, that could be compared with the sequence in Yorkshire.

The term Lower Lias is used in the title of this paper and elsewhere as an exact equivalent of Hettangian + Sinemurian + Lower Pliensbachian. This is the sense in which it was widely used and understood by palaeontologists when Bairstow worked in the 1920s and 1930s. Even in those days a different usage by those geologists more interested in lithology and sedimentation led to confusion on occasions: the boundary between Lower and Middle Lias was placed by them at a position that best marked the change from dominantly clayey beds below to dominantly sandy beds above. Such a change in lithology occurs at different horizons in different parts of Britain, so their usage of Lower and Middle Lias did not have an accurate date or age connotation. So much confusion resulted from these disparate usages that the terms are rarely used now-a-days. Lower Lias is retained here, in the sense given above, in deference to Bairstow and the long history of Robin Hood’s Bay geology, where it is well understood as being the Sinemurian + Lower Pliensbachian, there being no Hettangian exposed in the bay. In this usage the Middle Lias is exactly equivalent to the Upper Pliensbachian, and the Upper Lias to the Toarcian.

LESLEY BAIRSTOW

Biography

Leslie Bairstow (Fig. 3) was born in Halifax, Yorkshire, on 14 August 1907. After attending Ackworth School (1918–22) and Bootham School, York (1922–25), he went to King’s College, Cambridge, where he obtained a degree in Geology in 1928. He started research on the Lower Lias of Robin Hood’s Bay in the summer of 1928, supported by college scholarships. He had become interested in collecting fossils from the Yorkshire Lias during his school and undergraduate years, and in getting his ammonites identified he came into contact with Dr L.F. Spath at the British Museum (Natural History). It was at Spath’s suggestion that he decided to undertake serious research on the Lower Lias of Robin Hood’s Bay, and Dr W.D. Lang, also at the Museum, was keen to get another Lower Lias section accurately documented for comparison with his own work on the Lower Lias of Dorset. He also consulted S.S. Buckman, who advised him to record the location of every ammonite he...
collected with sufficient accuracy to enable the sequences of ammonite 'hemerae' to be compared at the north-western and south-eastern ends of Robin Hood's Bay. Initially the project was intended to be a thesis for a higher degree at Cambridge University, but the detailed mapping, bed-by-bed description and collecting during 1928–1930 were submitted as a dissertation in support of a fellowship application at King's College in late 1930. This was not successful, and Bairstow was preparing for a second application in 1931, when the offer of a permanent post at The Natural History Museum in South Kensington (then the British Museum (Natural History)), with the opportunity to continue work indefinitely on the Lower Lias of Robin Hood's Bay, appealed to him more than a fellowship at Cambridge of six years duration. In fact, during his early years at the Museum he was elected to a three-year visiting Fellowship at King's College in 1932–35. He started at the Museum in October 1931, and although initially put in charge of fossil echinoderms and later Coleoidea (including belemnites), he was able to continue work on Robin Hood’s Bay until his retirement in June 1965. He continued to work at the Museum until 1985, when he moved to Todmorden, Yorkshire, where he died on 10 August 1995.

The meticulous attention to detail that Bairstow lavished on the description, collecting and mapping of the Lower Lias of Robin Hood's Bay, made it unlikely that he would produce a final description with which he would be satisfied. It is fortunate, therefore, that for the Cambridge fellowship dissertation of 1930 he produced a finished manuscript version of the map and a stratigraphical description of the whole succession, which are the basis of the present paper. His most useful collecting occurred during the period 1928–34, and work during the following 40 years did not greatly enhance that original burst of activity. His ammonite collection of about 2,360 specimens is housed in The Natural History Museum, and is a prime record of the sequence of ammonite faunas for the upper two-thirds of the Lower Lias. Such a collection would be difficult to repeat today, because so many of the accessible ammonites have been removed from the Bay. Bairstow conducted field parties to the Bay for the 18th International Geological Congress in 1948 and the William Smith Jurassic Symposium in 1969, and gave brief summaries of the zonal sequence and his bed numbering in the guide books for those meetings (Bairstow, 1948, 1969). Apart from a summary in a guide to the fossils of the Scarborough district (Bairstow, 1953), he left no other published account.

The geological map of Robin Hood's Bay, the description of the stratigraphy and basic biostratigraphy formed the first half of his dissertation for the fellowship at King’s College, Cambridge, in 1930. The second half of that dissertation consisted of a description of the Lower Lias belemnites of Robin Hood's Bay, and included an assessment of the 19 specific names proposed by Simpson (1855: 22–31; 1884: 47–54) and partly revised by Phillips (1863–1909), for belemnites from the bay. This part of his work was also destined never to be published, but it did give Bairstow an interest in belemnites and related groups, which led to him being put in charge of fossil Coleoidea at the Natural History Museum. In fact, he did much valuable investigation into the early generic nomenclature of fossil Coleoidea, especially the non-belemnite groups, and his detailed notes were passed on first to Dr J.A. Jeletzky, then to later Treatise authors, for incorporation in the Coleoid volume of the Treatise on Invertebrate Paleontology (not yet published). In these and other matters, especially the geology of Robin Hood's Bay and general identification of specimens sent to the Museum, colleagues found him helpful and were always enlightened by his views. He had a long
The originals of the unfinished and unpublished manuscripts left by Bairstow's unpublished work obituary notices published by the Geological Society (Howarth. 1996: 27-29). [Other biographies on Bairstow can be found in the Palaeontographical Society, first as Treasurer for the years 1948 to 1955, then as Vice President from 1966 until 1969, and he was a Trustee of that Society for several years during the same period. [Other biographies on Bairstow can be found in the obituary notices published by the Geological Society (Howarth. 1996) and King's College, Cambridge (Annual Report, October 1996: 70 years after they were drawn.]

Bairstow's unpublished work

The originals of the unfinished and unpublished manuscripts left by Bairstow will be deposited in the Earth Sciences Library of The Natural History Museum, London. They can be divided into three main parts, which will now be described in sequence:

1. The geological map of Robin Hood's Bay.
2. The stratigraphical description of the Lower Lias.
3. His collection of ammonites and other fossils, and his list of the determinations of the ammonites.

GEOLOGICAL MAPS

Bairstow drew his geological map of Robin Hood's Bay in 1928-30 and the top copy formed part of his fellowship submission, now preserved in the archives of King's College, Cambridge. The map was drawn at a scale of 1:2500, and consists of eight sheets, each measuring 320 x 343 mm. Bairstow took (and variously modified) a few geographical lines from the 1:2500 sheets of the Ordnance Survey; these were mainly the top and bottom of the cliffs, some paths and field boundaries at the top of the cliffs, a few roads and prominent buildings, and the line of low tide mark. The latter is the low tide mark of ordinary tides on Ordnance Survey maps (ie. approximately half way between low water mark of spring and neap tides), but Bairstow modified the line to be that of low water mark of spring tides, when the maximum amount of rock is exposed on the foreshore. On some low lying areas low water of spring tides exposes much larger areas of rock than ordinary or neap tides, eg. the area occupied by beds 505–530 north of Robin Hood's Bay town.

Before submission to King's College, Bairstow made machine copies of his map, which he kept throughout his working life and they form the basis of the maps reproduced here. These copies differ from the original maps only in Bairstow's addition of 'datum lines' for locating the ammonites he collected (see the account of his ammonite collection, p. 117 below). I considered the possibility of reproducing Bairstow's original maps in the King's College archives, but the small size of the lettering of the bed numbers, the colour, thinness and lack of sufficient boldness of some of the lines, and logistical difficulties of reproducing maps that are larger than A3 (in one direction), were all against direct reproduction of the originals. After consideration of scale and legibility at the final printed size, it was decided to copy the maps at a different scale, and to divide them into the five sheets (see Fig. 4) that give a better division of the outcrops in Robin Hood's Bay than the original eight maps. Tracing was done with great care, so that the geological lines on the resulting maps reproduced here as Figs 5, 6, 8, 11 and 15 are as close as possible to the lines originally drawn by Bairstow. No alterations were made, and in those parts that were checked, such as the seaward edge of outcrops opposite the mouth of Mill Beck, south of Stoupe Beck, and in Wine Haven, the maps appear to be still accurate. 70 years after they were drawn.

Bairstow did not, however, include the lowest and highest beds on his map: the lowest bed he mapped was the seaward edge of bed 422, Low Balk, though he collected ammonites from lower beds down to bed 421.1. The outcrops of beds 418–421, seaward of Low Balk, were added to the map of Fig. 11 from observations made at the lowest spring tide of the year on 9 September 1991, when they were easily accessible. Similarly, at the top of the succession, the highest bed mapped by Bairstow was bed 590.3, on the south side of Bulmer Steel Hole, even though this is 250 m south of Castle Chamber, which is usually taken as marking the northern boundary of the bay. The higher beds northwards past Castle Chamber and up to the boundary between the Lower and Upper Pliensbachian (ie. the Lower/Middle Lias boundary) were also added to the map of Fig. 5 in September 1991. Thus, the mapping was completed between the lowest bed exposed by the lowest spring tides and the upper boundary of the Lower Pliensbachian. The five large-scale maps are printed here at a scale of 1:5315.

Map 1 (Fig. 5) is the northernmost map and starts from the highest beds outside the bay to the north-west at the junction with the Upper Pliensbachian. The main geographical feature is the cave of Castle Chamber, where the hard shelly sandstones of beds 599 and 601.1 form the floor and roof of the cave. The outcrop is fairly narrow along the whole of this east facing part of the bay, and is subject to aggressive wave action that results in relatively clean rock surfaces and good exposures.

Map 2 (Fig. 6) covers the whole sweep of the scars north and south of Robin Hood's Bay town, from the ironstone shales at the top of the map, down through the softer, pyritous shales opposite Dungeon Hole and Ground Wyke (Fig. 7), to the hard siliceous shales that form prominent scars opposite Robin Hood's Bay town. These are Landing.
Fig. 4  Summary geological map of the foreshore in Robin Hood's Bay, showing the main geographical features. The geological divisions shown are the subzones, and the areas covered by the five main maps of Figs 5, 6, 8, 11 and 15 are indicated by the rectangles of dashes. The cliff is indicated by vertical lines showing approximately the steepest direction of the face. The table containing the key to the subzones is a summary of Table 1.
Fig. 5 Map 1. the northernmost part of Robin Hood's Bay, showing the outcrops up to the north-west corner of the bay round to the junction with the Upper Pliensbachian (Middle Liassic).
Fig. 6  Map 2, showing outcrops down to the bottom of the Lower Pliensbachian and into the top of the Upper Sinemurian in the rock scars southwards past Robin Hood's Bay town.
Scar (bed 496) and East Scar (bed 494) opposite the town, and Cowling Scar (bed 474, Double Band) farther out to sea near the bottom edge of the map. The relatively soft beds of the Pyritous Shales around Ground Wyke are the wettest and lowest (relative to sea level) exposed part of the foreshore in the bay, where there is now little or poor rock exposure owing to the seaweed, barnacle and mussel bed cover.

Map 3 (Fig. 8) shows an interesting entity of outcrops around the mouth of Mill Beck, the cliffs that make up ‘The Nab’, and the major rock scars on the foreshore to the east. There are three prominent scars here — Low Scar, Middle Scar and High Scar, being the hard, calcified silty shales of beds 447, 449 and 455 respectively. Also notable on this map are Tinkler’s Stone and Strickland’s Dumps, north of the mouth of Stoupe Beck, and both are named on the larger scale Ordnance Survey maps. Tinkler’s Stone lies on bed 462 and is a boulder of very hard grey-brown massive limestone, of undetermined origin, but not derived from the Lower Lias. Strickland’s Dumps are small, but relatively deep, excavated pools in the dip slope of beds 455.1 and 455.2. The area around Bay Mill and The Nab is shown on a larger scale in Fig. 9. High tides penetrate well into the mouth of Mill Beck between The Nab and the road on the south side of the beck, and sometimes large masses of dead algae partly block or divert the outflow of Mill Beck. However, when the mouth and bed of Mill Beck are clear of algae, the underlying beds can be seen from bed 475 at the mouth of the beck, past Bay Mill and up to bed 494 in front of the weir. They were mapped by Bairstow as shown on Fig. 9 in an amount of detail that is too great to be shown clearly on the main map. The face of The Nab, with some individual beds identified, is shown in Fig. 10.

Map 4 (Fig. 11) features the foreshore north-east of Peter White Cliff where there are exposures down to the lowest beds in Robin Hood’s Bay (Fig. 12). At low tides the scars of Low Balk (bed 422; see Fig. 13) and the slightly less conspicuous Pseudo Low Balk (bed 424.2) are prominent rock platforms, both of which can normally be reached only by wading through the shallow channels between beds 424 and 425 and along the middle part of bed 422.2, which never dry out, even at the lowest spring tides. Bed 447 forms a long scarp face across the whole width of the map in front of Peter White Cliff (Fig. 14). On the Ordnance Survey maps, the name High Scar is used for two different beds: one for this bed 447 in front of Peter White Cliff, the other for bed 455 east of Mill Beck. So bed 447 forms both Low Scar east of Mill Beck and the Ordnance Survey’s ‘High scar’ at Peter White Cliff. In view of the possible confusion, the latter use of ‘High Scar’ is not perpetuated here.

Map 5 (Fig. 15) reaches the south-east corner of the bay, where the Lower Lias succession is truncated by the Peak Fault complex. The Main Peak Fault has a downthrow to the east and a large lateral movement, resulting in Upper Pliensbachian and Toarcian beds on the east abutting the top beds of the Sinemurian and bottom beds of the Lower Pliensbachian on the west. There is a narrow zone of severely shattered beds immediately west of the fault, and minor faults and cracks for some distance farther west. The highest bed exposed on the rock platforms below the cliffs is bed 501.1, the
Fig. 8  Map 3, the middle map of the bay, showing the prominent scars on the foreshore east of The Nab and the mouth of Mill Beck, down to the mouth of Stoupe Beck at the bottom of the map.
Fig. 9 Details of the outcrops of beds 475–494 in the bed of Mill Beck from the mouth of the beck up to the weir west of Bay Mill.

Fig. 10 The seaward face of The Nab immediately north of the mouth of Mill Beck. M.K. Howarth photograph. 11 September 1991. The beds here are the middle part of the Siliceous Shale Member and belong to the Oxynotum to basal Raricostatoides Subzones; the main beds are identified on the right hand side of the photograph.
Fig. 11  Map 4, showing outcrops down to the lowest beds exposed in the bay north-east of Peter White Cliff.
Fig. 12  Oblique aerial view of the foreshore in front of Peter White Cliff at low tide. Air Ministry photograph, 10 October 1938, formerly Crown Copyright. The line of Low Balk (bed 422.2) is the lowest bed visible farthest from the cliff (see Fig. 13), and the long outcrop of the prominent bed 447 can be seen just below the cliff (see Fig. 14).

Fig. 13  Low Balk (bed 422.2) at low water of spring tide, almost the farthest accessible point north-east of Peter White Cliff. M.K. Howarth photograph, 10 September 1991.
The pattern of the outcrops on the foreshore of the bay as seen in Fig. 4 is determined by the structure of the rocks (Fig. 17). That structure was first alluded to by Tate & Blake (1876: 27, 196) who described Robin Hood’s Bay as ‘a complete inlier... in the form of a mound, dipping in all directions from the centre... the centre of elevation beneath the sea, nearly opposite the centre of the bay’. In the Geological Survey memoir, Fox-Strangways & Barrow (1915: 3, 115) referred to the Lias as ‘curving over in a gentle arch or anticline’. Versey (1939: pl. 15) plotted the contours of the base of the Grey Limestone (=Scarborough Formation; Lower Bajocian) over a wide area and showed that around the southern and western sides of Robin Hood’s Bay they formed the outer part of a north-west to south-east elongated dome. According to Versey (1939) the dome was produced by tectonic movements probably in the late Pliocene. Kent (1974: 25, 26) and de Boer (1974: 281) accepted the date of formation of the dome as later than the mid-Tertiary Alpine movements and probably Pliocene.

The central part of the Robin Hood’s Bay dome can be defined by the outcrops of the Lower Lias on the foreshore of the bay. Fig. 17 shows contours on the outcrop at 10 m bed-thickness intervals, with the 0 m contour starting at the top of bed 422.2, Low Balk. Because the outcrop on the foreshore is essentially flat, the contours approximate closely to strike lines, and they form the pattern of a dome, with a NW to SE axis of elongation in approximately the position shown on the figure. The dip of the beds is at right angles to each contour line away from the centre of the dome. In the northern part of the bay the beds dip NW, and from the 50 m to the 150 m contours the average distance between adjacent contours is 128 m; this gives an average dip of 4.5° for the beds. Between the 20 m and 40 m contours the beds dip to the west, while the lowest beds between the 0 m and 20 m contours dip between west and south at an average of 3.2°. In the south-east corner of the bay near the Peak Fault the beds curve round to dip south-easterly. The Peak Fault throws down on its eastern side and has a lateral movement of several kilometres. Its northern continuation across Robin Hood’s Bay, passing close to the shore at the northern end of the bay, is shown on Fig. 17 in accordance with data on the latest map of the British Geological Survey that includes off-shore geology (British Geological Survey, 1995, Tyne Tees, sheet 54°N–02°W, 1:250,000, solid geology).

**GEOLOGICAL STRUCTURE OF ROBIN HOOD’S BAY**

Bairstow drew up a description of the succession in Robin Hood’s Bay in 1928–30 and the detailed sequence of beds formed an
Fig. 15  Map 5, showing the outcrops of Sinemurian and basal Pliensbachian beds in the south-eastern end of the bay, up to their junction with the Peak Fault, which throws them against Upper Pliensbachian and Toarcian to the east.
important part of his fellowship submission to King’s College. He kept carbon copies of the 85 typed pages of the sequence, and during subsequent years up to 1975 he made alterations, additions and notes on the originals until the final size of the manuscript was about 230 pages. Many alterations were made to the bed numbering, especially at the top, and to the bed thicknesses and details of the lithology, none of which were fully finalized at the time of his fellowship submission. This manuscript is the basis for the much edited version of the stratigraphical succession given below, where as much of the lithological description as necessary has been retained to describe and identify individual beds in the sequence. Bairstow measured bed thicknesses on both the foreshore scars and in the cliffs in order to arrive at figures he considered accurate, and his measurements in feet and inches have been converted to metric units for this paper.

The lithostratigraphical divisions given in the succession below are not those of Bairstow. They are based on more recent work described below in a separate section. Similarly, the zone and subzone divisions given in the succession are based on revisions of the identifications of all Bairstow’s ammonites, also as described in a separate section. Table 1 shows a detailed correlation between the zones and subzones, the bed numbers and the lithostratigraphical divisions.

**Bed numbers**

Bairstow started his detailed description of the beds in 1928 by giving the bed number 500 to the nodules that form the northern boundary of The Landing at Bay Town, and worked up and down the succession from that level. That bed number was selected because he did not know what his lowest and highest numbers would be, and also to ‘prevent confusion with the numbers [1–132] given by Lang to Lower Lias beds of similar age on the Dorset coast’. After several changes to his various schemes, especially in the top part of the succession, he finalized his numbering with bed 418 as the horizon exposed at the lowest level reached by spring tides in the bay, and bed 601 as the highest he described in the Staithes Sandstone Formation just beyond the northern end of the bay. In various places he subdivided individual beds by giving numbers after a decimal point (e.g. beds 485.1, 485.2, 485.3), and a few beds were subdivided to two places of decimals (e.g. beds 464.31, 464.32, 464.33). In bed 590,
Table 1  Summary of the bed numbers used in Robin Hood's Bay, and their grouping into zones and subzones (including thicknesses), and members and formations, showing the detailed correlation between biostratigraphical and lithostratigraphical divisions.

<table>
<thead>
<tr>
<th>STAGE</th>
<th>ZONE</th>
<th>SUBZONE</th>
<th>m</th>
<th>BED NO</th>
<th>STATION</th>
</tr>
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<tbody>
<tr>
<td>U. Pliensbachian</td>
<td>Margaritatus</td>
<td></td>
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<tr>
<td></td>
<td>Davoei 32.63 m</td>
<td>Figulinum</td>
<td>9.70</td>
<td>596.2-600.5</td>
<td>STAITHES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capricornus</td>
<td>3.04</td>
<td>591-596.1</td>
<td>SANDSTONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maculatum</td>
<td>19.89</td>
<td>581-590.7</td>
<td>FORMATION</td>
</tr>
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<td>Lower</td>
<td>Ibex 20.39 m</td>
<td>Luridum</td>
<td>7.24</td>
<td>578.1-580</td>
<td>Ironstone</td>
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<tr>
<td>Pliensbachian</td>
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<td>Valdani</td>
<td>7.66</td>
<td>571-577</td>
<td>Member 62.73 m</td>
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<td></td>
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<td>560.3-570</td>
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<td>Jamesoni 44.46 m</td>
<td>Jamesoni</td>
<td>5.66</td>
<td>550-560.3</td>
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<td></td>
<td>Brevispina</td>
<td>3.72</td>
<td>544.6-549</td>
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<td></td>
<td></td>
<td>Polymorphus</td>
<td>7.05</td>
<td>538-544.5</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Taylori</td>
<td>28.03</td>
<td>527-537</td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>Raricostatum 17.26 m</td>
<td>Aplanatum</td>
<td>5.57</td>
<td>497-500</td>
<td>Pyritous</td>
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<tr>
<td>Sinemurian</td>
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<td>4.48</td>
<td>494-495.7</td>
<td>Member 26.18 m</td>
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<td>Raricostatoides</td>
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<td>488-493.5</td>
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<td></td>
<td>Densinodulum</td>
<td>1.00</td>
<td>486.3-487</td>
<td></td>
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<td>Oxynotum 14.91 m</td>
<td>Oxynotum</td>
<td>9.19</td>
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<td>463-471</td>
<td>Member 38.74 m</td>
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<td>Stellare</td>
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<td>447-455.1</td>
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<td>Obtusum</td>
<td>1.71</td>
<td>446.31-446.5</td>
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<tr>
<td>Lower</td>
<td>Turneri 7.75 m</td>
<td>Birchi</td>
<td>5.89</td>
<td>433.3-446.2</td>
<td>Calcareous</td>
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<td>Brooki</td>
<td>1.86</td>
<td>429.7-433.2</td>
<td>Member 23.35 m exposed</td>
</tr>
<tr>
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<td>Semicostatum 13.89 m</td>
<td>Sauzeanum</td>
<td>13.89</td>
<td>418-429.64</td>
<td></td>
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<td></td>
<td>Scipionianum</td>
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<td>Not exposed</td>
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<td></td>
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</tbody>
</table>

However, he used three places of decimals (eg. bed 590.433) and in bed 598 he used four places of decimals (eg. bed 598.4322). Three and four places of decimals are considered here to be too cumbersome to be acceptable, so they have all been replaced in this description with the minimum amount of renumbering necessary to achieve single and double decimal numbering in beds 590 and 598. Unfortunately, it was not possible to replace all the double decimal numbering in the succession, because there are more than 9 divisions in beds 429, 495, 544 and 590, and to replace them would have involved renumbering the whole succession. This was not practicable in view of the large number of entries of the original bed numbers on specimen labels, index cards and original manuscripts and maps. It should be noted, however, that the subdivisions that Bairstow used for bed 600 are not in a decimal system like those in all the lower beds - subdivisions of bed 600 use the 13 suffix numbers 1–13 after the decimal point; as these are at the top of the succession extending out of Robin Hood's Bay to the north, they are retained here without alteration.

DETAILED SUCCESSION IN ROBIN HOOD'S BAY

In the following detailed succession records of all the ammonites and nautiloids in Bairstow's collection are included for each bed; the first number in brackets following each species is the total number of specimens, and is followed by their registration numbers, then by a reference to any specimens figured here; in a few cases the number of registration numbers quoted is less than the total number of specimens recorded, because specimens were lost, destroyed, poorly preserved, uncollectable (but observed by Bairstow), or too numerous to be worth registering all of them. The thickness of each bed is given in the right hand column in metres (m).

Specimen register numbers are identified here and in the remainder of the paper by the following prefixes: C. and CA – The Natural History Museum, London; GSM – British Geological Survey (Geological Survey Museum), Keyworth, Nottinghamshire; OUM – Oxford University Museum; SM – Sedgwick Museum, Cambridge; WM – Whitby Museum, Yorkshire.
Fig. 17 Map showing contours at 10 m bed thickness intervals in the Lower Lias on the foreshore of Robin Hood's Bay, from which the elongated dome geological structure can be deduced. The only geographical features shown are the line of the base of the cliff and the low tide mark. See text for further explanation.

**STAITHES SANDSTONE FORMATION (PART)**

*Zone of Amaltheus margaritatus*

*Subzone of Amaltheus stokesi (lower part)*

<table>
<thead>
<tr>
<th>Bed no.</th>
<th>Description</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>601.2</td>
<td>Sandstone, soft, micaceous, laminated</td>
<td>0.66</td>
</tr>
<tr>
<td>601.1</td>
<td>Sandstone, hard, shelly in parts; many Gryphaea sp.: forms the roof of Castle Chamber at north-west end of Robin Hood's Bay</td>
<td>0.81</td>
</tr>
<tr>
<td>600.13</td>
<td>Sandstone, soft, silty</td>
<td>0.33</td>
</tr>
<tr>
<td>600.12</td>
<td>Shale, silty</td>
<td>0.38</td>
</tr>
<tr>
<td>600.11</td>
<td>Limestone nodules</td>
<td>0.10</td>
</tr>
<tr>
<td>600.10</td>
<td>Shale, silty</td>
<td>0.08</td>
</tr>
<tr>
<td>600.9</td>
<td>Shale, sandy</td>
<td>0.38</td>
</tr>
<tr>
<td>600.8</td>
<td>Shale, silty, with horizon of limestone nodules near top</td>
<td>0.53</td>
</tr>
</tbody>
</table>

*Amaltheus stokesi (J. Sowerby) 0.3 m above base (1; CA 4605)*

<table>
<thead>
<tr>
<th>Bed no.</th>
<th>Description</th>
<th>m</th>
</tr>
</thead>
<tbody>
<tr>
<td>600.7</td>
<td>Shale, sandy, laminated; forms the most conspicuous positive feature between floor and roof of Castle Chamber</td>
<td>0.25</td>
</tr>
<tr>
<td>600.6</td>
<td>Flat limestone nodules</td>
<td>0.13</td>
</tr>
</tbody>
</table>

*Amaltheus stokesi (J. Sowerby) (1; MKH Coll, lost).*
Zone of *Productiloceras davoei*

Subzone of *Aegoceras (Oistoceras) figulinum*

600.5 Limestone nodules (≈ bed v of Howarth, 1955: 155) ................................................................. 0.36

600.4 Shale, silty, pale grey ......................................................................................................................... 0.06

*Aegoceras (Oistoceras) figulinum* (Simpson) (11; SM J35968, SM J44776-85).

600.3 Limestone, sideritic, forming a continuous bed (≈ bed iii of Howarth, 1955: 155) .................. 0.91

*Aegoceras (Oistoceras) angulatum* (Quenstedt) (9; SM J44790, CA 4595-4602).

600.2 Shale, silty ......................................................................................................................................... 0.18

600.1 Shale, silty ......................................................................................................................................... 0.15

599 Sandstone, flaggy, with ripple marks and oyster bands; the top surface forms the floor of Castle Chamber (≈ bed i of Howarth, 1955: 155) ................................................................. 1.42

*Aegoceras (Oistoceras) angulatum* (Quenstedt) (1; SM J44789)

598.35 Limestone nodules ......................................................................................................................... 0.33

598.34 Limestone nodules ......................................................................................................................... 0.08

598.33 Shale, silty, laminated .................................................................................................................... 1.00

598.32 Limestone, grey, weathering yellow; forms continuous tabular bed ........................................... 0.10

598.31 Shale, silty, soft, but harder near top ............................................................................................ 2.79

598.2 Shale, silty; forms a conspicuous feature in the cliff and on the scar ........................................... 0.15

598.1 Shale, silty, darker than the two beds above; occasional sideritic mudstone nodules in middle and upper part ......................................................................................................................... 0.67

*Aegoceras (Oistoceras) sinuosiforme* Spath (5; C.38930, C.39556, C.39579, CA 4594; Pl. 7, fig. 14).

597 Limestone nodules ............................................................................................................................. 0.13

*Aegoceras (Oistoceras) sinuosiforme* Spath (42; C.39398, C.39418-36; C.39421/22 and C. 39429/30 are single specimens; C.39499-39502, C.39505-07, C.39561, C.39568-77, CA 4588-93).

596.3 Shale, silty, with 0.09 m thick limestone nodules, especially in a band 0.3m below the top .......... 1.22

*Aegoceras (Oistoceras) sinuosiforme* Spath (28; C.39396-97, C.39399-39417, C.39437-38, C.39504, C.39549, C.39559, CA 4586-87), *Liparoceras (L.) divaricosta* (Trueman) (1; C.39455; Pl. 8, fig. 1).

596.2 Shale, silty, with occasional sideritic mudstone nodules ................................................................. 0.15

*Aegoceras (Oistoceras) sinuosiforme* Spath (18; C.39503, C.39508-10, C.39560, C.39562-67, C.39578, CA 4580-85).

Subzone of *Aegoceras (A.) capricornus*

596.1 Limestone nodules ............................................................................................................................ 0.85

595.2 Limestone nodules ............................................................................................................................ 0.56

595.1 Shale, silty, lower half soft, upper half harder; some lenses of oysters ........................................... 0.10

Scattered calcareous mudstone nodules in hard silty shale ........................................................................ 0.10

594 Shale, silty, with a few calcareous mudstone nodules ...................................................................... 0.10

*Aegoceras (A.) lataecosta* (J. de C. Sowerby) (1, lost); *Aegoceras (A.)* sp. indet. (10; CA 4579).

593 Sideritic mudstone nodules; conspicuous on the scar at Bulmer Steel Hole ......................................... 0.13

*Aegoceras (A.) artigyrus* (Brown) (4; CA 4604).

592 Shale, silty, with occasional calcareous mudstone nodules ................................................................. 0.04

591 The Oyster Bed. Hard, silty shale, with flat sideritic mudstone nodules; many oysters and other bivalves ................................................................................................................................. 0.18

*Aegoceras (A.) lataecosta* (J. de C. Sowerby) (1; C.39395).

**REDCAR MUDSTONE FORMATION**

IRONSTONE SHALE MEMBER

Subzone of *Aegoceras (A.) maculatum*

590.7 Sandstone, flaggy, with wave marks and oyster bands ................................................................. 1.42

590.66 Shale, silty ........................................................................................................................................ 0.10

590.65 Sideritic mudstone nodules ............................................................................................................ 0.23

590.64 Sideritic mudstone nodules ............................................................................................................ 0.08

590.63 Shale, silty, with scattered sideritic mudstone nodules near the base ........................................... 0.20

*Aegoceras (A.) maculatum* (Young & Bird) (8; C.38881, C.38886-90, C.38893, CA 4578), *Aegoceras (A.) maculatum* (Young & Bird) var. *lekenbyi* Spath (1; C.38880).

590.62 Shale, silty ........................................................................................................................................ 0.41

590.61 Shale, silty, with many sideritic mudstone nodules ...................................................................... 0.46

*Aegoceras (A.) maculatum* (Young & Bird) (8; C.38882-85, C.38891-92, C.38894, C.38896; Pl. 7, fig. 13).

590.5 Shale, silty ........................................................................................................................................ 1.30

590.43 Shale, silty, with a few sideritic mudstone nodules near the top .................................................. 0.23

590.42 Calcareous mudstone nodules ..................................................................................................... 0.08

590.41 Shale, silty, with a few sideritic mudstone nodules near the base .................................................. 0.20

590.3 Shale, silty, with occasional very large (up to 1 m diameter) sideritic mudstone nodules 0.5–1.5 m below the top; seen on the scar on the south side of Bulmer Steel Hole .................................................. 3.58
LOWER LIAS OF ROBIN HOOD’S BAY

Aegoceras (A.) maculatum (Young & Bird) (7; C.38895, CA 4573-77), Androgynoceras sp. indet. (1; CA 4603).

Large sideritic mudstone nodules; a strongly marked band crossing the shore south of Bulmer Steel Hole ........................................ 0.15

Sideritic mudstone nodules, sometimes septarian........................................................................................................................... 0.45

Aegoceras (A.) maculatum (Young & Bird) (5; C.39136, C.38878-79, CA 4571-72), Androgynoceras heterogenes (Young & Bird) (1; C.39136). Liparoceras (L.) sp. indet. (2; CA 4562-63).

Scattered sideritic mudstone nodules in shale................................................................................................................................. 0.08

Shale; one very large sideritic mudstone nodule 1 m below top .................................................................................................................. 4.95

Sideritic mudstone nodules........................................................................................................................................................................ 0.08

Lycoceras sp. indet. (1; CA 2795). Aegoceras (A.) maculatum (Young & Bird) (2; C.38876, CA 4570).

Flat septarian sideritic mudstone nodules, some with domed upper surfaces .......................................................... 0.13

Aegoceras (A.) maculatum (Young & Bird) (1; C.38877).

Shale, with scattered sideritic and calcareous mudstone nodules................................................................................................. 0.08

Sideritic mudstone nodules........................................................................................................................................................................ 0.15

Aegoceras (A.) maculatum (Young & Bird) (2; C.38871-72), Aegoceras (A.) maculatum (Young & Bird) var. atavum

Shale, silty, with small scattered spherical sideritic mudstone nodules 0.25 m below top .......................................................... 1.27

Sideritic shale, with many small sideritic mudstone nodules ................................................................................................................. 0.41

Aegoceras (Beaniceras) luridum (Simpson) (1; CA 4568), Liparoceras (L.) cf. naptonense Spath (1; C.39141).

Flat septarian sideritic mudstone nodules................................................. 0.23

Lycoceras sp. indet. (1; CA 4559). Aegoceras (A.) maculatum (J. Sowerby) (3; CA 2785-77).

Liparoceras (L.) cf. naptonense Spath (1; C.39140).

Flat sideritic mudstone nodules ......................................................... 0.15

Aegoceras (A.) maculatum (Young & Bird) (2; C.41307, CA 4569, Pl. 7, fig. 12).

Shale, silty, with occasional sideritic mudstone nodules; crosses the scar to reach low tide mark at Ness Ruck .................. 0.13

Aegoceras (Beaniceras) luridum (Simpson) (1; CA 4568). Liparoceras (L.) cf. naptonense Spath (1; C.39141).

Shale; contains fossil wood ........................................................................ 1.17

Liparoceras (L.) heptangulare (Young & Bird) (1; CA 4559), Lytoceras fimbriatum (J. Sowerby) (3; CA 2775-77).

Shale; contains fossil wood ........................................................................ 0.74

Sideritic mudstone nodules ........................................................................ 0.08

Shale; contains fossil wood ........................................................................ 2.59

Subzone of Aegoceras (Beaniceras) luridum

Aegoceras (Beaniceras) cf. luridum (Simpson) (1; CA 4568). Liparoceras (L.) cf. naptonense Spath (1; C.39141).

Sideritic shale, with many large (0.6 m diameter, or up to 0.5 m x 1.2 m) flat, septarian, sideritic mudstone nodules; forms a conspicuous bed on the scar just north of Ness Ruck; occasional logs of fossil wood ........................................ 0.23

Lytoceras fimbriatum (J. Sowerby) (8; CA 2787-94).

Liparoceras (L.) heptangulare (Young & Bird) (2; C.38876, CA 4570).

Shale, with scattered sideritic mudstone nodules.......................................................... 0.08

Lytoceras fimbriatum (J. Sowerby) (3; CA 2782-84).

Shale, grey, with a paler and harder middle band; contains several pieces of fossil wood ......................................................... 1.32

Aegoceras (Beaniceras) luridum (Simpson) (1; CA 4564).

Subzone of Acanthopleuroceras valdani

Sideritic shale, with occasional sideritic mudstone nodules; crosses the scar to reach low tide mark at Ness Ruck .................. 0.13

Liparoceras (L.) cf. heptangulare (Young & Bird) (1; CA 4560).

Scattered sideritic mudstone nodules in shale ................................................................................................................................. 0.08

Lytoceras fimbriatum (J. Sowerby) (3; CA 2775-77).

Scattered sideritic mudstone nodules in shale ................................................................................................................................. 0.08

Lytoceras fimbriatum (J. Sowerby) (3; CA 2775-77).

Shale; contains fossil wood ........................................................................ 1.17

Liparoceras (L.) heptangulare (Young & Bird) (1; CA 4559), Lytoceras fimbriatum (J. Sowerby) (3; CA 2775-77).

Shale; contains fossil wood ........................................................................ 0.74

Sideritic mudstone nodules ........................................................................ 0.08

Shale; contains fossil wood ........................................................................ 0.74

Sideritic mudstone nodules ........................................................................ 0.08

Shale; contains fossil wood ........................................................................ 2.59
Shale, with many scattered oval sideritic mudstone nodules up to 0.15m thick ................................................................. 0.81

Liparoceras (L.) heptangulare (Young & Bird) (1; C.39137), Lytoceras fimbriatum (J. Sowerby) (1; CA 2774).

Subzone of Tropidoceras massecum

Shale, with occasional sideritic mudstone nodules that contain gastropods and poorly preserved Crustacea ..................... 1.73

Lytoceras fimbriatum (J. Sowerby) (3; CA 2771-73).

Continuous bed of sideritic mudstone; outcrops in a gully on the scars, and forms a conspicuous datum line in the cliff ................................................................. 0.08

Tropidoceras loscombi (J. Sowerby) (2; CA 2761-62).

Shale, in 7 or 8 pale and dark bands ............................................................................................................................. 1.68

Lytoceras sp. indet. near top of bed (1; lost); Tropidoceras futtereri Spith near base of bed (1; CA 4545; Pl. 7, fig. 11);

Tropidoceras massecum (d’Orbigny) var. rotundum (Futterer) at boundary of beds 567 and 568 (11; CA 4546-55).

Shale, hard and silty; forms a slight feature on the scar ........................................................................................................ 0.15

Shale ..................................................................................................................................................................................... 0.28

Liparoceras (L.) sp. indet. (1; lost).

Shale, hard and silty; forms a slight feature on the scar ........................................................................................................ 0.08

Shale, with harder silty bands at the base and the middle; the higher silty band contains occasional sideritic

mudstone nodules ............................................................................................................................................................... 0.56

Liparoceras (L.) sp. indet. (1; lost).

Sideritic mudstone nodules; contains large logs of fossil wood .......................................................................................... 0.08

Shale, with occasional sideritic mudstone nodules .............................................................................................................. 0.69

Tropidoceras sp. indet. (3; CA 4556-58), Liparoceras (L.) chelidense (Murchison) (2; C.39138-39).

Flat sideritic mudstone nodules ........................................................................................................................................ 0.08

Tropidoceras sp. indet. or ?Uptonia cf. jamesoni (J. de C. Sowerby) (2; lost).

Shale, with shelly layers (top 0.08 m only) .......................................................................................................................... 0.08

Tropidoceras futtereri Spith (1; CA 4544; Pl. 7, fig. 10).

Zone of Uptonia jamesoni

Subzone of Uptonia jamesoni

Shale, with shelly layers (all below the top 0.08 m) .............................................................................................................. 1.32

Tragophylloceras sp. indet. (1; CA 2770), Polymorphites bronni (Roemer) (7; CA 4224-30; Pl. 7, fig. 5), Uptonia lata

(Quenstedt) (1; CA 4538) and Uptonia cf. jamesoni (J. de C. Sowerby) (1; CA 4532).

Flat sideritic mudstone nodules; together with bed 559, forms a distinctive pair of nodule beds on the scar ......................... 0.08

Uptonia jamesoni (J. de C. Sowerby) (1; CA 4531), Polymorphites bronni (Roemer) (2; CA 4222-23).

Shale ..................................................................................................................................................................................... 0.15

Polymorphites bronni (Roemer) (1; CA 4221).

Flat sideritic mudstone nodules ........................................................................................................................................ 0.08

Uptonia jamesoni (J. de C. Sowerby) (1; CA 4530), Uptonia sp. indet. (1; CA 4543), Polymorphites bronni (Roemer)

(1; CA 4220).

Shale, with occasional sideritic mudstone nodules at about the middle of the bed ................................................................. 0.66

Uptonia lata (Quenstedt) (5; CA 4533-37), Uptonia sp. indet. (4; CA 4539-42), Polymorphites bronni (Roemer)

(16; CA 4204-19), Tragophylloceras sp. indet. (1; CA 2769).

Flat sideritic mudstone nodules; conspicuous in the cliff ...................................................................................................... 0.13

Uptonia cf. jamesoni (J. de C. Sowerby) (1; CA 4529).

Shale ..................................................................................................................................................................................... 0.41

Uptonia jamesoni (J. de C. Sowerby) (1; CA 4528).

Small spherical, grey, calcareous mudstone nodules, with a few larger flat sideritic mudstone nodules ......................... 0.08

Uptonia jamesoni (J. de C. Sowerby) (5; CA 4523-27), Polymorphites bronni (Roemer) (3; CA 4201-03).

Shale ..................................................................................................................................................................................... 0.71

Polymorphites bronni (Roemer) (5; CA 4196-4200).

Grey calcareous mudstone nodules mixed with larger sideritic mudstone nodules .......................................................... 0.10

Uptonia jamesoni (J. de C. Sowerby) (1; CA 4522), Polymorphites polymorphus (Quenstedt) (2; CA 4316-17; Pl. 7,

fig. 3).

Shale ..................................................................................................................................................................................... 0.76

Uptonia jamesoni (J. de C. Sowerby) (2; CA 4520-21), Polymorphites bronni (Roemer) (1; CA 4195), Parinodiceras

parinodum (Quenstedt) (1; C.39142).

Flat sideritic mudstone nodules mixed with a few smaller grey calcareous mudstone nodules ........................................ 0.13

Tragophylloceras sp. indet. (1; CA 2768).

Shale ..................................................................................................................................................................................... 0.33

Scattered sideritic mudstone nodules, mixed with smaller grey calcareous mudstone nodules, in shale .......................... 0.08
LOWER LIAS OF ROBIN HOOD'S BAY

Uptonia jamesoni (J. de C. Sowerby) (5; CA 4515-19).

550 Shale

Uptonia jamesoni (J. de C. Sowerby) (5; CA 4510-14). Platyploceras cf. brevispina (J. de C. Sowerby) (3; CA 4469-71).

Subzone of Platyploceras brevispina

549 Flat sideritic mudstone nodules ................................................................. 0.10

548 Shale ........................................................................................................... 0.36

Parinodiceras parinodum (Quenstedt) (1; C.39144), Platyploceras brevispina (J. de C. Sowerby) (2; CA 4467-68), Radstockiceras sp. indet. (1; CA 3761).

547 Flat sideritic mudstone nodules ................................................................. 0.10

546.5 Shale. with occasional small siderite mudstone nodules in the lower part ................................................................. 1.02

Platyploceras aureum (Simpson) (7; CA 4489-95). Platyploceras brevispina (J. de C. Sowerby) (2, lost). Polymorphites sp. indet. (1; lost).

546.4 Scattered sideritic mudstone nodules in shale ........................................ 0.08

Platyploceras brevispina (J. de C. Sowerby) (1; CA 4488), Tragophylloceras sp. indet. (2; CA 2766-67).

546.3 Shale ........................................................................................................... 0.23

Platyploceras brevispina (J. de C. Sowerby) (11; CA 4448-57), Platyploceras aureum (Simpson) (5; CA 4483-87), Platyploceras sp. indet. (8; CA 4502-09). Polymorphites trivialis (Simpson) (1; CA 4396).

546.2 Sideritic mudstone nodules ..................................................................... 0.08

Platyploceras brevispina (J. de C. Sowerby) (2; CA 4446-47). Platyploceras aureum (Simpson) (4; CA 4479-82; Pl. 7, fig. 6). Polymorphites trivialis (Simpson) (1; CA 4395).

546.1 Shale ........................................................................................................... 0.33

Platyploceras brevispina (J. de C. Sowerby) (10; CA 4436-45). Platyploceras aureum (Simpson) (6; CA 4473-78). Platyploceras sp. indet. (6; CA 4496-4501). Polymorphites trivialis (Simpson) (1; CA 4394).

545 Flat sideritic mudstone nodules; forms a minor feature in a conspicuous gully on the scar ................................................................. 0.15

Platyploceras brevispina (J. de C. Sowerby) (1; CA 4435).

544 Shale with horizons of nodules, 4.27 m thick; forms a cambered pavement on the scar. bordered on north and south by conspicuous gullies; might be called the ‘Polymorphites Bed’. ................................. 0.71

544.9 Shale ........................................................................................................... 0.71

Platyploceras brevispina (J. de C. Sowerby) (4; CA 4431-34). Polymorphites trivialis (Simpson) (13; CA 4381-93).

544.8 Scattered flat sideritic mudstone nodules in shale ..................................... 0.10

Polymorphites trivialis (Simpson) (3; CA 4378-80).

544.7 Shale ........................................................................................................... 0.36

Platyploceras obsoleta (Simpson) (1; CA 4472), Platyploceras brevispina (J. de C. Sowerby) (38; CA 4398-4430). Polymorphites trivialis (Simpson) (3; CA 4375-77). Radstockiceras buvignieri (d’Orbigny) (2; CA 3749-50).

544.6 Flat sideritic mudstone nodules .................................................................. 0.10

Polymorphites trivialis (Simpson) (5; CA 4370-74). Platyploceras brevispina (Simpson) (1; CA 4397). Radstockiceras sp. indet. (1; CA 3760).

Subzone of Polymorphites polymorphus

544.5 Shale ........................................................................................................... 0.33

Polymorphites trivialis (Simpson) (25; CA 4347-69). Tragophylloceras cf. numismale (Quenstedt) (1; CA 2760).

544.4 Scattered flat sideritic mudstone nodules in shale ..................................... 0.10

Polymorphites trivialis (Simpson) (20; CA 4327-46). Radstockiceras sphenonotum (Monke) (2; CA 3757-58; Pl. 5, fig. 4). Radstockiceras sp. indet. (1; CA 3759).

544.35 Shale. with a few grey calcareous mudstone nodules .............................. 0.93

Polymorphites trivialis (Simpson) (11; CA 4319-26; Pl. 7, fig. 7).

544.34 Small grey calcareous mudstone nodules ............................................. 0.08

544.33 Shale ........................................................................................................... 0.32

544.32 Scattered flat sideritic mudstone nodules in shale ..................................... 0.05

544.31 Shale ........................................................................................................... 0.40

Tragophylloceras cf. numismale (Quenstedt) (1; CA 2759).

544.2 Small grey calcareous mudstone nodules ................................................. 0.08

544.1 Shale. with two horizons of small spherical grey calcareous mudstone nodules ................................................................. 0.71

543 Continuous bed of sideritic mudstone; forms the northern boundary of a deep gully ................................................................. 0.15

542.5 Shale ........................................................................................................... 0.71

Polymorphites caprarius (Quenstedt) (10; CA 4306-15). Radstockiceras sphenonotum (Monke) (2; CA 3755-56).
Scattered small dark grey calcareous mudstone nodules in shale ........................................................................................................ 0.08

Apoderoceras sp. indet. (2; CA 4071-72), Polymorphites caprarius (Quenstedt) (15; CA 4292-4305), Polymorphites trivialis (Simpson) (1; CA 4318), Radstockiceras sphenonotum (Monke) (3; CA 3752-54), Tragophylloceras sp. indet. (1; CA 2765). 0.04

Polymorphites caprarius (Quenstedt) (6; CA 4286-91). 0.33

Scattered small grey calcareous mudstone nodules in shale ........................................................................................................ 0.04

Polymorphites caprarius (Quenstedt) (5; CA 4281-85). 0.58

Shale .................................................................................................................................................................................................. 0.58

Polymorphites caprarius (Quenstedt) (8; CA 4273-80), Radstockiceras sphenonotum (Monke) (1; CA 3751). 0.08

Flat sideritic mudstone nodules .................................................................................................................................................. 0.08

Polymorphites caprarius (Quenstedt) (4; CA 4269-72), Tragophylloceras numismale (Quenstedt) (1; CA 2758). 0.53

Shale .................................................................................................................................................................................................. 0.53

Polymorphites caprarius (Quenstedt) (11; CA 4258-68). 1.02

Scattered sideritic mudstone nodules in shale .......................................................................................................................... 0.08

Polymorphites caprarius (Quenstedt) (6; CA 4253-57). 0.86

Shale .................................................................................................................................................................................................. 0.86

Polymorphites caprarius (Quenstedt) (14; CA 4239-52), Hyperderoceras sp. indet. (1; CA 4053). 0.64

Flat or spherical sideritic mudstone nodules .................................................................................................................................. 0.06

Polymorphites caprarius (Quenstedt) (2; CA 4237-38; Pl. 7, fig. 9). 0.81

Shale .................................................................................................................................................................................................. 0.81

Polymorphites caprarius (Quenstedt) (6; CA 4231-36).

Subzone of Phricodoceras taylorti

Scattered flat or spherical sideritic mudstone nodules in shale ........................................................................................................ 0.08

Shale .................................................................................................................................................................................................. 0.74

Flat or spherical sideritic mudstone nodules .................................................................................................................................. 0.08

Shale .................................................................................................................................................................................................. 0.86

Flat sideritic mudstone nodules .................................................................................................................................................. 0.08

Shale, with occasional sideritic mudstone nodules ..................................................................................................................... 1.22

Large flat sideritic mudstone nodules: forms the northern boundary of a gully cut by the Dungeon Hole fault ............................................................................................. 0.15

Shale .................................................................................................................................................................................................. 0.91

Grey calcareous mudstone nodules .................................................................................................................................................. 0.05

Phricodoceras cornutum (Simpson) (1; CA 4060). 0.81

Gemmellaroceras rutilans (Simpson) (2; CA 4179-80); Pinna folium (Young & Bird) abundant. 0.05

Widely scattered sideritic mudstone nodules in shale: the lowest nodule bed exposed on the northern side of the Dungeon Hole fault ........................................................................................................ 0.05

Apoderoceras sp. indet. (1; CA 4052). 0.81

Gemmellaroceras sp. indet. (1; CA 4194). 0.81

Continuous bed of sideritic mudstone; weathers red-brown, and is yellow-brown when broken; a distinctive bed forming a scarp face on the northern boundary of a gully. ...................................................................................................................... 0.18

PYRITOUS SHALE MEMBER

Shale, with occasional masses of pyrites, and a few calcareous mudstone nodules .......................................................................................................................... 1.57

Apoderoceras sp. indet. (1; CA 4051), Tragophylloceras sp. indet. (1; CA 2764). 0.10

Septarian calcareous mudstone nodules .................................................................................................................................................. 0.10

Apoderoceras cf. aculeatum (Simpson) (4; CA 4032-35). 1.02

Shale, with occasional masses of pyrites, and a few calcareous mudstone nodules .......................................................................................................................... 1.02

Apoderoceras aculeatum (Simpson) (3; CA 4029-31; Pl. 6, fig. 2). 0.06

Calcareous mudstone nodules .................................................................................................................................................. 0.06

Apoderoceras sp. indet. (2; CA 4049-50). 0.25

Shale, with many masses of pyrites and ‘nests’ of pyrites with a radiating structure .......................................................................................... 0.25

Apoderoceras cf. aculeatum (Simpson) (1; CA 4028). 0.05

Calcareous mudstone nodules, some with circular septarian jointing .......................................................................................... 0.05

Apoderoceras cf. aculeatum (Simpson) (1; CA 4027). 1.32

Shale, with a few ‘nests’ of pyrites, and some calcareous mudstone nodules, especially in the lower part ........................................................................................................ 1.32

Phricodoceras cornutum (Simpson) (5; CA 4055-59), Gemmellaroceras rutilans (Simpson) (2; CA 4177-78; Pl. 7, fig. 4), Apoderoceras aculeatum (Simpson) (3; CA 4024-26), Apoderoceras sp. indet. (1; CA 4048). 0.10

Large flat sideritic mudstone nodules, with a very irregular top surface which weathers dark red; a very conspicuous bed crossing the scar south of the Dungeon Hole fault (see bed 520.4) .......................................................................................................................... 0.10
Apoderoceras aculeatum (Simpson) (1; CA 4023), Phricodoceras cornutum (Simpson) (1; CA 4070; Pl. 7, fig. 2).

524.3 Shale, with a few calcareous or sideritic mudstone nodules, and some 'nests' of pyrites ................................................. 0.51

524.2 Sideritic mudstone nodules; some pyrites .......................................................................................................................... 0.04

524.1 Shale ...................................................................................................................................................................................... 0.52

Phricodoceras cf. taylori (J. de C. Sowerby) (1; CA 4069), Apoderoceras sp. indet. (1; CA 4047).

523 Flat sideritic mudstone nodules ........................................................................................................................................... 0.06

Apoderoceras aculeatum (Simpson) (1; CA 4021).

522.3 Shale, with occasional sideritic mudstone nodules .............................................................................................................. 0.74

522.2 Flat sideritic mudstone nodules, with circular septarian jointing ...................................................................................... 0.04

522.1 Shale, with occasional sideritic mudstone nodules, some with veins of pyrites, and some 'nests' of pyrites ....................... 0.66

Apoderoceras subtriangularare (Young & Bird) (1; CA 4020).

521 Flat sideritic mudstone nodules, with circular septarian jointing ........................................................................................... 0.05

Tragophylloceras numismale (Quenstedt) (1; CA 2757).

520.7 Shale ...................................................................................................................................................................................... 0.48

Apoderoceras subtriangularare (Young & Bird) (2; CA 4018-19; Pl. 6, fig. 4).

520.6 Sideritic mudstone nodules .................................................................................................................................................... 0.07

Apoderoceras subtriangularare (Young & Bird) (2; CA 4016-17), Tragophylloceras cf. numismale (Quenstedt) (1; CA 2756).

520.5 Shale, with many scattered sideritic mudstone nodules ......................................................... 0.36

Apoderoceras subtriangularare (Young & Bird) (1; CA 4015), Apoderoceras sp. indet. (4; CA 4043-46), Phricodoceras cf. nodosum (Quenstedt) (1; CA 4061), Gemmellaroceras sp. indet. (2; CA 4192-93), Tragophylloceras numismale (Quenstedt) (4; CA 2752-55).

520.4 Sideritic mudstone nodules, with an irregular top surface; similar to bed 525 about 50 m to the north, but less conspicuous ............................................... 0.10

Apoderoceras sp. indet. (1; CA 4042).

520.3 Shale, with many sideritic mudstone nodules ..................................................................................................................... 0.82

Apoderoceras subtriangularare (Young & Bird) (1; CA 4014), Tragophylloceras numismale (Quenstedt) (3; CA 2749-51).

520.2 Sideritic mudstone nodules .................................................................................................................................................... 0.04

Tragophylloceras numismale (Quenstedt) (1; CA 2748).

520.1 Shale ...................................................................................................................................................................................... 0.64

Apoderoceras subtriangularare (Young & Bird) (3; CA 4011-13), Tragophylloceras numismale (Quenstedt) (1; CA 2747).

519 Clay; forms a conspicuous parting in the cliff, but difficult to recognize on the scars .......................................................... 0.03

518 Band of sideritic mudstone, with irregular top surface; outcrops at the foot of a low scarp face that forms the northern side of a gully .................................................. 0.04

517.7 Shale ...................................................................................................................................................................................... 0.66

Apoderoceras subtriangularare (Young & Bird) (1; CA 4010), Tragophylloceras numismale (Quenstedt) (1; CA 2746).

517.6 Flat sideritic mudstone nodules ........................................................................................................................................... 0.05

517.5 Shale ...................................................................................................................................................................................... 0.15

517.4 Sideritic mudstone nodules .................................................................................................................................................... 0.05

517.3 Shale ...................................................................................................................................................................................... 0.23

Gemmellaroceras sp. indet. (2; CA 4190-91).

517.2 Sideritic mudstone nodules .................................................................................................................................................... 0.05

Gemmellaroceras sp. indet. (1; CA 4189).

517.1 Shale ...................................................................................................................................................................................... 0.23

516 Large flat sideritic mudstone nodules ........................................................................................................................................ 0.06

515.7 Shale ...................................................................................................................................................................................... 0.26

515.6 Sideritic mudstone nodules .................................................................................................................................................... 0.08

515.5 Shale ...................................................................................................................................................................................... 0.26

Tragophylloceras cf. numismale (Quenstedt) (1; CA 2745).

515.4 Occasional sideritic mudstone nodules in shale .................................................................................................................... 0.08

515.3 Shale ...................................................................................................................................................................................... 0.26

515.2 Flat sideritic mudstone nodules ........................................................................................................................................... 0.08

515.1 Shale ...................................................................................................................................................................................... 0.26

514 Flat sideritic mudstone nodules ........................................................................................................................................... 0.04

513.7 Shale ...................................................................................................................................................................................... 0.58

Apoderoceras sp. indet. (1; CA 4041).

513.6 Sideritic mudstone nodules .................................................................................................................................................... 0.08

Apoderoceras sp. indet. (1; CA 4040).

513.5 Shale, with a few sideritic mudstone nodules ....................................................................................................................... 0.13

513.4 Sideritic mudstone nodules .................................................................................................................................................... 0.10

513.3 Shale ...................................................................................................................................................................................... 0.08

513.2 Occasional sideritic mudstone nodules in shale .................................................................................................................... 0.05
Shale, with occasional sideritic mudstone nodules ................................................................. 0.33

*Apoderoceras subtriangulare* (Young & Bird) (1; CA 4009).

Scattered flat sideritic mudstone nodules in shale ................................................................. 0.04

Shale ........................................................................................................................................ 0.25

*Apoderoceras cf. subtriangulare* (Young & Bird) (1; CA 4008).

Band of elongated sideritic mudstone nodules up to 1 m long, with two sets of joints at 60° ................................................................. 0.04

Shale ........................................................................................................................................ 0.18

Scattered sideritic mudstone nodules in shale ........................................................................... 0.08

Shale ........................................................................................................................................ 0.53

*Apoderoceras cf. subtriangulare* (Young & Bird) (1; CA 4007), *Gemellaroceras sp. indet.* (1; CA 4188).

Irregular, septarian sideritic mudstone nodules, set in pale silty shales ................................. 0.10

Shale ........................................................................................................................................ 0.43

Scattered sideritic mudstone nodules in shale ........................................................................... 0.05

*Phricodoceras cf. taylori* (J. de C. Sowerby) (1; CA 4068).

Shale, with a few sideritic mudstone nodules .......................................................................... 0.30

*Apoderoceras subtriangulare* (Young & Bird) (3; CA 4004-06).

Sideritic mudstone nodules, set in pale silty shale ................................................................. 0.08

*Apoderoceras subtriangulare* (Young & Bird) (4; CA 4000-03), *Tragophylloceras sp. indet.* (1; CA 2763).

Shale ........................................................................................................................................ 0.64

*Apoderoceras subtriangulare* (Young & Bird) (2; CA 3998-99).

Shale, with many scattered sideritic mudstone nodules ......................................................... 0.20

*Apoderoceras subtriangulare* (Young & Bird) (2; CA 3996-97), *Radstockiceras buvigleri* (d’Orbigny) (1; CA 3748).

*Tragophylloceras numismale* (Quenstedt) (1; CA 2744; Pl. 1, fig. 1).

Shale ........................................................................................................................................ 1.30

*Apoderoceras subtriangulare* (Young & Bird) (2; CA 3994-95), *Gemellaroceras tubellum* (Simpson) (1; CA 4176).

*Cenoceras striatum* (J. Sowerby) (1; CN 87).

Sideritic mudstone nodules set in pale silty shales ................................................................. 0.08

*Phricodoceras taylori* (J. de C. Sowerby) (1; CA 4067), *Apoderoceras subtriangulare* (Young & Bird) (2; CA 3992-93).

Shale; 0.51 m thick in Wine Haven ......................................................................................... 0.41

*Gemellaroceras sp. indet.* (6; CA 4182-87).

Occasional grey calcareous mudstone nodules, set in pale silty shales ................................. 0.08

*Phricodoceras cf. taylori* (J. de C. Sowerby) (3; CA 4064-66), *Apoderoceras subtriangulare* (Young & Bird) (6; CA 3986-91; Pl. 6, fig. 5).

Shale ........................................................................................................................................ 1.52

*Phricodoceras cf. taylori* (J. de C. Sowerby) (2; CA 4062-63), *Apoderoceras sp. indet.* (5; CA 4036-39), *Gemellaroceras sp. indet.* (4; CA 4181).

Occasional grey calcareous mudstone nodules in shale ......................................................... 0.05

*Apoderoceras cf. subtriangulare* (Young & Bird) (3; CA 3983-85), *Gemellaroceras tubellum* (Simpson) (63; CA 4113-75).

Shale; with calcareous mudstone nodules, 0.05 m thick, at about the middle, which is the highest nodule bed on the foreshore on the west side of the Peak Fault complex in Wine Haven ................................................................. 1.83

*Bifericeras donnovani* Dommergues & Meister (18; CA 3793-3810; Pl. 8, fig. 3), *Apoderoceras subtriangulare* (Young & Bird) (3; CA 3980-82; Pl. 5, fig. 8).

**Zone of Echioceras raricostatum**

**Subzone of Paltechioceras aplanatum**

Flat sideritic mudstone nodules; forms the north-western boundary of The Landing at Bay Town ................................................................. 0.08

Shale, with a few large calcareous mudstone nodules; forms the north-western part of the floor of The Landing at Bay Town; 1.83 m thick in Wine Haven ......................................................................................... 1.57

*Paltechioceras tardicrescens* (Hauer) (2; CA 4607-08), *Eoderoceras armatum* (J. Sowerby) (7; CA 3885-91; Pl. 8, fig. 2), *Gleviceras guibalianum* (d’Orbigny) (1; CA 4606).

Shale, with numerous septarian sideritic mudstone nodules; runs down the middle of The Landing ......................................................................................... 0.23

*Paltechioceras tardicrescens* (Hauer) (72; CA 3573-3643; Pl. 4, fig. 6), *Eoderoceras armatum* (J. Sowerby) (8; CA 3878-84), *Gemellaroceras tubellum* (Simpson) (15; CA 4098-4112).

Shale, dark grey with 3 paler stripes of silty shale; contains at least one log of fossil wood 2 m long; forms the south-eastern part of the floor of The Landing at Bay Town ......................................................................................... 2.29

*Paltechioceras tardicrescens* (Hauer) (154; CA 3428-3572; Pl. 4, fig. 3), *Paltechioceras regustatum* (Buckman) (2; CA 3426-27), *Eoderoceras armatum* (J. Sowerby) (44; CA 3834-77), *Gleviceras guibalianum* (d’Orbigny) (6; CA 3735-40), *Gemellaroceras tubellum* (Simpson) (24; CA 4074-97).

**SILICEOUS SHALE MEMBER**

Hard calcified, silty shale; forms the capping to Landing Scar at Bay Town ......................................................................................... 1.40
LOWER LIAS OF ROBIN HOOD’S BAY

Gleviceras guibalianum (d’Orbigny) (2; CA 3733-34), Paltechioceras regustatum (Buckman) (16; CA 3410-25),
Paltechioceras sp. indet. (6; CA 3644-49).
In Wine Haven bed 496 caps a conspicuous scar running from 130 m east of Tan Beck waterfall into the west
side of the Peak Fault complex, where it can be divided into:
496c Hard calcified, silty shale ................................................................. 0.28 m
496b Shale, with a few large sideritic mudstone nodules .......................... 0.21 m
496a Hard calcified, silty shale, especially hard near base ..................... 0.91 m

Subzone of Leptechioceras macdonnelli

495.7 Shale ............................................................................................... 0.84
495.6 Harder shale, with a few sideritic mudstone nodules .............. 0.13
495.5 Shale ............................................................................................... 0.15
495.4 Harder calcified shale ................................................................. 0.15
495.3 Shale ............................................................................................... 0.30
495.2 Hard calcified shale ......................................................................... 0.36
495.15 Shale .............................................................................................. 0.43
495.14 Harder shale ................................................................................... 0.13
495.13 Shale, with rare sideritic mudstone nodules in Wine Haven ...... 0.33
495.12 Harder shale .................................................................................. 0.13
495.11 Shale .............................................................................................. 0.53
494 Hard calcified, silty shale; forms the capping of East Scar at Bay Town, and forms a well-marked scar in Wine Haven
running eastwards from Tan Beck waterfall, where a few sideritic mudstone nodules occur in the top 0.20 m ............ 1.00
Leptechioceras aff. macdonnelli (Portlock) (3; CA 3400-02), Eoderoceras armatum (J. Sowerby) (1; CA 3831),
Radstockiceras buvignieri (d’Orbigny) (4; CA 3744-47; Pl. 5, fig. 1).

Subzone of Echioceras raricostatoides

493.5 Shale .............................................................................................. 0.86
493.4 Hard calcified, silty shale; two 0.08 m partings of softer shale seen in the Wine Haven cliff ................. 0.91
493.3 Shale .............................................................................................. 0.38
493.2 Hard calcified, silty shale; contains a few sideritic mudstone nodules in Wine Haven ....................... 0.33
Echioceras intermediate (Trueman & Williams) (5; CA 3383-87), Eoderoceras hastatum (Young & Bird)
(4; CA 3892-95; Pl. 6, fig. 3).
493.1 Shale ............................................................................................. 0.22
492 Hard calcified, silty shale; 0.28 m in Wine Haven; caps a strong scar south of East Scar, and a conspicuous scar in
Wine Haven where it passes from cliff to scar at the foot of Tan Beck waterfall .............................................. 0.23
491.3 Shale ............................................................................................. 0.37
491.2 Harder shale .................................................................................. 0.48
491.1 Shale, with one or two slightly harder bands ......................... 1.19
Echioceras raricostatoides Vadasz (1; CA 3399).
490 Hard calcified, silty shale; forms the highest scar that passes in front of Tan Beck waterfall in Wine Haven; crosses Mill
Beck just west of Bay Mill ................................................................. 0.18
Echioceras raricostatoides Vadasz (5; CA 3394-98).
489 Shale, soft, laminated; 0.88 m in Wine Haven ................................. 0.91
Echioceras raricostatoides Vadasz (8; CA 3389-93; Pl. 4, fig. 2).
488 Hard calcified, silty shale; has a softer central part and is 0.22 m thick in Wine Haven; crosses Mill Beck beside
Bay Mill .............................................................................................. 0.15
Echioceras raricostatoides Vadasz (1; CA 3388), Crucilobiceras densinodulatum Buckman (1; CA 3830).

Subzone of Crucilobiceras densinodulatum

487 Shale, with two 0.09 m slightly harder bands .................................. 0.92
Crucilobiceras densinodulatum Buckman (2; CA 3829) in lower part.
Zone of *Oxynoticeras oxynotum*

Subzone of *Oxynoticeras oxynotum*

486.3 Hard calcified, silty shale, with many small calcareous mudstone nodules; the 'Crucilobiceras Bed' ......................... 0.08

*Crucilobiceras densinodulum* Buckman (18; CA 3812-28; Pl. 6, fig. 1).

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**Shale**

486.2

*Bifericeras* cf. *vitreum* (Simpson) (1; CA 3811).

486.1 Hard calcified, silty shale; 0.33 m in Wine Haven, where there is a softer central 0.10m parting ...................... 0.25

485.3 Shale; a few lenticles of calcareous mudstone in Wine Haven ................................................................. 0.55

485.2 Harder shale; 0.17 m in Wine Haven .................................................................................................................. 0.22

*Gleviceras* doris (Reynès) (1; CA 3727). *Angulaticeras* sp. indet. (1; CA 2801).

485.1 Shale .............................................................................................................................................................. 0.43

484 Hard calcified, silty shale; with a central parting about 0.09 m thick; similar to, but less conspicuous than, bed 474, the Double Band; 0.56 m thick in Wine Haven .................................................................................................................. 0.44

*Gleviceras* cf. *guibalium* (d'Orbigny) (2; CA 3728-29).

483.5 Shale .............................................................................................................................................................. 0.13

483.4 Harder shale ......................................................................................................................................................... 0.46

483.3 Shale, with a few harder lenticles near the base in Wine Haven ............................................................................... 0.43

*Oxynoticeras* sp. indet. (1; CA 3722). *?Gleviceras* sp. indet. (1; CA 3743).

483.2 Harder shale; 0.09 m in Wine Haven .................................................................................................................. 0.48

483.1 Shale; 0.25 m in Wine Haven .......................................................................................................................... 0.18

*?Gleviceras* sp. indet. (1; CA 3742). *Bifericeras bifer* (Quenstedt) (5; CA 3788-92).

482.5 Hard calcified, silty shale; forms the capping to the main Dab Dumps scar; 0.08 m in Wine Haven .............. 0.10

482.4 Shale .............................................................................................................................................................. 0.10

482.3 Hard calcified, silty shale; 0.10 m in Wine Haven .............................................................................................. 0.08

*Oxynoticeras* sp. indet. (1; CA 3721).

482.2 Shale; 0.10 m in Wine Haven .......................................................................................................................... 0.08

482.1 Hard calcified, silty shale; caps a fairly prominent scar on Dab Dumps; crosses Mill Beck nearly opposite the foot of Mill Bank where the road reaches the shore ............................................................................. 0.13

*Oxynoticeras* sp. indet. (1; CA 3720).

481 Shale; 0.43 m in Wine Haven .......................................................................................................................... 0.38

*Oxynoticeras oxynotum* (Quenstedt) (1; CA 3716; Pl. 4, fig. 4).

480 Hard calcified, silty shale; 0.89 m in Wine Haven, where the upper half is less hard ........................................ 0.80

*Oxynoticeras* sp. indet. (2; CA 3718-19).

479 Shale .............................................................................................................................................................. 0.20

*Oxynoticeras cf. oxynotum* (Quenstedt) (1; CA 3715).

478 Hard calcified, silty shale .............................................................................................................................................. 0.14

477 Shale, with some thin slightly harder bands ........................................................................................................ 0.42

476 Hard calcified, silty shale; 0.14 m in Wine Haven; crosses Mill Beck just inside the mouth of the valley .......... 0.10

*Gleviceras* doris (Reynès) (2; CA 3725-26; Pl. 4, fig. 7).

475.6 Shale, slightly indurated in places .................................................................................................................... 0.13

475.5 Hard calcified mudstone lenticles ...................................................................................................................... 0.02

475.4 Shale, slightly harder in basal 0.05 m .................................................................................................................. 0.77

475.3 Blue or red-weathering calcareous mudstone nodules .................................................................................... 0.05

*Oxynoticeras oxynotum* (Quenstedt) (1; CA 3714).

475.2 Shale, slightly harder in top 0.13 m ...................................................................................................................... 0.43

475.1 Harder shale; 0.10 m in Wine Haven .................................................................................................................. 0.08

474 The Double Band. Hard calcified, silty shale, with a softer central parting, forming a conspicuous double band; caps Cowling Scar in the middle of the bay, forms a terrace in front of Mill Beck Nab and Boggle Hole, and caps Billet Scar in Wine Haven in the south of the bay.

474.3 Hard calcified, silty shale; 0.25 m in Wine Haven, where there are some patches of pyrites ...................... 0.20

*?Paroxynoticeras salisburgense* (Hauer) (2; CA 3723-24).

474.2 Shale, softer, only partially calcified .................................................................................................................. 0.08

474.1 Hard calcified, silty shale ...................................................................................................................................... 0.15

473 Shale, soft, but a partially calcified band in the middle .......................................................................................... 0.25

*Oxynoticeras* sp. indet. (1: lost).

472.3 Partly calcified shale .............................................................................................................................................. 0.13

472.2 Hard calcified, silty shale ...................................................................................................................................... 0.13

472.1 Shale, slightly calcified in places .......................................................................................................................... 0.61

*Oxynoticeras oxynotum* (Quenstedt) (1; CA 3713).
Subzone of Oxynoticeras simpsoni

467 Shale, with scattered calcareous mudstone 'cheese' doggers .............................................................. 1.83

468 Shale, with many calcareous mudstone nodules about 0.08 m thick enveloped in cone-in-cone structures, and thin lenticles of shelly limestone .......................................................... 0.10

469 Shale, with scattered calcareous mudstone 'cheese' doggers .............................................................. 0.08

470 Shale; with occasional calcareous mudstone 'cheese' doggers and masses of pyrites: 0.91 m near Miller's Nab .......... 0.97

471 Calcareous mudstone nodules enveloped in cone-in-cone structures, some 'cheese' doggers and a few strings of pyrites .............................................................. 0.08

472 Gagaticeras exortum (Simpson) (1; CA 3297), Gagaticeras neglectum (Simpson) (35; CA 3348-64), Oxynoticeras simpsoni (Simpson) (2; CA 3711-12).

473 Stage of Oxynoticeras simpsoni

464.1 Shale, with scattered calcareous mudstone 'cheese' doggers .............................................................. 0.10

464.2 Harder calcified shale .................................................................................................................. 0.06

464.3 Shale, with indurated patches and scattered 'cheese' doggers of lenticular limestone up to 0.2 m thick and up to 2.5 m diameter .............................................................. 0.39

464.33 Shale .................................................................................................................................................. 0.13

464.32 Band of irregularly-shaped limestone nodules in a shale matrix ......................................................... 0.35

464.31 Shale .................................................................................................................................................. 0.10

465 Eparietites impendens (Young & Bird) (2; CA 3260-61).

466 Shale .................................................................................................................................................. 0.08

467 Oxynoticeras cf. simpsoni (Simpson) (2; CA 3656-57).

468 Hard and micaceous calcified shale .................................................................................................. 0.12

469 Eparietites impendens (Young & Bird) (13; CA 3248-59), Cymbites laevigatus (J. de C. Sowerby) (1; CA 3776), Angulaticeras sp. indet. (1; CA 2799).

470 Calcareous mudstone nodules; many Cardinia ................................................................................. 0.05

471 Oxynoticeras simpsoni (Simpson) (2; CA 3650-51), Eparietites impendens (Young & Bird) (3; CA 3245-47).

Zone of Asteroceras obtusum

Subzone of Eparietites denotatus

472 Shale, with occasional sideritic mudstone 'cheese' doggers: 0.91 m thick between Peter White Cliff and Miller's Nab .......... 0.97

473 Eparietites impendens (Young & Bird) (16; CA 3229-44; Pl. 4, fig. 1), Cymbites laevigatus (J. de C. Sowerby) (7; CA 3769-75), Angulaticeras sp. indet. (2; CA 2797-98). 'Tinkler's Stone' is a boulder of very hard grey-brown massive limestone, not derived from the Lower Lias, resting on bed 462 about 150 m north of the mouth of Stoupe Beck; it measures 1.8 m x 1.3 m x 0.85 m high and weighs about 6000 kg.

469 Partly calcified shale ................................................................................................................. 0.08

470 Eparietites impendens (Young & Bird) (3; CA 3262-28; Pl. 1, fig. 6), Angulaticeras sp. indet. (1; CA 2796).

471 Shale .................................................................................................................................................. 0.29

469 Partly calcified shale, with occasional calcareous mudstone nodules in the lower part ......................................................... 0.10

472 Eparietites impendens (Young & Bird) (2; CA 3222-23).

458.3 Shale .................................................................................................................................................. 0.18

458.2 Partly calcified shale ................................................................................................................. 0.23

458.1 Shale; with occasional calcareous mudstone nodules ............................................................................. 0.20

473 Aegasteroceras crassum Spath (2; CA 3051-52), Aegasteroceras sp. indet. (2; CA 3177-78), Eparietites impendens (Young & Bird) (1; CA 3221), Cymbites sp. indet. (1; CA 3781).

457 Calcareous mudstone nodules ..................................................................................................... 0.08

457.1 Aegasteroceras crassum Spath (4; CA 3047-50; Pl. 2, fig. 4), Aegasteroceras sp. indet. (1; CA 3176).

456 Shale, with scattered small calcareous mudstone nodules in the lower half ......................................................... 0.66

456.1 Aegasteroceras crassum Spath (1; CA 3046), Aegasteroceras sagittarium (Blake) (60; CA 3108-67; Pl. 1, fig. 7), Cymbites sp. indet. (2; CA 3779-80).
Hard calcified shale, with two softer partings; bed 455 caps High Scar north of Stoupe Beck, and it also forms the highest scar in front of Miller’s Nab, west of Wine Haven; the dip slope of beds 455.1 and 455.2 is pierced by several small excavated pools known as Strickland’s Dumps (after Sir Charles Strickland). 285 m north of the mouth of Stoupe Beck.

455.5 Hard calcified shale, with occasional small calcareous mudstone nodules near the top ................................................................. 0.15

Aegasteroceras crassum Spath (1; C.49345), Aegasteroceras sagittarium (Blake) (1; C.49305), Eparietites bairstowi sp. nov. (2; C.49318-19; PI. 2, fig. 8).

455.4 Shale .................................................................................................................................................................................. 0.23

Asteroceras cf. blakei Spath (2; C.49308-09), Cymbites laevigatus (J. de C. Sowerby) (2; C.49367-68).

455.3 Partially calcified shale ......................................................................................................................................................... 0.10

Asteroceras blakei Spath (4; C.49304-07).

455.2 Shale .................................................................................................................................................................................. 0.13

Asteroceras blakei Spath (1; C.49303), ?Cymbites sp. indet. (1; C.49378), Eparietites bairstowi sp. nov. (1; C.493217; PI. 3).

Subzone of Asteroceras stellare

455.1 Partially calcified shale .......................................................................................................................................................... 0.10

Aegasteroceras sagittarium (Blake) (4; C.49310-06), Asteroceras cf. blakei Spath (1; C.49302).

454.2 Shale with occasional calcareous mudstone nodules ........................................................................................................... 1.04

Aegasteroceras sagittarium (Blake) (49; C.49354-51), Cymbites laevigatus (J. de C. Sowerby) (1; C.49376).

454.1 Shale with many small calcareous mudstone nodules; more calcified in lower part ............................................................... 0.10

Promicroceras planicosta (J. Sowerby) (31; C.49425-31, C.49353-75), Asteroceras blakei Spath (4; C.49399-3001),

Aegasteroceras sagittarium (Blake) (1; C.49335), Cymbites laevigatus (J. de C. Sowerby) (1; C.49375).

453.3 Partially calcified shale .......................................................................................................................................................... 0.25

Promicroceras planicosta (J. Sowerby) (10; C.49418-21, C.49423-24, C.49350-51), Xipheroceras sp. indet. (1; C.49422).

453.2 Shale .................................................................................................................................................................................. 0.13

?Cymbites sp. indet. (1; C.49377), Promicroceras planicosta (J. Sowerby) (18; C.49406-14, C.49417, C.49344-49),

Xipheroceras sp. indet. (1; C.49405), Asteroceras blakei Spath (3; C.49396-98).

453.1 Partially calcified shale, with many calcareous mudstone nodules ....................................................................................... 0.08

Promicroceras planicosta (J. Sowerby) (12; C.49402-03, C.49415-46, C.49396-43), Xipheroceras ziphus (Zieten)

(1; C.49404), Asteroceras sp. indet. (4; C.49340-43), Asteroceras blakei Spath (2; C.49394-95).

452 Shale .................................................................................................................................................................................. 0.43

Xipheroceras ziphus (Zieten) (2; C.49400-01), Promicroceras planicosta (J. Sowerby) (27; C.49383-99), Asteroceras

blakei Spath (12; C.49282-93; PI. 2, fig. 2).

451 Calified shale, with occasional small calcareous mudstone nodules ....................................................................................... 0.10

Promicroceras planicosta (J. Sowerby) (158; C.49369-82, C.49318-35; PI. 5, fig. 3), Xipheroceras ziphus (Zieten)

(2; C.49378-85; PI. 5, fig. 5), Xipheroceras sp. indet. (1; C.49368), Cymbites laevigatus (J. de C. Sowerby)

(1; C.49376), Asteroceras stellare (J. Sowerby) (7; C.49328-34), Asteroceras sp. indet. (2; C.49338-30).

450.3 Partially calcified shale; the top 0.3 m of this bed is the lowest horizon present in the cliff; it occurs in the base of Peter

White Cliff, and all lower beds outcrop on the wave-cut platform of the foreshore only ......................................................... 0.91

450.2 Shale, with many calcareous mudstone nodules and a few ‘cheese’ doggers ............................................................................ 0.10

Asteroceras stellare (J. Sowerby) (1; C.49327).

450.1 Shale, with some partly calcified lenticles and a few red-weathering ‘cheese’ doggers ................................................................. 0.82

Asteroceras stellare (J. Sowerby) (2; C.49325-26), Promicroceras planicosta (J. Sowerby) (1; C.49317), both species

0.3 m above the base.

449 Hard calcified silty shale, with well-marked jointing in two directions; forms the capping to Middle Scar between Stoupe

Beck and Mill Beck; 0.19 m thick near Miller’s Nab ................................................................. 0.15

Asteroceras stellare (J. Sowerby) (7; C.49318-24), Aegasteroceras crassum Spath (1; C.49344).

448.5 Shale; 0.73 m on Miller’s Nab scars .......................................................................................................................................... 0.56

Promicroceras planicosta (J. Sowerby) (2; C.49315-16), Asteroceras sp. indet. (1; C.49337).

448.4 Harder, partially calcified silty shale ........................................................................................................................................... 0.10

Asteroceras sp. indet. (1; C.49336).

448.3 Shale; 0.41 m on Miller’s Nab scars .......................................................................................................................................... 0.33

Asteroceras stellare (J. Sowerby) (1; C.49317).

448.2 Grey calcareous mudstone nodules .......................................................................................................................................... 0.09

448.1 Shale .................................................................................................................................................................................. 1.52

Promicroceras planicosta (J. Sowerby) (3; C.49312-14), Epophioceras landrioti (d’Orbigny) (2; C.49377-78),

Cymbites laevigatus (J. de C. Sowerby) (1; C.49376; PI. 5, fig. 6).

447 Hard indurated, well-jointed, silty, calcified shale; a very conspicuous bed, forming the capping to Low Scar between

Mill Beck and Stoupe Beck, and the capping to the most prominent scar between Stoupe Beck and Miller’s Nab .......... 0.56

Asteroceras stellare (J. Sowerby) (1; C.49316).
CALCAREOUS SHALE MEMBER

Subzone of Asteroceras obtusum

446.5 Shale, with occasional cone-in-cone enveloped grey calcareous mudstone nodules, especially in a band from 0.10 m to 0.25 m below the top ................................................................. 0.56

Epophioceras lauritoti (d'Orbigny) (1; CA 3276), Xipheroceras ziphus (Zieten) (1; C.49360), Cymbites laevisagatas
(J. de C. Sowerby) (1; CA 3762), Promicroceras planicosta (J. Sowerby) (20; C.49343-59, C.49366-67).

446.4 Harder, partially calcified shale .......................................................... 0.15

Epophioceras sp. indet. (1; CA 3279), Xipheroceras cf. ziphus (Zieten) (1; C.49337), Promicroceras planicosta
(J. Sowerby) (1; C.49338).

446.3 Shale, with widely scattered calcareous nodules .................................. 0.25

Promicroceras planicosta (J. Sowerby) (7; C.49362-65, CA 3909-11), Asteroceras confusum Spath (3; CA 3012-14),
Xipheroceras dubressieri (d'Orbigny) (1; C.49356; Pl. 5, fig. 2), Xipheroceras sp. indet. (2; C.49361, CA 3787).

446.32 Large scattered calcareous nodules in a shale matrix .......................... 0.15

Promicroceras capricornoides (Quenstedt) (10; C.49327-34).

446.31 Shale, finely laminated, with occasional strings and masses of pyrites ............................................................... 0.60

Promicroceras capricornoides (Quenstedt) (7; C.49339, CA 3902-07), Asteroceras sp. indet. (1; CA 3035).

Zone of Caenisites turneri

Subzone of Microderoceras birchi

446.2 Cone-in-cone enveloped calcareous mudstone nodules ........................ 0.15

446.1 Shale ........................................................................................................ 0.30

Promicroceras capricornoides (Quenstedt) (1; C.49335).

445 Hard calcified shale .................................................................................. 0.13

444 Calcareous mudstone nodules ................................................................. 0.06

443.3 Shale, with a few calcareous mudstone nodules .................................... 1.37

Promicroceras capricornoides (Quenstedt) (10; C.49327-34).

443.2 Hard calcified shale .............................................................................. 0.25

Promicroceras capricornoides (Quenstedt) (1; CA 3901).

443.1 Grey calcareous mudstone nodules .................................................... 0.05

442.2 Hard partially calcified shale ............................................................... 0.48

442.1 Grey crystalline shelly limestone, weathering yellow-brown; lenticular or nodular in some places .......................... 0.08

441.3 Shale with occasional small calcareous mudstone nodules, especially at the middle of the bed ...................... 0.30

441.2 Harder calcified shale and shaly limestone ........................................... 0.15

Microderoceras scoresbyi (Simpson) (1; C.49327).

441.1 Shale, with occasional calcareous mudstone nodules ......................... 0.41

440 Grey shaly limestone, weathering yellow-brown ................................ 0.13

39 Grey calcareous mudstone nodules ......................................................... 0.05

38 Shale ........................................................................................................... 0.15

38 Shale, with occasional small calcareous mudstone nodules, especially at the middle of the bed ...................... 0.30

Promicroceras capricornoides (Quenstedt) (3; C.49323-25).

436 Shale ........................................................................................................... 0.61

Promicroceras capricornoides (Quenstedt) (13; C.49315-22, CA 3896-3900), Arnioeras sp. indet. (1; CA 2938).

435 Hard calcified shale and shaly limestone ................................................ 0.15

Caenisites cf. turneri (J. de C. Sowerby) (2; CA 3211-12), ?Caenisites sp. indet. (4; CA 3213-16), ?Arnioeras sp. indet.
(2; CA 2937).

434 Grey calcareous mudstone nodules ......................................................... 0.06

33 Shale, with imperistent calcified patches and thin shaly limestones ........... 0.91

Microderoceras birchi (J. Sowerby) (5; C.49314, CA 3976-79; Pl. 5, fig. 7), Caenisites turneri (J. de C. Sowerby)
(24; CA 3187-3210; Pl. 2, figs 3, 5), Caenisites brooki (J. Sowerby) (4; CA 3183-86).

Subzone of Caenisites brooki

433.2 Harder calcified shale, with limestone lenses ....................................... 0.11

433.1 Shale, with occasional small calcareous mudstone nodules and cone-in-cone structures .............................. 0.15

432 Grey shaly limestone, weathering yellow-brown, nodular in the lower half, and shelly in places .......................... 0.10

31 Shale, with some thin lenses and patches of shelly limestone, especially in the upper part ........................................ 0.86

Caenisites brooki (J. Sowerby) (2; CA 3181-82), Arnioeras sp. indet. (1; lost).

431.2 Hard, grey, shelly limestone, nodular in the lower half; some masses of pyrites ........................................ 0.08

Caenisites cf. brooki (J. Sowerby) (5; CA 3179-80, 3 lost).
429.64 Grey calcareous mudstone nodules ................................................................. 0.05
Arnioceras semicostatum (Young & Bird) (1; CA 2913), Coroniceras (Arietites) alcinoe (Reynès) (2; CA 2803-04; Pl. 1, fig. 8).

429.63 Shale, with thin lenses of shaly limestone, especially at the top of the lower third ................................................................. 0.61
Arnioceras semicostatum (Young & Bird) (4; CA 2909-12).

429.61 Shale, with small sideritic mudstone nodules, and occasional much larger ‘cheese’ doggers up to 2 m diameter .................. 0.61
Arnioceras semicostatum (Young & Bird) (2; CA 2907-08).

429.5 Grey limestone, shaly in places, weathering yellow-brown, with small nodules on its upper surface .................................. 0.08
Arnioceras semicostatum (Young & Bird) (1; lost).

429.4 Shale, containing many small grey calcareous mudstone nodules ................................................................. 0.08
Arnioceras semicostatum (Young & Bird) (1; CA 2934).

429.3 Shale, with very occasional calcareous mudstone nodules ................................................................. 0.36
Arnioceras obliquecostatum (Zieten) (1; lost). Arnioceras sp. indet. (2; CA 2935-36).

429.2 Thin continuous or nodular grey limestone, shaly in places ................................................................. 0.03
Arnioceras semicostatum (Young & Bird) (2; CA 2907-08).

429.1 Shale ................................................................. 0.18
Arnioceras oblidgecostatum (Zieten) (1; lost). Arnioceras sp. indet. (2; CA 2935-36).

428 Shale, with lenses or a continuous band of grey shaly limestone in the top third, and calcareous mudstone nodules in the lower third ................................................................. 0.15
Arnioceras semicostatum (Young & Bird) (5; CA 2902-06).

427.8 Grey calcareous mudstone nodules ................................................................. 0.05
Arnioceras semicostatum (Young & Bird) (1; CA 2913), Coroniceras (Arietites) alcinoe (Reynès) (2; CA 2803-04; Pl. 1, fig. 8).

427.7 Shale, with thin lenses of shaly limestone, especially at the top of the lower third ................................................................. 0.61
Arnioceras semicostatum (Young & Bird) (4; CA 2909-12).

427.6 Irregular band of hard grey shaly limestone, weathering brown ................................................................. 0.15
Arnioceras semicostatum (Young & Bird) (4; CA 2895-97). Coroniceras (Arietites) sp. indet. (1; CA 2805).

427.5 Shale, with some lenses of shaly limestone, and a few large ‘cheese’ doggers of sideritic mudstone ................................................................. 0.71
Arnioceras sp. indet. (1; CA 2934).

427.4 Shale, very occasional large calcareous mudstone ‘cheese’ doggers ................................................................. 0.15
Arnioceras semicostatum (Young & Bird) (16; CA 2857-72). Arnioceras miserabile (Quenstedt) (2; CA 2919-20).

427.3 Shale ................................................................. 0.11
Arnioceras sp. indet. (1; CA 2934).

427.2 Shale, with a few indurated patches ................................................................. 0.15
Arnioceras sp. indet. (1; CA 2934).

427.1 Hard grey shaly limestone, weathering brown, with a rough top surface; forms a conspicuous scar landward of Pseudo Low Balk (bed 424.2); many Gryphaea ................................................................. 0.05
Coroniceras (Arietites) alcinoe (Reynès) (1; CA 2802). Arnioceras semicostatum (Young & Bird) (10; CA 2885-94).

427.0 Hard calcified shale, weathering brown ................................................................. 0.15
Arnioceras semicostatum (Young & Bird) (3; CA 2882-84). Euagassiceras sp. indet. (1; CA 2973).

426.7 Shale, with a few indurated patches ................................................................. 0.15
Arnioceras sp. indet. (1; CA 2930).

426.6 Grey calcified shale, weathering brown ................................................................. 0.11
Arnioceras semicostatum (Young & Bird) (9; CA 2873-81).

426.5 Shale; very occasional large calcareous mudstone ‘cheese’ doggers ................................................................. 0.15
Arnioceras semicostatum (Young & Bird) (16; CA 2857-72). Arnioceras miserabile (Quenstedt) (2; CA 2919-20).

426.4 Grey calcified shale, weathering brown ................................................................. 0.11
Arnioceras sp. indet. (1; CA 2932).

426.3 Shale ................................................................. 0.15
Arnioceras sp. indet. (1; CA 2931).

426.2 Grey calcified shale, weathering brown ................................................................. 0.11
Arnioceras sp. indet. (1; CA 2930).

426.1 Shale, with a few indurated patches ................................................................. 0.52
Euagassiceras sp. indet. (2; CA 2971-72). Arnioceras sp. indet. (11; CA 2921-29).

426.0 Calcified shale, harder in the upper half; occasional small calcareous mudstone nodules ................................................................. 0.61
Euagassiceras sp. indet. (3; CA 2968-70). Arnioceras semicostatum (Young & Bird) (18; CA 2839-56). Arnioceras miserabile (Quenstedt) (3; CA 2916-18). Coroniceras (Arietites) alcinoe (Reynès) (1; CA 41310).

425.9 Shale, partially calcified in the top half; this middle division of bed 424 forms the scar ‘Pseudo Low Balk’ which emerges immediately landward of Low Balk (bed 422.2) ................................................................. 0.30
Arnioceras semicostatum (Young & Bird) (10; CA 2829-38; Pl. 1, fig. 2). Arnioceras miserabile (Quenstedt) (2; CA 2914-15).

425.8 Shale, partially calcified near the top ................................................................. 0.61

425.7 Shale, no subdivisions observed ................................................................. 1.58

425.2 Hard blue-grey flaggy limestone, weathering brown, with a rough top surface; slightly micaceous; forms the capping of
The Lower Lias of Robin Hood's Bay is 163.74 m thick and belongs to the Redcar Mudstone and the lower part of the Staithes Sandstone Formations. These names were introduced as formations by Powell (1984: 53) and Howard (1985: 262), and details of their definitions were given by Cox et al. (1998: 35, 39). Fig. 18 is a complete vertical section of the succession of the Lower Lias in Robin Hood's Bay, showing the changes in lithology, the lithological divisions and the main features of significance formed by the harder beds, some of which have received formal names; bed thicknesses are drawn to scale on this figure, giving a visual indication of the relative thicknesses of the subzones and lithostratigraphical divisions.

Staithes Sandstone Formation (beds 591–601.2 and higher)

Consists of sandstones, that are mid to pale grey, fine to medium-grained, micaceous, with grey siltstone bands and some beds of silty shales; nodules of argillaceous limestone occur in the shales and are occasionally sideritic; there is much bioturbation, cross-bedding and ripple marked bedding, especially in the sandstones.

The type area is in Robin Hood's Bay. The formation is somewhat transitional from the underlying Redcar Mudstone Formation, as a convenient marker bed that defines the lower boundary just south of Castle Chamber is bed 591, the Oyster Bed, which is a hard, calcified, silty shale or argillaceous sandstone, containing many oysters and other fossils. Above this level the amounts of silt and sand are higher than lower in the sequence and hard and soft sandstones are frequent. The formation has no subdivisions and extends up into the lower half of the Upper Pliensbachian. The Lower Pliensbachian (i.e. Capricornus and Figulinum Subzones) part of the formation is 12.74 m thick.

Redcar Mudstone Formation (beds 418–590; 151 m thick)

Consists of mudstones and shales, grey, soft and well-bedded, but some beds are indurated due to calcification, and there are some harder siltstones; thin beds of shelly limestone occur in the lower part, and nodules of calcareous or sideritic mudstone occur, especially in the upper part; pyritized nodules or irregular aggregations of iron pyrites occur at some horizons.

Although the name is derived from the Lower Lias exposures at Redcar to the north-west, and the lower boundary is defined in the BGS Felixkirk borehole (Cox et al. 1998: 35), the type section consists of the whole sequence exposed in Robin Hood’s Bay below the base of the Staithes Sandstone Formation. Here the lithology is more argillaceous than in the Staithes Sandstone Formation, though different parts are variously more calcareous, siliceous, pyritous or ferruginous, and they form the basis of the following four members:

4. Ironstone Shale Member.
3. Pyritous Shale Member.
2. Siliceous Shale Member.
1. Calcareous Shale Member.

These members were introduced as ‘Shales’ by Buckman (1915: 61) for lithological divisions in Robin Hood’s Bay below the ‘Sandy Series’ (= Staithes Sandstone Formation), and he based them on groups of the ammonite zones that he applied to the succession. His zones can be linked to beds in his detailed sections, but they are not the same as the ammonite zones recognized now, and in any case it is not satisfactory to base lithological divisions on the ranges of palaeontological zones. No formal definitions have been given to these divisions, though Hesselbo & Jenkyns (1995: 114–135) applied them informally to the succession, and placed boundaries between them at appropriate levels in the succession, all of which are followed here. The four members are defined formally here, and their type sections are in Robin Hood’s Bay.

Ironstone Shale Member (beds 527–590; 62.73 m thick). Mudstones and shales, grey, soft, with some beds of micaceous silty shales, many grey sideritic mudstone nodules, weathering red on the outside, and a few calcareous mudstone nodules. The nodules are scattered sparsely through the shale, but are more often developed at single horizons, either scattered or as near-continuous beds. The distinctive beds of red-weathering nodules have frequently been referred to as ‘ironstones’, but they are better described as sideritic mudstones.

The base is defined at the bottom of bed 527 in Robin Hood’s Bay, which is a prominent continuous bed of sideritic mudstone weathering red-brown. Although sideritic mudstone nodules occur at several
Fig. 18 Vertical section of the Lower Lias of Robin Hood's Bay, showing the main lithological features, relative thickness of all the beds, and named beds and other beds that form prominent features on the foreshore.
lower horizons down as far as bed 500 and those of bed 525 are especially conspicuous, pyrites is very common at most horizons up to bed 526.7 but does not occur higher. So the strong sideritic mudstone of bed 527 is a good base for this member. Such sideritic mudstone nodules and occasional continuous beds are a feature of the whole thickness of the member up to the base of the Staithes Sandstone Formation. Several of them form prominent features on the scars, eg. beds 527, 531, 543, 545, 559 and 560.2 (a distinctive pair of nodule beds), 569, 578.4 and 589.

**Pyritous Shale Member** (beds 497–526; 26.18 m thick). Consists of dark grey, soft and micaceous shales, with many calcareous and/ or sideritic mudstone nodules; there are many nodules or irregular masses of iron pyrites, especially in the lower part. This member is similar to the Ironstone Shale Member in containing both calcareous and sideritic mudstone nodules, but it also contains much iron pyrites as irregular nodules or masses of crystals.

The base is defined here as the bottom of bed 497 in Robin Hood’s Bay. This is the horizon at which the sand and silt content almost disappears and calcification is much diminished, leaving the beds above as softer shales. Iron pyrites is common at many horizons, appearing variously as irregular masses or strings of pyrites, or pyrite-rich concretions, and many of the fossils are partly pyritized in these beds. The softness of the shale leads to this part of the succession forming the wettest and lowest part of the bay relative to sea level.

**Siliceous Shale Member** (beds 447–496; 38.74 m thick). Dark-grey shales, interbedded with much harder and lighter-coloured beds of calcified mudstones, silts and fine sandstones; a few nodules and doggers of calcareous or sideritic mudstone occur. This member forms the series of hard calcified beds alternating with soft shales that is typical of the lower part of the succession in Robin Hood’s Bay. Red-weathering sideritic nodules are now scarce, and most of the harder beds are calcareous cemented muds and silts, in which the arenaceous content is higher than in the underlying Calcareous Shale Member. Large, circular ‘cheese’ doggers of hard argillaceous limestone, containing vertically orientated cystals of calcite, occur at several horizons in both this member and the Calcareous Shale Member below. Such doggers are generally up to only about 10 cm thick, but they can reach 2.5 m in diameter; they occur at 7 levels between beds 450 and 471.

The base is defined here at the bottom of bed 447 (Low Scar) in Robin Hood’s Bay. This is the first prominent bed of very hard calcified slate or argillaceous limestone that has a significant sand content. Sand and silt occur in many of the hard calcified shales or sandstones at horizons up to the base of the Pyritous Shale Member. Most of the prominent ‘scars’ in the bay are formed of beds in this member – ie. Low Scar, Middle Scar (Gryphaea Scar), High Scar (Lower Triplet), Double Band (Cowling Scar and Billet Scar), Upper Triplet, East Scar and Landing Scar.

**Calcareous Shale Member** (beds 418–446; 23.35 m thick). Dark-grey shales, interbedded with hard, calcified, silty mudstones; doggers of calcareous mudstone and some beds of limestone also occur; cone-in-cone enveloped calcareous mudstone nodules also occur at several horizons. This member is less arenaceous than the Siliceous Shale Member, the hard beds now having no sand and less silt, and the hardness being due mainly to calcification. The very prominent Low Balk and the less prominent Pseudo Low Balk are formed by limestones or highly calcified shales. Large ‘cheese’ doggers, similar to those in the Siliceous Shale Member, are found at three levels in beds 425–429.

In Robin Hood’s Bay the base has to be placed at the lowest horizon exposed, ie. at the base of bed 418. If it is thought that the base should coincide with the base of the Redcar Mudstone Formation, then it must be defined at the same level (ie. 288.87 m depth) in the BGS Felixkirk Borehole (Cox et al. 1998: 35).

## Exposures in Robin Hood’s Bay Now

The extent of the foreshore exposures of the solid geology on the north Yorkshire coast has always depended on the vagaries of shifting sand and boulder cover, algal growth, barnacle growth, and major cliff falls, all caused or cleared away by the actions of tides and storms. But in the last 25 years much more extensive, and possibly more permanent, sand, boulder, algal and barnacle cover, and mussel beds have made major inroads into the amount of rock exposed in some areas. Especially serious on some of the scars are mussel beds that trap mud and silt to form a thick, impenetrable cover that completely obscures the rock underneath. At the end of the 1990s the foreshore exposures were largely obscured from Way Foot at the bottom of Robin Hood’s Bay Town northwards to just south of Dungeon Hole. In fact there are few or no exposures of beds 497–525 owing to the sand and seaweed cover, which has possibly been exacerbated by the high concrete seawall built to protect Robin Hood’s Bay in 1975. That seawall covers the cliff face of the same beds, so that they are not now exposed in either the cliff face or on the foreshore. Exposures improve upwards from bed 526, especially north of the Dungeon Hole fault, though there is still much algal growth and large areas are covered by loose boulders. Around the north side of the bay in the top half of Map 1 (Fig. 5) the foreshore continues to be washed clean by tides and storms and exposures are still good. Exposures seaward and south of Boggle Hole (Map 3; Fig. 8) are also better, and they are good in front of Peter White Cliff (Map 4; Fig. 11). The lowest beds on the latter map, especially from bed 430 down to below Low Balk have always suffered from algal cover, of which Laminaria is a significant factor at those low sea-levels, but barnacle growth is also very pronounced and makes observations difficult on some beds.

For most of the past two centuries the foreshore of Robin Hood’s Bay has been largely clear of such cover, and collectors from Young & Bird in the 1820s, Phillips, Simpson, Tate & Blake, the Geological Survey in 1880–1910, up to Bairstow in the period from 1928 to the 1950s (see Fig. 7) were able to make significant fossil collections from all the beds. In particular, most of them obtained large specimens of *Apoderoceras* from the Taylori Subzone of beds 501 to 526. No such specimens can be collected today. The foreshore was largely clean in 1969 when Bairstow conducted a field party from the William Smith Jurassic Symposium to the Bay, but deterioration proceeded rapidly from the early 1970s. Bairstow’s work could not be repeated today, at least for the beds on Map 2 (Fig. 6) from Robin Hood’s Bay town northwards to the top of that map.

## Correlation with Previous Descriptions

The Lower Lias of Robin Hood’s Bay was mentioned by Young & Bird (1822, 1828) and Phillips (1829, 1875), and a few ammonites from the bay were figured by them, but their descriptions were not in sufficient detail to be correlated with the work in this paper. Prior to Bairstow’s work, detailed descriptions were published by Simpson (1868, 1884), Tate & Blake (1876) and Buckman (1915), all of whom numbered their beds from the top downwards. After Bairstow prepared his maps and stratigraphical descriptions, detailed accounts
of the geology of parts of the bay were published by Howarth (1935), Phelps (1985) and Hesselbo & Jenkyns (1995). The tables of Figs 19 and 20 give bed-by-bed correlation columns for all these schemes in as much detail as is possible; the columns of subzones in both figures are the subzones as determined in this paper.

Simpson first described the beds in 1868 (Simpson, 1868: 53–56), but in his later work (Simpson, 1884: xvii–xxii) there are more details at some horizons, and the Simpson columns in the tables are based on his later work. Tate & Blake (1876: 63–65, 73–75, 79–81, 91, 92, 109, 110) described the beds in greater detail, and in many parts of the succession their beds correspond closely with those in the present paper, though they omitted about 3 m of strata within their group Jam30–Jamm. 32. Tate & Blake (1876: 79, 91–2) also duplicated part of the succession in their descriptions, inasmuch as their Jamesoni beds 1–7 are the same as their Capricornus beds 28–33 (these are shown in Fig. 19 as Jam1–Jam 7 only).

The Geological Survey’s description of the succession first appeared in the memoir of Fox-Strangways & Barrow (1882: 4–10), where the beds were described in detail but not numbered, and the ammonites that they listed for individual beds are not accurately determinable in modern terms. The same description was used by Buckman (1915: 67–74) in his appendix to the 2nd edition of that memoir: the same basic data was used for the succession, but the beds were sometimes combined into thicker units and were now given numbers; lithological names were given to a few of the beds, and Buckman’s determinations of the ammonites and zonal divisions were added. Buckman’s 1915 description of the sequence is used for Figs 19 and 20, rather than the original 1882 description.

Howarth (1955: 155) described beds upwards from the bottom of the Upper Pliensbachian; the equivalence of his beds 1–6 are shown at the top of Fig. 19, with bed 1 being the same as beds 600.5 and 600.6, while the equivalence of a few lower beds that were given roman numbering in the upper part of the Figulinum Subzone is indicated in the detailed stratigraphical section above (p. 98).

Phelps (1985: fig. 4) described the succession in the Doveci upper part of the Ibex Zones in detail. When the vertical tabular section of his fig. 4 is compared at the same scale with the tabular section of Fig. 18 here, good correlations can be made from his top bed near the top of the Figulinum Subzone down to his bed 4b (= bed 567) in the Massignon Subzone, and at the bottom it seems fairly certain that his bed 1 is the same as bed 561. Phelps (1985: pl. 1, figs 1,3, pl. 2, figs 1, 6, 8) figured five ammonites from his beds 21, 23, 37, 47 and 63, the identifications of which are discussed below (pp. 141–144) in the description of the ammonite genus Aegoceras.

Hesselbo & Jenkyns’s (1995) sequence of the Lower Lias of Robin Hood’s Bay was based on new observations made by them. Their bed numbers are original from the bottom of the sequence up to their bed 121 at the base of the Massignon Subzone, then higher up they used the bed numbers of Phelps (1985), and finally the bed numbers of Howarth (1955) upwards from the top of the Figulinum Subzone. Although their descriptions and measurements were new, above bed 121 their identification and use of Phelps’ bed numbers is difficult to interpret at some horizons, especially in the Ibex Zone, so in Fig. 19 the correlation of Phelps’ beds 1–65 is based on Phelps’ original description of that sequence, not on Hesselbo & Jenkyns’ reinterpretation of it. However, from the base of the sequence up to bed 121, Hesselbo & Jenkyn’s description can be readily correlated with that of this paper at most levels, and is shown as their beds 1–121 in the relevant columns of Figs 19 and 20. The main areas of uncertainty are at the bottom of the succession below their bed 23 (= bed 447), though it appears likely that their bed 5 has been correctly identified as bed 422 (Low Balk), in their beds 73–94 in the Taylori Subzone, that are difficult to correlate in detail, and in beds 113–121 in the Brevispina and Jamesoni Subzones. In the upper part of the sequence between beds 102 and 116, a strikingly similar pattern can be seen by comparing Hesselbo & Jenkyns’ tabular section side-by-side with that of Fig. 17: eg. bed 102 = bed 527; 104 = 531; 112 = 543; 114, lower part = 545, and it is probable that bed 116 is the same as bed 547. Bed 1 of Phelps has already been correlated with bed 561, so this leaves Hesselbo & Jenkyn’s beds 117–121 (4.5 m thick) as equivalent to Bairstow beds 548–560 (6.3 m thick), but there are some differences in thickness and they are not correlatable in detail. The position of the subzone boundaries given by both Phelps and Hesselbo & Jenkyns differ in detail from those determined for this paper, except for the upper parts of the Raricostatum and Davoei Zones.

In addition to the previous descriptions in the works listed above, Getty measured and collected ammonites from the Oxynotum and Raricostatum Zones in the bay. The stratigraphical part of his work is only available in his unpublished thesis (Getty, 1972), but many of the ammonites he collected were described in his revision of the family Echioceratidae (Getty, 1973), and they are in the collections of the Natural History Museum. His stratigraphical sequence of ammonites and biostratigraphical divisions are very similar to those of Bairstow as determined here.

BAIRSTOW’S AMMONITE COLLECTION

More than 2360 ammonites were collected by Bairstow. The majority were obtained in the years 1927–1935, but small numbers of specimens were added up to about 1970. In addition there are a few specimens that were given to him by other collectors: the majority came from Dr J. Coggin Brown, who collected well-preserved ammonites at Robin Hood’s Bay in the period 1940–1960 (on retiring to north-east England after working for the Geological Survey of India). Bairstow checked the horizons of the specimens given to him with great care, and only those that he was satisfied came from definitely identifiable beds are included amongst those listed in this paper. All Bairstow’s ammonites are preserved in collections of the Department of Palaeontology, The Natural History Museum, London, and most have been given Museum registration numbers, in addition to the collecting numbers given by Bairstow. The identifiable Liparoceratidae were registered for Spath’s (1938) catalogue of that family, and received some of the numbers in the series C.38871–C.39579; some of the Eoderoceratidae were registered in the late 1950s in the series C.49314–C.49431; the remainder of the collection was registered in 2000 with the numbers CA 2744–CA 4608. The three nautiloids in his collection have the numbers CN 86, 87 and 93.

In 1928 Bairstow consulted with S.S. Buckman, a year or two before his death, who had expressed interest in the ammonites he was collecting in the bay. From his earlier work on ammonites collected by the Geological Survey, Buckman knew that the succession up to the top of the Sinemurian was exposed in both the north-western and south-eastern parts of the bay. The sequences of ammonites that Bairstow was obtaining in the two outcrops that are up to 3 km apart seemed to Buckman to be a good opportunity to test his hemeral theory1, and he advised Bairstow to record the geographical position.

1 Briefly, Buckman’s theory of hemera was that every species of ammonite reached its acme of abundance at a unique time that did not overlap with the acme of any other species. By discovering the order in which ammonites reached their acme, a sequence of ‘hemeras’ could be constructed, which would be smaller and finer divisions than ammonite subzones and would be applicable over wide areas. Contemporary palaeontologists were sceptical of the theory, and work by many palaeontologists during the following 70 years has shown that the hemeral theory is not valid.
Fig. 19 Correlation of the bed numbers used in this paper for the Lower Pliensbachian with divisions used in previous descriptions of the Lower Lias of Robin Hood’s Bay; the subzones in the right hand columns are those determined in this paper. See text for details of the sources of the previous descriptions.
as well as the stratigraphical horizon, of all his specimens. Bairstow did this by drawing 17 datum lines on his copies of the maps (i.e. they are not on the originals in King's College, Cambridge). Each was a straight line crossing the foreshore from the base of the cliff to the seaward edge of the scar; most cross the foreshore approximately at right angles to the cliff, but a few cross at an oblique angle. Originally he chiselled marks on the outcrops to record the exact position of each datum line, but all such marks have long since disappeared. Each ammonite he collected was related to the nearest point on a datum line by pacing yards (0.9 m) from the intersection of the line

![Fig. 20](image)

Correlation of the bed numbers used in this paper for the Sinemurian with divisions used in previous descriptions of the Lower Lias of Robin Hood's Bay; the subzones in the right-hand columns are those determined in this paper. See text for details of the sources of the previous descriptions.
with the bottom of the cliff, then yards at right angles to the line up to the position of the ammonite. By these means the geographical position of each ammonite was recorded to approximately the nearest square yard. This information, which is not included in this paper, occurs on many of the original specimen labels that are with the ammonites in his collection.

In 1957 Bairstow prepared a bed-by-bed list of the identifications of every ammonite in his collection. This is a large manuscript amounting to 390 pages. Not only is it a list of the specimens then in the collection (over the years a number had decayed or were lost), but its main value is as a record of the identifications made by Dr L.F. Spath. He saw the specimens as Bairstow collected them, and made identifications that date mainly from the period 1927–40, while a few were checked or reidentified by him up to 1956. In preparing the list of ammonites for this paper, all the identifications were verified, mainly in order to produce a consistent set of determinations from which the account of the biostratigraphy could be prepared, but also to revise the generic attributions of the species according to modern usage of the various genera. In general Spath’s identifications were found to be accurate, and only a few needed revision. The only previous publication of any of Spath’s identifications from which the account of the biostratigraphy could be made verified that date mainly from the period 1927—40, mainly in order to produce a consistent set of determinations from which the account of the biostratigraphy could be prepared, but also to revise the generic attributions of the species according to modern usage of the various genera. In general Spath’s identifications were found to be accurate, and only a few needed revision. The only previous publication of any of Spath’s identifications was in his catalogue of the Liparoceratidae (Spath, 1938), where all the Robin Hood’s Bay Liparoceratidae collected up to 1937 were listed by register number.

### SYSTEMATIC DESCRIPTION OF THE AMMONITES AND NAUTILOIDS

This section is not intended be a full description of the ammonites in the Sinemurian and Lower Pliensbachian of Robin Hood’s Bay, but all ammonites that have been figured before are included in a list in systematic order, and this gives an indication of their synonymies. All the Robin Hood’s Bay ammonites that have been described or figured by the following authors are included: J. Sowerby and J. de C. Sowerby (1812–1846), Young & Bird (1822, 1828), Phillips (1829, 1835, 1875), Brown (1837, 1889), Simpson (1843, 1855, 1884), Blake (1876), Wright (1878–82), Hyatt (1889), Buckman (1909–30), Spath (1923b, 1924, 1925a, 1938, 1956), Trueeman & Williams (1925), Jaworski (1931), Howarth (1955, 1962), Dean et al. (1961), Howarth & Donovan (1964), Guérin-Franiatte (1966), Getty (1973), Donovan & Forsey (1973), Schlegelmilch (1976, 1992), Phelps (1985), Dommergues (1987) and Dommergues & Meister (1992).

All the ammonites listed are from Robin Hood’s Bay, except where indicated otherwise, and the beds from which the type and figured specimens might have come are identified with varying degrees of confidence, as indicated in the list: register numbers are given, where known. The list also shows the data on which the identifications in the paper are based (eg. by giving references to the type specimens in most cases, including those that are not Yorkshire specimens). 56 of the better preserved ammonites in Bairstow’s collection are figured to illustrate the identifications and the contents of some of the subzones. Further discussion of synonymies, identifications and distribution in the zones and subzones is found in the section on Biostratigraphy, and more details of the identifications of the type specimens of some species can be found in Howarth (1962). All measurements are in millimetres (mm): D = diameter, Wh = whorl height, Wb = whorl breadth, U = diameter of the umbilicus.

**Tragophylloceras numismale** (Quenstedt, 1845) Pl. 1, fig. 1

1843 Ammonites huntoni Simpson: 41.
1845 Ammonites heterophyllus numismalis Quenstedt: 100, pl. 6, figs 4a, b, 5a, b, non figs 3a, b, 5c (figs 5a, 5b, from Germany, designated lectotype by Buckman, 1912: viii).
1855 Ammonites nanus Simpson: 38.
1921 Tragophylloceras huntoni (Simpson): Buckman: pl. 219 (paratype or holotype, WM 477; ?from bed 517 or 520).
1926 Tragophylloceras nanum (Simpson): Buckman: pl. 679 (holotype, WM 472; from bed 517 or 520).
1964 Tragophylloceras numismale (Quenstedt): Howarth & Donovan: 295, pl. 48, fig. 5 (BM C.67766; from bed 517 or 520).

**RANGE** Beds 505.2–544.5, Taylori to Polymorphus Subzones; 17 specimens.

**Tragophylloceras loscombi** (J. Sowerby, 1817)

1817 Ammonites loscombi J. Sowerby: 185, pl. 183.
1843 Ammonites ambiguous Simpson: 8.
1843 Ammonites robinsoni Simpson: 42.
1910 Rhacoceras ambiguous (Simpson): Buckman: pl. 16 (holotype, WM 89; ?from bed 569).
1914 Tragophylloceras loscombi (J. Sowerby): Spath: 336, pl. 49, fig. 1 (holotype, from Dorset).
1921 Tragophylloceras robinsoni Buckman: pl. 220 (paratype, WM 478; ?from bed 569).
1964 Tragophylloceras loscombi (J. Sowerby); Howarth & Donovan: 301, pl. 49, figs 4–7 (from Dorset).

**RANGE** Found in bed 569 only, Masseanum Subzone: 2 specimens.

**REMARKS** This single specimen high in the Masseanum Subzone is at a lower horizon than specimens in Dorset, where they have not been recorded from below the Luridum Subzone (Howarth & Donovan, 1964: 293, 302).

**Suborder LYTOCERATINA** Hyatt, 1889
Superfamily LYTOCERATACEAE Neumayr, 1875
Family LYTOCERATIDAE Neumayr, 1875
Genus **LYTOCERAS** Suess, 1865

**Lytoceras fimbriatum** (J. Sowerby, 1817) Pl. 1, fig. 3

1817 Ammonites fimbriatus J. Sowerby: 145, pl. 164.
1919 Fimbriolytoceras fimbriatum (J. Sowerby): Buckman: pl. 130A–C (from Dorset).

**RANGE** Beds 570–578.5, Ibex Zone; 25 specimens. Two *Lytoceras* of indeterminate species were found in beds 568 (top) and 584.

**REMARKS** *Lytoceras fimbriatum* is confined to the Ibex Zone in Robin Hood’s Bay, except for one poorly preserved specimen in bed 584 (Maculatum Subzone) that can only be determined as *Lytoceras* sp. indet. Many of those in the Ibex Zone are large and well-preserved, and one of the best specimens is figured in Pl. 1, fig. 3. Sowerby’s figured specimen, now lost, was from Dorset.
Blocks of limestone containing *Psiloceras*, *Caloceras* and other Hettangian and Lower Sinemurian ammonites are sometimes found loose in Robin Hood’s Bay, and species have been described by several authors as coming from ‘Robin Hood’s Bay’. They are not from the inter-tidal exposures (the lowest of which is in the upper part of the Semicostatum Zone), but are derived from Glacial Drift nodules that are widespread in the bay and were exploited by 19th century collectors.

Genus *PSILOCERAS* Hyatt, 1867

*Spiiloceras erugatum* (Phillips, 1829)

1829 *Ammonites erugatus* Phillips: 163, pl. 13, fig. 13; also Phillips, 1835: 135, pl. 13, fig. 13; and Phillips, 1875: 270, pl. 13, fig. 13.

1962 *Psiloceras erugatum* (Phillips); Howarth: 99, pl. 14, fig. 2 (holotype, BM 37982, from ‘Robin Hood’s Bay’).

*Psiloceras aff. sampsoni* (Portlock, 1843)

1879/81 *Aegoceras planorbis* (J. Sowerby); Wright: 308 (1881), pl. 14, figs 1, 2 (1879) (SM J18216, from ‘Robin Hood’s Bay’).

Genus *CALOCERAS* Hyatt, 1870

*Caloceras belcheri* (Simpson, 1843)

1843 *Ammonites belcheri* Simpson: 12.

1910 *Caloceras belcheri* (Simpson); Buckman: pl. 17 (holotype, WM 101, from Robin Hood’s Bay).

1879/81 *Aegoceras belcheri* (Simpson); Wright: 313 (1881), pl. 15, figs 7, 8 (1879) (SM J18217, from Robin Hood’s Bay).

1976 *Psiloceras* (Caloceras) *johnstoni* (J. de C. Sowerby); Schlegelmilch, 1976: 106, pl. 5, fig. 8 (WM 101).

*Caloceras convolutum* (Simpson, 1855)

1855 *Ammonites convolutus* Simpson: 43 (non *Ammonites convolutus* Schlotheim, 1820).

1910 *Caloceras convolutum* (Simpson); Buckman: pl. 18 (holotype, WM 491, from Robin Hood’s Bay).

*Caloceras wrighti* Spath, 1924

1880/81 *Aegoceras belcheri* (Simpson); Wright: 313 (1881), pl. 19, figs 1, 2 (1880) (holotype, from North Cheek, Robin Hood’s Bay, ?lost).

1924 *Caloceras wrighti* Spath: 191 (nom. nov. for Wright’s figured specimen).

Genus *SCHLOTHEIMIA* Bayle, 1878

*Schlotheimia redcarensis* (Young & Bird, 1822)

1822 *Ammonites redcarensis* Young & Bird: 248, pl. 14, fig. 13; also Young & Bird, 1828: 258, pl. 14, fig. 10.

1925 *Schlotheimia redcarensis* (Young & Bird); Buckman, pl. 608 (neotype, WM 314; if from Robin Hood’s Bay, as labelled, it must be from Glacial Drift).

Saxoceras aequale (Simpson, 1855)

1855 *Ammonites aequalis* (Simpson): 49.

1925a *Saxoceras aequale* (Simpson); Spath: 204, fig. 4 (drawing of holotype, BM 18109).

1962 *Saxoceras aequale* Howarth: 101, pl. 14, fig. 3 (holotype, BM 18109, from Robin Hood’s Bay or Redcar, more probably the latter).

Genus *ANGULATICERAS* Quenstedt, 1883

*Angulaticeras sulcatum* (Simpson, 1843)

1843 *Ammonites sulcatus* Simpson: 55 (non *Ammonites sulcata* Lamarck, 1822).

1911 *Schlotheimia sulcata* (Simpson); Buckman: pl. 38 (holotype, WM 743: ?from beds 461–464).

1976 *Angulaticeras sulcatum* (Simpson); Schlegelmilch: 112, pl. 8, fig. 7 (WM 743).

RANGE. Six small examples of *Angulaticeras* sp. indet. were found in beds 461–464.33 and 485.2, Denotatus to Oxynotum Subzones.

Genus *Macrogrammites* Buckman, 1928

*Macrogrammites antiquatum* (Simpson, 1855)

1855 *Ammonites antiquatus* Simpson: 36.

1927 *Schlotheimia antiquata* (Simpson); Buckman, 1927, pls 718A, B (holotype, WM 79/80); if this holotype is a large smooth outer whorl of the Hettangian genus *Macrogrammites* as identified by Buckman (1928: on caption to pl. 718A* (re-issue of 1927, pl. 718A)), then it comes from Glacial Drift in Robin Hood’s Bay, or from Redcar; it is not from beds exposed in Robin Hood’s Bay.

Family *ARIETITIDAE* Hyatt, 1875

Subfamily *ARIETITINAE* Hyatt, 1875

Genus *CORONICERAS* Hyatt, 1867

Subgenus *ARIETITES* Waagen, 1869

*Coroniceras* (Arietites) *alcinoe* (Reynès, 1879)

Pl. 1, fig. 8

1879 *Arietites alcinoe* Reynès: pl. 23, figs 7, 8, 9–11 (neotype, from France).

1955 *Pararonticeras alcinoe* (Reynès); Donovan: 14.

RANGE. Beds 424.3–429.64, Sauzeanum Subzone; 5 specimens.

*Coroniceras* (Arietites) *validanfractum* (Simpson, 1855)

1855 *Ammonites validanfractus* Simpson: 36.

1927 *Schlotheimia validanfracta* (Simpson); Buckman, 1927, pls 718A, B (holotype, WM 79/80); if this holotype is a large smooth outer whorl of the Hettangian genus *Macrogrammites* as identified by Buckman (1928: on caption to pl. 718A* (re-issue of 1927, pl. 718A)), then it comes from Glacial Drift in Robin Hood’s Bay, or from Redcar; it is not from beds exposed in Robin Hood’s Bay.

Family *SCHLOTHEIMIDAE* Spath, 1923

Genus *SCHLOTHEIMIA* Bayle, 1878

*Schlotheimia redcarensis* (Young & Bird, 1822)

1822 *Ammonites redcarensis* Young & Bird: 248, pl. 14, fig. 13; also Young & Bird, 1828: 258, pl. 14, fig. 10.

1925 *Schlotheimia redcarensis* (Young & Bird); Buckman, pl. 608 (neotype, WM 314; if from Robin Hood’s Bay, as labelled, it must be from Glacial Drift).
Arnioceras semicostatum (Young & Bird, 1828)

Tions contain many well-preserved and they have sometimes been considered to come from Glacial limestone nodules. Such good specimens were not found by Bairstow, the holotype is much better than Buckman’s (1918) figure. Older collections are figured in Pl. 1, fig. 2.

Coroniceras (Arietites) cf. planariae (Reynès, 1879)

1878/81 Arietites nodulosus (Young & Bird); Wright: 288 (1881), pl. 6, figs 2, 3 (1878) (C.1880, possibly from beds 426–429).

Genus ARNIOCERAS Hyatt, 1867

Arnioceras semicostatum (Young & Bird, 1828)

Pl. 1, fig. 2

1828 Ammonites semicostatus Young & Bird: 257, pl. 12, fig. 10.

1855 Ammonites vetustus Simpson: 88.

1876 Arietites semicostatus (Young & Bird); Blake: 288, pl. 5, fig. 4a (upper figure, BM C.17935; lower figure, BM C.17934 (?malformation); both from Redcar).

1876 Arietites difformis (Emmrich); Blake: 289, pl. 6, fig. 3 (C.17933, possibly from Redcar).

1889 Arietites semicostatum (Young & Bird); Hyatt: 165, pl. 2, figs 12, 13 (from “Whitby”, presumably from Robin Hood’s Bay).

1918 Arietites semicostatum Buckman: pl. 112 (holotype, WM 924).

1925a Arietites semicostatum (Young & Bird); Spath: 329, fig. 10a (BM C.86a).

1931 Arietites semicostatum (Young & Bird); Jaworski: 111, pl. 5, fig. 1 (WM 924).

1956 Arietites semicostatum (Young & Bird); Spath: 153, pl. 10, figs 6 (BM C.25651), 7 (BM C.17933).

1961 Arietites semicostatum (Young & Bird); Dean et al.: pl. 65, fig. 4 (BM C.25651).

1962 Arietites vetustum (Simpson); Howarth: 103, pl. 15, fig. 2 (holotype, GSM 26404, ?from bed 421 or 424).

1976 Arietites semicostatum (Young & Bird); Schlegelmilch: 138, pl. 21, fig. 4 (WM 924).

Range. Beds 421.4–429.64, Sauzeanum Subzone; 118 specimens.

Remarks. Jaworski’s (1931: pl. 5, fig. 1) enlarged figure of the holotype is much better than Buckman’s (1918) figure. Older collections contain many well-preserved Arietites semicostatum from limestone nodules. Such good specimens were not found by Bairstow and they have sometimes been considered to come from Glacial Drift, but judging from the preservation it is possible that they came from nodules near the top of bed 421.4 or from beds 424.2 or 424.3. Although Arnioceras persists elsewhere into the overlying Brooki and Birchia Subzones, all the well-preserved Robin Hood’s Bay specimens appear to have come from these limestone nodules of the Sauzeanum Subzone. One of the better examples in Bairstow’s collection is figured in Pl. 1, fig. 2.

The range of Arnioceras is extended down to bed 421.1 and up to beds 430–436 by six specimens of indeterminate species found by Bairstow.

Arnioceras acuticarinatum (Simpson, 1855)

1855 Ammonites acuticarinatum (Simpson); 94

1911 Amnioceras acuticarinatum (Simpson); Buckman: pl. 40 (holotype, WM 295; ?from beds 421–424).

1931 Amnioceras acuticarinatum (Simpson); Jaworski: 126, pl. 5, fig. 2 (WM 295).

1976 Amnioceras acuticarinatum (Simpson); Schlegelmilch, 1976: 138, pl. 21, fig. 3 (WM 295).

Remarks. The best figure of the holotype is that of Jaworski, and such a well-preserved specimen might have come from beds 421–424. Its more finely ribbed inner whorls possibly separate it from A. semicostatum.

Arnioceras miserabile (Quenstedt, 1856)

1856 Ammonites miserabilis Quenstedt: 71, pl. 8, fig. 7.

1876 Aegoceras nigrum Blake: 274, pl. 6, fig. 6 (lectotype, BM C.17889, possibly from bed 424.2 or 424.3).

1884 Ammonites miserabilis Quenstedt; Quenstedt: 106, pl. 13, figs 27–30.

1925a Arnioceras nigrum (Blake); Spath: 329, fig. 10b (BM 50150c, possibly from bed 424.2 or 424.3).

1966 Arnioceras miserabile (Quenstedt); Guérin-Franiatte: 254, pl. 136, figs 1 (neotype, from Germany, original of Quenstedt, 1884: pl. 21, fig. 27), 2–4 (from Germany and France).

1976 Arnioceras miserabile (Quenstedt); Schlegelmilch: 49, pl. 21, fig. 5 (neotype).

Range. Beds 424.2–425.5, Sauzeanum Subzone; 7 specimens.

Genus VERMICERAS Hyatt, 1889

Vermiceras multanfractum (Simpson, 1855)

1855 Ammonites multanfractus Simpson: 95.

1962 Vermiceras multanfractus (Simpson); Howarth: 101, pl. 14, fig. 6 (neotype, WM 281); not found by Bairstow, possibly derived from Glacial Drift in Robin Hood’s Bay.
Well-preserved Agassiceras scipionianum (d'Orbigny) and the smaller, smoother species A. personatum have been figured before from Robin Hood's Bay and are common in old collections, but none were found by Bairstow. Agassiceras mainly characterizes the Scipionianum Subzone, just below the lowest horizon exposed in Robin Hood's Bay, so, although it is possible that some of them came from beds 421 or 422, it is more likely that they were derived from Glacial Drift.

Agassiceras personatum (Simpson, 1843)

1843 Ammonites personatus Simpson: 9.
1920 Agassiceras personatum (Simpson); Buckman: pl. 187, figs 1, 2 (holotype, WM 2125), 3, 4 (paratype WM 67).

REMARKS. A small smooth species.

Agassiceras scipionianum (d'Orbigny, 1844)

1844 Ammonites scipionianus d'Orbigny: 207, pl. 51, figs 7, 8.
1855 Ammonites illatus Simpson: 39 (non Ammonites illatus Simpson, 1843: 10).
1876 Arietites scipionianus (d'Orbigny); Blake: 287, pl. 5, fig. 3 (BM C.17909; locality not recorded, but the preservation is like that of other specimens from Robin Hood's Bay).
1961 Agassiceras scipionianum (d'Orbigny); Dean et al.: pl. 65, fig. 3 (BM 37909).
?1962 Agassiceras illatum (Simpson, 1855, non 1843); Howarth: 102, pl. 15, fig. 1 (holotype, WM 84).
1994 Agassiceras scipionianum (d'Orbigny); Fischer: 53, pl. 16, figs 1 (lectotype), 2 (both from France).

Agassiceras decipiens (Spath, 1923)

1923b Aetomoceras decipiens Spath: 72.

REMARKS. Spath's three syntypes are BM C.22067a, C.22067b and a specimen at the top of the block WM 67 as figured by Buckman (1920: pl. 187, fig. 3), all from Robin Hood's Bay. Of these, C.22067a is here designated lectotype; it is similar to A. scipionianum (d'Orbigny), but has slightly more ribs.

Genus EUAGASSICERAS Spath, 1924

Euagassiceras resupinatum (Simpson, 1843)

Pl. 1, fig. 5

1843 Ammonites resupinatus Simpson: 15.
1844 Ammonites sauzeanus d'Orbigny: 304, pl. 95, figs 4, 5.
1855 Ammonites transformatum Simpson: 91.
1889 Coroniceras sauzeanum (d'Orbigny); Hyatt: 184, pl. 6, figs 4, 6–9.

Plate 2
Fig. 1 Asteroceras confusum Spath. Bed 446.32, CA 3011, × 0.6.
Fig. 2 Asteroceras blakei Spath. Bed 452, CA 2990, × 0.5.
Figs 3, 5 Caenisites turneri (J. de C. Sowerby). Bed 433.3, 3, CA 3194. 5, CA 3197; the asterisk marks the probable end of the phragmocone.
Fig. 4 Aegasteroceras crassum Spath. Bed 458.2, CA 3048; a body chamber fragment.
Fig. 6 Gagaticeras neglectum (Simpson). Bed 468, CA 3326; probably wholly septate.
Fig. 7 Gagaticeras exortum (Simpson). Bed 468, CA 3292; the asterisk marks the probable end of the phragmocone.
Fig. 8 Eparietites bairstowi sp. nov. Paratype, bed 455.5, CA 3218; probably wholly septate.

All figures natural size, except Figs 1 and 2.
Aegasteroceras sagittarium (Blake, 1876) PI. 1, fig. 7

Despite being named after Marston Magna, Somerset.

Aegoceras marstonense (Blake); Wright: 355, pi. 52A, figs 1, 2 (lectotype. BM 43969a, from Dorset).


Remarks. A. stellare is a large species, and is more involute and has more massive whorls than A. obtusum.

Aegasteroceras blakei Spath, 1925 Pl. 2, fig. 2

1876 Aegoceras sagittarium Blake: 276, pl. 7, figs 2A (lectotype. SM J18230), 2B (paralotype. BM C.17881).

Aegasteroceras sagittarium (Blake); Wright: 355, pl. 52A, figs 1–2 (BM C.1873); pl. 52A, figs 3, 4 (BM C.1873), 5 (BM C.1874), 6 (BM C.1875).

1925a Aegasteroceras marstonense Spath: 267, fig. 7 (holotype. BM 39748, probably from bed 452 or 453).


Remarks. A. blakei occurs at a higher stratigraphical level, and is more involute and more compressed than A. obtusum. A. marstonense is a synonym, and its holotype comes from Robin Hood’s Bay despite being named after Marston Magna, Somerset.

Genus AEGASTEROCERAS Spath, 1925

Aegasteroceras crassum Spath, 1925 Pl. 2, fig. 4

1882 Aegoceras sagittarium Blake: Wright: 355, pl. 52A, figs 1–2 (BM C.1922, from bed 458.2 or 458.3, holotype of Aegasteroceras crassum Spath, 1925).

1925a Aegasteroceras crassum Spath: 266.


Genus CAENISITES Buckman, 1925

Caenisites turneri (J. de C. Sowerby, 1824) Pl. 2, figs 3, 5

1824 Ammonites turneri J. de C. Sowerby: 75, pl. 452, upper figure.

1879/81 Arietites turneri (J. de C. Sowerby): Wright: 292 (1881), pl. 12, fig. 4 (1879) (lectotype. BM 43973a, from Glacial Drift, Norfolk).

1882 Aegoceras turneri (J. de C. Sowerby): Wright: 292 (1881), pl. 12, fig. 4 (1879) (lectotype. BM 43973a, from Glacial Drift, Norfolk).

1956 Euasteroceras turneri (J. de C. Sowerby); Arkell: 760, pl. 31, fig. 1 (BM 43973a).

1961 Caenisites turneri (J. de C. Sowerby); Dean et al.: pl. 66, fig. 2 (from Bredon Hill, Worcestershire).


Caenisites brooki (J. Sowerby, 1818)

1818 Ammonites brooki J. Sowerby: 203, pl. 190.

1961 Caenisites brooki (J. de C. Sowerby); Dean et al.: pl. 66, fig. 1 (BM C.5606, from Charmouth, Dorset).

1966 Caenisites brooki (J. de C. Sowerby); Guérin-Franiatte: 325, pl. 210 (holotype. OUM J.16020, from Lyme Regis, Dorset).


Remarks. One of those from bed 431.3 is notable in being extremely large: before removal from the rock, it was measured by Bairstow as 585 mm diameter. The outer part was not recovered, but the portion now preserved in the collection is 445 mm diameter and has a massive, almost smooth outer half whorl with keel and grooves on the venter. The inner whorls are covered in matrix and probably crushed.

Genus EPARIEBITES Spath, 1924

Eparietites impendens (Young & Bird, 1828) Pl. 1, fig. 6; Pl. 4, fig. 1

1828 Ammonites impendens Young & Bird: 266.

1855 Ammonites denotatus Simpson: 76.

1855 Ammonites tenellus Simpson: 97.

1876 Arietites impendens (Young & Bird): Blake: 290, pl. 6, fig. 7 (BM C.17936).

1878/81 Arietites collenoti (d’Orbigny): Wright: 304 (1881), pl. 6 (1878), fig. 1 (BM C.1881; probably from bed 464.32), pl. 7, figs 1–3 (holotype of Ammonites denotatus, SM J3273).

1912 Aaretites tenellus (Simpson): Buckman: pl. 54 (holotype, WM 293, probably from bed 461 or 464.32).


1961 Eparietites denotatus (Simpson): Dean et al.: pl. 66, fig. 4 (BM C.17936).

Range. Beds 457–464.32. Denotatus and Simpsoni Subzones: 57 specimens; all the figured specimens are from beds 461–464.

Remarks. Both denotatus and tenellus are synonyms of E. impendens; the best type specimen is the holotype of Simpson’s denotatus, but it is clearly the same as the holotype of Young & Bird’s impendens, and the holotype of tenellus differs only in having the crushed-flat type of preservation that is common at some horizons.

Eparietites bairstowi sp. nov. Pl. 2, fig. 8; Pl. 3

Holotype. CA 3217, from bed 455.2, lower part of Denotatus Subzone.

Paratypes. CA 3218 and 3219, from bed 455.5, lower part of Denotatus Subzone.

Diagnosis. An evolute species of Eparietites in which the umbili-
cal width is 38–40% of the diameter; the whorls are quickly expanding and massive, the whorl breadth is large, and the venter is tricarinate-bisulcate, but loses the sulci at the largest sizes; inner whors have radial ribs and small ventro-lateral tubercles, but all ornament fades by 230 mm diameter.

DESCRIPTION. Before removal from the rock, Bairstow measured the holotype as having a crushed outer whorl ending at 480 mm (19 inches) diameter. At that size it was probably complete, but the part he collected in 1933 is solid and uncrushed up to the end of the phragmocone at 330 mm diameter, followed by a short portion at the beginning of the crushed body-chamber ending at about 350 mm diameter. Slightly more than one whorl up to the end of the phragmocone is preserved, to which is attached a small portion of the upper part of the side of the next inner whorl. These whorls are massive, rapidly expanding, moderately evolute, and have a whorl section in which the whorl sides converge slightly towards the tricarinate-bisulcate venter, which has a strong central keel. Moderately strong radial ribs fade and disappear three-quarters of a whorl before the end of the phragmocone, and the remaining whorls are smooth.

The larger paratype (CA 3218) consists of inner whorls up to 40 mm diameter, but only a quarter of a whorl up to 25 mm is well preserved. This has quadratc, moderately evolute whorls with a tricarinate-bisulcate venter, and strong straight radial ribs up to small ventro-lateral tubercles; the ribs then bend strongly forwards on the side of the venter and join the lateral keels.

The smaller paratype (CA 3219) consists of small inner whorls up to only 12.5 mm diameter. Its whorl shape, ribs and tubercles are similar to those of the larger paratype.

MEASUREMENTS (in mm)

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<th>D</th>
<th>Wh</th>
<th>Wb</th>
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<tbody>
<tr>
<td>CA 3217</td>
<td>342</td>
<td>116 (0.34)</td>
<td>90 (0.26)</td>
<td>136 (0.40)</td>
</tr>
<tr>
<td>CA 3217</td>
<td>265</td>
<td>92 (0.35)</td>
<td>67 (0.25)</td>
<td>101 (0.38)</td>
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REMARKS. This is the oldest Eparietites and is more evolute than any of the succeeding species. The large holotype has massive whors, with a quadrate whorl section in which the whorl sides converge only slightly towards the venter, a large whorl breadth, and a tricarinate-bisulcate venter; the sulci bordering the central keel on the venter slowly disappear at the largest sizes. E. impendens occurs higher up at Robin Hood’s Bay and has much more compressed and involute whors, the umbilical width being 22–24% of the diameter compared with 38–40% in E. bairstowi.

Many Eparietites occur in the Denotatus Subzone in the top 0.5 m of the Frodingham Ironstone at Scunthorpe, Lincolnshire. Specimens attain very large sizes, some in the NHM collections being up to 600 mm diameter. Most of the smaller specimens are E. impendens, but the larger specimens belong mainly to the more evolute species Eparietites undaries (Quenstedt), in which the umbilical width is 27–34% of the diameter (Guérin-Franiatte, 1966: 319). There is also one good example of E. bairstowi in the Frodingham Ironstone: it is a quarter whorl uncruched fragment, wholly septate, with a whorl height and breadth of 103.5 and 69.3 mm respectively, and is closely similar to the Robin Hood’s Bay holotype at the same size.

Genus *EPOPHIOCERAS* Spath, 1924

*Eopphioceras landrioti* (d’Orbigny, 1849)

1849 *Ammonites landrioti* d’Orbigny: 213.
1907 *Ammonites landrioti* d’Orbigny: Thevenin: 94, pl. 7, figs 4, 5 (holotype, from the Obtusum Zone, France).

1966 *Epophioceras landrioti* (d’Orbigny); Guérin-Franiatte: 329, pl. 217 (holotype).

**RANGE.** Beds 446.5–448.11. Obtusum and Stellare Subzones: 3 specimens. A single *Epophioceras* sp. indet. was found in bed 446.4.

Family ECHIOCATIDAE Buckman, 1913

Genus *PALAEOECHIOCERAS* Spath, 1929

Palaeoechioceras sp. indet.

1973 *Palaeoechioceras* sp.: Getty: 9, pl. 1, figs 1 (BM C.79680), 5 (BM C.79678). 9 (BM C.79679); all from bed 467.

**RANGE.** Bed 467. Simpsoni Subzone: 3 specimens.

Genus *GAGATICERAS* Buckman, 1913

REMARKS. In Robin Hood’s Bay examples of *Gagaticeras* are found only in beds 467–470, the top half of the Simpsoni Subzone. Although they are divided here into *G. neglectum* with medium to coarse ribs, *G. finitimum* with finer ribs, *G. exortum* with strongly rursiradiate ribs, and *G. gagateum* with markedly depressed whors, larger collections of better specimens might suggest that there are fewer than four species present.

*Gagaticeras exortum* (Young & Bird, 1828)

1828 *Ammonites exortus* Young & Bird: 255, pl. 12, fig. 7.
1876 *Aegoceras exortum* (Young & Bird): Blake: 275, pl. 6, fig. 8 (BM C.17883, from bed 467).
1880/82 *Aegoceras exortum* (Young & Bird): Wright: 364, pl. 37, figs 8, 9 (BM C.2228, probably from bed 467).
1913 *Gagaticeras exortum* (Young & Bird); Buckman: pl. 78 (holotype, WM 104, from bed 467).
1919 *Gagaticeras funiculatum* Buckman: pl. 122 (holotype, BM C.41783).
1962 *Gagaticeras exortum* (Young & Bird); Howarth: 102, pl. 14, fig. 6 (WM 744, paratype of *Ammonites multanfractus* Simpson, 1855).
1976 *Gagaticeras gagateum* (Young & Bird); Schlegelmilch: 138, pl. 21, fig. 7 (WM 104).

**RANGE.** Occurs only in bed 467, Simpsoni Subzone: 2 specimens; has strongly depressed whors.

*Gagaticeras gagateum* (Young & Bird, 1828)

1855 *Ammonites gagateus* Young & Bird: 255, pl. 12, fig. 7.
1855 *Ammonites integricostatus* Simpson: 44.
1855 *Ammonites integricostatus* Simpson: 46.

**RANGE.** Beds 467–70, Simpsoni Subzone: 15 specimens; characterized by markedly rursiradiate ribbing.

*Gagaticeras neglectum* (Simpson, 1855)

1855 *Ammonites neglectus* Simpson: 45.
1976 *Gagaticeras neglectum* (Simpson): Schlegelmilch: 138, pl. 21, fig. 8 (WM 98).
RANGE. Beds 467-70. Simpsoni Subzone; 77 specimens; the holotype came from bed 468 or 470; has medium to coarse ribbing.

**Gagaticeras finitimum** (Blake, 1876)

1876 *Aegoceras (?) finitimum* Blake: 273, pl. 6, fig. 9.
1914 *Parechioceras finitimum* (Blake); Buckman: pl. 100A (holotype, SM J3280, possibly from bed 468).

RANGE. Beds 467 and 468. Simpsoni Subzone; 11 specimens; finely ribbed.

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**Echioceras raricostatum** (Zieten, 1831)

1831 *Ammonites raricostatus* Zieten: 18, pl. 13, fig. 4.
1855 *Ammonites cereus* Simpson, 1855: 47.
1912 *Echioceras cereum* (Simpson); Buckman: pl. 49 (holotype, WM 461).
1973 *Echioceras raricostatum* (Zieten); Getty: 13, pl. 1, fig. 7 (neotype, designated Getty, from Wurttemberg, Germany).

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**PLATE 3**

*Eparietites bairstowi* sp. nov. **Holotype**, bed 455.2, CA 3217, x 0.48.
**Remarks.** Examples of *Echioceras* with strongly depressed whorls and coarse ribs were not found by Bairstow, and the horizon of Simpson's holotype WM 461 is not known; presumably it ought to have come from the Raricostatoides Subzone.

**Echioceras raricostatoides** (Vadasz, 1908)  
*Pl. 4, fig. 2*

1908 *Arietites raricostatoides* Vadasz: 373.

1925 *Echioceras fulgidum* Trueman & Williams: 717, pl. 1, fig. 12 (BM C.17424, possibly from bed 489).

1973 *Echioceras raricostatoides* (Vadasz): Getty: 13, pl. 1, fig. 12 (neotype, designated by Getty, from Nancy, France).

**Range.** Beds 488-491.1. Raricostatoides Subzone; 15 specimens.

**Remarks.** The very well preserved specimen from bed 489 figured in *Pl. 4, fig. 2* has a closely similar rib-density to that of the neotype shown in Getty's (1973: 15, fig. 3) graph. The more densely ribbed species *E. aeneum* Trueman & Williams, *Echioceras laevidomum* (Quenstedt; Schlegelmilch, 1976: pi. 21, fig. 12, lectotype) which has modified ribbing at large whorl sizes, and *E. pauli* (Dumortier, 1867: pl. 29, figs 5, 6), all said to occur in the lowest part of the Raricostatoides Subzone by Getty (1973: 14), were not identified amongst Bairstow's material.

**Echioceras intermedium** (Trueman & Williams, 1925)

1925 *Pleurechioceras intermedium* Trueman & Williams: 720, pl. 2, fig. 2 (holotype, BM C.26787, from bed 493).


**Range.** Beds 491.2 and 493.2. Raricostatoides Subzone; 7 specimens.

**Remarks.** The very well preserved specimen from bed 489 figured in *Pl. 4, fig. 2* has a closely similar rib-density to that of the neotype shown in Getty's (1973: 15, fig. 3) graph. The more densely ribbed species *E. aeneum* Trueman & Williams, *Echioceras laevidomum* (Quenstedt; Schlegelmilch, 1976: pi. 21, fig. 12, lectotype) which has modified ribbing at large whorl sizes, and *E. pauli* (Dumortier, 1867: pl. 29, figs 5, 6), all said to occur in the lowest part of the Raricostatoides Subzone by Getty (1973: 14), were not identified amongst Bairstow’s material.

**Genus LEPTECHIOCERAS** Buckman, 1923

**Leptechioceras macdonnelli** (Portlock, 1843)

1843 *Ammonites macdonnelli* Portlock: 134, pl. 29A, fig. 12.

1880/81 *Arietites nodotatus* (d'Orbigny): Wright: 301 (1881), pl. 37, figs 3, 4 (1880) (holotype of *Ammonites macdonnelli* Portlock, from Larne, northern Ireland, Ulster Museum no. K8117).


**Range.** Beds 494-495.7. Macdonnelli Subzone; 5 specimens.

**Remarks.** The earliest examples in bed 494 are identified as *L. aff. macdonnelli* because reduced ribbing persists on their outer whorls, which do not become as smooth as in the later specimens from beds 495.13 and 495.7. Nevertheless, in those early specimens the ribs are more reduced than in *L. nodotatus* (d'Orbigny, 1843; Fischer, 1994: 48, pl. 20, fig. 4, holotype). *L. charpentieri* (Schaffhäutl, 1847; Getty, 1973: pl. 2, fig. 6, lectotype) or *L. meigeni* (Hug, 1899), all of which are more strongly ribbed throughout.

**Genus PALTECHIOCERAS** Buckman, 1924

**Paltechioceras planum** (Trueman & Williams, 1925)

1925 *Leptechioceras planum* Trueman & Williams: 731, pl. 2, fig. 5 (holotype, from Radstock, Somerset).


**Range.** Beds 493.3-493.5. Raricostatoides Subzone; 5 specimens.

**Paltechioceras tardecrescens** (Hauer, 1856)

1855 *Ammonites aureolus* Simpson: 94.

1856 *Ammonites tardecrescens* Hauer: 20, pl. 3, figs 10-12.

1876 *Arietites tardecrescens* (Hauer): Blake: 285, pl. 5, figs 5 (?BM C.17879, from bed 498), 5b (?BM C.17898).

1889 *Echioceras aplanatum* Hyatt: 146, figs 23, 24 (on p. 147).

1889 *Amniceras tardecrescens* (Hauer): Hyatt: 168, pl. 2, fig. 19.


1961 *Paltechioceras aplanatum* (Hyatt): Dean et al.: pl. 68, fig. 2 (BM C.37999, from bed 498).

1973 *Paltechioceras aplanatum* (Hyatt): Getty: 21, pl. 4, fig. 1 (BM C.17898, from bed 498).

1973 *Paltechioceras tardecrescens* (Hauer): Getty: 21, pl. 4, fig. 2 (lectotype, designated by Getty, from Adneth, Saltzburg, Austria).


**Range.** Beds 497-499. Aplanatum Subzone: 228 specimens.

**Remarks.** *P. tardecrescens* is abundant in beds 497 and 498; those in bed 498 are up to 175 mm diameter and are preserved in limestone nodules (*Pl. 4, fig. 6*), and many of the previously figured specimens undoubtedly came from this bed (including the holotype of Hyatt's species *aplanatum*). Most of the specimens in bed 497 are much smaller pyritized whorls up to about 40 mm diameter (*Pl. 4, fig. 3*), though there are a few crushed and partly pyritized fragments of larger whorls up to 90 mm diameter. The lectotype of *P. aureolum* (Simpson, 1855; Buckman, 1914: pi. 96c) is pyritized like most specimens in bed 497 and can be matched closely with several of them (eg. CA 3456 and 3480); it is only 25 mm diameter, but *Ammonites aureolus* Simpson, 1855, might be a senior synonym of *Paltechioceras aureolum* (Hauer, 1856). In addition, two specimens were found at the base of bed 499 and 0.08 m above the base of that bed respectively.

**Paltechioceras regustatum** Buckman, 1914

1911 *Echioceras aureolum* (Simpson): Buckman: pl. 28 (parallectotype of *Ammonites aureolus* Simpson, WM 872, from bed 497).

1914 *Paltechioceras regustatum* Buckman: 96c.

1973 *Paltechioceras aureolum* (Simpson): Getty: 20, pl. 5, figs 3 (holotype of *Echioceras regustatum* Buckman, GSM 26439, from bed 496 or 497), 4 (BM C.79681, from bed 497).

**Range.** Beds 496 and 497. Aplanatum Subzone: 18 specimens.

**Remarks.** *P. regustatum* is the second and less common species of *Paltechioceras* in the Aplanatum Subzone, and is represented by a few poorly preserved specimens in bed 496 and two in bed 497; it has much more widely spaced ribs than *P. tardecrescens* at diameters of more than 25 mm. Two larger examples figured by Getty (1973: pl. 5, figs 3, 4) as *P. aureolum* are 50 and 64 mm diameter respectively, and the latter...
was said to be from bed 497 (Getty, 1973: 20, ‘Tate & Blake’s Jameson’s Zone bed 60’). The former of Getty’s specimens is the holotype of *P. regustatum* (Buckman, 1914), and this seems to be the correct specific name for the less densely ribbed *Palaeochoiceras* in beds 496 and 497, because the lectotype of *P. aureolum* has the same rib density as in *P. tardecrescens*, of which it might be a senior synonym.

**Family OXYNOTICERATIDAE** Hyatt, 1867

**Genus OXYNOTICERAS** Hyatt 1867

**Remarks.** Determination of species of *Oxynoticeras* in the Simpsoni Subzone presents many problems: Simpson (1843, 1855) proposed the specific names *simpsoni, limatus, bucki, flavus and lens*, and Spath (1925) proposed the name *eboracense*, all for specimens from beds 467 or 468 (the type specimens of *allicaenum* and *dejectum*), both of Simpson, 1855, are lost and the names are not usable. The name *simpsoni* has date and page priority, and is frequently used for these ammonites. However, Spath’s *eboracense* also has a well-preserved type specimen, and if this represents a species different from *O. simpsoni*, then it differs only by its more compressed whorls up to 40 mm diameter. But the many examples of *Oxynoticeras* in beds 467 and 468 show a large amount of variation in whorl compression and rib strength on whorls up to 50 mm diameter, and there are no larger ammonites that can be identified as *O. eboracense* in having more compressed whorls than *O. simpsoni* at large sizes. *O. bucki* (Simpson, 1843) and *O. lens* (Simpson, 1855) are clearly the same as *O. eboracense*, of which they are senior synonyms; *O. flavum* and *O. limatum*, both of Simpson, 1843, are smaller and have slightly thicker whorls like those of *O. simpsoni*. The lectotype of *O. collenoti* (d’Orbigny, 1844; figured by Fischer, 1994: 85, pl. 17, fig. 3) is also very similar to the types of *lens* and *eboracense*.

Larger collections of better preserved specimens will be needed to determine whether these *Oxynoticeras* can really be divided into more than one species. So in this paper all the specimens in beds 463–472.1 are identified as *O. simpsoni*.

**Oxynoticeras simpsoni** (Simpson, 1843)  
Pl. 4, figs 5, 8

1843  *Ammonites simpsoni* Simpson: 37.
1843  *Ammonites limatus* Simpson: 41.
1843  *Ammonites bucki* Simpson: 42.
1843  *Ammonites flavus* Simpson: 43.
1843  *Ammonites lens* Simpson: 80.
1876  *Amaltheus simpsoni* (Simpson); Blake: 291, pl. 8, fig. 4 (BM C.17903).
1881/82  *Amaltheus simpsoni* (Bean); Wright: 392 (1882), pl. 47 (1881), figs 4, 5 (SM J18231), 6, 7 (SM J18232).
1912  *Oxynoticeras flavum* (Simpson); Buckman: pl. 55 (holotype, WM 481).

1912  *Oxynoticeras limatum* (Simpson); Buckman: pl. 56, fig. 1 (holotype, WM 480).
1912  *Actinoceras simpsoni* (Simpson); Buckman: pls 66A, B (holotype, WM 813).
1920  *Oxynoticeras bucki* (Simpson); Buckman: pl. 165A (holotype, WM 479a).
1925a  *Oxynoticeras eboracense* Spath: 108, 110, figs d,e (holotype, BM C.18060).
1961  *Oxynoticeras simpsoni* (Simpson); Spath: 110, figs f, g (BM 37998).
1962  *Gleviceras lens* (Simpson); Howarth: 105, pl. 15, fig. 3 (holotype, GSM 26405).
1976  *Oxynoticeras bucki* (Simpson); Schlegelmilch: 140, pl. 22, fig. 12 (WM 479a).

**Range.** Beds 463–470, Simpsoni Subzone; 63 specimens.

**Remarks.** All the figured specimens listed in the synonymy above probably came from beds 467 or 468. *O. simpsoni* is a distinctive species that has a larger umbilicus and thicker whorls than *O. oxynotum* and similar species. In Robin Hood’s Bay it overlaps in stratigraphical range with *Eparietites impendens*, from which it differs mainly in whorl section: *E. impendens* has a differentiated ventral keel, flanked by narrow flat areas then angled ventro-lateral shoulders, and a vertical umbilical wall and rounded umbilical edge; in *O. simpsoni* the venter is either lanceolate or fastigate with no angles at the umbilical shoulders and without a differentiated keel, and the broad umbilical wall typically slopes at a low angle and merges gradually into the side of the whorl. *E. impendens* has ribs at least on the inner whorls; most *O. simpsoni* are smooth, though some examples retain ribs on small inner whorls.

The lowest *O. simpsoni* with no ventro-lateral angles at the side of the keel occurs in bed 463, where there are two large examples: one is part of a solid body-chamber ending at about 340 mm diameter; the other is 380 mm diameter and has half a whorl of body-chamber, but is crushed and less well-preserved. A large fragment from bed 464.33 is septate up to at least 256 mm diameter. A smaller *O. simpsoni* from bed 464.32 is figured in Pl. 4, fig. 8, which has ribbing on its inner whorl at about 80 mm diameter, and a small specimen from bed 468 is also figured (Pl. 4, fig. 5).

**Oxynoticeras oxynotum** (Quenstedt, 1843)  
Pl. 4, fig. 4

1843  *Ammonites oxynotus* Quenstedt: 161.
1843  *Ammonites polyophyllus* Simpson: 39.
1845  *Ammonites oxynotus* Quenstedt: 98, pl. 5, fig. 11 (holotype).
1884  *Ammonites oxynotus* Quenstedt: 175, pl. 22, fig. 29 (holotype).
1909  *Oxynoticeras polyophyllum* (Simpson); Buckman: pl. 8 (holotype, WM 739).

**PLATE 4**

Fig. 1  *Eparietites impendens* (Young & Bird). Bed 462, CA 3243.
Fig. 2  *Echioceras raricostatoides* Vadasz. Bed 489, CA 3393; wholly septate.
Figs 3, 6  *Palaeochoiceras tardecrescens* (Hauer). 3, bed 497, CA 3572. 6, bed 498, CA 3616; probably wholly septate.
Fig. 4  *Oxynoticeras oxynotum* (Quenstedt). Bed 481, CA 3716; wholly septate.
Figs 5, 8  *Oxynoticeras simpsoni* (Simpson). 5, bed 468, CA 3692; wholly septate. 8, bed 464.32, CA 3652, ×0.8; the outer whorl is part of the body chamber.
Fig. 7  *Gleviceras doris* (Reynés). Bed 476, CA 3726, ×0.6.

All figures natural size, except Figs 7 and 8.
Oxynoticeras oxynotum (Quenstedt); Dean et al.: pl. 66, fig. 5 (holotype, Geol.-Pal. Institut, Tubingen, from Württemberg, Germany).

**Range.** Beds 472.1–481, Oxynotum Subzone; 4 specimens.

**Remarks.** The lowest Oxynoticeras that are more involute and flat-whorled than O. simpsoni occur in bed 472.1, which is therefore the base of the Oxynotum Subzone. Better preserved O. oxynotum occur higher up in beds 475.3 and 481 (Pl. 4 fig. 4), and there are several fragments of Oxynoticeras sp. indet. from beds 480, 482 and 483 consisting of large compressed whorls up to 260 mm diameter that have acute venters and complex suture-lines.

**Other species of Oxynoticeras:**

?Oxynoticeras aliaenum (Simpson, 1855: 85).

?Oxynoticeras dejectum (Simpson, 1855: 85).

The type specimens of both Simpson's species are lost, and the species are not identifiable.

Genus **Gleviceras** Buckman, 1918

Gleviceras doris (Reynès, 1879) Pl. 4, fig. 7

1879 *Ammonites doris* Reynès: pl. 41, figs 13–15 (probably from France).

1914 *Oxynoticeras doris* (Reynès); Pia: 7, 30, pl. 1 fig. 1; pl. 8, fig. 1.

**Range.** Beds 476 and 485.2, Oxynotum Subzone: 3 specimens.

Gleviceras guibalianum (d'Orbigny, 1844)

1844 *Ammonites guibalianus* d'Orbigny: 259, pl. 73, figs 1–4.

1973 *Gleviceras subguibalianum* (von Pia) (sic); Donovan & Forsey: 9, pl. 2, fig. 1 (lectotype of *Ammonites guibalianus* d'Orbigny, designated by Donovan & Forsey, from Nantua, France).

1994 *Gleviceras guibalianum* (d'Orbigny); Fischer: 66, pl. 17, fig. 2 (lectotype refigured).

**Range.** Beds 484.1–499, Oxynotum to Aplanatum Subzones; 14 specimens.

**Remarks.** Most specimens are large body-chambers, or fragments thereof, up to 300 mm diameter.

Genus **Paracymbites** Trueman & Williams, 1927

Paracymbites dennyi (Simpson, 1843)

1843 *Ammonites dennyi* Simpson: 9.

1843 *Ammonites arctus* Simpson: 10.

1909 *Oxynoticeras dennyi* (Simpson): Buckman: pl.7, figs 1 (lectotype, WM 470), 2, 3 (two paralectotypes).

1911 *Oxynoticeras arctum* (Simpson): Buckman: pl. 36 (holotype, WM 471).

1966 *Paracymbites dennyi* (Simpson); Donovan: 315, pl. 53, figs 5–12 (from Oxfordshire and Gloucestershire).

**Remarks.** As revised by Donovan (1966), the holotype of this species should have come from the lower part of the Raricostatum Zone in Robin Hood’s Bay, but no examples were found by Bairstow.

Genus **Paroxynoticeras** von Pia, 1914

Paroxynoticeras salisburgense (Hauer, 1856)

1856 *Ammonites salisburgensis* Hauer: 47, pl. 13, figs 1–3 (lectotype, designated Donovan & Forsey (1973: 9), from Adneth, Austria).

1914 *Paroxynoticeras salisburgense* (Hauer); Pia: 18, 73, pl. 1 fig. 2; pl. 7, fig. 22; pl. 13, fig. 12.

**Range.** Two probable examples of this species were found in bed 474.3, Oxynotum Subzone.

Genus **Radstockiceras** Buckman, 1918

**Remarks.** As well as the two species described below, two very large fragments of *Radstockiceras* sp. indet. were found in beds 544.4 and 544.6; both are about 350 mm diameter and one of them is septate up to about 300 mm diameter; a poorly preserved specimen was also found in bed 548.

In their revision of the holotype of *Radstockiceras buvignieri*, Donovan & Guérin-Franiatte (in Fischer, 1994: 68) said that *Radstockiceras* was a late oxynoticeratid that appeared in the Jamesoni Zone (from the evidence of Tutcher & Trueman, 1925: 598, 642) and was not present in the Raricostatum Zone (which was the supposed horizon at Radstock of Buckman's (1918: 288) holotype of the type species of *Radstockiceras*). However, the four large examples from bed 494 described below are a genuine record of *Radstockiceras* from the Macdonnelli Subzone, Raricostatum Zone, whatever may be held to be their specific determination.

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**PLATE 5**

**Fig. 1** Radstockiceras buvignieri (d'Orbigny). Bed 494, CA 3744, x 0.6; wholly septate.

**Fig. 2** Xipheroceras dudressieri (d'Orbigny). Bed 446.33, C.49336; the asterisk marks the probable end of the phragmocone.

**Fig. 3** Promicroceras planicosta (J. Sowerby). Bed 451, CA 3927.

**Fig. 4** Radstockiceras sphenonom (Monke). Bed 544.4, CA 3758; wholly septate.

**Fig. 5** Xipheroceras ziphis (Zieten). Bed 451, CA 3784; wholly septate.

**Fig. 6** Cymbites laevigatus (J. de C. Sowerby). Bed 448.1, CA 3763; 6a, 6b, x 1; 6c, d, x 3; the last septa at the position shown are approximated and probably adult.

**Fig. 7** Microderoceras birchi (J. Sowerby). Bed 433.3, CA 3977, x 0.5; a complete (?adult) specimen with a body chamber nearly 1½ whorls long.

**Fig. 8** Apoderoceras subtriangulare (Young & Bird). Bed 501.1, CA 3981; a septate fragment.

**Fig. 9** Eudroceras armatum (J. Sowerby). *Neotype*, probably from bed 497, C.67323, x 0.75.

All figures natural size, except Figs 1, 6c, 6d, 7 and 9.
Radstockiceras buvignieri (d’Orbigny, 1844) Pl. 5, fig. 1

1844 Ammonites buvignieri d’Orbigny: 261, pl. 74, figs 1–3.
1855 Ammonites complanatus Simpson: 79, 80.
1855 Ammonites retentus Simpson: 84.
1920 Retenticeras retentum (Simpson); Buckman: pl. 166 (holotype, GSM 26401).
1962 Metoxynoticercis complanatus (Simpson); Howarth: 105, pl. 15, fig. 4 (holotype, WM 239, now lost).
1992 Radstockiceras complanatus (Simpson); Schlegelmilch: 60, pl. 54, fig. 2 (WM 239).
1994 Radstockiceras buvignieri (d’Orbigny); Fischer: 67, pl. 21, fig. 3 (holotype, from Breux, Meuse, France).

REMARKS. Occurs in beds 494, Macdonnelli Subzone, 505.2, Taylori Subzone, and 544.7, Brevispina Subzone: 7 specimens.

MEASUREMENTS (in mm)

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<td>79.0 (0.57)</td>
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REMARKS. The five large specimens from bed 494 are all large specimens of 145–250 mm diameter preserved in grey limestone. The best one (Pl. 5, fig. 1) is wholly septate up to its maximum size of 168 mm diameter. The single specimen from bed 505.2 is a well-preserved fragment of a part of a whorl, with whorl height 72 mm and whorl breadth 27 mm (if the whorl height is 0.57 of the diameter, then the whorl breadth is 0.21 of the diameter). One of the two pyritized specimens found in bed 544.7 is 25 mm diameter and is similar to the holotype of Simpson’s species complanatum, and the almost identical specimen BM 37960 (from Robin Hood’s Bay), undoubt­edly belong to the same species, but it is difficult to identify their horizons – they could have come from any of the beds 494, 505 and 544.

Radstockiceras sphenonotum (Monke, 1888) Pl. 5, fig. 4

1888 Ammonites sphenonotus Monke: 228, pl. 2/3, fig. 14 (holotype, from Germany).
1914 Oxynoticeras sphenonotum (Monke); Pia: 65, pl. 7, fig. 12.

RANGE. Beds 542.1–544.4, Polymorphus Subzone: 8 specimens.

REMARKS. The best preserved specimen occurs in bed 544.4 (Pl. 5, fig. 4).

Family CYMBITIDAE Buckman, 1919
Genus CYMBITES Neumayr. 1979

Cymbites laevigatus (J. de C. Sowerby, 1827) Pl. 5, fig. 6

1827 Ammonites laevigatus J. de C. Sowerby: 135, pl. 570, fig. 3.
1957 Cymbites laevigatus (J. de C. Sowerby); Donovan: 413, figs 1–8 (topotypes (the holotype is lost), from Brookey to Stellare Subzones, Dorset coast).

RANGE. Beds 446.5–464.1, top Obtusum to Simpsoni Subzones; 15 specimens; 2 specimens of Cymbites sp. indet. occur slightly higher in beds 464.32 and 464.33.

REMARKS. The main species present in Robin Hood’s Bay is C. laevigatus, but a more compressed species with obsolete ribbing, eg. C. fastigatus Schindewolf (1961: 211, pl. 30, figs 8–10), may also be present amongst the small specimens determined as Cymbites sp. indet. in the Denotatus and Simpsoni Subzones.

Superfamily EODEROCERATACEAE Spath, 1929
Family EODEROCERATIDAE Spath, 1929
Genus MICRODEROCERAS Hyatt. 1871

Microderoceras scoresbyi (Simpson, 1843)

1843 Ammonites scoresbyi Simpson: 12.
1911 Microderoceras scoresbyi (Simpson); Buckman: pl. 39A, B (holotype, WM 173), C (topotype, GSM 23616), both probably from bed 441.2.

RANGE. One specimen found in bed 441.2, Birchi Subzone.

REMARKS. This single specimen differs from M. birchi in having higher and thicker whorls that are slightly less evolute.

Microderoceras birchi (J. Sowerby, 1820) Pl. 5, fig. 7

1820 Ammonites birchi J. Sowerby: 121, pl. 267.
1961 Microderoceras birchi (J. Sowerby); Dean et al.: pl. 66, fig. 3 (BM 67973, from the Dorset coast).
1973 Microderoceras birchi (J. Sowerby); Donovan & Forsey: 10, pl. 1, fig. 1 (lectotype, BM 43923, from the Dorset coast).

RANGE. Found only in bed 433.3, Birchi Subzone: 5 specimens.

REMARKS. The five large specimens in bed 433.3 have typical very evolute whorls, with bituberculate ribs up to the end of the largest specimen at 235 mm diameter, and considerable variation in whorl thickness. The specimen figured in Pl. 5, fig. 7 appears to have a complete body-chamber nearly 1½ whorls long, ending in an (?adult) aperture at 210 mm diameter.

Genus XIPHEROCERAS Buckman, 1911

Xipheroceras dudressieri (d’Orbigny, 1845) Pl. 5, fig. 2

1845 Ammonites dudressieri d’Orbigny: 325, pl. 103, figs 1.2.
1926b Xipheroceras dudressieri (d’Orbigny); Spath: 172, pl. 9, fig. 6 (BM C.2235a, a typical example from the Obtusum Subzone, Dorset).
1994 Xipheroceras dudressieri (d’Orbigny); Fischer: 91, pl. 19, fig. 3 (from Mulhausen, France).

RANGE. One specimen in bed 446.33, Obtusum Subzone.

Xipheroceras ziphus (Zieten, 1830) Pl. 5 fig. 5

1830 Ammonites ziphus Zieten: 6, pl. 5, fig. 2 (holotype, BM 62590, from Heiningen, Württemberg, Germany).
1926 Xipheroceras ziphus (Zieten); Buckman: pl. 732 (GSM 47832, coarsely ribbed inner whorls, from the Obtusum Subzone, Dorset).
1928 Xipheroceras revertens Buckman: pls 772A, B (a typical large example of X. ziphus from the Obtusum Subzone, Dorset).
Genus **Bifericeras** Buckman, 1913

**Bifericeras bifer** (Quenstedt, 1845)

1845 Ammonites bifer Quenstedt: Quenstedt: 83, pl. 4, fig. 14 (from Württemberg, Germany).

1925a Ophideroceras zhiphoides Spath: 138–40, figs 1, 2a, 2b (from low in the Oxynotum Subzone, Mill Beck Nab. Robin Hood’s Bay; originally in Hull Museum, but now destroyed; see Donovan & Forsey, 1973: 16).

1957 **Bifericeras bifer** (Quenstedt); Söll: 402, pl. 19, figs 1–7 (from Württemberg, Germany).

1976 **Bifericeras bifer** (Quenstedt); Schlegelmilch: 58, pl. 25, fig. 3 (‘neotype’, from Württemberg, Germany).

1990 **Bifericeras bifer** (Quenstedt); Hollingworth et al.: 165, pl. 2, figs 1–12 (BM C.93398–93409, from the Oxynotum Subzone, Somerset).

**Range.** Bed 483.1, Oxynotum Subzone; 5 specimens. The destroyed holotype of Ophideroceras zhiphoides Spath might have been a large example of Bifericeras bifer.

**Bifericeras vitreum** (Simpson, 1855)

1855 Ammonites vitreus Simpson: 46.

1924 *Microceras vitreum* (Simpson); Buckman: pl. 529 (holotype, WM 462, possibly from bed 486.2).

1976 **Bifericeras vitreum** (Simpson); Schlegelmilch: 146, pl. 25, fig. 9 (WM 462).

**Range.** One specimen in bed 486.2, Oxynotum Subzone.

**Bifericeras donovani** Dommergues & Meister, 1992

1992 **Bifericeras donovani** Dommergues & Meister: 223, figs 5(8)–5(10), figs 7(1), 7(2), 7(3) (holotype), 7(4)–7(11) (all from nodules in the lower part of bed 501.1 at Wine Haven).

**Range.** Occurs only in bed 501.1, base of Taylori Subzone; 18 specimens.

Genus **Crucilobiceras** Buckman, 1920

**Crucilobiceras densinodulum** Buckman, 1923

1876 *Aegoceras obsoletum* (Simpson); Blake: 276, pl. 7, fig. 1 (BM C.17939, from bed 486.3).

1923 **Crucilobiceras densinodulum** Buckman: pl. 442 (holotype, from Lyme Regis, Dorset).

1926b *Crucilobiceras ornatiolatum* Spath: 176, pl. 11, fig. 1 (holotype, from Lyme Regis, Dorset).

**Range.** Beds 486.3–488, Densinodinum and Raricostatoides Subzones; 19 specimens.

**Remarks.** The well-preserved *C. densinodulum* in beds 486.3 (Pl. 6, fig. 1) are unituberculate (ie. have ventro-lateral but no prominent umbilical-lateral tubercles), are moderately to finely ribbed on the inner whorls, and are characteristically much more compressed than *C. densinodulum* (Oppel). Small specimens or inner whorls of *C. densinodulum* are similar to ‘Bifericeras (Hemimicroceras)’ subplanicosta (Oppel, 1856) and the relationship between the two (eg. a macroconch/microconch pair or size difference only) has yet to be resolved.

**Eoderoceras armatum** (J. Sowerby, 1815)

Pl. 5, fig. 9; Pl. 8, fig. 2

1815 Ammonites armatus J. Sowerby: 215, pl. 95.

1843 Ammonites anguiformis Simpson: 17.

1843 Ammonites owenensis Simpson: 25.

1855 Ammonites miles Simpson: 65.

1880/82 *Aegoceras armatum* (J. Sowerby); Wright: 340 (1882), pl. 28 (1880), figs 1, 2 (SM J18222), 3–5 (SM J18223), both from beds 497–99; non pl. 29, =Eoderoceras pugnax (Buckman, 1914: 103c).

1911 *Deroceras miles* (Simpson); Buckman: pl. 44 (holotype, WM 162, from bed 498 or 499).

1912 *Deroceras anguiforme* (Simpson); Buckman: pl. 64 (holotype, WM 86, from beds 497–99).

1912 *Deroceras owenense* (Simpson); Buckman: pl. 65 (holotype, WM 476, from beds 497–99).

1926b *Deroceras eusculptum* Spath: 175, pl. 10, fig. 3 (BM C.26907, from Lyme Regis, Dorset).

1992 *Eoderoceras gr. miles* (Simpson); Dommergues & Meister: 231, figs 5(5), 5(7) (from bed 497).

2000 *Eoderoceras armatum* (J. Sowerby); Blau et al.: 269, figs 4 (1–7), 5 (1, 3, 5), 6 (1), 7, 8 (from NW Germany).

**Range.** Beds 494–499, Macdonnelli and Aplanatum Subzones; 62 specimens.

**Type Specimen.** BM C.67323, Sowerby Collection, from Robin Hood’s Bay, probably from bed 497, is here designated neotype.

**Measurements (in mm)**

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<td>102.0</td>
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**Remarks.** Sowerby (1815: 215) stated that many examples of his species, including the specimen that he figured, which was collected by Mr. Strangewayes, came from ‘the great Alum-clay formation at Whitby’ (a stratigraphical term that was used by Sowerby, Young & Bird, Sedgwick and others for beds that included ones as low as the Upper Sinemarian/Lower Pliensbachian clays). Sowerby did not mention any other locality in his original description, so it is not possible to agree with Spath’s (1925a: 137, 167) statements that ‘the true *D. armatum* apparently does not occur in Yorkshire’, and ‘Sowerby’s type is not preserved in the BM ... and has always seemed to me to be more like a Charmouth than a Whitby specimen’, nor with Donovan’s (1958: 32) opinion that ‘Sowerby’s type specimen ... was almost certainly obtained from the Dorset coast’. It is not permissible to transfer the type locality to Dorset on the opinion that the Yorkshire specimens are morphologically different from those in Dorset, or the belief that the pyritic preservation and frequency of decay perceived from Sowerby’s figure are more reminiscent of Dorset examples. The Yorkshire specimens are not morphologically different from those in Dorset (two especially fine
Yorkshire specimens had been figured by Wright, 1880: pl. 28, and there are many Yorkshire examples preserved in iron pyrites, especially in beds 497 and 499, which are also subject to decay, though less readily than the Dorset ones.

After Spath wrote about the species in 1925, the remaining ammonites in the Sowerby's collections were obtained by the Natural History Museum in 1935, and amongst them is a medium to large example (BM C.67323) of Eoderoceras armatum from Robin Hood's Bay, which might even have been one of Sowerby's original syntypes. At 132 mm diameter it is slightly larger than Sowerby's figure of a 117 mm diameter specimen (assuming that his figure is natural size), but it does not differ in any morphological feature from that figure, and the part now missing at the beginning of the final whorl was once present, judging from remaining traces of old glue. There are some patches of pyritic preservation on the inner whorls, which fortunately do not appear to be subject to decay. As a possible original syntype, and a definite topotype, it is a close morphological match with Sowerby's figured specimen and is clearly the best neotype that can now be selected. It presents an unexpected opportunity to finally settle the identity of this frequently quoted species.

The neotype (Pl. 5, fig. 9) consists of 6½-7½ septate whorls up to about 110 mm diameter, followed by a quarter of a whorl of body chamber ending at 132 mm diameter. The whorls are very evolute, the whorl section is near-circular and the umbilical wall and edge are evenly rounded. There are many fine indistinct radial ribs between stronger periodic lateral ribs that end in prominent ventro-lateral tubercles. Ribs of moderate strength cross the venter, curving gently forwards, and there are 3-5 such ribs between adjacent ventro-lateral tubercles. There are no umbilical tubercles.

In Robin Hood's Bay there are a few specimens in the Macdonnelli Subzone, then the species becomes much more common in the Aplanat Subzone, with 44, 8 and 7 examples collected by Bairstow from beds 497, 498 and 499 respectively. The highest in bed 499 is 0.15 m below the top, and only 0.23 m below the top of the Sinemurian. Six specimens were found lower in bed 499 (0.15-0.37 m above the base), and the lowest preserved of them is figured in Pl. 8, fig. 2; the latter has a phragmocone ending at ca. 68 mm diameter at the position indicated on the figure, then it has a body-chamber 1.125 whorls long ending at a final aperture at ca. 125 mm diameter (the final 0.35 whorls are still visible). There are no umbilical tubercles.

The neotype represents a highly evolute, serpenticone species, which might be an Eoderoceras, but no specimens were found by Bairstow.

Genus PROMICROCRAS Spath, 1925

Promicrocras planicosta (J. Sowerby, 1814) Pl. 5, fig. 3

1814 Ammonites planicosta J. Sowerby: 167, pl. 73.
1822 Ammonites aureus Young & Bird: 248, pl. 13, fig. 6 (type specimen lost).
1843 Ammonites siphuncularis Simpson: 46.
1912 Androgyrovcras siphunculare (Simpson): Buckman; pl. 48 (holotype, WM 485, from beds 451–454).
1925a Promicrocras planicosta (J. Sowerby); Spath: 299–302, fig. 8f.
1925a Promicrocras aureum (Young & Bird); Spath: 301, fig. 8d (BM 17160, possibly from 451).
1926b Promicrocras planicosta (J. Sowerby); Spath: 171, pl. 9, fig. 1 (BM C.26337), 7 ('neotype', BM C.2235b); both from Charmouth, Dorset.

Range. Beds 446.33–454.1, Obtusum and Stellare Subzones; 290 specimens.

Remarks. The current interpretation of Promicrocras planicosta may not be satisfactory. After lengthy discussion, Spath (1925a: 299–302) selected as neotype the specimen BM C.2235b (T. Wright Colln, 1887) from Charmouth, Dorset (almost certainly from bed 85), even though Sowerby (1814: 167) said that his main specimens came from Marston Magna, and it is highly probable that the original block of specimens that he figured (Sowerby, 1814: pl. 73, now lost) came from the Marston Marble at Marston Magna, Somerset. Spath (1925a: 305) then created a new species, P. marstonense, for the form at Marston Magna, using as holotype a specimen (BM 43914b) from Sowerby's syntypes of P. planicosta. The selection of a Charmouth specimen as neotype of P. planicosta was unfortunate, and may be invalid because there were Marston Magna specimens available amongst the original syntypes. The designation of a Marston Magna specimen as neotype (or lectotype) would have been much more in accordance with Sowerby's original concept of his species. In any case, the forms of Promicrocras at Charmouth and Marston Magna appear to be very close and the two names are probably
**Promicroceras capricornoides** (Quenstedt, 1883)

1883 **Ammonites capricornoides** Quenstedt: 129, pl. 17, fig. 11 (from Württemberg, Germany).

1926b **Promicroceras capricornoides** (Quenstedt); Spath: 172, pl. 9, fig. 3 (from the Turneri Zone, Charmouth, Dorset).

**Range.** Beds 436–446.32. Birchi and basal Obtusum Subzones; 39 specimens.

**Remarks.** *P. capricornoides* is slightly more involute, has a more rapidly increasing whorl height and slightly fewer ribs than *P. planicosta*.

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**Family COELOCERATIDAE** Haug, 1910

**Genus APODEROCERAS** Buckman, 1921

**Remarks.** Identification of the horizons from which the Yorkshire type and figured specimens were obtained is especially uncertain in Apoderoceras. The originals of *A. subtriangulare* and its two synonyms (*A. hamiltoni* and *A. spicatum*) could have come from any of beds 502, 504–07, 520 and 522, all of which contain many large fragments of outer whorls as well as a few more complete specimens like the original of *A. hamiltoni*. Similarly, the originals of *A. aculeatum* and its three synonyms (*A. decussatum, A. mutatum* and *A. leckenbyi*) could have come from any of beds 523–526.

**Apoderoceras subtriangulare** (Young & Bird, 1822)

Pl. 5, fig. 8; Pl. 6, figs 4, 5

1822 **Ammonites subtriangulatus** Young & Bird: 250, pl. 12, fig. 4.

1843 **Ammonites hamiltoni** Simpson: 27.

1843 **Ammonites spicatus** Simpson: 28.

1913 **Dero ceras subtriangulare** (Young & Bird): Buckman: pl. 71 (holotype, WM 927).

1914 **Dero ceras spicatum** (Simpson): Buckman: pl. 103 (holotype, WM 920).

1924 **Apoderoceras hamiltoni** (Simpson): Buckman: pls 530A, B (both are the holotype, WM 165).

1992 **Apoderoceras sp. indet.** Dommergues & Meister: 232, fig. 5(6) (from nodules at the middle of bed 501.1, W i ne Haven).

**Range.** Beds 501.1–522.1, Taylori Subzone; 41 specimens.

**Remarks.** The lowest examples of Apoderoceras are three specimens in bed 501.1. Two are very small cadicones, one large enough to have ventro-lateral tubercles, while the third (Pl. 5, fig. 8) is part of one side of a whorl at a whorl height of 35 mm that has obscure radial ribs and striae and pointed ventro-lateral tubercles. It is identical with *A. subtriangulare* at a similar size, and is important for fixing the base of the Taylori Subzone at this level.

Large *A. subtriangulare* up to 350 mm in diameter, with large ventro-lateral spines and broad flat venters occur in bed 502 and at many more horizons up to bed 522.1. Most are fragments of outer whorls with nothing to link them to the few inner whorls, but an example in bed 507.1 (CA 4006) has both inner and outer whorls, and proves that small inner whorls like those in Pl. 6, fig. 5 and the very well-preserved specimen of Pl. 6, fig. 4 develop into the massive outer whorls with broad flat venters and very large ventro-lateral spines that are characteristic of *A. subtriangulare*. The holotype of *A. subtriangulare* (Buckman, 1913; pl. 71) is a fragment of such a large outer whor. Of the two Simpson species that are placed in synonymy, the holotype of *A. spicatum* (Buckman, 1914; pl. 103) is a very similar fragment of a large outer whorl, though the broad flat venter is not shown because only one side is preserved, while the holotype of *A. hamiltoni* (Buckman, 1924; pl. 530) is one of the few specimens that show inner and outer whorls preserved in the same individual. [Note the remarkable resemblance of Pl. 6, fig. 4 to a depressed-whorled species of the Toarcian genus *Peronoceras*, e.g. *P. perarmatum* (Young & Bird), Howarth, 1978: pl. 4, fig. 7; the latter differs only in having well-defined ribs on the side of the whorl, compared with the poor, irregular or striate ribs on the inner whorls of *Apoderoceras subtriangulare*].

**Apoderoceras aculeatum** (Simpson, 1843)

Pl. 6, fig. 2; Pl. 7, fig. 1

1843 **Ammonites marshallani** Simpson: 24.

1843 **Ammonites decussatus** Simpson: 25.

1843 **Ammonites aculeatus** Simpson: 27.

1855 **Ammonites mutatus** Simpson: 63.

1876 **Aegoceras aeuleatum** (Simpson); Blake: 278, pl. 7, fig. 4 (BM C. 17878).

1880/82 **Aegoceras leckenbyi** Wright: 344 (1882), pl. 30 (1880), figs 1–3 (lectotype of *leckenbyi* designated Howarth, 1962: 109), SM J18224), figs 4–7 (paralectotype of *leckenbyi*, also holotype of *decussatum*, SM J18225).

1913 **Dero ceras aculeatum** (Simpson); Buckman: pls 72A–C (paratype, WM 177: the holotype is lost).

1914 **Dero ceras mutatum** (Simpson); Buckman: pl. 105 (holotype, GSM 26406).

1962 **Apoderoceras decussatum** (Simpson); Howarth: 109, pl. 16, fig 1 (holotype, SM J18225).

1962 **Apoderoceras marshallani** (Simpson); Howarth: 109, pl. 15, fig. 5 (holotype, WM 468); the holotype is only 16 mm in diameter, and although it could be a very small example of *A. aculeatum*. Simpson's species is not accurately determinable.

**Range.** Beds 523–526.6, Taylori Subzone; 15 specimens. There are also single specimens of *Apoderoceras* sp. indet. in beds 526.7 and 529.

**Remarks.** Specimens from beds 523–526 differ from *A. subtriangulare* in beds 501–522 in having the outer whorls more rounded, with evenly arched whorl sides and venter, no definite ventro-lateral angle, and smaller ventro-lateral tubercles on the inner whorls. These stratigraphically higher specimens belong to the species *A. aculeatum* (Simpson), of *A. decussatum* and *A. leckenbyi* are synonyms (Ammonites aculeatus and A. decussatum) are both of Simpson, 1843, and therefore have equal priority; the name for the species was selected by Blake (1876: 278), who, as 'First Reviser' (ICZN Code, art. 24.2), chose *aculeatum* as the name for the species). A. marshallani, another Simpson name of the same date (1843), is probably also a synonym, but the holotype is too small to be definitely identifiable, and A. mutatum (Simpson, 1855) and A. leckenbyi (Wright, 1880) are two more synonyms, judging from their well-preserved type specimens.

The specimen figured in Pl. 7, fig. 1 is a fairly large, wholly septate example of *A. aculeatum* and Pl. 6, fig. 2 has well-preserved inner whorls showing much smaller ventro-lateral tubercles than in *A. subtriangulare* (cf. inner whorls of Pl. 6, fig. 5).

**Other species of Apoderoceras:**

1. **Apoderoceras sinuatum** (Simpson, 1855: 62); Buckman, 1914:
pl. 94 (holotype, WM 160). No specimens resembling this holotype were found by Bairstow.

2. ?A. armiger (Simpson, 1855: 66) (non Ammonites armiger J. de C. Sowerby, 1840); Howarth, 1962: 107. From Simpson’s description this was probably an Apoderoceras, but the type specimen is lost and the species is not identifiable.

**Genus** HYPERDEROCERAS Spath, 1926

**REMARKS.** Bairstow found only one poorly preserved example (CA 4053) of Hyperderoceras sp. indet. in bed 540.1 (Polymorphus Subzone). This shows parts of inner whorls at 15-50 mm diameter that have strong ribs and ventro-lateral tubercles, followed by septate fragments of larger whorls with a quadrate whorl section, where both whorl height and breadth are 50-60 mm. ie. they are not compressed like Epideroceras at this size. Any of the following four Simpson species might have come from this horizon, but the Bairstow specimen is not specifically identifiable:


2. H. validum (Simpson, 1855: 39); Blake, 1876: 278, pl. 7, fig. 3 (SM – ?holotype); Buckman, 1913: pl. 83 (holotype, SM J3275).

3. H. retusum (Simpson, 1855: 62); Buckman, 1913: pl. 82 (holotype, WM 184).

4. H. nativum (Simpson, 1855: 68); Buckman, 1913: pl. 84 (holotype, WM 931).

**Family** PHRICODOCERATIDAE Spath, 1938

**Genus** PHRICODOCERAS Hyatt, 1900

**REMARKS.** Species of Phricodoceras show a considerable amount of variation in rib-density, in the development of lateral tubercles, and in overall size of the tubercles. The specimens from Robin Hood’s Bay suggest that a sparsely-ribbed species, here identified as *P. taylori*, occurs in the lower half of the Taylori Subzone, while a more densely-ribbed species, *P. cornutum*, occurs in the upper half of the subzone. Tubercle strength depends to some extent on preservation, and in any species tubercles are more prominent when the shell is preserved, compared with their appearance on internal moulds. The Robin Hood’s Bay specimens are identified below mainly according to their rib-density, but tubercles are accorded some significance when they are especially large.

**Phricodoceras taylori** (J. de C. Sowerby, 1826)

1826 Ammonites taylori J. de C. Sowerby: 23, pl. 514, fig. 1 (holotype, lost (originally in Norwich Museum), from Glacial Drift, Happisburgh, north Norfolk, perhaps derived from the Yorkshire coast).

1855 Ammonites quadricornutus Simpson: 71.

1884 Ammonites quadricornutus Simpson: 106.

1911 Phricodoceras quadricornutum (Simpson); Buckman: pl. 33 (holotype, WM 495: possibly from beds 501-517, lower than *P. cornutum*).

**RANGE:** Beds 501.3-524.1. Taylori Subzone: 8 specimens.

**REMARKS.** *P. taylori* occurs in the lower and middle parts of the Taylori Subzone at Robin Hood’s Bay, where the poorly preserved specimens have the widely spaced ribs (12-13 per whorl at 50 mm diameter) that are typical of the species. The holotype of *Ammonites quadricornutus* has the same rib-density, and the strength of the tubercles is similar to that shown in Sowerby’s figure of *taylori*, even after allowances are made for slightly different modes of preservation.

**Phricodoceras cornutum** (Simpson) Pl. 7, fig. 2


1855 Ammonites cornutus Simpson: 71.

1884 Ammonites taylori J. de C. Sowerby: Simpson: 105 (including *Ammonites cornutus* which is now considered to be a synonym).

1911 Phricodoceras cornutum (Simpson); Buckman: pl. 32 (holotype, WM 185).

1976 Phricodoceras cornutum (Simpson); Schlegelmilch: 152, pl. 28, fig. 1 (WM 185).

**RANGE:** Beds 524.3-530.2, Taylori Subzone: 8 specimens.

**REMARKS.** *P. cornutum* occurs higher in the Taylori Subzone than *P. taylori*, and differs from the latter in having more ribs (17-20 per whorl at 50 mm diameter) and smaller tubercles.

**Phricodoceras nodosum** (Quenstedt, 1846)

1846 Ammonites taylori nodostts Quenstedt: 136, pl. 9, fig. 21 (holotype, from Württemberg, Germany) (non Ammonites nodostts, Brugiére, 1789).

1961 Phricodoceras aff. taylori (J. de C. Sowerby); Dean et al.: pl. 68, fig. 5 (BM C.17981, probably from bed 520).

1980 Phricodoceras nodosum (Quenstedt); Schlatter: 78, pl. 6, figs 5, 6 (from Württemberg, Germany).

**RANGE.** A single specimen in bed 520.5, Taylori Subzone.

**REMARKS.** All the specimens listed above have the same rib-density as *P. taylori*, but they have much more prominent tubercles. Even on the internal mould the tubercles appear to be genuinely much larger, as can be seen on the specimen figured by Dean et al. (1961), which has both shell and internal mould preserved on different portions of the shell.

**Genus** EPIDEROCEFAS Spath, 1923

**REMARKS.** The only examples of Epideroceras found by Bairstow were parts of two specimens in bed 542.4, Polymorphus Subzone. They are fragments of large septate whorls, with compressed whorl sections at 45-60 mm whorl height, a rounded venter, and radial ribs, but no tubercles. They are too fragmentary and poorly preserved to be specifically identified. The following Simpson species might have come from bed 542.4:

**Epideroceras sociale** (Simpson, 1855: 39); Blake, 1876: 278, pl. 7, fig. 6 (SM collection); Buckman, 1914: pl. 95 (holotype, WM 68).

**Family** POLYMORPHITIDAE Haug, 1887

**Genus** GEMMELLAROCERAS Hyatt, 1900

**SYNONYMS.** Tubellites Buckman, 1924: Leptonotoceras Spath, 1925.

**REMARKS.** Gemmellaroceras has been divided in two subgenera: Gemmellaroceras s.s., in the Jamesoni Zone and younger beds, in which the first lateral lobe is trifid, and an earlier Raricostatum to basal Jamesoni Zone subgenus G. (Leptonotoceras), in which the first lateral lobes are bifid (Dubar & Mouterde, 1961: 237; Geczy, 1976: 73-75). In Robin Hood’s Bay Gemmellaroceras ranges from the top part of the Macdonnelli Subzone up to near the top of the Taylori Subzone. Most specimens belong to the very small species *G. tubellum* (Simpson) (the type species of Tubelliutes Buckman, 1924), and those specimens that
are large enough to have divided first lateral lobes appear to have the bifen lobes of *Leptonotoceras*. However, many of the specimens are very small and the largest (in bed 501.2) is only 19 mm diameter. In the top part of the Taylori Subzone at Robin Hood’s Bay the much larger species *Gemmellaroceras rutilans* has the trifid first lateral lobes of *Gemmellaroceras s.s.* Whether this division into subgenera is real, or is a function of the size to which species grow and therefore the complexity attained by their suture-lines, has still to be resolved.

**Gemmellaroceras tubellum** (Simpson, 1855)

1855 *Ammonites tubellus* Simpson: 42.
1876 *Aegoceras tubellum* (Simpson); Blake: 279, pl. 5, fig. 7.
1924 *Tubellites tubellus* (Simpson); Buckman: pl. 491 (holotype, WM 981: ?probably from bed 497 or 498).

**Range.** Beds 495.7–505.1, Macdonnelli to Taylori Subzones; 104 specimens.

**Remarks.** *G. peregrinum* (Haug, 1887: 114, pl. 4, fig. 5) is a very similar (or identical) species that occurs in the upper part of the Taylori Subzone in Dorset (bed 108), where specimens attain large sizes of up to 90 mm diameter.

**Genus POLYMORPHITES** Haug, 1887

**Polymorphites caprarius** (Quenstedt, 1856) Pl. 7, fig. 9

1856 *Ammonites caprarius* Quenstedt: 131, pl. 16, fig. 1 (holotype, from Balingen, Württemberg, Germany; BM C.55358 is a cast of this specimen).
1885 *Polymorphites caprarius* Quenstedt: 87. pi. 4, figs 40, 41 (holotype refigured).
1897 *Platypleuroceras caprarium* (Quenstedt); Schlegelmilch: 63, pl. 29, fig. 5 (holotype refigured).
1980 *Polymorphites caprarius* (Quenstedt); Schlatter: 92.

**Range.** Beds 546–548, Polymorphus Subzone; 84 specimens.

**Remarks.** There seems to be no doubt that Quenstedt’s figure of 1885 (pl. 30, fig. 41) is a drawing of the same specimen that he figured in 1856 (pl. 16, fig. 1). This specimen (Geological Institute, Tübingen University, Ce 5/3041) was figured again by Schlegelmilch (1976); it is the holotype. Schlegelmilch’s (1976: 63) designation of this specimen as neotype was not necessary. One of Bairstow’s better preserved specimens from bed 539 is figured in Pl. 7, fig. 9.

**Polymorphites trivialis** (Simpson, 1843) Pl. 7, fig. 7

1843 *Ammonites trivalis* Simpson: 10.
1876 *Amaltheus trivalis* (Simpson); Blake: 292, pl. 5, figs 6a (BM C.17891), 6b–d.
1912 *Polymorphites trivialis* (Simpson); Buckman: pl. 53, figs 1, 1a, 1b (the lectotype, WM 105, now lost), figs 2, 3 (paralectotypes).

**Range.** Beds 542.4–546, Polymorphus and Brevispina Subzones; 84 specimens.

**Remarks.** Many examples of *P. trivalis* are found in beds 544.35–544.9 at the top of the Polymorphus and bottom of the Brevispina Subzones, and it is highly probable that the type specimens came from 544.35, 544.4, 544.5 or 544.9.

**Polymorphites bronni** (Roemer, 1836) Pl. 7, fig. 5

1836 *Ammonites bronni* Roemer: 181, pl. 12, fig. 8 (holotype, from north Germany).
1884 *Ammonites bronni* Roemer: Quenstedt: 245, pl. 30, figs 44, 46, 48 (from Württemberg, Germany).
1976 *Polymorphites bronni* (Quenstedt); Schlegelmilch: 62, pl. 28, fig. 8 (original of Quenstedt, 1885: pl. 30, fig. 48).
1980 *Polymorphites bronni* (Quenstedt); Schlatter: 82, pl. 7, fig. 1, pl. 11, fig. 5 (from Württemberg, Germany).

**Range.** Beds 554–560.3, Jamesoni Subzone; 36 specimens.

**Remarks.** Occurs in the upper half of the Jamesoni Subzone, and it differs from *P. trivalis* and *P. polymorphus* in having consistently stronger ribbing, small ventro-lateral tubercles and a mid-ventral keel. The Robin Hood’s Bay specimens have been identified from Schlatter’s (1980: 82) interpretation of the species.

**Polymorphites polymorphus** (Quenstedt, 1845) Pl. 7, fig. 3

1845 *Ammonites polymorphus quadratus* Quenstedt: 87, pl. 4, fig. 9 (lectotype, from Germany, designated by Donovan & Forsey, 1973: 12).
1961 *Polymorphites polymorphus* (Quenstedt); Dean et al.: pl. 68, fig. 4 (from Gloucestershire).
1973 \textit{Polymorphites polymorphus} (Quenstedt); Donovan 
& Forsey: 11, 12.

1980 \textit{Polymorphites polymorphus} (Quenstedt); Schlatter: 84, pl. 
7, fig. 2 (from Württemberg, Germany).

\textbf{Range.} Found only in bed 555, Jamesoni Subzone; 2 specimens.

\textbf{Remarks.} Although the lectotype of \textit{P. polymorphus}, as validly 
designated by Donovan & Forsey (1973: 12), is probably lost, Schlegelmilch's 
(1976: 61) designation of a 'neotype' is not valid because it is radically different in 
morphology from the lost lectotype. That specimen (Schlegelmilch, 1976: pl. 28, fig. 3) 
is the original of Quenstedt. 1885, pl. 30, fig. 9, and represents a round-whorled, striate 
species of \textit{Polymorphites}, which was described as \textit{P. lineatus} (Quenstedt, 1845) by Schlatter (1980: 86).

The relationship between \textit{P. trivialis} (Simpson, 1843) and \textit{P. polymorphus} 
(Quenstedt, 1845) remains to be clarified: both have wide ranges of morphological variation, 
and they may be synonyms. \textit{P. trivialis} is abundant in the lower half of the Brevispina Subzone, 
but two examples of \textit{P. polymorphus} (Pl. 7, fig. 3) that are identical with the 
specimen figured by Dean et al. (1961: pl. 68, fig. 4) and Schlatter (1980: pl. 7, fig. 2) were found in bed 555 in the Jamesoni Subzone. They have broad 
whorls, widely spaced ribs and ventro-lateral tubercles that are characteristic of the most strongly 
ornamented forms of both species.

\textbf{Genus \textit{PLATYPLEUROCERAS}} Hyatt, 1867

\textbf{Platyleuroceras brevispina} (J. de C. Sowerby, 1827)

1827 \textit{Ammonites brevispina} J. de C. Sowerby: 106, pl. 556, fig. 1.

1843 \textit{Ammonites ripleyi} Simpson: 11.

1880/82 \textit{Aegoceras brevispina} (J. de C. Sowerby); Wright: 361 
(1882), pl. 32, fig. 2, 3 (1880) (holotype, BM 43915, from 
Pubb, Inner Hebrides, Scotland).

1909 \textit{Uptonia ripleyi} (Simpson); Buckman: pl. 2 (holotype, WM 
106, probably from beds 544.7–546.4).

1961 \textit{Platyleuroceras brevispina} (J. de C. Sowerby); Dean \textit{et al.}: pl. 69, fig. 1 (holotype).

\textbf{Range.} From beds 544.6–550, Brevispina and Jamesoni Subzones; 
83 specimens.

\textbf{Platyleuroceras obsoleta} (Simpson, 1843)

1843 \textit{Ammonites obsoletus} Simpson: 23.

1882 \textit{Aegoceras brevispina} (J. de C. Sowerby); Wright: 361, pl. 
50, figs 13, 14 (BM C.3126).

1914 \textit{Uptonia obsoleta} (Simpson): Buckman: pl. 92 (holotype, 
WM 157).

\textbf{Range.} A single specimen in bed 544.7, Brevispina Subzone.

\textbf{Remarks.} This is a single poorly preserved specimen with many 
ribs and ventro-lateral tubercles which is not good enough to elucidate the 
horizon of Simpson’s larger and better preserved holotype.

\textbf{Platyleuroceras aureum} (Simpson, 1855)

1855 \textit{Ammonites aureus} Simpson: 44 (non \textit{Ammonites aureus} 
Young & Bird, 1822).

1855 \textit{Ammonites tenuispina} Simpson: 69 (the holotype is lost – 
see Howarth, 1962: 111).

1909 \textit{Platyleuroceras aureum} (Simpson): Buckman: pl. 3 
(holotype, WM 107, from bed 546.2 or 546.5).

\textbf{Range.} Beds 546.1–546.5, Brevispina Subzone; 23 specimens.

\textbf{Remarks.} \textit{P. aureum} is a more evolute species than \textit{P. brevispina}, 
and is bituberculate (ie. both umbilical and ventro-lateral tubercles are 
well developed). A small, typical specimen is figured in Pl. 7, fig. 6.

\textbf{Genus \textit{UPTONIA}} Buckman, 1897

\textbf{Uptonia jamesoni} (J. de C. Sowerby, 1827)

1827 \textit{Ammonites jamesoni} J. de C. Sowerby: 105, pl. 555, fig. 1.

1855 \textit{Ammonites ignotus} Simpson, 1855: 61.

1910 \textit{Uptonia ignota} (Simpson); Buckman: pl. 21 (holotype, 
WM 159).

1973 \textit{Uptonia jamesoni} (J. de C. Sowerby); Donovan & Forsey: 
12, pl. 4, fig. 3 (neotype, BM C.40426, designated by 
Donovan & Forsey, 1973: 12, from Pabba, Inner Hebrides, 
Scotland).

\textbf{Range.} Beds 550–560.3, Jamesoni Subzone; 23 specimens.

\textbf{Remarks.} Many of the 23 specimens in the Jamesoni Subzone are 
typical examples of the species, but they are mostly fragmentary, and 
none are preserved well enough to be figured.

\textbf{Uptonia lata} (Quenstedt, 1845)

1845 \textit{Ammonites jamesoni} var. \textit{latus} Quenstedt: 
88, pl. 4, fig. 1 (holotype, from Württemberg, Germany).

1980 \textit{Uptonia lata} (Quenstedt); Schlatter: 113, pl. 12, figs 3, 4 
(from Württemberg, Germany).

\textbf{Range.} Beds 558 and 560.3, Jamesoni Subzone; 6 specimens.

\textbf{Remarks.} A more involute species than \textit{U. jamesoni}, with much 
finer ribbing; identified according to Schlatter’s (1980: 113) interpretation 
of Quenstedt’s species.

\textbf{Genus \textit{TROPIDOCERAS}} Hyatt, 1867

\textbf{Tropidoceras futtereri} Spath, 1923

1923 \textit{Tropidoceras futtereri} Spath: 8.

1928 \textit{Tropidoceras futtereri} Spath: Pl. 16, fig. 8 
(holotype, BM C.23687, from bed 118b, Charmouth, Dorset).

\textbf{Range.} Single specimens in beds 560.3 (top) and 568 (base), 
Masseanum Subzone.

\textbf{Tropidoceras masseanum} (d’Orbigny), var. \textit{rotundum} 
(Futterer, 1893)

1893 \textit{Cycloceras masseanum} (d’Orbigny), var. \textit{rotundum} Futterer: 
330, pl. 12, figs 3, 4 (holotype, from Württemberg, Germany).

1980 \textit{Tropidoceras masseanum} (d’Orbigny) \textit{rotundum} (Futterer): 
Schlatter: 138, pl. 19, fig. 4, pl. 20, figs 1, 2 (from 
Württemberg, Germany).

\textbf{Range.} Found only at the boundary of beds 567 and 568, Masseanum 
Subzone; 11 specimens.

\textbf{Remarks.} Although considered by Spath (1938: 81) to be a subgenus 
of \textit{Liparoceras}, \textit{Parinodiceras} (including its synonym \textit{Platynoticeras}) 
is now thought to have been derived from \textit{Polymorphites} and is therefore 
**Parinodiceras parinodum** (Quenstedt, 1884)

1828 *Ammonites striatus parinodum* Quenstedt: 225, pl. 28, fig. 16.
1938 *Liparoceras* (Parinodiceras) *parinodum* (Quenstedt); Spath: 82, pl. 6, fig. 5 (from Radstock, Somerset), pl. 25, figs 1, 4, 5 (all from Württemberg, Germany).
1976 *Liparoceras* (Parinodiceras) *parinodum* (Quenstedt); Schlegelmilch: 67, pl. 32, fig. 3 (lectotype from Olfterdingen, Württemberg, Germany).

**RANGE.** Beds 546.3, 548 and 554, Brevispina and Jamesoni Subzones; 3 specimens.

**Family LIPAROCERATIDAE** Hyatt, 1867

**Genus LIPAROCERAS** Hyatt, 1867

**Subgenus LIPAROCERAS** Hyatt, 1867

**Liparoceras (L.) cheltiense** (Murchison, 1834)

1834 *Ammonites cheltiensis* Murchison: 20, fig. 1.
1904 *Liparoceras cheltiense* (Murchison); Buckman: pls 67, 67a (holotype, BM 74955a, from Gloucestershire).
1938 *Liparoceras cheltiense* (Murchison); Spath: 46.

**RANGE.** Two specimens in bed 562, Masseanum Subzone.

**Liparoceras (L.) heptangulare** (Young & Bird, 1828)

1828 *Ammonites heptangularis* Young & Bird: 263, pl. 14, fig. 1.
1914 *Liparoceras heptangulare* (Young & Bird); Buckman: pls 108A-C (holotype, WM 170, probably from bed 575).
1938 *Liparoceras heptangulare* (Young & Bird); Spath: 59, pl. 7, fig. 1 (BM C.2685, possibly from bed 575).

**RANGE.** Single specimens in beds 571, 575 and 577, Valdani Subzone; the best preserved is in bed 577.

**Liparoceras (L.) cf. naptonense** Spath, 1938

1938 *Liparoceras naptonense* Spath: 63, pl. 6, fig. 1, pl. 9, fig. 7, pl. 10, fig. 6 (holotype, BM C.12638, from Napton, Warwickshire), pl. 14, fig. 6, pl. 16, fig. 10 (all from Warwickshire or Leicestershire).

**RANGE.** Single specimens in beds 580 and 582.3, Luridum and Maculatum subzones.

**Liparoceras (L.) divaricosta** (Trueman, 1919) Pl. 8, fig. 1

1919 *Androgynoceras divaricosta* Trueman: 278, pl. 22, fig. 1 (holotype, BM C.38326, from Lincolnshire).
1938 *Liparoceras divaricosta* (Trueman); Spath: 68, pl. 5, fig. 1 (holotype).

**RANGE.** A single specimen in bed 596.3, Figulinum Subzone.

**Genus AEGOCERAS** Waagen, 1869

**Subgenus AEGOCERAS** Waagen, 1869

**Aegoceras (A.) maculatum** (Young & Bird, 1822)

Pl. 7, figs 12, 13

1822 *Ammonites maculatus* Young & Bird: 248, pl. 14, fig. 12.
1828 *Ammonites maculatus* Young & Bird; Young & Bird: 259, pl. 14, fig. 9.

1829 *Ammonites arcigerens* Phillips: 163, pl. 13, fig. 9.
1835 *Ammonites arcigerens* Phillips: 135, pl. 13, fig. 9.
1875 *Ammonites arcigerens* Phillips: 270, pl. 13, fig. 9.
1880/82 *Aegoceras maculatum* (Young & Bird); Wright: 368 (1882), pl. 34 (1880), figs 1-3 (SM J18227), 4-7 (SM J18228).
1912 *Androgynoceras maculatum* (Young & Bird); Buckman: pl. 45A, B (holotype, WM 493; from bed 590.61).
1938 *Androgynoceras maculatum* (Young & Bird); Spath: 126, pl. 20, fig. 6 (BM C.17752, from bed 590.61).
1938 *Androgynoceras maculatum* (Young & Bird), var. rigidum; Spath: 186, pl. 19, figs 2 (BM C.28175, from bed 590.61), 13 (BM C.24601, from bed 590).
1961 *Androgynoceras maculatum* (Young & Bird); Dean et al.: pl. 70, fig. 4 (BM C.17752; from bed 590.61).
1962 *Androgynoceras arcigerens* (Phillips); Howarth: 112, pl. 16, fig. 5 (holotype, BM 17139; from bed 590.61).
1976 *Androgynoceras (A.) maculatum* (Young & Bird); Schlegelmilch: 162, pl. 33, fig. 9 (WM 493).
1985 *Androgynoceras (Beaniceras) luridum* (Simpson); Phelps: 350, pl. 1, fig. 3 (from bed 583).
1985 *Androgynoceras (Aegoceras) sparsicosta* (Trueman); Phelps: 351, pl. 1, fig. 1 (from bed 585).
1985 *Androgynoceras (Aegoceras) maculatum* (Young & Bird); Phelps: 350, pl. 2, fig. 8 (probably from bed 590.61).

**RANGE.** Beds 581-590.63, Maculatum Subzone; 35 specimens.

**REMARKS.** Ammonites in bed 590.61 have a distinctive style of preservation. Where the dark brown or black shell of the ammonite has small near-circular patches of white calcite; such a well-preserved example is figured in Pl. 7, fig. 13. This type of preservation does not occur at any other level and allows the horizon of many of the figured specimens, including the holotype, to be identified precisely, as given in the list of figured specimens above. The lowest specimens in bed 581 are typical examples of the species, being much larger and more developed than is found in transitions from *Aegoceras (Beaniceras) luridum*. The latter transitions are represented by two specimens in bed 583.2 determined as A. (A.) maculatum var. atavum (see discussion below). The specimen from bed 583 figured by Phelps as *A. (Beaniceras) luridum* is also an A. maculatum; it has ribs on the venter that are bold and well developed and are not much reduced on a nearly flat venter as in *B. luridum*.

Phelps (1985: 351) divided the Maculatum Subzone into a lower ‘Sparsicosta Zone’ and an upper ‘Maculatum Zone’. His lower division was based on the range of ammonites in the lower part of the Subzone that have low rib densities on their inner whorls of 16–18 ribs per whorl, and were identified as *Androgynoceras (Aegoceras) sparsicosta* (Trueman). Such rib densities are not different from the rib densities of *Aegoceras maculatum*, and in any case *A. maculatum* is also an A. maculatum; it has ribs on the venter that are bold and well developed and are not much reduced on a nearly flat venter as in *B. luridum*.

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Fig. 1  *Liparoceras (L.) divaricosta* (Trueman). Bed 596.3, C.39455, x 0.67; wholly septate.

Fig. 2  *Eoderoceras armatum* (J. Sowerby). Bed 499, near Bay Town, 0.18 m above base of bed, CA 3885, x 1.

Fig. 3  *Bifericeras donovani* Dommergues & Meister. Bed 501.1, near Bay Town, 0.22 m above base of bed, CA 3804; 3a, 3b, x 1; 3c, d, x 2; wholly septate.
LOWER LIAS OF ROBIN HOOD’S BAY

**Range.** Two specimens in bed 583.2, Maculatum Subzone.

 Remarks. This record is based on two specimens (C.38873-74) from bed 583.2 that were determined by Spath (1938: 133) as belonging to his var. atavum; two other specimens in the same bed (C.348871-72) are typical of the normal variety of maculatum. C.38873-74 are both only 34 mm diameter, possibly nearly adult, with reduced ribbing on the nearly flat venter (Pl. 7, fig. 8). The whorl breadth is not as large as in Spath’s (1938: 127, pi. 20, fig. 3) type of his variety, but otherwise they are closely similar. Spath (1938: 128) himself remarked that an alternative place for such specimens might be in the genus Beaniceras, and it is possible that bed 583.2 might be the horizon from which the holotype of Aegoceras (Beaniceras) luridum was obtained (SM J3274, figured Dean et al., 1961: pl. 69, fig. 6). That holotype is somewhat larger (46 mm diameter), more complete and better preserved than Bairstow’s specimens, and no others that are as well-preserved have been found in beds 578–583. Spath’s determination as var. atavum for these Bairstow collection ammonites is retained here.

*Aegoceras (A.) maculatum* (Young & Bird), var. *leckenbyi*

Spath, 1938

1938 *Androgy noceras maculatum* (Young & Bird), var. *leckenbyi*:

Spath: 126, pl. 13, fig. 2 (C.3741, from bed 590.1).

1938 *Androgy noceras maculatum* (Young & Bird), var. *arcigerens* (Phillips):

Spath: 126, pl. 20, fig. 5 (from Dorset).

**Range.** A single specimen in bed 590.1, Maculatum Subzone.

 Remarks. This variety is kept distinct from the normal type of *A. maculatum* only because it develops massive whorls with ‘*Liparoceras*-type’ of ornamentation at sizes of more than 100 mm diameter. Bairstow’s specimen is 120 mm diameter, and a Dorset specimen with similar whorls at 120–150 mm diameter was figured by Spath (1938: pl. 20, fig. 5) as *A. maculatum* var. *arcigerens* (Phillips).

*Aegoceras (A.) lataecosta* (J. de C. Sowerby, 1827)

1827 *Ammonites lataecosta* J. de C. Sowerby: 106, pl. 556, fig. 2.

1880/82 *Aegoceras lataecosta* (J. de C. Sowerby): Wright: 365 (1882), pl. 32, fig. 1 (1880) (holotype, BM 43916, from Drift, locality unknown).


**Range.** Single specimens in beds 591 and 594, Capricornus Subzone.

*Aegoceras (A.) artigy rus* (Brown, 1837)

1837 *Ammonites artigyrus* Brown: 26, pl. 19, fig. 5.

1843 *Ammonites defossus* Simpson: 15.

1855 *Ammonites defossus* Simpson: 48.

1884 *Ammonites defossus* Simpson: 78.

1889 *Ammonites artigyrus* Brown: 20, pl. 19, fig. 5.

1938 *Androgy noceras artigyrus* (Brown): Spath: 158, pl. 14, fig. 5, pl. 18, fig. 1, pl. 23, figs 3 (holotype, Manchester Museum LL.230, possibly from bed 593), 12, 14.

1973 *Aegoceras maculatum* (Young & Bird); Donovan & Forsey: 14, pl. 4, fig. 1 (SM B11945, paratype of *Ammonites defossus* Simpson, 1843).

1973 *Aegoceras (Oistoceras) cf. figulinum* (Simpson); Donovan & Forsey: 14, pl. 4, fig. 2 (SM B11946, lectotype of *Ammonites defossus* Simpson, 1843, designated by Donovan & Forsey).

1985 *Androgy noceras (Aegoceras) capricornus* (Schlotheim), morphotype *A. artigyrus*; Phelps: 352, pl. 2, fig. 6.

**Range.** Found by Bairstow only in bed 593, Capricornus Subzone. 4 specimens, but Phelps’ figured specimen is from bed 595.2.

 Remarks. Donovan & Forsey’s (1973: 14) designation of the Robin Hood’s Bay specimen SM B11946 as lectotype of *Ammonites defossus* Simpson, 1843, has consequences for the position of both the genus Defossiceras Buckman, 1913, and Simpson’s species *defossus*. That lectotype and the paratype (SM B11945), also figured for the first time by Donovan & Forsey, are closely similar to each other, and both have robust, quickly expanding whorls and moderately fine ribs on the inner whors. The robust whors are not like the slender whors of *Oistoceras* at similar sizes, and the ribs are more closely spaced on the inner whors than in *Aegoceras (A.) maculatum*. The ribs are projected slightly forwards on the venter of both lectotype and paratype of *defossus*, but a varying amount of projection of the ribs on the venter occurs in Capricornus Subzone species of *Aegoceras (A.)*, though it is never as pronounced as in the later subgenus *Oistoceras*. The holotype of *A. (A.) artigyrus* figured by Spath (1938) has similarly robust whors, the same rib-density on the inner whors and similar slight forward projection of the ribs on the venter. This is considered here to be the best place for *defossus*, and places the genus Defossiceras as a junior synonym of Aegoceras (*A.*) (ie. not a synonym of the subgenus Oistoceras), and the species *defossus* as a junior synonym of Aegoceras (*A.*) artigyrus.

Subgenus *BEANICERAS* Buckman, 1913

*Aegoceras (Beaniceras) luridum* (Simpson, 1855)

1855 *Ammonites luridus* Simpson: 46.

1913 *Beaniceras luridum* (Simpson); Buckman: pl. 73 (holotype, SM J3274).

1961 *Beaniceras luridum* (Simpson); Dean et al.: pl. 69, fig. 6 (holotype, SM J3274, possibly from bed 583.2) (see description of Maculatum Subzone, p. 150 below).

**Range.** Beds 578.1–580, Luridum Subzone; 8 specimens; possibly also from bed 583.2, Maculatum Subzone.

 Remarks. Although the eight specimens in beds 578 and 580 are crushed, they are much larger (up to 37 mm diameter) and more compressed than *A. (B.) centaurus* (d’Orbigny), and so can be confidently referred to *A. (B.) luridum*.

Subgenus *OISTOCERAS* Buckman, 1911

*Aegoceras (Oistoceras) sinuosiforme* Spath, 1938

1938 *Oistoceras sinuosiforme* Spath: 167, pl. 18, fig. 6, pl. 19, fig. 7 (holotype, BM C.38564), pl. 26, figs 6, 7, 9 (all Spath’s figured specimens are from Lincolnshire).

**Range.** Beds 596.2–598.1, Figulinum Subzone: 93 specimens.

 Remarks. *A. (O.) sinuosiforme* has more widely spaced ribs and much less well-developed chevrons on the venter than *A. (O.) figulinum*.

*Aegoceras (Oistoceras) angulatum* (Quenstedt, 1856)

1856 *Ammonites maculatus angulatus* Quenstedt: 121, pl. 14, fig. 12.

1885 *Ammonites maculatus angulatus* Quenstedt; Quenstedt: 270, pl. 34, fig. 11.
1938 *Oistoceras angulatum* (Quenstedt): Spath: 171, pl. 21, fig. 5 (from France). pl. 22, fig. 5 (from Lincolnshire). pl. 26, figs 10, 12 (both from Lincolnshire).

1976 *Androgynoceras (Oistoceras) angulatum* (Freboldt, 1922) (sic): Schlegelmilch: 69, pl. 34, fig. 4 (from Germany).

1985 *Androgynoceras (Oistoceras) angulatum* (Quenstedt): Phelps: 354, pl. 2, fig. 4 (from Germany).

**Range:** Bed 599, Figulinum Subzone; 1 specimen.

**Remarks:** Quenstedt (1856: 121) had specimens from Metzingen and Iggingen, Germany, and he figured one from the former locality. So the original of Quenstedt (1884: pl. 34, fig. 11), refuged by both Schlegelmilch (1976: pl. 34, fig. 11) and Phelps (1985: pl. 2, fig. 4), is almost certainly a syntype and can be designated lectotype; its designation by Schlegelmilch as the neotype is not correct. *A. (O.) angulatum* is more evolute, has more slowly expanding whorls, has no ventro-lateral tubercles, and has fewer ribs on the inner whorls, than *A. (O.) figulinum*. The angle of the ribbing varies between rectiradiate and prorsiradiate in both species.

*Aegoceras (Oistoceras) figulinum* (Simpson, 1855)

1855 *Ammonites figulinus* Simpson: 47.

1855 *Ammonites omissus* Simpson: 47.

1876 *Aegoceras defossum* (Simpson): Blake: 282, pl. 8, fig. 9 (SM J17988, see Donovan & Forsey, 1973: 13).

1911 *Oistoceras figulinum* (Simpson): Buckman: pl. 26A (holotype, WM 115).

1911 *Oistoceras omissum* (Simpson): Buckman: pl. 27 (holotype, WM 502, now lost).

1938 *Oistoceras figulinum* (Simpson): Spath: 162, pl. 19, fig. 10 (BM C.17988), pl. 22, fig. 8 (BM 37973a).

1938 *Oistoceras omissum* (Simpson): Spath: 170, pl. 21, fig. 3 (BM 38561).

1955 *Oistoceras aff. figulinum* (Simpson): Howarth: 161, pl. 11, fig. 4 (SM J35968, from bed 600.4).

1976 *Androgynoceras (Oistoceras) figulinum* (Simpson): Schlegelmilch: 69, pl. 34, fig. 3 (WM 115, holotype).

1985 *Androgynoceras (Oistoceras) figulinum* (Simpson): Phelps: 353, pl. 2, fig. 1 (from bed 600.2).

1987 *Oistoceras figulinum* (Simpson): Dommergues: pl. 11, figs 5, 6.

**Range:** Beds 600.2 and 600.4, Figulinum Subzone; 20 specimens.

**Remarks:** This is the most highly developed species of *Oistoceras*, which has fine ribs on the inner whorls, small ventro-lateral tubercles, and well-developed chevrons in the ribs that are connected together into a rudimentary pseudo-keel along the middle of the venter.

**Other species of Oistoceras from Yorkshire:**

1. *A. (O.) curvicorne* (Schloenbach, 1863): Spath. 1938: 164, pl. 19, fig. 11 (BM C.19228; indeterminate inner whorls), pl. 22, fig. 9 (BM C.6235); both of Spath’s figured specimens were probably from Staithes, not Robin Hood’s Bay.

2. *?A. (O.) angulatum* (Phillips. 1829: 163, pl. 13, fig. 19: 1835: 135, pl. 13, fig. 19: 1875: 270, pl. 13, fig. 19); the type specimen is lost, and Phillips’ figure cannot be interpreted.

**Genus ANDROGYNUOCERAS** Hyatt, 1867

*Androgynoceras heterogenes* (Young & Bird, 1828)

1828 *Ammonites heterogenes* Young & Bird: 264, pl. 14, fig. 7.

1880/82 *Aegoceras heterogenum* (Young & Bird): Wright: 370 (1882), pl. 35, figs 4-6 (1880) (SM J18229), pl. 36, figs 1-4 (1880) (BM C.1870).

1912 *Androgynoceras heterogenes* (Young & Bird): Buckman: pl. 46 (holotype, WM 195).

1938 *Androgynoceras heterogenes* (Young & Bird): Spath: 113, pl. 13, figs 7a (BM C.19225), 7b (BM C.38457), pl. 20, fig. 2 (BM C.38496, as var. *gigas* from bed 590.61).

**Range:** Maculatum Subzone: Bairstow found single specimens in beds 583.2 and 588, but BM C.38496 definitely came from bed 590.61, and the other figured specimens are probably from bed 590.63.

**Order** NAUTOILOIDEA

**Family** NAUTOILOIDAE d’Orbigny, 1840

**Genus** CENOCERAS Hyatt, 1883

*Cenoceras striatus* (J. Sowerby, 1817)

1817 *Nautilus striatus* J. Sowerby: 183, pl. 182 (3 figures, all syntypes, from Dorset).

1829 *Ammonites annularis* Phillips: 163, pl. 12, fig. 18: 1835: 134, pl. 12, fig. 18: 1875: 263, pl. 12, fig. 8.

1855 *Ammonites heterogeneus* Simpson: 33.

1956 *Cenoceras striatus* (J. Sowerby): Kummel: 362, pl. 3, figs 1, 2 (BM 43852, from Dorset).

1962 *Cenoceras heterogeneum* (Simpson): Howarth: 96, pl. 13, fig. 1 (holotype, WM 442).


**Range:** Bairstow found single specimens in beds 464.32, 468 (both Simpsoni Subzone) and 505.1 (Taylori Subzone).

**BIOSTRATIGRAPHY**

In the description below the ammonite distribution and the placement of the boundaries are discussed for all the zones and subzones in Robin Hood’s Bay. Additionally, it is noteworthy that Wine Haven at the south-eastern end of the bay has recently been proposed as the world standard for the definition of the base of the Pliensbachian Stage.

The scheme of ammonite zones used here is based on that regularized by Dean, Donovan & Howarth (1961), with a few later refinements to the details of some of the definitions. Cariou & Hantzpergue (1997) used the same scheme of divisions for the Sinemurian and Lower Pliensbachian in eastern France and the central Mediterranean area. The distribution of the ammonites, on which the biostratigraphical divisions are based, is shown in detail in Figs 21, 22, 24 and 25, which give the number of specimens of each species found in each bed, and a visual indication of the range of each species.

**Lower Sinemurian**

**Semicostatum Zone, Sauzeanum Subzone**, beds 418-429.64. No ammonites were found in beds 418-420, which are the first 2.48 m of strata exposed above the lowest level to which the tide ever falls in Robin Hood’s Bay. Above this, *Euagassiceras* occurs up to about the middle of the subzone, and *Coroniceras* (Arietites) *alcinoe* occurs in a broad middle part of the subzone: both are...
**LOWER LIAS OF ROBIN HOOD’S BAY**

- **ZONE**
  - **SUBZONE**
    - **BED**
      - Lower Lias
        - *Euagassiceras resupinatum*
        - *Arnioceras preplotti*
        - *Caenisites brooki*
        - *Promicroceras capricornoides*
        - *Microderoceras birchi*
        - *Microderoceras scoresbyi*
        - *Promicroceras hippocrepialis*
        - *Promicroceras capricornoides*

**Fig. 21** Distribution of ammonites in the Lower Sinemurian of Robin Hood’s Bay.

characteristic of the Sauzeanum Subzone. *Arnioceras semicostatum* is common through most of the subzone.

**TURNERI ZONE**, **Brooki Subzone**, beds 429.7–433.2. The only ammonites found in the beds that are allocated to this subzone are seven *Caenisites brooki* in the middle part and two *Arnioceras sp.* indet. in the middle and lower beds. *Caenisites brooki* probably only occurs in the upper or top part of the subzone (Dean et al., 1961: 453), and the ammonite *Caenisites preplotti* Spath, which is characteristic of the base of the subzone, does not occur in Robin Hood’s Bay. So the Brooki Subzone has to be defined according to the boundaries of the adjoining subzones: the highest occurring *Coroniceras* (*Arietites*) *alcinoe* in bed 429.6 at the top of the Sauzeanum Subzone defines the base of the Brooki Subzone at the bottom of bed 429.7, and the appearance of *Microderoceras birchi* in bed 433.3 at the base of the Birchi Subzone defines the top of the Brooki Subzone at the top of bed 433.2.

**Birchi Subzone**, beds 433.3–446.2. This subzone is generally considered to correspond to the range of *Microderoceras*: five *M. birchi* occur in bed 433.3, so defining the base of the subzone, and a single

*M. scoresbxi* occurs in bed 441.2 at the middle of the subzone. The top of the subzone is delimited by the appearance of the first *Asteroceras* at the base of the Obtusum Zone. *Caenisites brooki* persists into the basal bed (433.3) of the Birchi Subzone, and the same bed also contains 24 examples of *Caenisites turneri*. *Promicroceras capricornoides* appears just above the lowest part and extends to the top of the subzone. There are no other ammonites in the subzone.

**UPPER SINEMURIAN**

**OBTUSUM ZONE**, **Obtusum Subzone**, beds 446.31–446.5. The base of both zone and subzone is drawn at the first appearance of a single *Asteroceras* in bed 446.31; that specimen is a definite example of the genus, but is not specifically determinable. The only specimen of *A. obtusum* that was found occurs in the overlying bed 446.32, and *A. confusum* is more common in beds 446.32 and 446.33. *Promicroceras capricornoides* persists into the lowest two beds of the Obtusum Subzone, then is immediately replaced by *P. planicosta* for the remainder of the subzone; the two species do not overlap. Other ammonites are *Xipheroceras dudrressieri* (confined to the subzone) and *X. ziphus*, *Epophioceras landrioti* in the upper half and *Cymbites laevigatus* at the top of the subzone.

**Stellare Subzone**, beds 447–455.1. The base of the subzone is placed at the first appearance of the distinctive index species *Asteroceras stellare*, which ranges up to the middle of the subzone, and the top is limited by the first *Eparietites* at the base of the Denotatus subzone. In the upper half of the subzone the index species is replaced by *Asteroceras blakei*, which persists into the overlying subzone. *Aegasteroceras crassum* appears at about the middle of the subzone, then *A. sagittarium* occurs in the top part. *Promicroceras planicosta* is very common in all but the highest beds of the subzone, and 262 specimens were collected by Bairstow. Other ammonites in the subzone are *Cymbites laevigatus*, *Xipheroceras ziphus*, and *Epophioceras landrioti* near the base.

**Denotatus Subzone**, beds 455.2–462. The base of this subzone is placed at the first appearance of the genus *Eparietites*, i.e. the new species *E. bairstowi*, which is more evolute and has thicker and more massive whorls than any other *Eparietites*. The main species ranging through the middle and upper parts and up into the Simpsoni Subzone is *E. impendens*. From the subzone below *Asteroceras blakei*, *Aegasteroceras crassum* and *A. sagittarium* persist into the bottom and middle parts of the Denotatus Subzone. *Cymbites laevigatus* occurs throughout the subzone, and the Schlotheimid *Angulatriceras* sp. indet. occurs in the top two beds.

**OXYNOTUM ZONE**, **Simpsoni Subzone**, beds 463–471. The base of the subzone is placed at the first appearance of the index species *Oxynoticeras simpsoni* in bed 363, where there are two large specimens that show typical characters of the species; there are four more specimens in bed 464.3, poorly preserved examples in beds 465 and 466, then the species becomes common in bed 467 and 468 in the mid to upper part of the subzone. From the subzone below, *Eparietites impendens* persists into beds 463–464.32, where it overlaps with *O. simpsoni* in the bottom 1.68 m of the Simpsoni Subzone. In fact at its highest level in bed 464.32 there are many typical *E. impendens*. A similar overlap between *E. impendens* and *O. simpsoni* is also found in the top part of the Frodingham Ironstone near Scunthorpe, Lincolnshire.

*Gagaticeras* is characteristic of the upper half of the Simpsoni Subzone, from bed 467 upwards, where there are many specimens belonging to four species, *Palaeoechiceras* occurs in bed 467, and
Fig. 22
Distribution of ammonites in the Upper Sinemurian of Robin Hood's Bay.

M. K. HOWARTH
Cymbites laevigatus and Angulaticeras sp. indet. occur in the lower half of the subzone.

**Oxynotum Subzone**, beds 472.1–486.2. More involute and compressed Oxynoticeras like O. oxynotum rather than O. simpsoni first occur in bed 472.1, so the base of the subzone is placed at that level. Better specimens occur higher in the subzone, as well as fragments of large specimens. Other oxynoticeratids present are two possible specimens of Paroxynoticeras salisburgense in the lower half, and Gleviceras doris and G. guibalianum in the upper half of the subzone. Angulaticeras sp. indet., Bifericeras bifera and B. cf. vitreum, also occur in the upper half of the subzone.

**Raricostatum Zone**, **Densinodulum Subzone**, beds 486.3 and 487. The base of the subzone is placed at the first appearance of Crucilobiceras in bed 486.3 and the top is limited by the first occurrence of Echioceras in bed 488 marking the base of the Raricostatoidea Subzone. So the Densinodulum Subzone consists only of the 1.0 m thick beds 486.3 and 487. C. densinodulum is abundant in bed 486.3, but there are no other ammonites in the subzone.

**Raricostatoidea Subzone**, beds 488–493.5. The base of the subzone is placed at the first appearance of Echioceras: E. raricostatoidea in the basal one-third of the subzone is followed by E. intermedium in the middle part, then by Paltechioceras planum in the upper one-third of the subzone. Crucilobiceras densinodulum persists from the subzone below into the basal bed, and the only other ammonite in the subzone is Eoderoceras hastatum in the upper part.

**Macdonelli Subzone**, beds 494–495.7. This subzone is based on the range of the index species Leptechioceras macdonelli, which occurs in the top and bottom beds and does not range higher. The earliest Eoderoceras armatum occurs in the bottom bed, and the first Polymorphytid, Gemmellaroceras tubellum, occurs in the top bed. The only other ammonites present are the Oxynoticeratids Gleviceras guibalianum near the top of the subzone and Radstockiceras bavignieri in the bottom bed. The latter record seems to be the first provable occurrence of Radstockiceras in the Raricostatum Zone.

**Aplanatum Subzone**, beds 496–500. The base of the subzone is placed at the first occurrence of Paltechioceras regustum, and P. tardecrescens (of which P. aplanatum is a synonym) becomes abundant in the middle and upper parts of the subzone. Paltechioceras first occurs in the top part of the Raricostatoidea Subzone, but the genus is much more common in the Aplanatum Subzone and does not range higher. Another ammonite that is characteristic of the Aplanatum Subzone is Eoderoceras armatum, which first appears as rare examples in the Macdonelli Subzone, but becomes much more common in the Aplanatum Subzone; it ranges up to 0.15 m below the top of bed 499, but it does not occur higher and does not overlap with Apoderoceras in the Taylori Subzone. Gemmellaroceras tubellum is common in the middle part, and Gleviceras guibalianum occurs in the lower part of the subzone.

**LOWER PLIENSCHIAN**

The exposures at the base of the cliff in Wine Haven, Robin Hood’s Bay, have recently been proposed as the Global Stratotype Section and Point (GSSP) for the base of the Pliensbachian Stage (Hesselbo et al., 2000). The sequence across the Sinemurian/Pliensbachian boundary is sufficiently expanded and rich in ammonites here to be suitable for such an important global reference section. Hesselbo et al.’s (2000: 604, fig. 4) stratigraphical sequence is closely similar to the sequence described here, as are their ammonite records and identifications. Their bed 73 at the base of the Pliensbachian is the same as bed 501 here (see the correlation table of Fig. 19), and their photograph (Hesselbo et al. 2000: fig. 3) shows the nodules of their bed 72 (=bed 500 here) and the basal reference point of the Pliensbachian low in the cliff at Wine Haven.

Fig. 23 shows details of the stratigraphical distribution of Bairstow’s ammonites at the Sinemurian/Pliensbachian boundary. The first ammonites to occur above the boundary are 16 Bifericeras donnovani Dommergues & Meister (one is figured in Pl. 8, fig. 3) and
two *Apoderoceras subtriangulare* (Young & Bird) (Pl. 5, fig. 8) 0.13–0.22 m above the bottom of bed 501.1. Hesselbo *et al.* (2000) did not find ammonites in the 1.8 m of strata below the base of the Pliensbachian (i.e. in the nodules of bed 500 and the shales of bed 499). Bairstow did not find ammonites in bed 500, but he collected six specimens of *Euderoceras armatum* from bed 499 in the middle of the bay near Robin Hood's Bay town. These are well-preserved, readily identifiable examples of the species (one is figured in Pl. 8, fig. 2), and Bairstow's records show that they were collected 0.15–0.37 m above the base of that bed. A single *E. armatum*, less well-preserved than those lower down, but still readily identifiable with that species, was collected from Wine Haven high in bed 499, only 0.15 m from the top. The thickness of strata across the Sinemurian/Pliensbachian boundary from which no ammonites have been collected is thus reduced to only 0.36 m.

**JAMESONI ZONE, Taylori Subzone**, beds 501.1–537. The base of the subzone (and the Jamesoni Zone, and the Pliensbachian Stage) is placed at the bottom of bed 501.1, which contains the lowest occurrence of the characteristic genus *Apoderoceras*, and this is the only horizon at which *Bifericeras donovani* Dommergues & Meister occurs. *Phricodoceras taylori* and other species of *Phricodoceras* are present through much of the subzone and do not range higher. Many examples of *Gemmellaroceras tubellum* are found near the base of the subzone, and the larger species *G. rutilans* occurs in the top part. A single specimen of *Radstockiceras buvignieri* was also.

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**Fig. 24** Distribution of ammonites in the Jamesoni Zone. Lower Pliensbachian, of Robin Hood's Bay.
found in the subzone, along with widely scattered specimens of *Tragophylloceras numismale*.

**Polymorphus Subzone**, beds 538-544.5. The first appearance of *Polymorphites* marks the base of this subzone. The earliest species is *P. caprarius* which occurs in the bottom half of the subzone, followed by *P. trivialis* in the upper half. The latter species extends into the Brevispina Subzone, and other species occur in the Jamesoni Subzone. The only other ammonites in this subzone in Robin Hood’s Bay are the last examples of *Tragophylloceras numismale*, a single *Hyperderaceras* sp. indet. low in the subzone and the oxynoticeratid genus *Radstockiceras*: the small species *R. sphenonotum* is confined to the Polymorphus Subzone, and another much larger fragment of a *Radstockiceras* was found in bed 544.4 near the top of the subzone.

**Brevispina Subzone**, beds 544.6-549. The base is placed at the first appearance of *Platypleuroceras brevispina*, which is common throughout the subzone and extends up to its highest occurrence in the basal bed of the Jamesoni Subzone. Many of those in beds 544 and 546 are large, crushed and fragmentary, though they show the

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**Fig. 25** Distribution of ammonites in the Ibex and Davoei Zones, Lower Pliensbachian, and in the base of the Margaritatus Zone, Upper Pliensbachian, of Robin Hood’s Bay.
typical features of the species. The more evolute *P. aureum* occurs in the middle part of the subzone, and the more finely ribbed *P. obsoleta* is represented by only one specimen in Bairstow’s collection from the lower part of the subzone. *Polymorphites trivalis* is common in the lower and middle parts of the subzone, and there are rare occurrences of *Radstockiceras*, *Parinodiceras* and *Tragophylloceras*.

**Jamesoni Subzone**, beds 550–560.3 (except the top 0.08 m)–577. These two subzones are delimited according to the *Liparoceras (L.) heptangulare*. and rare examples of are not well-preserved. None, however, have the definite bituberculate *naptonense*. In the Valdani Subzone. Unfortunately ammonites are rare in this *maculatum* vars. *evidence to refer beds 578 to 580 to the Luridum Subzone. Other Tropidoceras (d'Orbigny). var. *560.3 to include this earliest *Tropidoceras*, in which umbilical tubercles are much reduced or absent. The lowest example (Pl. 7, fig. 10) from the top 0.08 m of bed 560.3 and another (Pl. 7, fig. 11) from near the bottom of bed 568 are best determined as *T. futtereri* (Spath), while several specimens from the boundary of beds 567 and 568 have the much more massive ribs at larger sizes and the more widely spaced ribs of *T. maseanum* (d’Orbigny), var. *rotundum* (Futterer). The base of the Masseanum Subzone (and of the Ibex Zone) is placed 0.08 m below the top of bed 560.3 to include this earliest *T. futtereri*, and bed 568 probably belongs to the same subzone.

In the absence of *Acanthopleuroceras* there is no good evidence for the position of the base of the Valdani Subzone, so it is placed provisionally at the bottom of bed 571 from the occurrence of *Liparoceras (L.) heptangulare*. There are two more specimens of that species in beds 575 and 577. According to Spath (1938: 59) *L. (L.) heptangulare* might be confined to the Valdani Subzone (ie. Spath’s ‘Centaurus Subzone’), so its presence in beds 571–577 (7.66 m thick) suggests that they are probably of Valdani Subzone age.

The only other ammonites in either subzone are two *Liparoceras (L.) chelitense* low in the Masseanum Subzone, one *Tragophylloceras loscombi* high in the same subzone, and *Lytoceras fimbriatum* in the upper part of the Masseanum Subzone and throughout the Valdani Subzone. The latter species becomes more common in the Luridum Subzone.

**Luridum Subzone**, beds 578.1–580. The presence of eight *Aegoceras (Beaniceras) luridum* in beds 578.1, 578.5 and 580 is sufficient evidence to refer beds 578 to 580 to the Luridum Subzone. Other ammonites in this subzone are a single *Liparoceras (L.) cf. naptomense*, two *Liparoceras (L.) sp. indet.* and 14 examples of *Lytoceras fimbriatum*.

**Davoel Subzone, Maculatum Subzone**, beds 581–590.7. The base of this zone and subzone is placed at the bottom of bed 581 which contains the lowest *Aegoceras (A.) maculatum* (Pl. 7, fig. 12). Two more, typical examples occur in bed 582.3, then there are many well-preserved specimens at higher levels, especially in beds 590.61 and 590.63. Other ammonites in the Maculatum Subzone are *A. (A.) maculatum* vars *atatium* and *leckenbyi*, *Liparoceras (L.) cf. naptomense*, *Andrognyceras heterogenes* and *Lytoceras* sp. indet. See remarks on the identification of *Aegoceras maculatum* (p. 141) for discussion of the division of the Maculatum Subzone into smaller units.

**Capricornus Subzone**, beds 591–596.1. The base of the subzone is placed at earliest occurrence of *Aegoceras (A.) lataecosta* in bed 591. This is 1.83 m above the highest *A. (A.) maculatum* in bed 590.63, but the intervening strata (beds 590.64–590.7) did not yield any ammonites and are retained in the Maculatum Subzone. The only other ammonites in the subzone are *A. (A.) artigyrus*, which has more massive whors and coarser ribbing than *lataecosta*, and a number of poorly preserved *Aegoceras (A.)* sp. indet.

**Figulinum Subzone**, beds 596.2–600.5. This subzone is based on the range of the subgenus *Ostoceras*. The index species, *Aegoceras (Oistoceras) figulinum*, occurs in beds 600.2 and 600.4 near the top of the subzone, but the base of the subzone is placed at the lowest appearance of *A. (O.) sinuosiforme* in bed 596.2. This and *A. (O.) angulatum* in bed 600.2 have more widely spaced ribs than *figulinum*, especially on the inner whors. The only other ammonite in the subzone is a single *Liparoceras (L.) divaricosta* in bed 596.3 (Pl. 8, fig. 1).

The top of the subzone is limited by the base of the Stokesi Subzone (Margaritatus Zone. Upper Pliensbachian), which is placed at the first appearance of *Amaltheus stokesi* in bed 600.6. There are other examples of *A. stokesi* in bed 600.8 and at higher levels in the Stokesi Subzone. *Aegoceras (Oistoceras) figulinum* and *Amaltheus stokesi* are confined to their respective subzones in Robin Hood’s Bay and their ranges do not overlap.

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