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A MONOGRAPH

ON THE

INFERIOR OOLITE AMMONITES

OF

THE BRITISH ISLANDS.

BY

S. S. BUCKMAN, F.G.S.

PART I.

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INFERIOR OOLITE AMMONITES.

It was with great hesitation that I offered to prepare a Monograph on the Inferior Oolite Ammonites. I was, however, strenuously urged to do so by Dr. Davidson,[1] to whom I am greatly indebted for every possible kindness and encouragement, which I most gladly acknowledge. When I considered the vast amount of study and labour that such a monograph would entail, and compared the limited amount of time at my disposal owing to the cares of business, I was for deferring my work or giving to others with more leisure the opportunity to undertake the task. Dr. Davidson, however, pointed out to me the advantage that I had of a very large amount of material collected during many years by my father and myself, and also that I was acquainted with the different localities and horizons from which the various species came, by having myself obtained and developed so large a number of them. This, however, only applies to a small area of the Inferior Oolite in the South-west of England, and I must rely on the kindness of correspondents to enable me to figure those species which occur in this formation in other districts. It is, however, pretty well known that the Inferior Oolite in the South-west of England contains a far larger proportion of Ammonites than any other district except perhaps Dundry. With the Dundry beds I am not actually acquainted, but the Ammonites that I have seen from them are certainly in every way similar to ours in the South-west.

As far as possible I intend to figure the best procurable examples, and also enough specimens to show the different ages and variations of each species, so that it may without doubt be easily recognised. It sometimes happens to be a very hard matter to show in a plate the particular characters which dis-

[1] Since the above was written, I unfortunately have to say "the late Dr. Davidson." I cannot take a better opportunity to express my sorrow, and to acknowledge the unfailing kindness which I always received from him.

tinguish a certain species from any others, but I shall endeavour to point them out as clearly as possible in my descriptions. I would also draw particular attention to the study of the suture lines of Ammonites, which has, in many cases, been very much neglected, and I hope to be able to give an accurate delineation of those of each species which will come under my notice.

Geological Characters.

The first point to be considered is the vertical extent of those beds of the Ammonites which I propose to describe, that is to say, the limits of the Inferior Oolite, its commencement and its close. And it is more especially with the former of these questions—whether certain beds belong to the Inferior Oolite, or should be classed as a continuation of the Upper Lias—that we have to deal, since the different development of these, so to speak, intermediate beds in different districts has given occasion for a large amount of writing and a great difference of opinion, and has been the frequent cause of confusion. The subdivision of formations into zones and subzones will most probably help us to more thoroughly elucidate the matter, and leave us with a single point to determine, namely, whether a particular zone shall belong to the Lias or Inferior Oolite. Upon this matter it may be as well to give shortly the opinions of a few authorities. For instance, Dr. Oppel, who studied the whole of the Jurassic rocks in England, France, and Germany, and who was probably the first to separate the various formations into zones, gives in his work,[1] page 305, the Torulosus-bett as the lowest bed belonging to the Inferior Oolite, and underneath he ends the Upper Lias with the Jurensis-bett; see also his opinion, page 299. Between the Murchisonæ and Jurensis beds he places two others, the Trigonia navis bed and the Torulosus bed. These two are now generally united under the name of "Opalinum-zone." Therefore Dr. Oppel begins the Inferior Oolite with the "*Opalinum-zone*." The next point to determine is what Dr. Oppel calls the Torulosus bed, and on this point we have his opinion on page 296 of the same work, where he gives a section of Frocester Hill, and there places the upper portion of the Ammonite bed in the zone of Torulosus and the lower portion in the zone of Jurensis, making the division between Lias and Oolite in the middle. So far we have the opinion of one authority as to the proper starting point of the Inferior Oolite in Gloucestershire, and of course according to his decision we should know the beginning of the Inferior Oolite in other parts to be with the zone of Torulosus, provided we can determine the position of the said zone.

[1] Oppel, 'Die Juraformation Englands, Frankreichs und des Südwestlichen Deutschlands,' 1856—1858.

Prof. Quenstedt in his 'Cephalopoden,' page 12, would seem to make the division between Lias and Oolite between the bed with Jurensis and that of Opalinus. At any rate his "Schwarzer Jura" ends with the Jurensis bed and his "Brauner Jura" begins with that of Opalinus.

My father, the late Prof. Buckman, wrote several papers on the Oolites, and more especially the Inferior Oolite of Gloucestershire and Dorset, with both of which counties a long residence had made him well acquainted. Whilst in the former county, and even afterwards, he wrote several pamphlets to combat Dr. Wright's upward extension of the Upper Lias, so as to include the sands and the Frocester Hill Cephalopoda bed, because my father contended that not only the Cephalopoda bed, but also the sands below, should be included in the Inferior Oolite as is shown by a section of Frocester Hill (Buckman, 'Journal Geological Society,' 1857, page 103), and he also contended that these sands were in reality on the same horizon as the Pea Grit (Pisolite) beds of other parts of the Cotteswolds, and differed from them only by their chemical composition having produced sand instead of stone.

This view as to the sands and Pisolite beds we find in 1857 expressed as follows. "What, then, is here meant by the *equivalents of the sand?* My present opinion is, that the sands of Frocester are identical in time with the mixed pisolitic beds of the Cheltenham district, and that the iron-shot sands of the Dundry Hill and Somerset sections are also of the same period; the pisolitic conditions prevailed in one part of the Oolite sea, and sandy ones in another; and hence the difference of the fauna."[1] After my father had removed to Dorset and had the opportunity of studying the Inferior Oolite there, we find the same view expressed in a paper read to the Somersetshire Archæological and Natural History Society on the Cephalopoda bed, &c., in 1874, viz. (page 7): "The so-called 'Lias or Oolite Sands' underlying the Bradford Oolitic stone are really the representatives of the lower members of the Inferior Oolite of Gloucestershire, at least for 100 feet of their thickness," and we have the Dorset Cephalopoda bed defined as the representative of the Rubbly Oolite at the top of Leckhampton Hill and Cold Comfort, or the equivalent of the Gryphite and Trigonia Grits (see same page). For further remarks on this subject I must refer the reader to another paper on "The so-called Midford Sands," 'Quarterly Journal Geological Society,' 1879, by my father. Now, if these opinions as to the correlation of the Midford or Yeovil Sands with the Pisolite beds of Cheltenham district be correct, those sands naturally belong to the Inferior Oolite as my father contended, and he would therefore commence the Inferior Oolite with the Murchisonæ-zone; but for this he had to suppose the existence in Dorset of two portions of sands separated by a Cephalopoda bed, the

[1] "The Oolitic Rocks of Gloucestershire and North Wilts," by Prof. Buckman, 'Quart. Journ. Geological Society,' vol. xiv, 1857, p. 106.

upper portion of these sands being equivalent to the Pisolite and the lower portion to the sands and marls of the Upper Lias which occur in Gloucestershire. I shall give some further opinions on this view presently.

In reading the descriptions of Brachiopoda by M. E. Deslongschamps, 1862, we find that he places between the Oolite and the Lias certain beds which he calls Infra-Oolitic marls. In these Infra-Oolitic marls he places the Opalinum-, Murchisonæ-, and Sowerbyi-zones (see pages 213, 209, &c.), and he would seem to wish to begin the Inferior Oolite proper with the zone of Am. Sauzei. Mr. Hudleston once suggested the proposal of two large divisions for the Inferior Oolite, the one called the Harpoceras-zone to end with the Sowerbyi-bed, because Ammonites belonging to the division Harpoceras are the characteristic fossils, the other to contain the Sauzei-, Humphriesianum-, and Parkinsoni-zones and to be called the Stephanoceras-zone, or probably I would rather suggest, Stephanoceratites-zone. This, however, is a digression, and does not help us to determine the lowest zone of the Inferior Oolite, except that it shows how a division could be made. Deslongschamps has recognised this, and proposed to make as it were a small intermediate formation, as if to combine the various views of different authors, under the name Infra-Oolitic marls. It must, however, be noticed that he ends the Lias with the Jurense-zone.

Dr. Wright, in his 'Monograph on the Lias Ammonites,' at page 148 (Palæontographical Society, vol. xxxiii, 1879) brings in the Opalinum-zone as the highest zone of the Lias; and after describing where it occurs and its characteristics, he says, "From the Haresfield bed I have taken a piece of rock having the impression of *Harpoceras opalinum* on its underside, whilst the block itself contained Inferior Oolite fossils." These words to my mind do not point to any great advantage in making the division between Lias and Oolite at a point where the zones are so intimately connected, unless the majority of authors express a preference for this as the distinguishing point. At the same time it could probably be urged that wherever the distinction were drawn some locality or other would present this difficulty. Dr. Wright has, however, so far carried out his opinion that he has figured and described in his Monograph a number of Ammonites from the Opalinum-zone. Consequently, even if it be determined, that it is advantageous that the Opalinum-zone should belong to the Inferior Oolite, I should find part of my work done by Dr. Wright. It is not improbable, however, that wherever the division between Lias and Oolite may be drawn, I may have some species to describe from the Opalinum-, and perhaps Jurense-zone, so as to be able to connect Dr. Wright's splendid 'Monograph on the Lias Ammonites' with the present work without any break.

Dr. Branco, in 'Der Untere Dogger Deutsch-Lothringens' (page 14), begins his description of the Dogger as follows:—"(1) Die Schichten mit *Harpoceras*

striatulum. (*a*) Unterregion: Thone mit *Astarte Voltzii* und *Cerithium armatum* ('Oppel's Zone des Amm. torulosus')."

I have now given the opinions, as far as I have been able to ascertain them, of a few of the authors who have made the Inferior Oolite their study, and it certainly seems that the more usual custom is to divide the Lias from the Oolite at the top of the Jurense-zone, of course commencing the Inferior Oolite proper with the Opalinum-zone. I now propose to give some few sections of the beds of the Inferior Oolite to try and clear up some of the differences which exist as to their correlation, and I think I shall be able to clearly prove that the Yeovil Sands and the Cotteswold Sands are identical, and that the Inferior Oolite in the South of England, although not very thick, contains good representatives of all the zones into which that formation has been divided in different countries.

The following is a section of the Inferior Oolite showing its relation to the sands below. This section is as it were made up of two portions; the first, from Nos. 1 to 7 inclusive, is taken, with some slight alterations and additions, from my paper read to the Geological Society on the Inferior Oolite Ammonites, 1881, and is the result of my own observations. For the lower part of the section I am indebted to my father's paper on the Cephalopoda bed.[1] This is a very carefully measured section of the sands of Babylon Hill near Yeovil; and, although it is situated about a mile from the quarry which my section represents, yet there is on the top of the hill a quarry (Anbury) which is, stone for stone, the exact counterpart of the Bradford Abbas East Hill Quarry, indeed I do not know any species which the one possesses foreign to the other, their Fauna and lithological characters being practically identical. For further evidence on this point see my father's paper just quoted, page 3.

Section of the Inferior Oolite and the Sands at Bradford Abbas, Dorset.

	Ft.	In.	
1	6	6	White Oolite, rather soft, almost unfossiliferous except in its lower part.
2	0	3	Marl bed, contains *Tereb. Morieri, Rhynch. parvula, Wald. carinata.*
3	0	6	Bluish stone, contains small *Stephanoceras Humphriesianum, Tereb. sphæroidalis.*
4	0	6	Irony stone, contains one or two species of *Harpoceras.*
5	2	0	Yellowish stone, contains a quantity of Gasteropoda and Ammonites.
6	1	0	Yellowish brown stone, comes out in large slabs.
7	1	2	Very hard blue centred stone, contains many fragments of shells, also *Harpoceras Moorei,* Lyc.
8	?		A slight break of uncertain amount, but not more than 10 feet.
9	5	0	Fine yellow sands.
10	0	9	Sands with stone, or hardened sandy stone.
11	1	6	Fine yellow sands.
12	1	0	Sands with stone, or hardened sandy stone.
13	10	0	Sands with irregular stone.
14	2	6	Sands with stone, or hardened sandy stone.
15	15	0	Sands with irregular stone.
16	2	0	Stone.
17	5	0	Fine yellow sands.
18	2	9	Irregular masses of stone.
19	4	0	Fine yellow sands.
20	1	6	Two bands of stone.
21	3	6	Fine yellow sands.
22	2	0	Stone.
23	50	0 about.	Sands with occasional layers of stone in the upper part.

[1] "The Cephalopoda Bed and Oolite Sands," by Prof. Buckman, 'Proceedings Somersetshire Archæological Soc.,' vol. xx, 1874.

This section contains the following zones:

1 and 2. Parkinsoni-zone.
3. Probably representative of Humphriesianum-zone.
4. Perhaps equivalent to the Sauzei bed at Oborne.
5. Sowerbyi-zone.
6. Murchisonæ-zone.
7—23 (7 ?). Jurense-zone.

This section and the one of Stroud Hill given below show how remarkable is the difference in thickness between the rocks of the Inferior Oolite at Bradford Abbas and Stroud, but that there is not really so very much difference in the thickness of the Yeovil and the Cotteswold Sands. The Dorset section, however, does not give the full depth of the sands at this point as it could not be exactly ascertained right down to the Lias shales.

These sands are extraordinarily well exposed near Bridport Harbour and at the Cliffs at Burton Bradstock, and are estimated to be upwards of 200 feet thick. Of the Cotteswold district I cannot speak from my own knowledge, but Mr. Witchell gives the depth of the sands at Stroud Hill at about 110 feet, whilst from Dr. Wright's section of Cleeve Hill, Gloucestershire, given in his 'Monograph on Lias Ammonites,' page 155, they would appear to be only from 2 to 3 feet thick. It would therefore seem that the depth of these sands varies more between different localities in the Cotteswolds than it does between some parts of the Cotteswolds and Dorset.

The Yeovil Sands are of a more clayey tenacious character and of a darkish blue colour towards the lower part. This may be well observed in a railway cutting between Yeovil and Yeovil Junction. They are not greatly fossiliferous, but I have met with *Harpoceras Moorei* (Lycett) in various places at the top, middle, and lower parts, and *Lytoceras jurense* has also been obtained. These fossils always occur in the bands of stone. At Yeovil Junction to the west of the station is a fine quarry from which a considerable number of fossils have been procured, while a few yards farther on in a field is a capital quarry of the Inferior Oolite containing very small representatives of all the zones of that formation, very much thinned out, so that its total depth does not here exceed about 6 feet; a few yards still farther on westwards one comes to the Fuller's Earth Clay.

I here give part of a section of Stroud Hill, which I have taken from the 'Geology of Stroud' (the section faces page 5 of that work), by my friend, Mr. E. Witchell, to whom I am indebted for much information regarding the Cotteswold Hills. Below is his explanation according as I have numbered the beds.

Section of Stroud Hill (Cotteswolds).

	Ft.	In.		
0	25	0		Blue marly clay.
1	3	0		Upper bed of Inferior Oolite.
2	8	0	{	Clypeus Grit, *Tereb. globata, Clypeus Plottii.*
3	4	6	{	Three beds of hard brown Grit.
4	3	0		Upper coral bed.
5	6	0		Upper Trigonia Grit.
6	12	0		Gryphite Grit.
7	10	0		Upper Freestone.
8	6	0		Oolite Marl.
9	70	0	About.	Building Freestone.
10	3	0		Pea Grit, *Tereb. plicata*, &c.
11	25	0		Lower Limestone in thick beds.
12	9	0		Brown ferruginous beds.
13	5	0	About.	Cephalopoda bed.
14	110	0	About.	Cotteswold Sands, the lower part occasionally concretionary.
15	70	0		Upper Lias, bands of blue shale.

A point suggested by a consideration of this section and that of Bradford Abbas Quarry, given at p. 5, is whether the "Dew bed" (No. 7) which I have placed as the top of the Jurense-zone may not in reality be the exact equivalent of the Gloucestershire Cephalopoda bed which is No. 13 in the section of Stroud Hill. It directly underlies the paving bed or Murchisonæ-zone, so that we must suppose that the Opalinum-zone is not represented; but that this is not unusual appears from Dr. Wright's section of Leckhampton Hill, near Cheltenham,[1] in which he places the zone of Murchisonæ directly upon the zone of Jurense, omitting any mention of the Opalinum. At a quarry at East Coker in Somerset, from which the sinistral gasteropods *Cirrus nodosus*, *Leachii*, &c., are obtained, as far as I can make out, the Parkinsoni-zone rests directly on the Murchisonæ-zone, there being not the slightest trace of the intermediate zones or their fossils. When one considers this and the thinness of the Inferior Oolite in Dorset in many other places, one can scarcely wonder at zones being looked upon as fanciful divisions, nor at the statement that all the zonal Ammonites, Parkinsoni, Humphriesianum, Sowerbyi, and Murchisonæ occurred mixed together in a few feet of rock.

Now, as regards the correlation of the two sections: In the Bradford Abbas section, Nos. 1, 2, are in the zone of Parkinsoni, and are probably the equivalent of Nos. 1—5 Stroud section; Nos. 3—5 are probably equivalent to No. 6, and perhaps 7. Whether 8 of the Stroud section should be included it is difficult to say, the Fauna being so dissimilar, or whether it should be included with 9—12 as the equivalent of No. 6 in the Bradford section. No. 7 of the Bradford section seems to me to be very probably the equivalent of No. 13, the Cephalopoda-bed of the Stroud section, and Nos. 9—23 of No. 14. I can see no reason why Nos. 9—23 should be supposed, as my father did, to be of the same age as the Oolite marl and Pea Grit or Nos. 7—12 of the Stroud section, as this puts a bed containing *Harpoceras Moorei*, Lyc. (No. 7 of Bradford Abbas

[1] 'Monograph on the Lias Ammonites,' by Dr. Wright. Palæontographical Society, vol. xxxiii, 1879, pp. 151, 152.

section), up above, or else equivalent to, the Upper Freestone or Oolite marl of the Cotteswolds. Besides this we have some very good evidence showing the identity of the Murchisonæ-zone in Dorset with at any rate the Pea Grit of Gloucestershire, so that there seems no reason for supposing that the Yeovil Sands are of any higher horizon than those of the Cotteswolds, especially as we find an extensive amount of Cotteswold Sands shown in the Stroud section. Our evidence as to the identity of the Murchisonæ bed in Dorset with the Pea Grit and other beds (9—12) in Gloucestershire is founded on the following list of species which occur in both places: *Harp. Murchisonæ*, *Terebratula perovalis*, *Tereb. Etheridgii*, *Tereb. simplex*, *Rhynch. subangulata*, *Rh. subdecorata* (the small kind), *Rh. cynocephala*. I believe that this is the first time that that most characteristic species *Tereb. simplex* has been found outside the Cotteswolds. I possess, however, as many as eight fine large examples of this shell from two quarries in Bradford Abbas and one near Sherborne (Dorset). The first I found were submitted to Dr. Davidson, and were by him identified as undoubtedly belonging to this species.

Section at Oborne Quarry, near Sherborne, Dorset.

	Ft.	In.	
Light coloured stone	2	0	Parkinsoni-zone.
Soft sandy stone	2	0	Humphriesianum-zone.
Harder stone iron grains	3	0	
White marl with green grains	0	6	Sauzei-zone.
Hard blue and yellow stone	2	0	Sowerbyi-zone.
Several feet unseen			
Soft yellow sandstone containing *Rhynch. ringens* at the top of it	Uncertain		

Section at Wyke Quarry, near Halfway House, Sherborne, Dorset.

	Ft.	In.	
Whitish stone extending up the hill, perhaps	20	0	Parkinsoni-zone.
Dark red stone filled with iron	0	7	Humphriesianum-zone.
Bluish stone, sometimes yellow with plenty of iron grains. *Rhynch. ringens* found in lower part	3	10	Sowerbyi-zone.
Lighter yellow stone, the lower part hidden, visible	2	0	Murchisonæ-zone.

I have here given two sections in the Inferior Oolite which are taken from my paper on "Ammonites," 'Quart. Journ. Geol. Soc.,' vol. xxxvii, p. 588, &c., 1881. They are of Oborne in Dorset, and of Wyke Quarry near Halfway House, Sherborne, and I have reproduced them to show the difference that exists in the beds in Dorset in a little distance, these two quarries being about five miles apart, and also to show their correlation. It seems to me that the section at Oborne must have very much the character of the Oolite of Normandy, while our Bradford Abbas or Wyke sections are different, in fact differing as much from it as they

do from Oborne. This seems to be supported by the fossils, because if we look through d'Orbigny's 'Paléontologie française (Céphalopodes)' we find none of what might be called the fossils peculiar to Bradford Abbas represented; the real fact being that of the species figured by d'Orbigny, probably *Am. Sowerbyi* is the only one which came from the zone of that name, and it is *this zone* which is so fossiliferous at Bradford. *Stephanoceras Humphriesianum* has been found at Bradford in the bed No. 3, but it is rare and generally very poor, so that roughly speaking the Fauna at Bradford Abbas is totally distinct from that at Oborne. There seems, therefore, to be in the south a parallel to the Normandy beds, both in fossils and characters, and also to the Cotteswold beds in fossils, but not in character.

I need scarcely remark on the correlation of the two sections given above, as it seems to be evident from the sections themselves. Practically identical lists of fossils have been obtained from the various beds allocated in each quarry to the same horizons or zones,[1] and these lists of species having been compiled, after particularly observing the exact position from which every species that I collected was taken, I am enabled to definitely assign the zone to which the beds belonged. It is interesting to note the occurrence of *Rhynchonella ringens* in both places. The Oborne and Bradford Abbas' quarries are the types of the two classes of Inferior Oolite rocks to be met with in the south-west. In one class it is the Sowerbyi-zone that preponderates and is most fossiliferous, while in the other it is the Humphriesianum.

One bed of which there seems to be no representative in the south is the Oolite marl. It is in fact a most difficult matter to say with what it should be correlated. It is true that in the south *Terebratula curvifrons* has been found in the Murchisonæ-zone, but it is rather different in shape from the one found in the Oolite marl of the Cotteswolds. At a quarry on Corton Downs in Somerset there is a blue clay with bands of stone in it, much resembling the blue parts of Oolite marl shown at Notgrove Station, Gloucestershire. This clay is quite stiff and some 3—4 feet thick. It contains, however, the usual fossils of the Sowerbyi bed at Bradford Abbas, *Lioceras concavum* (Sow.), *Terebratula Eudesi*, *Rh. Forbesi*, *&c.*, being found there, but we have never seen anything at all like the Fauna of the Oolite marl.

As regards the thickness of the Inferior Oolite rocks in the South of England: They probably at no one place from the zone of Murchisonæ upwards occupy more than 40 feet, although of this we cannot be certain. Just to the north of Sherborne in Dorset the Parkinsoni beds are quarried and expose a thickness

[1] I ought here to explain that the Humphriesianum-zone is fossiliferous both at Oborne and Wyke quarries, and that the list of fossils mentioned refers more particularly to this bed. At Oborne the Sowerbyi-zone has yielded but few fossils, but enough to identify it. Wyke quarry differs from Bradford Abbas in having the Humphriesianum-zone fossiliferous.

of quite 30 feet, and we do not then find either the top or bottom of the zone. It is almost unfossiliferous, but occasionally *Cosmoceras Parkinsoni*, *Perisphinctes Martinsii*, and some Brachiopods are found. The most fossiliferous exposure of the Parkinsoni-zone, as far as Ammonites are concerned is at Halfway House, where the fossils occur in the lower portion, and at Broad Windsor, and Burton Bradstock, Dorset, and Crewkerne Station, Somerset. The deepest development of the Humphriesianum-zone with which I am acquainted is at Oborne, where it is divided into two distinct beds with distinct Faunæ, measuring 5 feet altogether. The upper portion contains *Cosmoceras subfurcatum* (Schloth.) = *Am. niortensis*, d'Orb., *Cosm. Garantianum* (d'Orb.), *Perisph. Davidsoni*, S. Buck., &c. Below the Humphriesianum-zone proper comes the Sauzei bed, which may probably after all be only a subzone of the Humphriesianum. It is 6 inches thick at Oborne. The greatest development of the Sowerbyi-zone is at Halfway House, where it is about 4 feet, and contains a large number of species of the genus Harpoceras. We have lastly the Murchisonæ-zone, which attains as much as 4—5 feet at Corton Downs in Somerset.[1] Therefore we have, putting these maxima developments of the Inferior Oolite all together, a thickness of not much less than 50 feet. Were we able to see a complete opening near Sherborne we should expect the beds there to be best developed in every way; while, as they extend westwards, they gradually thin out until at Stoford they are only about 6 feet thick; and at East Coker, because some are absent they are not more than 3—4 feet. We do not know, however, how much of the upper part of the Parkinsoni-zone, there represented, may have been denuded.

Palæontology.

Before commencing any description of the various species we must consider their classification. The genus "Ammonites" having become unwieldy, and not being in accordance with the usages of modern science, we find that a large number of new genera have been proposed, with the intention of taking its place. The late Dr. Wright in his 'Monograph on the Lias Ammonites,' devoted a considerable amount of space to a very full and excellent description of all the systems of classification that had been proposed. In fact he gives us an account of the classification, not only of the Ammonites, but of the Cephalopods in general. With the Ammonites he commences with the first efforts at subdivision, viz. L. von Buch's, into families, continuing with Prof. Quenstedt's additions, a whole *résumé* of d'Orbigny's twenty-one sections, and ending with a complete account of the

[1] The Opalinum-zone is shown near Broad Windsor and at Burton Bradstock, Dorset, and near Haselbury, Somerset, and the amount exposed varies from 2—5 feet in thickness. *Lioceras opalinum*, and *Terebratula infra-oolithica* are the typical fossils.

various systems of classification proposed by Hyatt, Neumayr, Waagen, Favre, and others, he gives us that system which he himself thought it best to adopt. It is quite unnecessary for me to go over all this ground again. The general principle and the general mode of subdivision are now almost unanimously agreed upon and recognised. I intend to introduce new genera and to restrict many of those now in use; and I shall as occasion requires give my views concerning them. During the last few years the introduction of new genera, to partially take the place of the large subdivisions that one finds, for instance, in Dr. Wright's Monograph, has been frequent. Thus, part of what Dr. Wright included under Harpoceras is now put into Hammatoceras, and this genus again has been lately divided into that and Sonninia. These new genera arise out of the necessities of the case. It having been once agreed that a division of "Ammonites" was necessary, limits cannot directly be set to such division. The introduction of Arietites, Harpoceras, and Stephanoceras was a step in advance, but each included very diverse forms.

It will thus be seen that there has been a constant tendency to more and more subdivision, and I venture to advance still farther in this direction. Exception may probably be taken by some persons to the number of genera into which I shall propose to divide the Ammonites in this Monograph, but I would draw attention to other sciences, entomology, botany, &c., and would point out the large number of genera which they contain, and ask why we should not in palæontology proceed on the same lines, viz. make a genus for the reception of a group of a larger or smaller number of species having certain points and characters *in common*, distinguishing them from other groups. This will be more clearly brought out in the definition of each genus, which I shall give. It is now several years since Hyatt attempted to divide the Ammonites into what may be called small genera. His system was at the time too great a stride in advance, and also too faulty, to find acceptance. Since then we have had the division of Ammonites into genera brought into ordinary use, but the genera used were much more comprehensive than Hyatt's, including, in fact, not only several of his genera, but two or three or more of his families in one. Now, however, we are returning towards the direction taken by Hyatt, and in fact we use, on account of their priority, a number of the generic names that he proposed.

I have found that the importance of accurate examination of the various suture lines was not to be overlooked, and that instead of the sutures varying in specimens of the same species, as had been asserted, they were generally very constant in form, not only in a species, but for a genus. I found, however, that owing to the usually very perfect preservation of the Inferior Oolite Ammonites in the South of England, and to collectors rejecting specimens not having the test, I had often great difficulty in making out the suture line as I could wish.

It is very singular that, so far as I know, no Aptychus has been found in the

South of England, either *in sitû* or separate. This is very much to be wondered at and regretted, as there is little doubt that a knowledge of the Aptychus would give us help and information in the matter of subdivision.

I commence this Monograph with the study of the Falciferi or part of the genus Harpoceras of Waagen, and I here give a short account of the history and origin of some of the principal genera.

It was in 1867 that Alpheus Hyatt published in the 'Bulletin of the Museum of Comparative Zoölogy at Harvard College,' in Cambridge, U.S.A., a comprehensive system of families and genera for the Ammonites contained in that Museum. Unfortunately, however, his paper is unaccompanied by any plates, and his descriptions are rather short and terse, the paper chiefly being made up of references to various authors and to the localities whence the specimens came.

Hyatt does not seem to have dealt with anything besides Ammonites from the Lias, to which formation almost all his genera belong, only one species in his paper being from the Inferior Oolite proper, namely, *Lioceras concavum*, although *Lioceras opalinum*, *Grammoceras radians*, &c., may be said to belong to it. This paper, however, is most important to us in the study of the Inferior Oolite Ammonites. It enables us to assign, if possible, the correct generic appellations to the various species, because it was one of the early efforts made towards a very complete subdivision of the genus "Ammonites," and because Hyatt went so much farther in that direction than his contemporaries. Let us now examine a few of his genera, and, as one in which we shall be soon interested, let us take *Lioceras* In this genus Hyatt seems both to myself and others to have united several very different groups of species. For instance, Haug,[1] who has written a capital pamphlet on the Harpoceratidæ, has retained under the subgenus Lioceras, *L. concavum*, *L. opalinum*, *L. elegans* of Hyatt's paper, but he has placed *Am. lythensis* in a group of its own and *Am. discoides* in the group of *Am. falcifer*. We must, therefore, as Hyatt has not given us a species as his type of the genus, take the larger number which evidently comprise one group, and we consequently select *Lioceras opalinum* as the type, followed by *Lioceras elegans*, &c. It may be objected that, as Hyatt placed *Am. lythensis* first, he intended it for his type; but the Opalinum group are in a majority, and have been usually taken as the types of Lioceras to the exclusion of other forms. We wish, therefore, to amend Hyatt's genus by restricting it to the group of which *Lioceras opalinum* is the type.

As to the genus *Grammoceras*, which also contains species of diverse character, *Grammoceras striatulum* seems to be usually taken as the type with *Gram. radians*, *Am. aalensis* and *Am. costula* undoubtedly form a distinct group, while *Am.*

[1] E. Haug, "Beiträge zu einer Monographie der Ammoniten-Gattung Harpoceras," 'Neues Jahrbuch für Mineralogie, &c.,' Beil.-Bd. iii.

serpentinus is by Haug placed in the genus Hildoceras. In the Inferior Oolite there are some species which very closely approach the type of this genus, but may have to be separated. The only other genus of Hyatt's that we need remark upon is that of Hammatoceras (see Hyatt, page 88), mentioned again on page 98 and spelt Ammatoceras. Under this genus, the type of which is *Ham. insigne*, have been placed by some authors a number of Inferior Oolite species such as *Sowerbyi*, *adicrum*, *patella*, &c. These species have been generally placed in the genus Harpoceras, which was created by Waagen to include the Falciferi and Insignes. Dr. Wright, too, in his Lias Monograph has adhered to the plan of keeping the Insignes in the genus Harpoceras. Previously, however, Neumayr[1] in a very interesting paper, had expressed his opinion that it was advisable to keep Hammatoceras for the group of *Am. insignis*, and this plan has been followed by the majority of Continental authors. Bayle, however, in the same year in his 'Explication de la Carte géologique de la France,' proposed the genus *Waagenia* for a species allied to *Am. Sowerbyi*. The name Waagenia, however, having just previously been used by Neumayr, was changed to *Sonninia* (see 'Bullet. Société géol. France,' vol. vii, series 3, page 92, 1878-79).

In 1869 Waagen proposed the name Harpoceras as a generic name for all those Ammonites with falciform sculpture and distinct keel, and cited as his examples of this genus, *Harpoceras Actaeon*, *Masseanum*, and *arietiforme*, which belong to the Falciferi of the Lias; and he proceeds to say that next come the Insignes, the Falciferi of the Brown Jura with keeled body chamber, *Harp. opalinum*, *Edouardianum*, *hecticum*, *Henrici*, *canaliculatum*, *trimarginatum*, and lastly *Harp. Zio*.[2] Hyatt had, however, a year or two previously more minutely divided a large portion of Ammonites,[3] and had dealt with part of these very fossils which Waagen here mentions. He had divided what Waagen wished to called Harpoceras, as far as the Lias is concerned, into four families—Phymatoidæ, Cycloceratidæ, Discoceratidæ, and Hildoceratidæ; and into eight genera—Phymatoceras, Hammatoceras, Tropidoceras, Ophioceras, Pelecoceras, Hildoceras, Grammoceras, Leioceras. These divisions were, however, thought too fine, and we consequently find that Waagen's genus Harpoceras was more generally used. Tate and Blake[4] use it throughout their work, and Dr. Wright throughout the whole of his Monograph in the entire form in which Waagen proposed it. Now, however, that smaller divisions are found

[1] Neumayr, "Ueber unvermittelt auftretende Cephalopodentypen," &c., 'Jahrbuch der K. k. geologischen Reichsanstalt,' Band xxviii, 1878, pp. 37-80 (see footnote, p. 67). I would also call attention to another important paper of Neumayr's in 'Zeitschrift der deutschen geologischen Gesellschaft,' Band xxvii, 1875, where the generic grouping and classification of Ammonites is most thoroughly worked out.

[2] Waagen. 'Die Formenreihe des *Ammonites subradiatus*,' p. 250 (72).

[3] Hyatt, 'Bulletin of the Museum of Comparative Zoology of Harvard College,' 1867, pp. 71—102.

[4] 'The Yorkshire Lias,' 1876.

desirable and Hyatt's genera are being adopted in consequence of priority, it becomes very hard to say to what to apply the genus Harpoceras. For instance, in the genus Tropidoceras, Hyatt had placed *Am. Actaeon* and *Am. Masseanus*, which Waagen had specially mentioned, and *Am. opalinus* in the genus Lioceras. We could then scarcely use Harpoceras as the generic name for some of the remainder, because if we pursue the mode of division that we have sketched out we should confine the genus within limits never intended by the author who proposed it for "all Ammonites having a falciform sculpture and distinct keel," and who showed by his list of synonyms[1] the wide application he intended for it.

Haug, in his pamphlet on 'Harpoceras,' makes three genera—Harpoceras, Hammatoceras, and Hildoceras, for what Waagen intended as Harpoceras, and he treats as subgenera of these Tropidoceras, Cycloceras, Sonninia, &c. Since we intend to treat these latter as genera, this plan will not help us. We suppose, however, that Harpoceras must not be rejected, but it is difficult to know how best to apply it.

Neumayr[2] has divided the subfamily "Ammonites" into four sections, viz. Arcestidæ, Tropiditæ, Lytoceratidæ, Ægoceratidæ. The section Ægoceratidæ he divided into three subsections, viz. Ægoceratinæ, containing Ægoceras and Arietites; Harpoceratinæ, containing Harpoceras, Oppelia, Haploceras; Stephanoceratinæ, containing Stephanoceras, Cosmoceras, Ancyloceras, Perisphinctes, &c.

Douvillé[3] has proposed to unite Arietites and Harpoceras into a tribe Harpoceratinæ; and Oppelia, Lissoceras (= Haploceras) and Neumayria into Lissoceratinæ; and then these two, Lissoceratinæ and Harpoceratinæ, to "form a subfamily Harpoceratidæ." I have given considerable time to the classification of these groups, and I venture to suggest that the following method more nearly represents the affinities of the various forms. It will be noticed that I have removed Amaltheus from the Arcestidæ, as I consider that its general shape, sutures, and structure bring it into closer relationship with Harpoceras and Oppelia forms.

Family—Ammonitidæ, to contain subfamily Ammonites (*i.e.* what was previously included in the old genus), and also Hamites, Baculites, &c.

Subfamily—Ammonites, to contain tribes[4] Arcestidæ, Tropiditæ, Lytoceratidæ, Ægoceratidæ.

Tribe—Ægoceratidæ, to contain subtribes Ægoceratinæ,[5] Harpoceratinæ.

[1] Waagen, before quoted, p. 245 (67).

[2] 'Zeitschrift d. deutschen geol. Gesellschaft,' p. 854—942 (see p. 905), 1875.

[3] Zone of Am. Sowerbyi, 'Bulletin Soc. géol. France,' ser. 3, vol. 13 p. 14.

[4] These divisions, as well as the one above (Ammonitidæ), are called by Wright and Neumayr families, but this seems confusing, since they are two different classes of divisions, and by Douvillé subfamilies. This latter term seems in contradiction to the rule given by Strickland ('Scientific Writings, Zoological Nomenclature,' p. 394) that families should end in *idæ* and subfamilies in *inæ*.

[5] This includes Neumayr's Stephanoceratinæ. See further on.

Subtribe—HARPOCERATINÆ, to contain generic groups Arietidæ, Amaltheoidæ, Hammatoceratidæ,[1] Lissoceratidæ.

Generic group—HAMMATOCERATIDÆ, to contain generic subgroups Hildoceratinæ, Hammatoceratinæ, &c.

The generic subgroup Hildoceratinæ would include such genera as Lioceras, Ludwigia, &c., whilst Hammatoceratinæ would include Hammatoceras, Sonninia, &c., but I propose not to give the definition of the subgeneric divisions of the Hammatoceratidæ at present, as new forms are constantly cropping up and new characters discovered so that it is at present difficult to say what should be included in them.

[1] Hyatt's names Phymatoidæ, Hildoceratidæ, would only express probably what is equal to the subgroups Hildoceratinæ, Hammatoceratinæ, and cannot therefore be used here. This name (Hammatoceratidæ) is not open to that objection, but at the same time expresses the same as Waagen's genus Harpoceras.

Tribe—ÆGOCERATIDÆ, Neumayr.

SUBTRIBE—HARPOCERATINÆ, *Neumayr.*

Generic group—HAMMATOCERATIDÆ, *Buckman.*

Generic subgroup—HILDOCERATINÆ, *Buckman.*

Genus—LUDWIGIA, *Bayle*, 1878.

(*Type*—LUDWIGIA MURCHISONÆ, *Sowerby*, sp.)

Definition.—Variable, sometimes much compressed; strongly marked reflexed bifurcating ribs, primary large, especially conspicuous in youth, and sometimes almost developing spines. Ventral area plain, without ribbing, somewhat flattened, keel variable. Mouth border with an elongated lappet on the lateral area, and very slightly produced on ventral area. Inner margin always concave. Umbilicus open, the inclusion generally half the whorl. Suture lines very simple, not numerous, having a well-defined space between each succeeding suture. Siphonal saddle divided by a somewhat rudimentary accessory lobe, lateral saddle scarcely divided by any such lobe. Inferior lateral lobe considerably smaller than superior lateral. Three small auxiliary lobes.

Remarks.—This genus does not contain many species, and is hard to define on account of its variability. The most constant characters are the suture lines and the ribs.[1] It will be seen that the suture line[2] enables us to distinguish this genus from Lioceras, being more simple, farther apart from one another, possessing only a small accessory lobe in the siphonal and scarcely one in the lateral saddle, which lobes are always well developed in Lioceras. The suture line in Ludwigia is also less branched, and the saddles proportionately deeper than in Lioceras. The umbilicus in Ludwigia is also proportionately larger and more open than in Lioceras, and does not increase so irregularly when the body-chamber is present.

The genus Ludwigia was founded by Bayle in 1878 in his 'Explication de la Carte géologique de la France,' and he places in this genus the following Ammonites, viz. *L. aalensis*, *costula*, *opalina*, *mactra*, *exarata*, *Sinon*, and *Murchisonæ*,

[1] It should be especially noticed that, whilst in Ludwigia the secondary ribs are well developed, yet the primary are as large or larger than the secondary. On the other hand Lioceras has, practically, no primary ribs. The secondary ribs unite more or less about the middle of the side and disappear into lines of growth, or at the most very small ribs which decrease in size as they near the inner margin. This of course does not apply to *Lioceras opalinum* and others, which are merely striated.

[2] See Plate II, fig. 5.

from among which he subsequently[1] chose *L. Murchisonæ* to be the type of his genus. Unfortunately, however, his figure of *L. Murchisonæ* 'Explic. Carte géol. France,' plate lxxxv, fig. 1, cannot possibly be considered as a typical specimen of Sowerby's *species*. It is a variation, and a well-marked variation. I have carefully examined Sowerby's type specimen of *L. Murchisonæ*, which is in the Natural History Museum of South Kensington, and compared it with specimens of my own, which I have taken there. Bayle's figure shows a much more finely ribbed specimen with smaller umbilicus, and is a sufficiently distinct variation to require a name. It is too, unfortunately, the variety of *L. Murchisonæ* that most nearly connects that species with the genus Lioceras. Further particulars I shall give under the description of *Ludwigia Murchisonæ*. It only remains for me now to say that to retain the generic name Ludwigia for a class of species having in common characteristics different from any others, I think it necessary to slightly amend Bayle's genus making the type of Sowerby's species the type of the genus. I paid another visit to the South Kensington Museum on purpose to examine the suture line of Sowerby's original specimen of *L. Murchisonæ*, and I found it to possess a more rudimentary accessory lobe dividing the siphonal saddle, and a rather thinner and longer superior lateral lobe than the specimen figured by Bayle, besides the other differences mentioned above. As these features are characteristic of the genus, I am anxious to amend Bayle's genus in the way I have stated.

LUDWIGIA MURCHISONÆ (*Sowerby*). Plates I; II, figs. 1—5; III, figs. 1—3.

1829	AMMONITES MURCHISONÆ, *Sow.*		Min. Conch, pl. 550.
1830	—	—	*Zieten.* Verstein. Württem., pl. 6, fig. 4 only.
1845	—	—	*d'Orb.* Ter. Juras., pl. 120, fig. 3 only.
1856	—	—	*Oppel.* Juraformation, p. 368, No. 18.
1881	HARPOCERAS	—	*S. Buck.* Quart. Journ. Geol. Soc., vol. xxxvii, p. 603.
1885	HILDOCERAS	—	*Haug.* Neues Jahrbuch für Mineral., p. 686.

LUDWIGIA MURCHISONÆ, var. OBTUSA (*Quenstedt*). Plate III, figs. 4, 5.

1830	AMMONITES MURCHISONÆ, *Zieten.*		Verstein. Württemb., pl. 6, figs. 2 *a—e*.
1846	—	—	OBTUSUS, *Quenstedt.* Ceph., pl. 7, fig. 12.
1858	—	—	— *Quenstedt.* Jura, pl. 46, fig. 5 only.
1884	LUDWIGIA HAUGI, *Douvillé.*		Bull. Soc. géol. France, sér. 3, vol. xiii, p. 26.
1885	HILDOCERAS MURCHISONÆ and HAUGI.		*Haug.* Neues Jahrbuch für Mineral., Beil.-Band. iii, p. 686.

[1] 'Bulletin Société géologique de France,' sér. iii, p. 91, vol. vii, January, 1879.

Ludwigia Murchisonæ, var. Baylii, *S. Buckman*. Plate III, figs. 6, 7.

1878 Ludwigia Murchisonæ, *Bayle*. Explication Carte géol. France, pl. 85, fig. 1 only. (Without further detail I am uncertain about the other three figures.)

Discoid, carinated, whorls somewhat compressed, ornamented in the young stage with reflexed, bifurcating, rounded ribs, of which the primary are rather coarse. Ribs becoming smaller, and finally losing themselves in lines of growth in adult age. Ventral area without ribs, somewhat flattened, with a distinct rounded keel, not so conspicuous on body-chamber. Inner margin concave, inclusion about half the whorl. Mouth border simple, with lateral elongated lappets, and not produced to a point on ventral area.

The variety *L. obtusa* has much the same characters, but the primary ribs are coarser, producing spines in the young stage; the whorls are thicker, narrower, and more quadrangular, the centre is deeper.

The variety *L. Baylii* is like the typical form in general, but has very fine ribs, a smaller centre, and is somewhat thinner.

Ludwigia Murchisonæ is a somewhat variable species. What might be called the middle form was figured by Sowerby, and is consequently the type of the species on each side of which stand these varieties, the one coarser ribbed and thicker, the other finer ribbed and thinner. Quenstedt was the first to give a second or varietal name to *L. Murchisonæ*, when he described as *Ammonites Murchisonæ obtusus* the specimen figured in his 'Cephalopoden,' pl. vii, fig. 12, and again in his 'Jura,' pl. xlvi, fig. 5. (It should, however, be observed that his *Am. Murchisonæ acutus* on this plate has no connection with the true *L. Murchisonæ*, but belongs to the genus Lioceras, being my *Lioc. bradfordense* to be described presently.) It is this *Am. Murchisonæ obtusus* which Douvillé raised to specific rank under the name *Ludwigia Haugi*. But Herr Haug himself, in his pamplet on 'Harpoceras,' page 687, thinks that it is merely a variety, and not a species. In this opinion I quite concur, and since this form has long been known as a variety of *Am. Murchisonæ* under the name of *obtusus*, I have thought it advisable to retain this name. If, however, it had been raised to specific rank, it might probably have been preferable to have retained Douvillé's name of *Haugi*. I have also thought it advisable that the opposite variety of *L. Murchisonæ* should be distinguished, and I have consequently proposed the varietal name *Baylii*, because of the capital figure of this form given by Bayle in the reference quoted at the heading. It will be found that there is a very slight variation in the suture lines of these

three forms, that of *L. obtusa* being the simplest. On Plate II, fig. 5, is a drawing of the suture line of Sowerby's original specimen of this species, made expressly for comparison with that of Lioceras. It will be noticed that the lobes are somewhat long and narrow and the saddles rather deep. A small accessory lobe divides the siphonal saddle, while the superior lateral may be said to be quite undivided. The inferior lateral lobe is very much smaller than the superior; and it should be observed that the sutures are apart from each other, hardly anywhere overlapping. Though this perhaps can scarcely be treated as a generic difference, yet it is more the rule in Ludwigia and the exception in Lioceras.

This species occurs in the zone of the same name. Good typical examples of it are uncommon in the South of England, and the variety *L. Baylii* is the rarest of the three forms. They are generally met with in a very poor state of preservation, and in fact all the good specimens with which I am at present acquainted came from Bradford Abbas, where it occurs in a bed of light brown, somewhat soft stone called the Paving Bed, from the fact that it can be taken up in large layers or slabs and hardens on exposure, when it can be used for flooring. The zone of Murchisonæ is met with in many places, viz. Sherborne, Bradford Abbas, Halfway House (Compton), Beaminster, Burton Bradstock, &c., in Dorset; Haselbury, Misterton, Stoford, Corton Downs, &c., in Somerset, from most of which places specimens of either the typical or varietal forms have been obtained. Dr. Wright quotes the species from Cleeve, Frocester, and Leckhampton Hills in Gloucestershire. Sowerby's type specimen came from Scotland.

Plate I represents a fine typical example of this species in very perfect preservation. Plate II, figs. 1, 2, represent the original specimen named and figured by Sowerby and reproduced here (side and front views instead of three quarters front) for reference and comparison. Fig. 5 represents the suture line of this specimen, and is the typical suture line of the genus Ludwigia. Figs. 3, 4, represent a young shell of this species showing its open umbilicus in youth. On Plate III, figs. 1 and 2, is represented a medium-aged specimen in very good preservation, and of the size usually found. It is figured to show the transition from ribs to lines of growth, and also the bifurcating, reflexed ribs better than the other specimens. Fig. 3 is given to show the termination of the body-chamber, and is the only example at present under my notice. The lateral lappet of the termination is not complete and some other parts of the specimen are somewhat poorly preserved. Figs. 4, 5, show the characters of the variety *L. obtusa* with its coarse, knotted ribs, and its quadrangular section. The keel of this specimen is rather badly preserved and, perhaps, is more prominent. Figs. 6, 7, show the variety *L. Baylii* and its different aspect from the others. I have a larger specimen showing the characteristics of this variety (which becomes

square with a less prominent keel as it gets larger), but it is too poor to figure. I hope to be enabled to figure better specimens of both these varieties of *L. Murchisonæ* another time.

LUDWIGIA CORNU, *S. Buckman*. Plate IV, figs. 1—4.

1881 AMMONITES SUBRADIATUS, *J. Buckman* (non Sowerby). Quart. Journ. Geol. Soc., vol. xxxvii, p. 61, fig. 2.

1881 HARPOCERAS CORNU, *S. Buckman*. Quart. Journ. Geol. Soc., vol. xxxvii, p. 605.

1885 HILDOCERAS (LUDWIGIA) CORNU, *E. Haug*. Neues Jahrbuch für Mineralogie, &c., Beil.-Bd. iii, p. 687, tab. 12, fig. 11.

Discoid, much compressed, carinated, whorls flattened, ornamented with well-marked reflexed bifurcating ribs. Ventral area plain, slightly sloping towards a fairly prominent sharp keel. Inner margin concave. Inclusion variable, about $\frac{3}{4}$ to $\frac{7}{8}$ of whorl; centre shallow, regularly coiled, with numerous rather coarse ribs. Termination of body-chamber has long lateral lappets (most probably not increasing in breadth at the end), and is produced and pointed on ventral area.

This species is only variable to a very slight extent, the specimens with the larger umbilicus having rather coarser ornamentation than the others. From the preceding species, this one differs considerably, being more compressed, with a sharper, more angular keel. Its suture lines are the same as those of *Ludwigia Murchisonæ;* if anything, more simple. This seems to have been a small species as I have never seen a specimen much larger than those figured in the plate. It is not uncommon with more or less of the terminal lappets preserved, and on account of them was always formerly quoted from the Bradford Abbas district under the name of *Ammonites subradiatus*, Sow. (to which species it bears no other resemblance), until I corrected the mistake and gave it the name of "*cornu*" on account of these lappets. This species occurs in the Sowerbyi-zone at Bradford Abbas and other quarries in the neighbourhood where the zone is exposed, and it is not uncommon. It is associated with *Lioceras concavum* (Sow.), and several other species of that group, and is probably not unfrequently confounded with the common *L. concavum*.

Plate IV, figs. 1—4, show the two forms of this species, and give a back and front view. The keel of fig. 2 is hardly prominent enough, owing to absence of test in many places. The flatness of the side view of fig. 1 seems to me not quite sufficiently brought out.

Hildoceratinæ.

Genus—Lioceras, *Hyatt*, 1867.

(*Type*—Lioceras opalinum, *Reinecke*, sp.)

Definition.—Compressed, discoidal, divisible into two groups, one, the more typical, subcarinated, the other acutely and distinctly carinated. Umbilicus in general small, the inner whorls in some species being almost entirely occluded. Inner margin always concave. Termination, so far as known, has a double bend, sometimes produced and pointed on ventral area.[1] Body-chamber just half a whorl. In young state ornamented with falciform, more or less bifurcating ribs, in adult with plain falciform ribs[2] inconspicuous on inner area or else the whole perfectly smooth, with merely lines of growth. The inner margin of body-chamber always recedes from the regular line of coil of the centre, giving to the umbilicus of complete specimens a sub-oval appearance. As the shell grows and the chambers are formed, the inner margin advances towards its regular place nearer the centre. (This peculiarity exists in some genera of other groups of Inferior Oolite Ammonites and requires to be well understood.) The suture line is peculiar and very constant. The general characters are that the siphonal lobe is rather short. The siphonal saddle is divided into two parts by a well-marked accessory lobe, the inner part being invariably the deeper. The principal lateral lobe is broadly stemmed, digitated, and with three terminal branches which partly penetrate the same lobe of the preceding suture line and almost touch the preceding saddles on both sides of it. The lateral saddle is divided by an accessory lobe. The inferior lateral lobe is smaller than, but very similar to, the principal one; there are four auxiliary lobes and three saddles, the first lobe being well developed.

Remarks.—This genus, as I have pointed out, is divisible into two portions, the one almost without a distinct keel, the other with a very distinct, prominent keel, leaving the ventral area flat and almost furrowed. The principal lateral lobe of this latter class has not three such distinct terminal branches, but I am unable to say

[1] The young specimens of some species of this genus have lateral lappets. *Lioceras opalinum* also possesses these lappets at maturity.

[2] The character of the ribs in adult Lioceras is shown on Plates V and VI. The inner area is smooth and depressed, the secondary ribs on the outer area are few but conspicuous, and appear like a succession of notches. Still the type of the genus, *Lioceras opalinum*, has really no ribs, but merely very numerous lines of growth, which are sometimes fasciated (as Dr. Wright calls it), producing *false* irregular ribs.

whether this character may be constant and peculiar to this class. As at present constituted, this genus is one of the most important of the Hildoceratinæ in the Inferior Oolite. Of the type of this genus, *Lioceras opalinum*, Dr. Wright has already given excellent figures and an exhaustive description;[1] he claims it and its zone as belonging to the Upper Lias, although he admits on page 464 that the Germans hold different views. I have referred to this subject before (see the Introduction) and stated the information and opinions I could obtain. There is little doubt that in Gloucestershire the Opalinum-zone is more allied to the Upper Lias, whilst in Dorset the sequence of strata is not sufficiently shown. We must, however, look at general characters, and not at the peculiarity of a particular district like Gloucestershire, when settling the question.

Special Distinctive Characteristics.—These may be shortly stated as, when young, evolute; in middle age, involute; adult becoming less involute proportionally; inner margin concave; differing especially from Ludwigia in absence of ribs on the inner area and in having the siphonal saddle divided by a good-sized accessory lobe, leaving the interior portion deeper than the exterior; the lateral saddle also divided by an accessory lobe, the inferior lateral lobe nearly as long as the superior lateral, the first auxiliary lobe nearly as large as the inferior lateral; all these lobes touching those preceding them, and one suture line seeming to overlap another. Suture line generally much incised. Four auxiliary lobes.

Lioceras bradfordense, *S. Buckm.* Plate IV, figs. 5—8; Plate V.

1881 Harpoceras Murchisonæ, var. bradfordiense, *S. Buckman.* Quart. Journ. Geol. Soc., p. 604.

1858 Ammonites Murchisonæ acutus, *Quenstedt.* Der Jura, pl. 46, fig. 4 only, not 5.

Shell discoidal, compressed, subcarinated, whorls compressed, very little convex, ornamented with a number of small, plain, curved, but not prominent costæ, sometimes bifurcated. Body-chamber smooth, with outer margin almost rounded in adult specimens, and about half a whorl in length. Inner margin concave. Inclusion quite three quarters of a whorl in half-grown specimens, less in very young forms, and decreasing to half a whorl in full-grown ones. Aperture from sagittate to suboblong. Mouth-border plain, produced on lateral and ventral areas, rounded on the first and pointed on the second. Umbilicus always showing portions of each of the inner whorls, like so many small steps. The suture line of

[1] 'The Lias Ammonites,' Wright, Palæont. Soc., vol. xxxviii, 1884, Plate LXXX, figs. 6—8, pp. 463—466.

this species answers in general to the description given of that of the genus. It differs in no important points. The accessory lobe dividing the siphonal saddle is not so large as in *Lioc. opalinum*.

This species occupies a most extraordinary position. As its age varies it so nearly approaches in shape either to *Lioceras concavum* or else to *Ludwigia Murchisonæ*, that until we had the evidence of the suture line it was a constant source of perplexity to decide its true position. *Ludwigia Murchisonæ* is also such a variable form that it seemed quite possible to include this species, occurring as it does in the same bed, as one of its varieties. This is the view that I took in 1881, in the reference quoted above, and is also the view taken by Prof. Quenstedt in his 'Jura,' plate xlvi. It has no doubt been figured in other places under the name of *Am. Murchisonæ;* for so closely does our species sometimes simulate the varieties of the latter that unless we had the additional evidence of the suture line we should often be unable to identify figures. Again, this species is not at all easy to separate from specimens of *Lioceras concavum* in middle age. There can, however, be no difficulty with the adult forms, because the umbilicus of *Li. bradfordense* is then large and open, while that of *Li. concavum* keeps to its small hollow form. The best distinction between middle-aged *Li. bradfordense* and *Li. concavum* is that in the umbilicus of the former a small portion of *each* of the inner whorls is exposed, forming small steps and showing the ribs, while in *Li. concavum* this is not the case. Did we, however, not possess the large adult forms of this species, it would seem scarcely sufficient to make a distinction between it and *Li. concavum*. The most peculiar character about this species is its approach to the form of *Ludwigia Murchisonæ* when it is rather more than half grown, and to *Li. concavum* when younger. In fact, it possesses the shape of Ludwigia except from young to middle age, while it has the suture line of Lioceras. It should be noticed that Quenstedt's figure, referred to as a synonym of this species, gives the suture line very clearly, figures 4 and 5, plate xlvi ('Der Jura'), illustrating the difference in the suture line of Ludwigia and Lioceras. We can note that in Ludwigia the suture lines are far removed from one another, are rather simpler, and possess only a very rudimentary accessory lobe to divide the siphonal saddle, whereas we see the suture lines of Lioceras more or less overlapping, much closer together, and possessing a well-developed accessory lobe in the middle of the siphonal saddle.

Lioceras bradfordense is not a common shell, and on account of the nature of the beds it is seldom well preserved. It belongs to the Murchisonæ-zone, and in Dorset it has been obtained from Bradford Abbas and other quarries near. From near Beaminster the larger adult examples mostly come, and it is here more frequent. From East Coker in Somerset I have seen very large examples, but they are generally fractured in all directions.

The position of *Lioceras bradfordense* is somewhat peculiar, it being the one species of Lioceras which approaches in some things nearest to Ludwigia. Though occurring in the Murchisonæ-zone, or midway as it were between *Lioceras opalinum* in the zone of that name, and *Li. concavum* in the Sowerbyi-zone, it is not the connecting link, as one would expect, between *Li. opalinum* and *Li. concavum*. Bigger than either, with larger umbilicus, it has not quite the true Lioceras form.. Nor again, is this species, in spite of the resemblances I have pointed out, any intermediate form between *Lud. Murchisonæ* and *Li. concavum*. The latter species is not derived through *Li. bradfordense* from *Lud. Murchisonæ* as I have heard it stated, but is clearly a descendant of *Li. opalinum*. When I first applied the name *bradfordense* I was uncertain if Quenstedt's *Am. Murchisonæ acutus* was the same. Still, the name *acutus* having been used for an Ammonite by Sowerby and again by Tate for a Harpoceras, I could not have retained it in any case. Having then, in 1881, more or less established the name *bradfordense* I do not think it at all advisable to alter it, although it is now in the genus Lioceras.

On Plate IV, figs. 5, 6, is shown a medium-sized specimen of this species with the termination. At this size the species may be said to be in all respects of the true Lioceras form, and, with its broad flat sides and small deep centre, could not, I think, be easily confounded with any specimen of *L. Murchisonæ*. In fact, I have generally found it more difficult to distinguish poorly-preserved specimens of this size from *Li. concavum*. Fig. 7 gives the side view of a younger and smaller shell. Its front view is proportionately much the same as Fig. 6. Fig. 8 shows two suture lines taken from the large specimen figured on Plate V and placed here for convenience. Plate V, figs. 1, 2, show a larger, but hardly full-grown example, with the body-chamber, occupying just half a whorl, present. (The specimen has just an indication of termination.) Fig. 1 shows the receding of the inner margin mentioned before, which in this species varies in amount with the age. Fig. 2 shows the small amount of keel present even where the test is on, and the almost rounded character of the ventral area on the body-chamber.

PLATE I.

Murchisonæ-zone.

LUDWIGIA MURCHISONÆ (*Sowerby*).

Fig. 1.—A large adult specimen with greater portion of body-chamber present. Side view. Natural size. My Collection. Bradford Abbas, Dorset. (Page 17.)
Fig. 2.—Front view.

Fig 1

PLATE 1

Fig 2

PLATE II.

Figs. 1—5.—Ludwigia Murchisonæ (*Sowerby*).

Fig. 1.—This is the original specimen figured by Sowerby in his 'Mineral Conchology,' plate 550. I have had a fresh drawing made of this type for comparison. Side view. Natural size. Natural History Museum, South Kensington. From Holme, near Portree, Isle of Skye. (Page 17.)

Fig. 2.—Front view.

Fig. 3.—Young shell showing nodose primary ribs. Side view. Natural size. My Collection. Bradford Abbas, Dorset. (Page 17.)

Fig. 4.—Front view of same.

Fig. 5.—A drawing of two consecutive suture lines of the original specimen. Their simplicity and the distance between them are seen in fig. 1. (Page 19.)

Figs. 6, 7.—Lioceras concavum (*Sowerby*).

Fig. 6.—The original specimen figured by Sowerby in his 'Mineral Conchology,' plate 94. Side view. Natural size. Natural History Museum, South Kensington. From between Ilminster and Yeovil, Somerset. I have had this original specimen redrawn to show its characters accurately.

Fig. 7.—Front view of the same.

Fig 1

Fig 2.

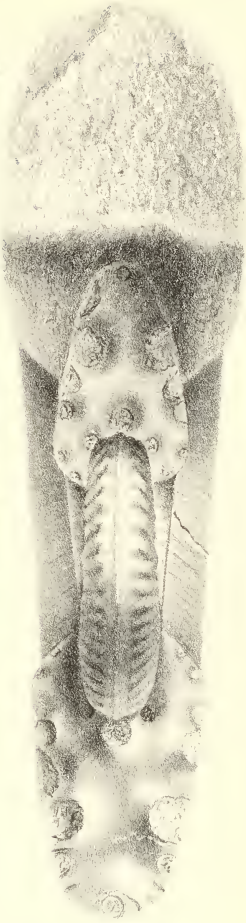


Fig 3.

Fig 4.

Fig 5.

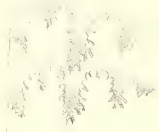


Fig 6.

Fig 7

wan. del et lith.

Mintern Bros. imp.

PLATE III.

Murchisonæ-zone.

Figs. 1—3.—Ludwigia Murchisonæ (*Sowerby*).

Fig. 1.—A typical specimen; test complete; middle age; showing the passage of the ribs into mere lines of growth. Side view. Natural size. Bradford Abbas, Dorset. My Collection. (Page 17.)

Fig. 2.—Front view, showing plain ventral area.

Fig. 3.—A specimen with slightly larger umbilicus, showing mouth border with lateral lappet. It should be observed that the ribs continue well marked right up to the mouth border. Natural size. My Collection. From near Halfway House, Dorset. (Page 17.)

Figs. 4, 5.—Ludwigia Murchisonæ, var. obtusa (*Quenstedt*).

Fig. 4.—Side view of specimen without much shell but showing a tendency to develop spines. Natural size. My Collection. From near Beaminster, Dorset. (Page 17.)

Fig. 5.—Front view, showing the coarseness of the ribs and the squareness of the section.

Figs. 6, 7.—Ludwigia Murchisonæ, var. Baylii, *S. Buckman.*

Fig. 6.—Side view. Showing small umbilicus and fine and numerous ribs. Natural size. In my Collection. Probably from Bradford Abbas. (Page 18.)

Fig. 7.—Front view, showing section. The keel is drawn too sharp and prominent, and the ventral area should be flatter and rather more angular, thus giving the shell a squarer appearance.

Fig. 1.

Fig. 2.

Fig. 3.

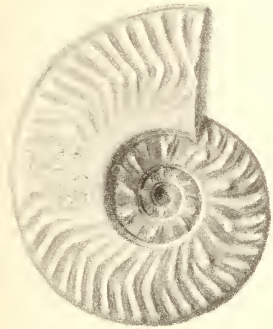


Fig. 4.

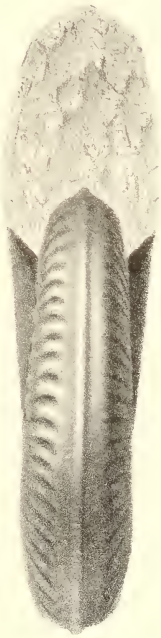


Fig. 5.

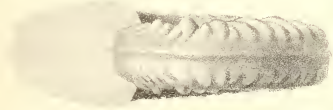


Fig. 6.

Fig. 7.

del et lith.

Mintern Bros. imp.

PLATE IV.

Sowerbyi-zone.

Figs. 1—4.—Ludwigia cornu, *S. Buckman.*

Fig. 1.—Side view of a specimen with open umbilicus, showing lateral lappet. Natural size. My Collection. Near Halfway House (Sherborne), Dorset. (Page 20.)

Fig. 2.—Front view of the same, to show section.

Fig. 3.—Side view of a specimen with small umbilicus, showing the termination. Natural size. My Collection. Bradford Abbas, Dorset. (Page 20.)

Fig. 4.—Back view of ditto, showing the prominent keel.

Murchisonæ-zone.

Figs. 5—8.—Lioceras bradfordense, *S. Buckman.*

Fig. 5.—Side view of a specimen about half-grown, showing a regularly coiling centre and termination to body-chamber. Natural size. My Collection. Bradford Abbas, Dorset. (Page 22.)

Fig. 6.—Front view of ditto.

Fig. 7.—Side view of young shell. Natural size. My Collection. Halfway House, Dorset. (Page 22.)

Fig. 8.—Suture lines as shown by the specimen figured on the next plate. (Page 24.)

Fig 1

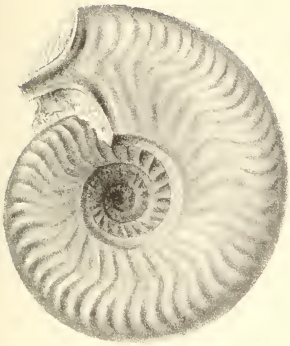


Fig 2

Fig 4

Fig 3

Fig 5

Fig 6

Fig 7

Fig 8

PLATE V.

Murchisonæ-zone.

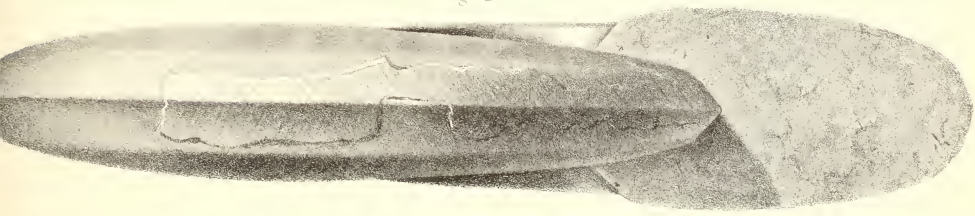
Lioceras bradfordense (*S. Buckman*).

Fig. 1.—Nearly adult specimen, showing the peculiar ribbing in centre, also the rather quick expansion of the centre after a certain size, thus giving the shell a much flatter appearance. Specimens much larger have been met with, but imperfect. Natural size. My Collection. From near Beaminster, Dorset. The whole of the body-chamber is present. (Page 22.)

Fig. 2.—Front view. The keel is scarcely more conspicuous where the test is present.

Fig. 1.

Fig. 2.



wan. del et lith.

Mintern Bros. imp.

PLATE VI.

Sowerbyi-zone.

LIOCERAS CONCAVUM (*Sowerby*). Var. A.

Fig. 1.—Large adult specimen, showing the greater portion of the termination of the body-chamber, also the peculiar increase in the width of the umbilicus, due to the recession of the inner margin of the body-chamber from the regular line of coil round the centre. The umbilicus (which is not quite distinctly shown in the figure) is, until about the last whorl, regularly hollow like the inside of a thimble-top, the inner whorls not projecting at all. The inner area of the whorl is also shown somewhat too flat, and the outer area is too steep. Side view. Natural size. My Collection. Bradford Abbas, Dorset.

Fig. 2.—Front view of same, showing the small amount of keel possessed in adult age. The inclusion is rather more than is shown.

Fig. 1.

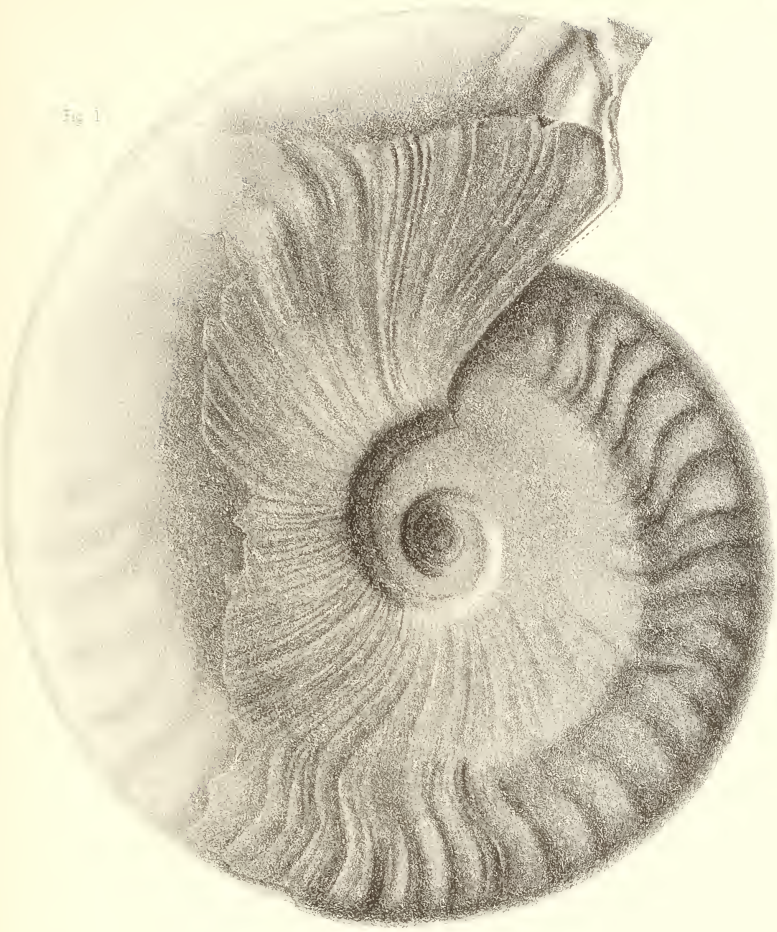


Fig. 2.