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ENGLISH BATHONIAN AMMONITES

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PART I

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SECTION I. INTRODUCTION.

1. THE BATHONIAN AMMONITE FAUNA.

THE British Bathonian ammonites belong to at least three successive predominantly European faunas. Outside Europe the characteristic genera of one or two of these faunas, but never all three together, are known from North Africa, Sinai, Arabia, Persia, Baluchistan, and the East Indies. In North America, Siberia, and Greenland, rocks presumed from their stratigraphical position to be Bathonian contain a peculiar ammonite fauna not yet satisfactorily dove-tailed with the European succession. The fullest known development of both ammonites and rocks of this age occurs in England and France.

The Bathonian ammonites are the last in the European Jurassic to defy attempts to make them subserve the purposes of Oppel's zonal stratigraphy. The Rhaetic Beds and Purbeck Beds of North-West (extra-Alpine) Europe contain no ammonites, but these formations can be equated approximately with series of ammonite zones in southern France and the Alps, and in Russia. The Bathonian is the only major Jurassic stage for which no satisfactory zonal scheme has yet been devised in any part of the world.

Excepting the Zigzag Zone at the base, which is rich in ammonites and usually forms the top of the Inferior Oolite Series, the Bathonian stage yields impoverished and peculiar ammonite assemblages of exceptional interest. The most characteristic components represent two extremes of aberrant evolution, both regarded as " end-forms " : on the one hand the inflated " sphærocones " and " cadicones " formerly classed as Sphæroceratidæ, now as Tulitidæ, including *Tulites* and *Bullatimorphites* ; on the other hand the " oxycones," flat and smooth with sharp keels, a type repeatedly evolved in the Mesozoic from different stocks (*e.g. Oxynoticeras, Amaltheus, Hudlestonia, Leioceras, Oppelia, Cardioceras, Ringsteadia*). The latter have been interpreted as a form of streamlining for rapid swimming, but in that case the adaptation was not conspicuously successful, since genera showing it are generally short-lived ; moreover, in *Clydoniceras* it is combined with a type of suture-line that has been claimed (Solger, 1902) to result from a creeping mode of life.

Some of the sphærocones (certain *Tulites*) have a wide and deep crater-like umbilicus and an extremely depressed body-chamber, which continues to widen and flatten almost to the end. These forms closely resemble Bajocian *Teloceras* and Callovian *Cadoceras,* hardly differing except in weaker ribbing and in the septal sutures. Others (most *Tulites,* all *Bullatimorphites*) develop more or less elliptical coiling, and in the adult undergo marked lateral compression of the body-chamber, a peculiarity which has been taken (Graham Kerr, 1931) to indicate that the shell was internal, as in *Spirula*. Contraction of the adult body-chamber and elliptical coiling also occur in another especially Bathonian stock, *Oecotraustes*, an Oppelid which has no affinity with the sphærocones.

Morrisiceras, another distinctively Middle Bathonian genus, has been found to comprise several genera. The true *Morrisiceras* may have been a forerunner of the Macrocephalitidæ of the Callovian (though if *Arctocephalites* is really Upper Bathonian as Imlay (1948) holds, that too may have produced Macrocephalitids independently in Arctic regions). Other forms hitherto not separated from *Morrisiceras* are found to have the sutures and peculiar modes of coiling of the Tulitidæ ; they also produced elliptical coiling and contracted body-chambers. Some of these are homœomorphs of the Callovian *Pachyceras*. They and *Morrisiceras* and *Tulites* have been found to account for records of *Pachyceras* and " *Cadoceras sublæve* Sowerby " in the European Bathonian.

Classification of the various Bathonian sphærocones involves problems of great theoretical interest and practical difficulty. They may be polyphyletic, yet they all have closely similar and peculiar suture-lines. In the hope of throwing light on their origins, a study has been made of the Bajocian Stephanoceratidæ, Otoitidæ and Sphæroceratidæ, and the matter will be discussed in some detail in the appropriate place.

The Bathonian oxycones certainly belong to two distinct families. In the Lower and Middle Bathonian the characteristic forms are *Œcotraustes* and *Oxycerites*, the latter here regarded as a subgenus of *Oppelia*, which persisted with little change from the Upper Bajocian into the Callovian. In the Middle and Upper Bathonian *Oxycerites* is gradually replaced by *Clydoniceras*, a genus characterized by remarkable degenerated suture-lines which hark back to those of *Frechiella* of the Toarcian. *Clydoniceras* has been taken to be an aberrant offshoot of Oppeliidæ, but it is now believed to be a degenerate oxyconic survival of Harpocerataceæ, analogous with earlier offshoots of the same superfamily, such as *Polyplectus* in the Upper Toarcian and *Staufenia* in the Lower Bajocian (Aalenian). A unique ammonite is described below, which appears to be an oxyconic survival into the Lower Bathonian of another Bajocian Harpoceratacean family, the Sonninidæ.

Side by side with the outstandingly characteristic Bathonian forms, the sphærocones and oxycones, there occur various Perisphinctaceæ, the classification of which is, if possible, even more difficult. They range in size from giants usually referred to *Procerites*, 30—40 cm. in diameter without the body-chamber, to small *Siemiradzkia* 10 cm. in diameter with the body-chamber, which has lappets.

Both forms have their counterparts in the Corallian Beds (Upper Oxfordian). Some of the species of Bathonian *Choffatia* are, indeed, so like Corallian *Perisphinctes* (*Arisphinctes* and *Kranaosphinctes*), in form, coiling, ribbing and suture-lines, that after handling Corallian ammonites for nearly thirty years I would not trust myself to sort out a mixed collection of plaster casts of Corallian and Cornbrash specimens. It is noteworthy that the closest counterparts of the Great Oolite and Cornbrash forms should be found in the lithologically similar Coralline Oolite, not in the intervening Callovian or Lower Oxfordian stages, in the predominantly clay formations of which other Perisphinctids abound in great variety. Proponents of Salfeld's theory of Iterative Evolution in the ammonites, and their opponents (*e.g.* Buckman, 1926, TA vi, p. 23) who believe that many stocks thought to have died out survived in some retreat not yet discovered and periodically blossomed anew when the environment became favourable, may both claim support from these facts. The persistence over so long a period of the two main types, the giants with simple peristome and the dwarfs with lappets, just as among the Bajocian Stephanoceratids, lends attraction to the hypothesis of sexual dimorphism. But in the absence of evidence better than conjecture it is impossible to take account of the hypothesis in a classification; though to attempt to base a classification on shape of peristome, as done by Mascke (1907) for the Stephanoceratidæ, leads to results equally unreal.

The Perisphinctaceæ were a conservative superfamily which persisted for an enormous length of time: as is now known, from the Middle Bajocian to the Neocomian. The Bathonian Zigzagiceratinæ were probably polyphyletic, and it will be shown below to what ancestors in the Upper Bajocian several of the *Procerites* can probably be traced. In the last resort, however, all such filiations are unprovable, and their subjective nature makes them a poor foundation for recasting the nomenclature in a vertical system. Accordingly, in all groups the existing mainly horizontal classification is retained here. The horizontally-defined Bathonian families and subfamilies such as Clydoniceratidæ, Tulitidæ and Zigzagiceratinæ (all of Buckman) are convenient morphological groups which can be referred to non-committally, without phylogenetic implications, and at the same time the wider perspective can be retained by subordinating them to the superfamilies Harpocerataceæ, Stephanocerataceæ and Perisphinctaceæ respectively.

The most abundant Bathonian Perisphinctid genus, *Procerites*, and another peculiarly Bathonian genus *Wagnericeras*, both produced many species of large size characterized by total loss of ribbing on the outer whorls, even before septation had ceased. They thus fall into line with the sphærocones, cadicones and oxycones in giving to the Bathonian ammonite fauna a general aspect of smoothness, due to feeble ribbing lost early. If, as is generally supposed, ribbing strengthened the shell against water pressure, loss of ribbing, especially in such large shells as *Procerites*, presumably indicates shallowing of the water.

The best way to sum up the peculiarities of the ammonite faunas of the Bathonian is to contrast them with their predecessors of the Bajocian and their successors of the Callovian. The contrast is between two periods of active radiation and evolution of new and virile stocks (including three new superfamilies in the Bajocian, the long-lived Oppeliaceæ, Stephanocerataceæ and Perisphinctaceæ), and an intervening long period (the Bathonian) of relative stagnation, when survivors from existing stocks persisted without major innovations or degenerated and became extinct. In no other stage is there such a preponderance of unrelated racially gerontic types.

Expressed in the terminology of Garstang (1922, p. 100) and de Beer (1940, p. 377; 1948, p. 184), the Bajocian and Callovian were periods of evolution by pædomorphosis, during which cænogenetic novelties were thrown up freely and incorporated in the adults and in the phylogeny, with production of new and virile stocks having high potentialities for further evolution. The Bathonian, on the other hand, was a period of gerontomorphosis, or specialization of the adult stages of successive ontogenies, with progressive loss of the ability to evolve further. "As evolution proceeds, pædomorphosis is succeeded by gerontomorphosis, which actualizes the further evolutionary potentialities opened up by pædomorphosis and exhausts them. The group then lingers or becomes extinct unless a new bout of pædomorphosis supervenes" (de Beer, 1940, p. 377). Such was the Bathonian ; and it will be shown below (p. 15) that the biological phenomena were correlated with adverse peculiarities in the physical environment of the ammonites.

2. MATERIAL ; PREVIOUS WORK ; ACKNOWLEDGMENTS.

Bathonian ammonites, though seldom abundant except in the Zigzag Zone and the Cornbrash, are preserved in most geological museums, especially those in London, Oxford and Cambridge. Hitherto the material has never been worked through systematically. James Sowerby and William Smith each figured a couple of species ; Morris and Lycett (1851—3, 1863) figured and named nine species in their monographs on the Great Oolite Mollusca ; Phillips in his 'Geology of Oxford' (1871) figured two more, and Blake in his monograph on the 'Fauna of the Cornbrash' (1905) dealt with most of the Cornbrash forms. Finally, S. S. Buckman in his 'Type Ammonites' (TA, 1920—25) published 29 new species and 21 new genera, besides 21 species from the Zigzag Zone, mainly in Inferior Oolite facies.

The preponderance of Buckman's names in the following pages may give the impression that he "worked out" the ammonite fauna and that a monograph is superfluous. This, however, is far from the truth. Buckman's method was to publish a photograph of a single specimen, with a new name, and dimensions and sometimes a few words of description. These "types" were drawn mainly from his own collection, which was partly purchased and partly inherited from his father, James Buckman, and to some extent from the collection of J. W. Tutcher, M.Sc., of Bristol. Buckman also borrowed and refigured Morris and Lycett's types ; but he seems never to have seen the bulk of the material in the museums.

When every specimen is given a new name, in an almost virgin field, most of the names are bound to survive ; but during this last decade of his career (1919—1929) Buckman's criteria for separating species and genera were trivial and capricious. Minute details in the pattern of a single lobe of the septal suture in *Clydoniceras discus* were to him grounds for recognizing three separate genera ; other genera were erected on the shape of an umbilicus "developed" by Buckman himself, which turned out on investigation to be a work of art rather than of nature, or again on small differences in the proportions of a suture-line which had been wrongly inked in. These are sad blemishes on Buckman's great work ; for he it was who taught us the value of highly critical treatment of ammonites.

Thus the characters and relationships of the faunas had to be worked out from the beginning, and in addition Buckman's types, often poor specimens, sometimes lost, had to be investigated to establish how his names were to be used. The Tutcher Collection was destroyed in the German bombing of Bristol, but the S. S. Buckman Collection is in London; most of the types are in the Geological Survey Museum, the rest in the British Museum (Natural History). Much of the British Museum material is insufficiently documented stratigraphically to be used here.

Other museums containing Bathonian ammonites are the Sedgwick Museum, Cambridge (including the Leckenby and Walton Collections), Oxford University Museum (including some of Phillips' material and the Douglas and Arkell Cornbrash Collection), Bristol University Geological Department (T. Fry Collection), Bristol Museum and Art Gallery (a few survivors of the Chaning Pearce Collection, the rest destroyed by bombing in 1942), Taunton Castle Museum (E. Bower and H. F. Parsons Collections[1]), Manchester Museum (a few of J. Buckman's and S. S. Buckman's types, which unfortunately cannot be borrowed for study outside the museum), Nottingham University (one of S. S. Buckman's types—*Homœoplanulites stabilis*—the rest, recorded by Buckman as at Nottingham, since transferred to the British Museum, Nat. Hist.), Reading University Geological Department (a few), Sherborne School (the Museum dismantled in 1948 and the fossils packed in boxes in the attic of "Middle House," Castleton, Sherborne), and Kingswood School, Bath (the most important specimens generously placed by the Headmaster, Mr. A. B. Sackett, on permanent loan in the Sedgwick Museum, Cambridge). Specimens have also been seen in private collections, especially those of Brigadier Bomford and Mr. P. J. Channon, and there is a good *Tulites subcontractus* among the archæological antiquities in Sherborne Castle Museum, and an *Oppelia waterhousei* and small *Tulites cadus* in Cheltenham College Museum (C. I. Gardiner Coll.).

The following abbreviations are used:

BM.	British Museum (Natural History), London.
GSM.	Geological Survey Museum, London.
SM.	Sedgwick Museum, Cambridge.
OUM.	Oxford University Museum.

S. S. Buckman's work, 'Type Ammonites' (1909—1927, vols. i—vii), is quoted so often, and its dates of publication spread over those of so many of his other papers, that it is here always referred to by the letters TA, following the date of the relevant part. References to Buckman without the letters TA are to his other publications.

[1] The following notes are kindly supplied by Mr. A. D. Hallam, B.Sc., of Somerset County Museum, Taunton Castle (1948):

The Rev. E. Bower, Rector of Closeworth, nr. Yeovil, collected between 1828 and 1874. "Where-ever there is a locality it is nearly always one in the Yeovil-Sherborne area, so I think it may be taken that most of the [Bathonian and Bajocian] material in the collection comes from this district."

Dr. H. F. Parsons, born at Beckington, nr. Frome, died 1913. Most of his fossils are marked with a locality, chiefly in the Frome district. "He was a fairly sound naturalist, and I think it may be assumed that any data of his with specimens are correct."—(A.D.H.)

The work has been made possible by a Research Fellowship at Trinity College, Cambridge, and by facilities to work in the Sedgwick Museum, Cambridge, generously put at my disposal by Prof. W. B. R. King, F.R.S. For help in assembling the material, and for discussion of countless difficulties and problems, I am deeply indebted to Mr. A. G. Brighton, Curator of the Sedgwick Museum.

The following have helped in various ways and incurred my gratitude; without their help the work would have been impossible: Mr. R. Baker, Dr. A. Bramkamp, Mr. E. E. S. Brown, Brigadier G. Bomford, Mr. P. J. Channon, Mr. F. G. Dimes, Mr. D. T. Donovan, Prof. J. A. Douglas, Dr. R. M. C. Eagar, Mr. J. M. Edmonds, Mr. W. N. Edwards, the Rev. J. Fowler, Mr. T. R. Fry, Mons. L. Guillaume, Mr. A. D. Hallam, Prof. H. L. Hawkins, Mr. S. W. Hester, Dr. R. W. Imlay, Mr. W. S. McKerrow, Prof. L. Krumbeck, Dr. W. Kühne, Dr. F. H. McLearn, Dr. P. L. Maubeuge, Mr. R. V. Melville, Dr. H. M. Muir-Wood, Mr. A. Reeley, Mons. J. Roger, Mr. H. B. Rowbotham, Mr. A. B. Sackett, Prof. H. H. Swinnerton, Mr. P. C. Sylvester Bradley, Dr. F. S. Wallis and Mr. J. H. Williams. Outstanding contributions, which I must mention individually, have been made by Mons. P. L. Maubeuge of Nancy, who has sent me important collections of Bathonian ammonites from the east of the Paris Basin, by Mons. Jean Roger, who has sent me superb plaster casts of all the relevant types and possible types in the d'Orbigny Collection in Paris, by Dr. F. H. McLearn, who has sent me casts of *Defonticeras* and various Canadian Stephanoceratids, Dr. Lothar Krumbeck of Erlangen, who has sent me a splendid collection from the Aspidoides Beds of Schwandorf and other places in Bavaria, and the Rev. Joseph Fowler, Mr. A. B. Sackett, Brigadier G. Bomford and Dr. W. Kühne, to whom I owe the loan or gift of whole collections of English Bathonian ammonites.

Nor do I forget fruitful discussions in the field on the Bathonian in many parts of England with Mr. L. Richardson, in Normandy with Professor A. Bigot and Monsieur Jean Mercier, in the Boulonnais with the late Monsieur A. P. Dutertre, in the Rhone valley with the late Professor F. Roman, in the Cotswolds and Oxford district with Professor Roman and Monsieur L. Guillaume, in Dorset with Brigadier Bomford, and in the Bath district with Mr. D. T. Donovan.

The photographs have been taken at the Sedgwick Museum by Mr. Albert Barlow, excepting those of types in the British Museum, which are by Mr. J. Rhodes, and a few others acknowledged in the underlines or explanations of plates.

3. STRATIGRAPHY.

(*a*) The Great Oolite Series and its Subdivisions, and the Distribution of Ammonites.

With minor exceptions specified below, the formations yielding the ammonites dealt with in this monograph together comprise the Great Oolite Series, which unites a great variety of rocks, chiefly limestones, marls, and clays, falling between the Inferior Oolite Series below and the Kellaways Beds and Oxford Clay above. In general the component formations form a sequence established and named by William

Smith : Fuller's Earth clays (with usually an important median rock band, the Fuller's Earth Rock), Great (or Bath) Oolite, Bradford Clay, Forest Marble, and Cornbrash.

The distribution of ammonites is very uneven, both vertically and horizontally, and to some extent these time-honoured formations have proved to be diachronic ; *i.e.* the minor formational boundaries within the Series do not necessarily coincide with time-planes. The problem of zonal classification is therefore much more complicated than appears at first sight.

The following tabular statements of the sequences, arranged geographically from south to north, as far as the northern limit of ammonites, with explanatory notes, are intended to elucidate the records listed under " Distribution " for each species. More detailed correlations, within the South of England and abroad, will be put forward at the end of the monograph.

As shown in Table I and explained in Section 3 (*c*) (p. 16), the Upper Cornbrash is excluded because its fauna is Callovian, and the topmost zone of the Inferior Oolite is included because by the definition here adopted its fauna is Lower Bathonian.

Dorset and South Somerset.

From the Dorset coast to within 5 miles of Bath (Somerset) there is no Great Oolite ; Forest Marble rests directly on Fuller's Earth, thus :

	Ft. max. thickness.
Lower Cornbrash	10
Forest Marble, with, in the south, a bed of *Goniorhynchia boueti* at base	130
Upper Fuller's Earth clay, with, as far north as the Sherborne district, an " Upper Fuller's Earth Rock " or Wattonensis Beds	170
Fuller's Earth Rock	35
Lower Fuller's Earth clay	140
Zigzag Bed ($\frac{1}{2}$ ft.), or whitish Crackment Limestones (*pro parte*) and Lenthayensis Limestones, say .	15
Total	500

On the coast (Burton Bradstock) and as far north as the Beaminster district (Broad Windsor, etc.), the lowest bed yielding Bathonian ammonites (as here defined, p. 16) is the so-called Zigzag Bed, or " 1st Bed " of the Inferior Oolite (Buckman, 1910, p. 72). It is only 6 inches thick and firmly cemented to the underlying Inferior

TABLE I.—*Stages, Formations and Zones.*

Stages.		Zones (see pp. 19-22).	Formations.
Callovian	Upper	*Quenstedtoceras lamberti*	Oxford Clay, p. p.
		Peltoceras athleta	
	Middle	*Erymnoceras coronatum*	
		Kosmoceras jason	
	Lower	*Sigaloceras calloviense*	Kellaways Beds.
		Proplanulites koenigi	
		Macrocephalites macrocephalus (auctt.)	Great Oolite Series.
Bathonian	Upper	*Clydoniceras discus*	
		Oppelia aspidoides	
	Middle	*Tulites subcontractus*	
		Procerites progracilis[1]	
	Lower	*(Oppelia fallax)*[2]	
		Zigzagiceras zigzag	Inferior Oolite Series.
Bajocian	Upper	*Parkinsonia parkinsoni*[3]	
		Garantiana garantiana[4]	
		Strenoceras subfurcatum[5]	
	Middle	*Stephanoceras humphriesianum*	
		Otoites sauzei	
		Sonninia sowerbyi	
	Lower	*Ludwigia murchisonæ*	
		Leioceras opalinum	

This table is intended for reference in connection with the following text. For general discussion and Jurassic zones, see Arkell, 1946, pp. 8—13.

[1] *Procerites progracilis* Cox & Arkell, 1950, p. 94, = *Ammonites gracilis* J. Buckman, 1844, *non* Münster in Zieten, 1830.

[2] *Oppelia fallax* (Guéranger) 1865, = *O. fusca* auctt. *non* Quenstedt as interpreted by the lectotype designated by Rollier, 1911.

Oolite, but as shown by Buckman it contains a completely different suite of ammonites, in great abundance; and they are the typical assemblage of the Lower Bathonian of Continental geologists. The most important are *Parkinsonia convergens* (S. Buckman), *P. pachypleura*[1] S. Buckman, *P.* **dorni** sp. nov. (*P. ferruginea* Dorn, 1927, p. 231, pl. iv, figs. 5, 6, *non* Oppel sp. 1857, *non Ammonites ferrugineus* Simpson, 1855), *Zigzagiceras zigzag* (d'Orb.), *Z. crassizigzag* (S. Buckman), *Z. euryodos* (Quenstedt), *Z. pseudoprocerum* (S. Buckman), *Z. pollubrum* S. Buckman, *Z. rhabdouchus* S. Buckman, *Procerites tmetolobus* S. Buckman, *P. clausiprocerus* (S. Buckman), *P. subprocerus* (S. Buckman), *P. phaulomorphus* (S. Buckman), *Planisphinctes planilobus* (S. Buckman), *Morphoceras patescens* (S. Buckman), *M. macrescens* (S. Buckman), *M. replictum* (S. Buckman), *M. multiforme* sp. nov. (see below, p. 17), *Ebrayiceras pseudo-anceps* (Ebray), *E. jactatum* S. Buckman, *Oppelia* (*Oxycerites*) *fallax* (Guéranger), *O.* (*O.*) *limosa* (S. Buckman), *O. nivernensis* de Grossouvre, *Œcotraustes costiger* S. Buckman, *Œcotraustes*, at least three new species.

Upon the Zigzag Bed and often difficult to separate from its rotted upper surface are 3 or 4 inches of brown, often iron-stained marl, called The Scroff, which seems to yield some of the same ammonites and no new ones; then follow the Fuller's Earth Clays, almost barren of ammonites and still little known palæontologically.

Where the Inferior Oolite and Great Oolite Series re-emerge on the north side of the Chalk downs, in the Sherborne district, the Zigzag Bed has disappeared. Instead, the Fuller's Earth clays (unexplored and virtually unknown) pass down into marly limestones (Lenthayensis Beds) with the peculiar *Sphæroidothyris lenthayensis*, and these rest in turn (Kellaway and Wilson, 1941, p. 157) upon ochreous and white

[1] Buckman's dating of the holotype to the Garantiana Zone was apparently an error.

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[3] Mainly the Schloenbachi Zone of Buckman (1907), but includes the subzone of *Strigoceras truellei* (proposed by Buckman, 1891). *Parkinsonia parkinsoni* (J. Sow.), d'Orbigny's and Oppel's index species, is abundant in the so-called *schloenbachi* beds from Burton Bradstock to Fawler in Oxfordshire—the Clypeus Grit (see Arkell, 1947*b*, p. 90). With it everywhere occurs *P. schloenbachi* Buckman (TA, Pl. CDXCIII, GSM. 47534) = *P. depressa* Nicolesco (1927, p. 39, pl. x), *non* Quenstedt (refigd. Schmidtill & Krumbeck, 1931, p. 863), *non Ammonites depressus* Bruguière, 1789; but it is uncertain whether this is the same species as *P. schloenbachi* Schlippe, 1888, p. 210 (of which the lectotype designated by Rollier, 1911, p. 299, is Schlippe's small figure, pl. iv, fig. 4, not Schloenbach's figure, 1865, pl. xxix, fig. 1, as supposed by Nicolesco (1927, p. 41), Dorn (1927, p. 238), Schmidtill & Krumbeck (1931, p. 788) and Arkell (1947*b*, p. 90)). Schloenbach's figure, which is lectotype of *P. eimensis* Wermbter, 1891, p. 271 (*non* Wetzel, 1911), is very different from Buckman's *schloenbachi*, but with Schlippe's small figure there is no overlap and it is impossible to say at present whether the species is the same or not.

[4] Garantiana Zone proposed by Buckman, 1893. The "Pseudogarantianenschichten," without *Strenoceras*, of Bentz, 1928, p. 140.

[5] The Subfurcatum Zone of Terquem and Jourdy (1869), de Grossouvre (1888), Schlippe (1888), Lissajous (1923), Wetzel (1924) and others. Synonym, the Niortense Zone of Buckman, proposed 1893. In any case, *Strenoceras niortense* (d'Orbigny) is a synonym of *S. bajocense* (Defrance), the type of which has been refigured by R. Douvillé (1909, 'Pal. Universalis,' no. 133). For types of *S. subfurcatum* (Schlotheim) see Bentz, 1928, p. 150, pl. xiv, figs. 1, 2.

limestones, the Crackment Limestones, 20—30 ft. thick and forming an important part of the local Inferior Oolite. (For descriptions see Richardson, 1932, pp. 49, 66—7, 71).

For many years Buckman (1891, p. 503) was of the opinion that the Crackment Limestones of Bradford Abbas (where he knew them best) and other quarries in the Sherborne district pass laterally into the lower part of the Lower Fuller's Earth on the coast, and therefore are younger than the Zigzag Bed of S. Dorset. This notion, thus originated by Buckman, lay at the back of Richardson's classification of the Crackment Limestones and the whole Zigzag Zone with the Great Oolite Series (Richardson, 1911, p. 22; 1927, p. 36; 1932, p. 49), adopted by me (Arkell, 1933, chapter IX). (For discussion see Arkell, 1939, pp. 172—3.) But latterly Buckman (1927, TA vi, p. 51) saw a temporary section one furlong south of Bradford Abbas vicarage, which caused him to withdraw his suggestion and to perceive that the bulk of the Crackment Limestones of Bradford Abbas lie below the equivalents of the S. Dorset Zigzag Bed. This has been confirmed by important collections of ammonites made by Mr. G. A. Kellaway of H.M. Geological Survey, and by the Rev. Joseph Fowler in temporary exposures for a pipeline at Milborne Port in 1936, and by Mr. Fowler in excavations for an extension of Sherborne Girls' School in 1937, as well as by stray finds by Mr. Fowler in Crackment road-cutting (1949), and by Mr. P. C. Sylvester Bradley in the south or limekiln quarry at Halfway House (1948). At these places the *upper* part of the Crackment Limestones has yielded abundant *Parkinsonia convergens* (S. Buckman), *P. pachypleura* S. Buckman, and *Procerites* spp. (*P. subprocerus* S. Buckman sp., *P. costulatosus* S. Buckman sp., *P.* sp. nov.). At Milborne Port these occurred in 2 ft. of limestone (Kellaway and Wilson, 1941, p. 157, lowest bed); at Sherborne Girls' School in not more than 3½ ft. (J. Fowler, *in lit.*); at Halfway House limekiln quarry, in the highest 5 ft. at most (P. C. Sylvester Bradley, *in lit.*). The bulk of the Crackment Limestones at Bradford Abbas, which presumably lie below this *Parkinsonia convergens* horizon, yielded the types of *Œcotraustes costiger* and *O. nodifer* S. Buckman, and various other Oppeliids (Buckman, 1893, p. 485, and 'Mon. Inf. Ool. Am.,' 1905, Suppl., p. cxciv). But there are still other elements of the South Dorset Zigzag Bed that have yet to be found *in situ* in the Sherborne district, notably *Zigzagiceras* and the Morphoceratids. Probably these should be sought above the *Parkinsonia convergens* horizon, as in Normandy (Guillaume, 1927*b*). It seems that the Zigzag Bed of South Dorset is a condensed deposit which may represent three subzones.

Separated from these basal Bathonian beds by the thick unexposed clays of the Lower Fuller's Earth, another rich and interesting ammonite assemblage comes in with the Fuller's Earth Rock. It has been collected in many exposures along the outcrop from Troll Quarry, Thornford, near Sherborne, throughout Somerset to beyond Bath. This is the Middle Bathonian assemblage, comprising mainly the genera *Tulites* and *Morrisiceras* and their allies, with more rarely *Berbericeras, Siemiradzkia, Procerites, Wagnericeras* and *Œcotraustes*.

From the "Upper Fuller's Earth Rock," or Wattonensis Beds, are known a few *Procerites* and rare specimens of *Morrisiceras*, crushed and indeterminable specifically, but not visibly different from species of the true Fuller's Earth Rock (the specimens recorded by Kellaway and Wilson, 1941, p. 160, collected by the Rev. J. Fowler in a stream bank near Whistle Bridge and near Trill Farm respectively, and now SM. J.23008—9).

The Upper Fuller's Earth on the coast near Langton Herring yields abundant crushed *Procerites* indet. and more rarely small *Hecticoceras* (Arkell, 1940). Thereafter ammonites are unknown until the Cornbrash. With the Lower Cornbrash come in *Clydoniceras* and *Choffatia*; with the Upper Cornbrash *Macrocephalites* and again *Choffatia.* The two parts of the Cornbrash maintain these characteristics all across England (see Douglas and Arkell, 1928, 1932; Cox and Arkell, 1950, Stratigraphical Introduction).

Bath and the South Cotswolds.

Numerous large *Procerites* spp. (*P. cf. schloenbachi* de Grossouvre, *P. subprocerus* (S. Buckman), *P. clausiprocerus* (S. Buckman), *P. fullonicus* (S. Buckman), etc.) with an occasional *Zigzagiceras* and *Morphoceras*, have been collected from the Zigzag Zone of Brambleditch quarry, half a mile south of Doulting, where the zone consists of 3 ft. of rubbly argillaceous limestones with four clay partings containing *Ostrea lotharingica* [*knorrii*] and rests directly on the Anabacia Limestones. (It is the "Rubbly Beds" of Richardson, 1907, p. 393.) The same beds have recently been exposed in excavations for a hockey pitch at Kingswood School, Bath, whence the Headmaster, Mr. A. B. Sackett, has collected *Procerites fullonicus* (S. Buckman), *P. tmetolobus* S. Buckman, *P.* between *tmetolobus* (S. Buckman) and *clausiprocerus* (S. Buckman), *Zigzagiceras pollubrum* S. Buckman, *Z. rhabdouchus* S. Buckman, *Morphoceras densicostatum* Thalmann, *M.* sp., *Oppelia fallax* (Guéranger) and *O. limosa* (S. Buckman). (Mixed with these were some *Tulites, Morrisiceras*, etc., slipped down the hill from Fuller's Earth Rock.) The lower part of the Lower Fuller's Earth here also yielded some giant smooth *Procerites*, but they were broken up by the excavator and are indeterminable.

The Fuller's Earth Rock has yielded the same suite of ammonites as farther south. In places around Bath (Dunkerton, near Duncorn Hill, and the slopes of Lansdown) they are common enough to be picked up on the ploughed fields. The most northerly records at present are a *Morrisiceras* from Kilcott and a *Wagnericeras* from Wotton-under-Edge, both sent me by Mr. D. T. Donovan.

Between Norton St. Philip and Wellow, about 5 miles south of Bath, Great Oolite begins to be intercalated between the Upper Fuller's Earth and Forest Marble. It begins suddenly, and within a mile is 100 ft. thick, although neither the Upper Fuller's Earth nor the Forest Marble becomes appreciably thinner. The Fuller's Earth Rock continues in its usual position, and both formations crop out in sequence round the same hills. The Great Oolite consists of Lower and Upper Rag Beds, with the Bath Stone in the middle. The Lower Rags contain a highly fossiliferous, coarsely oolitic to pisolitic division of brown limestone resembling Inferior Oolite, which locally on the Wellow ridge and on the opposite side of the valley near Hinton Charterhouse becomes an ironshot oolite, and is referred to hereafter as the Twinhoe Ironshot. At Twinhoe quarry (Cox and others, 1941, p. 24) and at other exposures on both sides of the valleys it has yielded *Oppelia aspidoides* (Oppel) and two undescribed species of *Procerites*, while at Hinton Charterhouse in associated beds I have found the true *Wagnericeras arbustigerum* (d'Orbigny).

The higher sequence of the Great Oolite still remains to be worked out in detail, and the position of the Bath Stone remains doubtful; it may have been quarried on more than one horizon in different places. The occurrence of the type specimen and one topotype of *Bullatimorphites bullatimorphus* S. Buckman in the topmost bed of the White Limestone at Tiltup's End, south of Nailsworth (Lycett, 1863, pp. 3—4; Witchell, 1886, p. 267) is unique. The only other rock below the Cornbrash that has yielded ammonites is the Bradford Clay, or its equivalent Acton Turville Beds facies (Reynolds & Vaughan, 1902, pp. 742—6), which has yielded a single *Clydoniceras hollandi* (Buckman) at Bradford-on-Avon. The same species has occurred in the Bradford Clay at Tetbury Road Station, near Cirencester. The succession is:

	Ft. max. thickness.
Lower Cornbrash	25
Forest Marble (Wychwood Beds and Hinton Sands) .	120
Bradford Clay and Acton Turville Beds . . .	45
Great Oolite, including Bath Stone and Lower and Upper Rags, up to . . .	100
Upper Fuller's Earth	90
Fuller's Earth Rock, splitting into two northwards .	25
Lower Fuller's Earth	50
Zigzag Beds	3
Total . . .	*c.* 460

Mid Cotswolds.

Before approaching Stroud and Nailsworth the formations undergo two lateral changes. First the Fuller's Earth Rock changes in facies to Great Oolite limestones, which expand to form the fossiliferous Great Oolite of Minchinhampton, of which the molluscan fauna early became famous through the monographs of Morris & Lycett (1851—63, recently revised; Cox & Arkell, 1948—50). Secondly, a mile or two after, the (local) Upper Fuller's Earth wedges out, bringing into contact two sets of Great Oolite of similar facies, but considerably separated in age. Beyond the line where this happens correlations become very difficult. The Fuller's Earth Rock assemblage of ammonites, chiefly *Tulites* spp. and *Morrisiceras* spp., occurs at Minchinhampton in the Great Oolite, though the exact horizons are not known and the stratigraphical sequence is uncertain. At Chedworth the stratigraphy is clear from a series of deep railway-cuttings, but only one ammonite has been found: half a specimen indistinguishable, so far as it goes, from *Morrisiceras morrisi*, near the middle of the White Limestone division (Richardson, 1911, p. 111).

On the north side of the Chalford or Golden Valley, near Stroud, the Stonesfield Slate Beds make their first appearance. They consist of sandy, compact, fissile limestones and stinkstones, interbedded haphazard with coarse shelly oolites indistinguishable from the Minchinhampton Shelly Beds; but the ammonite fauna is quite different. Slates were worked round Bisley, but no ammonites are recorded until the North Cotswolds. The full succession is:

		Ft. max. thickness.
Lower Cornbrash		15
Wychwood Beds; Bradford Fossil Bed; Kemble Beds	Forest Marble	80
White Limestone, upper part, with *Epithyris oxonica* and, below, *Ornithella* spp.		50
White Limestone, lower part, at Chedworth, and white limestones of Pinfarthing; Minchinhampton Beds and Taynton Stone		65
Stonesfield Slate Beds (Cotswold Slates)		15
[Lower] Fuller's Earth, with Acuminata Beds at or near top		100
Total		*c.* 325

North Cotswolds and Oxfordshire.

The Fuller's Earth, already reduced in the Mid Cotswolds to the Lower Fuller's Earth, becomes thinner soon after crossing the Coln valley into the North Cotswolds, and wedges out along a line passing near Condicote, Stow-on-the-Wold, and Burford (Maps in Welch, 1926, p. 222, and Arkell, 1947*c*, fig. 27). Beyond this it seems to be replaced by the Sharp's Hill Beds and Chipping Norton Limestone. In the latter, two poorly preserved casts of *Oppelia limosa* ? (S. Buckman) have been found, one at Oakham, near Chipping Norton, the other at Lower Swell, Gloucestershire. In Oxfordshire the Hook Norton Limestone comes in below, with some large *Procerites* and Parkinsonids, probably representing the Zigzag Zone (and perhaps also lower Crackment Limestones). (Identifications in Arkell, 1947, p. 32, and 1947*a*, p. 90).

The [Lower] Fuller's Earth passes up gradually into the Stonesfield [Cotswold] Slates, which in the Cotswolds and at Stonesfield have yielded a peculiar assemblage comprising *Procerites progracilis* Cox & Arkell and its allies (large and abundant), *Micromphalites micromphalus* (Phillips), *Clydoniceras tegularum* sp. nov. (see p. 42), *Oppelia* cf. *limosa* (S. Buckman), *Œcotraustes* sp., and a single *Tulites*. Above these beds (which are by no means everywhere present) follows the Great Oolite proper.

In the Great Oolite proper a new subdivision, the Hampen Marly Beds, makes its appearance, and thence eastwards consistently separates the Taynton Stone below from the White Limestone above. The Taynton Stone has yielded no ammonites, and the Hampen Marly Beds only one, the holotype of *Procerites* ? *imitator* (S. Buckman) from near the base in the Ardley-Fritwell railway-cutting near Bicester. From the lower part of the White Limestone, however, there are three specimens of ammonites, all isolated finds from widely scattered localities. All are *Tulites*, and they belong to two species, both found in the Dorset Fuller's Earth Rock. The localities are Salperton near Northleach, Asthall near Witney, and the Ardley-Fritwell railway-cuttings near Bicester, and the horizon in each case was near the base of the White Limestone.

The full succession (not all present in any one locality) is as follows :

	Ft. max. thickness.
Lower Cornbrash	10
Forest Marble	30
White Limestone	50
Hampen Marly Beds	25
Taynton Stone	30
Stonesfield Slate Beds, 0 to	25
Fuller's Earth, 0 to	40
Sharp's Hill Beds, 0 to	10
Chipping Norton Limestone, 0 to	20
Hook Norton Limestone, 0 to	8
Total	*c.* 250

Northamptonshire.

The only ammonites are from the Cornbrash and the Great Oolite, which is mainly a continuation of the White Limestone. The succession is :

	Ft. max. thickness.
Lower Cornbrash	5
Blisworth Clay (=Lower Forest Marble, Kemble Beds ?)	30
Great Oolite Limestone	30
Upper Estuarine Series (=mainly Hampen Marly Beds ?)	35
Total	*c.* 100

The most northerly records of Lower Cornbrash ammonites are *Clydoniceras*, *Delecticeras* and *Choffatia* from Sudbrook, north of Lincoln, but in the Upper Cornbrash Macrocephalitids are abundant on the Yorkshire coast.

In the rest of the series the most northerly known ammonites are a few large smooth *Procerites* (or *Wagnericeras* ?) known only by their outer whorls, from Stamford, Kingsthorpe, Blisworth and Belmisthorpe, Northants, and a single *Choffatia* from Moulton near Northampton. Nautilids, on the other hand—*Procymatoceras baberi* (Morris & Lycett) and *P. subtruncatum* (Morris & Lycett)—are common (Sharp, 1870, pp. 361, 378 ; 1873, pp. 263, 264).

In an old collection there is a specimen of *Morrisiceras morrisi* (Oppel) apparently from the Somerset Fuller's Earth Rock, labelled as from Great Oolite at Stoke Doyle (near Oundle), Northants, but two *Macrocephalites* from the Upper Cornbrash bore the same label, and all are as certainly labelled in error as is a fine specimen of *Emileia vagabunda* S. Buckman in the same collection from the Inferior Oolite, probably of Cleeve Hill, Cheltenham, labelled "*Perisphinctes*, Great Oolite, Blisworth" (Northants) (SM. B3955, 3956). A Northamptonshire ammonite from Cranford, near Kettering, has been figured as from the Great Oolite White Limestone and identified as "*Wagnericeras* sp. nov." (Spath, 1931, p. 282, pl. xlviii, figs. 2*a*—*c*, and pl. lxxix, fig. 7), but inspection of the specimen (BM. C35823) shows that it is a Lower Kimeridgian Rasenid from the Chalky Boulder Clay, which is highly fossiliferous in the Cranford quarries. (It is the species figured by Petitclerc, 1916, p. 47, pl. viii, figs. 1—5.)

(*b*) Summary of the Distribution of Bathonian Ammonites.

Thus in Britain as the world over the Bathonian shelf seas were for the greater part inimical to ammonites. It was a period of restriction in ammonite distribution, when the waters were invaded by deltas of great rivers, an environment where cephalopods never thrived, and in the deposits of which they are generally rare or absent.

In Bajocian times and again after the marine transgression of the Lower Callovian, ammonites abounded from Normandy across England from the Dorset coast to the Yorkshire coast, and up both sides of northern Scotland, to the eastern shores of Sutherland and the Western Isles. But the Murchisonæ Zone is the last ubiquitous ammonite-bearing zone of the British Lower Oolites. Already in the Middle and Upper Bajocian ammonites retreated before deltaic deposition from much of north-eastern England. In the Sowerbyi Zone they reach to Scotland up the west side, but on the east extend, as rarities, only as far north as Lincoln. In Yorkshire only the upper part of the Humphriesianum Zone has yielded ammonites. In the Upper Bajocian and Lower Bathonian ammonites occur in the Parkinsoni Zone and Zigzag Zone as far as northern Oxfordshire, but not beyond. During the rest of the Bathonian up to the base of the Cornbrash, as the records of the preceding pages show, the frontier of primary ammonite habitation shifted south to the Mid Cotswolds ; it is probable that the scattered finds north of that represent wanderers or drift shells, not autochthones. The ammonites in the Stonesfield Slate are mingled with bones of land animals and plants, and may have drifted from far to the south, like Nautilus shells that to-day sometimes reach the shores of Japan.

The retreat culminated at the time of the Forest Marble, when cross-bedded deposits of marine origin but rapidly-accumulated, and almost of deltaic facies, extended all across England as far south as the Dorset coast and the Boulonnais. At this time ammonites disappeared from Britain altogether.

Only two stocks survived in France in sufficient force to recolonize England with the conformable transgression of the Lower Cornbrash: *Clydoniceras* and *Choffatia*. Their reign was brief. The second conformable transgression (Arkell, 1933, pp. 91—2), represented by the Upper Cornbrash, brought in the Macrocephalitids, probably from the north. *Choffatia* survived in the south, but *Clydoniceras* was extinguished. During the Callovian period England was colonized by successive waves of invaders, coming sometimes from the north or north-east, sometimes from the south. Never again, until the shrinking of the seas in the Portlandian and Purbeckian, did the ammonite population suffer such a setback as that of the Bathonian.

It is significant, therefore, that the Bathonian was for ammonites a period of gerontomorphosis. (See above, p. 4.)

(c) Definition of the Bathonian Stage.

I have elsewhere (Arkell, 1946) advocated the adoption of d'Orbigny's stages, but at the same time pointed out that, owing to the imperfect state of knowledge in 1850, there are sometimes inconsistencies in d'Orbigny's definitions. Above all, d'Orbigny's lists of ammonites (1850, pp. 611—623) are unreliable, and should not be used as criteria for defining his stages when they contradict other lines of evidence. For instance, d'Orbigny listed *A. macrocephalus* and *A. herveyi* as both Bathonian and Callovian, *A. mariæ* as Callovian (it is Oxfordian), *A. koenigi* as Oxfordian (it is Callovian), *A. uralensis* as Oxfordian (it is Kimeridgian), *A. decipiens* as Kimeridgian (it is Oxfordian), *A. gravesiana*, *A. irius* and *A. gigas* as Portlandian (they are Kimeridgian). Accordingly I advocated that the normal procedure should be to interpret the Stages by the formations included by d'Orbigny at the type localities cited by him, after which it is a simple matter to determine the zones comprised in those formations at those localities.

D'Orbigny's definition of the Bathonian stage (1850, pp. 607—8) in terms of formations and ammonite-content left several uncertainties. It is essential to arrive at a definition for use in the present work.

Boundary with the Bajocian.—D'Orbigny (1850, pp. 606—8, 615—7) placed the Marls of Port-en-Bessin and the Fuller's Earth in the Bajocian and the Calcaire de Caen (which replaces the *lower* part of the marls) in the Bathonian; he placed *Ammonites zigzag* and *A. polymorphus* in the Bajocian, but the Marnes à *Ostrea acuminata* of the east of the Paris basin (which are now known to be equivalent to the Garantiana and Parkinsoni Zones, older than *A. zigzag*) in the Bathonian. In this as in most other matters of Jurassic stratigraphy no reviser is more competent or more worthy to be followed than Oppel. Oppel at first (1856, pp. 341, 344), as also his pupil Waagen (1864, p. 56), followed d'Orbigny by including *A. zigzag* and *A. polymorphus* in the fauna of the Parkinsoni Zone and the Bajocian. (*A. polymorphus* was d'Orbigny's alternative zonal index fossil to *A. parkinsoni* for the whole Bajocian in 1852.) But a short time later Oppel's extended researches led him to found the zone of *Ammonites zigzag* as a separate zone and place it in the " Bath-Gruppe " (Oppel, 1865, pp. 309, 315).

Now one of the most characteristic associates of *A. zigzag* in the Zigzag Zone is *Morphoceras polymorphum* (d'Orbigny), which d'Orbigny had used as one of his only two zonal indices of the Bajocian. But *Ammonites polymorphus* d'Orbigny (1846, p. 379, pl. 124, fig. 4 designated lectotype by Buckman, 1920, TA iii, p. 22) is a homonym of *A. polymorphus* Quenstedt (1845, p. 86, pl. iv, figs. 9—13) of the Lower Lias, and a synonym of *A. parkinsoni inflatus* Quenstedt (1846, p. 145, pl. xi, figs. 6, 7), which is itself (*A. inflatus*) a name several times preoccupied. *Morphoceras polymorphum* therefore has to be renamed, and **M. multiforme** nom. nov. is now proposed. When Oppel found that *A. polymorphus* d'Orbigny was not alternative to *A. parkinsoni* as d'Orbigny had placed it, but marked a higher zone, and when he named this zone and transferred it to the Bathonian, he was making an emendation of the pre-existing scheme which was an improvement and should be followed, just as much as his insertion of a Sauzei Zone into the Bajocian at a date subsequent to the promulgation of his original scheme (cf. Oppel, 1856—8, tables on pp. 305, 360, and at end of book).

Oppel's revised scheme has been followed by the overwhelming majority of French and German geologists, and it would be ill-advised to overthrow it now merely on the grounds that d'Orbigny originally placed *A. zigzag* in his list of Bajocian ammonites. The Zigzag Zone and its characteristic, highly distinctive, ammonite fauna has been standardized as Lower Bathonian, not only in the great " Traités " of Haug and de Lapparent, but in all the most important works, such as those of Baron (1885), Haug (1891), Welsch (1903), Riche and Roman (1921), Lissajous (1923), de Grossouvre (1925, 1930), Gillet (1928, 1937), and Guillaume (1927, 1929). (See discussion in Arkell, 1939, pp. 172—4.)

Accordingly it would seem to be a retrograde step to set aside Oppel's revision and downgrade the Zigzag Zone to a subzone of the Parkinsoni Zone and incorporate it in the Bajocian. On the authority of Spath (1936) and Muir-Wood (1936) I adopted this arrangement in two general works (1946, 1947) published shortly after a five-year interruption in my own studies due to the war, but I now consider that it is not warranted by either historical or palæontological considerations.

Some authors, such as Terquem and Jourdy (1869), Schlippe (1888), de Grossouvre (1888) and Wetzel (1924), have extended the Bathonian down to the base of the Parkinsoni Zone, *sensu lato*, including the Subfurcatum Zone (see Table I); but de Grossouvre corrected himself in several later papers. This course seems to have no arguments in its favour and need not be further considered.

My own conclusions may be tabulated as follows :

1. The distinctive fauna of the Zigzag Zone comprises *Zigzagiceras zigzag* and allied species, numerous early *Procerites* (of which a number were figured by Buckman), *Morphoceras multiforme* sp. nov. and its allies, *Ebrayiceras pseudoanceps* (Ebray) and allied species, *Œcotraustes costiger* and *O. nodifer* S. S. Buckman and other spp., and *Oppelia* (*Oxycerites*) *fallax* (Guéranger) which passes up into the Fuller's Earth.

2. The distinctness of this zone from the Bajocian faunas in Dorset and Somerset, pointed out by Buckman (1910, p. 72), is confirmed by records in France from Normandy (Guillaume, 1927*b*, 1929) to the Rhône Valley (Riche and Roman, 1921), and the Mediterranean coast near Toulon (Parent, 1938), and as far afield as Engelberg in the Swiss Alps (Thalmann, 1923), and Jebel Sekika in Algeria (Roman, 1933).

3. The occurrence of Parkinsonids in the Zigzag Zone does not subordinate it to the Parkinsoni Zone any more than the occurrence of *Garantiana* in the Middle Bathonian (*G. bathonica* Lissajous, 1923, p. 49, pl. iii) in France subordinates the Middle Bathonian to the Garantiana Zone. Oppel was right to separate the Zigzag Zone from the Parkinsoni Zone, of which it should not be classed as a subzone. It is an important major zone and may be itself divisible.

4. Order was brought into the French Bathonian faunas for the first time by de Grossouvre (1925, 1928), whose Lower, Middle and Upper assemblages may be recognized also in this country. De Grossouvre's Lower Bathonian is the Zigzag Zone.

5. The pre-d'Orbigny term Vesulian should be dropped. The original Vesulian of Vesoul is said to equal the Garantiana and Parkinsoni Zones only, *i.e.* the Garantiana, Truellei and Schloenbachi Zones of Buckman (Corroy, 1929, p. 180); its upward extension was based on mis-correlation by lithology and oyster-beds (see Lissajous, 1910, pp. 259—61).

Boundary with the Callovian.—D'Orbigny (1850, pp. 617—8) included three critical ammonites, *A. macrocephalus, A. herveyi, A. hecticus*, in his lists from both the Bathonian and Callovian stages, but at the same time he pointed out that they definitely occurred in the Callovian and were but doubtful records for the Bathonian. The ammonites recorded from the Bathonian as *A. macrocephalus* and *A. herveyi* were probably *Morrisiceras* (which is based on the Great Oolite *A. macrocephalus* of Morris and Lycett, 1851), and the *A. hecticus* may have been *Hecticoceras retrocostatum* de Grossouvre, now known to be common in the French Upper Bathonian. Hébert (1857, p. 30) soon pointed out that the true *macrocephalus* and *herveyi* occur only in the Callovian, and the Macrocephalus Zone was established as the basal zone of the Callovian by Oppel (1856—8) and Waagen (1864).

Oppel has been followed by nearly all authors and the arrangement has been incorporated in all the leading text-books, such as the "Traités" of Haug and de Lapparent (see *e.g.* Wohlgemuth, 1883; Baron, 1885; de Grossouvre, 1888; Haug, 1891; Riche and Roman, 1921; Lissajous, 1923; Wetzel, 1924). Nevertheless a few authors have argued that the Macrocephalus Zone should be transferred to the Bathonian: *e.g.* de Grossouvre (1887 and 1930), perhaps influenced by Lambert (1885), and lately Spath (1932, 1933) and Corroy (1941). This monograph will follow the arrangement standardized by Oppel and for many years the practice of the

British Geological Survey (*e.g.* Arkell, 1947*a*, p. 10), which accords with almost the whole of world geological literature. Consequently the ammonites of the Upper Cornbrash, being of the Macrocephalus Zone, will not be included.

(*d*) Provisional Table of Bathonian Zones.

Researches in the south-west of England have now proceeded far enough to establish a framework of ammonite horizons which correlate with the sequence worked out by Guillaume (1925, 1927, 1929) in the Caen district of Normandy. On this basis Table II is now offered as a working zonal and stratal sequence for reference in this monograph. The table avoids problems still under investigation, such as the position of the Bath Stone and the relation of the Zigzag Zone of England and France to the Wurttembergica Zone of Germany, but elucidation of these questions in the future is not likely to involve serious alterations to the zonal sequence here proposed. (Since this was written, evidence from Lorraine published by Maubeuge (1950) has shown that, as supposed by Wetzel (1924), the Wurttembergica Zone is a synonym of the Zigzag Zone.) Further research may reveal new horizons to be inserted, especially in the Lower and Upper Fuller's Earth clays, of which the ammonites are little known; any such modifications will be discussed and incorporated in the final Part.

As a rule the zonal index selected is the earliest to be published, but some exceptions have been made on various grounds, as indicated in the following notes.

Zigzag Zone (proposed by Oppel, 1865, pp. 309, 315).—For the characteristic fauna see above, p. 9. *Morphoceras polymorphum* (d'Orb.) was used as a zonal index by d'Orbigny in 1852, but as subsidiary to *Parkinsonia parkinsoni* and for the whole of the Bajocian; and since it is entirely unfamiliar as a zonal index, and since its name must be changed because preoccupied (p. 17), it is not now revived at the expense of Oppel's familiar *Ammonites zigzag*. Schloenbach (1865, p. 29), in the same year as Oppel but slightly earlier according to Waagen, introduced a zone of *Ammonites ferrugineus* Oppel, and Waagen (1869, p. 205) adopted it although he considered it the same as Oppel's Zigzag Zone. But it is fortunate that *A. ferrugineus* Oppel (1857), a *Parkinsonia*, is invalid because a homonym of *A. ferrugineus* Simpson (1855), an Amaltheid from the Middle Lias (see Buckman, TA, Pl. CXLII), for Oppel's *Parkinsonia* is impossible to interpret, and attempts to do so for three-quarters of a century have caused nothing but confusion. Schloenbach (1865), who adopted it as zonal index, figured two specimens, neither considered by later authors to be the same as *P. ferruginea* (Oppel): Schloenbach's small and malformed example (1865, pl. xxviii, fig. 4) is type of *Parkinsonia brunsvicensis* Rollier (1911, p. 299); his large and easily recognizable specimen (1865, pl. xxix, fig. 1) was considered by Schlippe (1888) to belong to but is not type of *P. schloenbachi* Schlippe, and is itself type of *P. eimensis* Wermbter (1891, p. 271) (*non* Wetzel, 1911). (Presumably the inner whorls of *P. eimensis* Wermbter are as figured by Schmidtill & Krumbeck, 1931, pl. 90, figs. 1*a*, *b*, sub. *P. schloenbachi* " typus.")

Fusca Zone (recte **Fallax Zone**).—Waagen (1869, p. 205) wrote of a "Fusca Niveau" and Neumayr (1871*a*, p. 356, 1871*b*, p. 520) of a Fusca Zone. Waagen (1869, pl. xvi, fig. 6) figured a specimen from the [basal] Fuller's Earth near Yeovil, and Buckman (1893, pp. 482 ff) retained Fusca and Zigzag as two zones. In 1893 (p. 482) he stated that he had no evidence for the distinctness of the two zones, but in his Palæont. Soc. monograph (1905, tables) and in 1910 (p. 72, and Table III) he assigned the basal Fuller's Earth and "The Scroff" (see above, p. 9) to the Fusca Zone "with oxynote Oppelids," as distinct from the Zigzag Bed below, and this arrangement has always been followed (Richardson, 1932, and previous papers). However, Waagen (1869, p. 202, pl. xvii, fig. 5) had already figured a specimen from the "Ferrugineus" Zone (=Zigzag Zone) of Shipton Gorge, Dorset. In the collections, specimens in the hard oolitic limestone matrix of the Zigzag Bed are commoner than those (very few) either in marl or clay matrix or recorded as having been obtained from the Fuller's Earth. The collections carefully made *in situ* by Brigadier Bomford in recent years confirm this impression. He has several *Oppelia fusca* Waagen et auct. from the Zigzag Bed. The correct name for the species seems to be *Oppelia fallax* (Guéranger), as will be explained below (Rollier, 1911, having changed the concept of *Oppelia fusca* (Quenstedt) by designation of lectotype). How far up in the Lower Fuller's Earth *Oppelia fallax* or its allies, such as *O. limosa* (S. Buckman), range is unknown; perhaps to the Stonesfield Slate (cf. Plate VI, fig. 6). At present there is insufficient evidence for regarding them as indicative of a zone separate from the Zigzag Zone, and there is a large gap representing much of the Lower Fuller's Earth (see p. 9) for which no zonal index fossil can yet be supplied.

Progracilis Zone (proposed by S. Buckman, 1913, TA ii, p. x).—The peculiar assemblage of the Stonesfield and Cotswold Slates, comprising *Ammonites gracilis* J. Buckman 1844, *non* Zieten 1830 (=*Procerites progracilis* Cox & Arkell, 1950) and other large allied species to be described below, with *Micromphalites*, *Oxycerites*, *Œcotraustes* and *Clydoniceras* (sp. nov.), has not yet been recognized anywhere else in Europe, but the two genera *Micromphalites* and *Clydoniceras* are associated in Sinai (H. Douvillé, 1916) and Arabia (unpublished). The zone is included in the Middle Bathonian rather than the Lower on account of the occurrence of *Clydoniceras* and *Tulites* (a single distorted specimen). Its stratigraphical position above the Lower Fuller's Earth and below the Subcontractus Zone has now been established by mapping, and the fauna is so distinct from that of either that it seems advisable to retain it as a separate zone.

Subcontractus Zone (proposed by S. Buckman, 1898 and 1901; the Subcontractus Schichten of Schlippe, 1888).—This is the same as the Morrisi Zone of Buckman (1913, 1918) and Rehbinder (1914, p. 329), and possibly the Ymir Zone of Baron (1885). It is characterized by numerous *Tulites* spp. and *Morrisiceras* spp., with subordinate *Procerites*, *Siemiradzkia* and *Wagnericeras*. The characteristic assemblage occurs in the Great Oolite of Minchinhampton, the Fuller's Earth Rock of the Bath district and North Dorset, and the Caillasses de Longues et Marigny in Normandy (Guillaume, 1927, p. 169). *Oppelia* (*Oxycerites*) *waterhousei* (Morris &

TABLE II.—*Bathonian Zones.*

	Zones.	*Supporting Ammonites.*	*Bath District.* * = *correlation by ammonites.*	*Normandy.* * = *correlation by ammonites.*
UPPER BATHONIAN	**Clydoniceras discus**	*Choffatia homœomorpha*, *C. longilobata*	*Lower Cornbrash	*Cornbrash inférieur.
	Clydoniceras hollandi		Forest Marble, *Bradford Clay and Acton Turville Beds	Pierre Blanche de Langrune, Marne à Z. digona, Zone à Rh. boueti.
	Oppelia aspidoides	*Wagnericeras wagneri*, *W. arbustigerum*, *Procerites* spp. nov.	Kemble Beds and Bath Stone; Lower Rags with *Twinhoe Ironshot	*Caillasse inf. à céphalopodes de Ranville, Pierre de taille de Ranville.
MIDDLE BATHONIAN	**Tulites subcontractus**	*Tulites modiolaris*, *T. cadus*, *Morrisiceras morrisi*, *M. comma*, *M. sknipum*, *Wagnericeras suspensum*	Upper Fuller's Earth *Fuller's Earth Rock *[Stonesfield Slates]	Grès du Planet, *Caillasses de Longues et de Marigny.
	Procerites progracilis	*Micromphalites micromphalus*, *Procerites* spp. nov., *Clydoniceras* sp. nov., *Oppelia oxus*, *Œcotraustes* sp. nov.	Lower Fuller's Earth	Calcaires de Maisy, Calcaires de Cricqueville, Couches de Vierville, Marnes de Port-en-Bessin.
LOWER BATHONIAN	**(Oppelia fallax)**	*Oppelia limosa*		
	Zigzagicera zigzag	*Z. euryodos*, *Procerites subprocerus* et spp., *Morphoceras multiforme*, *Ebrayiceras pseudoanceps*, *Parkinsonia convergens*	*Basal Fuller's Earth and * Zigzag Bed	*Couches de Passage A—C, Port-en-Bessin

(The right-hand column from the works of Guillaume, 1925–1929.)

Lycett) was listed by Buckman (1913, TA ii, p. x) as an additional zonal index above *morrisi*, but there is no evidence for this. The four known specimens of *O. waterhousei* were all collected long ago at Minchinhampton, and there is no record of the relative stratigraphical positions of any of the ammonites from there. There is no reason to doubt that *O. waterhousei*, like the other Minchinhampton ammonites, is a species of the Subcontractus Zone.

Aspidoides Zone (proposed by Oppel, 1862).—The index species, *Oppelia aspidoides* (Oppel), is widespread in Europe, from Minchinhampton to Switzerland. Good specimens have been found by the writer in the Twinhoe Ironshot of the Lower Rags near Bath, and the species also occurs in the contemporary Caillasse inf. à céphalopodes de Ranville, in Normandy (Guillaume, 1929, p. 173). Repeated allegations of long range through the Middle and even Lower Bathonian are probably based on misidentifications. Separation from *O. fallax*, *O. waterhousei* and other allied forms requires well preserved material. The index is therefore not ideal, but all the alternatives seem worse. *Bullatimorphites bullatus* (d'Orb.), one of d'Orbigny's two zonal indices for the single zone that he equated with his Bathonian in 1852, probably occurs in this zone, but it is unknown in England or in Normandy and is nowhere common, nor has a single specimen to my knowledge been anywhere collected *in situ* in a known bed. *Procerites quercinus* was proposed by Terquem and Jourdy in 1869 in an exceedingly loose sense, apparently for the Lower and Middle Bathonian, but the only specimens seen by me that seem to agree specifically with the type figures came, according to M. Maubeuge, from the Aspidoides Zone. These large *Procerites* are no easier to identify than the Oppeliids. *Wagnericeras arbustigerum* (d'Orbigny) was proposed by Martin in 1878 (pp. 10, 11). As used by Martin for the Côte-d'Or, by Baron (1885) for the Vendée, and by Lissajous (1923) for the Maconnais, the Arbustigerus Zone was a vague concept based on various misidentified Middle Bathonian *Procerites* (see Buckman, 1923, TA iv, p. 49). Guillaume (1925) showed, however, that the true *Wagnericeras arbustigerum* (d'Orbigny) is restricted in Normandy to the Caillasse à céphalopodes de Ranville, where it is associated with *Wagnericeras wagneri*, *Oppelia aspidoides*, and *Hecticoceras retrocostatum*, and there is confirmatory Ranville material, which can have come only from this horizon, in the British Museum. *Wagnericeras wagneri* (Oppel) was proposed by Buckman (1918) and misplaced by him below the Gracilis [Progracilis] Zone, but this was only a guess; it has proved to occur in the Aspidoides Zone in its type-locality, Normandy (Guillaume, 1925). Neither this nor *Hecticoceras retrocostatum*, proposed by Lissajous (1923), seems to have any advantage over their predecessors; and from our point of view both have the disadvantage of never having been found in England.

Hollandi Zone (proposed by S. Buckman, 1924).—*Clydoniceras hollandi* is the only ammonite found (in two places far apart) in the Bradford Clay or Acton Turville Beds, and it may serve as index for these beds and their even thicker equivalents in Normandy (see table).

Discus Zone.—*Ammonites discus* was one of d'Orbigny's two original zonal indices for the Bathonian (proposed 1852), but he did not mean by it *Clydoniceras discus* (Sowerby) as now intended, for his figure of *A. discus* is the type of *Oppelia* (*Oxycerites*) *fallax* (Guéranger), index of the Fallax Zone. The Discus Zone was first introduced with its present meaning by Buckman (1898), but in the meantime no other index had been proposed for the topmost Bathonian. No more appropriate index could be found, for *Clydoniceras discus* is abundant in and characteristic of the Lower Cornbrash in England and northern France, and recent finds have extended its area to the east of the Paris basin.

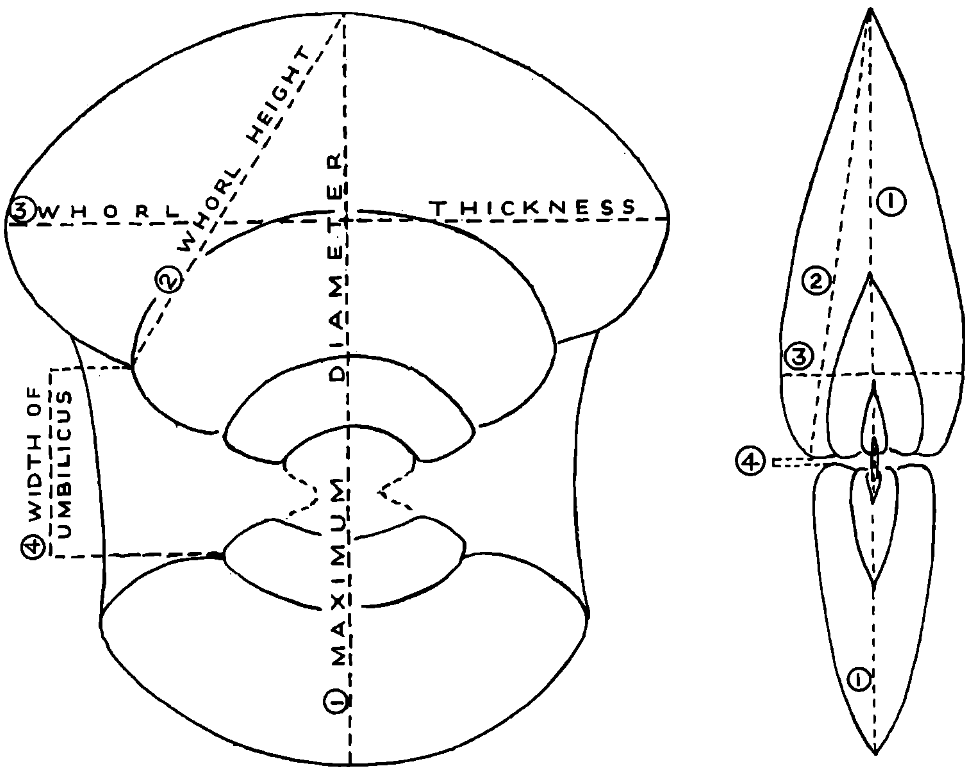
4. MORPHOLOGY.

The Bathonian ammonites comprise forms varying between the extremes shown in Text-fig. 1. On the left is a *Tulites*, exemplifying cadicone coiling (sphærocone when the umbilicus is smaller) and depressed whorl; on the right is a *Clydoniceras* or *Oppelia*, exemplifying discoidal and extremely involute, or oxycone, coiling, with almost completely occluded umbilicus, and compressed whorl. *Tulites*, again, has a wide venter (external area) and narrow whorl-sides (lateral areas); *Clydoniceras* when adult has wide whorl-sides which meet in a sharp edge (fastigate), so that there is no venter. In earlier stages there is a shouldered venter with a keel. *Clydoniceras* has a well-defined umbilical area, bounded by an umbilical angle; *Tulites* often has no umbilical angle, and the umbilical area and lateral area merge insensibly together.

Subject to such variations imposed by the variety of the material, the nomenclature used is that explained in the introduction to the monograph on the Ammonites of the English Corallian Beds (Arkell, 1935, pp. xxv—xxxii), the example there illustrated and discussed being a *Perisphinctes*, which is intermediate in form between the two extremes shown in the present Text-fig. 1, and is a type also abundant in the Bathonian. It is variously known as the planulate type, when the whorls overlap more or less, up to about a half of their height, or serpenticone when the whorls are only just in contact, with little or no overlap.

Dimensions.—When the dimensions of an ammonite are given they are expressed according to Buckman's formula in five figures, thus: Max. 126 mm. At 100 mm.: ·46, ·32, ·17. The first figure is the maximum actual size of the specimen (not the estimated maximum size if it were complete, as in S. S. Buckman's works). The second figure is the diameter (again in millimetres) at which the measurements that follow were taken. This may be the same as the first, but if the first is not a round number, or some other place affords better opportunity for obtaining accurate measurements, another diameter (if possible a round number) is chosen. In Text-fig. 1 the measurements are assumed to have been taken at the maximum diameter (1). The next three figures, which are always preceded by decimal points, represent the whorl-height (*i.e.* oblique whorl-height as shown in Fig. 1), whorl-thickness, and width of umbilicus, measured as shown in Text-fig. 1 (2, 3, 4), and always in the same order. These values, however, are not given in millimetres, as absolute values, but as decimal fractions (percentages) of the diameter at which they were taken, so that they are comparable, both between different specimens and species, and at different stages in the development of the same individual. Ideally these values should provide data for graphs to represent the ontogeny of each species, but in practice, without destroying specimens, it is seldom possible to obtain measurements at more than one or two diameters far enough apart to be worth tabulating. Buckman frequently printed dimensions which could not have been obtained by direct measurement, but (although not stated to be so) were estimates at estimated diameters on enclosed whorls. In all but the most evolute, many-whorled ("polygyral") ammonites the possibilities of error in such estimates are so great that the results are worthless.

Whorl-shape and coiling, and the effects upon them of rock-distortion.—In the Tulitidæ, especially, modes of coiling and, consequently, whorl-shape, change fundamentally during development. Accordingly inner and outer whorls of the same species found separately may be very different in shape. Until these changes are understood



TEXT-FIG. 1.—Diagrammatic cross-sections through a *Tulites* and an *Oppelia*, to show methods of measuring and the order in which the dimensions are printed throughout this monograph.

for all species, infallible determination of incomplete material will remain impossible. For some of the commoner species it has now been possible to link up nuclei with middle growth-stages and outer whorls, but for many species the material is still too scanty and the aspect of the young stages remains unknown.

Owing to these changes, it is essential when comparing material to compare like stages with like. Further, allowance must sometimes be made for distortion by rock-pressure. Flattening by crushing in the plane of the spiral is common in many clays, and is suspected of having affected, more or less, all the ammonites of the Stonesfield Slate, although they are preserved in hard stone. In the calcareous mudstone or argillaceous limestone which is the Fuller's Earth Rock, however, some distortion often occurs in other directions, and not infrequently at right-angles to the plane of the spiral. When this has occurred (and it is not always obvious, because unexpected), there may develop remarkable "specific" differences in form and coiling.

Two important effects are (1) narrowing of the umbilicus, and (2) apparent acceleration of whorl-enlargement. Examples will be cited below.

Sectioning of several specimens of Tulitidæ from the Fuller's Earth Rock has shown that rock pressure causing distortion has not acted uniformly on all parts of the shell, and this again may give deceptive results. Generally the body-chamber is an internal cast in solid mudstone ; the septate middle whorls are a natural external cast in calcite,[1] hollow inside or filled with crystalline calcite ; while the nucleus, to a diameter up to 5 or 10 mm., is flattened in the plane of the spiral to the thickness of a sheet of cardboard. It seems that the open body-chamber alone was filled with mud as the shell lay on the sea bottom ; that the middle whorls were later filled or lined with calcite crystals deposited from solutions which entered by the siphuncle ; and that the innermost whorls were crushed by compaction of the surrounding rock before they had time to receive a strengthening of calcite.

Septal sutures.—The morphology and taxonomic value of septal sutures in the family Perisphinctidæ were discussed in the Corallian Ammonite monograph (Arkell, 1935, pp. x—xiii, xxx—xxxiii). In studying the Bathonian ammonites the same problems have been encountered, and little needs to be changed in the discussion written 15 years ago. As with the Corallian ammonites, Buckman attached far too much importance to differences of detail in septal sutures, and failed to allow for the changes that they undergo during development of the individual. His influence is no doubt traceable in the writings of some other authors, for instance, de Grossouvre, who wrote (1930, p. 379) of the almost infinitely variable sutures of *Clydoniceras* : " The sutures seem to me to constitute an excellent basis of specific differentiation " ; and again F. Douvillé (1943, p. 8), who asserts that the genus *Clydoniceras* can be classified in no other way than by means of the suture-lines. The chaotic results into which this method led F. Douvillé are shown below in dealing with *Clydoniceras discus* (see p. 40).

Nevertheless, a reasonable discretion is called for. Where, as in *Clydoniceras discus*, the details of the sutures are seldom alike in any two individuals, the main trends in variation of the details clearly cannot be given higher systematic status than varieties, while within and between those varieties fall an infinite number of individual variations. On the other hand, when, irrespective of the details, there can be detected certain constant major differences in the proportions of the main components of the suture-line, for instance the external lobe relatively much longer or shorter, such differences may reasonably be given specific status : though when there is a marked correlation between such characters and distribution, " geographical subspecies " may be a more accurate description. (Text-fig. 6, p. 38.)

Similarly, when it is found that some of the Bathonian ammonites of tumid, involute, and almost smooth appearance have a second lateral lobe consisting of a single slender main stem with tapered lateral branches springing from either side like a fir tree, while others, externally similar, have a thick and short second lateral lobe

[1] Cf. Quenstedt, 1886—7, vol. ii, pl. 78, figs. 29, 30 ; it is remarkable that the same preservation is found in *Tulites* or *Bullatimorphites* of about the same age in Swabia, and in the Malay archipelago.

forked into two main branches which in turn are forked, it is reasonable to suspect homœomorphy.

Ribbing.—The degree of emphasis of the ribbing, and the stage in ontogeny when it fades, vary considerably from one individual to another in the Bathonian ammonites as in all others. While considerable allowance must be made for variation in density and strength of ribbing within the species, however, the general appearance and habit, or style, of the ribbing is of the utmost importance in classification, and often serves at once to distinguish, for instance, the Perisphinctid genera *Procerites*, *Choffatia* and *Wagnericeras*. Sometimes it saves us from worse pitfalls, such as accepting as a Perisphinctid the crushed and distorted fragment of a Cornbrash Macrocephalitid which is the holotype of "*Perisphinctes flagellans*" Blake (1905, pl. v, fig. 3; BM. C11794).

SECTION II. SYSTEMATIC PART.

Order AMMONOIDEA de Haan, 1825.

Suborder *AMMONITINA* Hyatt, 1889.

Superfamily *HARPOCERATACEÆ* Wedekind, 1917.

Family SONNINIDÆ S. Buckman, 1892.

The genus *Sonninia* Bayle, principally of the Sowerbyi Zone, was excessively split up by Buckman (1886 ff, and TA, 1909—30), and has since been " lumped " again by P. Dorn (1935), Spath (1936), and Hiltermann (1939). The affinities of the new Lower Bathonian form here described are much more with the Sonninidæ than with the earlier Hammatoceratidæ (Buckman, 1887), with which some authors prefer to merge the Sonninidæ.

The occurrences of *Vastites* in the Lower Bathonian and of the Clydoniceratidæ in the Middle Bathonian seem to support the hypothesis that some forms " lay, more or less dormant, in unknown or untapped areas, ready to take advantage of favouring recurrent conditions to spring into flourishing development. . . . Some such theory is necessary to account for the reappearances after temporary absence of forms which, from their essential similarity, appear to be actually related, as distinguished from those forms which are superficially alike but are obviously not related " (Buckman, 1926, TA, vi, p. 23).

VASTITES gen. nov. (*vastus*, clumsy, uncouth).

Type species **V. vastus** sp. nov., described below. Large, smooth, compressed, involute ammonites, the inner whorls strongly keeled, the keel hollow (septicarinate), the outer whorls with rounded venter ; little or no ornament on the sides, but some vague, coarse, sigmoid ridge-ribs near the aperture. Septal sutures with long but thick-stemmed first and second lateral lobes, and wide, blunt auxiliaries, the first bifid and possibly formed by twinning of the first two auxiliaries of the ancestor (cf. Hiltermann, 1939, p. 182, fig. 85.)

1. **Vastites vastus** sp. nov. Plate I, figs. 1*a*, *b*, *c*, and text-figs. 2, 3.

Dimensions of holotype :

Max. 274 mm.	At 274 :	·435,	·29,	·23
	At 250 :	·435,	·28,	·215
	At 200 :	·49,	·29,	·185.

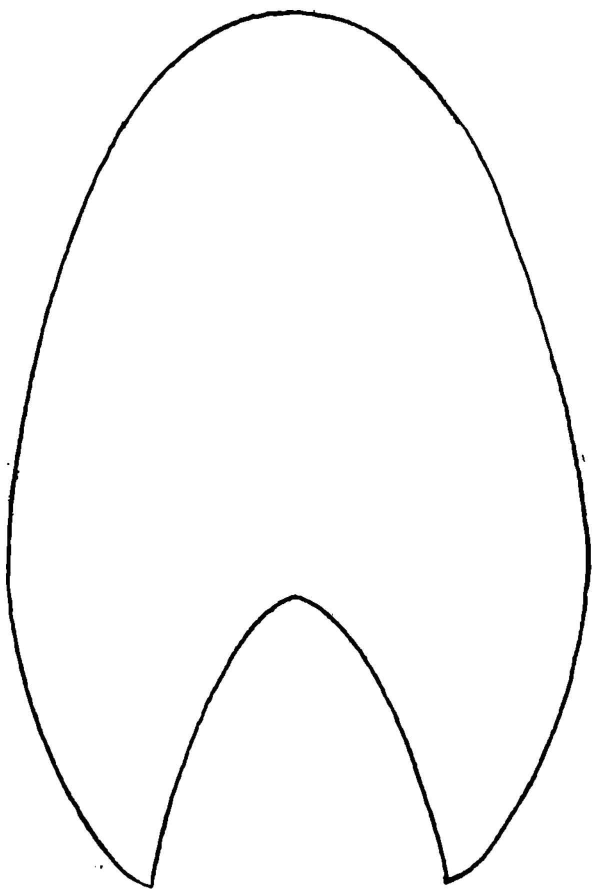
Description of holotype.—The umbilicus is clear on both sides and on one side has the test preserved. It shows no ornament, only rursiradiate growth-lines. It begins to open out suddenly at a diameter of 220—225 mm. The umbilical slope at all stages rises gently from the umbilical suture, without any umbilical angle. The whorl-sides are smooth and gently convex, the venter narrow but rounded, becoming wider, but still rounded, in the last quarter whorl, where a faint blunt keel develops. Coarse blunt sigmoid ridges near the mouth pass over the venter with a steep forward swing from the ventro-lateral angle. First lateral lobe long and narrow; second

TEXT-FIG. 2.—*Vastites vastus* sp. nov. Holotype. Umbilicus with test on side opposite to that figured on Plate I, fig. 1c. Natural size.

asymmetric; third lobe thick and bifid; fourth thick and blunt. The cross-section shows that the inner whorls are strongly keeled up to a diameter of about 90 mm.

Comparisons.—The unique specimen on which *Vastites vastus* gen. et sp. nov. is based was collected by the Sedgwick Club in 1946 in Brambleditch (Doulting Bridge) quarry, Doulting, in circumstances which preclude its having come from any horizon lower than the Zigzag Zone. It was in fact obtained *in situ* between clays with *Ostrea lotharingica* [*knorrii*] near the base of the Fuller's Earth. No Sonninidæ have previously been recorded from so high an horizon. Consequently I was at first inclined to regard this ammonite as an aberrant Oppeliid ; for in size, though gigantic for an Oppeliid, it falls short of Quenstedt's "Riesen-*fuscus*" from Laufen (1886—7, pl. lxxv, fig. 21), which is wholly septate at 270 mm. diameter ; and in general form it is not unlike "*Alcidia*" auct.

The faint gerontic ribbing and the septal sutures, however, as well as the appearance of the growth-lines on the test in the umbilicus (Text-fig. 2), are all Sonninid rather than Oppeliid. The ribbing suggests that of *Sonninia propinquans* Bayle sp.,



TEXT-FIG. 3.—*Vastites vastus* sp. nov. Whorl-section of holotype at diameter of 273 mm. Two-thirds natural size.

S. Buckman (1922, TA, iv, Pl. CCXCVIII). The broad, blunt auxiliary lobes are paralleled in *Shirbuirnia* spp. (*e.g. S. trigonalis* S. Buckman, 1924, TA, v, Pl. DXVII, A, B ; and *S.* ("*Fissilobiceras*") *phlyctænodes* S. Buckman, 1923, TA, iv, Pl. CCCLXXXVII). There is, in fact, a remarkable general resemblance to these large, nearly smooth *Shirbuirniæ* of the Sowerbyi Zone. A comparable two-pronged blunt first auxiliary lobe in a *Sonninia* is figured by Hiltermann (1939, p. 182, fig. 85).

A similar type of suture-line has been figured from the Bajocian of Cape St. Vigilio on Lake Garda in *Oppelia subplicatella* Vacek and *O. gracililobata* Vacek (1886, pl. x, figs. 1—4, pl. xi, figs. 1—5), and notwithstanding the uncarinate venters these species may also be derivatives of Sonninidæ rather than Oppeliidæ. *Ammonites augescens* Quenstedt (1886—7, pl. lxxv, fig. 24) may possibly be congeneric with *Vastites vastus*.

Mons. P. L. Maubeuge kindly examined photographs of the ammonite in November, 1949, and allows me to say that he agrees with my verdict. He writes : "Affinity with the Sonninidæ is close, unless there is convergence from some other group. Ornament, whorl-section, coiling are truly like those of *Shirbuirnia*, etc., and the traces of ribbing are also in keeping. As to the sutures, they are like enough to those of the Sonninidæ. You are quite right to erect a new genus. I am convinced that this is a survivor of the Bajocian Sonninidæ."

Distribution.—Zigzag Zone, Brambleditch quarry, ½ mile S. of Doulting, Somerset (holotype, SM. J21368). The matrix confirms Mr. Brighton's statement that this ammonite was found in *situ* in the same bed as numerous large *Procerites fullonicus* Buckman sp. (SM. J21366—7) and *Procerites* aff. *clausiprocerus* Buckman sp. (SM. J21364*a*, *b*, 21365*a*—*c*), in the topmost band of nodular argillaceous limestone of the " Inferior Oolite " immediately below the main *Ostrea knorrii* [*lotharingica*] clays. I studied and measured the section in July, 1949, and again with Mr. D. T. Donovan in August, 1949, and on both occasions collected large *Procerites* spp. in the bed indicated by Mr. Brighton. The bed is the highest of five bands of nodular argillaceous limestone separated by clays (some of which contain *O. knorrii*), together 3 ft. thick, which constitute the " Rubbly Beds " of Richardson's description (1907, p. 393 : " Doulting Bridge Quarry ").

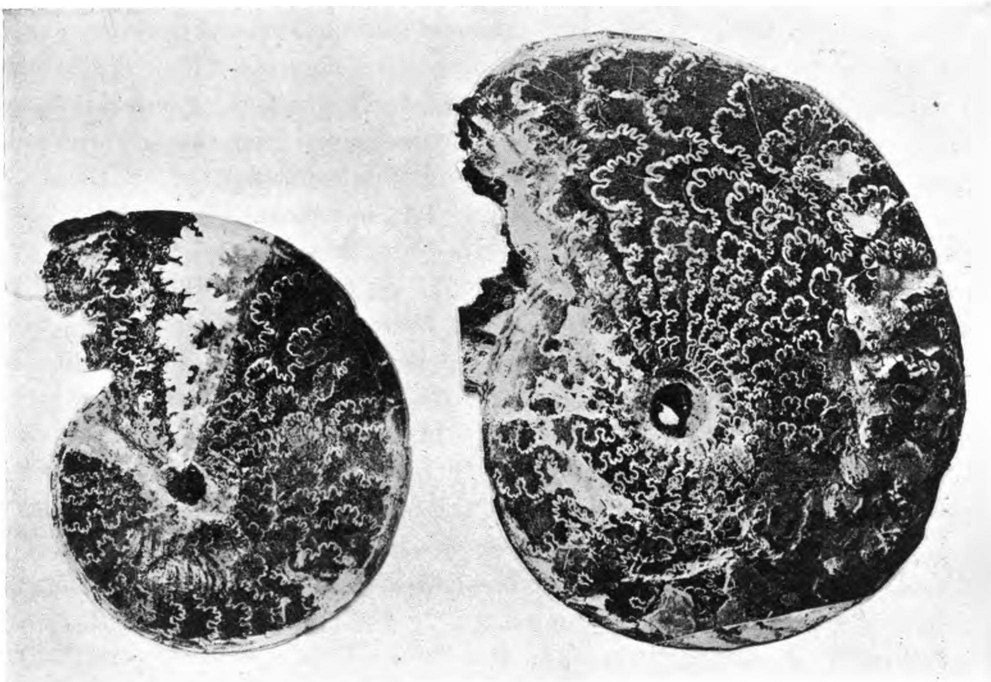
Family Clydoniceratidæ S. Buckman, 1924.

Buckman (1924, TA, v, p. 32 and Pl. D) founded this family for the genus *Clydoniceras* Blake, to which he added two other genera, *Harpoceratidarum* Pompeckj, and *Benedictites* S. Buckman, now considered synonyms of *Clydoniceras*. Nevertheless, the genus *Clydoniceras* still remains awkward to fit into other families, by reason of its unique style of suture-line. Spath (1928) assigned it doubtfully as a separate subfamily to the Oppeliidæ ; Roman (1938) listed it under Oppeliidæ but as " incertæ sedis " ; and F. Douvillé (1943) in his special monograph of the genus avoids any reference to its affinities or origin. His father, R. Douvillé, who classified the Oppeliidæ (1913), did not include *Clydoniceras* in that family.

Anyone who studies suture-lines of *Clydoniceras* will have borne in on him the fact that the differences from all the Oppeliaceæ are fundamental. The biochron of *Clydoniceras* spans only the Middle and Upper Bathonian. There were abundant Oppeliaceæ before, during, and after this, but none of them developed a suture-line anything like that of *Clydoniceras*. Buckman (1924, TA, v, p. 32) truly wrote : "Any argument from the oxycone shape for alliance with Oppelacea is valueless ; it would simply recall the practice of olden days, when any oxycone from Lias to Cretaceous, if not an *Oppelia*, was called *Oxynoticeras*."

On the other hand, the Harpoceratacean characters of Clydoniceratidæ are substantial. The ribbing of all the genera is clearly Harpoceratacean, not Oppeliacean ; the venter of *Delecticeras* is that of *Hildoceras*, with depressed keel between two sulci; the peculiar swollen form of *Micromphalites* is foreshadowed in the aberrant Toarcian Hildoceratid *Frechiella;* and above all, the suture-line of *Clydoniceras* finds its closest parallels in *Frechiella* (Plate I, fig. 3) and another aberrant end-form, the Bajocian Leioceratid, *Staufenia* (Plate I, fig. 2).

The genus *Staufenia* Pompeckj (1906, p. 251) of the Continental Murchisonæ Zone (type species *Ammonites staufensis* Oppel, 1856, p. 371 = *Am. discus* Quenstedt, 1846, pl. viii, fig. 13, *non* Sowerby; Text-fig. 4 and Plate I, fig. 2) shows striking analogies with *Clydoniceras*, both in form and suture-lines. Pompeckj pointed out its affinity with *Leioceras* and denied that the suture-lines had anything in common



TEXT-FIG. 4.—*Staufenia staufensis* (Oppel), Aalenian (Lower Bajocian), Sehnde, Germany, for comparison with *Clydoniceras*. (After Hoffmann.) Natural size.

with those of *Clydoniceras*, but this seems to have been because he relied on the poor and inaccurate drawings of *Clydoniceras* published by de Grossouvre and Schlippe; his own drawings of the suture-line of *Staufenia* bear out Quenstedt's (1886—7, pl. lvii) and justify the comparison with *Clydoniceras* made by Oppel (1856, p. 371). There is in both genera the same number of elements, the degeneration of the details, the rounding of the saddles, and the cloven first lateral lobe (shown in Pompeckj's pl. ii, figs. 12—14). Thus, while *Staufenia* and *Clydoniceras* are too far separated in time to justify Rollier's words (1909, p. 619) " *Clydoniceras* begins with " *Staufenia*, it is reasonable to consider them analogous end-forms of parallel offshoots from the Harpoceratacean stock. Even if some of the Oppeliaceæ are also derived from Harpoceratacеæ, Clydoniceratidæ did not originate by way of Oppeliaceæ.

Finds by members of the American-Arabian Oil Company in Central Arabia during 1948 and 1949, which I have had the good fortune to study, suggest that the headquarters of the Clydoniceratidæ were in far distant seas and our English representatives only selected colonists. The material shows that in Arabia surviving Harpoceratacean stocks were still in the evolutionary melting-pot in Bathonian times. Besides true *Clydoniceras* there are several species of *Micromphalites* and transitions between them, also Clydoniceratid oxycones with sutures like Sinemurian Oxynoticeratidæ, and others with non-specialized standard Harpoceratacean sutures. These will be described and figured elsewhere.

1. **CLYDONICERAS** Blake (1905, p. 53). Blake narrowed down the name *discus* to *Am. discus* J. Sowerby (1813, pl. xii), and in his generic diagnosis and explanatory remarks preceding it he mentioned no other species but *A. discus* Sowerby except to eliminate others from the genus; concluding the diagnosis with " Ex[ample] *C. discus*." The type species may therefore be considered to be *C. discus* (J. Sowerby) by monotypy ; the type specimen being Sowerby's original from the Lower Cornbrash of Bedford (BM. 43942), *not* the specimen from Sudbrook figured by Blake (1905, pl. vi, fig. 1) as asserted by Buckman (1924, TA, v, p. 25). The holotype is here figured, Plate II, fig. 2 ; the species is described and figured below, p. 33.

Harpoceratidarum Pompeckj (1906, p. 260). S. Buckman (1924, TA, v, p. 25) wrote as follows : " No definite type selected. Group of *Am. discus* cited, p. 260 ; but on p. 251, where the group of *Am. discus* is discussed, the form is cited thus, '*Amm. discus* (Sow.) Oppel (1862, p. 146, pl. xlvii, fig. 1).' This specimen is, therefore, the genoholotype of Pompeckj's genus." Buckman (1924, TA, v, p. 28) renamed Oppel's figure *Harpoceratidarum typus*, and pointed out that its suture-line agrees with that of a specimen which he named *H. hollandi* (J. Buckman MS.) S. Buckman, the name *hollandi* having page priority over *typus*. Neither Spath (1928, p. 77) nor Roman (1938, p. 180) considers *Harpoceratidarum* distinguishable generically or subgenerically from *Clydoniceras*. I agree.

Benedictites S. Buckman (1924, TA, v, p. 29). Type species by original designation *Am. hochstetteri* Oppel (1857, p. 473 ; figured Oppel, 1862, p. 147, pl. xlvii, fig. 2), from the Lower Cornbrash of the Chippenham district, Wiltshire. Buckman wrote : " *Benedictites* nov. Genoholotype, *B. hochstetteri* Oppel sp., in TA, Pl. CXXIV," but in accordance with the Rules of Nomenclature the type of the genus is the species cited by name, *Am. hochstetteri* Oppel, and the holotype of that is Oppel's Chippenham specimen, not Buckman's Fairford specimen wrongly called " holotype " and " genotype " on Buckman's Plate DXXIII. In any case, *Am. hochstetteri* cannot be considered generically or subgenerically distinct from *Clydoniceras* ; in fact, it is here considered to be one of many varieties of *C. discus* (Sowerby).

2. **DELECTICERAS** gen. nov. Type species **D. delectum** sp. nov., from the Cornbrash of Bedford (see below, p. 45). Hitherto included in *Clydoniceras*, from which it differs by developing a squared venter with two deep and sharp spiral grooves, one on each side of the median carina, also flatter whorl-sides and wider umbilicus. Suture-lines similar to those of *Clydoniceras* but simpler. Nucleus with simple keeled venter. (Named from *delectare*, to please, because the Hildoceratid venter is one of

the clues to the ancestry of the Clydoniceratidæ.) There is a general resemblance to the Bajocian *Pœcilomorphus* Buckman (TA, vii, Pl. DCCXLVI), of the Sonninidæ.

3. **MICROMPHALITES** S. Buckman (1923, TA, v, Pl. CDLIII). Type species by original designation *Ammonites micromphalus* Phillips (1871, p. 181, pl. x, fig. 38), Stonesfield Slates, Stonesfield. A peculiar genus with narrow, vertical-walled cylindrical umbilicus surrounded by a bulge which occupies the inner third to half of the whorl-sides, and with wide, blunt ribs, bifurcated at the umbilical edge, tending in some species to tuberculation on the umbilical edge and the ventro-lateral edge. Venter square-shouldered, with a strong smooth keel. Suture-lines not known from European material, but seen in Arabian specimens to have narrow first lateral and broad second lateral lobes on the earlier whorls, but the first laterals broadening on later whorls until the suture resembles that of *Clydoniceras discus* (typical form). In central Arabia have been found specimens transitional to *Clydoniceras*, and plentiful material showing suture-lines (Text-fig. 9). De Grossouvre (1919, p. 142) is therefore proved to have been right in placing *Micromphalites* close to *Clydoniceras* ; and its assignment to Oppeliidæ, near *Phlycticeras*, which was never justified by the style of ribbing, has proved to be erroneous.

Neactinoceras Spath (1924, p. 5). Objective synonym of *Micromphalites* Buckman. (See Spath, 1928, p. 89.)

4. **ORANICERAS** Flamand (1911, p. 918, pl. vii, figs. 10–13). Type species by monotypy *O. hamyanense* Flamand, Bathonian, Algeria.

Genus **CLYDONICERAS** Blake (see p. 32).

1. **Clydoniceras discus** (J. Sowerby). Plate II, figs. 1—10, Plate III, figs. 1—10, and Text-figs. 5, 6.

Ammonites discus J. Sowerby, 1813, vol. i, p. 37, pl. xii.

Non Ammonites discus Zieten, 1832, pl. xvi, fig. 3 (*Staufenia* sp.).

Non Ammonites discus d'Orbigny, 1846, p. 394, pl. 131, figs. 1—3 (type of *Oppelia fallax* Guéranger).

Non Ammonites discus Quenstedt, 1846, p. 121, pl. viii, fig. 13 (type of *Staufenia staufensis* Oppel sp., 1856, p. 371).

? *Ammonites discus* Oppel, 1862, p. 146, pl. xlvii, figs. 1*a*, *b* (type of *Clydoniceras typus* S. Buckman sp., 1924, p. 28).

Non Ammonites discus Lycett, 1863, p. 4, pl. xli, figs. 8, 8*a* (*Clydoniceras hollandi* S. Buckman sp., 1924, TA, v, p. 28).

Non Ammonites discus Guéranger, 1865, p. 184, pl. i, pl. ii, fig. 2 (*Clydoniceras guérangeri* de Grossouvre, 1930, p. 380).

Non Ammonites discus Brauns, 1869, p. 126, pl. ii, figs. 4, 5, 6 (type of *D. ptychophorum* Neumayr sp., 1871, p. 27).

Non Ammonites discus de Grossouvre, 1888, p. 378, pl. iv, figs. 4, 5 (types of *Clydoniceras planum* de Grossouvre, 1930, p. 381) ; *nec* fig. 6 (too-wide umbilicus) ; *nec* p. 381, fig. 2 (type of *C. nivernense* de Grossouvre, 1930, p. 382).

Non Ammonites discus Schlippe, 1888, p. 195, pl. viii, figs. 1, 1*a* (type of *C. schlippei* S. Buckman, 1924, TA, v, p. 28).
Clydoniceras discus Blake, 1905, p. 54, pl. vi, fig. 1.
Clydoniceras discus Lissajous, 1923, p. 108, pl. xxiv, fig. 2 only.
Clydoniceras discus S. Buckman, 1924, TA, v, p. 29, Pl. DVI.
Clydoniceras discus S. Buckman, 1927, TA, vi, Pl. DVI, A; TA, vii, Pl. DVI, B.
Non Clydoniceras discus F. Douvillé, 1943, p. 10, pls. i, ii, iv (various species).
Clydoniceras hochstetteri F. Douvillé, 1943, pl. iv, fig. 1.

Synonymy of var *hochstetteri* Oppel.

Ammonites discus Wm. Smith, 1816, p. 26, Cornbrash plate, fig. 2.
Ammonites Hochstetteri Oppel, 1857, p. 473.
Ammonites Hochstetteri Oppel, 1862, p. 147, pl. xlvii, figs. 2, 3.
Clydoniceras hochstetteri Blake, 1905, p. 55, pl. vi, fig. 2.
Benedictites hochstetteri S. Buckman, 1924, TA, v, p. 29, Pl. DXXIII.
Non Clydoniceras hochstetteri F. Douvillé, 1943, pl. i, fig. 5 (*C. guérangeri* de Grossouvre); *nec* pl. ii, fig. 4; *nec* pl. ii, fig. 9 (*C. hollandi* Buckman sp.); *nec* pl. iii, figs. 4, 5; *nec* pl. iii, fig. 6 (*C. typus* Buckman sp.); *nec* pl. iv, fig. 1 (*C. discus*, typical); *nec* pl. iv, fig. 9 (*C. guérangeri*); *nec* pl. iv, figs. 2—4.

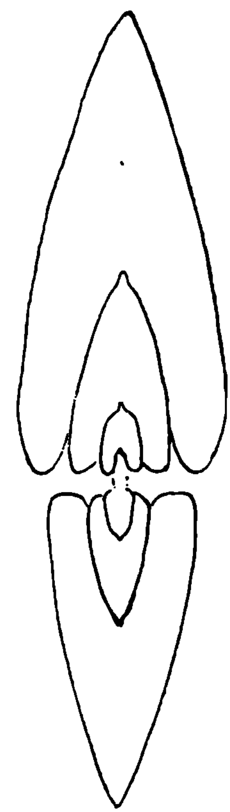
Description of holotype.—The holotype (BM. 43942) from the [Lower] Cornbrash of Bedford, now refigured (Plate II, fig. 2) for the first time, is a cast of a young individual, septate to about 71 mm., with a quarter-whorl of body-chamber. The final septa show no approximation or degeneration. The dimensions are 98 mm. max., at 98 mm.: *c.* ·59, *c.* ·25, *c.* ? ·03. The visible whorl is only feebly ribbed, already becoming smooth; considerably worn. The umbilicus is completely occluded. The septal sutures are different on the two sides (see Plate II, figs. 2*a*, 2*c*, and Text-fig. 6, no. 9). Those on the left side show a narrow, pointed first lateral lobe; those on the right side, which is deeply worn, show a broad, blunt, ill-defined first lateral lobe.

Description of species.—The shell is extremely compressed and discoidal, the greatest thickness not exceeding 25 per cent. of the diameter. The umbilicus is very small and becomes almost completely occluded after a diameter of about 30 mm. (see Blake, 1905, pl. vi, fig. 2). From at least 12 mm. diameter onwards the section is lanceolate, the keel tall, sharp, and unserrated, with only faintly developed shoulders, which gradually disappear, leaving the section fastigate. Two topotypes from Bedford are wholly septate at 130 mm. and 136 mm. diameter respectively; this seems to be about the maximum septate size, to which must be added a body-chamber of uncertain length, but occupying at least two-thirds of a whorl.

The ribbing up to a diameter of 50—60 mm. is fine and sharp. On the inner third of the whorl-sides it consists merely of growth-lines, out of which arise gradually a series of regular, gracefully sigmoid ribs, to the number of about 55—60 to the whorl. At first they appear simple, but gradually a proportion of adjoining ribs pair and form bifurcating and trifurcating ribs, the process taking place by the gradual appearance of faint primaries on the middle part of the whorl-sides; but the inner third still remains unribbed. There follows a stage of wider and fainter bifurcating and intercalatory ribs. Between 70 mm. and 80 mm. diameter all ribbing usually fades, though on well-preserved specimens faint traces persist here and there for much longer.

Septal sutures characterized by short external lobe and large, more or less multifid first lateral lobe, which is extremely variable in shape and in the number of minor accessory lobes or tines upon it. Second lateral lobe small and inconspicuous.

Variation of the Suture-line.—Most authors (*e.g.* Buckman, 1924, TA, v, pp. 25—32; de Grossouvre, 1930, p. 379 ; F. Douvillé, 1943) have attempted to subdivide *C. discus* into a number of species based upon differences in the suture-line, and in particular upon the detailed form of the first lateral lobe. When a small number of specimens are compared, the differences appear so striking that such a classification seems plausible. When a more numerous material is considered, however, the criterion breaks down and the form and extent of elaboration of the lateral lobe are seen to vary almost infinitely. Analogous variations in the details of the septal sutures have been seen to have no specific value in other ammonite families, *e. g.* the Perisphinctidæ (Arkell, 1935—48), and in the light of the numerous Douglas & Arkell collection of Clydoniceratids collected from the English Cornbrash the writer has long held this basis of differentiating species to be unsound. When through a whole range of such variations the external lobe is consistently much longer, as it is in most of the French forms figured by authors, this distinction might justifiably be held to have specific value, or at least must be taken as the mark of a geographical subspecies. In the whole of the English material, however, the external lobe is relatively short, and the essential proportions of the suture-line remain constant. The innumerable variations in form and degree of subdivision of the individual major lobes, and in degree of prolongation of the accessory lobes or tines upon them, all occur within the framework of an essentially constant suture plan. Accordingly they will here be treated merely as varieties.



TEXT-FIG. 5.—*Clydoniceras discus* var. *blakei*, Kidlington, Oxford, Douglas & Arkell Coll., OUM. J1329. Cross-section, natural size.

It was satisfactory to find in 1948, when the Geological Survey collection was worked through, that I had apparently arrived independently at the same conclusion as Dr. L. F. Spath, for in 1942 he had determined as " *Clydoniceras discus* var. *hochstetteri* " the specimens that would previously have been called *Clydoniceras hochstetteri* Oppel sp.

Although any number of intermediate forms are found, the following main varieties, based on the first lateral lobe, seem worth naming :

1. Var. **discus**, based on the holotype (Plate II, fig. 2), which has a narrow, pointed lobe without major subdivision, and on its outer slope only two tines, of which the outer is larger and simple. This is a young specimen, and if growth had proceeded

more tines would have developed, especially on the inner side of the lobe, as in Plate II, fig. 1 (a Bedford topotype).

2. Var. **hochstetteri** (Oppel). Oppel's type (Pl. I, fig. 4) came from the [Lower] Cornbrash of Chippenham. In it the first lateral lobe is conspicuously two-pronged. There are many gradations to var. *discus*, which show that this extreme variety arises through further enlargement and elaboration of the large second outer tine of var. *discus*.

3. Var. **blakei** nov., based on Blake's *C. discus*, 1905, pl. vi, fig. 1 (SM. J3311, see Plate II, fig. 8). In this the first lateral lobe is broad and blunt, with four major tines flanked each side by pairs of minor tines. It occurs with the type form at Bedford, and something like it on the more worn side of the holotype of *C. discus*.

4. Var. **digitatus** nov., based on the specimen from the Lower Cornbrash of Enslow Bridge, near Oxford, shown in Plate II, fig. 6 (Douglas & Arkell Coll., OUM. J1304). In this the first lateral lobe is wide but long, and bears a series of five or six very long, finger-like tines as well as several minor ones on each side. The accessory minor lobes are also all long and finger-like. An analogous variety from France has been figured as *C. hochstetteri* by F. Douvillé (1943, pl. iii, fig. 7).

5. Var. **crenellatus** nov., based on the specimen from the Lower Cornbrash of Ducklington Lane quarry, Witney, Oxon, shown in Plate III, fig. 1 (OUM. J923). In this the first lateral lobe is wide and blunt with short irregular " frilly " tines. (Cf. F. Douvillé, 1943, pl. iii, fig. 8 ; but in that the ribbing remains fine and distinct to a later stage than in any English *C. discus*.)

Variation of the second lateral lobe, though less conspicuous, is just as great. Sometimes the lobe is much thicker than usual and shows a tendency to fork, like the first lateral in var. *hochstetteri*. Bifurcation of the two lateral lobes, however, may be quite independent ; for instance, in Plate III, fig. 7, the first lateral is that of typical var. *hochstetteri*, but the second lateral is simple, whereas in Plate III, fig. 8, both lateral lobes are forked. Extension of this tendency leads to the large two-pronged second lateral lobe in the *Clydoniceras* (" *Harpoceras* ") from Mazar Drik in Baluchistan figured by Noetling (1896, p. 10, pl. vi, fig. 1). Spath (1933, p. 809, pl. cxxx, fig. 3) in renaming this interesting ammonite referred to the " simplifying, *Clydoniceras*-like suture-line," but called it an *Oppelia* ; but the ribbing also is typically Clydoniceratid, not Oppeliid. Reference to *Clydoniceras* is supported by the large but typical example of *Bullatimorphites bullatus* (d'Orbigny) figured with it and the undoubtedly Bathonian *Choffatiæ* (Noetling, 1896, pl. xiii, figs. 1, 2, 3, 5). It is clear from Noetling's memoir that, like the English Cornbrash and other well-known condensed beds in Rumania (Mount Strunga, Popovici-Hatzeg, 1905) and Sicily (Gemmellaro, 1872—8), the Mazar Drik Limestone (olim " Polyphemus " Limestone) contains a truly Bathonian element as well as a representative of the basal Callovian Macrocephalus Zone. (That the latter also is called Bathonian in Spath's works, *e.g.* 1933, pp. 872—3, is only a matter of nomenclature ; see above, p. 18).

It is significant that those who have studied some of the genera in earlier formations with suture-lines most closely analogous to the Clydoniceratidæ, namely *Staufenia* in the Aalenian and *Bouleiceras* in the Lower Toarcian, have come to the same conclusions as those expressed here. Hoffmann (1913, p. 138) explained that the sutures of *Staufenia* (Text-fig. 4) could be classified from at least four points of view :

1. Sometimes the decrease of saddle-height is gradual from the first lateral to the last auxiliary saddle; sometimes the decrease occurs with a jump, the second lateral being only half as high as the first and more comparable with the auxiliaries.

2. Some specimens [as in many if not all ammonites] have the sutures much closer together than others.

3. In some specimens the lobes are more club-shaped.

4. Sometimes the first lateral saddle is cut by no or only weak accessory lobes, and sometimes these are more or less excentric.

At the same time all these variations occur in such endless combinations that all attempts to distinguish named varieties had to be given up.

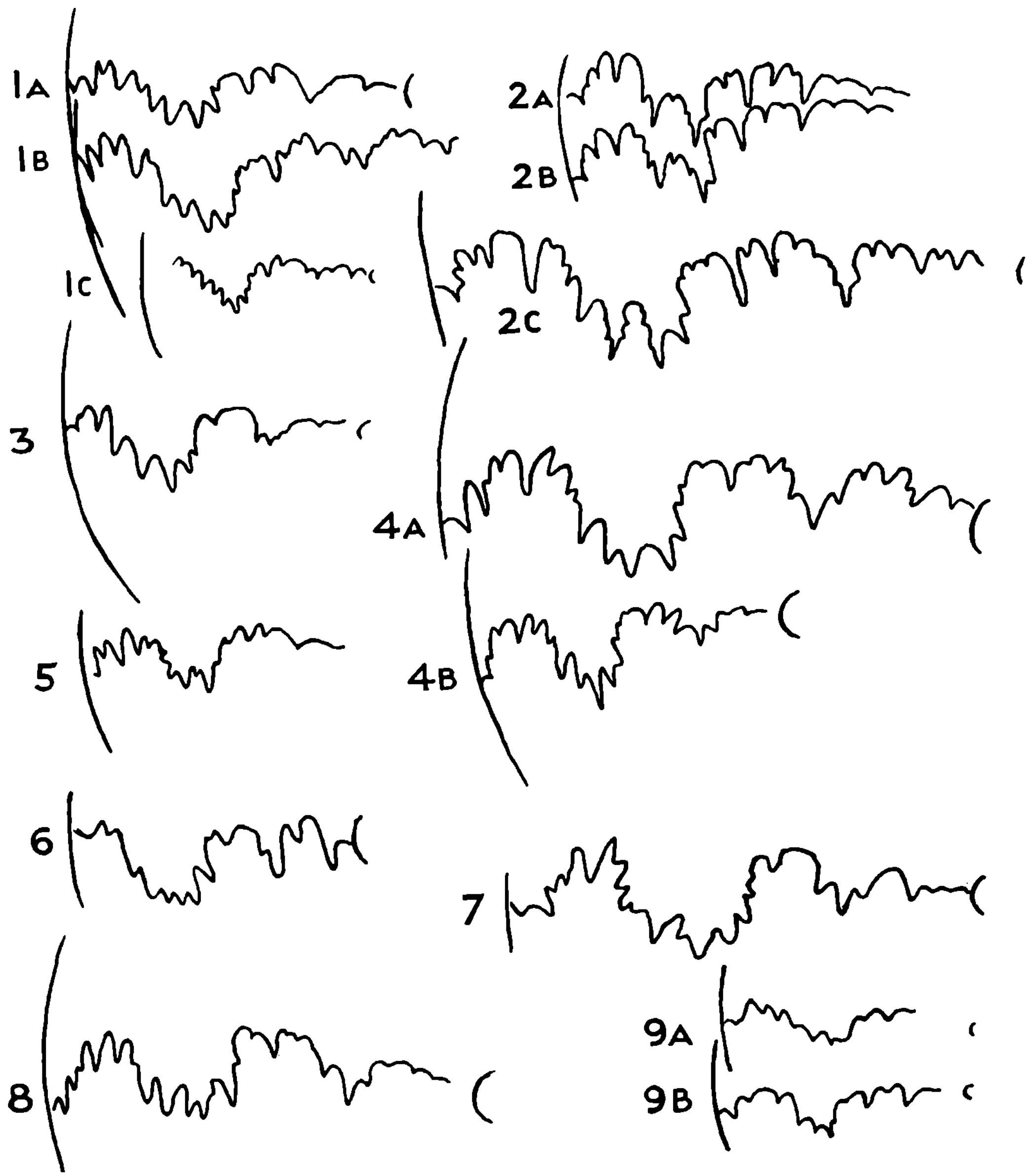
Bouleiceras Thevenin is another remarkable Harpoceratacean genus known from the Domerian or Lower Toarcian of Madagascar, Baluchistan, Arabia and Morocco, in which simplification of the suture-lines has striking analogies with that in *Clydoniceras*, but has gone farther, producing a pseudoceratite. In his careful studies of this genus, Thevenin (1906, 1908) showed that there is a great amount of variation in the sutures, not only in different individuals, but in the same individual at different stages of growth, and also sometimes on the two sides of an individual at the same stage of growth. In connection with *Clydoniceras* it is especially relevant that the greatly developed but simple first lateral lobe of *Bouleiceras* varies from wide and short with six or seven tines to long and narrow with only four tines, and the second lateral lobe may be simple, or two-pronged, or three-tined.

W. Lange (1925, p. 468) likewise found in studying rich material from the Hettangian of North-West Germany that in *Psiloceras* and *Schlotheimia* the sutures vary within very wide limits and are valueless as specific characters. There are other examples in the literature. Perhaps the most illuminating in connection with *Clydoniceras* is the variation in the sutures of the Turonian *Hoplitoides nigeriensis* Woods. Among the sutures of six specimens figured by Woods can be recognized forms of first lateral lobe strangely analogous with var. *discus* (Woods, 1911, p. 285, text-fig. 1*a*, *b*), var. *blakei* (*c*, *g*) and var. *hochstetteri* (*d*, *f*). At the same time the first lateral lobe has sides sometimes convergent, sometimes parallel, and sometimes divergent (bud-shaped), as in *Staufenia*.

Variation of the ribbing.—Ribbing shows only in small to medium-sized specimens. In these it displays considerable variation. But there are a few specimens that are much more coarsely ribbed than all the others, and one quite smooth. These are regarded as separate species (see *C. thrapstonense* and *C. douglasi*, below).

Comparisons.—The following notes supplement the synonymy printed above (p. 33). (Herewith Text-fig. 6.)

Buckman (1924, p. 28) thought Oppel's *C. discus* (1862, pl. xlvii, figs. 1*a*, *b*) generically distinct and renamed it *Harpoceratidarum typus* (Text-fig. 6, no. 3). It has the minute umbilicus and short external lobe and large first lateral of *C. discus*, but perhaps may be specifically distinct, since the second lateral lobe is shown as much wider than in any *discus*, and the shell is drawn as stouter and more finely ribbed to a late stage.



TEXT-FIG. 6.—Suture-lines of species of *Clydoniceras*, traced from type figures and orientated uniformly for comparison. All natural size except fig. 6, which is × 2.

1. *Clydoniceras discus* (Sowerby); 1A, Blake's specimen from Sudbrook; 1B, Buckman's from Blackthorn Hill; 1C, Buckman's from Cards Farm.
2. Var. *hochstetteri* Oppel sp.; 2A, B, holotype from near Chippenham; 2C, paratype from Lochen.
3. *C. typus* (Buckman), holotype.
4A and B, *C. hollandi* (Buckman), holotype.
5. *C. davaiacense* Lissajous, lectotype, from photo.
6. *C. planum* de Grossouvre, from de Grossouvre's drawing, 1930, p. 381, fig. 2. (× 2.)
7. *C. nivernense* de Grossouvre, from drawing of lost holotype, de Grossouvre, 1888, p. 381, fig. 2.
8. *C. guérangeri* de Grossouvre, lectotype, from photo, 1930, pl. xxxix, 1.
9A and B, *C. discus* (Sowerby), holotype, traced from the two sides, 9A the worn side.

The large specimen figured by Lissajous (1923, pl. xxiv, fig. 2) meets all the requirements of specific identity with *C. discus*, but the smaller specimens (*ibid.*, figs. 1, 1*a*, 3, and pl. xxiii, fig. 6) have much too wide an umbilicus, as well as being too inflated. The complete occlusion of the umbilicus in *C. discus* was pointed out by Sowerby in 1813, but has been persistently disregarded by foreign authors ; see for instance de Grossouvre, 1888, pl. iv, fig. 6, and F. Douvillé, 1943, pl. ii, figs. 2, 5, and pl. iv, fig. 7.

C. davaiacense Lissajous (1923, p. 110, pl. xxiii, fig. 4, lectotype here chosen) has a suture-line (Text-fig. 6, no. 5) showing some peculiar features not seen in any English specimen, and the umbilicus is much larger. If the small specimen (fig. 5) is conspecific, the inner whorls are much more coarsely ribbed than in any varieties of *C. discus* or even *C. thrapstonense*.

Clydoniceras orientale (H. Douvillé sp., 1916, p. 40, pl. vi, fig. 1) is insufficiently known, but seems remarkably like *C. discus* except that it has a wider umbilicus. Possibly *C. schlippei* Buckman and *C. guérangeri* de Grossouvre (see below) will prove to be synonyms of this species.

The assertion by de Grossouvre (1888, p. 379), taken up by F. Douvillé (1943), that the young of *C. discus* is the same as *C. legayi* (Rigaux & Sauvage) can easily be disproved by cross-sectioning *C. discus* (Text-fig. 5). Of five specimens successfully sectioned, three (from Thrapston, Northants, and Kidlington and Enslow Bridge, near Oxford) show the internal structure clearly down to a diameter of 12 mm., and at this diameter the whorl-section is still lanceolate, with tall keel rising high above sloping shoulders. The other two specimens (from Thrapston and Fairford, Glos.) show the same whorl-section down to 17 mm. and 29 mm. diameter respectively. In any case it is obvious that the specimens of *C. legayi* figured as *C. discus* by F. Douvillé (1943, pl. ii, figs. 2, 3, 5, 6) could not possibly grow into *C. discus* (as was clear from Buckman's figure, 1927, TA, vii, pl. DVI, B).

Nor is de Grossouvre's other opinion (1930, p. 379) any more acceptable, that Buckman's name *C. schlippei* (Buckman, 1924, p. 28) must be disregarded " because the data given by Schlippe do not suffice to define the type ; in fact the two sutures figured on his pl. viii, fig. 1, are different, and still more different from that figured in the text, p. 185, fig. 2." Anyone who has painted the suture-lines on many *Clydoniceras* would doubt an author's veracity if he showed the details of three suture-lines exactly alike. Schlippe's figures show adequately the essentials of the form, coiling, ribbing, and sutures, which last differ from those of *C. discus* in having a longer external lobe. Since this is also the distinctive character of *C. guérangeri* de Grossouvre (1930, p. 380, pl. xxxix, fig. 1, lectotype here designated), it is probable that *guérangeri* is a synonym of *schlippei* Buckman. The adult type of *C. guérangeri* (Text-fig. 6, no. 8) differs from *C. discus* in the longer external lobe and also in the open umbilicus (cf. Blake, 1905, pl. vi, fig. 2) and (*teste* de Grossouvre's text) somewhat greater inflation. *C. guérangeri* has not been recognized in this country.

Clydoniceras planum de Grossouvre (1930, p. 381, pl. xxxix, fig. 5, lectotype here designated ; Text-fig. 6, no. 6) differs from *C. discus* in possessing sharper and more numerous ribs and an open umbilicus, and suture-lines with longer external lobe and deeper saddles (see F. Douvillé, 1943, pl. i, figs. 7, 8); also the young is quite different (see de Grossouvre, 1888, pl. iv, figs. 4, 5).

Clydoniceras nivernense de Grossouvre (1930, p. 382), never having been figured, is an unknown quantity. The suture-line sketch (de Grossouvre, 1888, p. 381, fig. 2) suggests that it may be a variety of *C. guérangeri*, and therefore of *C. schlippei* (Text-fig. 6, no. 7).

In 1938, 50 specimens of *Clydoniceras discus* and its varieties were sent on request to Paris on loan to M. F. Douvillé. Not one came back correctly labelled. No specimen of either *C. discus* or *C. hochstetteri* was recognized by him. It follows, unfortunately, that all F. Douvillé's English records in his monograph (1943) are incorrect.

Distribution.—*Clydoniceras discus* is the most abundant ammonite of the Lower Cornbrash, but has yet to be found in the Upper. There are specimens from almost every quarry, from the shores of the Fleet and Radipole Backwater, near Weymouth, through North Dorset, Somerset, Wiltshire, Gloucestershire, Oxfordshire, Bedfordshire, Northamptonshire and Lincolnshire. The most northerly record is Sudbrook, north of Lincoln (SM. J3311). In the Boulonnais also it is confined to the Lower Cornbrash, with " *Terebratula* " *intermedia* (Dutertre, 1928, p. 59).

Blake (1905, p. 55) made the surprising statement that shells of *Clydoniceras discus* " do not characterize any lower portion of the Cornbrash, but where found are absolutely associated with *Macrocephalites*," an assertion discredited by every subsequent find of either genus between the coasts of Dorset and Yorkshire (see Douglas & Arkell, 1928 and 1932). This was before the rediscovery of William Smith's Lower and Upper Cornbrash. Since then it has been recognized that these subdivisions correspond with two major zones, the lower characterized by *Clydoniceras*, the upper by *Macrocephalites* (Douglas & Arkell, 1928, pp. 117—8).

2. **Clydoniceras thrapstonense** sp. nov. Plate III, figs. 12, 13, 14.

Clydoniceras ptychophorum Blake, 1905, p. 56, pl. vi, fig. 3 (*non* Neumayr sp.).

Description.—Resembles *C. discus* in size, shape and coiling, but differs by its much coarser and more persistent ribbing and fewer secondaries. A topotype is still appreciably ribbed up to 100 mm. The holotype (SM. J16492) is 71 mm. in diameter, and has only 7 secondary ribs on the last quarter-whorl and about 20 on the last half-whorl. In *C. discus* the ribbing never becomes so widely spaced, and there are normally four secondaries to every primary, as compared with two in *C. thrapstonense*. The sutures also are peculiar, having an extremely broad and short first lateral lobe with five subequal tines, some of which show incipient secondary branching. Nothing quite like this has been met with in any variety of *C. discus*.

Remarks.—Oppel (1857, p. 473) mentioned as a subsidiary character of his *C. hochstetteri* that it differed from *C. discus* (Sow.) by having broader and more widely spaced ribbing on the young. Since Oppel figured only the suture line of the holotype we cannot be sure how much broader and more widely spaced its ribbing was, but attempts to find a correlation between width and spacing of ribbing and the *hochstetteri* style of suture line have proved unsuccessful. Probably Oppel's holotype would fall within the range of variation in respect of ribbing here allowed within the species *C. discus.* The specimens now given a new specific name are altogether more coarsely ribbed than any other material known, except *C. davaiacense* Lissajous (1923, p. 110, pl. xxiii, figs. 4, 5), which have a wider umbilicus and peculiar suture. A specimen from Gloucestershire with the sutures of var. *crenellatus* (GSM. 8648) has peculiar ripple-like primary ribbing; but this is probably due to bending of the shell; it is visible on one side only. For *C. ptychophorum* Neumayr (*non* Blake), see p. 45.

Distribution.—Lower Cornbrash: Islip Iron Co.'s quarry, 1 mile west of Thrapston, Northants (SM. J16491—2, the latter holotype; Enslow Bridge, Oxon (OUM. J1303); Trowbridge (Blake's specimen, BM. 33541). Folly Farm, Corsham, bed 9 (Douglas & Arkell Coll., OUM. J1345) (much damaged and incomplete).

3. **Clydoniceras douglasi** sp. nov. Plate III, fig. 11.

Clydoniceras, Douglas & Arkell, 1928, p. 152 (Corscombe).

Description of Holotype.—The diameter is about 92 mm. and the whorl first appears at about 48 mm. Septa cease a quarter-whorl later, at 59 mm., leaving $\frac{2}{3}$ whorl of body-chamber. The preservation is unusually perfect, though only one side is visible. At about 50 mm. there is a faint trace of secondary ribbing, but thereafter the shell (cast, as usual) is perfectly smooth. All other characters are as in *C. discus.* The sutures are as in *C. discus* var. *hochstetteri.*

Remarks.—The specimen now made holotype of *C. douglasi* was from the moment of collecting regarded as probably a new species owing to its complete innocence of ribbing. (It is quite unworn.) No other specimen nearly so smooth is known. On the other hand, the species may be commoner than supposed, for it can be detected only at diameters less than about 80 mm., above which *C. discus* also becomes smooth. The many fragments of whorls at larger diameters are all smooth, but are regarded as belonging to *C. discus* in default of evidence to the contrary. The species is named in honour of Professor J. A. Douglas, who has found more specimens of *Clydoniceras* than anyone, living or dead.

Distribution.—Lower Cornbrash: Corscombe, Dorset (Douglas & Arkell Coll. OUM. J1355).

4. **Clydoniceras hollandi** (S. Buckman). Plate I, figs. 5, 6, and Text-fig. 6, no. 4.

Ammonites Hollandi J. Buckman MS. label; and see 1858, p. 117, and footnote.

Ammonites discus Lycett, 1863 (*pars*), p. 5, pl. xli, figs. 8, 8*a*.

Harpoceratidarum hollandi S. Buckman, 1924, TA, v, pp. 25—9, Pl. D.

Clydoniceras discus var. *hollandi* F. Douvillé, 1943, *pars*, p. 12, pl. iii, fig. 1; pl. iv, fig. 10.

Clydoniceras discus var. *davaiacense* F. Douvillé, 1943, pl. ii, fig. 9.

Description.—A large species, perhaps larger than *C. discus*: a specimen is wholly septate at 140 mm. Differs from *C. discus* in retaining an umbilicus 8—10 mm. in diameter, and in its suture-line, which has all the main lobes longer and more pointed, especially the second lateral. The first lateral lobe resembles that of the type variety of *C. discus* in being not cloven, but in both known specimens of *C. hollandi* the first lateral lobe is more compact, more produced, and more symmetrical than in any known example of *C. discus* of any variety, except the Bedford specimen shown in Plate II, fig. 1, and perhaps one ill-preserved fragment in the Douglas and Arkell collection.

Remarks.—Judging by F. Douvillé's figures this species is commoner in France than in England, and it would be interesting to discover whether it occurs in a lower part of the Bathonian than *C. discus*. In England it has occurred very rarely and only on the horizon of the Bradford Clay.

The holotype, figured by S. Buckman (1924, Pl. D), was salvaged after the 1914—18 war from the wreck of the geological collection of the Royal Agricultural College, Cirencester, where James Buckman's collection had been housed. S. Buckman believed it to be the specimen referred to in J. Buckman's paper (1858, p. 117, footnote and list), and figured by Lycett (1863, pl. xli, fig. 8, half natural size, not " slightly reduced ") which had been obtained from the Bradford Clay of Tetbury Road Station, near Cirencester, by Prof. J. Coleman, Professor of Agriculture at the college. James Buckman named it *hollandi* in honour of Edward Holland, who took a prominent part in founding the Agricultural College, and his cousin, Robert Holland, an early pupil at the college, whose daughter subsequently became the wife of S. S. Buckman. S. S. Buckman supported the Bradford Clay age of the specimen by pointing to " many highly-polished oolite grains in the matrix " (the Gloucestershire Cornbrash is never oolitic), and by a list of 5 species of Forest Marble and Bradford Clay fossils identified in the matrix by J. W. Tutcher.

For 90 years the holotype remained the only ammonite known from the Bradford Clay or Forest Marble. In 1948 I wrote to Dr. F. S. Wallis asking him to send me any Bathonian ammonites that may have survived the German bombing of Bristol Museum in 1942. There were only two specimens, a Fuller's Earth *Procerites* and a *Clydoniceras*, both from the Chaning Pearce collection. The *Clydoniceras* bears a label, " Great Oolite, Bearfield, near Bradford, Wilts," and clearly shows the sutures of *C. hollandi*. Attached to it is a large quantity of matrix, which is an intensely oolitic, marly, shelly limestone, unmistakably Forest Marble of Bradford Clay age; in it can be seen with a lens the usual minute gastropods and fragments of lamellibranchs, echinoid spines, polyzoa and Rhynchonellids, typical of the Bradford Clay horizon.

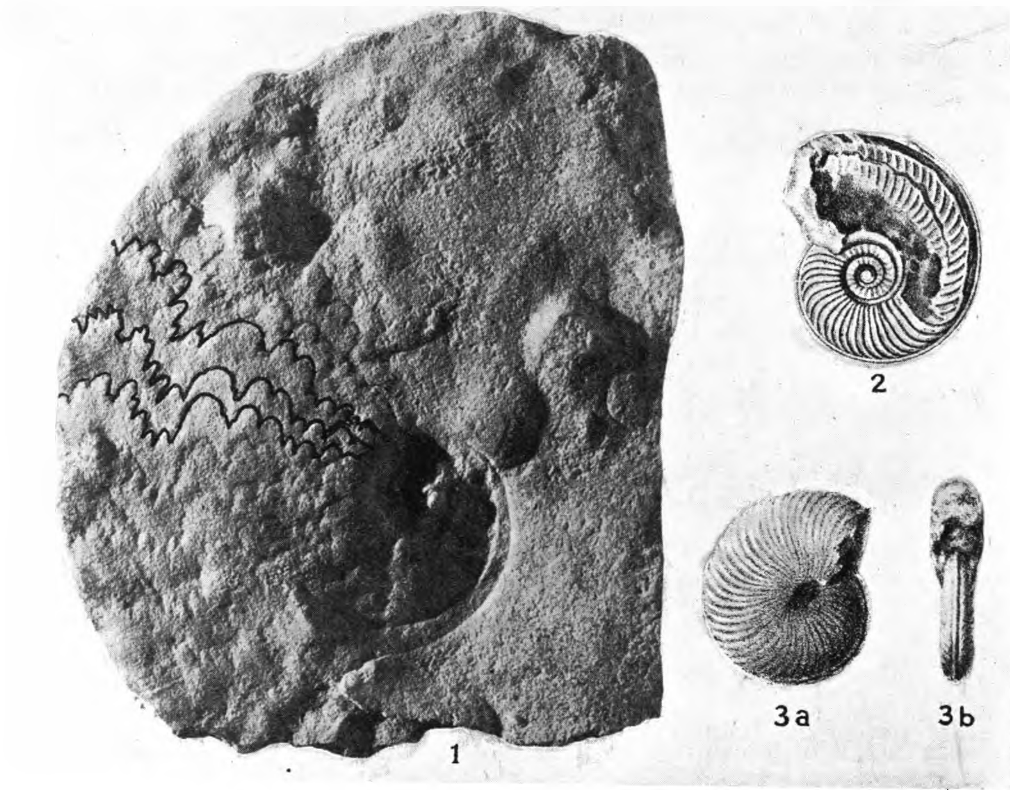
Distribution.—Bradford Clay horizon: Tetbury Road Station, near Cirencester, Glos. (holotype BM. C40576); Bearfield, near Bradford-on-Avon, Wilts. (Chaning Pearce Coll., Bristol Museum, no. 472).

5. **Clydoniceras tegularum** sp. nov. Plate IV, fig. 7, Text-fig. 7.

Oxynoticeras sp., Crick, 1898, p. 85, pl. xviii, figs. 5, 6.

Cf. *Clydoniceras discus* var. *hollandi* F. Douvillé, 1943, pl. ii, fig. 8.

Description.—Differs from the other English species in developing excentrumbilication in the last half-whorl. The umbilicus begins to widen at about 100 mm. diameter, just after the beginning of the adult body-chamber, which in the holotype seems to be complete and occupies three-quarters of a whorl. At the maximum diameter of 143 mm. the umbilicus measures 15·5 per cent. The suture-lines are probably somewhat degenerated and approximated where seen. They most resemble



TEXT-FIG. 7.—Fig. 1, *Clydoniceras tegularum* sp. nov., Stonesfield Slates, Stonesfield, the specimen figured by Crick, 1898. BM. 36710. Fig. 2, *Delecticeras ptychophorum* (Neumayr), the type figure after Brauns, 1869. Fig. 3, *Delecticeras legayi*, the type figure after Rigaux & Sauvage. (Natural size).

those of *C. hollandi*, but the lobes are shorter and narrower, and the first lateral lobe is more ventral. Length of external lobe unknown.

Remarks.—The occurrence of *Ammonites discus* in the Stonesfield Slates was recorded by Lycett (1863, p. 5) and a specimen was poorly figured by Crick (1898) as showing muscular attachments (Text-fig. 7).

The specimen figured by F. Douvillé as " *C. discus* var. *Hollandi* " (1943, pl. ii, fig. 8) has an essentially similar suture-line and seems to show excentrumbilication beginning ; but it is septate for half a whorl farther than the holotype and would have been considerably larger ; also the detail of the suture-line is peculiar, though this is probably of only varietal significance.

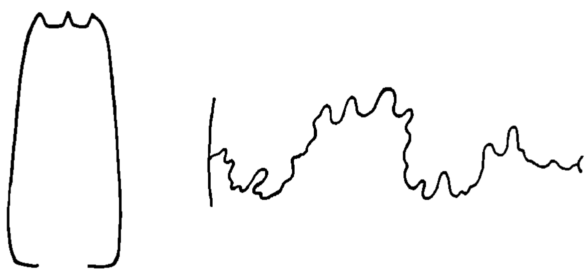
Distribution.—Stonesfield Slates: Stonesfield (holotype, OUM. J915; also BM. 36710).

Genus **DELECTICERAS** nov. (see p. 32).

1. **Delecticeras legayi** (Rigaux & Sauvage). Plate IV, figs. 9—11 and Text-figs. 7, 8.

Ammonites Legayi Rigaux & Sauvage, 1867, p. 21, pl. i, figs. 1, 2.
Clydoniceras legayi Blake, 1905, p. 57, pl. vi, figs. 4, 5, 6.
Non Clydoniceras legayi Lissajous, 1923, p. 112, pl. xxiv, figs. 5, 6, 7.
Clydoniceras legayi Dutertre, 1928, p. 59, with figure of suture.
Clydoniceras discus F. Douvillé, 1943, *pars*, pl. ii, figs. 2, 3, 5, 6; ? pl. iv, figs. 4, 7, 8.

Description.—A miniature species, with flat sides, square shoulders, nearly flat venter bearing a carina which on the middle and outer whorls is sunk between two



1 2

TEXT-FIG. 8.—Fig. 1, *Delecticeras delectum* sp. nov., whorl-section of holotype ($\times$ 2). Fig. 2, *Delecticeras legayi* (Rigaux & Sauvage), suture-line of specimen at 36 mm. diameter, from Pougues-les-Eaux, Nièvre (after Dutertre, 1928, p. 60).

grooves; umbilicus small but not closed; ribs fine, fading on inner third of whorl-sides. For detailed description and discussion see Blake, *loc. cit.* For suture-line see Text-fig. 8.

Remarks.—Lissajous (1923, p. 112) and Dutertre (1926, p. 48) rightly refuted de Grossouvre's assertion (1888, p. 379), repeated by F. Douvillé (1943) that *Am. legayi* is simply the young of *Clydoniceras discus.* The original specimens figured by Blake, in the Sedgwick Museum and now before me, are quite distinct from the young of *C. discus,* which at early and middle stages has a lanceolate whorl-section with tall keel sloping evenly into the (feeble) shoulders, and later becomes fastigate.

A quarter-whorl of a small *Delecticeras,* 9 mm. long, found by Mr. Channon in the Upper Fuller's Earth of Cliff End, Burton Bradstock, is close to *C. legayi,* but more coarsely ribbed. The cast shows a hairlike riblet in each interspace.

Distribution.—Cornbrash (Lower ?), Rushden, Northants. (SM. J5729) and Sudbrook, Lincs. (SM. J5727—8). Blake's other records not verified.

France.—Holotype (Text-fig. 7) and other specimens from the Lower Cornbrash, Les Pichottes, near Boulogne (with *C. discus* and "*Terebratula*" *intermedia, teste* Dutertre, 1928, p. 59). Nièvre (*teste* Dutertre).

2. **Delecticeras delectum** sp. nov. Plate IV, fig. 12, and Text-fig. 8.

Clydoniceras legayi Lissajous, 1923, p. 112, pl. XXIV, figs. 5, 6, 7 (*non* Rigaux & Sauvage sp.).

Description of Holotype.—Shell 36 mm. in diameter, with dimensions at 35 mm. ·49, ·23, ·24. Whorl sides nearly flat, the greatest thickness near the umbilical margin, which is very sharp, the umbilicus wide and cylindrical. Venter wide and flat, with sharp keel recessed between two deep spiral grooves, which give the venter a tricarinate aspect, all three carinæ of about equal height. Ribs strong, regular, flexuous, about 60 in number, occupying only the outer two-thirds of the whorl-side, some simple, others faintly paired at the point of origin. Sutures unknown.

Comparisons.—Differs from *C. legayi* (as interpreted by Blake) in having a much wider umbilicus and a more deeply recessed carina between deeper ventral grooves. De Grossouvre (1930, p. 380) has already pointed out that Lissajous' figures cannot represent *C. legayi* because they show too wide an umbilicus.

Distribution.—Cornbrash (Lower ?), Bedford (holotype, GSM. 62626). Retrocostatum Zone of the Maconnais (Lissajous).

3. **Delecticeras** cf. **ptychophorum** (Neumayr). Plate IV, fig. 8 and Text-fig. 7.

Ammonites discus Brauns, 1869, p. 126, pl. ii, figs. 4, 5, 6.

Harpoceras ptychophorum Neumayr, 1871, p. 27.

Non Clydoniceras ptychophorum Blake, 1905, p. 56, pl. vi, fig. 3.

Cf. *Clydoniceras discus* Lissajous, 1923, *pars*, pl. xxiii, fig. 6 only.

Descriptive Remarks.—The type-figure of Neumayr's species in Brauns (*loc. cit.*) (Text-fig. 7) shows such peculiar features that it seemed as if some mistake in provenance must have occurred. But there is in the Sedgwick Museum a very poor specimen that agrees with it except that the ribs are slightly farther apart than in the figure. The ribs are simple, strong and rod-like, the venter narrow and bisulcate, with a strong sharp keel which stands well above the incipient carinæ on either side. The umbilicus is obscured, but is certainly wide, as in Brauns' figure. Diameter 21·5 mm., thickness 4·5 mm. Lissajous' figure (1923, pl. xxiii, fig. 6) has similar ribbing, but smaller umbilicus.

Comparisons.—Differs from *D. legayi* and *D. delectum* by its fewer and stronger ribs and their continuation across the inner half of the whorl-sides in undiminished strength.

For Blake's interpretation of *C. ptychophorum*, see p. 40.

Distribution.—Labelled " Langton Herring, Cornbrash " (SM. J19884). The matrix is uncertain, but could be Upper Cornbrash. Holotype from the " Macrocephalus Beds " of Lechstedt, near Hildesheim.

Genus **MICROMPHALITES** S. Buckman (see p. 33).

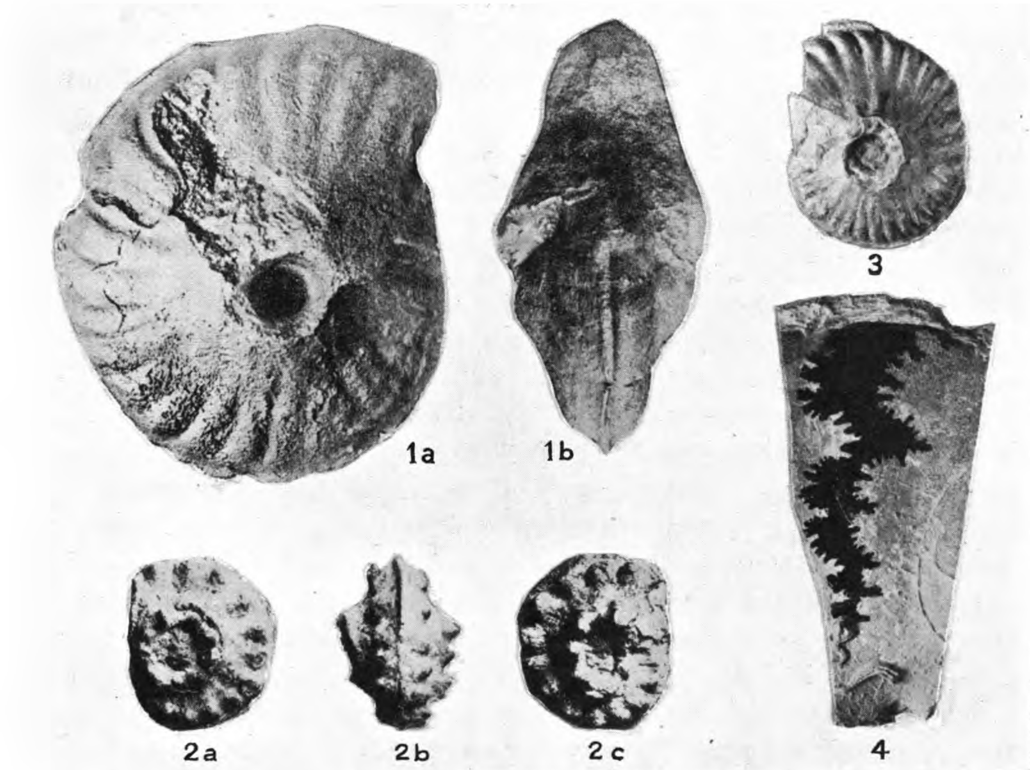
1. **Micromphalites micromphalus** (Phillips). Plate IV, figs. 1—6. and Text-fig. 9.

Ammonites micromphalus Phillips, 1871, p. 177, pl. x, fig. 38.

Micromphalites micromphalus S. Buckman, 1923, TA, v, Pl. CDLIII.

Type.—OUM. J1117 (Stonesfield) was, I am informed by Mr. J. M. Edmonds, one of the specimens available to Phillips in 1871, and is now designated lectotype. It is probably the specimen figured by Phillips. The diameter is 70 mm. (Plate IV, fig. 4).

Description.—The largest known specimen slightly exceeds 70 mm. in diameter, with apparently rather more than a whole whorl of body-chamber. There are 16 primary ribs at the umbilical margin and about 40 secondaries. The secondaries



TEXT-FIG. 9.—Figs. 1*a*, *b*, *Micromphalites busqueti* (de Grossouvre), Bathonian, Nièvre, France. Type figures after de Grossouvre. Figs. 2*a*, *b*, *c*, *Micromphalites pustuliferus* (H. Douvillé), Bathonian, Sinai. Type figures after H. Douvillé. Fig. 3, *Micromphalites* cf. *busqueti* (de Grossouvre), Jebel Tuwaiq, Saudi Arabia. Fig. 4, *Micromphalites* sp., suture-line. Jebel Tuwaiq, Saudi Arabia. (Natural size.)

are blunt-ended and rectiradiate except in the last quarter-whorl, in which they begin to swing forward and attenuate at the ventral margin like those of *Clydoniceras*. The circum-umbilical bulge (see above, p. 33) is not marked, though perceptible, but probably all ammonites from the Stonesfield Slates are crushed, and in this species a spiral fracture or dent just dorsal to the centre of the whorl sides suggests that there has been considerable crumpling-in owing to rock pressure. At least one specimen (OUM. J917) however, still has part of the circum-umbilical bulge preserved to a height of about $2\frac{1}{2}$ mm., and the lectotype retains traces of it. Venters are preserved

PLATE I.

Fig.		Page
1*a*. *b*, *c*.	*Vastites vastus* sp. nov. Holotype, Zigzag Zone, Brambleditch Quarry, Doulting, Somerset. SM. J21368. Fig. 1*a*, cross-section, natural size. Figs. 1*b*, *c*, front and side views before sectioning. × 0·44.	27
2.	Sutures of *Staufenia staufensis* (Oppel), Aalenian, N.W. Germany, for comparison with *Clydoniceras*. (Photo after Hoffmann.)	31
3.	Suture of *Frechiella subcarinata* (Young & Bird), Toarcian, Fritwell Tunnel, nr. Aynho, Oxon., for comparison with *Clydoniceras*. GSM. Za 4916.	31
4*a*, *b*.	Sutures of *Ammonites hochstetteri* Oppel, the type figures. Lower Cornbrash, Chippenham, Wilts. (After Oppel.)	36
5, 6.	*Clydoniceras hollandi* (S. Buckman). 5, Bradford Clay, Bradford-on-Avon. Bristol Mus. 472. 6*a*, *b*, Holotype, Bradford Clay, Tetbury Road Station, near Cirencester. BM. C40576.	41

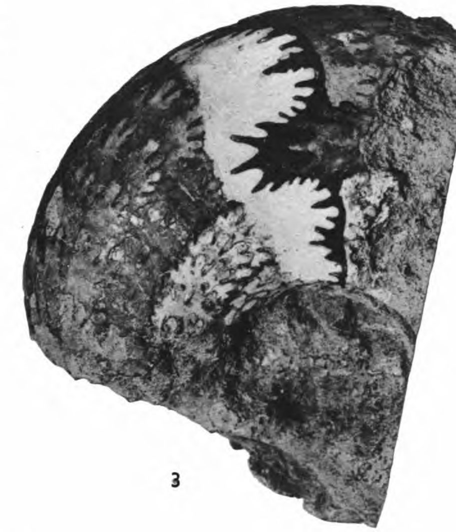
All photos natural size except figs. 1*b*, 1*c*.

1a

1b

1c

2



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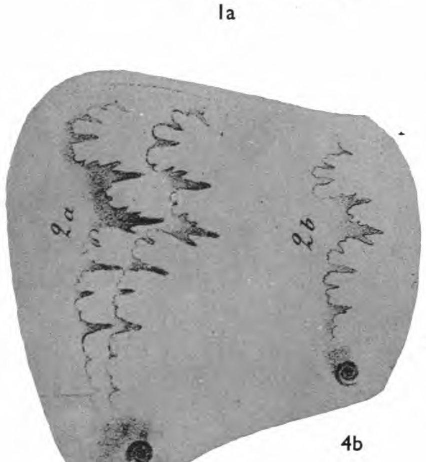

4a 4b

5

6a

6b

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PLATE II.

Fig. **Page.**

1—10. *Clydoniceras discus* (J. Sowerby), from the Lower Cornbrash.

1. Var. *discus*. Topotype, Bedford. GSM. 25621.

2*a*, *b*, *c*. Holotype, Bedford, BM. 23942.

3. Var. *blakei-crenellatus*. Enslow Bridge, Oxford. OUM. J924.

4. Var. *blakei*. Bedford. OUM. J1333.

5. Young. Shipton-on-Cherwell, Oxon. SM. J16493.

6. Var. *digitatus*, type of var. Enslow Bridge. OUM. J1304.

7. Var. *blakei*, with most of the test preserved. Cards Farm, South Brewham, Somerset. OUM. J1350.

8. Var. *blakei*, type of var. (*C. discus* Blake, 1905, pl. vi, fig. 1). Sudbrook, Lincs. SM. J3311.

9. Var. *blakei-hochstetteri*. Midland Railway pit, Bedford. BM. C5075.

10. Var. aff. *blakei*. Enslow Bridge. OUM. J1307. 33

Figs. 6, 7, 10, Douglas & Arkell Coll.

All photos natural size.

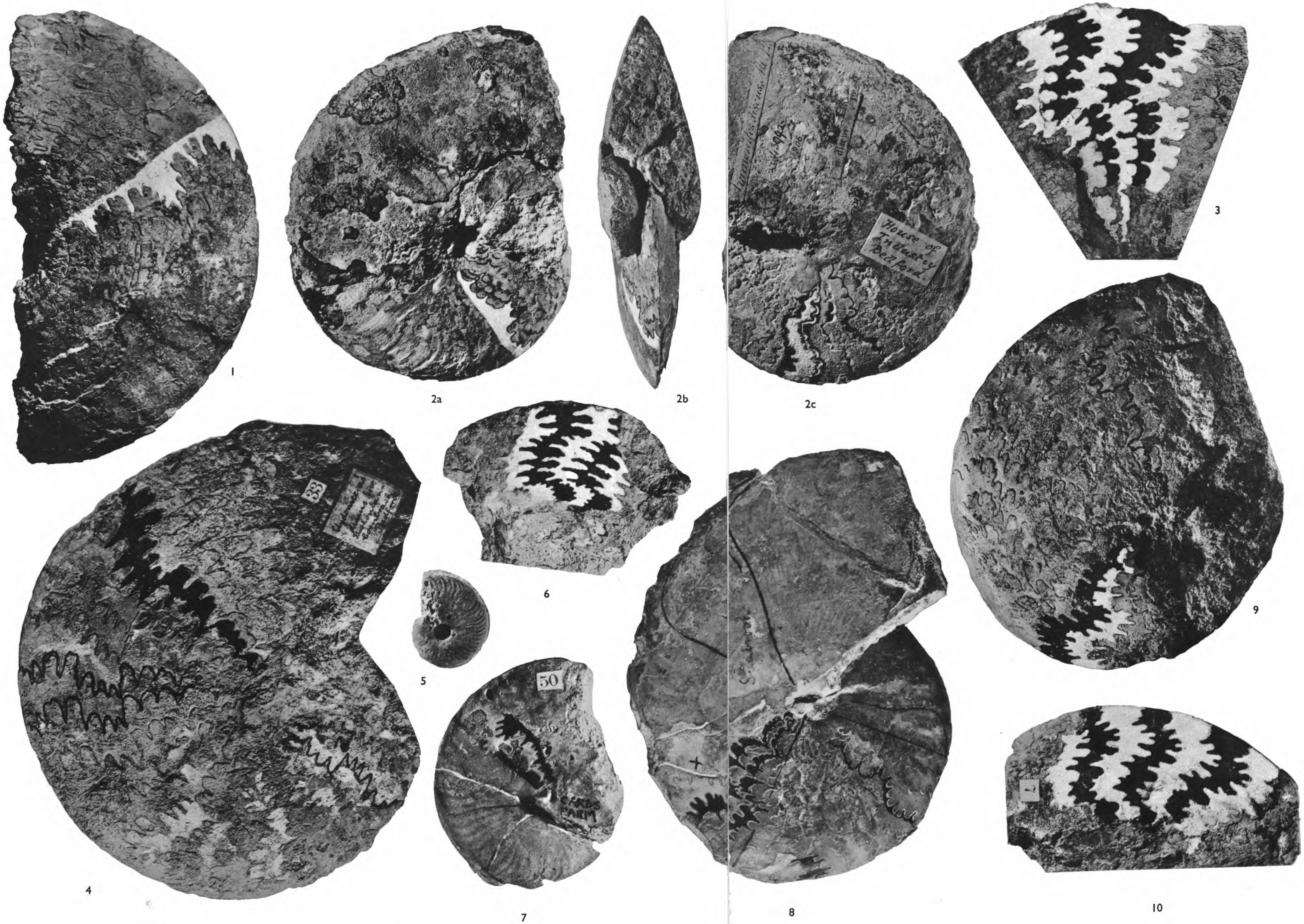

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PLATE III.

FIG.		PAGE
1—10.	*Clydoniceras discus* (J. Sowerby), from the Lower Cornbrash.	
1.	Var. *crenellatus*, type of var. Ducklington Lane quarry, Witney, Oxon. OUM. J923.	
2.	Var. *hochstetteri* Oppel. Filkins, Glos. Author's Coll., Nov., 1946. OUM. J1358.	
3.	Var. *crenellatus-hochstetteri*. Lay's Pit, Hanborough, Oxon. E.E.S. Brown Coll. OUM. J1360.	
4.	Var. *hochstetteri* Oppel. Filkins. Author's Coll., Nov., 1946. OUM. J1359.	
5.	Var. *hochstetteri* Oppel. Islip, near Thrapston, Northants. SM. J20172.	
6.	Var. *digitatus-crenellatus*. Enslow Bridge. OUM. J1310.	
7.	Var. *hochstetteri* Oppel, typical, Enslow Bridge. OUM. J1317.	
8.	Var. *hochstetteri*, degenerated. Thrapston. OUM. J1352.	
9*a*, *b*.	*C. discus* (J. Sow.). Islip, near Thrapston. L. Richardson Coll., GSM. Zd4561.	
10*a*, *b*, *c*.	*C. discus* (J. Sow.). Rushden, Northants. BM. 37787.	33
11.	*Clydoniceras douglasi* sp. nov. Holotype. Lower Cornbrash, Corscombe, Dorset. OUM. J1355.	41
12, 13, 14.	*Clydoniceras thrapstonense* sp. nov. Lower Cornbrash. Fig. 12, holotype. Islip, near Thrapston, Northants. SM. J16492. Fig. 13, topotype, SM. J16491. Fig. 14, Trowbridge, Wilts (figd. as *Clydoniceras ptychophorum* by Blake, 1905, pl. vi, figs. 3, 3*a*). BM. 33541.	40

Figs. 6, 7, 8, 11, Douglas & Arkell Coll.

All photos natural size.

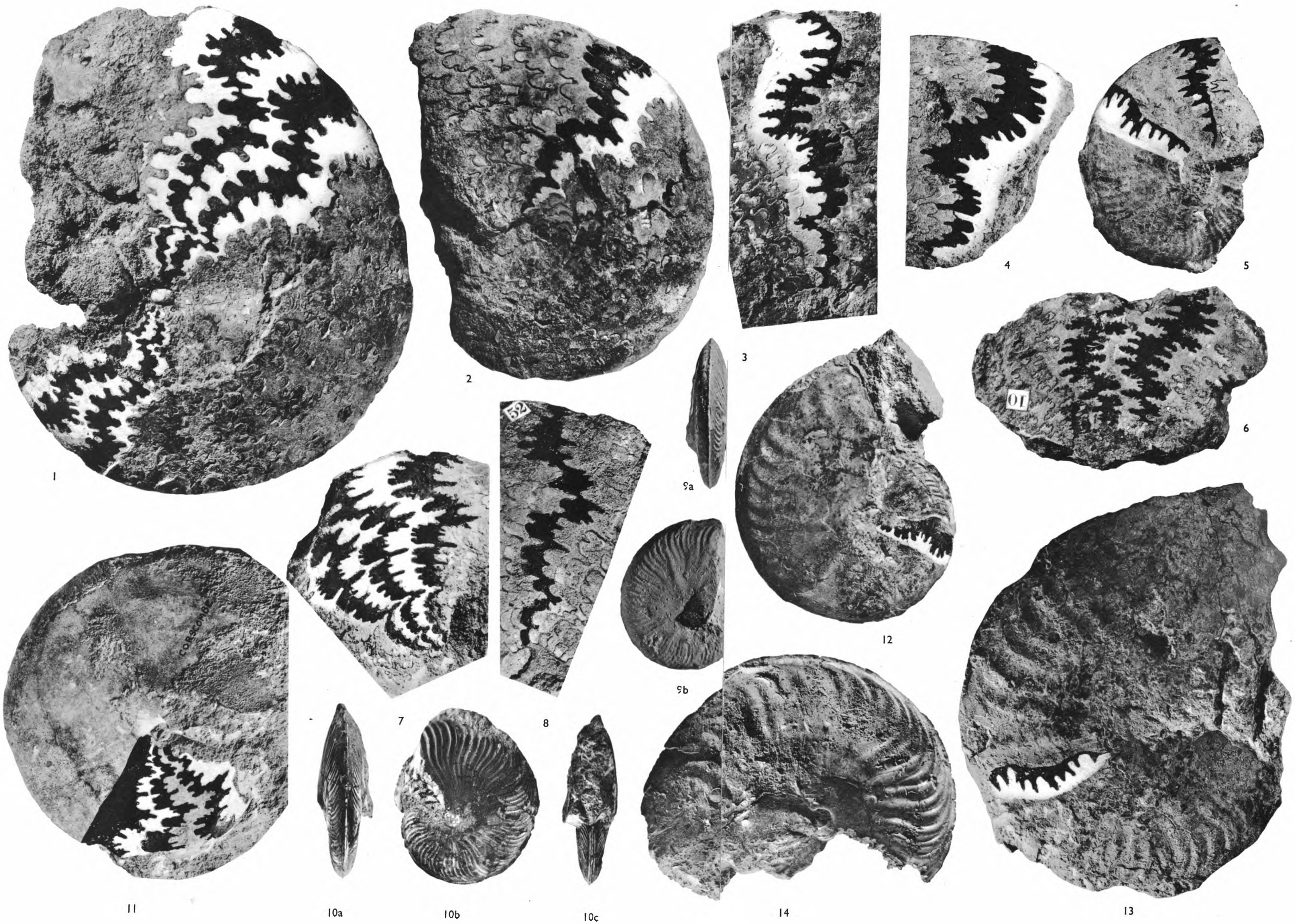

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PLATE IV.

Fig.		Page
1—6.	*Micromphalites micromphalus* (Phillips), Stonesfield Slates, Stonesfield, Oxon. Fig. 1, OUM. J1120. Fig. 2, OUM. J1121. Fig. 3, OUM. J917 (injured during life). Fig. 4, lectotype, OUM. J1117. Fig. 5, OUM. J916. Fig. 6, SM. J20176.	45
7.	*Clydoniceras tegularum* sp. nov., Stonesfield Slates, Stonesfield, Oxon. Holotype, OUM. J915.	42
8.	*Delecticeras* cf. *ptychophorum* (Neumayr), Cornbrash, Langton Herring, Dorset. SM. J19884.	45
9—11.	*Delecticeras legayi* (Rigaux & Sauvage), from the Cornbrash. Figs. 9, 10, Sudbrook, near Lincoln. SM. J5727—8. Fig. 11, Rushden, Northants. SM. J5729. (Figs. 9, 11, figured by Blake).	44
12*a*, *b*.	*Delecticeras delectum* sp. nov., Cornbrash, Bedford. Holotype, GSM. 62626.	45

All photos natural size.


1


2


7


3


4


9


8a


8b


5


10


11a


11b


6


12a


12b

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