

*PAPERS FROM THE GEOLOGICAL DEPARTMENT  
OF THE UNIVERSITY OF LIVERPOOL*

# AMMONITES

FROM THE

# UPPER KIMMERIDGE CLAY

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# I.—INTRODUCTORY

MANY of the ammonites described in the following pages have long been confused by English geologists with the Argovian form *Ammonites biplex* Sow.,<sup>1</sup> which is now taken by Mr. S. S. Buckman as the genoelectotype of *Perisphinctes* s. str.<sup>2</sup> So many species have been included under this name that, in 1896, Mr. G. W. Lamplugh wrote<sup>3</sup> :

“ *A. biplex*, as this name is usually applied in England, is almost without determinative value . . . since almost every round-whorled ammonite with bifurcating ribs, from whatever horizon, has in turn received the title, whether it be of the genus *Perisphinctes*, *Olcostephanus*, or what not.”

Long before this, however, Continental geologists had concluded that the English forms from the Upper Rimmeridge Clay were referable to *A. pallasianus* d'Orb.<sup>4</sup> Thus in 1874, Trautschold wrote<sup>5</sup> :

“ Ich habe den ächten *A. biplex* aus dem Kimmeridge von Aylesbury in Buckinghamshire im Breslauer Palaeontologischen Museum selbst gesehen, und überzeugt dass er vollständig identisch ist mit dem *A. pallasianus* d'Orb. der mittleren Moskauer Juraschicht.”

Later Nikitin,<sup>6</sup> Pavlow,<sup>7</sup> and Blake<sup>8</sup> remarked upon the identity of the two forms ; and Miss Healey<sup>9</sup> in refiguring *A. biplex* Sow., referred to the English Kimmeridgian ammonite as a variety of *Holcostephanus pallasianus* (d'Orb.). In 1908 Hudleston<sup>10</sup> pointed out that many specimens of the Kimmeridge “ *biplex* ” resemble *Perisphinctes* rather than *Holcostephanus*, to which genus they had been referred ; and R. Douvillé<sup>11</sup> (in 1911) included *A. pallasianus* d'Orb. in Pavlow's genus *Virgatites* on account of its inverse suture-line.<sup>12</sup> Similar ammonites have also been recorded from the Upper Jurassic (Middle Portlandian *sensu gallico*) of the Boulonnais, and these have been described by H. E. Sauvage<sup>13</sup> as identical with the Russian *A. pallasianus* and its allies.

Michalski<sup>14</sup> had already monographed the ammonities of the lower Volgian of Russia, and had concluded that several genera<sup>15</sup> were represented. Pavlow,<sup>16</sup> however, rejected this view and referred all these Russian forms to his genus

1. References are arranged in chronological order at the end of the paper, e.g., 1821, Pl. 293, figs. 1, 2.

2. Type Ammonites III, p. 27, 1920. 3. 1896, p. 196. 4. 1845, pp. 427, 428. Pl. XXXII, figs. 1-3.

5. 1874, p. 158. 6. 1889, pp. 44, 46. 7. 1889, p. 38. 8. 1904, p. 162.

9. 1904, p. 6». 10. 1908, p. 319. 11. 1911, No. 208.

12. This character, however, appears in late forms of various lineages and cannot, therefore, be regarded by itself as a generic character. See also Spath, 1919, pp. 28, 65, 66, 222 ; and Swinnerton and Trueman, 1918, p. 39.

13. 1912, pp. 457-462. 14. 1890, No. 2.

15. Some of these have recently been named by Dr. L. F. Spath, 1924, pp. 16, 17.

16. 1892, p. 113.

that figures of the ammonites are available the full sequence may be summarised thus :—

SUGGESTED ZONES.		PREVIOUS NOMENCLATURE.
5. <i>Holcosphinctes pallasioides</i> ...	...	} Pallasianus-zone of former authors.
4. <i>Pallasiceras rotundum</i> ...	...	
3. <i>Pectinatites pectinatus</i> .		] Virgatites-zones of Salfeld and other authors.
2. <i>Virgatosphinctoides nodiferus</i>		
1. <i>Virgatosphinctoides wheatleyensis</i>		i Aulacosphinctes- and dorsoplanus-zones of Buckman.

The wheatleyensis-zone rests on clays of the Gravesia-zones (Lower Kimmeridgian) and the pallasioides-zone is overlain in Dorset by sands containing a Kimmeridgian lamellibranch-fauna and in Bucks by a "lydite-bed," which probably marks a non-sequence of some magnitude.

During the progress of the present work, matters of detail have been discussed with Professor A. Morley Davies, Dr. F. L. Kitchin, Dr. P. Pruvost, Dr. L. F. Spath, Messrs. C. J. Bayzand, S. S. Buckman, C. P. Chatwin, E. Hollis and J. Pringle. Material has been lent by Dr. L. F. Spath, Mr. J. W. Tutcher and the Geological Survey; while facilities for investigating material in the Natural History Museum, the Museum of Practical Geology in Jermyn Street, and the Bucks. County Museum at Aylesbury have been readily granted. The expense of collecting material has been defrayed in part by a Grant from the Royal Society Committee. The present opportunity is taken by the author to acknowledge his indebtedness for this assistance.

The types collected by the author have now been deposited in the British Museum of Natural History: register numbers of these specimens are indicated in square brackets with the initials B.M.

## II.—NOMENCLATURE AND CLASSIFICATION

MANY difficulties concerning the nomenclature and classification of fossil organisms have been commented upon by various authors. The lack of uniformity in the application of specific and generic names is always apparent, phylogenetic problems are rendered more complex by the development of homoeomorphous forms, and the vagaries of preservation (or lack of it) further perplex the observer. It is not intended to dilate here upon these difficulties from a general standpoint, since this has already been done by other workers.<sup>1</sup> But, in view more especially of the great influence of the personal equation upon the institution of new genera and species, it is thought advisable to state the plan adopted in this work.

The large majority of ammonites in the Upper Kimmeridge Clay are flattened by pressure and form hopeless material for investigation. It is probably for this reason that the Kimmeridgian ammonites of this country have not been adequately illustrated. Good specimens are occasionally found, however, preserved in nodules which may occur in definite bands as at Chapman's Pool (I. of Purbeck) or sporadically as at Hartwell. In many cases, at both localities, the body-chamber has been infilled with the sedimentary deposit and has preserved its original shape, while the inner whorls are either crushed, or are so fragile that they fall to pieces when the nodule is broken. The collection of sufficient satisfactory material for description, therefore, has taken a considerable time. Thanks to numerous friends who have permitted the investigation of material in their charge, a total of over 300 specimens has been examined. Some of the specimens figured are not altogether satisfactory but, since the available exposures are decreasing in number and consequently the collection of new material is becoming more difficult, some fragmentary specimens are described because they illustrate phylogenetic tendencies.

Notwithstanding the views of some systematists as to the impossibility of expressing phylogeny in nomenclature, the attempt has been made to describe series of forms which show probable relationships. The characters relied upon for this purpose are the general form of the suture-line and the developmental stages shown by the ammonites. The character of the ribbing is less reliable since it varies considerably even in the same individual, while in general the ornament tends to great similarity throughout what have proved to be homoeomorphous groups.

1. e.g., Thomas, 1914.

Members of three series have been found in the lowest horizon characterised (in England) by the ammonite-fauna under consideration ; and these series have been traced upwards to the Hartwell Clay or its equivalent. At several horizons each series appears to give rise to one or more lineages (which are here given generic names) and these, in many cases, are homoeomorphous one with another.<sup>1</sup> Representatives of some of these lineages, viz. *Paravirgatites*, *Pectinatites*, *Wheatleyites*, have already been figured by Mr. S. S. Buckman<sup>2</sup> who, however, ascribed to them a horizon above the Hartwell Clay. These ammonites are mentioned in the following pages but full discussion must be postponed until the exact diagnoses are published. The members of each lineage differ among themselves in various characters such as height and thickness of whorl, degree of involution, and the period of persistence of the ancestral inner whorls. These are taken as specific characters ; in the Various species, therefore, the scope for variability existing within the genus is reflected.

1. A similar occurrence of the same phenomenon is seen in the *Dactyliocerates* of the Upper Lias—see S. S. Buckman, Q.J.G.S., Vol. LXXVIII, p. 454, 1922.

2. 1923, Nos. 308, 354, 365, 381-4.

### III.—DESCRIPTION OF SPECIES

#### VIRGATOSPHINCTOIDES GEN. NOV.

Genotype : *Virgatosphinctoides wheatleyensis* sp. nov. (Plate I, fig. 1).

THIS genus is proposed for a series of perisphinctoid forms with numerous crowded ribs which are chiefly triplicate on the body-chamber with a few biplicate and simple ribs interspersed. The ribbing is apparently biplicate on the earlier whorls. Beginning near the umbilical suture each rib curves backward and at the umbilical shoulder turns into a slight forward curve, becoming practically radial in the middle of the lateral area: the ribs pass over the rounded periphery without interruption. The point of branching is just in the outer half of the lateral area; usually the posterior branch joins the main rib at a higher point than the anterior branch but this is not an invariable rule. Constrictions are present chiefly on the body-chamber: the inner whorls are not constricted. The whorl-section is oval with rounded periphery and the whorls show only a slight degree of inclusion. The suture-line (Text-figure B, 5) is distinguished by very stout, broad lobes; the external lobe is about equal in length to the first lateral lobe (L1); the second lateral lobe extends to about half the length of L1 and is freely developed. The auxiliary lobes number three, are small and are obliquely disposed, but do not extend lower than the apex of L2. The saddles are divided by median lobes which are of the same stout character as the principal lobes.

Unfortunately it has not been possible to dissect any species belonging to this genus and consequently the early development of the suture-line is unknown. One species (*V. delicatulus*) appears to develop fairly coarse ribs **immediately** after the smooth inner whorls and before the typical finely-ribbed ornament appears.

The proposed series is near the ill-defined "genus" *Virgatosphinctes* Uhlig,<sup>1</sup> in its type of ribbing and development and in the absence of parabolae, but is distinguished by its suture-line, the broad, stout lobes and the free development of the second lateral lobe being obvious points of difference. Also the English forms pass from non-constricted to constricted whorls, the opposite to that which obtains in the Indian *Virgatosphinctes*.

"*Perisphinctes*" *capillaceus* Font. and "*Per.*" *ardescicus* Font.<sup>2</sup> have similar broad lobes in the suture-line but the general habit and the higher whorl-section distinguish them from the English forms, and they are geologically earlier,

1. 1910, p. 307.

2. 1879, pp. 53, 54. Pl. VIII, figs. 5, 6.

viz., from the "tenuilobatus-zone" which is equivalent to the *Rasenia*-zones of Salfeld.

The representatives of *Virgatosphinctoides* differ also from *Pseudovirgatites* Vetter in the curve of the ribbing, character of the branching of the ribs, in suture line and development.

While the ornament of *Virgatosphinctes* Uhlig, and the present genus develops along parallel lines from dichotomous to "virgate," that of *Virgatites* Pavlow<sup>1</sup> passes from virgatotome (in the inner whorls) to biplicate and simple ribbing in the adult. The fasciculi of ribs, so characteristic of the early development of *Virgatites*, have not been observed in the English forms. The suture line of *Virgatosphinctoides* also is more complex than that of *Virgatites* and there appears to be no tendency towards anterior deflection in the auxiliary lobes.

The genus *Ataxioceras* Fontannes,<sup>2</sup> from older strata, has also fasciculate ribbing in the inner whorls and, moreover, parabolae are frequent, while the suture line is less complex than in *Virgatosphinctoides*.

*Virgatosphinctoides wheatleyensis* sp. nov. (Plate I, fig. 1) (Text-figure B, 5).

Holotype from Author's collection B.M. No. C26897].

The specimen on which this species is founded has the following dimensions (all calculated, as is usual, in terms of the diameter of the shell):

Diameter	...	...	...	122 mm.
Height of whorl	.	.	.	33 per cent. of diameter
Thickness of whorl	...	...	...	28 " " "
Umbilicus	...	...	...	48 " " "

The ribbing partakes of the characters described for the genus and there are about 25 ribs in the last half-whorl preserved, which is the older part of the body-chamber. In the half-whorl at diameter 60 m.m. there are 34 ribs. The specimen being incomplete, the length of the body chamber and the form of the aperture are unknown. This ammonite becomes increasingly evolute with age, while the height of the whorl increases slowly, thus at 90 mm. the whorl-height is 31 and the umbilicus 44 per cent.; and at diameter of 60 mm. the same dimensions are 31 and 40 per cent. respectively. At 90 mm. diameter, the thickness is 29 per cent. of diameter. The suture-line (Text-figure B, 5) is comparatively simple, its stout lobes standing in marked contrast with the somewhat delicate minor sub-divisions of the saddles. *V. wheatleyensis* bears a striking resemblance to various forms which have been described by several authors under the collective name *Perisphinctes contiguus* (Catullo). The form figured by Uhlig as *Virgatosphinctes contiguus* (Cat.) Zittel,<sup>3</sup> is more involute and has a markedly different suture-line, the second lateral lobe especially being much confined by the auxiliary lobes. The ammonite described and figured as *Perisphinctes contiguus* (Catullo)<sup>4</sup> by Toucas possesses similar ribbing, but the point of bifurcation is

1. 1892, p. 471.

2. 1879, p. 66. Pl. X, figs. 1-4.

3. 1910, p. 339, PL LXVIII, fig. 2 a-d.

4. 1890, p. 581, PL XIV, fig. 4.



much lower than in *V. wheatleyensis*. Unfortunately the suture-line of the Ardèche form is not figured by Toucas, but the lower whorl-section and the difference in the branching of the ribs are probably indicative of a difference in relationship. E. Favre figures a form from the acanthicus-zone of the Tyrol which he identifies as *Ammonites (Perisphinctes) contiguus* (Cat.).<sup>1</sup> This ammonite differs from the present species chiefly in the height of its whorl-section, which is only 27 per cent. of the diameter as against 33 per cent. in *V. wheatleyensis*. The specimen figured by Favre exhibits only the body-whorl and nothing is known of the suture-line or the development of the shell. It would appear that comparison of English species with the various forms known as *Perisphinctes contiguus* will be profitable only after a complete revision of the South European material.

HORIZON AND LOCALITY : *V. wheatleyensis* is commonly found in the Nodule bed (wheatleyensis-zone) at Wheatley and Shotover Hill (Oxon). Similar ammonites (generally in a fragmentary state) are known from brickyards at Chawley, Culham, and Swindon.

*Virgatosphinctoide grandis* sp. nov. (Plate IV, fig. 2).

Holotype : Geol. Surv. Coll. No. 32068.

Dimensions of holotype :—

Diameter	...	...	...	320 mm.
Height of whorl	...	...	...	26 per cent. of diameter
Thickness of whorl	...	...	...	26    "       "
Umbilicus	...	...	...	47    "       "

The type-specimen consists of the uncrushed body-chamber, together with the external impression of the earlier whorls preserved in cement-stone. The ribbing is flexuous, the primary ribs are irregularly spaced and somewhat accentuated. The branching of the ribs varies considerably, simple, triplicate and quadruplicate ribs all occurring, and some peripheral ribs are not joined to primary ribs. There is a forward curve of the ribs on the venter. From the impression of the earlier whorls, it can be seen that the ribbing gradually becomes coarser during development of the shell, in fact the ammonite much resembles *V. wheatleyensis* at corresponding diameters. The greater whorl-height and the comparatively low relief of the primary ribs are sufficient to distinguish the latter species. Unfortunately the only septal suture visible is the last, and this is much damaged. But the development and form of the ornament, together with the geological age of the specimen, leave little doubt of its affinities. Pe. 1582 of the Collection of H.M. Geological Survey represents part of the body-chambers of a smaller specimen. These ammonites, obtained by Mr. Pringle from the Oil Shales of Kimmeridge, have been recorded<sup>2</sup> as *Pseudovirgatites scruposus* Veters.<sup>3</sup> There is some doubt, however, as to the exact horizon (in hemeral

1. 1877, p. 48, PL IV, fig. 2.

2. Buckman, 1923, T.A., pp. 17, 33, 36.

3. Veters, 1905, p. 227.

terms) of the latter species and it differs somewhat in general habit from the English form which is more coarsely-ribbed on the inner whorls and the rib-curve is not flexuous to the same degree. It is unfortunate that the suture lines cannot be compared. The occurrence of *V. grandis* at the same approximate horizon as *V. wheatleyensis* (though at different localities) and its association with *V. nodiferus*, the three forming apparently a single trend of development, is significant and suggests that evolution within the group actually occurred in the area now occupied by the Upper Kimmeridge Clay. On this account, possible relationship with *Pseudovirgatites* is left for determination by future research on the Mediterranean genus, though the belief may be expressed that the phenomenon of homœomorphy is responsible for the similarity between the two forms.

HORIZON AND LOCALITY: Known only from the Oil Shales (nodiferus-zone) of Kimmeridge, Dorset.

*Virgatosphinctoides nodiferus* sp. nov. (Plate IV, figs. 1a, b).

Type specimen from Author's collection [B.M. No. C26901].

The holotype consists of a quarter of the outer whorl representing the posterior part of the body-chamber: the last septum is present but damaged, and only fragments of the crushed inner whorls remain. The diameter of the complete ammonite would be about 260 mm. The whorl-section is rounded on the periphery, and somewhat depressed, the maximum height and thickness being calculated as 31 and 39 per cent. of the diameter respectively. The umbilicus is wide (about .45 per cent. of the diameter) and moderately deep, the umbilical margin being steep. The ornament is remarkable for the greatly accentuated development of the primary ribs which reach their greatest height just below the point of branching, where they are joined by (usually) three weaker peripheral ribs. The branching, however, is irregular, inasmuch as a secondary rib may join the primary on one side of the ammonite but remain free on the other side, dying away in the main inter-costal valley. The accentuation of the primary ribs begins on the antepenultimate whorl, the ribbing of earlier whorls being that of the normal *Virgatosphinctoides*-type. The suture-line cannot be described in detail, but the damaged last septum shows the first lateral lobe to be comparatively wide, the auxiliary lobes being feebly developed and slightly dependent.

HORIZON AND LOCALITY: Nodiferus-horizon (Clay immediately below Sands) of Shotover Hill.

A portion of the body-chamber of a similar ammonite was obtained by Mr. J. Pringle from the Oil Shales of Kimmeridge (Geol. Surv. Coll. No. 32070). This species is probably an end-form of the *Virgatosphinctoides* series, showing a development of the ornament which was foreshadowed by the previously described species *V. grandis*.

*Virgatosphinctoides delicatulus* sp. nov. (Plate 1, figs. 2, 3).

Holotype from Author's collection B.M. No. C26905].

The holotype, which is entirely septate, gives the following proportions :

Diameter	...	...	65 mm.	51 mm.
Height of whorl	...	...	34	37 per cent. of diameter
Thickness of whorl	...	...	30	30 " "
Umbilicus	...	...	35	31 " "

This is a fine-ribbed species, about 70 ribs occurring in the last whorl. The ribs are crowded, inclined forwards and bifurcate between the middle of the flank and the periphery ; the rib-curve is similar to that of other species of *Virgatosphinctoides*. On the inner whorls the ribs are at about the same distance apart, giving a somewhat coarser appearance. The ammonite is fairly evolute (becoming increasingly so with age), with moderately high whorl section and the flanks are flattened, the periphery being gently rounded. Constrictions, approximately parallel to the ribbing, occur on the outer whorls ; occasionally a trifold rib occurs behind and always a simple rib in front. This simple rib is in higher relief than the preceding ribs and stands out prominently like the " flare " in *Lytoceras*. The suture-line is moderately ramified and conforms to the type described with the generic characters.

HORIZON AND LOCALITIES : Wheatleyensis-zone (Nodule bed) of Wheatley (Oxon). This species seems to be the fine-ribbed form recorded by Mr. Pringle<sup>1</sup> as occurring abundantly in a crushed state in the Kimmeridge Oil Shales of Dorset, Norfolk, Lincs., etc.

#### PECTINATITES BUCKM., 1922.

The type-species is *Pectinatites pectinatus* (Phill.) which occurs, associated with a characteristic fauna, in the pectinatus-zone at Shotover Hill and Swindon. Representatives of this fauna are also found in the Oil Shales of Kimmeridge, but Mr. Buckman has recently instituted<sup>2</sup> a new genus *Pectiniformites* for Ammonites of the *pectinatus*-type from this faciès. There seems to be no justification for this, and *Pectiniformites* must be regarded as synonymous with *Pectinatites*. Mr. Buckman's procedure seems to be connected with his erroneous view that the Oil Shales of Kimmeridge occupy a much lower horizon than the pectinatus-sands of Swindon and Shotover Hill.

*Pectinatites aulacophorus* Buckm. (Plate I, fig. 5).

1923 Buckman, S. S. Type Ammonites IV. No. 381

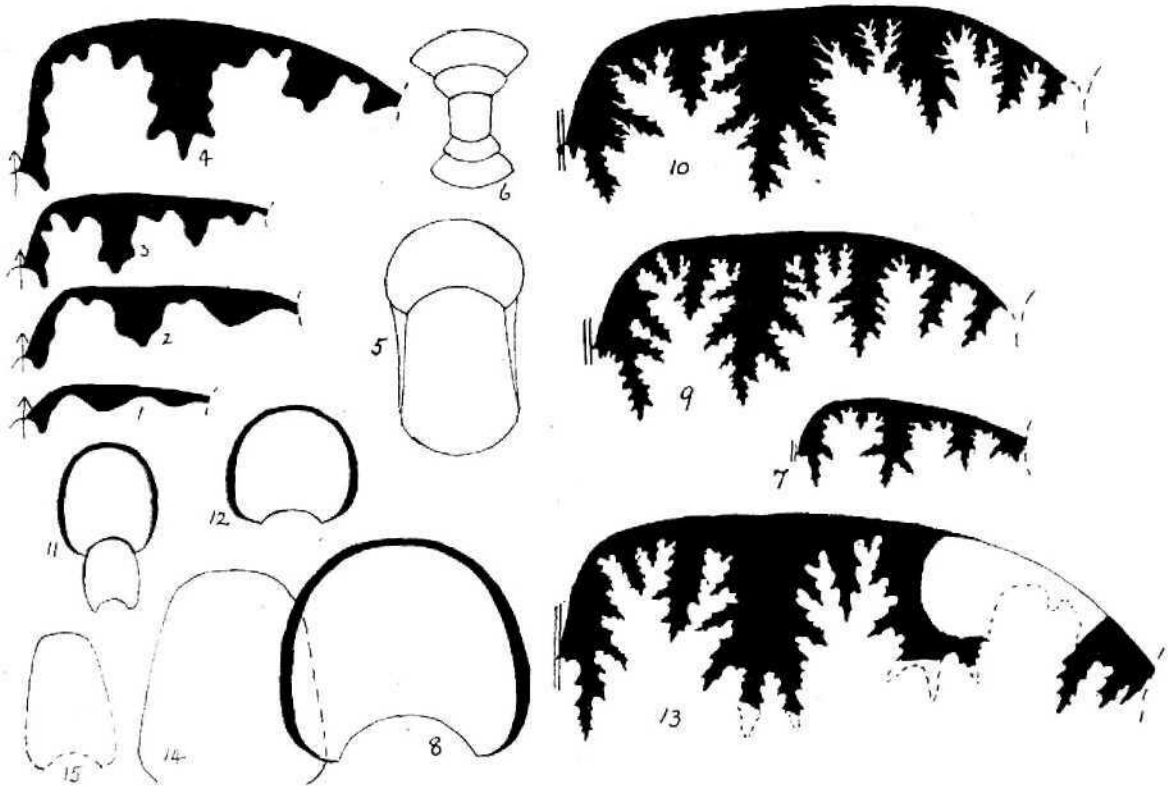
Among the pyritised ammonites from the Bituminous Shales of Kimmeridge Bay in the collection of H.M. Geol. Surv. is a fine-ribbed specimen (32072) giving the following proportions :

Diameter	...	...	52 mm.
Height of whorl	...	...	40 per cent. of diameter
Umbilicus	...	...	32 " "

1. 1919, p. 51.

2. T. A., 1925. No. 568.

The ammonite is enclosed in a shale-nodule which has weathered away on one side so that the thickness cannot be measured. Another specimen in the same collection (32071), however, showed a thickness of 30 per cent. at the same diameter. The sides are flattened and the periphery is somewhat square (Text-figure A, 15). The rib-curve is similar to that of other species of the genus and 47 ribs are present in the last half-whorl of the ammonite. The point of bifurcation of the ribs is extremely variable, many primary ribs dividing low in the lateral area, i.e., between the middle of the flank and the umbilical edge.



TEXT-FIGURE A,

(1), (2), (3), (4) *Pallasiceras gracile*, nov., suture-lines at diam. 2 mm., 3 mm., 6.5 mm. and 11 mm. respectively; (5) apertural view at diam. 6.5 mm.; (6) section at diam. 4.25 mm.

(7) *Pallasiceras rotundum* (Sow.)—suture line at diam. 68 mm.; (8) whorl-section at diam. 95 mm. (specimen in PL I, fig. 6); (9), (10) suture lines of a larger (damaged) specimen.

(11) *Pallasiceras concinnum*, nov., whorl-section of holotype at diam. 53 mm.

(12) *Pallasiceras gracile*, nov., whorl-section of holotype at diam. 42 mm.

(13) *Pallasiceras ultimium*, nov., suture-line of holotype at diam. 162 mm.

(14) *Pectinatites pyriticus*, nov., whorl-section of holotype at diam. 66 mm.

(15) *Pectinatites aulacophorus* Buckm.—whorl-section at diam. 52 mm.

Figs. 1-6 enlarged; 7-15 natural size.

The impersistent ventral groove shown by the holotype is not seen in this pyritised ammonite owing to injury to the periphery and the suture-line also is not preserved. The ammonite under discussion has been recorded as "*Am. pectinatus*" and agrees with *P. aulacophorus* in all visible characters. The holotype is from the "Lower Portland Sands" of Swindon which are thus to be correlated with the Bituminous Shales of Kimmeridge as pointed out long ago by Hudleston.<sup>1</sup>

*Pectinatiles pyriticus* sp. nov. (Plate I, fig. 4).

The holotype of this species (Coll. Geol. Surv. 32073) gives the following dimensions:

Diameter. . . . .	66 mm.
Height of whorl. . . . .	44 per cent. of diameter
Thickness of whorl . . . . .	37 " "
Umbilicus . . . . .	30. " "

This ammonite is a fairly involute form with a considerable whorl-height and has flattened sides and a somewhat square periphery (Text-figure A, 14): the greatest thickness is near the umbilical shoulders. The rib-curve shows the characters of other species of the genus and the holotype has 35 ribs in the last half-whorl. The point of branching is somewhat variable, generally in the upper third of the lateral area, but some primary ribs unite in the lower third of the area producing an approach to the "virgate" type of ribbing: some simple ribs are intercalated with the branched ribs. Though the type-specimen is a pyritised cast, no suture-lines are visible; but the rib-curve and the geological horizon of the ammonite leave no doubt as to its affinities.

This species has hitherto been recorded as "*Am. pectinatus*," from which it differs in its higher whorl section and greater thickness. *P. pyriticus* bears considerable resemblance to *P. aulacophorus* Buckm.<sup>1</sup> but has a higher and thicker whorl-section and is more coarsely ribbed.

HORIZON AND LOCALITY: Bituminous Shales (pectinatus-zone), Kimmeridge.

## PALLASICERAS SPATH, 1924

Type: *Am. rotundus* J. Sowerby, 1821: Min. Conch., p. 369, Plate 293, fig. 3.

A series of ammonites from Chapman's Pool (I. of Purbeck) shows coarse biplicate ornament on the adult whorls, while on the inner volutions the ribs are delicate and crowded and are inclined forwards. The whorls are deeply constricted only in the adult. Members of the series show considerable variation with regard to whorl-shape, degree of involution, and period of persistence of the finely-ribbed stage: the expression of these variations is found in the species described below. The series, as a whole, appears to represent a development of the *Virgatosphinctoides*-stock in which a coarse type of biplicate ribbing replaces the triplicate type of that genus. One species, *Pallasiceras rotundus* (Sow.), attains considerable size, and is widely distributed. The name *Pallasiceras* was recently proposed by Ur. L. F. Spath<sup>2</sup> for *Ammonites rotundus* Sow, and its allies. The suture-line is simple in small species and shows a tendency to become "inverse," the suspensive lobe being deflected anteriorly. In large specimens the suture is elaborate, the saddles especially being finely denticulated.<sup>3</sup> Compared with the suture-line of a large *Holcosphinctes* from the same horizon the saddles are high and comparatively narrow and the median lobule of the saddles is very wide and deep.

1. T.A., 1923, No. 381.

2. 1924, p. 16.

3. Text-fig. A, 7, 9, 10.

4. Text-fig. B, 11.

Species of *Pallasiceras* most nearly approach in external form the ammonites described by Michalski<sup>1</sup> from the Lower Volgian Series of Russia, which are usually placed in the genus *Virgatites* Pavl. The resemblance, however, is confined to the ribbing on the adult whorls, the development of ornament and suture-line showing marked differences. The confusion of the English and Russian forms has arisen from this superficial likeness and from the lack of adequate illustration of the English Kimmeridgian ammonites.

The name given to this genus expresses the external similarity with *Am. pallasianus* d'Orb. but is not meant to imply genetic relationship with this form.

The genus *Paravirgatites* Buckm.<sup>2</sup> from a lower horizon is also homoeomorphous with *Pallasiceras* but is distinguished by its development and suture-line. The affinities of *Lydistratites* Buckm.<sup>3</sup> have yet to be worked out; this genus, however, appears at a higher horizon and is probably a later lineage of the *Virgatosphinctoides* or the *Allovirgatites* stock.

*Pallasiceras rotundum* (Sow.). (Plate I, fig. 6).

1821 *Am. rotundus* J. Sowerby: Min. Conch., p. 369, Plate 293, fig. 3.

Dimensions of figured specimen [B.M. No. C26903]:

Diameter.	96 mm.	75 nun.
Height of whorl.	27	30 per cent. of diameter
Thickness of whorl ... ..	31	36 " "
Umbilicus.	48	48 " "

The type of this species (Brit. Mus., No. 43899) is a rolled fragment representing the cast of part of the body-chamber. As far as can be seen, the specimen here described agrees with Sowerby's specimen and both were obtained from the Kimmeridge Clay of the Isle of Purbeck. Though the ontogeny of the original type can never be known, the writer believes the present ammonite to be specifically identical, and considers the addition of another specific name to an already unwieldy nomenclature to be unnecessary in this case.

This topotype of *Pallasiceras rotundum* (Sow.) is evolute, with somewhat rounded whorls of which the thickness is slightly greater than the height: the greatest thickness is just above the umbilical shoulders. The ribs are prominent and sharp, forwardly inclined, and chiefly biplicate, but each constriction is bounded as a rule by a trifid rib behind and a simple rib in front. In some specimens the cast shows a shallow ventral depression on a few of the ribs, but this character is not constant. The constrictions, which appear to be confined to the later whorls, are deep and fairly wide, parallel with the ribbing, and are partially overhung by the backward projection of the simple rib immediately anterior.

The suture-line is comparatively simple (Text-figure A), The external lobe is longer than the first lateral lobe, which in turn greatly exceeds the length of the

1. *op. cit.*, 1890.  
2. 1922, T.A., IV, No. 308.

3. 1922, T.A., IV, No. 353.

second lateral lobe. The first lateral lobe is asymmetrically trifid: the second lateral lobe more so, even approaching a bifid condition. The saddles are broad and are divided by small subsidiary lobes; the lateral saddles are progressively higher towards the umbilicus. The "suspensive" lobe is slightly oblique.

The inner whorls are more finely ribbed than the later whorls, but the coarse-ribbed character is acquired earlier than in some species of the genus. During development from the low depressed inner whorls the whorl-section becomes gradually higher as growth proceeds. The development of the suture-line is given in Text-figure A.

Some specimens, especially fragmentary casts of the posterior portion of the body-chamber, give evidence of the shell muscles. Both left and right muscular scars occur: they are approximately triangular, the apex of the triangle pointing towards the periphery. As in the ammonites described by Crick,<sup>1</sup> the anterior border of the muscles-impression is more pronounced than the posterior boundary. No traces of the annulus have been observed.

HORIZON AND LOCALITY: Rotundum-zone. Chapman's Pool (I. of Purbeck).

Mr. Buckman has recently re-figured Sowerby's type (T.A., VI, No. 590). He refers the specimen to the "K. C. Nodule bed" of Chapman's Pool, but his correlation of this bed with the Portland Sands—lyditicus-zone cannot be accepted, since the lyditicus-beds in Bucks. are much higher in the sequence than the rotundum-zone. Anyone who has examined the cliff-section from Kimmeridge to St. Alban's Head will recognise that the only horizon for the specimen is the conspicuous Nodule bed (some distance below the base of the sands at Hounstout) which yielded all the uncrushed specimens of *Pallasiceras* here figured from Dorset.

*Pallasiceras concinnum* sp. nov. (Plate I, fig. 7).

Type: Coll. Geol. Surv. No. 32418.

Dimensions of holotype:

Diameter	...	...	...	53 mm.	39 mm.	28 mm.		
Height of whorl	...	...	...	31	34	38	per cent.	of diameter
Thickness of whorl...	...	...	...	32	33	35	"	"
<b>Umbilicus</b>	...	...	...	<b>46</b>	45	<b>40</b>	"	"

This species is a form of *Pallasiceras* in which the finely-ribbed stage persists to a greater diameter than in *P. rotundum*. Compared with the latter species *P. concinnum* is also more compressed; thus at diam. 53 mm. the whorl-thickness is 32 per cent. of the diameter, compared with 36 per cent. at diameter of 75 mm. in *P. rotundum* (Text-figure A, 11). The suture-line is similar to that of *P. rotundum* but shows a tendency to become more "inverse" than in the latter species. Otherwise, the type of ribbing, the general form of the suture-line, the increasingly evolute character of the whorls are points of similarity with the type-species of the genus.

DISTRIBUTION: Rotundum-zone; Chapman's Pool (I. of Purbeck).

*Pallasiceras pringlei* sp. nov. (Plate I, tig. TO).

Type : Coll. Geol. Surv. 32417

**Dimensions** of holotype :

Diameter	...	...	46 mm.	33 mm.
Height of whorl	...	...	35	34 per cent. of diameter
Thickness of whorl	...	...	37 (?)	— " "
Umbilicus	...	...	42	40 " "

*P. pringlei* occupies a position in the series intermediate between *P. concinnum* and *P. gracile* next to be described. There are 25 ribs in the last whorl, and about 50 in the penultimate whorl, the fine-ribbed condition persisting to about the same stage as in *P. concinnum*. The present species, however, is more inflated and has a higher whorl-section than *P. concinnum*, producing a form which is not likely to be confused with the species already described. The suture-line is simple but of the same general type as in *P. rotundum*.

HORIZON AND LOCALITY : Rotundum-zone ; Chapman's Pool (I. of Purbeck).

*Pallasiceras gracile* sp. nov. (Plate I, tigs. 8, 9).

Type : Coll. Geol. Surv. No. 32420.

**Dimensions** of holotype :

Diameter	...	...	42 mm.	34 mm.
Height of whorl	...	...	36	40 per cent. of diameter
Thickness	...	...	44 (?)	— " "
umbilicus	...	...	39	36 " "

This species is the most involute and the most inflated of the series and at the same time its whorl-section (Text-figure A) is higher than that of the other members of the genus. The whorls also are more finely ribbed than the preceding species at corresponding diameters, about 30 ribs being present in the last whorl at 42 mm. diameter. *P. gracile* then probably stands nearer the ancestral type than the other species of *Pallasiceras*.

HORIZON AND LOCALITY : Rotundum-zone ; Chapman's Pool (I. of Purbeck).

The types here described are selected to show as far as possible the varying trends in the evolution of the series. Other ammonites of the same series and from the same locality show similar variations in a greater or less degree but in the main fall into the classification adopted.

*Pallasiceras ultimum* sp. nov. (Plate I, fig. 11).

In the geological collection of the Bucks County Museum at Aylesbury there are five fragments of a nearly smooth, inflated type which appear to be referable to *Pallasiceras*. The specimen chosen as holotype of the present species is a half-whorl consisting of a part of the body-chamber and three of the air-chambers. Its dimensions are :

Diameter	...	...	208 mm.	162 mm.
Height of whorl	...	...	34	32 per cent. of diameter
Thickness of whorl	...	...	—	35 " "
Umbilicus	...	...	45	44 " "



The inner whorls are almost entirely concealed by matrix and the outer whorl is cracked and encrusted with specimens of ? *Anomia*. The shell, where preserved, is thick, though, in places, only the inner nacreous layer is present.

The ribbing of the outer whorl is much reduced: the widely spaced primary ribs persist in low relief but the peripheral ribs are almost obliterated. Growth-striae are plainly marked in places. In the visible part of the penultimate whorl, the primary ribs are prominent and the inner whorls are finely ribbed. The umbilicus is open and fairly deep, with an almost perpendicular edge consequent upon the inflation of the whorl.

The suture-line, well-ramified, is of the same general type as that of large specimens of *P. rotundum* (Text-figure A, 13). The external and first lateral lobes reach the same radius but the second lateral lobe is much shorter. The first lateral saddle is slightly in advance of the external saddle: both have deep median lobes. The auxiliary lobes are only slightly oblique and extend to about the level of the apex of the second lateral lobe.

Compared with *P. rotundum*, this species shows a remarkable reduction of ribbing and a development of the suture-line towards the "inverse" type accompanied by a widening of the second lateral saddle. These characters are usually seen in late forms of a lineage but the widening of the second lateral saddle may possibly be correlated with an increase in the height of the whorl.

This ammonite was collected by the late Dr. J. Lee from Hartwell. It was probably obtained from the lower Hartwell Clay—about rotundum-horizon—when the brick-pits were worked to a greater depth than at the present time. The preservation is similar to that of the Hartwell and Crendon ammonites and quite different from that of the Wheatley and Shotover forms.

*Pallasiceras* sp. n. aff. *ultimum*.

Two of the fragments of smooth ammonites in the Aylesbury Museum differ from the previously described species in possessing a thin shell, of which both inner and outer layers are preserved. The whorl-section, moreover, is less inflated than in *P. ultimum*. Otherwise these fragments show the widely spaced primary ribs with faint loosely-joined peripheral ribs characteristic of the former species. Owing to the fragmentary nature of the specimens it is considered advisable to postpone further discussion until more material is available.

HORIZON: Hartwell Clay (lower part ?).

COLLECTION: Aylesbury Museum (Lee collection).

SPHINCTOCERAS GEN. NOV.

Genotype: *Sphinctoceras crassum* sp. nov. (Plate II, fig. 1).

The ammonites included in this genus are massive forms which often attain considerable size (20 to 30 cm.). The whorl-section is somewhat depressed and often much inflated. The ribbing is massive and biplicate throughout development and in some species the ribs become more widely spaced with age than in

the genotype. The rib-curve has a slight backward trend on the umbilical margin and then continues in a radial direction, a secondary branch developing behind the main rib. The peripheral ribs show no weakening on the venter, but in the cast slight depressions, due to a thickening of the shell substance, are seen on the ribs just over the siphonal area. Constrictions occur throughout development and are wide, comparatively shallow, parallel with the main ribs. The suture-line is well ramified, the external and first lateral lobes approximating in length and the second lateral lobe extending to about half the length of the first lateral lobe. The first lateral saddle is in advance of the external saddle and both are deeply divided by subsidiary lobules. The auxiliary lobes form a "suspensive lobe" which is sharply deflected backwards.

Species of *Sphinctoceras* have been provisionally named by Mr. S. S. Buckman<sup>1</sup> as "*Perisphinctes dorsoplanus*." This group, according to Michalski,<sup>2</sup> develops trifid ribs after a biplicate "stage" and then shows an increase in the width of the intercostal spaces accompanied by accentuation of the primary ribs and a grouping of the peripheral ribs into trifid bundles. In *Sphinctoceras*, however, the ribbing is entirely biplicate and though the intercostal spaces become wider in later members of the lineage, the accentuation of the primary ribs does not result in the formation of radially elongated lumps such as Michalski describes for the *dorsoplanus*-group. Moreover, the suture-line is more elaborate than that of "*Per.*" *dorsoplanus* and is characterised by the great development and marked backward deflection of the auxiliary lobes.

*Sphinctoceras crassum* sp. nov. (Plate II, fig. 1).

Dimensions of holotype [B.M. No. C26900] :

Diameter	...	...	...	70 mm.
Height of whorl	...	...	...	30 per cent. of diameter
Thickness of whorl	...	...	...	40 "
Umbilicus	...	...	...	47 " "

This is a massive inflated form with somewhat depressed whorls, the greatest breadth of which is just above the umbilical shoulders. The specimen is entirely septate; the body-chamber and the form of aperture are therefore unknown. The ribbing is biplicate throughout with the exception of a few simple ribs which accompany the constrictions; the point of bifurcation lies in the outer third of the lateral area. The primary ribs, of which there are 27 in the last half-whorl, have practically a radial direction; a secondary rib develops behind the main rib and is directed backwards. The same coarse type of ribbing is shown on the visible inner whorls. Constrictions, parallel to the main ribs, are seen on each of the three visible whorls. The simple rib in front of each constriction has its edge deflected backwards, overhanging the constriction to some extent. The suture-line is ornate with long, comparatively broad lobes. The first lateral lobe is of the same length as the external lobe and is unsymmetrically trifid. The second lateral lobe with four irregular branches extends to about half the length

of the first lateral lobe. The saddles are deeply indented by subsidiary lobes, the first lateral saddle extending slightly in advance of the external saddle. The small second lateral saddle is almost entirely enclosed by the second lateral lobe and the large first auxiliary lobe which extends obliquely below the apex of the former. It is of interest to note here that the siphuncular tube is exposed where the periphery is damaged, the tube being black in colour and of a polished appearance. It appears 'probable that this structure is largely phosphatic in composition.

Only one specimen of this form has so far been discovered, and its characters are such that it is not likely to be confused with any other ammonite known to the writer.

HORIZON AND LOCALITY: Nodule bed (wheatleyensis-zone), Wheatley (Oxon).

*Sphinctoceras distans* sp. nov. (Plate IV, fig. 3).

The holotype (Geol. Survey, Engl., 27817) has the following dimensions:

Diameter	...	...	...	26	ram.	150 mm.
Height of whorl	...	...	...	27	„	jo per cent, of diameter
Thickness of Whorl	...	...	...	45	„	30 „ „
Umbilicus	...	...	...	51	„	52 „ „

This large ammonite is of the same general type as *Sphinctoceras crassum*, from which it differs externally in the gradual widening of the intercostal valleys and the consequent spacing-out of the ribs in the later whorls. That this is a definite character of the species and not merely the effect of growth is shown by the appearance of widely-spaced ribs in specimens of about the same diameter as the holotype of *Sph. crassum*. The suture-line resembles that of the previously-described species with regard to the external and first lateral lobes and saddles. The second lateral lobe, however, is more regularly trifid, and the second lateral saddle is more freely developed since the auxiliary lobes, though sharply deflected, do not encroach to the same extent as in *Sphinctoceras crassum*. The present species has the steep umbilical edge and depressed whorl section characteristic of the lineage, the later whorls arc constricted at intervals and a few trifid ribs appear on the body-chamber.

“*Perisphinctes*” *crussoliensis* Font.<sup>1</sup> differs from *Sph. distans* in becoming higher than thick in the last whorl-section while *Sph. distans* retains its depressed form. Moreover, the suture-line of the present species is apparently more complex and the auxiliary lobes more inflected, judging from Fontannes' figure. A figure given by P. de Lorio<sup>2</sup> differs from that of Fontannes in that it shows a more depressed section in the later whorls but is still much thinner than the present species. Only the inner portion of the suture-line is seen in Lorio's figure and though a general similarity with *Sphinctoceras* is apparent, relationship

1. 1876, p. 97, PL XIV, fig. 3.

2. 1877, p. 53, Pl. V, figs. 7, 8.

cannot be claimed without comparison of the actual specimens, especially as *Per. crussoliensis* occurs in the tenuilobatus-zone, i.e. much earlier than *Sphinctoceras*. *Sph. distans* is one of the many forms which have been mistaken for *Ammonites rotundus* Sow., though the latter has a very different development and suture-line. A large specimen in the University Museum, Oxford (labelled "*Per. cf. rotundus*, Kimmeridge Clay, Shotover") with highly complex suture-line and widely spaced ribs in the adult whorls, is probably closely related to *Sphinctoceras distans*. Large ammonites from Chettisham (Coll. University of Cambridge) also show similarity with this species but their indifferent preservation prevents exact determination.

HORIZON AND LOCALITY : Nodule bed (wheatleyensis-zone) Headington and Wheatley.

Judging by an observation of Mr. Buckman (Q.J.G.S., vol. lxxvi, p. 96, 1920), similar specimens, probably of this easily recognised species seem to have been encountered in the brickyard (now abandoned) at Long Crendon, Bucks., "a few feet below Hartwell Clay" (rotundum-zone) "that would be in the position of the same bed" (i.e., the Nodule bed of Shotover).

#### EPISPHINCTOCERAS GEN. NOV.

Genotype : *E. inflatum* sp. nov. (Plate II, fig. 2).

In the rotundum zone, several specimens which appear to belong to one species exhibit a divergence from the main *Sphinctoceras*-stock. These ammonites attain a large size and are characterised by a considerable degree of inflation as growth proceeds. The ornament consists of strong biplicate ribs which show no tendency towards wider separation in the adult whorls, thus being distinguished from the later members of the *Sphinctoceras* lineage. The inner whorls show the same coarse-ribbed character after a diameter of about 3 mm. The middle whorls are imperfectly known but apparently constrictions occur throughout, each constriction being accompanied by a simple rib in front and an irregularly branched rib behind. The suture-line (Text-figure B, 16) presents the same general features as that of *Sphinctoceras*, with high and broad external saddle, and narrow lateral saddles which are greatly hemmed in by the backward deflection of the second lateral lobe and the auxiliary lobes.

The generic separation of this series is justified by its distinctive general habit, and by the simpler character of the suture-line as compared with *Sphinctoceras*. as well as by considerable difference in age, *Episphinctoceras* being known only from the rotundum-zone, while *Sphinctoceras* is characteristic of the wheatleyensis-zone.

*Episphinctoceras inflatum* sp. nov. (Plate II, fig. 2).

Dimensions of holotype [B.M. No. C26902] :

Diameter	...	...	...	140 mm.	114 mm.
Height of whorl	...	...	...	39 "	38 per cent. of diameter
Thickness of whorl	...	...	...	40 "	37 "
Umbilicus	...	...	...	38 "	38 "

There are indications of nearly another whorl which would give the specimen a diameter of about 170 mm. The whorls in the adult become much inflated, a character which is reflected in the proportions by an increase in the thickness percentage.

The ribbing is biplicate, except near constrictions, and the ribs beginning with a backward sweep on the umbilical margin are inclined slightly forwards: there are 34 primary ribs in the last whorl. The point of bifurcation is about the middle of the flank. Two constrictions are present in the last whorl: they are deep and narrow and are slightly oblique to the preceding ribbing. Each is accompanied by a simple rib in front which being turned backwards overhangs the constriction and accentuates its depth. Behind each constriction the ribs are crowded so that the two primaries immediately preceding it unite on the umbilical shoulder forming a bidichotomous bundle. The periphery is gently rounded and the cast shows a slight ventral groove, comparatively broad and shallow, on the peripheral ribs. The suture-line is fairly simple (Text-figure B, 16). The external and first lateral lobes are equal in length; the second lateral lobe is much shorter and is slightly recurved; the first auxiliary lobe is well-developed, and is recurved backwards. The saddles are comparatively high; the external saddle broad, the first and second lateral saddles are narrow, being enclosed by the second lateral and first auxiliary lobes which almost meet.

This form appears to be a development of the *Sphinctoceras*-stock which becomes much inflated, but retains its strong biplicate ribbing, while the suture-line, though remaining of the same general type, shows a reduction in complexity. The inner whorls are not seen in the holotype: another specimen in the author's collection, however, gives evidence of coarse ribbing in the young stages.

*Episphinctoceras inflatum* has often been referred to "*Holcostephanus*" *Lomonosovi* (Vischn.), but the latter genus differs in characters of the suture-line and apparently also in the development of the ornament. In the suture-line of *H. lomonosovi*, the first lateral lobe is always shorter than the external lobe and the two lateral saddles are comparatively broad and shallow; moreover, the auxiliary lobes are only feebly developed. According to Michalski, constrictions are entirely wanting in *H. lomonosovi*; also traces of "parabolischer sculptur" are sometimes seen. These characters indicate differences between *H. lomonosovi* and *E. inflatum*, though the external appearance of the two forms is so similar as to cause confusion. There remains the improbability of direct geographical connection between Russia and the Anglo-French basin in Upper Kimmeridge times, which appears to preclude direct relation between the ammonites occurring in the two areas. This question is discussed on a later page.

HORIZON : Lower Hartwell Clay (rotundum-zone). Specimens formerly obtained at Hartwell when Locke's pit was worked to a greater depth. Some large fragments of body-chamber from the rotundum-zone of Long Crendon may also belong to this species.

#### AOSPHINCTOCERAS NEAVERSON, 1924.

Genotype : *Olcostephanus pallasianus* d'Orb. var. Healey 1904, Q.J.G.S., Vol. lx, p. 60, Plate XII, figs, 1, 2.

The ammonites for which this name is proposed are probably related to *Sphinctoceras* but the ribs become sharpened and much higher on the lateral area, this character giving a distinctive appearance to the shell. At the same time the suture-line is simplified and the constrictions become less conspicuous. The deep umbilicus with its almost perpendicular margins, and the coarsely ribbed inner whorls are characters in which the present genus approaches *Sphinctoceras*. Species of *Aposphinctoceras* are found in the upper part of the Hartwell Clay associated with homoeomorphous forms of other lineages from which they may be distinguished by ontogeny and the form of the suture-line. These characters also present differences from the "*pallasianus*" group of the genus *Virgatites*, with which the Hartwell ammonites have previously been identified.

*Aposphinctoceras* differs from its associates *Holcosphinctes* and *Pallasiceras* also in the form of the peripheral ribbing. In the present genus the secondary ribs are straight on the venter, i.e. approximately perpendicular to the median plane of the shell, whereas in *Holcosphinctes* and *Pallasiceras* the peripheral ribs exhibit a distinct forward curve in their passage over the venter. These two genera also show finely-ribbed ornament on their inner whorls, whereas *Aposphinctoceras* is coarsely ribbed throughout. The shallow umbilicus of *Holcosphinctes* also presents a difference from the comparatively deep steep-sided umbilicus of *Aposphinctoceras*.

Judging by Michalski's figures/ "*Perisphinctes*" *pavlovi* Mich., from the Lower Volgian of Russia, possesses a striking similarity with members of the series under discussion. Points of resemblance are seen in the wide whorl-section, the strong, radially-directed, biplicate ribs, the absence of trifid ribs, and the absence of a distinct curvature of the ribs on the periphery. On the other hand, Michalski mentions the scarcity of constrictions, the rounding of the umbilical margin and the corresponding high situation of the greatest whorl-thickness in *Per. pavlovi* which are features differing from corresponding characters in species of *Aposphinctoceras*. It is a matter for regret that the suture-lines cannot be compared, but as the present series is connected with earlier forms of the *Sphinctoceras*-stock and is widely separated geographically from the Russian series, the similarity in external form is probably not an indication of near affinity.

*Aposphinctoceras decipiens* Neaverson.

Type : *Olcostephanus pallasianus* d'Orb. var. Healey, Q.J.G.S., Vol. lx, p. 60,  
Plate XII, figs, 1, 2. 1904.

*Aposphinctoceras decipiens* Neaverson, Geol. Mag., Vol. lxi, p. 149. 1924.

Dimensions of holotype :

Diameter	...	...	...	72 mm.
Height of whorl	...	...	...	30 per cent. of diameter
Thickness of whorl	...	...	...	35 " "
Umbilicus	...	...	...	49 " "

This ammonite has already been figured and described by Miss Healey, who "identified this specimen with d'Orbigny's figure with some hesitation caused chiefly by the cross-section of the whorls which is more depressed, and by the number of the ribs, d'Orbigny's figure showing only twenty-six of which six are simple. The suture-line also is slightly different." The specimen, which has been examined for the purpose of the present work, shows the essential characters of *Aposphinctoceras*, viz., the somewhat depressed whorls with gently-rounded venter, the comparatively deep umbilicus with almost perpendicular margins, the sharp and prominent primary ribs, the absence of forward curvature on the venter of the secondary ribs, the simple suture-line with its high saddles and dependent auxiliaries. The ribs are highest at about the second lateral lobe, while the point of bifurcation is on the first lateral lobe of the suture-line. *A. decipiens* is less depressed and more evolute than other species of the genus.

It has already been pointed out that the Upper Kimmeridge ammonites have no direct relation with the Lower Volgian forms; it is therefore unnecessary to discuss these supposed affinities with regard to the present species. This ammonite also is not nearly related to *Am. rotundus* Sow. as Miss Healey supposed: there are marked differences in form, in ribbing, in suture-line and in ontogenetic development.

HORIZON AND LOCALITY: Upper Kimmeridge Clay, Chippinghurst, near Chiselhampton (Coll. Univ. Mus., Oxford).

*Aposphinctoceras ailesburiense* sp. nov. (Plate II, fig. 3).

The holotype [B.M. No. C26904] has most of the shell preserved and is infilled with pyrite: it gives the following proportions:—

Diameter	...	...	...	101 mm.
Height of whorl	...	...	...	30 per cent. of diameter
Thickness of whorl	...	...	...	38 " "
Width of umbilicus	...	...	...	44 " "

The somewhat depressed whorls are ornamented with strong biplicate ribs which arise on the almost perpendicular margin of the comparatively deep umbilicus, from 30 to 34 primary ribs appearing on each complete whorl. The ribs are most prominent just above the umbilical shoulders where they present sharpened edges, and the point of branching is about half-way between the umbilical margin

and the periphery. The constrictions (2 or 3 per whorl) are narrow and radially-directed. The postjacent rib has two or three branches, while the simple rib in front is generally turned backwards so as to overhang the constriction.

The suture-line of the holotype is barely visible owing to irregularities in the pyritic infilling. Another specimen in the author's collection shows a septal suture which is in the main similar to that of *Sphinctoceras* though the second lateral saddle is wider and is not restricted by a great development of the auxiliaries. This simplification is characteristic of *Aposphinctoceras* and follows the usual tendency towards an "inverse" type in late forms of a lineage. The species just described is more inflated and more involute than the genotype, *A. decipiens*, less depressed and more evolute than *A. hartwellense*, while *A. variabile* described below has a higher whorl-section and is more evolute than the form under discussion. From ammonites of other lineages, the differences given in the generic description are adequate for its separation.

HORIZON AND LOCALITY: Hartwell Clay (pallasioides-zone), Webster and Cannon's brickyard, Aylesbury.

*Aposphinctoceras hartwellense* sp. nov. (Plate II, fig. 4).

Dimensions of holotype :

Diameter	...	...	...	63 mm.	50 mm.
Height of whorl	...	...	...	33 "	31 per cent. of diameter
Thickness of whorl	...	...	...	45 "	47 " "
Umbilicus	...	...	...	37 "	40? " "

In common with other representatives of *Aposphinctoceras* this species has a depressed whorl-section with a gently-rounded, almost flattened periphery. The ribbing of the outer whorl is entirely biplicate except in front of the only-visible constriction, where a simple rib occurs. The peripheral ribs pass straight across the periphery as a general rule, but during one growth period an alternating arrangement occurs. The primary ribs attain their greatest height just below the point of branching, about the middle of the lateral area and exhibit sharpened edges. The specimens from Hartwell are infilled with a friable sandy clay and consequently the suture-line could not be investigated.

This is the most depressed and most involute species of *Aposphinctoceras* yet described and these characters serve to distinguish it from other members of the lineage. "*Perisphinctes*" *Pavlovi* Mich. has about the same breadth of whorl-section (which, however, is not so high as in *A. hartwellense*) is less involute, and the ribs are spaced more widely than in the Hartwell form.

HORIZON AND LOCALITY: Hartwell Clay, Locke's pit, Hartwell. (Coll. Aylesbury Museum).



*Aposphinctoceras variabile* sp. nov. (Plate II, fig. 5).

Dimensions of holotype :

Diameter	...	...	64 mm.	49 mm.
Height of whorl	...	...	33 "	33 per cent. of diameter
Thickness of whorl	...	...	39 "	43 "
Umbilicus	...	...	45 "	43 "

The above proportions show that this evolute form has a somewhat depressed whorl-section. The venter is gently rounded and the umbilical wall almost perpendicular. There are 29 sharp and prominent primary ribs in the last whorl and these are all biplicate except two simple ribs which arise in front of constrictions. The secondary ribs are straight on the venter except in the most anterior portion of the specimen where local alternation of branching occurs. In this portion of the shell the otherwise regular bifurcation takes place considerably below the middle of the lateral area, and this variable character of the ribbing suggests a name for the species. The suture-line cannot be exposed owing to the friable nature of the infilling material.

This species is less thick and more evolute than *A. hartwellense*, more depressed and less evolute than *A. decipiens*, while it is less inflated than *A. ailesburiense*.

HORIZON AND LOCALITY: Hartwell Clay, Hartwell (Coll. Geol. Surv., No. 26746). Other specimens from this locality are in the same collection.

## ALLOVIRGATITES GEN. NOV.

Genotype: *A. woodwardi* sp. nov. (Plate III, fig. 1).

Among the ammonites from the lower zone of the Upper Kimmeridge Clay which have hitherto been confused with species of *Virgatites* are several forms for which the generic name *Allovirgatites* is proposed. They are ornamented with numerous radially-disposed ribs, which are mostly biplicate, but a few triplicate ribs occasionally appear. There is a tendency in some species for the ribbing to become coarser with age, the inner whorls always being finely ribbed. The whorl-section is subquadrate, though somewhat rounded, and the cast shows in the median line a shallow depression on the peripheral ribs which dies away in the adult. The umbilicus is wide and the ammonite becomes more evolute as growth proceeds. The suture-line is moderately ramified. The apices of the external and the first lateral lobes lie on the same radius. The second lateral lobe is obliquely disposed and is about half the length of the first lateral lobe. The auxiliary lobes are inflected backwards and extend to about the level of the apex of the second lateral lobe. The external saddle is comparatively broad and is divided by a subsidiary lobe, the ventral part of the saddle being greater than the part on the dorsal side. The first lateral saddle is slightly higher than the external saddle and is frequently made narrow by the encroachment of the auxiliary lobes, this latter character varying with the degree of inflation of the shell.

The genus *Allovirgatites* comprises a series of forms which are homoeomorphous with species of *Virgatosphinctoides*, but differences in ontogeny and in later development justify their generic separation. Thus the suture-line of *Allovirgatites*-derivatives from the rotundum-zone presents broadened saddles in which the small subsidiary lobes and the large rounded minor saddles contrast strongly with the large subsidiary lobes and the reduced forwardly-directed denticulations of the narrower saddles in the suture-line of the *rotundum*-series. Though the suture-line of immature specimens is similar in *Allovirgatites* and *Virgatosphinctoides* the former is distinguished in general by its comparatively long and narrow lobes.

Species of *Allovirgatites* are externally similar to forms of *Aulacosphinctes* Uhlig,<sup>1</sup> but may be distinguished by their general habit, their higher whorl-section, their suture-lines and the absence of an external ventral groove. The suture-line of the Indian *Aulacosphinctoids* is characterised by the length of the external lobe, and the saddles are proportionately narrower than in the English *Allovirgatites*. The genus under discussion shows neither the external groove of *Aulacosphinctes* nor the reduction of external ornament on the periphery as in the earlier genera *Idoceras* and *Ataxioceras*, but the shallow sinus in the curvature of the ribs on the periphery of the cast is due to a thickening of the shell along the median line. This may have served for the protection of the siphuncle, as Neumayr<sup>2</sup> supposed, in the case of the groove of the above-mentioned forms, though it should be pointed out that the ventral groove is not restricted to *Aulacosphinctes*, as Neumayr apparently thought. The South European ammonites which were included in *Aulacosphinctes* by Uhlig<sup>3</sup> are distinguished from the Indian forms by their high whorl-section, while species of *Allovirgatites* approach in general habit more nearly to the Indian forms. The English ammonites are therefore not connected directly with either the Mediterranean or the Indian development of *Aulacosphinctes*.

From the Russian *Virgatitids*, species of *Allovirgatites* are distinguished by the absence of the fasciculate grouping of the ribs in the early stages of their development and by the different type of suture-line. Thus, so far as present knowledge goes, the early affinities of the English forms cannot be traced.

*Allovirgatites tutcheri* sp. nov. (Plate III, fig. 2).

Dimensions of holotype :

Diameter	...	...	88 mm.	77 mm.
Height of whorl	...	...	30 "	33 per cent. of diameter
Thickness of whorl	...	...	29 ? "	30 "
Umbilicus	...	...	50 "	5< "

The adult is an evolute form with flattened sides and somewhat square periphery bearing a ventral groove on the cast which gradually becomes less conspicuous. The ribs are fine and crowded, showing a striking similarity with those of *Virgatosphinctoides*

1. 1910, p. 345.

2. 1871, p. 172; 1875, p. 926.

3. 1910, p. 347-

*wheatleyensis* and the various species which have been described under the name "*Perisphinctes contiguus*." The present species is readily distinguished from the former, with which it is associated, by the form of its numerous constrictions and by its suture-line. The constrictions are comparatively wide on the lateral area, narrowing towards the periphery, and are somewhat obliquely placed and sigmoidally curved. They present an appearance which is readily distinguishable from that of *Virgatosphinctoides* in which the constrictions do not interfere with the normal course of the ribbing.

The suture-line is distinguished by the great breadth of the saddles, by the length of the first lateral lobe and by the obliquity of the subsidiary lobe in the first lateral saddle, the latter being a constant though a minor feature throughout the series.

This species is distinguished from the other members of the lineage by its fine, crowded ribbing; the series as a whole is remarkably constant in proportions and in the characters of the suture-line.

HORIZON AND LOCALITY: Nodule bed (*wheatleyensis*-zone), Wheatley. The holotype is in the collection of Mr. J. W. Tutchter.

*Allovirgatites woodwardi* sp. nov. (Plate III, fig. 1).

Holotype: No. 32069, Coll. Geol. Surv.

Dimensions of holotype:

Diameter	...	...	...	128 mm.	104 mm.
Height of whorl	.	.	.	30 "	31 per cent. of diameter
Thickness of whorl	...	...	...	27 "	31 " "
Umbilicus	...	...	...	50 "	48 " "

This form shows well the evolute character of the genus and the typical form of the ribbing which is almost entirely biplicate, a few trifid and simple ribs being interspersed, the number of triplicate ribs increasing with age. The ribs are thickened in the median line, and this character is reflected on the cast by slight depressions on the ribs over the region of the siphuncle. The whorl-section is rounded but slightly flattened on the venter. Six deep and wide constrictions which are forwardly inclined are present in the last whorl. Suture-line moderately ramified and of the form characteristic of the *Allovirgatites*-series though the first and second lateral saddles are perhaps narrower than usual. About one-third of the outer whorl in the incomplete specimen consists of body-chamber. The innermost whorls are not seen in the holotype but a gradual broadening of the intercostal spaces occurs on the visible whorls. The species, in comparison with *A. tutchteri*, exhibits a tendency towards a coarse-ribbed type of ammonite, a development which is more strongly pronounced in *A. versicostatus*. The species is named after the late H. B. Woodward, who made many valuable observations on the Kimmeridge Clay and who collected the specimen chosen as holotype.

HORIZON AND LOCALITY: Nodule bed (*wheatleyensis*-zone), Headington (Oxon).

*Allovirgatites robustus* sp. nov. (Plate III, fig. 3).

## Dimensions of holotype :

Diameter	...	...	...	86 mm.	71 mm.
Height of whorl	...	...	...	32 "	35 per cent. of diameter
Thickness of whorl	...	...	...	36 "	35 "
Umbilicus	...	...	...	44 "	37 "

In the general characters of its ribbing, this species presents great similarity with *A. woodwardi*; there are 40 primary ribs in the last whorl, mostly biplicate but occasionally triplicate or simple in the neighbourhood of constrictions. The present form is thicker and more robust than *A. woodwardi* and becomes evolute more rapidly without, however, attaining the degree of evolution shown by this ammonite. The suture-line shows no essential difference from other species of the genus.

HORIZON AND LOCALITY : Nodule bed (wheatleyensis-zone), Wheatley. Author's collection [B.M. No. C26898].

*Allovirgatites versicostatus* sp. nov. (Plate III, fig. 4).

Holotype from Author's collection [B.M. No. C26899].

## Dimensions of holotype :

Diameter	...	...	...	86 mm.	65 mm.
Height of whorl	...	...	...	29 "	32 per cent. of diameter
Thickness of whorl	...	...	...	31 "	" "
Umbilicus	...	...	...	48 "	45 "

The development of this species proceeds rapidly from finely-ribbed inner whorls to a type of ribbing which attains a degree of coarseness not seen in the previously described forms of the series. The last whorl in the holotype, which is septate throughout, bears 43 primary ribs, of which three are trifid and two (in front of constrictions) are simple, the remainder being biplicate. Constrictions, about three in each whorl, are wide and deep, and make a conspicuous break in the contour of the shell.

The suture-line presents no especial feature of difference from those of other members of the series, but the lobes and saddles are somewhat shorter than usual owing to close approximation of the septa. Thus in *A. versicostatus* the development from fine to coarse ribbing is more rapid and the shell is more evolute, with lower and thinner whorl-section, than in the preceding species. The species foreshadows the later offshoots from the *Allovirgatites* stock and is the most advanced member of the lineage known at present.

HORIZON AND LOCALITY : Nodule bed (wheatleyensis-zone), Wheatley.

## PARAVIRGATITES BUCKM. 1922.

*Paravirgatites kimmeridgensis* sp. nov. (Plate IV, fig. 4).

The holotype (Geol. Survey coll., No. 27959) is a pyritic cast from the Bituminous Shales of Kimmeridge Bay and has the following proportions :

Diameter	51 mm.
Height of whorl	37 per cent. of diameter
Thickness of whorl	38     "     "
Umbilicus	40     "     "

The specimen shows a rib-curve which is similar to that of the genotype, but the ribs are more crowded, about 25 primary ribs appearing in the last half-whorl. Unfortunately the suture-line is not known, but the rib-curve and the geological age of the specimen leave little doubt as to its affinities. *P. kimmeridgensis* is considerably thicker, and has a higher whorl-section than *V. wheatleyensis* at the same diameter; otherwise the two species are very similar.

This and other ammonites from the Kimmeridge Bituminous Shales have formerly been labelled and recorded by Hudleston<sup>1</sup> under the name *Am. pectinatus* Phil.<sup>2</sup> Phillips' figure shows at a diameter of 27 mm. a whorl-height of 44 per cent. and the umbilicus equal to 25 per cent. of the diameter, thus giving a higher and more involute form than the present species. The crowded ribs of *Per. pectinatus* also prevent confusion with this form.

"*Perisphinctes*" *ardesicus* (Font.) is more finely-ribbed, and is less inflated than the newly-described form: the difference in geological age also precludes near affinity. This species is mentioned here only because the type-specimen is thus provisionally identified.

## HOLCOSPINCTES NEAVERSON, 1924.

Genotype : *Holcosphinctes pallasoides* sp. nov. (Plate III, fig. 5).  
= specimen No. 30721, Coll. Geol. Surv.

The ammonites for which this name is proposed are evolute forms with shallow umbilicus: the umbilical margin is gently sloping and rounded in the outer whorls, but is comparatively steep in the older part of the shell. The ribbing of the outer whorls is biplicate (with the exception that ribs immediately behind constrictions are usually trifid) and has a distinct forward curve on the periphery. In the middle whorls trifid ribs are more often seen interspersed with the dominantly biplicate ornament and the ribs are inclined forwards to a greater degree than in the later stages. The inner whorls are ornamented with numerous delicate ribs which are crowded together and are markedly inclined forwards. Constrictions are not numerous and are not conspicuously deep or wide. Each is accompanied by a simple rib in front, and the rib immediately behind the

1. 1896, p. 322.

2. 1871, Pl. XV, fig. 17.

constriction is usually trifold. Sometimes, however, the primary rib posterior to the constriction on one side of the shell is biplicate and that on the other side is triplicate; this produces a zigzag arrangement of the secondary ribs over the periphery: which may continue for the whole distance between two constrictions or may be terminated by the appearance of an undivided rib which unites with the available branch on the periphery. This arrangement is, however, so variable that it cannot be used even as a specific character. The suture-line is fairly simple. The saddles are broad and rounded with small subsidiary lobes: the principal lobes also are comparatively small. In older portions of the shell the saddles are proportionately higher and the lobes proportionately larger. The auxiliary lobes are slightly deflected.

This genus is probably an offshoot from the same stock as *Allovirgatites*, but it develops a somewhat flattened form owing to the shallowing of the umbilicus, and is also characterised by coarse biplicate ribbing and a simplified suture-line. The latter is of the type exemplified by species of *Allovirgatites*, and the finely-ribbed inner whorls also give evidence of close relation to this genus. *Holcosphinctes* also bears traces on the cast of a peripheral depression on the ribs, but as this character appears in other lines of descent it cannot be taken by itself as an indication of ancestry.

The ammonites comprised in the new genus have been referred by various authors to the genera (*sensu lato*) *Perisphinctes* and *Holcostephanus*, both of which are polyphyletic groups and have already been sub-divided to some extent. The forms of the present series show a striking degree of homocomorphy with representatives of *Aposphinctoceras* and *Pallasiceras* which occur in association with them. The former genus has acquired much the same type of ribbing and is associated with *Holcosphinctes*, but its species are distinguished by their suture-lines, their coarsely-ribbed inner whorls and their general habit (species of *Aposphinctoceras* having a much deeper umbilicus and a more inflated whorl-section than *Holcosphinctes*). *Pallasiceras* is also represented in the Hartwell Clay by strongly biplicate evolute forms with shallow umbilicus and fine-ribbed inner whorls; these, also, may be distinguished from *Holcosphinctes* by their suture-lines. Moreover, the shell of the late developmental forms of the *rotundum*-series is usually very thick, a character which had already appeared in the *rotundum*-zone.

Species of *Holcosphinctes* are also similar in external appearance to ammonites from the Lower Volgian Series of Russia described by Michalski. The similarity, however, is confined to the evolute character of the shell and the ornament of the outer whorls which is strongly biplicate with occasional simple and trifold ribs interspersed. The fasciculate grouping of the secondary ribs in early stages of the Russian forms is entirely absent from species of *Holcosphinctes* and the suture-lines show important differences though there is evidence of simplification in both cases.

*Holcosphinctes pallasoides* Neaverson (Plate III, fig. 5).

Holotype : *Ammonites biplex* Sow. H. B. Woodward : The Middle Oolite of England. Mem. Geol. Surv., 1895, p. 156, fig. 72.

= specimen 30721, Coll. Geol. Surv.

*Holcosphinctes pallasoides* Neaverson, Geol. Mag., Vol. lxi, p. 149. 1924.

Dimensions of holotype :

Diameter	.71 mm.
Height of whorl	31 per cent. of diameter
Thickness of whorl	32     "     "
Umbilicus	46.5     "     "

This ammonite is an evolute form with a shallow umbilicus. The adult whorls are ornamented by strong biplicate ribs (about 30 primary ribs appearing on the last whorl) which are practically radial in direction but show a distinct forward curve on the periphery. On the inner whorls, of which only the external impression is preserved, the ribs are much finer and somewhat crowded together. The whorl-section is approximately circular, the periphery being rounded, and, on the cast, traces of a ventral depression are seen on the ribbing. Constrictions are few in number and do not interrupt the normal course of the ribbing, being neither conspicuously wide nor deep. Each constriction has a simple rib in front and in some cases the ribbing is normally biplicate between two constrictions. Sometimes, however, the ribbing is irregular, one of the peripheral ribs joining the primary anterior to it in position, thus producing an alternating arrangement of the ribs over the periphery : the rib-bundle posterior to the next constriction is then biplicate on one side and triplicate on the other side of the ammonite.

The suture-line is simple and is marked by broad low saddles and short lobes. The median lobules of the saddles are small and inconspicuous. The auxiliary lobes are feebly developed and are projected forwards, forming an "inverse" suture-line.

HORIZON AND LOCALITY : Hartwell Clay (*pallasoides*-zone), Hartwell (Bucks).

*Holcosphinctes flexicostatus* sp. nov. (Plate III, fig. 6).

Dimensions of holotype :

Diameter	74 mm.	58 mm.
Height of whorl	29     "	30 per cent. of diameter
Thickness of whorl	29     "	32     "     "
Umbilicus	47     "	44     "     "

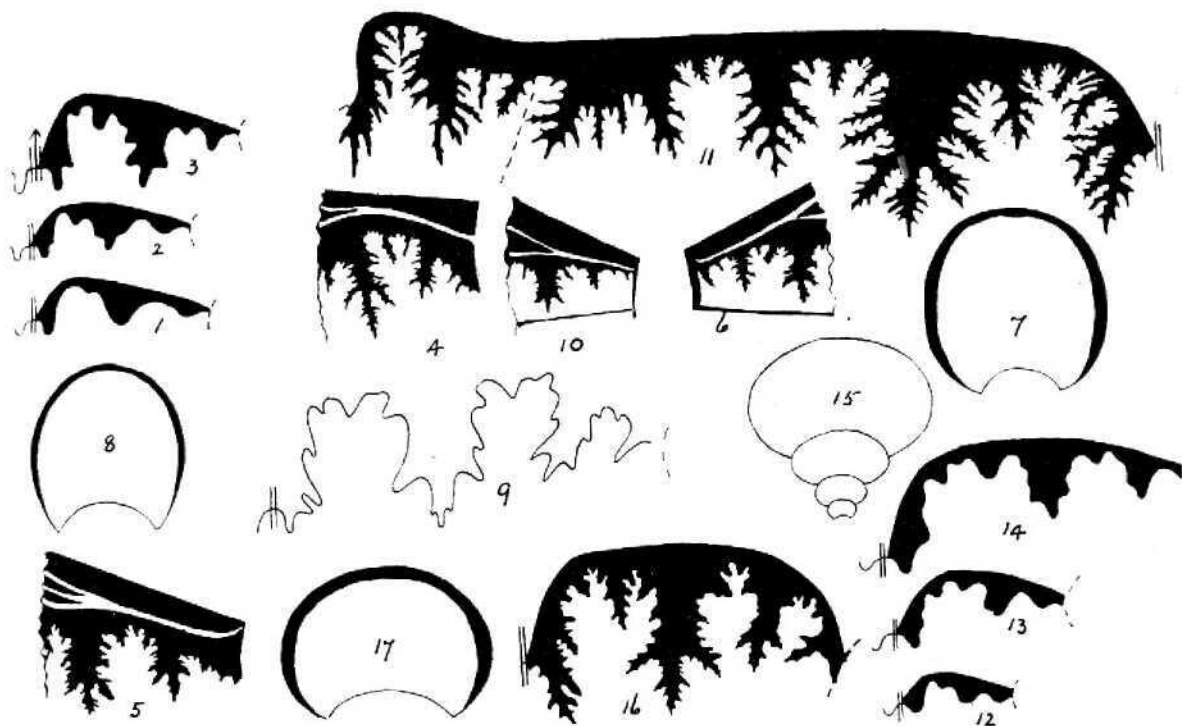
This species closely resembles *H. pallasoides* in its proportions, being an evolute form with approximately circular whorl-section and a shallow umbilicus. The ribbing, which is very irregular, is mainly biplicate as in the species just described, but the ribs show a marked curve backwards, giving the ammonite a distinctive appearance and contrasting strongly with the radial direction of the ornament in *H. pallasoides*. Also the ribs appear only in slight relief on the umbilical margin which is almost smooth. As these features of ornament are seen on several specimens it would seem that specific separation is desirable. There are three constrictions on the outer whorl of the holotype, each with a simple rib in front

and a biplicate rib behind. The constrictions do not change the normal course of the ribbing.

The suture-line is simple, the broad saddles are slightly notched by the small median lobule and the umbilical portion of the suture is slightly deflected backwards. The external lobe and the first lateral lobe are of about the same length, while the second lateral lobe is about half the length of the former. The two lateral lobes are, as is usual in species of *Holcosphinctes*, asymmetrically trifid.

Thus *H. sexicostatus* is closely allied to *H. pallasoides*, but in addition to the above-mentioned differences in ribbing, it shows a less "advanced" feature in the suture-line. Judging by fragments which have been collected from the Hartwell Clay, other members of the lineage exist, but they have yet to be obtained in a satisfactory state of preservation.

HORIZON AND LOCALITY: Hartwell Clay (*pallasoides*-zone), Hartwell (Coll. Aylesbury Museum).



TEXT-FIGURE B.

- (1), (2), (3) *Allovirgatites woodwardi* nov., suture-lines at diam. 2 mm., 3.5 mm. and 5 mm. respectively ;  
 (4) suture-line and rib-curve of figured specimen (Pl. III, fig. 1) painted on photograph.  
 (5) *Virgatosphinctoides wheatleyensis* nov., suture-line and rib-curve at 90 mm. diam.  
 (6) *Allovirgatites versicostatus* nov., suture-line and rib-curve of holotype painted on photograph ;  
 (7) whorl-section of holotype at diam. 86 mm.  
 (8) *Holcosphinctes sexicostatus* nov., whorl-section, and (9) outline of suture-line of holotype.  
 (10) *Holcosphinctes pallasoides* Neaverson, suture-line and rib-curve painted on photograph.  
 (11) *Holcosphinctes* (?) sp. indet., suture-line on fragment whose whorl height is 62 mm., and whorl thickness 70 mm. ; rotundum-zone, Chapman's Pool,  
 (12), (13), (14) *Sphinctoceras distans* nov., suture-lines at diam. 2 mm., 5 mm., and 8 mm. respectively ;  
 (15) section at diam. 9 mm.  
 (16) *Epispinctoceras inflatum* nov., suture-line of holotype at diam. 90 mm.  
 (17) *Aposphinctoceras hartwellensis* nov., whorl-section of holotype at diam. 63 mm.

[Figs. 1-3, 9, 12-15 enlarged, remainder natural size.]



## IV.—FAUNAL SEQUENCE

As already remarked, a summary of the stratigraphical relations shown by the deposits included in the Upper Kimmeridge has been published elsewhere.<sup>1</sup> It is therefore only necessary here to list the above-described ammonites under their respective zones, which are tabulated below in ascending order.

1. Wheatleyensis-zone.

**Virgatosphinctoides** : *wheatleyensis*, *delicatulus*.

**Allovirgatites** : *tutcheri*, *woodwardi*, *robustus*, *versicostatus*.

**Sphinctoceras** : *crassum*, *distanis*.

2. Nodiferus-zone.

*Virgatosphinctoides* : **grandis**, **nodiferus**.

3. Pectinatus-zone.

*Pectinatites* : *pectinatus*,\* *aulacophorus*,\* **pyriticus**.

*Paravirgatites* : *paravirgatus*,\* **kimmeridgensis**.

*Wheatleyites* : *eastlecottensis* \* *tricostulatus* \* *opulentus*,\* *reductus*.\*

4. Rotundum-zone.

*Pallasiceras* : *rotundum*, **concinnum**, **gracile**, **pringlei**, **ultimum**.

*Holcosphinctes* : sp. indet. (fragment of large ammonite—Text-fig. B, II).

**Episphinctoceras** : **inflatum**.

5. Pallasioides-zone.

*Holcosphinctes* : *pallasioides*, **flexicostatus**.

*Aposphinctoceras* : *decipiens*, **ailesburiense**, **hartwellense**, **variabile**.

\* Names marked by an asterisk are those of species recorded by Mr. Buckman from the pectinatus-zone of Shotover Hill and Swindon. New names are in **Clarendon** type.

## V.—GENERAL CONCLUSIONS

### (a) GENERAL VIEWS ON THE SUCCESSION OF AMMONITE-LINEAGES IN THE UPPER KIMMERIDGE.

BEGINNING with the lowest horizon of the Upper Kimmeridge Clay, the genus *Virgatosphinctoides* is characterised in its early members, e.g., *V. wheatleyensis*, by increase of virgatotome ribbing especially on the body-chamber, while the later representatives of the lineage, *V. grandis* and *V. nodiferus*, show remarkable accentuation of the primary ribs. Some species, such as *V. delicatulus*, probably gave rise to early forms of *Pectinatites* Buckm. The exact diagnosis of this genus has not yet been published, but figures show that it develops a characteristic type of fine-ribbing, its venter becomes flattened and in some cases hollowed, also its suture-line is always comparatively simple. The mouth-border shows a well-developed rostration on the venter, and side-lappets are absent or only feebly-indicated; the ribbing for a short distance behind the mouth-border also shows a strong forwardly-directed curve on the venter.

At a later period the *Pallasiceras* lineage appears to have diverged from the main stock; the finely-ribbed ornament of the inner whorls and the characters of the suture-line, however, show the relationship. This series develops large robust forms with coarse biplicate ribs, thus producing ammonites which are homœomorphous with representatives of other associated genera. It should be emphasised again that *Pallasiceras* is quite distinct from *Ammonites pallasianus* d'Orb. and its allies, the name indicating only a general external similarity in the outer whorls of the two groups. *Pallasiceras* appears to extend through the rotundum-zone into the overlying pallasoides-zone (Hartwell Clay), but it is difficult to define exactly the limits of the two zones in a uniform series of clays. A smooth development of the *Pallasiceras*-stock occurs in the rotundum-zone.

The genus *Allovirgatites* from the wheatleyensis-zone is the earliest known representative of another stock, and shows considerable similarity in external form with species of *Virgatosphinctoides*. The two genera are distinguished, however, by differences in development of the shell and in form of the suture-line. In the wheatleyensis-zone, *Allovirgatites* shows a development from delicate crowded ribs to coarse biplicate ornament, a character which is rapidly attained in some species. In the succeeding "pectinatus-zone" (the term being used in its wide sense) *Paravirgatites* Buckm. appears to be a derivative of the main *Allovirgatites*-stock. *Paravirgatites* is only known at present from figures of some of its species, the exact diagnosis not having been published. A third divergence from the main stock is seen in *Holcosphinctes* gen. nov., in which the fine ribbing is confined to the early whorls, the ornament passing rapidly to a coarse biplicate type. Also the whorl section becomes more nearly circular with a consequent shallowing of the umbilicus. This genus appears in the rotundum-zone, where individuals attained a large size, as shown by fragments from the Isle of Purbeck, and ranges

upwards into the pallasioides-zone. It is possible that a later divergence from this stock gave rise to some of the imperfectly-known ammonites in the lower horizons of the Portland, identified at present as *Perisphinctes gorei* Salf.

The *Sphinctoceras*-series is represented in the Virgatosphinctoides-horizon by massive biplicate forms with elaborate suture-line. The most obvious tendency in the development of the lineage is that of increasing coarseness of the ribbing, the primary ribs being, in the end-forms, separated by wide intercostal valleys. In the succeeding pectinatus-zone derivatives of the main *Sphinctoceras*-stock show the characteristic general habit and the same type of suture-line. The paratype of "*Wheatleyites*" *opulentus* Buckm.<sup>1</sup> from the pectinatus-zone of Swindon shows a close affinity with *Sphinctoceras crassum* described above. Examination of this specimen discloses an entirely coarse-ribbed development with the general habit of *Sphinctoceras* and with a suture-line which conforms in type with that of the latter genus except that the auxiliary lobes are less deflected posteriorly. The latter character is probably due to the adjustment of the suture-line to increased inflation of the shell. It should be pointed out that suture-lines in the several ammonite-lineages here considered are often closely similar in immature stages of the shells and it is only by examination of a series of specimens varying in age that the constant differences are appreciated. The further development of *Wheatleyites* consists in the acquisition of fine ribs, after which the secondaries gradually diminish in strength while the primaries persist, as in the *eastlecottensis* type.

A divergence from the main *Sphinctoceras*-stock in the rotundum-zone is characterised by extreme and rapid inflation of the shell. Though only one species has been discovered it is considered advisable to institute the genus *Episphinctoceras* for its reception, since the Sphinctoceratids of the pallasioides-zone do not show the same developmental trend. *Aposphinctoceras* from the Hartwell Clay is coarsely-ribbed from the early whorls, as in *Sphinctoceras*, but the suture-line is much more simple, the shell is more discoidal though still somewhat depressed in whorl-section and the ribbing again is distinctive, the primaries being widely separated (especially in end forms of the lineage) and the secondaries pass over the periphery without the forward-curve seen in the associated genera. Here again in some of the more discoidal forms is a similarity with some of the "*gorei*" forms of the Upper Portland.

#### (ft) COMPARISON WITH EXTRA-BRITISH AMMONITES.

Boulogne-sur-mer is the nearest locality on the continent of Europe where strata of Upper Kimmeridge age are exposed, and these are included in the "Portlandien" of French geologists. The Boulogne section has been described by Lorient,<sup>2</sup> Rigaux,<sup>3</sup> Salfeld,<sup>4</sup> Pruvost,<sup>5</sup> and others. Correlation with English deposits

1. 1923, T.A., IV, No. 383b.

3. 1892, pp. 1-108.

5. 1921, p. 76; 1925, p. 190.

2. 1866, pp. T-200.

4. 1914, p. 222.

is difficult owing to the different systems of zonal nomenclature employed by various writers, and the numerous ammonites figured from the Boulogne section need careful revision. For the present, comparison must be restricted to specimens collected during a short visit to the coast section between Wimereux and Boulogne under the guidance of Dr. P. Pruvost, of Lille University. Salfeld's list of ammonites is of little value for the present purpose, as this author followed Pavlow, Sauvage and others, in applying names of the Russian Lower Volgian ammonites to the Boulogne forms, and Sauvage figures neither suture-lines nor whorl-sections.

The latest reading of the Kimmeridge-Portland section of Boulogne is by Dr. P. Pruvost<sup>1</sup> and this will serve for comparison with the English deposits. Resting on the Grès de la Creche (Gravesia-zones) are the "Argiles à *Anomia laevigata*," from which Dr. Pruvost records "*Virgatites* aff. *virgatus*."<sup>2</sup> At the top of the clays is a phosphate bed containing rolled casts of lamellibranchs, etc. From this bed the writer obtained fragments of ammonites (with portions of the text still adhering) belonging to the genus *Pectinatites* and closely similar to pyritised specimens from the Bituminous Shales of Kimmeridge. The preservation of the phosphatic casts is similar to that of specimens from the Swindon phosphate-bed, and suggests a similar derivation, viz., that the fossils were scoured out of the underlying clay by the action of currents. Thus these ammonites represent the fauna of the denuded upper portion of the deposit upon which they rest. It is probable then that the "Argiles à *Anomia laevigata*" represent the *Virgatosphinctoides*-horizon with probably the lower part of the *pectinatus*-zone, since the ammonites of the phosphate bed were probably derived from these clays and the "*Virgatites*" recorded by Dr. Pruvost are now regarded by him as species of *Wheatleyites* and *Pectinatites*.<sup>3</sup>

The "Couches à *Exogyra dubiensis*" lie next in upward sequence and consist of clays with intercalated calcareous and phosphatic beds. The famous phosphate bed of Tour de Croi is at the top of this series and yielded numerous fragments of ammonites of the *rotundum*-type.<sup>4</sup> Many of these still possess the original iridescent shell and septate fragments are tolerably abundant, so that identification of many specimens is sufficiently precise to fix the horizon. The preservation indicates a derivation from a near source, probably from upper horizons of the "Couches à *Exogyra dubiensis*," which on this view represent the *rotundum*-horizon of England. An impersistent limestone band above the Tour de Croi phosphate bed contains large *rotundum*-like ammonites which recall the forms obtained from the Lower Hartwell Clay of Long Crendon and Hartwell.

The over-lying "Couches à *Ostrea expansa* et *Perna Bouchardi*" form the equivalent of the English Hartwell Clay, i.e. the *pallasioides*-horizon, which they resemble in texture and in the abundance of glauconite as well as in faunal

1. 1925, p. 190.

2. 1921, p. 75-

3. 1924, p. 399, and 1925, p. 399.

4. Judging from the figures of *Perisphinctes devilli* Lor. (1874, Pl. 1, fig. 13), and *P. boidini* Lor. (1874, PL VII, fig. 1), these species belong to *Pallasiceras*.

contents. It must be stated, however, that ammonites are rare in the clays of this horizon at Boulogne, and the correlation is based chiefly upon the lamellibranch fauna.

As far as can be seen from descriptions and figures, and from the writer's small collection of Upper Jurassic ammonites from Boulogne, these forms are closely allied to the English forms of equivalent horizons and have no relation to the Russian ammonites Math which they have previously been identified. This supposed boreal origin was supported by the record of *Aucella* from the phosphate bed of Tour de Croi, but Dr. Pruvost<sup>1</sup> and M. Dutertre of the University of Lille have recently shown that the shells so identified are merely rolled casts of *Protocardia morinica* de Lor., a typical lamellibranch of the Upper Kimmeridge Clay in England and the Boulonnais. Other elements of the fauna, lamellibranch gastropods, and the rare "*Waldheimia*" *boloniensis* are recorded also from the English equivalent of these deposits.

The Lower Volgian fauna of Russia has long been considered as equivalent to the fauna of the Hartwell Clay on account of the close similarity of the adult ammonites. The typically Russian "virgate" ammonites, however, seem to be totally absent from English strata, even the recently-recorded<sup>2</sup> "*Virgatites*" from Dorset recalling the development of *Virgatosphinctoides* rather than that of *Virgatites*.

Moreover, the exact horizon of the Lower Volgian is still uncertain, though this deposit is usually correlated with the Lower Tithonian of Southern Europe. Mr. Buckman considers it to be much later than Upper Kimmeridge—"perhaps later than Gigantan"<sup>3</sup> [Upper Portland]. Judging, however, by various figures of South European ammonites from the tenuilobatus-zone,<sup>4</sup> and by the opinion of R. Douville,<sup>5</sup> who regards *Virgatites* as derived from the Mediterranean genus *Ataxioceras*, the age of the Lower Volgian might well be earlier than the Hartwell Clay. The Gravesia-zones of North-west Germany are overlain by the Eimbeckhauser Plattenkalk, which is succeeded by the Munder Mergel. This series of fresh-water deposits indicates that the Anglo-French and Russian marine areas were not directly connected during Upper Kimmeridge times.

A petrographical investigation of the Upper Kimmeridge Clay has been made and, speaking generally, this deposit is characterised by the abundance of kyanite, staurolite, colourless garnet, rutile, tourmaline and zircon.<sup>6</sup> The abundance of kyanite and staurolite, in angular grains, and the rarer occurrence of glaucophane and chloritoid suggests that Brittany and its northward extension was the possible source of some of the terrigenous material, while the rarer occurrence of blue tourmaline and andalusite apparently indicates that Devon and Cornwall may have formed part of the drainage area, though these minerals also occur in Brittany. Thus it would appear that marine currents flowed towards the

1. 1921, p. 79.

2. Kitchin, 1919, p. 45.

3. 1922, T.A., TV, p. 17.

4. e.g., Loriol, 1877, PL X.

5. 1910, p. 730.

6. Neaverson, 1925, pp. 253-5.

north and it is suggested that the migration of these benthonic ammonites might be largely determined by the drifting of their planktonic young.

The distribution of the lamellibranch *Amelia* is of interest, since this shell is said to characterise a boreal type of fauna. *Amelia* occurs in most or the Upper Jurassic deposits known in the extreme north, including the Lower Volga, the mouth of the Petchora, Spitzbergen, Alaska, and Andøen in Northern Norway. It has also been recorded from South-eastern Europe<sup>1</sup> (e.g. Lower Austria), Poland, the Carpathians, the Himalaya region, California, Mexico, Brazil, and New Zealand. Holdhaus<sup>2</sup> concludes that "in the face of such a widespread distribution it does not seem admissible to regard *Aucella* as an essentially northern element, nor is it possible to discuss the original forms of diffusion of the genus." On the other hand, *Aucella* is significantly absent from the English Upper Kimmeridge, and its recorded occurrence at Boulogne was based on a mistaken identification.<sup>3</sup> Skeat and Madsen<sup>4</sup> failed to record this fossil in their work on Jurassic boulders in Denmark, and the ammonite-fragments identified by them as *Virgatites* appear rather to be related to *Pectinatites* of the English Upper Kimmeridge.

Taking the balance of the evidence, it would appear that the English and the Russian faunas, even if contemporaneous, developed in two separate provinces. The *Virgatites* fauna, according to R. Douvillé,<sup>5</sup> was derived from *Ataxioceras* migrating from the Mediterranean by way of the Caucasus area, and, it might be added, possibly also through the Austrian region. The Upper Kimmeridge fauna of the Anglo-French area may also have had its origin in the Mediterranean Province but its affinities are still obscure. For a solution of this problem a complete revision of the South European ammonites appears to be necessary. It may be noted here, however, that Haug<sup>6</sup> considers the *Gravesia*-fauna (in the upper zones of the Lower Kimmeridge Clay) to have originated from an unknown area in the Eastern Atlantic since *Gravesia* is characteristic of the Anglo-French basin and Western Germany and is only doubtfully recorded from Russia. The fauna of the succeeding zones, described "in this work, have much the same distribution during the same phase of sedimentation, and it would seem that Haug's idea of a "Western European Province" for the *Gravesia*-fauna might be extended to the succeeding faunas of the Upper Kimmeridge Clay, quite apart from the question of origin.

1. With *Virgatites*.

2. 1913, P. 405.

3. Pruvost, 1921, p. 79.

4. 1898, p. 154.

5. 1910, p. 736.

6. 1911, p. 1,080.

## (c) SUMMARY.

1. The ammonite-faunas of the Upper Kimmeridge Clay are now described for the first time. In the lowest horizon considered, representatives of three series of ammonites occur and are described under the new generic names, *Virgatosphinctoides*, *Allovirgatites*, and *Sphinctoceras*. Each of these genera gives rise to variants which at present appear to be practically isochronous and are considered as warranting specific rank. The succeeding horizons are each characterised by parallel lineages related to those of the horizons below, and thus the conception of three main stocks each giving rise to successive lineages is suggested.

2. The inclusion of Salfeld's "Zone of *Perisphinctes eastlecottensis* and *pectinatus*" in the Upper Kimmeridge Clay is in accord with the recent work of Messrs. Chatwin and Pringle at Swindon and the earlier correlation of the Kimmeridge Oil Shales with the so-called Lower Portland Sands of Swindon by W. H. Hudleston. It is probable that a complete solution will not be reached until the classic section in the Isle of Purbeck has been exhaustively examined—a long and arduous task. It may be stated, however, that the "Lower Portland Sands" of Shotover Hill (which were not dealt with by the above authors) must be correlated with the "Lower Portland Sands" of Swindon and therefore also with the Bituminous Shales of Kimmeridge.

3. The possible relation of the ammonites here described with those from extra-British deposits has been considered. The identification, by Pavlow and later authors, of the British forms with *Ammonites pallasianus* d'Orb. is here rejected since the development of the ammonites presents fundamental differences, and palaeogeographical considerations make it probable that the British and Russian forms developed in two separate zoogeographical provinces. The origin of the British Upper Kimmeridge ammonites is probably to be found in the Western Mediterranean area whence they migrated by way of the Rhone Basin and Boulogne. At present, however, they cannot be connected with described forms. A revision of the South European ammonites appears to be necessary and would perhaps result in the discovery of forms allied to elements of the British Upper Kimmeridge faunas.

4. Consequent upon the description of the Upper Kimmeridge ammonite-faunas, a revision of the zonal nomenclature is necessary. Zonal indices have been chosen for the main horizons except the *pectinatus*-zone (which is being investigated by Mr. S. S. Buckman) and the highest portion of the Kimmeridge "Clay" formerly known as the "Portland Sands." There seems to be no doubt that the use of the latter term must be discontinued as far as the sandy beds below the Portland Stone Series of Dorset are concerned, since their faunal affinities are Kimmeridgian rather than Portlandian and the sandy faciès of Dorset and Bucks is represented by clays in the Kent borings. The ammonites from this horizon are, however, practically unknown and much careful collecting is needed to provide a satisfactory basis for description.

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# EXPLANATION OF PLATES

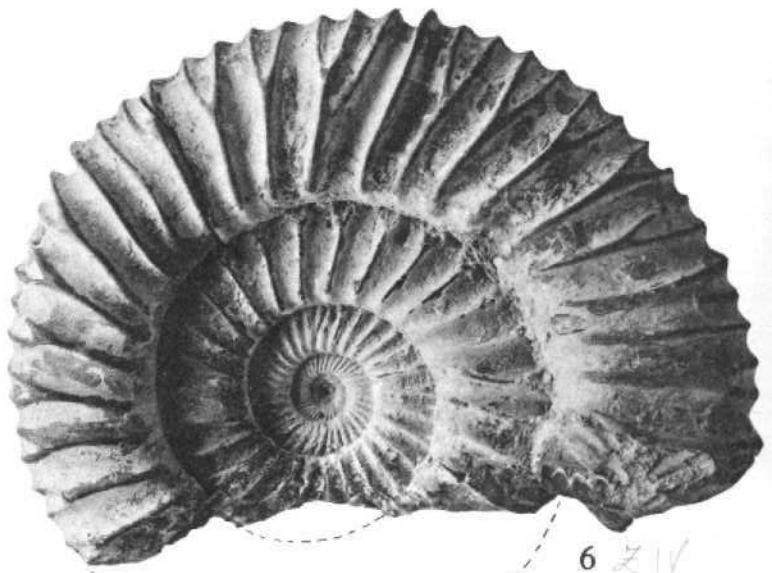
## PLATE I

- FIG. 1. *Virgatospinctoides wheatleyensis* sp. nov., p. 12.  
Genotype, Holotype (Coll. E. Neaverson). [B.M. No. C26897.]  
Nodule bed (wheatleyensis-zone) Wheatley (Oxon).
- FIGS. 2, 3. *Virgatospinctoides delicatulus* sp. nov., p. 15.  
(3) Holotype, (4) Paratype (Coll. E. Neaverson). [B.M. Nos. C26905-6.]  
Nodule bed (wheatleyensis-zone), Wheatley (Oxon).
- FIG. 4. *Pectinatites pyriticus* sp. nov., p. 17.  
Holotype (Coll. Geol. Surv., No. 32073).  
Bituminous Shales (pectinatus-zone), Kimmeridge.
- FIG. 5. *Pectinatites aulacophorus* Buckm., p. 15.  
(Coll. Geol. Surv., No. 32072.)  
Bituminous Shales (pectinatus-zone), Kimmeridge.
- FIG. 6. *Pallasiceras rotundum* (Sow.), p. 18.  
(Coll. E. Neaverson.) [B.M. No. C26903.]  
Kimmeridge Clay (rotundum-zone), Chapman's Pool, I. of Purbeck.
- FIG. 7. *Pallasiceras concinnum* sp. nov., p. 19.  
Holotype (Coll. Geol. Surv., No. 32418).  
Kimmeridge Clay (rotundum-zone), Chapman's Pool.
- FIG. 8. *Pallasiceras gracile* sp. nov., p. 20,  
Holotype (Coll. Geol. Surv., No. 32420).
- FIG. 9. Paratype (Coll. Geol. Surv., No. 32419).  
Kimmeridge Clay (rotundum-zone), Chapman's Pool.
- FIG. 10. *Pallasiceras pringlei* sp. nov., p. 20.  
Holotype (Coll. Geol. Surv., No. 32417).  
Kimmeridge Clay (rotundum-zone), Chapman's Pool.
- FIG. 11. *Pallasiceras ultimum* sp. nov., p. 20.  
Holotype (Lee Coll., Aylesbury Museum), x 0.7.  
Hartwell Clay (rotundum-zone), Hartwell (Bucks).

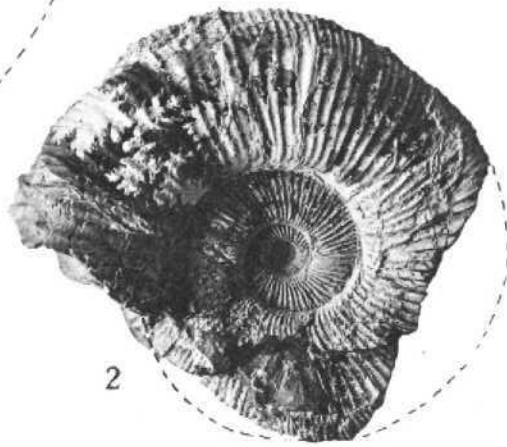
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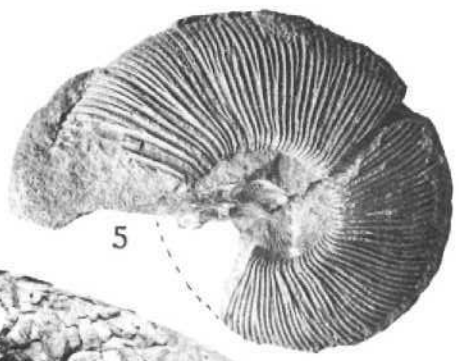
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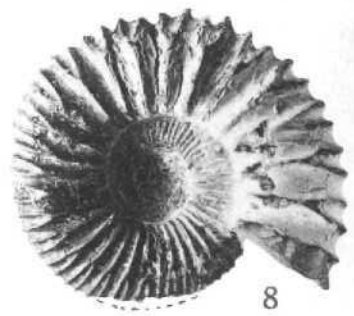
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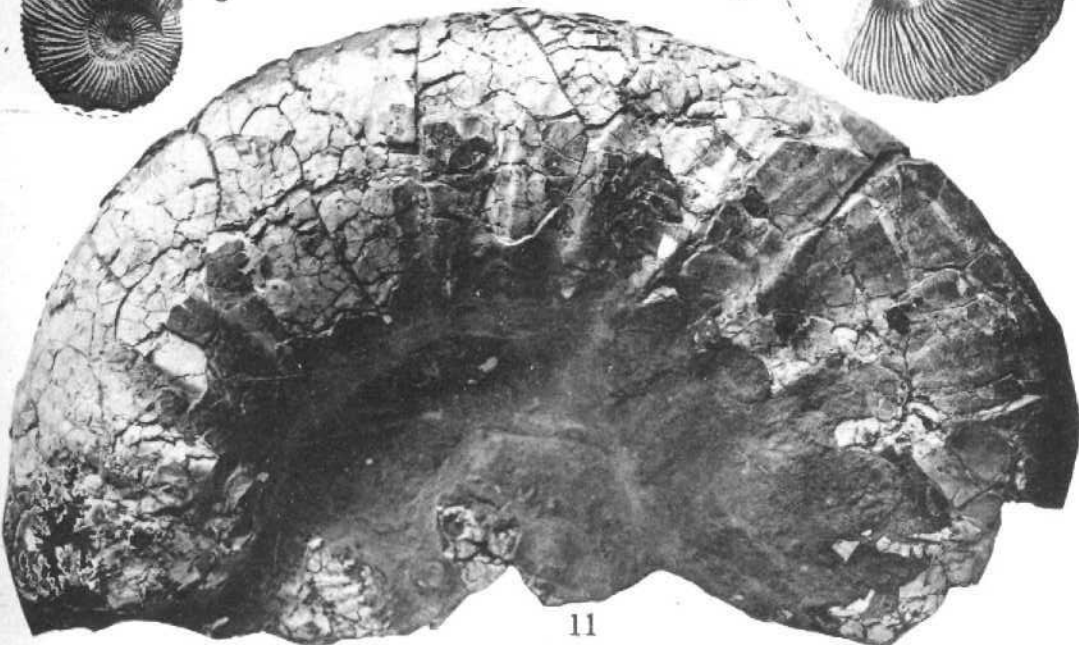
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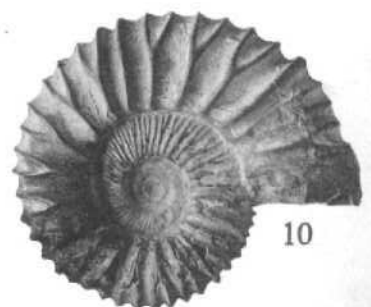
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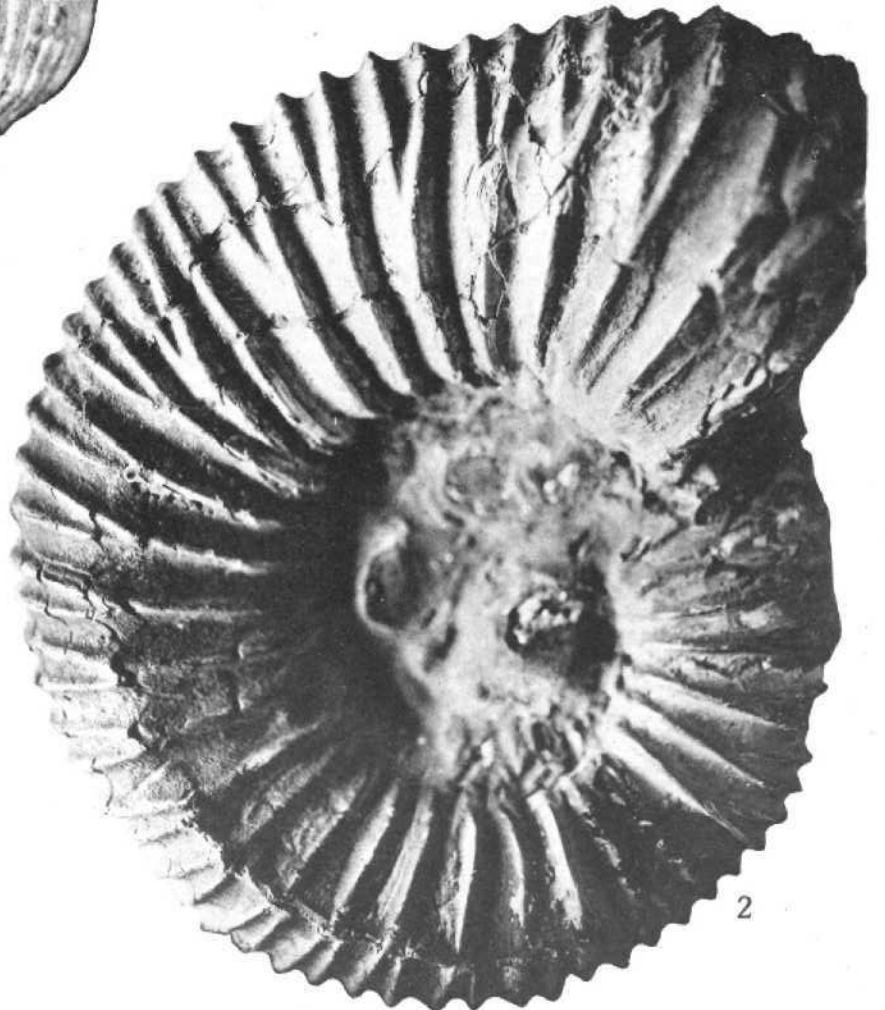
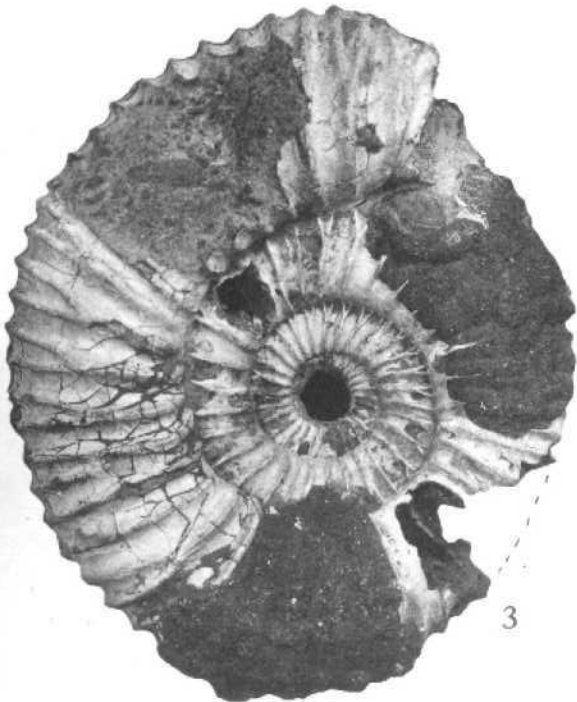
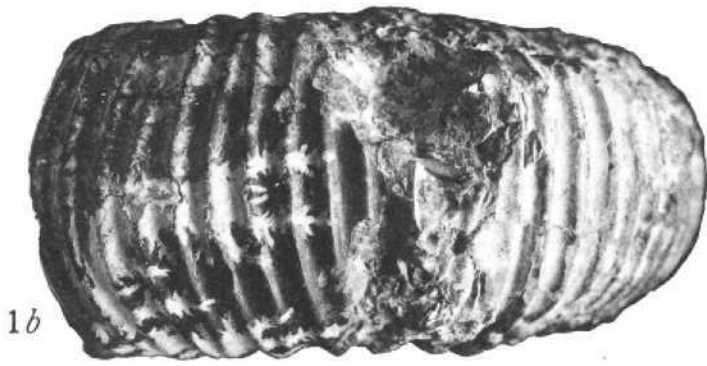
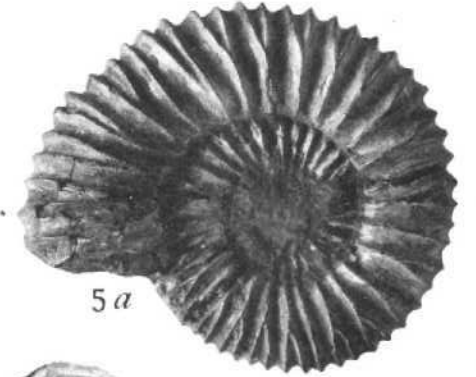
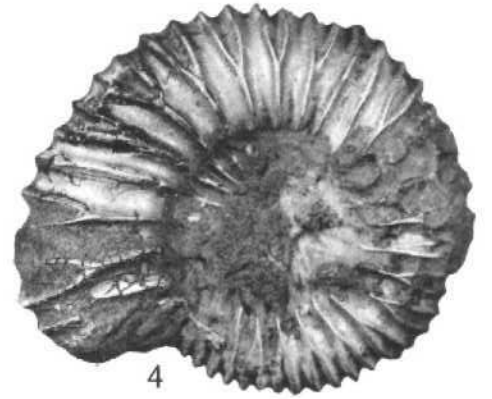
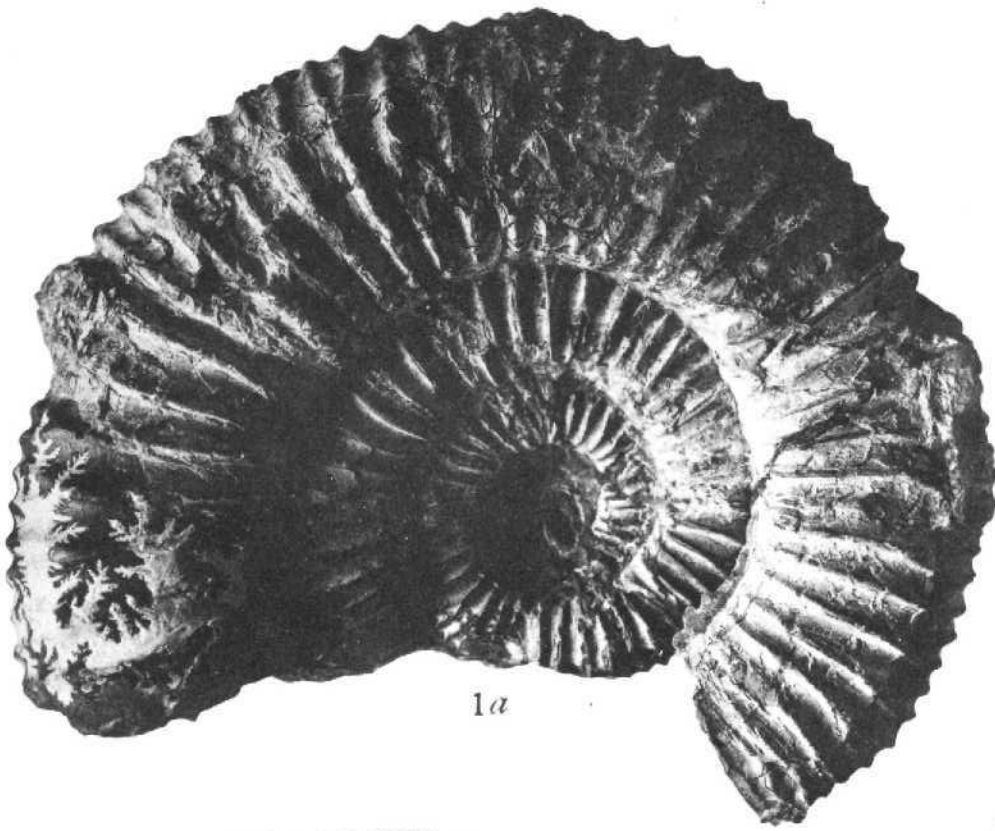


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## PLATE II

- FIG. 1. *Sphinctoceras crassum* sp. nov., p. 22.  
Genotype. Holotype (Coll. E. Neaverson). [B.M. No. C26900.]  
(a) side view, (b) peripheral view.  
Nodule bed (wheatleyensis-zone), Wheatley (Oxon).
- FIG. 2. *Episphinctoceras inflatum* sp. nov., p. 25.  
Genotype. Holotype (Coll. E. Neaverson). [B.M. No. C26902.]  
Hartwell Clay (rotundum-zone), Hartwell.
- FIG. 3. *Aposphinctoceras allesburiense* sp. nov., p. 27.  
Holotype (Coll. E. Neaverson), [B.M. No. C26904.]  
Hartwell Clay (pallasioides-zone), Webster and Cannon's brickyard, Aylesbury.
- FIG. 4. *Aposphinctoceres hartwellense* sp. nov., p. 28.  
Holotype (Coll. Aylesbury Museum).  
Hartwell Clay (pallasioides-zone), Locke's pit, Hartwell.
- FIG. 5. *Aposphinctoceras variabile* sp. nov., p. 29.  
Holotype (Coll. Geol. Surv., No. 26746).  
(a) side view, (b) apertural view.  
Hartwell Clay (pallasioides-zone), Hartwell,

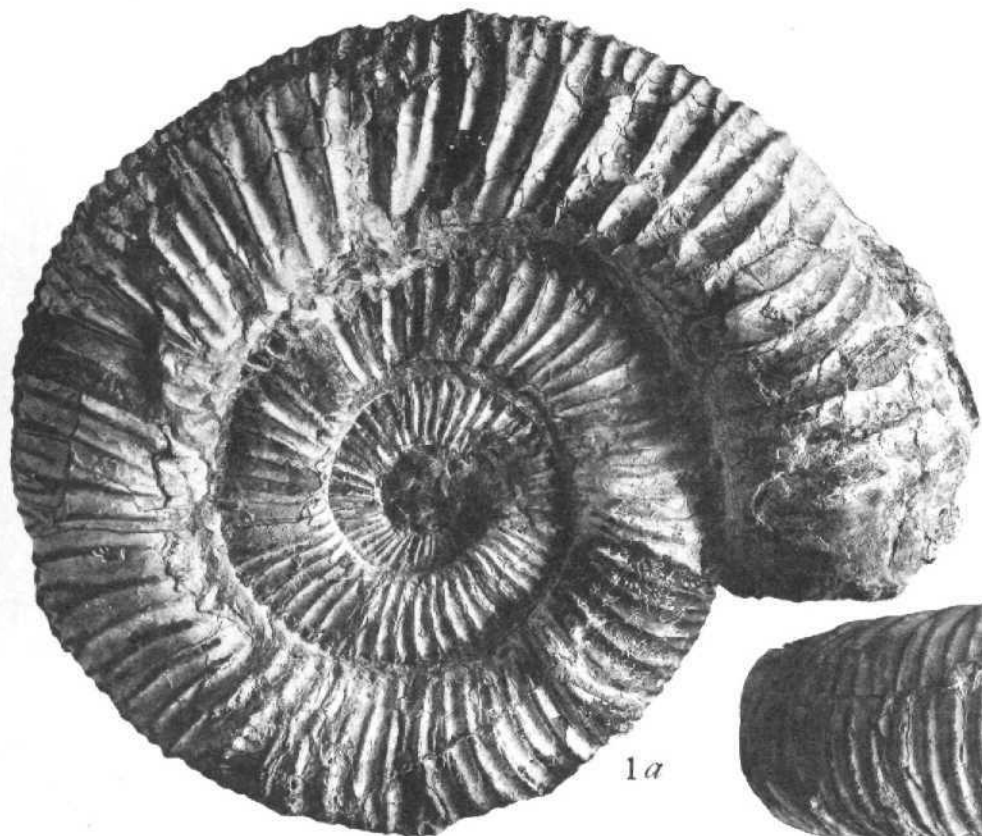
(All figures natural size.)



## PLATE III

- FIG. 1. *Allovirgatites woodwardi* sp. nov., p. 31.  
Genotype. Holotype (Coll. Geol. Surv., No. 32069).  
(a) side view, (b) peripheral view.  
Nodule bed (wheatleyensis-zone), Headington (Oxon).
- FIG. 2. *Allovirgatites tutcheri* sp. nov., p. 30.  
Holotype (Coll. J. W. Tutcher).  
Nodule bed (wheatleyensis-zone), Wheatley.
- FIG. 3. *Allovirgatites robustus* sp. nov., p. 32.  
Holotype (Coll. E. Neaverson). [B.M. No. C26898.]  
Nodule bed (wheatleyensis-zone), Wheatley.
- FIG. 4. *Allovirgatites versicoslatus* sp. nov., p. 32.  
Holotype (Coll. E. Neaverson). [B.M. No. C26899.]  
Nodule bed (wheatleyensis-zone), Wheatley.
- FIG. 5. *Holcosphinctes pallasioides* sp. nov., p. 35.  
Genotype. Holotype (Coll. Geol. Surv., No. 30721).  
Hartwell Clay (pallasioides-zone), Hartwell.
- FIG. 6. *Holcosphinctes flexicostatus* sp. nov., p. 35.  
Holotype (Coll. Aylesbury Museum).  
Hartwell Clay (pallasioides-zone), Hartwell.

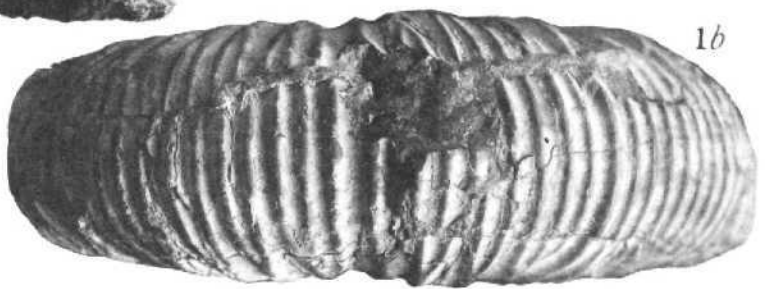
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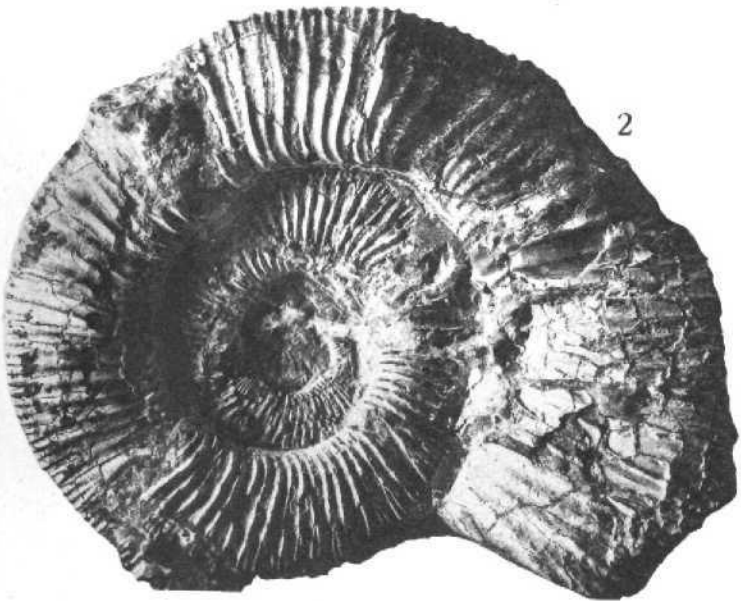
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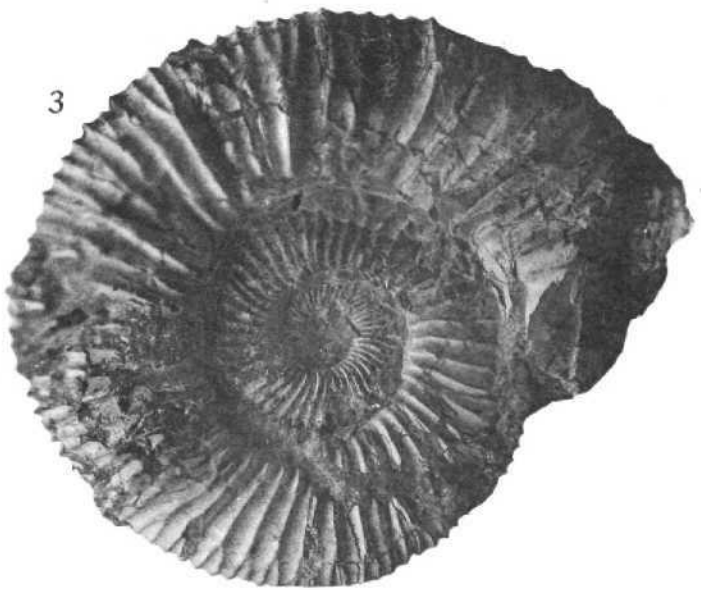
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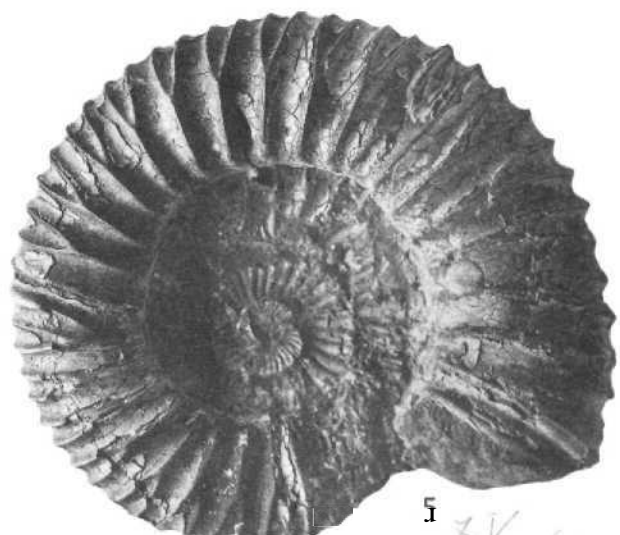
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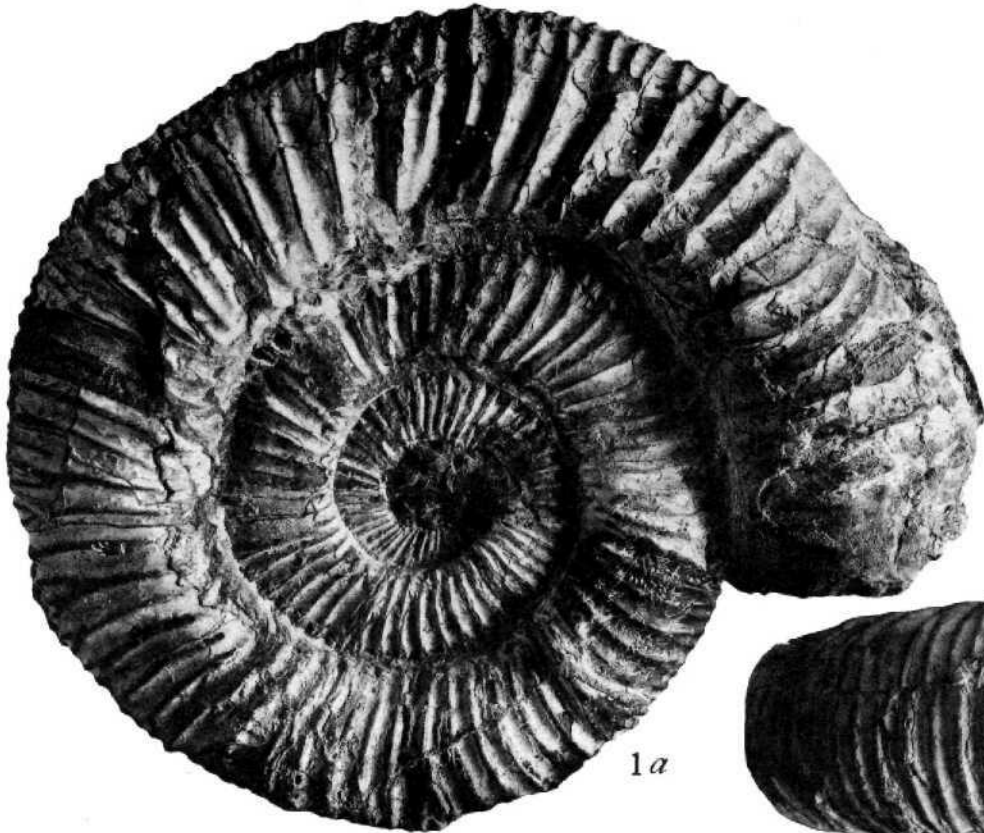
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## PLATE IV

- FIG. 1. *Virgatosphinctoides nodiferus* sp. nov., p. 14.  
Holotype (Coll. E. Neaverson). [B.M. No. C26901.]  
(a) side view.  $\times 0.6$ . (b) part of periphery showing accentuation of  
primary ribs (nat. size).  
Kimmeridge Clay (nodiferus-zone), Shotover Hill (Oxon).
- FIG. 2. *Virgatosphinctoides grandis* sp. nov., p. 13.  
Holotype (Coll. Geol. Surv., No. 32068).  $\times 0.4$ .  
Photo. J. Rhodes.  
Bituminous Shales (nodiferus-zone), Corton, Dorset.
- FIG. 3. *Sphinctoceras distans* sp. nov., p. 23.  
Holotype (Coll. Geol. Survey, No. 27817).  $\times 0.44$ .  
Photo. J. Rhodes.  
Nodule bed (wheatleyensis-zone). Headington.
- FIG. 4. *Paravirgatites kimmeridgensis* sp. nov., p. 33.  
• Holotype (Coll. Geol. Surv., No. 27959), nat. size.  
Bituminous Shales (pectinatus-zone), Kimmeridge,





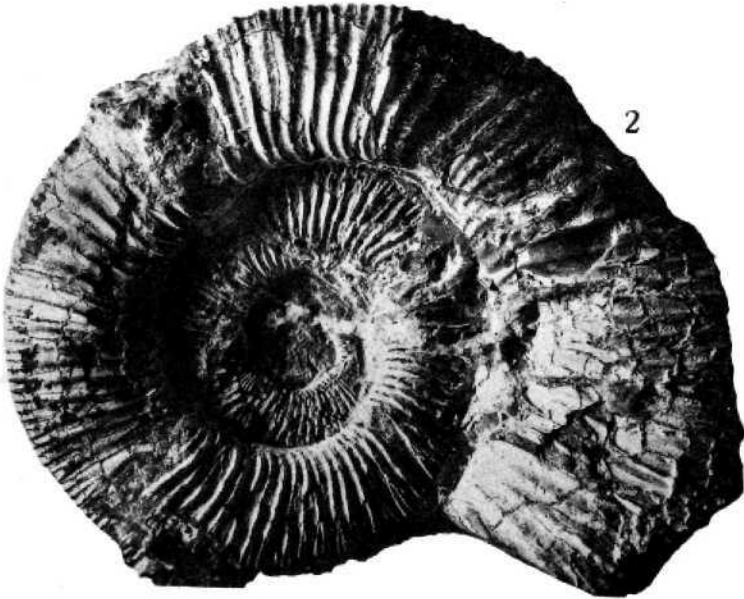
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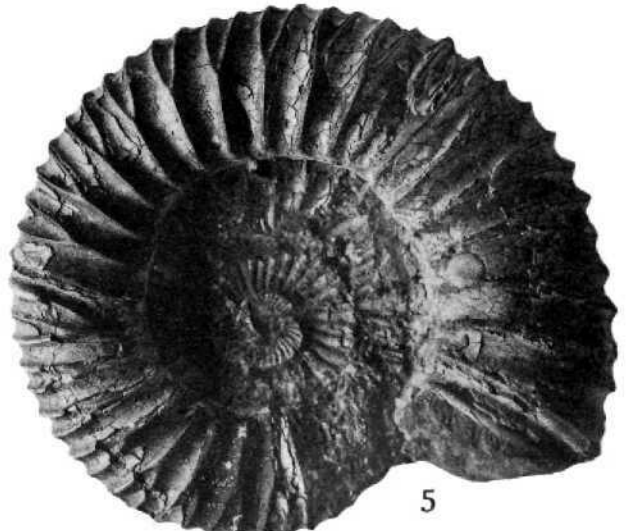
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