V.—REPORT ON AMMONITES COLLECTED AT LONG STANTON, CAMBS., AND ON THE AGE OF THE AMPTHILL CLAY

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V. REPORT ON AMMONITES COLLECTED AT LONG STANTON, CAMBS., AND ON THE AGE OF THE AMPTHILL CLAY

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Plates III, IV.

INTRODUCTION

THE specimens collected by Messrs. Dewar and Dixon from a casual opening in the Ampthill Clay at Long Stanton represent an assemblage of ammonites[1] hitherto unknown in this country, or in some instances known only by examples from the Glacial Drift. The species link up with elements in faunas known from Pomerania, the Moscow Basin and Greenland, and they enable the Ampthill Clay to be dated with greater precision than has been possible before.

I am indebted to the Director of H.M. Geological Survey for permission to study the specimens, and I also wish to acknowledge the valuable help received from Mr. A. G. Brighton, of the Sedgwick Museum.

DESCRIPTION OF THE MATERIAL

(a) STRATIGRAPHICAL DETAILS

The collection comprises:—

1. About 45 individuals and fragments of *Amoeboceras*, well preserved.
2. About 15 small fragments of various portions of medium-sized *Perisphinctes*, the shell mainly preserved.
3. About 12 more or less incomplete casts of body-chambers, some having a few septa and casts of gas-chambers attached, belonging to large Perisphinctids of a new genus named *Pomerania* below.
4. About 12 minute nuclei belonging mainly to a new genus described below as *Decipia*, all but one less than one inch in diameter, well preserved in pyrites.

The field-records show on analysis the following:—

All the large body-chambers and all the minute nuclei belonging to the two new genera came from Beds 1 and 2, at depths of 21½ ft. to 24½ ft.

[1] To be described and figured by the author in a monograph on the Ammonites of the English Corallian Beds in course of publication by the Palaeontographical Society.

About half the *Amoeboceras* and one minute nucleus of a tumid *Perisphinctes* (No. 54900) and one fragment of a medium-sized *Perisphinctes* (indet.) came from Bed 3, at depths of 15 ft. to 21½ ft.

About half the *Amoeboceras* and all except one of the fragments of medium-sized *Perisphinctes* came from Bed 5, at depths of 11 ft. to 14¾ ft.

From this analysis and from field evidence in the district, we can construct the following sequence :—

Upper Ampthill Clay (seen to 19½ ft.) :—

		Ft.
	Superficial deposits, to 5 ft., above	
6—7	Clay with no ammonites	6
4—5	Clay with *Amoeboceras* aff. *pseudocaelatum* Spath, *A.* (*Prionodoceras*) *truculentum* S. Buckman and *Perisphinctes spp.*	4
3	Clay with *Amoeboceras,* same species	6½
1—2	Clay with *Pomerania* and *Decipia, gen. nov.*	3
	Gap, unknown, perhaps 10 ft. or	? 20
Boxworth Rock		2—3
Lower Ampthill Clay ... ... about		? 25
Elsworth Rock		
Oxford Clay		

It will be shown below that there is evidence of three zones in the Ampthill Clay, and I therefore subtract indefinite amounts from the Upper and Lower divisions of this sequence and group them together with the Boxworth Rock as the Middle Ampthill Clay.

(b) PALAEONTOLOGICAL DETAILS

Amoeboceras aff. *pseudocaelatum* Spath

Plate III, figs. 6-12

1904 *Cardioceras* cf. *alternans* Ilovaisky, p. 272, pl. xi, fig. 6 only. (*non* von Buch)

1935 *Amoeboceras* (*Prionodoceras*) aff. *pseudocaelatum* Spath, *nom. nov.*, p. 19, pl. ii, fig. 4.

Dr. Spath founded this species as *nom. nov.* for Ilovaisky's *C.* cf. *alternans* (*loc. cit.*, fig. 6 only). The type, according to Ilovaisky's figure, has the following dimensions :—Diameter 54mm., Whorl height 0.45, Umbilicus 0.24. At a diameter of 40 mm., which is more comparable with the Long Stanton material, the dimensions are the same except that the umbilicus is 0.23 and there are 31 primary ribs.

The most complete of the Long Stanton specimens (crushed, but with mouth-border and rostrum preserved) measures 42 mm., with whorl-height 0.42 and umbilicus 0.24, and there are likewise 31 primary ribs to the whorl.

Long Stanton yielded about 40 specimens assignable to this species, all from Beds 3 and 5. One block of clay measuring 5 x 3 cm. has remains of 7 specimens. Many are crushed, but a number have only the body-chamber crushed, while the septate inner whorls are in a beautiful though fragile whitish and iridescent state of preservation. They agree with the inner whorls of Ilovaisky's figure except that lateral nodes are less definite. In this respect, therefore, they compare better with Dr. Spath's East Greenland specimen.

The material collected by Messrs. Dixon and Dewar at Long Stanton substantiates Dr. Spath's opinion that a wide variation must be allowed for, and justifies his referring to his material as an 'enodate variety.' In some the suggestion of nodes is stronger than in others. There is also much variation in the spacing of the ribs. In a specimen from Long Stanton (No. 54907 (3)) the ribs, both primaries and secondaries, are more widely spaced than in the others. But on the reverse side the ribbing is normal. This specimen has 29 secondary ribs per half whorl at 20 mm. on one side and 33 at the same diameter on the other.

Amoeboceras (Prionodoceras) truculentum S. Buckman

1927 *Prionodoceras truculentum* S. Buckman, pl. dcciv.

Three fragments from Bed 5, Nos. Dw. 2758, 2760-1, belong to a *Prionodoceras* of the group of *A.* (*P.*) *serratum* (J. Sowerby) (1813, p. 65, pl. xxiv). The first is a fragment representing rather less than a quarter whorl at about 50 mm. diameter. It shows six strong simple primary ribs, separated by regular short intercalatories. The second specimen is the first quarter of a body-chamber at a diameter of about 80-90 mm., and shows ribbing of the same type fading rapidly. The primary ribs are still strong, long and simple, and one or two are somewhat nodate. The third specimen is a quarter whorl at a slightly larger diameter just after the ribs have died out. In all three specimens the keel is rubbed off.

The nearest match with these specimens is *Prionodoceras truculentum* S. Buckman (1927, pl. dcciv). The primary ribs of the holotype are more numerous at corresponding diameters, but the ribbing is of the same strength and proportions, and the difference is probably of only varietal significance.

The ribbing is much coarser than and does not fade so early as in *A.* (*P.*) *serratum* (J. Sowerby) (*loc. cit.*). Both syntypes of that species, from the Drift of Suffolk, are lost. The upper figure if accurate represents a specimen which cannot readily be matched. The lower figure, which I designate as lectotype, represents the commonest *Prionodoceras* of the Drift and Ampthill Clay; it becomes smooth at a diameter of about 50 mm. The species has been thoroughly described and figured (as *Cardioceras serratum*) by Salfeld (1915, p. 172, pl. xviii). Other specimens, which may prove to belong to the same species, have been figured by Buckman as *Prionodoceras prionodes* and *P. excentricum* (Buckman, 1920, pl. clv; and 1924, pl. cdlxiv).[1]

The specimen figured as *Am. serratus* by Damon from the *Trigonia clavellata* Beds (not Kimeridge[2] Clay) near Weymouth, and identified by Spath (1933, p. 863) as " a coarse variety of *Amoeboceras serratum* Sowerby sp." and as " a finely-ribbed variety of *A. truculentum* (Buckman) " (1933, p. 868) does not closely resemble either of these species. It is distinguished by its short primary ribs, its long and regular paired secondaries, rarity of either simple primaries or intercalatory secondaries, and absence of nodes on the secondaries.

Perisphinctes spp. [Fragments]

Most of the fragments of true *Perisphinctes* are too small for certain identification. They are well preserved, however, some with the shell perfect although fragile. They do not represent any of the numerous species of *Perisphinctes* found in the Berkshire Oolite Series or Osmington Oolite Series, with which close comparison has been made. Nor do they resemble any forms known in the English Kimeridge Clay.

Since by far the commonest Perisphinctid in the Drift of the Midland counties is *P. variocostatus* Buckland (= *P. biplex* J. Sowerby), a species which is always assumed to have been derived from the Ampthill Clay, it is surprising that the Long Stanton collection contains only two fragments closely comparable with this species (Nos. Dw. 2748-9). Even these cannot definitely be identified as such specifically, and they are in a different state of preservation from the familiar forms in the Drift.

Other fragments (Nos. Dw. 2750, 2752-3, 2757) are identical with the inner whorls of a species to be described elsewhere, so far known in the complete state only from the Drift of Bourne, Cambridgeshire (Sedgwick Mus. No. J. 3786), and from the Drift (?) of Lincolnshire (Day Coll., Geol. Surv. Mus., No. 58060, locality unknown) (both presumed to have been derived from Ampthill Clay). Fragments which appear to belong to the same species have been collected also in the Ampthill Clay (10 ft. below the Lower Greensand) in Gamlingay brickpit (Sedgwick Mus., No. 2679); in the Ampthill Clay (level unknown) of Ampthill railway cutting (Geol. Surv. Mus., No. JR. 3314); and in the Boxworth Rock (Sedgwick Mus., No. J. 389). It is a new species, not classifiable in any existing subgenus. The ribbing and whorl-

[1] Spath (1935, p. 24, footnote) seeks to restrict the name *serratum* to the upper of Sowerby's figures; calling the common smooth form represented in the lower figure *prionodes* Buckman) and thereby virtually suppressing the name *serratum*, current for over a hundred years. He did not designate a lectotype. I consider the species *serratum* to have been fixed once and for all by Salfeld in his monograph, but I here designate Sowerby's lower figured specimen lectotype, and failing that Salfeld's specimen as neotype (Salfeld, 1915, pl. xviii, figs. 1a, 1b, 1c, Geol. Surv. Mus. No. 26059).

[2] The author has given reasons elsewhere (Arkell 1933, p. 441 footnote) for retaining the spelling, Kimeridge, the form originally adopted by the Ordnance Survey (O.S., Sheet 16, 1811); in accordance with its usual custom the Geological Survey has followed the spelling Kimmeridge, in use on the present Ordnance maps.

section closely resemble *Dichotomoceras dichotomum* S. Buckman, but the suspensive lobe of the suture is not so dwarfed and the ribs on the body-chamber modify differently towards the aperture.

Some of the fragments from Long Stanton showing no body-chamber or suture may possibly belong to *Dichotomoceras dichotomum,* and others (e.g., No. Dw. 2751) suggest by their ribbing the subgenus *Biplices* (*sensu stricto*). Lastly, there is a tiny nucleus of a tumid biplicate Perisphinctid with deep constrictions, too small for identification (Plate III, fig. 5).

It will be seen that these Perisphinctids are of little help in correlating, since they belong to species known only from either the Drift or isolated exposures of Ampthill Clay themselves imperfectly dated.

Perisphinctid Nuclei

Decipia gen. nov., Pl. III, figs. 1-4

The majority of the tiny nuclei from Beds 1 and 2 are assigned to a new genus *Decipia,* to be described elsewhere, the type being *Ammonites decipiens* J. Sowerby. This species represents a genus distinct from *Perisphinctes* and its many subgenera, and perhaps as worthy of full generic separation as *Pictonia* or *Ringsteadia,* to which it seems to be closely allied.

The largest of the Long Stanton nuclei (Geol. Surv. Mus., No. 54897) (Pl. III, fig. 2) measures 27 mm. in diameter, and it overlaps by a few mm. with the smallest visible part of the smallest undoubted *Decipia decipiens* that I have been able to obtain—a specimen from the Ampthill Clay of North Kelsey, Lincolnshire (Sedgwick Mus., No. J. 2664). It is not identical specifically, the ribbing of the Long Stanton nucleus being finer and the whorl less compressed; but the style of ribbing is essentially similar. From a diameter of about 20 mm. onwards the ribs bifurcate fairly regularly at a low angle, with regular intercalatories, and the secondaries pass quite strongly over the venter with only a gentle forward sweep.

At diameters less than about 20 mm. in all the specimens (the best are Nos. 54896-9, *see* Pl. III figs. 1-4) the ribbing, from the point where it first begins to be discernible (about 9-12 mm.) up to about 20 mm., is regularly triplicate in distinctly dischizotomous sheaves. In some of the specimens the sheaves are almost rectiradiate, or may branch slightly forward, in others they branch backward, and the direction is backward in all of them at the earliest stage. Some specimens show regular intercalatories, others only a few. Constrictions are more marked than at later stages (as in *D. decipiens*), and number about three per whorl. The secondaries are wholly concealed by the overlapping whorls, none being visible in the umbilicus.

At first sight these small nuclei recall the Lower Kimeridgian Rasenids, especially the genus *Prorasenia,* but comparison with a series of different species of *Prorasenia* from the Rasenia and Pictonia Zones of Stratton, Hatton and Abbotsbury, shows that they are not congeneric or even closely related. They differ from *Prorasenia* in having much finer ribbing, which becomes finer and smoother instead of coarser and sharper as growth proceeds, in possessing longer primary ribs (the secondaries are nearly always visible in the umbilicus of *Prorasenia*), and in displaying constrictions and numerous intercalatories. In the genus *Prorasenioides* Schindewolf the primaries are still shorter and the ribbing is more flexiradiate.

In the other Rasenid genera, *Rasenia, Involuticeras, Rasenioides* and *Pararasenia*[1] the triplicate and dischizotomous ribbing is not confined to the earliest whorls but persists much later, and so comparisons are still less close.

Apart from the rest of the fauna, therefore, it can confidently be stated that these nuclei are not Rasenids and that a Kimeridgian age need not be postulated for them. They may possibly be nuclei of the large body chambers found in the same beds, but against this must be set the facts that they are differently preserved and that no specimens of intermediate sizes were found to connect them.

Perisphinctid Body-Chambers

Pomerania gen. nov.[2]

The twelve large body-chambers and parts of body-chambers, with a few gas-chambers attached to some of them, constitute perhaps the most interesting part of the assemblage. They belong to a new genus, resembling *Decipia* in some respects. I propose for it the name *Pomerania* gen. nov., with genotype *P. dohmi,* n.n. for " *Pictonia* " *baylei* Dohm (1925, p. 32, pl. v, fig. 6) from the Ringsteadia Zone of Zarnglaff in Pomerania.

The identifiable Long Stanton material belongs to three species.[3] One may be conspecific with *P. robusta* Dohm 1925, p. 32, pl. vii, fig. 3) and another is comparable with *P. latecosta* Dohm (1925, p. 32, pl. ix, fig. 6, and pl. iv, fig. 2; non *latecostata* Törnquist, 1896), both from the Ringsteadia Beds of Zarnglaff. The characteristic features of this genus are the *Perisphinctes* suture, the large size, and the ontogeny of the ribbing, which is believed to be like that of *Decipia* on the inner whorls, but fades on the middle whorls, and then strengthens to large swollen ridges and wedges on the outer whorl—both the later formed gas-chambers and the body-chamber.

It has been pointed out previously (Arkell, 1935a, p. 247) that, contrary to what has been said by Dohm and Spath (1933, p. 867),[4]

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[1] *See* Arkell, 1935a, p. 252.
[2] Too large to be figured except on quarto plates.
[3] Some of the pieces are too fragmentary to be worth discussion.
[4] Dr. Spath has since admitted that Dohm's fossils are not the Kimeridgian *Pictoniae* (Spath, 1935, p. 42).

these giant Perisphinctids with coarse-ribbed outer whorls cannot be congeneric with *Pictonia*, as understood by Bayle, Salfeld, or any previous author, and that they represent a distinct genus not yet known from strata so high as the Pictonia Zone (basal Kimeridge). They are, in fact, characteristic of the Ringsteadia Zone of the uppermost Oxfordian in Pomerania, and the Long Stanton specimens, together with another mentioned below, confirm this dating.

Correlation and Dating

(a) *Amoeboceras pseudocaelatum*

At the type-localities, Miatschkowo and Novoselski in Western Russia, *Amoeboceras pseudocaelatum* is confined to Ilovaisky's Bed D, where it is abundant. Bed D consists mainly of shaly clay and is about 6 metres thick at Miatschkowo. Unfortunately little else occurs with it that gives any clue to correlations, the only other characteristic ammonite being a small Cardiocerate which Ilovaisky calls *C. cordatum* var. B (1904, pl. x, fig. 30). From the small fragment figured it is not possible to identify this with certainty, but it suggests part of a nucleus of the enodate variety of *A. pseudocaelatum*. Bed D, however, overlies strata (Beds A and B, together about 3½ metres thick), which contain Cardiocerates characteristic of the Transversarius Zone: *C. cordatum* auct., *C. excavatum, C. goliathum, C. vertebrale*, etc., together with large Perisphinctids (rare) identified as *P. martelli*. In between comes only 0.7 metre of clay with '*C. cordatum* var. B' and *C. zieteni* Rouiller (Bed C).

At Cape Leslie in East Greenland Spath records *A. pseudocaelatum* "several metres below the Pecten Sandstone, Neoxfordian (Upper Argovian-Rauracian), *transversarius* or *bimammatum* zones." From the Pecten Sandstone he records *A. alternoides* (Nik.), and from 11 metres above its base another *Prionodoceras* which he identifies as aff. *superstes* (Phillips). Buckman (1923, pl. cdxxii has figured *A. superstes* from the Brill Serpulite Bed, which is believed to be on the borderline between Upper Calcareous Grit and Kimeridge Clay, and Spath (1935, p. 23) records *A. alternoides* in the Ampthill Clay.

In England, " an evolute variety of *pseudocaelatum,* without lateral nodes and therefore showing resemblance to the form figured in de Loriol's fig. 10," is said by Spath (1935, p. 20) to have been collected by Blake from the Upper Calcareous Grit of Nunnington, Yorkshire, and recorded by him as *Amm. alternans = serratus*.

Hence, on the evidence of this Amoeboceratе we can date the clay at Long Stanton as of Bimammatum Zone age and in N.W. European chronology post-Plicatilis Zone and therefore somewhere in either the *Perisphinctes variocostatus* or the *Ringsteadia pseudocordata* Zone.[1]

(b) *Amoeboceras truculentum*

The holotype of *A.* (*P.*) *truculentum* S. Buckman came from Wood Walton railway cutting, six miles N.N.W. of Huntingdon (map, Fig. 1, p. 60), from clay which H. B. Woodward described as Oxford Clay and Buckman as Kimeridge Clay. From the same cutting came the holotype of *A.* (*P.*) *excentricum* S. Buckman (1924, pl. cdlxiv), and a large and typical specimen of *Perisphinctes variocostatus* (Buckland) (Geol. Surv. Mus. No. 48499).[2]

The holotype of *Prionodoceras excentricum* S. Buckman, which was found associated with *P. truculentum* at Walton cutting, is probably conspecific with *A.* (*P.*) *serratum* of J. Sowerby and of Salfeld, a species more widely distributed, both in the Drift and *in situ*. The latter species was collected by Salfeld *in situ* in clay formerly exposed at Telford Road claypit, Swindon, and with it he found what he identified as *Perisphinctes decipiens* (J. Sowerby) (Salfeld, 1914, p. 196, and 1915, p. 174). Although Buckman subsequently assumed the acme of *Prionodoceras spp.* to have been attained after the *Ringsteadia* hemera, Salfeld in 1914 considered the clay with *P. serratum* at Telford Road to lie *below* the band of ironshot oolite with *Ringsteadiae*; in other words, that it was Upper Oxfordian (Corallian) and not Kimeridgian.

A single specimen probably referable to *P. serratum* but more discoidal is known from the ironshot oolite itself, in the same matrix as the *Ringsteadiae*, from Stratton railway cutting, near Swindon (Taunton Museum, Tomkins Coll., No. 3666). The commoner *Prionodoceras* from that bed, however, is the smaller, still more discoidal, and more coarsely-ribbed *A.* (*P.*) *marstonense* Spath (1935, pl. iv, fig. 5; and Oxford University and Taunton Museums), which is not known from Ampthill Clay.

[1] Since this was written Dr. J. Pringle has kindly put at my disposal the cores from the borings at Southery, Norfolk, described by him (1923, pp. 129-30). He allows me to say that in my opinion the ammonites referred to by him as *Cardioceras sp.* on p. 130 are *Amoeboceras* aff. *pseudocaelatum*. The specimens are marked as coming from depths of 283 and 290 ft. in the Severals Ho. boring (C). Forty feet higher come 20 ft. of clays with abundant *Raseniae* (depths 208-228 ft.). The *Amoeboceras* from 247 ft. seems to indicate basal Kimeridge Clay, and the *Cardioceras* from 268½ ft. is a *Prionodoceras* (probably Corallian). *See* later, p. 83, ' The Ampthill Clay in some Norfolk Borings.'

[2] If the clay in which these fossils were found was in place, it must have been Ampthill Clay; but it seems to me more likely to have been Drift. Wood Walton is well out in the outcrop of the Oxford Clay according to the Geological Survey Map (Sheet 16, colour printed ¼-inch, 1909). It lies six miles west of the nearest known occurrence of Corallian clays, at Warboys brickyard (where an argillaceous limestone at the top of the pit and underlying a few feet of clay has yielded Corallian—Berkshire Oolite—Perisphinctids to Mr. Brighton, Mr. Dixon and myself) and at Fenton (*see* Roberts, 1892, p. 47). It is not impossible, however, that the outcrop of the Elsworth Rock does not turn northwards under the Drift near Houghton Hall, east of Huntingdon, as Wedd supposed (1901, p. 80), but continues farther west along the left bank of the Ouse, just under the Drift. My attention is drawn by Mr. C. H. Dinham to a note to the effect that " Corallian fragments " were observed on a small isolated hill standing north of the main high ground 1,800 yards W.N.W. of Great Raveley Manor House (about midway between Wood Walton and Warboys). *See* the library copy of the Geological Survey map, 6" to mile, Sheet Hunts. 14 N.W. A third possibility is that at Wood Walton some Ampthill Clay is let down by a fault belonging to the same system as the fault which brings up the inlier of Cornbrash between Yaxley and Stilton, six miles to the north-west.

Again, there are fragments of *Prionodoceras* which appear to be *P. serratum* or a near form in the Sandsfoot Grits of Weymouth, where they are associated with *Ringsteadiae* but are below the acme of that genus, which is reached in the overlying ironstone band (= Ringstead Coral Bed) and Ringstead Waxy Clay (Arkell, 1933, pp. 385-6).[1] Salfeld also recorded *P. serratum* from the Sandsfoot Grits.

A fragmentary young specimen less than 20 mm. in diameter from the Boxworth Rock is preserved in the Sedgwick Museum (No. J. 386), but it can only be identified specifically with the greatest hesitation as *A.* (*P.*) *serratum*.

It is tantalising that at the only place where *A.* (*P.*) *serratum* and *Perisphinctes variocostatus* (Buckland) have been found together in a Jurassic clay the clay had been transported by ice. The erratic was pierced by a well 2 miles S.S.E. of Biggleswade Station, Bedfordshire, and was 67 ft. thick, with 8½ ft. of boulder clay above and 16½ ft. below, the whole resting on undisturbed but eroded Gault (Home, 1903). The ammonites from the 67 ft. of Jurassic clay were identified by E. T. Newton as *Cardioceras excavatus* (J. Sowerby) and *Perisphinctes variocostatus* (Buckland) and on this evidence the clay was considered to be Ampthill Clay by Messrs. Newton, Kitchin and H. B. Woodward, though W. H. Hudleston thought the erratic might have come from the Lower Kimeridge. Some of the ammonites are preserved in the Sedgwick Museum, Cambridge, and they can be identified with certainty as fragments of *Perisphinctes variocostatus* (Buckland) (typical; Nos. J. 3788-9, 2687) and well preserved complete specimens of *Amoeboceras* (*Prionodoceras*) *serratum* (J. Sowerby) (Nos. J. 3790-1), with fragments of young specimens exactly like that figured by Salfeld, 1915, pl. xviii, fig. 1a, 1b (No. J. 3795-7) and several others ribbed to a rather later stage (J. 3793-4). They are all in the state of preservation typical of those in the Drift, and this large erratic undoubtedly came from the horizon from which the numerous well-preserved Drift specimens were derived.

(c) *The Perisphinctids*

The Perisphinctids give us corroborative and more precise information. Little can be inferred from the tiny nuclei or from the fragments of *Perisphinctes*, for they all belong to species which, with the exceptions mentioned, are known exclusively from the Drift.

The large body-chambers of *Pomerania*, on the other hand, can be dated with precision. They are closely comparable, in two instances perhaps specifically identical, with forms figured by Dohm (1925) from beds yielding abundant *Ringsteadiae* at

[1] The only fragments known to me from this locality are unfortunately worn and devoid of the keel, having been picked up by me from the beach at Wyke Regis, but they are in unmistakable red grit matrix.

Zarnglaff in Pomerania. Dohm's ammonites have also been identified in association with *Ringsteadiae* in Swabia (Beurlen, 1926, p. 89). (Cf. *Am. gigantoplex* and *ptychodes* Quenstedt).

Confirmation of this dating comes from Wiltshire in a single well-preserved specimen of the same genus discovered about a century ago in the Westbury Ironstone of Stratton railway-cutting, near Swindon (Tomkins Coll., Taunton Museum, No. 3670). From the same cuttings (or borrow-pits?) at Stratton and Marston, came numerous *Ringsteadiae,* and the Amoebocerates just discussed. All the ammonites are in the same argillaceous ironshot matrix as that in which the *Ringsteadiae* occur at the top of the Upper Calcareous Grit at Weymouth.

As recently pointed out (Arkell 1935a, pp. 248-9), the ironshot bed underlies the basal Kimeridge Clay with numerous *Pictonia* and *Prorasenia,* which is dug close to the railway cutting at Stratton brickyard (Messrs. Iles and Sons). In November, 1935, I learnt that a hole had been dug 9 ft. below the bottom of the pit, and that nothing but clays with layers of *Ostrea delta* had been encountered (evidently still *Pictonia baylei* Zone). Close below must lie the ironshot oolite encountered in the adjacent cutting, and we know from borings at Swindon and Red Down, Highworth (Arkell, 1933, p. 395) that this is separated by 21½ ft. of clay from the Coral Rag.[1]

With these borings to give us the thicknesses, we can now piece together the following lithological and palaeontological succession for the Swindon district:—

	Ft.	In.
KIMERIDGE CLAY (penetrated to 42′ at Swindon; *see* Chatwin and Pringle, 1922, p. 164).		
Bluish-grey clay in boring	21	0
Bluish-grey clay in Iles' brickyard with *Pictonia spp.* and *Prorasenia spp.*, and *Ostrea delta,* seen to about... ...	12	0
Clay with layers of *Ostrea delta,* at least	9	0
Seam of pale grey shelly limestone with *O. delta*		1
CORALLIAN BEDS		
Ironshot oolite band, grey and brown, earthy, with many *Ringsteadia spp.*, also *Pomerania sp. nov.*, *Amoeboceras marstonense* Spath, *A. serratum* (J. Sowerby) (1 specimen), and *Camptonectes sandsfootensis* Arkell (2 giant double-valved examples at Oxford and Taunton Museums). Formerly seen in railway cuttings... ... 6 inches to	1	0
Clay, the upper 2 ft. hard, brown, calcareous and muddy in Swindon boring, and much of it red and sandy at Red Down. *Amoeboceras serratum* (J. Sowerby) and *Decipia sp.* (?) recorded by Salfeld at Telford Road old claypit, Swindon, in upper part (presumably); passes into red and yellow sands at Shrivenham	21	6
Coral Rag, limestones, etc., below.		

Another species that seems to belong to the genus *Pomerania* occurs at Le Havre: *Ammonites berryeri* Lesueur (Dollfus,

[1] Contrary to what I wrote in 1927, p. 151, when I under-estimated the dip of the Coral Rag below Stratton brickyard.

1863, pp. 15, 42 pl. iv). Dollfus recorded it from the "Marnes à Ptérocères" (in the form of a cast, as figured). The record is vague, for Dollfus included in this rock-group not only the restricted "Calcaire marneaux à Ptérocères" of Lennier's record (Douvillé, 1881, p. 450, bed h), only 3 ft. thick, from which were obtained most of the *Pictoniae* and *Raseniae* figured by Törnquist (1896), but also an unknown proportion of the 40 ft. of marls and other rocks below, above his next-lowest rock-group, the "Calcaires à Trigonies". (Dollfus, p. 4, and Douvillé, 1881, p. 450, beds a-g). Tornquist (1896, pl. viii) figured an ammonite under the name *Olcostephanus berryeri* (Dollfus), from the restricted Pteroceras limestone (bed h of the section), but the ammonite is a Rasenid and quite different from Dollfus' original. If this was the closest match that Törnquist could find among the material from the *Pictonia* and *R. cymodoce* bed, there is reason for inferring that the original *Am. berryeri* of Dollfus did not come from that horizon but from some lower part of the 40 ft. of beds called Marnes à Ptérocères by Dollfus. These beds, at least up to Lennier's bed f, correlate bed for bed with the Marnes et Argiles de Villerville, and so thence with the Sandsfoot Grit and Sandsfoot Clay, according to H. Douvillé (1881, p. 452). Salfeld (1914, p. 212) recorded *Ringsteadia frequens* from some part of them at Villerville, and the occurrence there of ironshot oolite in bed f suggests the Ringstead Coral Bed at Weymouth and the same horizon in Wiltshire. In my opinion the vague "Calcaires et argiles à Trigonies" at Cap de la Hève, to judge by their lamellibranch fauna, are considerably higher than the *Trigonia clavellata* Beds, probably at least as high as the Sandsfoot Grits, as Waagen believed in 1865. They are less likely to correspond with part of the Sandsfoot Clay, of which the fauna in England is poor and little known. The only ammonites recorded from the Calcaires à Trigonies at Le Havre are "*Am. cymodoce* d'Orb." and "*Am. erinus*? d'Orb.", which in the terminology of 1863 may conceal *Ringsteadiae*. *A. cymodoce* also appears in Douvillé's record against Bed b, where it is probably a *Ringsteadia*.

Thus the evidence on the whole favours the supposition that the true *Am. berryeri* Dollfus occurs at Le Havre on about the same horizon as its congeners in England and Pomerania; namely in the Zone of *Ringsteadia pseudocordata*.

It seems probable that Salfeld recorded members of the genus *Pomerania* in various places as *Perisphinctes achilles* d'Orb., as did also H. Douvillé in 1881, and that this led to *P. achilles* being used by those authors as a zonal index for part of the uppermost Oxfordian strata now under discussion (Salfeld, 1914, Table I). In Swabia, however, the form referred to *P. achilles* seems to occur below the horizon with *Ringsteadia* and *Pomerania*, although still in the Bimammatum Zone. (*See* Beurlen, 1926, pp. 88-9). The precise nature of the original *P.*

achilles of d'Orbigny is doubtful, and it seems more likely to have been a Lower Kimeridge form (Tenuilobatus Zone).[1]

CONCLUSIONS AS TO THE ZONAL RANGE OF THE AMPTHILL CLAY.

In 1927, S. S. Buckman (1927, vol. vi, p. 49) and the writer (1927, p. 153) simultaneously and independently published the opinion that the bulk of the Ampthill Clay occupied a higher stratigraphical position than had usually been supposed. Buckman, basing his opinion on the occurrence of *Perisphinctes variocostatus* (Buckland) and his new genus *Prionodoceras*, declared that the Ampthill Clay was of Lower Kimeridgian age. My conclusion was based on some small fragments of Perisphinctids collected by Prof. A. Morley Davies from a rock band about 20 ft. above the base of the Ampthill Clay, in a railway-cutting between Ashendon Junction and Rushbeds Wood Tunnel, Bucks. These fragments indicated a higher horizon than was represented in any of the normal Corallian Beds in Oxfordshire and Berkshire, and I concluded that the rock band, which suggested the Boxworth Rock, " tells us definitely, I think, that we have here an horizon probably equivalent to some part of the *Trigonia clavellata* beds of Dorset " (Arkell 1927, p. 153).

The section of the cutting examined by Prof. Morley Davies was as follows (much condensed):—

Ampthill Clay		Ft.
7.	Pale grey clay with small selenite crystals	30
6.	Stone band with Perisphinctids, less than	1
3-5.	Clay, with three unfossiliferous 9-inch stone bands ...	19
		50
Oakley Beds		
2.	*Exogyra nana* Beds; clays, marls, marly limestone full of *E. nana* and many other fossils, including *Perisphinctes spp.*	6 to 10 ft. or more
Oxford Clay		
1.	Clay, with many large *Gryphaea dilatata* and Cardiocerates " of *praecordatum* and *tenuicostatum* types" [*Cardioceras costellatum* Buckman?]	

I pointed out in 1927 that it was the *Exogyra nana* Beds (2) (= Buckman's Oakley Clay near Brill) alone that contained the Perisphinctids and lamellibranchs of the Upper Corallian (Plicatilis Zone) of the Oxford district; and that as these beds apparently pass eastwards into the Elsworth Rock they should not be included in the Ampthill Clay, which appears to be mainly of later date (*see* also Arkell, 1933, pp. 410-412). I except the lowest layers of the Ampthill Clay, for instance the lowest 18 ft. above the Serpulite Bed, as exposed at Gamlingay (*see* Fearn-

[1] Dr. J. Cottreau has kindly searched for types on my behalf in Paris but was unable to find any. It remains for a French author to work out the species and figure neotypes.

sides, 1904, p. 15, and Roberts, 1892, pp. 37-40), which have yielded *Cardioceras* and *Cawtoniceras spp.*, comparable with forms found in the Berkshire Oolite Series of the Oxford district and Yorkshire. Plicatilis-Zone clay has also been exposed at Swavesey, Cambs. (lowest 23 ft., *see* Roberts, 1892, p. 46).

It is now possible to say that at least one of the commonest ammonites of the Dorset *Trigonia clavellata* Beds, a new species to be described elsewhere, occurs in the Boxworth Rock of Boxworth (Sedgwick Mus., nos. J. 387, J. 385; and Geol. Surv. Mus., nos. 103, 104 C.B.W.). Another Dorset species is represented from the Ampthill Clay of Lincolnshire (*P. boweni* Arkell, 1935, p. 16; Brit. Mus.) and this probably comes from about the same horizon, because another Lincolnshire species (undescribed) in the same state of preservation, is among the few ammonites known from the Boxworth Rock (Sedgwick Mus., No. J. 389). In Dorset the position of these species is at the top of the *Trigonia clavellata* Beds, in the Red Beds, close to the junction with the Sandsfoot Clay. Now Roberts considered the Boxworth Rock in his area to lie at least 20 ft. above the base of the Ampthill Clay, and at Swavesey, if present at all, it must be more than 23 ft. above the base, according to his records, since it was not encountered in a well that struck Elsworth Rock at that depth. Hence we can say that about the lowest 25 ft. of the Ampthill Clay may bring us up to the horizon of the base of the Sandsfoot Clay (*see* Arkell, 1935, pp. 5-7).

It is noteworthy that, among the many ammonites from Long Stanton, there are only two fragments identifiable with *Perisphinctes variocostatus* (Buckland) (= *biplex* J. Sowerby) and no signs of *Amoeboceras* (*Prionodoceras*) *serratum* (J. Sowerby). Yet these are by far the commonest ammonites yielded by the Drift, supposedly derived from the Ampthill Clay. Since the Ampthill Clay at Long Stanton is definitely above the horizon of the Boxworth Rock, the absence there of the common *P. variocostatus* and *A.* (*P.*) *serratum* may be explained by inferring that the principal source of these species is a lower horizon in the clay, either close above or below the Boxworth Rock; *i.e.*, Middle Ampthill Clay. If they came from above the clays exposed at Long Stanton, they would be as much Lower Kimeridgian, as Buckman thought, as Oxfordian. But it has been shown that the Boxworth Rock contains some ammonites from the Red Beds at the top of the Dorset *Trigonia clavellata* Beds. Neither the true *A.* (*Prionodoceras*) *serratum* nor the true *Perisphinctes variocostatus* is known from the Dorset Red Beds, but they have yielded a specimen of *Prionodoceras* (*Am. serratus* Damon) which was considered a variety of *A.* (*P.*) *serratum* by Damon and by Spath (though I regard it as a different species), and they also contain what are undoubtedly the nearest allies of *P. variocostatus* and *P. strumatum*, namely *P. cautisnigrae* Arkell and *P. uptonensis* Arkell (1935, pp. 10, 14, plates i, ii, iii, vii).

Hence, on the evidence available, it may be inferred that the main source of *P. variocostatus* and perhaps also *A.* (*P.*) *serratum* is below the clays exposed at Long Stanton and probably close to the horizon of the Boxworth Rock. At present, there is no satisfactory index for this important ammonite zone, which probably represents approximately the South-West German and Portuguese Tiziani Zone of Siemiradzki (1898). *P. variocostatus* being so common and characteristic in this country, I propose tentatively to adopt it as zonal index for the Middle Ampthill Clay and Dorset Trigonia Beds. It was figured by Buckland in 1836, in the sixth Bridgwater Treatise, and was chosen by Hudleston as a Characteristic Fossil for his " Supracoralline group " in 1878 (table facing p. 410). It should be clearly understood, however, that the placing of this zone below instead of above that of *Ringsteadia pseudocordata* is still only tentative, for correlation with the Boxworth Rock and thence with the Dorset Trigonia Beds is not altogether satisfactory.

From what has been stated, it is evident that the Upper Ampthill Clay of Long Stanton belongs to the Ringsteadia Zone, the highest zone of the Upper Oxfordian (Corallian) Beds, and so may be correlated with the Upper Calcareous Grit of other counties. *Ringsteadia* itself was not found at Long Stanton; it seems to be absent from the whole Ampthill Clay area, and is unknown from the Drift. This is remarkable in view of its abundance in Dorset, Pomerania and Normandy and its extension to Swabia; even more remarkable than the absence of *Perisphinctes variocostatus* from Dorset or Yorkshire.

Comparison with Upware

Roberts (1892, p. 8) after successfully refuting Seeley's opinion that the Ampthill Clay was older than the Coralline Oolite of Upware and that the Elsworth and St. Ives Rocks occupied different horizons in the Oxford Clay, summarised his knowledge of the correlation of these strata by means of the following table:—

	Upware Section
4. Kimeridge Clay	
3. Ampthill Clay	{ Coral Rag Coralline Oolite
2. Lower Calcareous Grit (Elsworth and St. Ives Rocks)	
1. Oxford Clay	

In the ten years that followed, much new light was thrown on the succession at Upware. The three most important discoveries were the following. (1) Keeping showed that the Kimeridge Clay rests with signs of erosion directly on the Coral Rag, in an exposure no longer visible. (2) Wedd showed that the Elsworth Rock does indeed underlie the Corallian Rocks at Upware, as Roberts had supposed, but had been unable to prove. (3) Fearnsides, by excavations in the floor of the South Pit, and Wedd, by excavations near by, proved that a lower coral rag is developed in the Coralline Oolite below the South Pit, and that this lower coral rag rests directly on the Elsworth Rock (*see* Rastall, 1909, and Fearnsides, 1904).

Palaeontologically, the greatest advance was made by Wedd, who, in the course of his detailed mapping of the Elsworth and St. Ives Rock, found *Perisphinctes* " *plicatilis* " abundantly in the rock at three places, Papworth Everard, north of St. Ives, and north-east of St. Ives. He " dwelt upon the great abundance of ammonites of the *plicatilis* type in the Elsworth and St. Ives Rock" (Wedd, 1901, p. 85), and this abundance led him to infer that the Rock was of Upper Corallian date instead of Lower Calcareous Grit. Examination of the ammonites and other fossils from the Rock in the Sedgwick Museum has enabled Dr. Spath and the writer independently to confirm Wedd's dating. The majority of the fauna, in fact, indicates the Berkshire Oolite Series of the Oxford district, namely the lower part of the Plicatilis Zone (Spath, 1933, p. 866; Arkell, 1933, p. 413). Spath's conclusion that the Coralline Oolite (with its lower coral rag) cannot be distinguished zonally from the Elsworth Rock is in agreement with my own conclusion that in the south of England, and particularly the Oxford district, one zone suffices for the Berkshire and Osmington Oolite Series (Arkell, 1933, p. 376). This zone, the Martelli and Antecedens Zones of Salfeld,[1] should properly be called the Plicatilis Zone (having been first so called by Hudleston, 1878, *loc. cit.*).

I have on several occasions pointed out that the Coralline Oolite of Upware, with its lower coral rag, corresponds palaeontologically, lithologically and stratigraphically with the Osmington Oolite Series of the South of England (which contains the Coral Rag in the Oxford district); and that since the Coral Rag of Upware rests upon it and contains a number of special lamellibranchs not found in the Osmington Oolite Series, the Coral Rag of Upware is probably later in date than the Osmington Oolite Series; and further, that it may be correlated with the later coral reef of Steeple Ashton, Wilts., which occupies a similar position and seems to pass laterally into the *Trigonia clavellata* Beds of Dorset. If this correlation is correct, then the Coral Rag of Upware passes laterally into the Middle Ampthill Clay, including the Boxworth Rock, which we have seen yields some of the ammonites of the *T. clavellata* Beds, and which I place tentatively in the Zone of *Perisphinctus variocostatus* (old ' *decipiens* ' or ' *serratus* ' zone).

This correlation leaves the upper and thickest portion of the Ampthill Clay, with the Long Stanton ammonite fauna (Ring-

[1] Salfeld wrongly placed the Dorset Trigonia Beds in his *P. antecedens* Zone, for they are higher. *P. antecedens* is common in the Berkshire Oolite Series and ranges up into the Osmington Oolites.

steadia Zone), apparently unrepresented in the Corallian rocks of Upware.

The observation of Keeping, that Kimeridge Clay rests directly on the Coral Rag with signs of erosion, indicates that the Ringsteadia Zone is unrepresented at Upware. A similar non-sequence occurs in the Oxford district, but is of greater extent, for the Variocostatus Zone is absent also.

I would therefore amend Roberts' table as follows :—
(the wider correlation now suggested is shown in the table on p. 80).

Oxford	*Ampthill Clay Area*	*Upware*
Absent	Upper Ampthill Clay	Absent
Absent	Boxworth Rock & Middle Ampthill Clay	Coral Rag
Osmington Oolite Series (with Coral Rag)	Lower Ampthill Clay	Coralline Oolite and lower coral rag
Berkshire Oolite Series	Elsworth Rock (with *Exogyra nana* Beds)	Elsworth Rock
Lower Calcareous Grit	Absent	Absent

[TABLE

CORRELATION TABLE

ZONES	CAMBRIDGESHIRE	BUCKINGHAMSHIRE	OXON	N. WILTSHIRE	DORSET
Ringsteadia pseudocordata	Upper Ampthill Clay with *Pomerania spp. Amoeboceras pseudocaelatum, A. truculentum.*	Brill Serpulite Bed, 1 ft., and Upper Ampthill Clay.	Absent	Ironstone band, 1 ft. of Swindon and Marston, with *Ringsteadia spp. Pomerania sp.* and *Amoeboceras marstonense.*	Ironstone band with *Ringsteadia spp.*, passing to Coral Bed, Ringstead Waxy Clay (12 ft.), Sandsfoot Grits (30 ft.) with *Ringsteadia*, Sandsfoot Clay (40 ft.), *Trigonia clavellata* Beds (25 ft.) with *Per. osmingtonensis* and other spp.
Perisphinctes variocostatus(?)	Boxworth Rock, 2-3 feet, and Middle Ampthill Clay, with *Amoeboceras serratum, Per. variocostatus* and *P. osmingtonensis* (=Upware Rag?)	Boxworth Rock, 1 ft. with *Perisphinctes* cf. *wartae* and Middle Ampthill Clay.	Absent	Clay (21 ft.) with *Amoeboceras serratum* near top at Swindon. Absent ? (pars)	
Perisphinctes plicatilis	Lower Ampthill Clay (Gamlingay, etc.) = Upware Coralline Oolite with few ammonites, Elsworth Rock with many ammonites of *plicatilis* zone	Lower Ampthill Clay and *Exogyra nana* Beds (= Oakley Beds) with Perisphinctids of *plicatilis* zone.	Osmington Oolite Series 30-65 ft. with few, and Berkshire Oolite Series up to 60 ft., with many ammonites of the *plicatilis* zone.		
Aspidoceras catena	Absent	Absent	Lower Calcareous Grit (at least upper part).		

THE AMPTHILL CLAY IN SOME NORFOLK BORINGS

Light is thrown on some of the problems discussed above by the borings in the Norfolk fens near Southery, described by Dr. J. Pringle in 1923. The position of these borings (map, Fig. 1, p. 60) is only 22-24 miles north-east of the last surface exposures of the Corallian clays at Fenton and Warboys brickyards. At my request Dr. Pringle has allowed me to work through the core-samples from the Upper Jurassic clays penetrated in these borings and some others (unpublished) farther north, near King's Lynn, and in addition he has put at my disposal his manuscript notes and has given me every facility. For this kindness I wish to express my sincere thanks.

Every specimen from the cores has the depth clearly marked on it at the time of collecting and all are preserved in their order of sequence. Re-examination of the fossils is therefore an easy matter.

The results, which are summarized in the accompanying sections (Pl. IV), confirm Dr. Pringle's conclusions (Pringle, 1923), with some modification due to later work, and at the same time reveal some of the Long Stanton fauna in sequence with the rest of the Oxfordian-Kimeridgian succession.

The principal limestone bands, which are shown in the sections, are those in the published descriptions, and the columns A, B, C correspond with the three borings already so styled. Only the minimum number of fossils has been entered, for the sake of clarity.

As was shown before, the Lower Greensand rests unconformably on the Kimeridge Clay from a few inches (at A) to 17 ft. (at C) above a seam of oil-shale, the equivalent of the Blackstone of Clavell's Hard, Kimeridge, Dorset; and both in this seam in all three borings and in the Blackstone at Kimeridge Dr. Pringle discovered plates of the pelagic Crinoid, *Saccocoma*. He showed that this fossil has a vertical range of less than 1 ft. in the Norfolk borings and 13 ft. in Dorset. It therefore provides an invaluable datum in correlating, and indicates that approximately the lower half only of the Kimeridge Clay is present in South-west Norfolk. This conclusion the ammonites corroborate abundantly.

Below the *Saccocoma* band, in the lower part of the Kimeridge Clay, are two other prominent palaeontological datum lines. About 50 ft. below *Saccocoma* the bedding planes of the shale are covered with *Amoeboceras krausei* (Salfeld), which occurs at Ringstead Bay in the Pseudomutabilis Zone (Salfeld, 1915, p. 201, pl. xx, figs. 6-10). At a level about 50 ft. lower is a mass of small fine-ribbed Rasenids, likewise flattened in the bedding planes, and with them are numerous coarse-ribbed Astartids usually identified as *Astarte mysis* d'Orbigny (*A. extensa* Phillips ?). This is an unmistakable horizon and may be matched in the Mutabilis Zone of Ringstead Bay and elsewhere.[1]

[1] I am inclined to agree with Beurlen (1926, pp. 115-16) in suppressing the Yo Zone of Salfeld as merely a Teilzone of the Mutabilis Zone. The index fossil has never been found in Britain, and in Swabia it is found in the Rasenia Zones.

Dr. Pringle identified the Rasenids on this horizon as "*Involuticeras desmonotus* (Oppel) and allied forms" (1923, p. 135). In the absence of any monograph on the family, precise identification of Rasenids is difficult, and I hesitate to put any specific names to these small forms for the present. *Ammonites desmonotus* Oppel has since been made genotype of *Aulacostephanoides* Schindewolf, which Spath claims is a synonym of *Pararasenia* Spath, and as I have pointed out recently (1935a), since the genotype of *Aulacostephanus* is *Ammonites mutabilis* J. de C. Sowerby, if Spath is right both genera are strictly speaking synonyms of *Aulacostephanus* Sutner and Pompeckj.

Since the specimens are crushed I have not been able to determine whether the ribs pass over the venter as in *Amm. involutus* Quenstedt, the genotype of *Involuticeras* Salfeld, or whether they are interrupted by a narrow ventral smooth band as in *Amm. desmonotus* Oppel, the genotype of *Aulacostephanoides,* and in *Amm. striolaris* Quenstedt, the genotype of *Rasenioides* Schindewolf. I am inclined to agree with Schindewolf in not attaching generic or subgeneric importance to this feature and to regard it as a character likely to appear in some of the species of any lineage. This character apart, it seems that these Norfolk forms cannot be identified with *Amm. desmonotus* Oppel because they are more evolute and the primary ribs are more prominent. A closer comparison is with *Amm. striolaris* Quenstedt (1887-8, pl. cxxiv, fig. 8), a species said to come from the White Jura delta, which Roll equates with the Pseudomutabilis Zone. Pending monographic treatment of the Rasenids, therefore, it seems best to identify these forms as *Rasenioides spp.* (*Amm. striolaris* Quenst. being the genotype). If the venter proves to be wholly ribbed, then a better comparison will be with *Rasenia lepidula* (Oppel).

In boring B, *Rasenioides* occurred 11 ft. below this level and a fragment of a coarsely ribbed body chamber, probably belonging to a large Rasenid, at 23 ft. below it. In boring C a Rasenid occurred at 12 ft. and a smooth septate whorl-fragment which might belong to either a *Pictonia* or a *Rasenia* of the *cymodoce* group at 14 ft. below this same level. In Setch boring (unpublished), in which the *Rasenioides* level can also be recognized, a well-preserved specimen of *Rasenia involuta* Salfeld occurred 6 ft. below it and a *Rasenia* cf. *uralensis* (d'Orbigny) 36 ft. below it. So much therefore certainly belongs to the Zones of *Rasenia mutabilis, Rasenia cymodoce* and *Pictonia baylei* and is still Kimeridgian. Downwards there seems to be an imperceptible lithological passage into the Corallian (Upper Oxfordian), and it is noteworthy that no signs were found of layers of *Ostrea delta* or a phosphate bed, such as occurs in Cambridgeshire at the junction. Palaeontologically we must place the junction at Setch, and therefore probably also at Southery, at least 36 ft. (say 38-40 ft.) below the *Rasenioides* level; *i.e.*, at depths of about 210 ft. in boring B, 250 ft. in boring C, and

290 ft. at Setch. This is in each case about 22 ft. lower than is proposed in Dr. Pringle's published accounts.

The next fossils in descending sequence are highly interesting, but being for the most part large shells they are tantalisingly incomplete owing to the small diameter of the core. Reckoning from the arbitrary but uniform base of the Kimeridge proposed above, we may recognize fragments of medium-sized to large *Amoeboceras* (*Prionodoceras*) at the following depths: at 2 ft. in boring B; 1 ft., 18 ft., and 25 ft. in boring C; and 25 ft. at Setch. Most of these cannot be identified specifically, but one or two are certainly *Prionodoceras* near to, if not identical with, *P. serratum* (J. Sowerby), and the others are in harmony with this identification. It is interesting to find them here concentrated in the highest 25 ft. of the Ampthill Clay. On the other hand they are more crushed than the beautiful specimens so common in the Drift, and no trace of *Perisphinctes variocostatus* or other Perisphinctids was found. It is, therefore, still uncertain what level yields the Drift fossils discussed above.

The remaining Corallian clays yielded fossils only in boring C. At 33 ft. and 40 ft. below the base of the Kimeridge Clay (*i.e.*, at depths of 283 ft. and 290 ft.), were obtained well-preserved specimens of *Amoeboceras* aff. *pseudocaelatum,* unmistakably the same forms as those from Long Stanton described above. These fossils are marked as from levels which would fall below the base of the Ampthill Clay according to Dr. Pringle's grouping (1923, pp. 128, 130), which therefore stands in need of revision. A more satisfactory base for the Corallian occurs 30 ft. lower, below the 2 ft. of limestone at 320-322 ft. in boring C, which expands to 3 ft. 9 in. in boring B (289 ft.-292 ft. 9in.). I know of no limestone of this thickness in the Oxford Clay, but it may correspond with the limestone near the top of the pit at Warboys brickyard near Huntingdon, which, as mentioned above, has yielded Perisphinctids of the Plicatilis Zone.

The only objection to this readjustment is the entry "*Quenstedtoceras sp.* at 270½ ft." in the published account of boring B (1923, p. 128). But there is no specimen from anywhere near this level preserved in the core-samples; and Dr. Pringle, who has also kindly looked for it, agrees that there must have been a mistake in a field identification.

At a level about 28-33 ft. below the limestone in both borings are abundant pyritized specimens of *Quenstedtoceras scarburgense* (Young and Bird), which abounds at Warboys brickyard and indicates the Mariae Zone. The same species was also obtained abundantly from the Upper Oxford Clay at St. Ives and at Fen Stanton brewery boring (Wedd, 1901). Wedd recorded them as *C. cordatus,* but his specimens are in the Geological Survey Museum and are undoubtedly *Q. scarburgense.* With them he found *Q. mariae.* It appears, in fact, that the true Cordatus (Cardia)

Zone is absent from Cambridgeshire, or if present is unfossiliferous and reduced in thickness, for the Plicatilis Zone seems to rest on the Mariae Zone in all these sections.[1]

The Kosmocerates from lower down in the Oxford Clay cannot be identified with the same degree of certainty. Since Dr. Pringle described the borings many Kosmocerates have been figured by S. S. Buckman and we have the advantage of Brinkmann's monographs. In the light of this new information I do not think the Kosmocerates from boring B at levels only 35-70 ft. below the *scarburgense* level represent the early forms recorded in the published section from those levels and again from 30 to 50 ft. lower in boring C. Only one specimen from boring B (360 ft.) is in my opinion identifiable, and that seems to resemble *K. phaeinum* S. Buckman, which Brinkmann includes in *K. proniae* Teisseyre, a species commonest in the Athleta Zone (as at Wolvercote, Oxford). Three specimens from 458 ft. and 470 ft. in boring C seem to be best identifiable with *K. grossouvrei* R. Douvillé (*cf. K. zugium* S. Buckman). A smaller one from a foot lower may possibly be *K. jason*. These come from less than 10 ft. above the Cornbrash in boring C, but *K. grossouvrei* is by no means a basal Oxford Clay form—Brinkmann calls it " Upper Middle Callovian " and states that it spans the Castor and Pollux (Reginaldi) and Duncani Zones. Much of the basal Oxford Clay is therefore missing as well as the Kellaway Beds.

The total thicknesses of the formations according to this regrouping are as follows :—

	Feet	
	Boring B.	Boring C.
Kimeridge Clay (lower half only) ...	143	147
Corallian clays and limestone	83	72
Oxford Clay	106+	158

The considerable thickness of the Corallian clays appears to be due mainly to expansion of the uppermost zones. In view of the occurrence of *Amoeboceras* aff. *pseudocaelatum* in these clays both in Norfolk and at Long Stanton, it seems necessary to assign at least 40 ft. of the highest of the Corallian clays of Norfolk to the Zone of *Ringsteadia pseudocordata*. The *Amoeboceras* is not, however, necessarily on exactly the same level at the two places. Further, the abundance of shells of *Prionodoceras*, some at least of which are near to *P. serratum*, in this highest 40 ft. suggests equivalence with the clay seen by Salfeld at Telford Road, Swindon, which he placed *below* the Zone of *Ringsteadia pseudocordata*, the horizon of the Long Stanton clays. Nevertheless, on consideration of all the evidence available, the view is at present favoured that this part of the Norfolk Clays is referable to the *Ringsteadia* Zone, giving the latter a greater thickness in Norfolk than at any other place in this country.

[1] My own examination of the Warboys pit, however, has been far too superficial to establish this point firmly. Detailed work on this fine section by a geologist who can visit it frequently would yield valuable results.

No less remarkable is the thinness of the Oxford Clay, of which the top and bottom portions appear to be missing.

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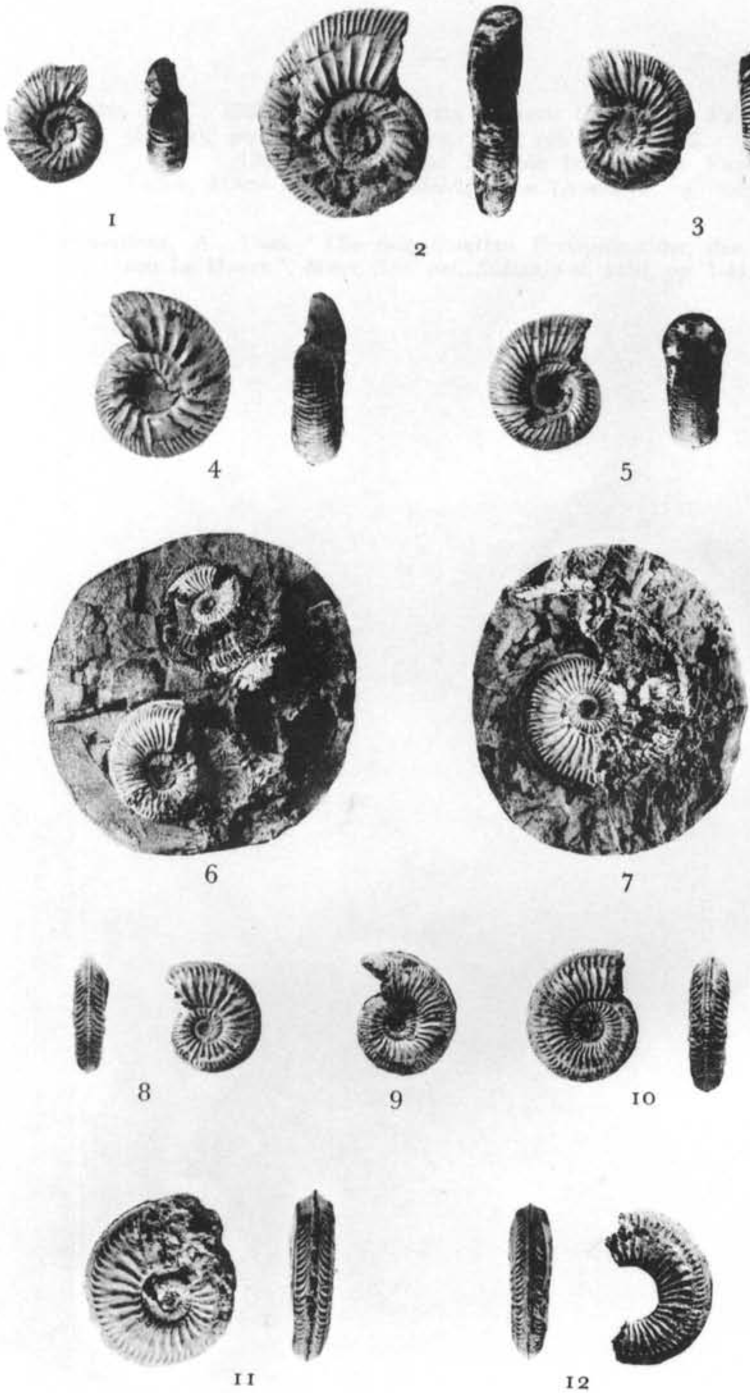


Photos by W. J. A.

AMPTHILL CLAY AMMONITES
FROM LONG STANTON, CAMBRIDGESHIRE.

Description of Plate III

Ammonites from Long Stanton, Cambridgeshire

1.	*Decipia sp.*, nucleus.	No. 54896	Bed 2.
2.	,, ,, ,,	No. 54897	,,
3.	,, ,, ,,	No. 54898	,,
4.	,, ,, ,,	No. 54899	Bed 1.
5.	*Perisphinctes sp.*, nucleus.	No. 54900	Bed 3.
6.	*Amoeboceras* aff. *pseudocaelatum* Spath.	No. 54901	Bed 3.
7.	,, ,, ,, ,,	No. 54902	,,
8.	,, ,, ,, ,,	No. 54903	,,
9.	,, ,, ,, ,,	No. 54904	,,
10.	,, ,, ,, ,,	No. 54905	Bed 5.
11.	,, ,, ,, ,,	No. 54906 (4)	,,
12.	,, ,, ,, ,,	No. 54907 (3)	,,

All photographs natural size, from specimens in the Geological Survey collection.

EXPLANATION OF PLATE IV

SECTIONS THROUGH THE KIMERIDGIAN, CORALLIAN, AND OXFORDIAN ROCKS IN SOME WEST NORFOLK BORINGS

Setch. Boring near West Winch, 3½ miles S. of King's Lynn. Height about 10 ft. O.D.

A. Boring at Decoy Farm, about 1¾ miles E. of Southery. Height about 5 ft. O.D.

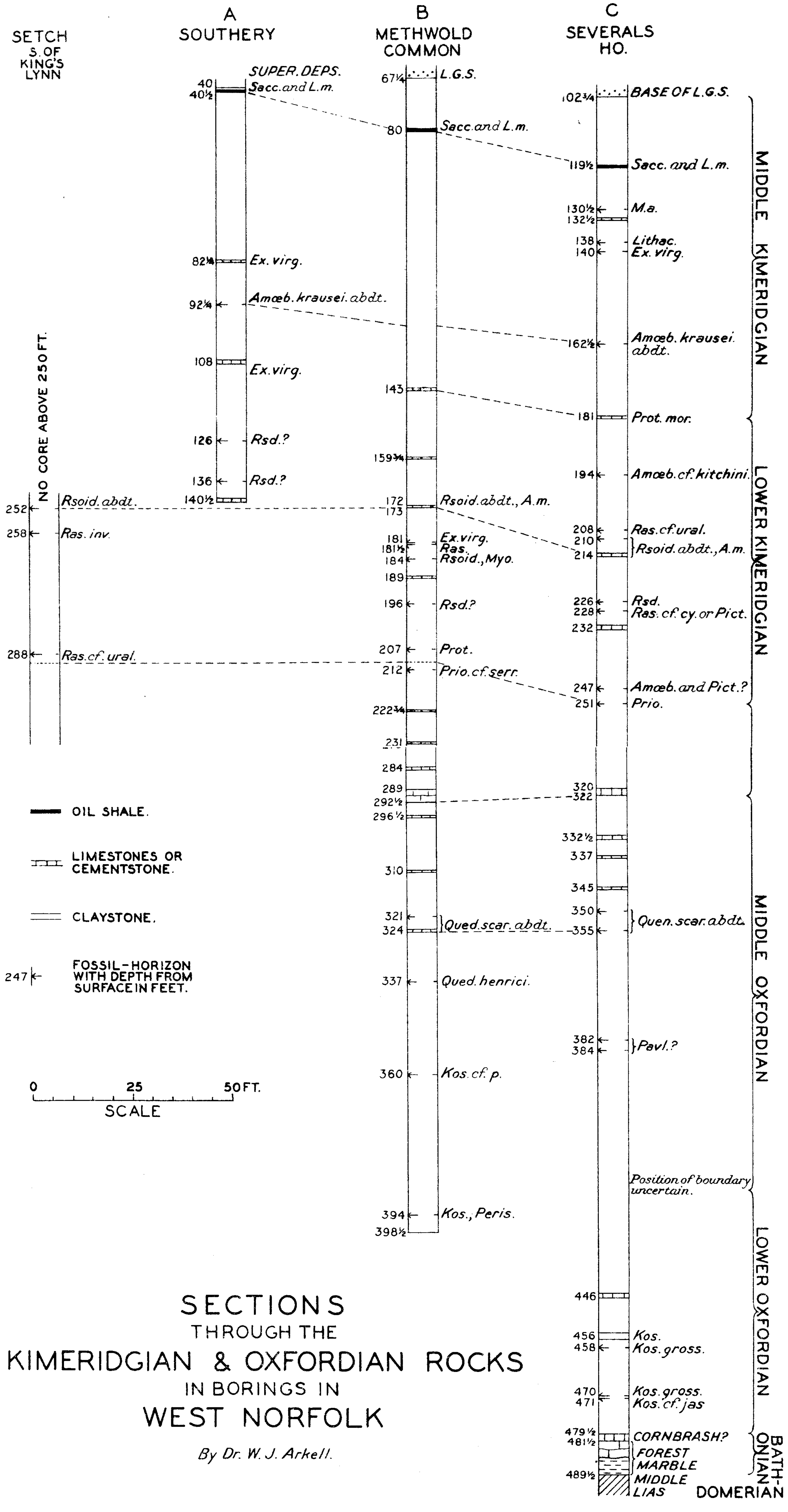
B. Boring on Methwold Common, about 3½ miles E. of Southery. Height 7 ft. O.D.

C. Boring, 1 mile N.E. of Severals Ho., 4½ miles E.N.E. of Southery. Height about 10 ft. O.D.

The Kimeridgian, Corallian and Oxfordian strata are clays or shales, with beds of oil-shale, limestone (or cementstone) and claystone at the horizons indicated on the sections.

Abbreviations

Abdt.	Abundant
Amoeb.	Amoeboceras
,, *aff.* ps.	,, *aff.* pseudocaelatum
A.m.	Astarte mysis
Ex. virg.	Exogyra virgula
Kos.	Kosmoceras
,, gross.	,, grossouvrei
,, *cf.* jas.	,, *cf.* jason
,, *cf.* p.	,, *cf.* proniae (*cf.* phaeinum)
L.G.S.	Lower Greensand
Lithac.	Lithacoceras
L.m.	Lucina minuscula
M.a.	Modiola autissiodorensis
Myo.	Myopholas
Pavl.	Pavloviceras
Prot.	Protocardia
,, mor.	,, morinica
Peris.	Perisphinctid
Pict.	Pictonia
Prio.	Prionodoceras
,, *cf.* serr.	,, *cf.* serratum
Quen.	Quenstedtoceras
,, scar.	,, scarburgense
Ras.	Rasenia
,, *cf.* cy.	,, *cf.* cymodoce
,, involuta	,, involuta
,, *cf.* ural.	,, *cf.* uralensis
Rsd.	Rasenid
Rsoid.	Rasenioides
Sacc.	Saccocoma
SUPER. DEPS.	Superficial Deposits



SECTIONS THROUGH THE KIMERIDGIAN & OXFORDIAN ROCKS IN BORINGS IN WEST NORFOLK

By Dr. W. J. Arkell.

PLATE IV