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## The Upper Oxford Clay at Purton, Wilts, and the Zones of the Lower Oxfordian

By W. J. ARKELL

### I. INTRODUCTION

**A**T Messrs. Hills' brickyard,  $\frac{1}{2}$  mile north-north-west of Purton Station and about 4 miles north-west of Swindon, Wiltshire, a large pit in Upper Oxford Clay (Lower Oxfordian) is worked by modern methods to a depth of over 60 feet. Ammonites are for the most part preserved as white powdery or flaky impressions, as in the Jordan Cliff Clay at Weymouth, and their collection involves technical difficulty. For help with the collecting and measuring I am indebted to Messrs. C. W. and E. V. Wright, and for every facility at the pit to Mr. Hill.

The section provides an interesting comparison with the large pits described almost simultaneously by Dr. L. F. Spath and myself at Warboys, Huntingdonshire (Spath, 1939), and Woodham, Buckinghamshire (Arkell, 1939), and with work on the Dorset coast, not yet published (Arkell, 1941?). Before the Purton pit can be described it is necessary to harmonize the results obtained and the terminology used at the other two pits, and to clear up some matters of nomenclature.

Dr. Spath's paper was published on 25th April, 1939, and mine, although read and published in abstract on 25th May,

1938, did not appear in full until 26th May, 1939. Luckily, however, none of the new names in the two papers clash and no alterations are necessary on that account. On the other hand, a number of new varieties of *Cardioceras praecordatum* Douvillé and *C. scarburgense* (Young and Bird) named by Dr. Spath are invalidated by a monograph on the genera *Quenstedtoceras* and *Cardioceras* published in the previous year (V. Maire, 1938) and the zonal terminologies employed need harmonizing.

## II. CARDIOCERAS PRAECORDATUM Douvillé and C. SCARBURGENSE (Young and Bird)

These two *Cardioceratids* are the commonest fossils at Purton and at Warboys. Both have been used as zonal indices. Sayn (1930, p. 228) and Maire (1938, p. 57) like previous authors accepted as types of *Cardioceras praecordatum* the fragments figured in Douvillé's monograph (1912*b*, p. 62, pl. iv, figs. 10-18).<sup>1</sup> Being of the same opinion, and considering these fragments inadequate as types and hardly identifiable, but for the most part capable of being matched with specimens which cannot be separated from typical *C. scarburgense* (Young and Bird, 1822), I placed *praecordatum* in the synonymy of *scarburgense* (Arkell, 1939, p. 157). Spath, however, although he equated the two species in 1933, now separates them and takes as holotype the small nucleus figured by Douvillé in a semi-popular article in *La Nature* published in the same year (Douvillé, 1912*a*, p. 246, text-fig. 7*b*). The date of the *La Nature* article is 9th March, 1912, but inquiries of three London libraries and the Bodleian, and of the Geological Society of France and the three most likely French professors, have failed to establish the date (even the month) of publication of Douvillé's monograph. However, in spite of the *a priori* improbability that Douvillé would have published the new name first in a semi-popular article, it seems likely that the monograph was held up until after the appearance of the article, for Douvillé gave the exact date of the article when referring to it in the monograph, and his remarks therein seem consistent with a change of genus from *Cardioceras* in the article to *Quenstedtoceras* in the monograph rather than *vice versa*. In his 1913 work he again used *Quenstedtoceras*.

<sup>1</sup> Maire excluded figs. 10, 13, 17, 18, without stating how they were to be interpreted.

If the *La Nature* nucleus be accepted as holotype of *Cardioceras praecordatum*, as seems indicated, it is important to notice that the original figure is reduced by 0.8. This is shown by the fact that the specimen of *Quenstedoceras brasili* figured beside it reappears natural size as pl. iv, fig. 3, of the monograph, where it is 1.25 times the diameter of the original figure.<sup>1</sup> Hence the holotype of *Cardioceras praecordatum* is about 16 mm. in diameter, and it is probably refigured, reversed, and the natural size, as pl. iv, fig. 13, of the monograph.<sup>2</sup>

Fixation of the type as the 1912*a* nucleus enables precision to be achieved in the interpretation of *Cardioceras praecordatum*. That nucleus is certainly distinguishable from *C. scarburgense* (Young and Bird, 1822) (holotype figured, Arkell, 1939, pl. x, figs. 1*a-c*). Comparison of specimens at progressively larger stages of growth shows that Douvillé's figures represent the form called var. *douvilléi* Maire (1938, p. 60), which I raised to specific rank (1939, p. 157), designating as lectotype *C. praecordatum* Douvillé, 1913, pl. vii, fig. 7 (synonym var. *praemartini* Spath, 1939, p. 92). For instance, a specimen of intermediate size to be figured in the Weymouth Memoir (Arkell, 1941?, pl. iii, fig. 4) is identical with the figures of the holotype of *praecordatum*. This result is a happy one, for it legalizes and stabilizes Douvillé's own interpretation of his species, published only a year after first publication of the name and since followed in nearly all the literature. If modern rules and terms had been current in 1913 Douvillé would have designated the better and commoner of his "deux beaux représentants" as neotype, for the 1913 figures were published expressly to supersede those of the nucleus and fragments previously published. While Douvillé's own virtual selection is thus literally correct now that the type is fixed, it is desirable to follow it rather than to accept as typical the nondescript English form ("not in place") figured as typical by Spath (1939, pl. vi, fig. 2), which is much more difficult to separate from *C. scarburgense*

<sup>1</sup> Acceptance of the priority of the *La Nature* article involves raising *Q. brasili* to specific rank with priority over *Q. henrici* and *Q. praelamberti* Douvillé (1912*b*, pp. 55-7).

<sup>2</sup> Spath, in referring to the "confusion increased" by my failure in 1933 to notice the error in Douvillé's plate iv, figs. 21-3, omits to mention that I was the first to point it out (Arkell, 1936, p. 176). Douvillé's fig. 21 (perhaps the same specimen as Douvillé, 1912*a*, fig. 7*c*), is a form of the Cordatus Zone near to *Cardioceras costellatum* Buckman. Maire (1938, p. 60) still has not noticed the error.

(Young and Bird). I therefore regard as neotype *C. praecordatum* Douvillé, 1913, pl. vii, fig. 7, a neotype being necessary to show the characters which the holotype is too small to show.

The distinctions which Spath (1939, p. 90) adduces between *C. scarburgense* and *C. praecordatum* still apply, and with added force: "The latter species has more flexuous and more projected ribbing as well as more pronounced keel and, indeed, is altogether a more typical *Cardioceras*."

Of the eleven new varieties and one mutation named by Maire and Spath, many overlap. The following notes indicate the meanings of the names still held to be valid and those which fall in synonymy.

1. *Cardioceras (Scarburgiceras) scarburgense* (Young and Bird). Holotype figured by Arkell (1939, p. 156, pl. x, fig. 1). In practice, *C. praecordatum* var. *transitoria* Spath (1939, p. 92, pl. vi, figs. 5, 6) cannot be distinguished. It is identical with specimens I matched with the type when on loan from Whitby, as being closest to the true *scarburgense* of all the material from Woodham and Warboys pits.
- 1a. Var. *intermedia* Maire (1938, p. 58, pl. vi, fig. 6, now designated lectotype). Synonym var. *normandiana* Spath\* (1939, p. 90). Ribs number about thirty-two at 30 mm. instead of about twenty-four in the type form.
- 1b. Var. *crassa* Spath (1939, p. 90, pl. vii, fig. 12). Ribs number about twenty-one at 30 mm. and are coarser; coiling more involute.
2. *Cardioceras (Scarburgiceras) praecordatum* Douvillé. Holotype figured Douvillé (1912a, fig. 7b ( $\times 0.8$ ), and 1912b, pl. iv, fig. 13, natural size). Neotype figured Douvillé (1913, pl. vii, fig. 7). Synonyms var. *douvillei* Maire (1938, p. 60), and var. *praemartini* Spath (1939, p. 92).
- 2a. Var. *mixta* Maire (1938, p. 61, pl. vi, fig. 12). This seems to cover "mut  $\beta$ " of Spath (1939, p. 93, pl. vi, figs. 3, 9).
- 2b. Var. *stricta* Maire (1938, p. 58, pl. vi, figs. 7, 8; pl. vii, fig. 1). Lectotype pl. vi, fig. 7, now designated. Synonym var. *extremis* Spath (1939, p. 93), based on *C. praecordatum* Sayn (1930, pl. xxi, fig. 13). Ribs occasionally branch a second time before meeting the keel.

Maire also named a *C. praecordatum* var. *multicostata* (1939, p. 59, pl. vii, fig. 2) and a var. *bukowskii* (1939, p. 64, pl. vii, fig. 8), better regarded as a separate species. The latter was called a separate species by Maire in the explanation of his plate vii, and it provides a better name than the doubtfully identical Alaskan *C. martini* Reeside for the common *Scarburgiceras* of the Yorkshire Lower Calcareous Grit.

Douvillé's coarse-ribbed "beau représentant" (1913, pl. vii, fig. 6), which Maire (1938, p. 57) places in the synonymy of *C. praecordatum sensu stricto*, is believed to be the nucleus of a different species, perhaps *C. alphacordatum* Spath (1939, pl. vi, fig. 10). Maire's own figures from other French localities

(1938, pl. vi, figs. 3, 4) show varieties of *C. scarburgense*. Fig. 4 is var. *transitoria* Spath, fig. 3 is var. *crassa* Spath.

### III. CORRELATION OF WOODHAM AND WARBOYS PITS

At first sight it seems that beds A and B at Woodham (the *Mariae* Clays) are equivalent to beds 1-3 at Warboys (Spath's Lower *Mariae* Zone). The impression is enhanced by the chance that the beds in both pits measure 29 feet in thickness. Moreover, as I had predicted (1939, p. 206), some of the ammonites peculiar to collections from Warboys and St. Ives, and absent from Woodham, have proved to come from strata higher than beds 1-3 (*Quenstedtoceras stibarum* Buckman sp., *Oekotraustes scaphitoides* Coquand sp., *Peltoceras* cf. *eugenii* Raspail sp., recorded from Spath's beds 4 and 5, Spath, 1939, pp. 86-7).

There are certain facts, however, which indicate that the bottom of Warboys pit does not reach down so far as the top of Woodham pit and that there is no overlap of the two sections. In particular, Spath states (p. 85) that the true *Cardioceras praecordatum* (= *douvillei* Maire = *praemartini* Spath) occurs throughout his beds 1-6; whereas among over 150 *Cardioceras* so far collected at Woodham pit there is only a single example of this form, a limonitic cast not found in situ, possibly from the soil. Moreover, the abundance of *Creniceras renggeri* in the lowest 12 feet of beds A and B at Woodham and its absence from beds 1-3 at Warboys is remarkable, and is not adequately explained by the appearance of *C. renggeri* and *C. crenatum* through a range of 13 ft. 6 in. of strata in beds 7 and 8, some 50 feet higher up and above the range of *Q. mariae*. The association of *C. renggeri* with *Q. mariae* and *C. scarburgense* in Buckinghamshire, Yorkshire, Surrey, the Boulonnais, and farther afield, makes it probable that *Mariae-Renggeri* Beds exist also at Warboys but lie below the floor of the pit. The reappearance of *renggeri* with *crenatum* at a much higher level may be compared with a recent record from bed H 13 in Normandy, only a few feet below the *Oolithe ferrugineuse* (Mercier, 1936).

### IV. THE SUCCESSION AT PURTON BRICKYARD

Zonal collecting at Purton pit is rendered more difficult than at Warboys or Woodham, not only by the inferior preservation of the ammonites; but also by the absence of stone bands. The main mass of the section consists of 60 feet of unbroken

clays, most of it exposed on a steep face. Consequently the sequence was measured off arbitrarily from the floor of the pit (in May, 1939) into six beds, each with a thickness of 10 feet. This arrangement has the advantage that the top of bed 3 coincides with the main platform in the middle of the section, and that the tops of beds 1 and 5 correspond with important changes of fauna. Even in the driest part of the summer, in June, 1939, the base-level stood under 6 feet of water. In May, 1940, beds 1 and 2 were submerged.

Purton pit does not overlap Woodham, but shows the same zones as Warboys, plus an interesting development of the Cordatus Zone, in the facies of the Red Nodule Beds of Dorset.

The following notes describe the ammonite succession traced through the six beds, from the base upwards.

Bed 1 (0-10 feet).—From water level to 10 feet above datum were 4 feet of clay, the lower part crowded with *Peltocheras arduennense* (d'Orbigny), *P. choffati* de Loriol, *P. cf. gerberi* Prieser, and occasional *Cardioceras praecordatum* Douvillé and *Quenstedtoceras aff. mariae* (d'Orbigny). Also *Hibolites hastatus* and crinoid ossicles.

Bed 2 (10-20 feet).—Abundant *Cardioceras praecordatum* Douvillé. Crushed *Grossowria* sp. Many *Gryphaea dilatata* and *Hibolites hastatus*.

Bed 3 (20-30 feet).—No change in the fauna, but ammonites less common. At 2 feet from top a giant spinous *Aspidoceras* in fragments (? *loricatum* Bean MS., Spath).

Bed 4 (30-40 feet).—Cardiocerates very abundant, belonging to species characteristic of the Ball Beds at the top of the Scarborough Lower Calcareous Grit, though for the most part unnamed. Most characteristic are *C. bukowskii* Maire (= *C. martini* var. *anglica* Spath), *C. (Vertebriceras)* sp. nov., *C. anacanthum* Buckman, and *C. svelta* Maire (synonym *C. suessi-forme* Spath) (all found at Scarborough). All these forms will be figured in my monograph on Corallian Ammonites.

Bed 5 (40-50 feet).—Some of the same Cardiocerates but less common. *C. bukowskii* ranges up at least to within 2 feet of the lowest band of red nodules. *Gryphaea dilatata*. Three black streaks in beds 4 and 5 do not keep to bedding planes and seem to be of tectonic origin.

Bed 6 (50-65 feet).—Red Nodule Beds. Pale grey clays with lines of red and grey kidneystones, some containing well-preserved

(uncrushed) casts as at Weymouth. *Cardioceras costicardia* Buckman, *C. (Vertebriceras) quadrarium* Buckman, *Peltoceras (Peltoceratoides) constantii* (d'Orb.), *P. (Parawedekindia) schlosseri* Prieser.

There are at least 100 feet of Oxford Clay above the highest bed seen in the pit and below the Lower Calcareous Grit which crops out in the neighbouring escarpment at Paven Hill, unless there is a fault in between. No exposures have been seen in these beds. The clay changes to loam at about the base of the big landslip at the N.E. extremity of Paven Hill and there follow about 60 feet of loams and loamy sands before the Coral Rag is reached. The position of the brick pit in relation to the geology of the district is shown in Arkell 1941a.

The chief point of interest in this section is the presence of the characteristic *Cardioceras* fauna of the Ball Beds of the Scarborough Lower Calcareous Grit (beds 4 and 5), underlying the Red Nodule Beds of Weymouth (bed 6), with their characteristic fauna. For the first time these two faunas are seen in a single section and their order of succession is established.

Bed 6 of Purton is represented by a non-sequence above bed 8 at Warboys (Spath, 1939, p. 89). Beds 4 and 5 of Purton (20 feet) presumably correspond approximately with bed 8 at Warboys (23 feet), but the local distribution of ammonites at Warboys (Spath, 1939, p. 84) is not recognizable at Purton. Beds 1 to 3 of Purton (30 feet) may be assumed to be the equivalents of approximately beds 4 to 6 at Warboys (21 ft. 6 in.). Beds 1 to 5 at Purton are represented in Dorset by part of the Jordan Cliff and Furzedown Clays.

## V. ZONAL SEQUENCE AND TERMINOLOGY

One of the unequivocal results of recent studies on the Oxford Clay of Dorset, Oxford, and Woodham Pit has been to establish the distinctness of the Lamberti and Mariae Zones. "The most satisfactory palaeontological line of separation between the Callovian and Oxfordian would be between the Lamberti and Mariae Zones" (Arkell, 1939, p. 213). Hence the Mariae Zone cannot be considered a subzone of the Lamberti Zone (Spath, 1939, p. 84).

The characteristic fauna of the Mariae Zone is *Q. mariae*

(d'Orb.), *Q. omphaloides* (Sowerby), *Cardioceras scarburgense* (Young and Bird), *Creniceras renggeri* (Oppel), and *Taramelliceras richei* (de Loriol). This fauna is especially abundant and typical in the lowest 29 feet of the Mariae Zone as exposed at Woodham, and there *C. praecordatum* does not occur. At Warboys Spath describes another 29 feet of Mariae beds (1-3) in which *C. scarburgense* and *C. praecordatum* occur together; and since his var. *transitoria* is shown to range throughout his beds 4 to 6 (Spath, 1939, p. 84) a further 21 ft. 6 in. must be included in the beds with both *scarburgense* and *praecordatum*. At Warboys Spath does not mention any beds characterized by *Cardioceras praecordatum* alone, but 30 feet of such beds (without *C. scarburgense*) are seen at Purton (beds 1 to 3), and these are higher than at least beds 1 to 3 at Warboys. This is the Praecordatum Zone of de Grossouvre, Buckman, and Morley Davies.

The Mariae Zone may therefore be divided into three subzones: a lower subzone with *C. scarburgense* (Woodham); a middle with *scarburgense* and *praecordatum* (Warboys); and an upper with *C. praecordatum* only (Purton); the thickness of each subzone being at least 30 feet.

At about the junction of beds 3 and 4 at Purton there is an important change of fauna. The subgenus *Scarburgiceras* continues to be represented, but by a form with ribs that are still finer than those of *praecordatum*, and projected more acutely at the ventral margin, to form a completely differentiated keel. This is a species that abounds in the Ball Beds at the top of the Lower Calcareous Grit of Scarborough. The correct name for it appears to be *C. (S.) bukowskii* Maire (synonym *C. martini* var. *anglica* Spath). Some specimens are much larger than others, and more than one species may be represented. With this form comes in an abundance of *Cardioceras* of other subgenera, not previously represented, but all characteristic of the Scarborough Ball Beds. Here for the first time appear strong tuberculate primary ribs, square shoulders, and flat venters; but not yet, apparently, large smooth body-chambers. None of the forms seems to exceed about 3 or 4 inches in diameter. Among them are early *Cardioceras sensu stricto* and an unnamed *Vertebrioceras*, characteristic of Scarborough.

Of these forms *C. bukowskii* is recorded from beds 7 and 8 at Warboys, and *C. svelta* Maire (= *suessiforme* Spath) from bed 8. These two highest beds (7 and 8, 30 feet) Spath calls the subzone of *C. martini* var. *anglica* (= *bukowskii*) and *C. praecordatum* mut  $\beta$  (? synonym of var. *mixta* Maire), and he

assigns it to the *Cordatus Zone sensu lato*. At Purton and at Scarborough there is no "mut  $\beta$ ", from which it may perhaps be inferred that most of the Warboys beds 7 and 8 are rather lower than the Purton beds 4 and 5: perhaps an earlier part of the same subzone. It is now proposed to call the Purton and Scarborough beds the *Bukowskii Subzone* of the *Cordatus Zone*.

Finally with bed 6 there enters a third fauna of *Cardiocerates*, accompanied by some large *Peltocerates*. This fauna has been listed by me on several previous occasions as characteristic of the Red Nodule Beds of Weymouth, the Oolithe ferrugineuse of Normandy, the Studley Clay near Oxford, and the Lower Elsworth Series of Cambridgeshire. The species are all distinct from those in the Ball Beds, except *Goliathiceras goliathum* (d'Orbigny), which occurs in both. Some of the *Cardiocerates*, however, occur in the Hambleton Oolite Series (especially the Passage Beds) of the Yorkshire Coast, which are the home also of the large *Peltocerates*, *P. (Peltoceratoides) williamsoni* (Phillips), *P. constantii* (d'Orb.), *P. hoplophorus* Buckman, and others. This is the *Cordatus Zone* par excellence of d'Orbigny and other writers, which Spath (1939, p. 84, and earlier papers) calls the *Cardia Zone* or *Cardia Subzone*. There are two objections to this name, however. In the first place, if it is thought necessary to use a different name for the index fossil owing to a divergent interpretation of *C. cordatum*, Buckman's *cardia* will not do, because it is a synonym of *Cardioceras subcordatum* Pavlow (1913, p. 48).<sup>1</sup> In the second place, and more serious, the true *C. cordatum* (J. Sowerby's, fig. 4) (= *subcordatum*, = *cardia*) does not occur in this fauna. It has been found in England probably at only two localities, in the Lower Calcareous Grit of the Seend district, Wiltshire,<sup>2</sup> and the Lower Calcareous Grit of the Birdsall and Malton district of Yorkshire. In both places it is associated with a fauna of other *Cardiocerates* closely allied to it but not found in the Red Nodule Beds assemblage: fairly large *Cardioceras sensu stricto* with smooth body-chambers. The position of this fauna relative to the others has not been proved by direct observation, but it may be inferred to be later, and it might be expected in the lower parts of the Nothe Grits in Dorset and perhaps the Lower Limestone (Hambleton Oolite)

<sup>1</sup> Not invalidated by *Ammonites subcordatus* d'Orbigny, 1845, *Géol. Russie*, p. 434, pl. xxiv, figs. 6, 7, a Kimeridgian *Amoeboceras*.

<sup>2</sup> The type specimen is in the Calcareous Grit matrix of this district, not Oxford Clay as asserted by Healey and Buckman. The original label probably read "Hinton near Semington".

|                 | Zoues    | Subzones                             | Dorset                               | Purton   | Woodham   | Warboys      | Yorkshire                               |
|-----------------|----------|--------------------------------------|--------------------------------------|--|-----------|--------------|---|
| LOWER OXFORDIAN | CORDATUM | cordatum<br>(= subcordatum = cardia) | ? Nothe Grits                        | [Calcareous Grit of Seend]<br>Clay not exposed |           |              | Calcareous Grit of Birdsall             |
|                 |          | costicardia                          | Red Nodule Beds                      | Red Nodule Beds                                |           |              | Passage Beds of the coast               |
|                 |          | bukowskii                            |                                      | Beds 4, 5                                      |           | Non-sequence | Scarborough Ball Beds                   |
|                 | MARIÆ    | praecordatum                         | Jordan Cliff Clay and Furzedown Clay | Beds 1-3                                       |           | Bed 8        | ? Lower Calcareous Grit and Oxford Clay |
|                 |          | praecordatum and scarburgense        |                                      |  |           | Beds 1-7     |   |
|                 |          | scarburgense                         |                                      |  | Beds A, B |              |   |
|                 | LAMBERTI |                                      | Tidmoor Point Clay                   |  | Bed C     |              | Hackness Rock                           |

Revised correlation table of the Lower Oxfordian at English localities.

in Yorkshire. If this inference is correct, the Lower Calcareous Grit of Birdsall is later than the Passage Beds of Scarborough ; namely, on approximately the horizon of the Lower Limestone north of the Vale of Pickering and Coxwold Gap. At Purton there is plenty of room for the subzone in the 100 feet of unexposed clay and 60 feet of Calcareous Grit above the highest bed seen in the pit.

Provisionally, therefore, the Cordatus Zone is divided into three subzones, of which the two lowest are fixed by observation at Purton and in Yorkshire, and the highest is still inferential. Appropriate indices are *C. bukowskii* Maire, *C. costicardia* Buckman, and *C. cordatum* (J. Sowerby) (= *subcordatum* Pavlow) (see Table herewith).

The Vertebrale Zone, referred to by Spath in numerous papers (lastly in 1939, p. 89) has no existence in fact, since *C. vertebrale* is a fossil of the Plicatilis Zone in its type district (Oxfordshire and Berkshire). It has forerunners in earlier zones, for example, *C. (V.) quadrarium* Buckman in the Red Nodule Beds and *C. (V.)* sp. nov. in the Ball Beds of Scarborough and bed 4 at Purton.

Nor is there any separate Excavatum Zone (Spath, 1939), for *C. excavatum*, like *C. vertebrale*, is a characteristic companion of *Perisphinctes plicatilis* in the type locality.

The Cordatus Zone is in fact immediately followed by the Plicatilis Zone (Arkell, 1936, p. 153), of which the earliest ammonite-bearing beds are either the epibole with *Aspidoceras catena* at Marcham, Berkshire, or those with small Cardiocerates at Arngrove, Bucks (Arngrove Stone) and Heersum near Hanover (Lower Heersum Beds). Further discussion of the Plicatilis Zone, however, lies outside the scope of this paper.

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or when types or single specimens alone are available, but for casts preserved in argillaceous sediments, particularly when these are soft, the phenol formaldehyde plastic is preferred because the impression is permanent and unshrinkable.

W. F. WHITTARD.

THE UNIVERSITY,

BRIEGL.

15th March, 1941.

### THE UPPER OXFORD CLAY AT PURTON

SIR,—On page 170 of the May-June number of the *Magazine* the compositor has not quite accurately copied the correlation table. In the Warboys column the broken line representing the non-sequence should have been placed about an eighth of an inch higher, so as to include some of the Bukowskii Sub-zone. In the Woodham column, beds A, B should have been shown as almost as thick as the Scarburgense Sub-zone.

W. J. ARKELL.

BOYNE COURT,

BOSSDON ROAD,

MAIDENHEAD.

9th June, 1941.

### THE "DUNGHAN" LIMESTONE, AND RANIKOT BEDS IN BALUCHISTAN

SIR,—In my last letter (1941) I referred to collections recently made by the Burmah Oil Company on or near Dunghan Hill. The company have since sent these collections to me, and preliminary examination shows them to be of considerable stratigraphic interest.

One collection is from a section (29° 51' : 68° 19') on the Dunghan Range, where 1,215 feet of "Dunghan Limestone" had been judged to succeed Parh Limestones and intermediate beds of Cretaceous age. I found that the first 500 feet of this "Dunghan Limestone" is of Lower to Upper Macstrichtian age, having *Orbitoides media* d'Archiac in its earlier levels and *Omphalocyclus macropora* Lamarck in its later ones. The middle of the "Dunghan Limestone" contains at least 260 feet of Upper Ranikot beds, in which *Miscellanea miscella* abounds. Only the uppermost 230 feet or so of this "Dunghan Limestone" is of Laki age; *Alveolina globosa* Leymerie, *Alveolina ovoidea* d'Orbigny and *Sakesaria cotteri* Davies being its most notable contents. This fauna resembles that of the Sakesar Limestone of the Salt Range (Davies, 1937) more than the Laki of the Bolan region (Nuttall, 1925).