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STRATIGRAPHY

Biostratigraphy of Oxfordian Limestones from the Zawodzie Quarries in Częstochowa Polish Jura Chain

by

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The quarries at Zawodzie, a suburb of Częstochowa, have been known for over one century. The nearly 50-meter section of Oxfordian limestones with rich ammonite fauna, here exposed, was considered a "classic" for the Upper Jurassic of Poland by Koroniewicz and Rehbinder [4], and Różycki [10], who proposed a lithostratigraphical unit of "Zawodzie Beds". Although these exposures have been the subject of numerous investigations the age of the limestones has been evaluated variously. These deposits were ascribed to the Malm β by Zejszner [13], to the P. transversarium zone and the lowest part of the P. bimammatum zone by Bukowski [1], to the P. transversarium zone by Siemiradzki [12], and Koroniewicz and Rehbinder [4], to the A. perarmatum, the P. transversarium and the P. bimammatum zones by Premik [8] and to the P. chloroolithicus zone and the P. martelli and P. wartae zone by Różycki [11]. In spite of numerous studies, the ammonite sequence of this section has been characterized in a rather general fashion. The present paper represents the first attempt at a more exact determination of this sequence. The ammonite sequences of the older, i.e. Lower Oxfordian deposits from the vicinity of Częstochowa were already studied by Malinowska [5].

The erosional limit of the outcrops of Oxfordian deposits passes through Częstochowa in a NW—SE direction. The Zawodzie quarries are situated on a cuesta, formed in the Oxfordian limestones overlying sandy and clayey Bathonian and Callovian deposits. The boundary between the Oxfordian limestones and underlying Jurassic deposits is concealed by a Quaternary cover. At present only 3 out of 7 quarries in Zawodzie are being worked, but the deposits in question are quite well exposed in all of them. The Zawodzie quarries are rather large — 150 to 250 m wide, and the exploitation walls reach up to 14—23 m. In the particular quarries various parts of the Oxfordian section are exposed. The quarries are separated and deposits occurring in them are cut by numerous faults. Particular columns from almost all outcrops were correlated on the basis of a characteristically uniform marker bed (Fig. 2, bed 14) and the generally constant thickness of the beds.

The following beds form outcrops in particular quarries (see Fig. 2): quarry 1 — beds 3—26; quarry 2 — beds 12—32; quarry 3 — beds 1—20; quarry 2 — beds 9—26; quarry 5 — beds 12—16 and 20—39. The column from quarry 6, probably the youngest, was not correlated with the others because of its isolation and the

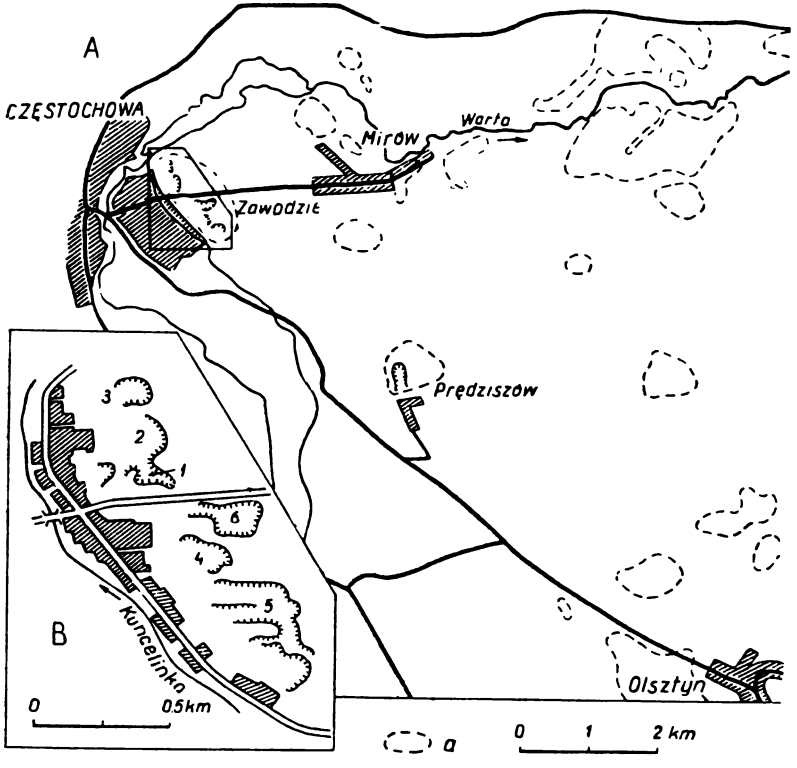

Fig. 1. A — Upper Jurassic outcrops in the eastern vicinities of Częstochowa
a — Upper Jurassic outcrops, B — sketch of Zawodzie quarries

absence of suitable marker beds. Bed 1 from quarry 3 is the oldest one presently exposed at Zawodzie. On the basis of fauna cited by Bukowski [1], Różycki [11] and others, it may be supposed that some slightly older Oxfordian deposits were also exposed at Zawodzie in the past.

Lithological remarks

The limestones occurring at Zawodzie are thick-bedded (30—200 cm), white or light-yellow coloured, porous and not very compact. Limestones of this type have been called "platy" by previous authors. In thin sections, calcilutite and fine-grained calcarenite are observed. They are composed mainly of pellets and larger aggregation grains of micrite. Microonkoids are quite common. Skeletal debris is always present but in lesser amounts.

Sponges, ammonites, brachiopods, serpulids and crabs predominate in the limestones under discussion.

The bedding of the limestones is accentuated by thin (0.5—2.0 cm) intercalations of marls only in the lower and middle part of the section. Irregular siliceous nodu-

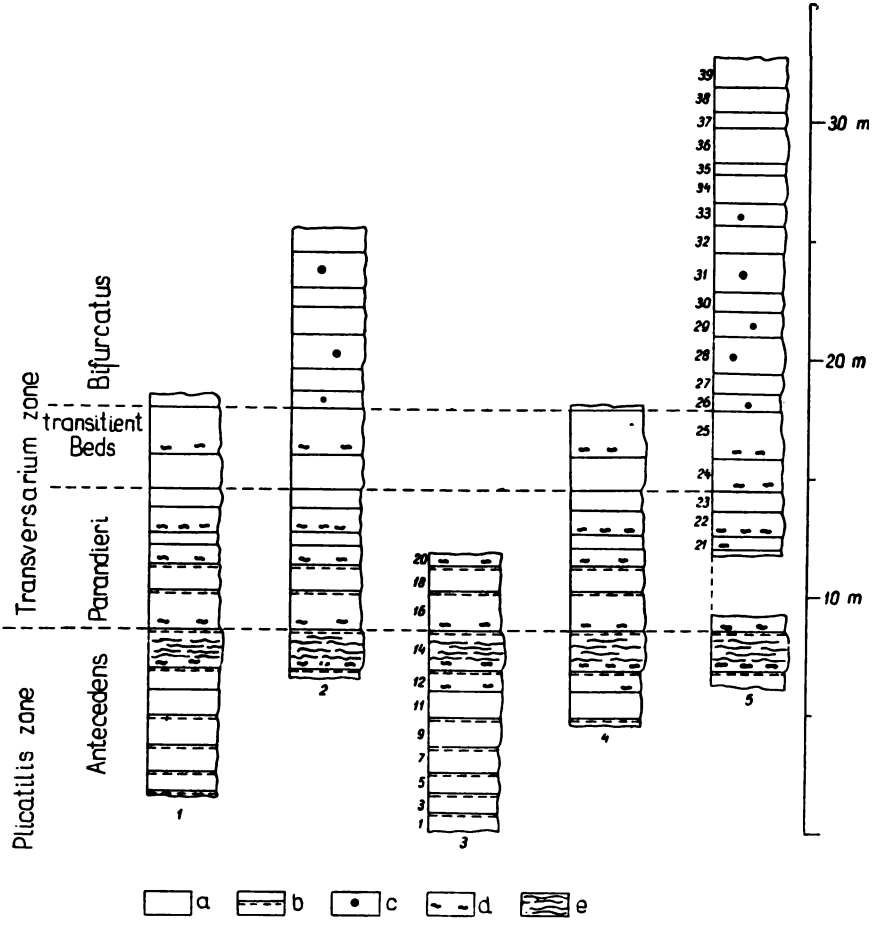

Fig. 2. Correlation of columns from quarries 1—5

a) limestones, b) marly intercalations, c) spherical siliceous nodules, d) irregular siliceous nodules, e) marker bed

les, distributed parallel to the bedding, occur quite often in the middle part of the section. Their number decreases gradually in the upper part, where spherical siliceous nodulus begin to appear, but in noticeably smaller numbers.

The marker bed (14th) mentioned above, is built of relatively compact and resistant limestone with siliceous bands especially rich in skeletal debris. This bed was found in all quarries except the 6th.

Distribution of ammonites in section

The ammonites listed below are kept in the collection of the Institute of Geology, University of Warsaw.

Bed 3: *Glochiceras subclausum* (Opp.): *Campylites* (*Neoprionoceras*) *lautlingen is* (Rol.).

Bed 7: *Aspidoceras* (*Euaspidoceras*) *paucituberculatum* Ark.; *Lithococeras* (*Discosphinctes*) sp.; *Perisphinctes* (*Perisphinctes*) sp.

Bed 9: *Glochiceras* cf. *distortum* (Buk.).

Bed 11: *Ochetoceras* cf. *canaliculatum* (Buch); *Ochetoceras hispidum* (Opp.) *Perisphinctes* (*Dichotomosphinctes*) *antecedens* Salf.; *Lithacoceras* (*Discosphinctes*) *jelskii* (Siem.); *L.* (*D.*) sp.

Bed 12: *Cardioceras* (*Subvertebriceras*) sp.; *Perisphinctes* (*Perisphinctes*) sp.

Bed 14: *Creniceras* cf. *crenatum* (Brug.); *Ochetoceras hispidum* (Opp.); *Taramelliceras* (*Taramelliceras*) *callicerum* (Opp.); *T.* (*T.*) cf. *callicerum* (Opp.) — 3 specimens.

Bed 16: *Perisphinctes* (*Ampthillia*) sp.; *P.* (*Dichotomosphinctes*) *buckmanni* Ark.; *P.* (*D.*) *wartae* (Buk.); *P.* (*D*) sp.; *Lithacoceras* (*Discosphinctes*) cf. *mindowe* (Siem.).

Bed 18: *Taramelliceras* (*Taramelliceras*) *bachianum* (Opp.).

Bed 20: *Campylites* (*Neoprionoceras*) *henrici* (d'Orb.); *Perisphinctes* (*Dichotomoceras*) *wartae* (Buk.) — 2 specimens; *P.* (*D.*) *elisabethaeformis* Buckl.; *P.* (*D.*) sp.; *Lithacoceras* (*Discosphinctes*) sp.

Bed 21: *Campylites* (*Neoprionoceras*) *henrici* (d'Orb.); *Perisphinctes* (*Perisphinctes*) *martelli* (Opp.); *P.* (*Dichotomosphinctes*) *wartae* (Buk.); *P.* (*D.*) *elisabethaeformis* Buckl.; *Lithacoceras* (*Larcheria*) sp.; *L.* (*Discosphinctes*) *mindowe* (Siem.); *L.* (*D.*) cf. *kreutzi* (Siem.); *L.* (*D.*) sp.

Bed 22: *Aspidoceras* (*Euaspidoceras*) *paucituberculatum* Ark.; *Perisphinctes* (*Perisphinctes*) *martelli* (Opp.); *P.* (*P.*) sp.; *P.* (*Dichotomsphinctes*) *wartae* (Buk.) — 5 specimens; *P.* (*D.*) *elisabethae* (de Riaz); *Lithacoceras* (*Discosphinctes*) *mindowe* (Siem.); *L.* (*D.*) *kreutzi* (Siem.).

Bed 23: *Perisphinctes* (*Perisphinctes*) *martelli* (Opp.); *P.* (*Liosphinctes*) *laevipickeringius* Ark.; *P.* (*Dichotomosphinctes*) *wartae* (Buk.); *Lithacoceras* (*Larcheria*) sp.; *L.* (*Discosphinctes*) sp.

Bed 24: *Perisphinctes* (*Perisphinctes*) *panthieri* Enay; *P.* (*Arisphinctes*) *pickeringius* (Y. and B.); *P.* (*Dichotomoceras*) *bifurcatoides* Enay; *Lithacoceras* (*Discosphinctes*) sp. — 2 specimens.

Bed 25: *Taramelliceras* (*Strebliteceras*) *externnodosum* (Dorn); *Perisphinctes* (*Arisphinctes*) *pickeringius* (Y. and B.); *P.* (*Dichotomosphinctes*) sp. — 2 specimens; *P.* (*Dichotomoceras*) *bifurcatoides* Enay; *Lithacoceras* (*Discosphinctes*) sp. — 2 specimens.

Bed 26: *Aspidoceras* (*Euaspidoceras*) *oegir* (Opp.); *Perisphinctes uptonioides* Enay; — 2 specimens; *P.* (*Dichotomoceras*) sp.

Bed 27: *Trimarginitus arolicus* (Opp.); *Aspidoceras* (*Euaspidoceras*) *oegir* (Opp.); *Perisphinctes* (*Perisphinctes*) *cautisnigrae* Ark.; *P. uptonioides* Enay;

Bed 28: *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.); *P.* (*D.*) *bifurcatoides* Enay; *P.* (*D.*) sp.

Bed 29: *Aspidoceras* (*Euaspidoceras*) *oegir* (Opp.); *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* Enay.

Bed 30: *Perisphinctes* (*Perisphinctes*) *variocostatus* (Buckl.); *P.* (*Dichotomoceras*) *bifurcatus* (Qu.) — 3 specimens; *P.* (*D.*) *grossouvrei* (Siem.); *P. bonarelli* (Siem.).

Bed 31: *Taramelliceras* (*Taramelliceras*) *costatum auritum* (Hölder); *Aspidoceras* (*Euaspidoceras*) *oegir* (Opp.); *Persphinctes uptonioides* Enay; *P.* (*Dichotomoceras*) *bifurcatus* (Qu.) — 2 specimens.

Bed 32: *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.).

Bed 34: *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.).

Bed 37: *Aspidoceras* (*Euaspidoceras*) sp.

Bed 38: *Perisphinctes Dichotomoceras bifurcatus* (Qu.); *Amoeboceras alternans* (Buch).

Bed 39: *Taramelliceras* (*Taramelliceras*) *callicerum* (Opp.); *T.* (*T.*) sp.; *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.); *P.* (*D.*) sp. sp.

Ammonite fauna from quarry 6 is noticeably less frequent. In this 14-m column only a few sufficiently preserved ammonites were found, and among them predominated the forms belonging to subgenus *Dichotomoceras*. Two specimens of *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.) and one specimen of *P.* (*D.*) *grossouvrei* (Siem.) were found here.

Paleontological comment to the ammonites illustrated

Some ammonites stratigraphically important or interesting for other reasons are presented in Plates I—X. Measurements are given in the Plates. The following abbreviations were used: D — diameter, D Ph — diameter of phragmocone, H — height of whorl, W — whorl width, U — outside umbilical diameter, R/D — number of ribs at given diameter. Sutures are rarely preserved and thus D Ph is given only in a few instances.

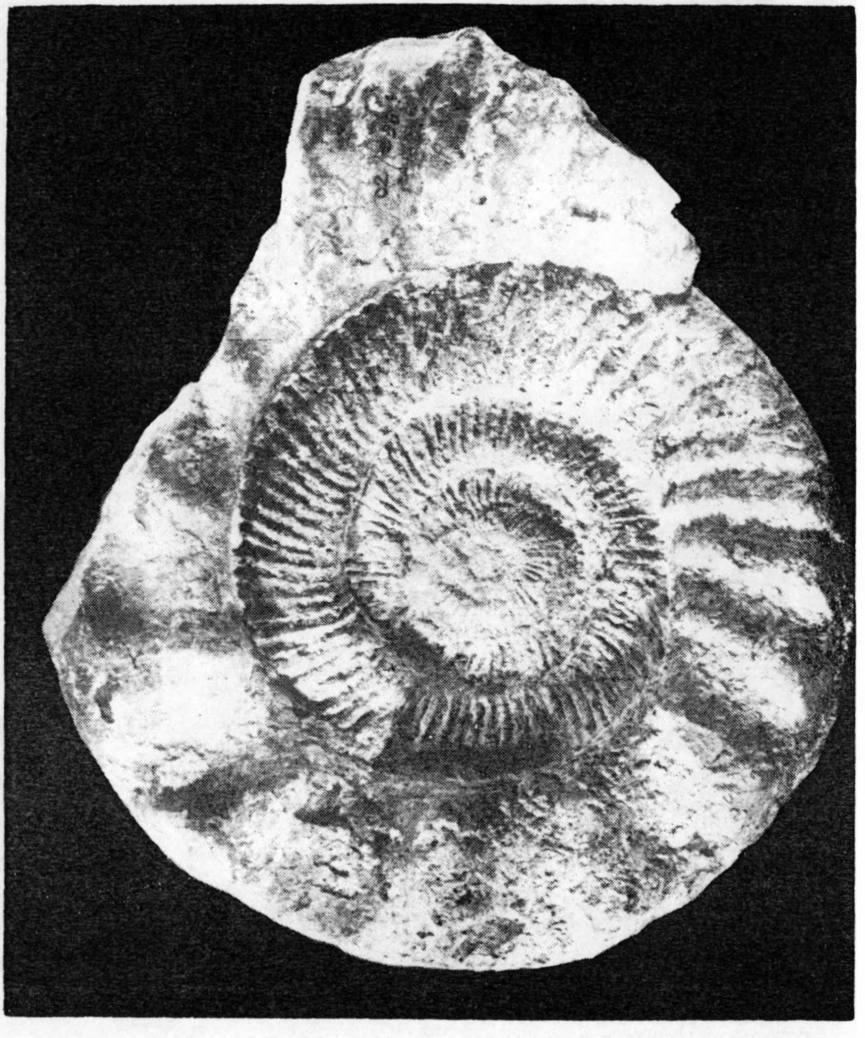

Plate I

Perisphinctes (*Perisphinctes*) *martelli* (Oppel): D — 343 mm (D Ph — 260 mm); H — 91; U — 181; R/D — 25/340 mm, 45/280, 61/240, 73/160, 64/120 (× 0,40)

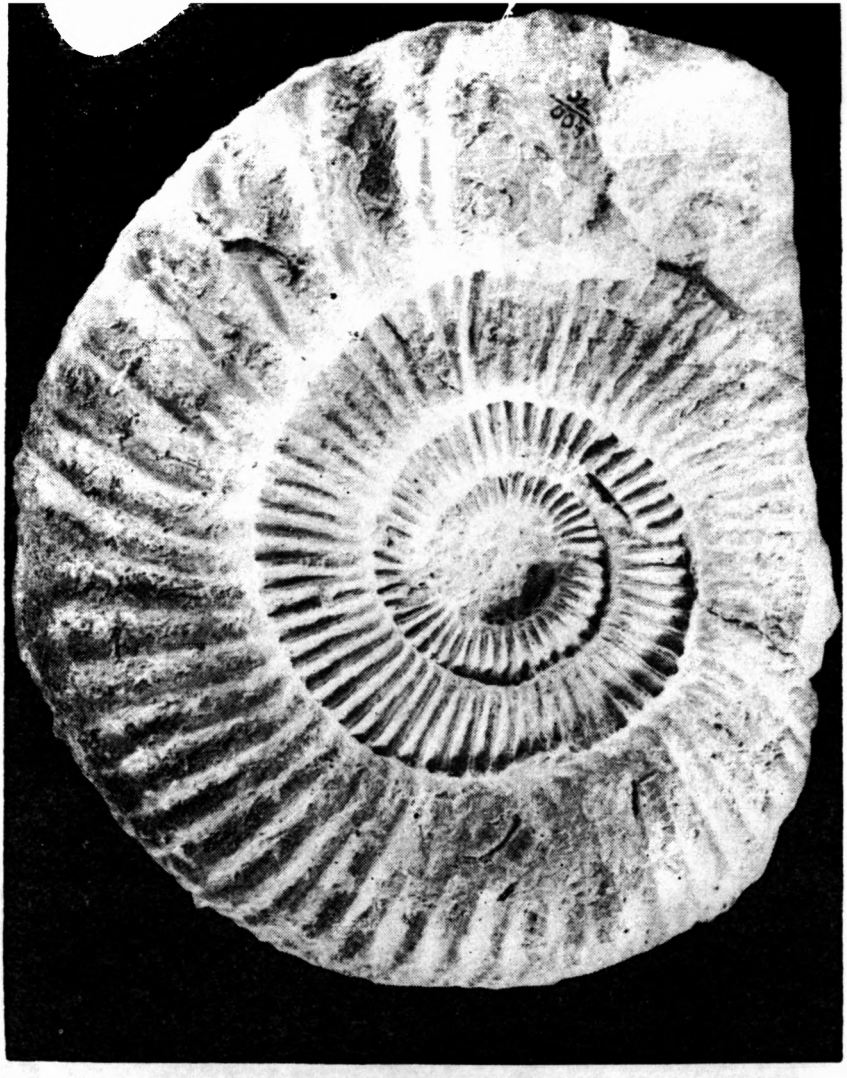

Plate II

Perisphinctes (*Perisphinctes*) *variocostatus* (Buckland); D — (215 mm) 206 mm; H — 56; W — 63; U — 106; R/D — 53/215 mm, 56/180, 58/140, 51/100, 42/60 (× 0.70)

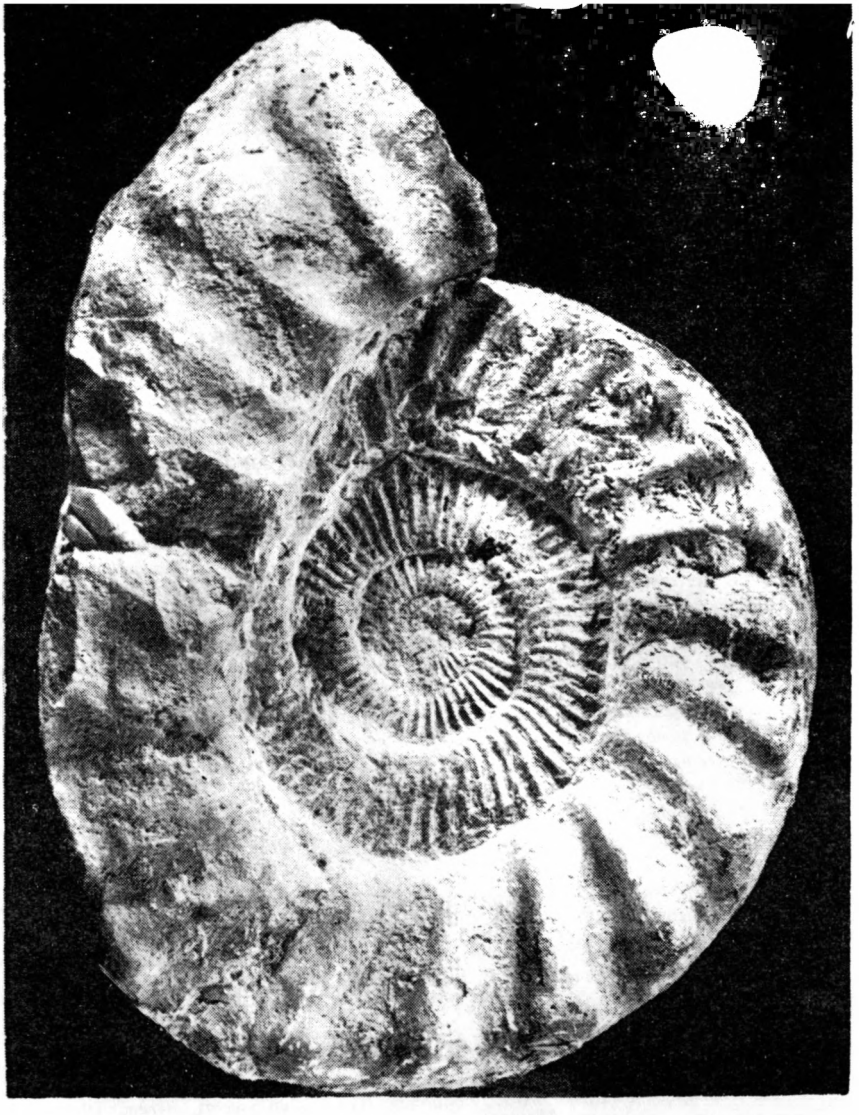

Plate III

Perisphinctes (*Perisphinctes*) *cautisnigrae* Arkell; D — (380 mm) 275 mm; (D Ph — about 230 mm); H — 84; U — 133; R/D— 38/280 mm, 48/240, 57/200, 58/160, 50/120 (≈ 0.45)

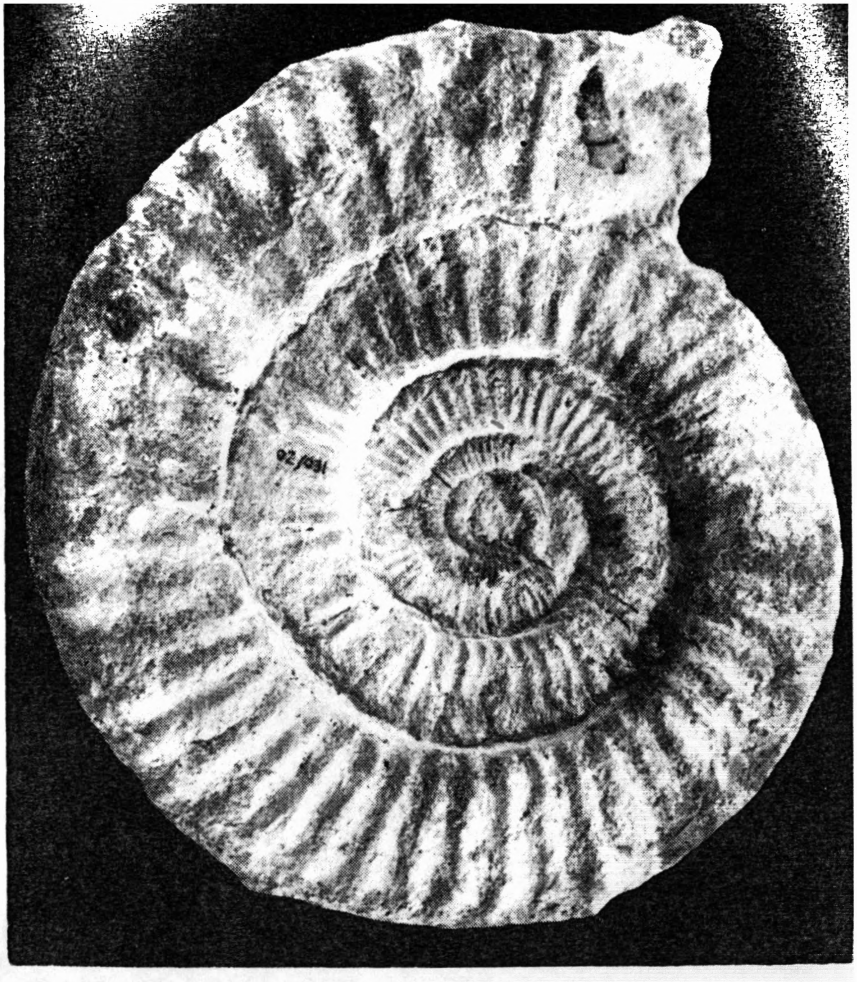

Plate IV

Perisphinctes uptonioides Enay; D — 248 mm; H — 56; U — 144; R/D — 48/240 mm, 46/200 46/160, 51/120, 54/100 (× 0.55)

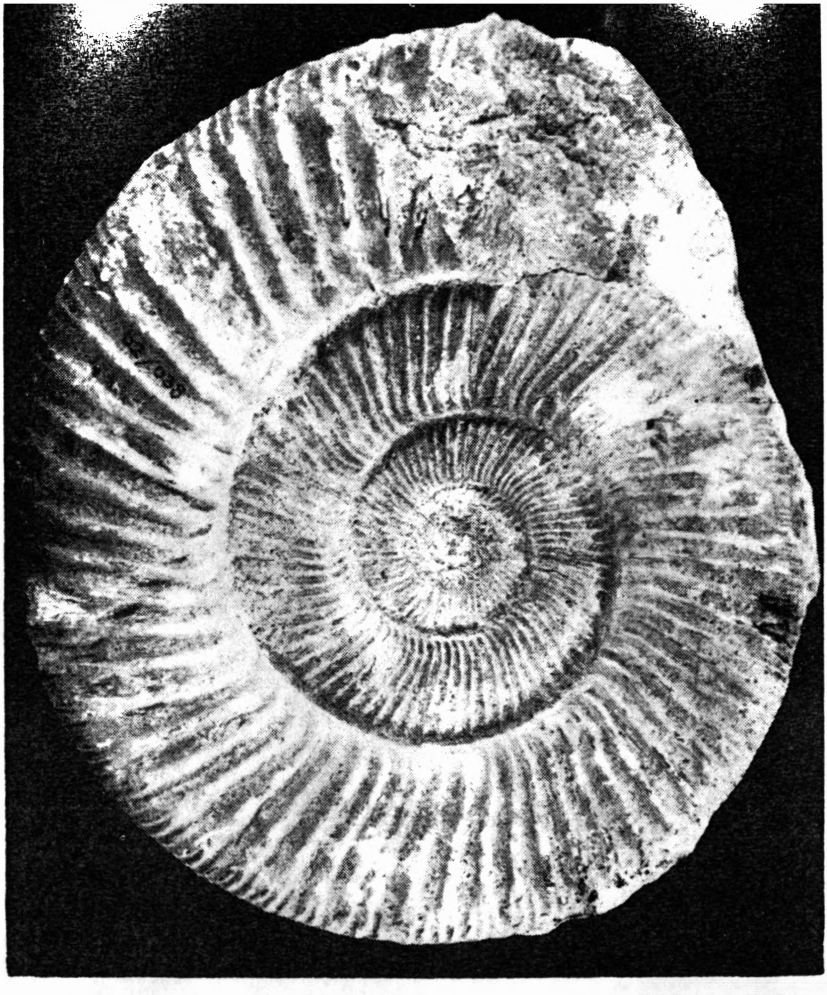

Plate V

Perisphinctes (*Arisphinctes*) *pickeringius* (Young and Bird); D — 254 mm; H — 72; U — 124; R/D — 63/240 mm 70/200, 73/160, 73/230, 65/80 (× 0.55)

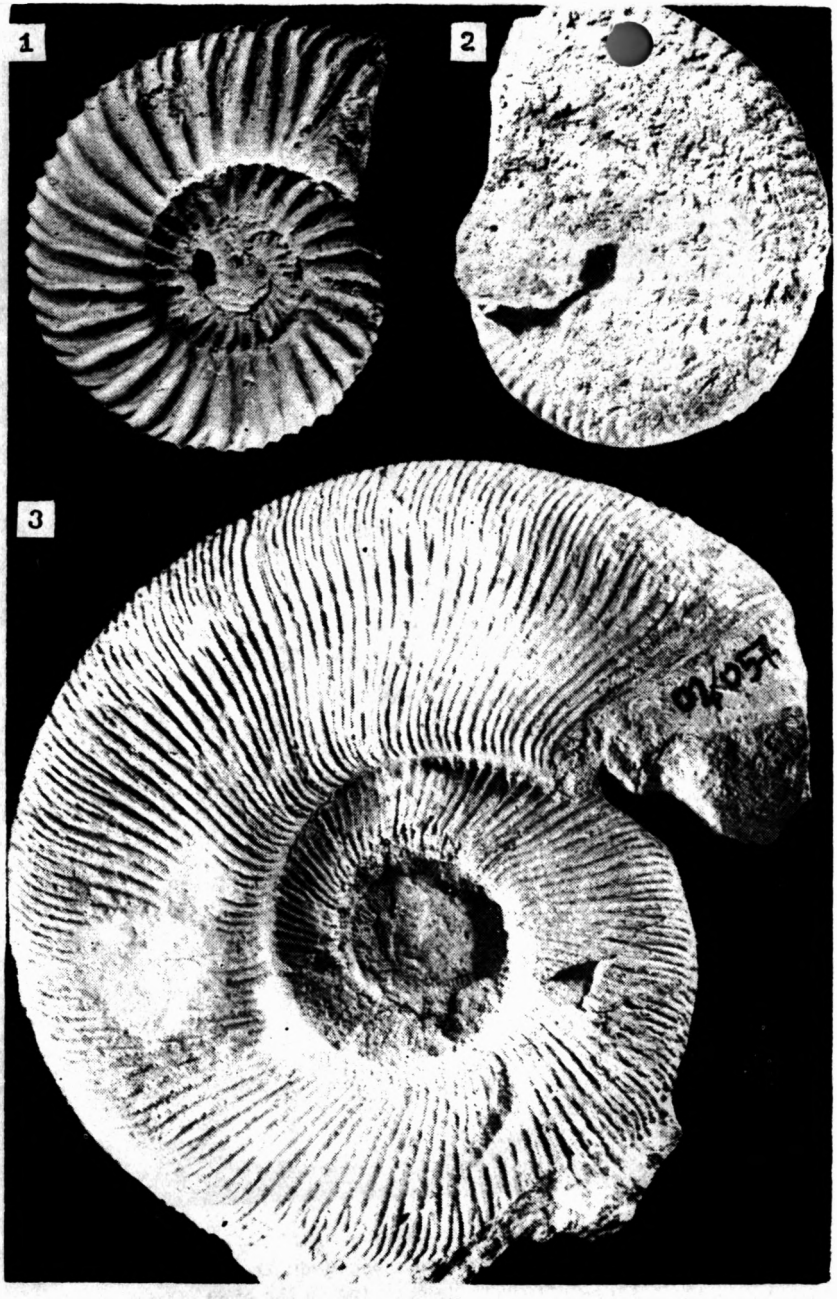

Plate VI

1) *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Quenstedt); D — 66 mm; H — 24, W — 17; U — 28; R/D — 30/66 mm, 28/50, 28/40, 29/30 (×1.0)

2) *Taramelliceras* (*Strebliticeras*) *externnodosum* Dorn; D — 64 mm; H — 37, W — 23; U — 6 3 (×1.0)

3) *Lithacoceras* (*Discosphinctes*) *mindowe* (Siemiradzki); D — 143 mm; H — 53, W — 36; U — 54; R/D — 108/143, 98/120, 93/110, 89/100 (×0.9)

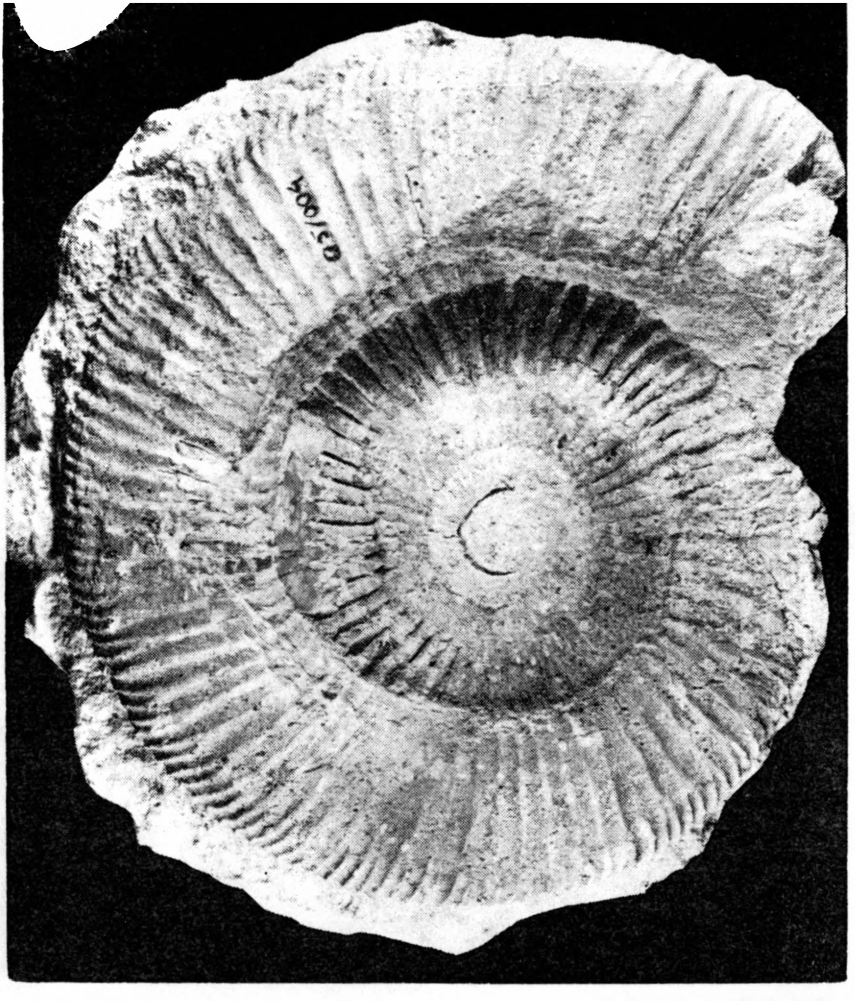

Plate VII

Perisphinctes (*Dichotomosphinctes*) *wartae* (Bukowski); D — 171 mm; H — 49; W — 30; U — 87; R/D — 76/171, 64/140, 56/120, 54/100, 51/80, cf. 48/60 (×0.80)

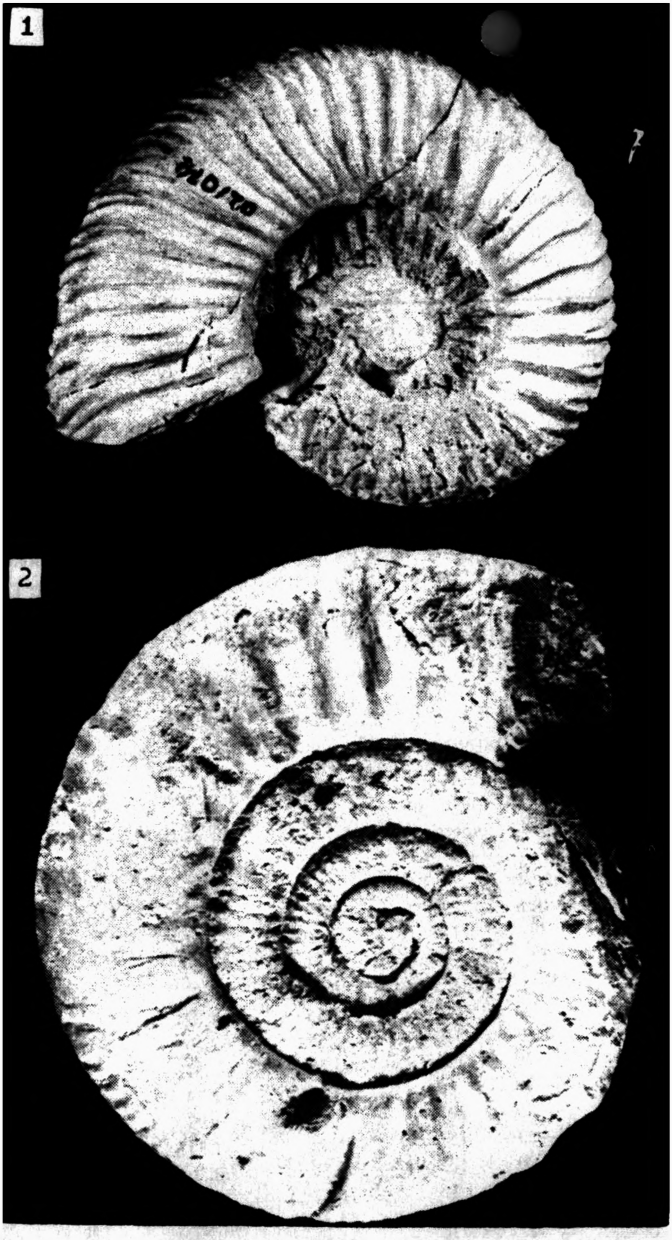

Plate VIII

1) *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Quenstedt); D — 85 mm (D Ph — 52 ; H — 32; R/D — 40/85 mm, 34/70, 31/60, 29/50, 29/40 (× 1.0)

2) *Perisphinctes bonarelli* Siemiradzki; D — 104, H — 30; U — 52; R/D — 37/100, 43/80 (×1.0)

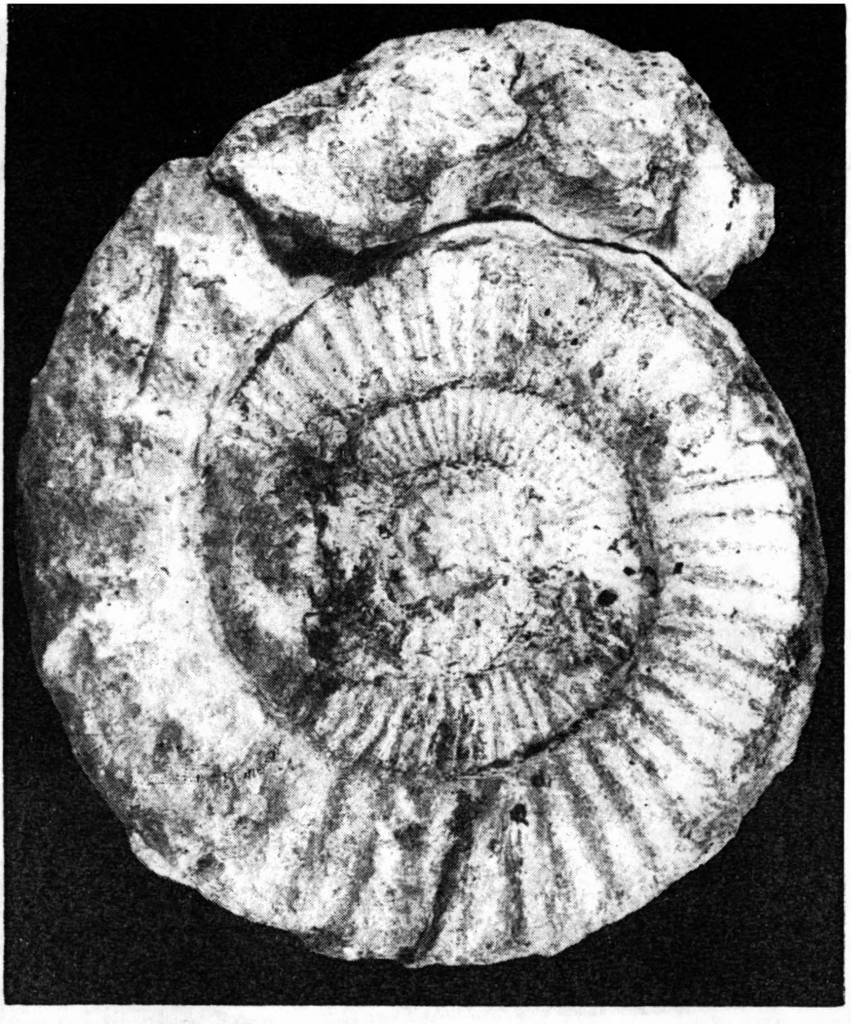

Plate IX

Perisphinctes (*Arisphinctes*) *pickeringius* (Young and Bird); D — (385 mm) 368 mm; H — 85; U — 210; R/D — 41/380 mm, 49/340, 56/300, 58/280, 60/240, 61/200 (× 0.40)

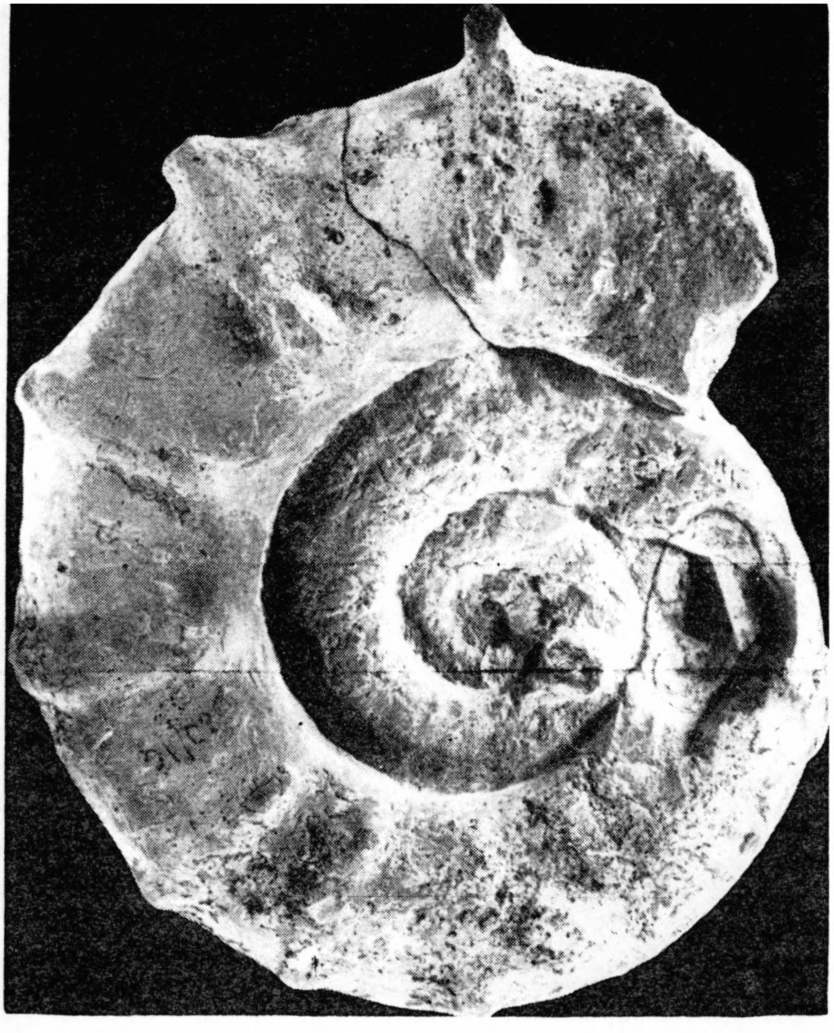

Plate X

Aspideceras (*Euaspidoceras*) *paucituberculatum* Arkell: D — 202 mm (D Ph — 124); H — (
U — 94 (× 0.85)

Stratigraphy

The subdivision of the Oxfordian stage as presented by Enay [2] is assumed in this paper.

The ammonite assemblage from beds 3—14 of the Zawodzie section may be included in the Antecedens subzone. No ammonites characteristic of this zone exclusively occur in these beds. On the other hand, no ammonites diagnostic for the Parandieri subzone have been found here, and the subgenus *Subvertebriceras* occurring in bed 12 has so far not been recorded from deposits younger than the Antecedens subzone. Also the frequent occurrence of *Perisphinctes buckmanni* and *P. antecedens* is typical for this subzone. *P. (Kranaosphinctes) promiscus* Buk., cited by Bukowski [1], Koroniewicz and Rehbinder [4] and by Różycki [11], could have been found in the discussed beds or in somewhat older ones, presently not exposed.

It is of interest here that the subgenus *Discosphinctes* appears in the Zawodzie section as early as in the Antecedens subzone. Specimens of *Discosphinctes* have also been found heretofore in the same stratigraphical position in other parts of Poland (J. Kutek, personal information). They appear in the French Jura from the upper part of the Parandieri subzone [2], but are also known from much older beds in other parts of France [3].

TABLE

Percentage of various ammonite families from particular beds of the Zawodzie section

No. of quarry	No. of bed	No. of specimens	*Perisphinctidae*	*Aspidoceratidae*	*Oppelidae*	*Haploceratidae*	*Cardioceratidae*
			%				
6	14-meter section	279	97.49	—	0.36	2.15	—
5	39	125	95.20	0.80	3.20	0.80	—
5	38	46	91.31	—	6.52	—	2.17
5	35—37	58	98.28	1.72	—	—	—
1, 2	32	110	95 45	1.82	1.82	—	0.91
1, 2	31	320	95.65	2.19	0.63	1.56	—
1, 2	29—30	130	95.38	2.31	0.77	1.64	—
1, 2	26—28	230	94.78	1.74	3.48	—	—
1, 2	24—25	207	93.72	1.93	3.86	0.48	—
1, 2	21—23	151	95.32	1.34	2.67	0.67	—
1, 2, 3	16—20	125	88.80	3.20	4.00	4.00	—
1, 2, 3	14	56	78.57	1.78	14.28	3.57	1.78
1, 2, 3	12	22	54.54	—	36.36	9.10	—
3	9—11	15	66.67	—	20.00	6.66	6.67
3	7	83	55.42	1.20	12.05	30.12	1.20
3	5	69	57.97	—	21.73	20.29	—
3	3	30	70.00	3.33	20.00	6.67	—

A typical assemblage of the Parandieri subzone occurs in beds 16—23. *Perisphinctes (Dichotomosphinctes) wartae* Buk. and *Perisphinctes (Perisphinctes) martelli* (Opp.) are particularly numerous here. Moreover, such characteristic forms as

P. (*Dichotomosphinctes*) *elisabethae* (Riaz), *Lithacoceras* (*Discosphinctes*) *mindowe* (Siem.), *L.* (*Larcheria*) sp. and *Taramelliceras* (*Taramelliceras*) *bachianum* (Opp.), were also found. It is worth noting that ammonites of the subgenus *Discosphinctes* were found almost in every layer. The assignation of this assemblage to the Parandieri subzone seems to be out of the question.

The assemblage from beds 24—25 is of a transitional character. Here, ammonites from the subgenera *Dichotomosphinctes* and *Discosphinctes* still occur, while such species typical for the next, i.e. the Bifurcatus subzone, as a *Taramelliceras* (*Streblíticeras*) *externnodosum* (Dorn), *Perisphinctes* (*Perisphinctes*) *panthieri* Enay, and *P.* (*Dichotomoceras*) *bifurcatoides* Enay, begin to appear.

The whole upper part of the Zawodzie section may be included in the Bifurcatus subzone. The index species, *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.), is here represented by quite a large (14) number of specimens. Other, rather rare but stratigraphically significant species, such as *P.* (*Perisphinctes*) *cautisnigrae* Ark., *P.* (*P.*) *variocostatus* (Buckl.), *P. uptonioides* Enay and *P.* (*Dichotomoceras*) *grossouvrei* (Siem.) occur here as well.

The 14-m column from quarry 6, previously mentioned, is also of that age. Almost exclusively ammonites of the subgenus *Dichotomoceras* were found here. Two specimens of *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.) were found in the uppermost part of that column.

It follows from the above discussion that three distinct ammonite assemblages occur in the Zawodzie section. These assemblages clearly correspond to the upper subzone of the Plicatilis zone (the Antecedens subzone) and to both subzones of the Transversarium zone (the Parandieri and the Bifurcatus subzones), respectively. Moreover, these assemblages are quite similar to assemblages found in sections from Western Europe [2, 3]. In the case of Zawodzie the subdivision by Enay [2] is quite convenient, so there is no reason for rejecting it. Moreover, this subdivision may be considered as a modification of Oppel's subdivision of the Jurassic, which was introduced and applied in Poland by Roemer [9], and later i.a. by Siemiradzki [12], and Rehbinder and Koroniewicz [4].

Recently, the Middle Oxfordian in Poland has been subdivided by Malinowska [6] into two zones — the Perisphinctes chloroolithicus and C. tenuiserratum zone and the A. alternans and P. wartae zone. The ammonite succession in the Middle Oxfordian deposits was presented in a rather general way, and no detailed "bed -by-bed" sequence has been offered. Therefore, it is rather difficult to trace the boundary between the zones mentioned above. From the species listed by Malinowska [6] it follows clearly that her A. alternans and P. wartae zone corresponds to a large part of the Oxfordian including the whole Parandieri and Bifurcatus subzones and some part of the Hypselum zone (e.g., *Microbiplices microbiplex* and *Epipeltoceras uhligi* were recorded by Malinowska [6] from the discussed zone). In a later paper by Malinowska [7], two other Oxfordian zones, e.g. the Perisphinctes cautisnigrae sensu lato zone and the Ringsteadia pseudocordata zone, have been proposed. The interrelations between the Perisphinctes cautisnigrae s.l. zone and

the A. alternans and P. wartae zone were not discussed by Malinowska and there is no doubt that these zones overlap to a great extent.

If the zones proposed by Malinowska [6] and [7] had been applied to the Zawodzie section, the lowest beds would correspond to the P. chloroolithicus and C. tenuis-erratum zone and the rest of the section to the P. wartae and A. alternans zone, whereas beds beginning with the 27th would represent simultaneoulsy the P. caustis-nigrae s.l. zone.

Quantitative distribution of ammonites

The distribution of various families of ammonites 3341 specimens in particular beds from the Zawodzie section (Table I) shows the *Perisphinctidae* to prevail in all beds, whereas *Oppelidae* and *Haploceratidae* decrease abruptly at the boundary of the Antecedens and the Parandieri subzones. *Aspidoceratidae* and *Cardioceratidae* are subordinate, and neither *Phylloceratidae* nor *Lytoceratidae* occur. No *Cardioceratidae* were found in the Parandieri subzone, so the "*Cardioceras* gap" of Malinowska [6] may be confirmed. It is of interest here, that *Cardioceratidae* disappear in Zawodzie in those beds, where the number of *Haploceratacea* noticeably decreases. It would seem that this coincidence is not accidential and may be related to ecological factors. Probably for these reasons the genus *Amoeboceras*, which appears in France as early as the Parandieri subzone [2], has not been noted at Zawodzie until the Bifurcatus subzone.

Some remarks concerning zoogeographical problems may be added. At Zawodzie the assemblages of the submediterranean type predominate and are recorded by the presence of *Haploceratidae* and the subgenera *Discosphinctes*, *Larcheria* and *Dichotomoceras*. Thus it follows that the submediterranean zones are the most acceptable for the area of the Polish Jura Chain.

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