



BRONISŁAW ANDRZEJ MATYJA & RADOSŁAW TARKOWSKI

Lower and Middle Oxfordian ammonite biostratigraphy at Zalas in the Cracow Upland

ABSTRACT: The succession of ammonites collected bed-by-bed in three Lower to Middle Oxfordian sections at the Zalas quarry in the Cracow Upland, Southern Poland, indicates that the Lower Oxfordian strata are thin and stratigraphically condensed; they include the bukowskii, costicardia, and cordatum Subzones. The investigated sections include also the lowermost part of the Middle Oxfordian, viz. the tenuicostatum Subzone. The latter subzone yielded some cardioceratids unknown thus far from Poland, namely *Cardioceras (Subvertebriceras) densiplicatum* Boden and *C. (Scoticardioceras) serrigerum* (Buck.). Some new taxa representative of the subgenera *Cardioceras*, *Plasmatoceras*, and *Scoticardioceras* are described from the strata close to the Lower/Middle Oxfordian boundary.

INTRODUCTION

The present paper gives an account of research on the lower part of the Oxfordian strata overlying the Permian porphyres exploited at the Zalas quarry in the Cracow Upland, southern part of the Polish Jura Chain (Text-fig. 1). The present authors' research was carried over beginning with 1977. In fact, the investigated strata made the subject of the graduate paper (Tarkowski 1978) and will be discussed also in the Ph. D. thesis of the junior author.

The Jurassic rocks of Zalas area have been studied for more than a hundred years. They yielded lots of fossils described by Roemer (1870), Siemiradzki (1891, 1899), Wójcik (1910), and Różycki (1953), among others.

New exposures of the Jurassic strata developed in the Zalas quarry made accessible interesting geological sections and yielded rich col-

lections of fossils, which recently made the subject of several papers (Garlicka 1976, Gizejewska & Wieczorek 1977, Tarkowski 1978, Trammer 1979, Garlicka & Tarkowski 1980).

Out of the ammonites described in the present paper, those labelled with *Mt* symbol are housed at the Institute of Geology of the Warsaw University, and those labelled with *RT* symbol at the Institute of Paleontology and Stratigraphy of the University of Mining and Metallurgy in Cracow.

GEOLOGICAL SECTIONS

The Oxfordian strata overlie either nodular crinoid limestones (section *II*), or stromatolites developed here and there over the latter rocks (sections *I* and *III*) in the investigated geological sections of the Zalas quarry (cf. Gizejewska & Wieczorek 1977). They are represented by a calcareous-marly sequence. In spite of this general lithological monotony, there is a considerable vertical and lateral variation in lithology.



Fig. 1
Location of the Zalas area within the occurrence zone (hatched) of Upper Jurassic deposits in the Polish Jura Chain; inset shows position of the area in Poland

It is expressed in distribution of siliceous sponges, bed thickness, and rock color. The lateral variation is, indeed, a sharp one, as the investigated sections are over a distance of some 30 m (Text-fig. 2).

SECTION I

The lowermost bed of the Oxfordian (bed *1* in Text-fig. 3) consists of yellow calcareous marls that yielded some siliceous sponges and unidentifiable ammonites.

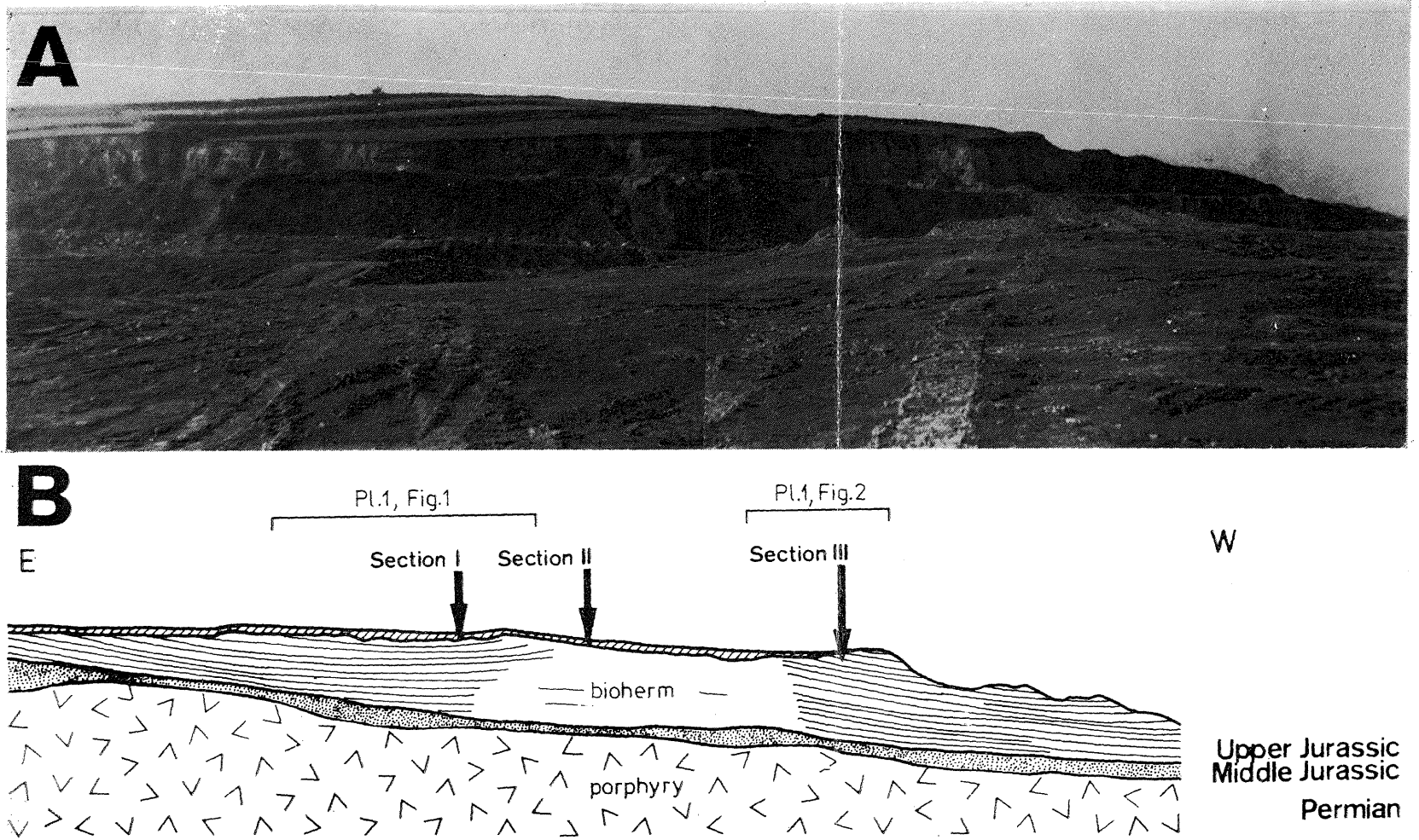


Fig. 2. General view of the southern wall at the Zalas quarry (A), and sketch-drawing of this wall (B), to show the location of investigated sections (I, II and III — see Text-fig. 3); for details see Pl. 1, Figs 1—2

This bed is overlain by a set of red-colored marls interbedded with marly limestones (beds 2—13). The rocks contain abundant siliceous sponges and ammonites, and infrequent brachiopods. The following ammonites have been identified:

- bed 2 — *Creniceras crenatum* (Brug.);
 - bed 8 — *Peltoceratoides* sp.;
 - bed 9 — *Peltoceratoides* sp.;
 - bed 10 — *Peltoceratoides* sp.;
 - bed 13 — *Taramelliceras bukowskii* (Siem.), *Peltoceratoides* cf. *constantii* (d'Orb.);
- and in addition: *Holcophylloceras zignodianum* (d'Orb.), *Lissoceratoides erato* (d'Orb.), *Taramelliceras oculatum* (Phill.), *T. minax* (Buk.), and *Neocampylites thirriai* (Petitclerc & Maire).

The bed 14 is represented by red-colored nodules of marly limestones coated with marly matter, red-brownish or green to grey in color. There are abundant siliceous sponges and ammonites including: *Glochiceras* (*Coryceras*) *distortum* (Buk.), *Scaphitoides paucirugatus* (Buk.), *Popanites paturattensis* (Grepp.), *Neocampylites thirriai* (Petitclerc & Maire), *Cardioceras* (*Subvertebriceras*) cf. *densiplicatum* Boden, and several *Cardioceras* (*Plasmatoceras*) sp. A. Debris of this bed yielded in addition: *Cardioceras* (*Cardioceras*) cf. *persecans* (Buck.), *Cardioceras* (*Cardioceras*) sp. C, *Mirosphinctes bukowskii* (Choffat), and *Euaspidoceras ovale* (Neum.).

Higher up in the section, there is a set of grey-colored calcareous marls interbedded with marly limestones (beds 15—24; Pl. 1, Fig. 1). The beds are literally replete with siliceous sponges, which makes their surfaces uneven, nodular. The following ammonites have been identified:

- bed 15 — *Lissoceratoides erato* (d'Orb.), *Cardioceras* (*Cardioceras*) *ashtonense* Arkell, *Cardioceras* (*Plasmatoceras*) sp. A, *Cardioceras* sp.;
- bed 16 — *Euaspidoceras ovale* (Neum.);
- bed 18 — *Popanites paturattensis* (Grepp.), *Cardioceras* (*Plasmatoceras*) sp. A, *Cardioceras* sp.;
- bed 19 — *Popanites paturattensis* (Grepp.), *Neocampylites delmontanus delmontanus* (Oppel), *Cardioceras* (*Cardioceras*) *ashtonense* Arkell, C. (C.) cf. *ashtonense* Arkell, *Cardioceras* sp., *Euaspidoceras* sp.;
- bed 20 — *Neocampylites delmontanus delmontanus* (Oppel), *N. villersi* (Rollier), *Cardioceras* (*Plasmatoceras*) *tenuicostatum* (Nik.), *Goliathiceras* (*Goliathites*) *cyclops* Arkell, *Cardioceras* sp.

The uppermost lithological set in the section I consists of grey-colored, poor in sponges, marly limestones interbedded with calcareous marls (beds 25—41). The following ammonites have been identified:

- bed 28 — *Lissoceratoides erato* (d'Orb.), *Goliathiceras* (*Goliathites*) *cyclops* Arkell;
- bed 29 — *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden var. *anglicum* var. n.;
- bed 32 — *Lissoceratoides erato* (d'Orb.), *Cardioceras* (*Plasmatoceras*) *tenuistriatum* Bor.;
- bed 35 — *Lissoceratoides erato* (d'Orb.), *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden var. *anglicum* var. n., *Perisphinctes* sp.

SECTION II

The lowermost lithological set includes yellow-grey to green-grey marly limestones and calcareous marls (beds 1—3) with abundant siliceous sponges and infrequent ammonites, belemnites, and gastropods. The following ammonites have been identified:

- bed 2 — *Cardioceras* sp.;
- bed 3 — *Lissoceratoides erato* (d'Orb.), *Popanites paturattensis* (Grepp.), *Neocampylites thirriai* (Petitclerc & Maire), *Cardioceras* (*Cardioceras*) *cordatum* var. *costicordatum* Arkell, C. (C.) cf. *ashtonense* Arkell, C. (*Vertebriceras*) sp., *Goliathiceras* (*Goliathites*) cf. *cyclops* Arkell.

Higher up in the section, there are grey-colored calcareous marls and marly limestones (beds 4—7) with abundant siliceous sponges and infrequent ammonites. The following ammonites have been identified:

- bed 4 — *Cardioceras (Plasmatoceras) sp. A*;
 bed 5 — *Lissoceratoides erato* (d'Orb.), *Popanites paturattensis* (Grepp.), *Neocampylites thirriai* (Petitclerc & Maire), *Cardioceras (Plasmatoceras) sp. A*, *C. (Vertebriceras) sp.*, *Euaspidoceras sp.*;
 bed 6 — *Cardioceras (Plasmatoceras) sp. A*.

The uppermost lithological set in the section II is represented by marly limestones very rich in siliceous sponges. The spatial form of the set, the absence of bedding, and the high density of sponges permit a recognition of these rocks for a bioherm (Text-fig. 2; Pl. 1, Fig. 2). For the purposes of collecting, the set has been subdivided into a number of 60 cm thick "beds" (cf. beds 8—14, section II in Text-fig. 3). Out of the abundant ammonite fauna, the following forms have been identified:

- bed 8 — *Lissoceratoides erato* (d'Orb.), *Neocampylites delmontanus delmontanus* (Oppel), *Cardioceras (Scoticardioceras) roemeri* Siegfried, *C. (?Scoticardioceras) sp. B*, *Cardioceras sp.*, *Euaspidoceras sp.*;
 bed 9 — *Lissoceratoides erato* (d'Orb.), *Neocampylites thirriai* (Petitclerc & Maire), *Cardioceras (Plasmatoceras) tenuistriatum* Bor., *C. (?Scoticardioceras) sp. B*, *Euaspidoceras sp.*;
 bed 10 — *Lissoceratoides erato* (d'Orb.), *Popanites paturattensis* (Grepp.), *Neocampylites delmontanus delmontanus* (Oppel), *Cardioceras (Scoticardioceras) excavatum* (Sow.), *C. (?Scoticardioceras) sp. B*;
 bed 11 — abundant *Lissoceratoides erato* (d'Orb.), *Neocampylites thirriai* (Petitclerc & Maire), *N. delmontanus delmontanus* (Oppel), *Cardioceras sp.*;
 bed 12 — *Lissoceratoides erato* (d'Orb.), *Neocampylites thirriai* (Petitclerc & Maire), *N. delmontanus helveticus* (Jeannet), *Cardioceras sp.*;
 bed 13 — *Lissoceratoides erato* (d'Orb.);
 bed 14 — *Lissoceratoides erato* (d'Orb.), *Neocampylites delmontanus delmontanus* (Oppel), *N. delmontanus helveticus* (Jeannet), *Cardioceras (Plasmatoceras) tenuistriatum* Bor.

SECTION III

The lowermost bed of the Oxfordian (bed 1) consists of marly limestones, yellow-colored at the base and red at the top, with infrequent siliceous sponges.

It is overlain by a set (beds 2—8) of grey marly limestones interbedded with calcareous marls, grey-green at the base of the set and grey at the top. These strata contain abundant siliceous sponges and ammonites, the latter especially in the upper part of the lithological set; there are also infrequent brachiopods and belemnites. The following ammonites have been identified:

- bed 2 — *Lissoceratoides erato* (d'Orb.), *Popanites paturattensis* (Grepp.), *Neocampylites delmontanus delmontanus* (Oppel), *Cardioceras (Cardioceras) ashtonense* Arkell, *C. (Plasmatoceras) sp. A*, *Euaspidoceras sp.*, *Perisphinctes sp.*;
 bed 3 — *Cardioceras (Subvertebriceras) densiplicatum* Boden var. *lithuanicum* var. n., *Perisphinctes sp.*;
 bed 4 — *Lissoceratoides erato* (d'Orb.), *Popanites paturattensis* (Grepp.), *Neocampylites delmontanus delmontanus* (Oppel), *Cardioceras (Cardioceras) sp. D*;
 bed 5 — *Lissoceratoides erato* (d'Orb.), *Cardioceras (Scoticardioceras) roemeri* Siegfried;
 bed 6 — abundant *Lissoceratoides erato* (d'Orb.), *Neocampylites delmontanus delmontanus* (Oppel), *N. delmontanus helveticus* (Jeannet), *N. thirriai* (Petitclerc & Maire), *Cardioceras (Plasmatoceras) tenuicostatum* (Nik.), *C. (Plasmatoceras) tenuistriatum* Bor., *Euaspidoceras ovale* (Neum.), *Perisphinctes sp.*;
 bed 7 — *Lissoceratoides erato* (d'Orb.), *Cardioceras (Plasmatoceras) tenuicostatum* (Nik.), *C. (Subvertebriceras) densiplicatum* Boden var. *anglicum* var. n.;
 bed 8 — abundant *Lissoceratoides erato* (d'Orb.), *Neocampylites delmontanus delmontanus* (Oppel), *N. delmontanus helveticus* (Jeannet), *N. villerst* (Rollier), *N. thirriai* (Petitclerc & Maire), *Cardioceras (Vertebriceras) cf. dorsale* Buck., *C. (Plasmatoceras) tenuistriatum* Bor., *Perisphinctes sp.*

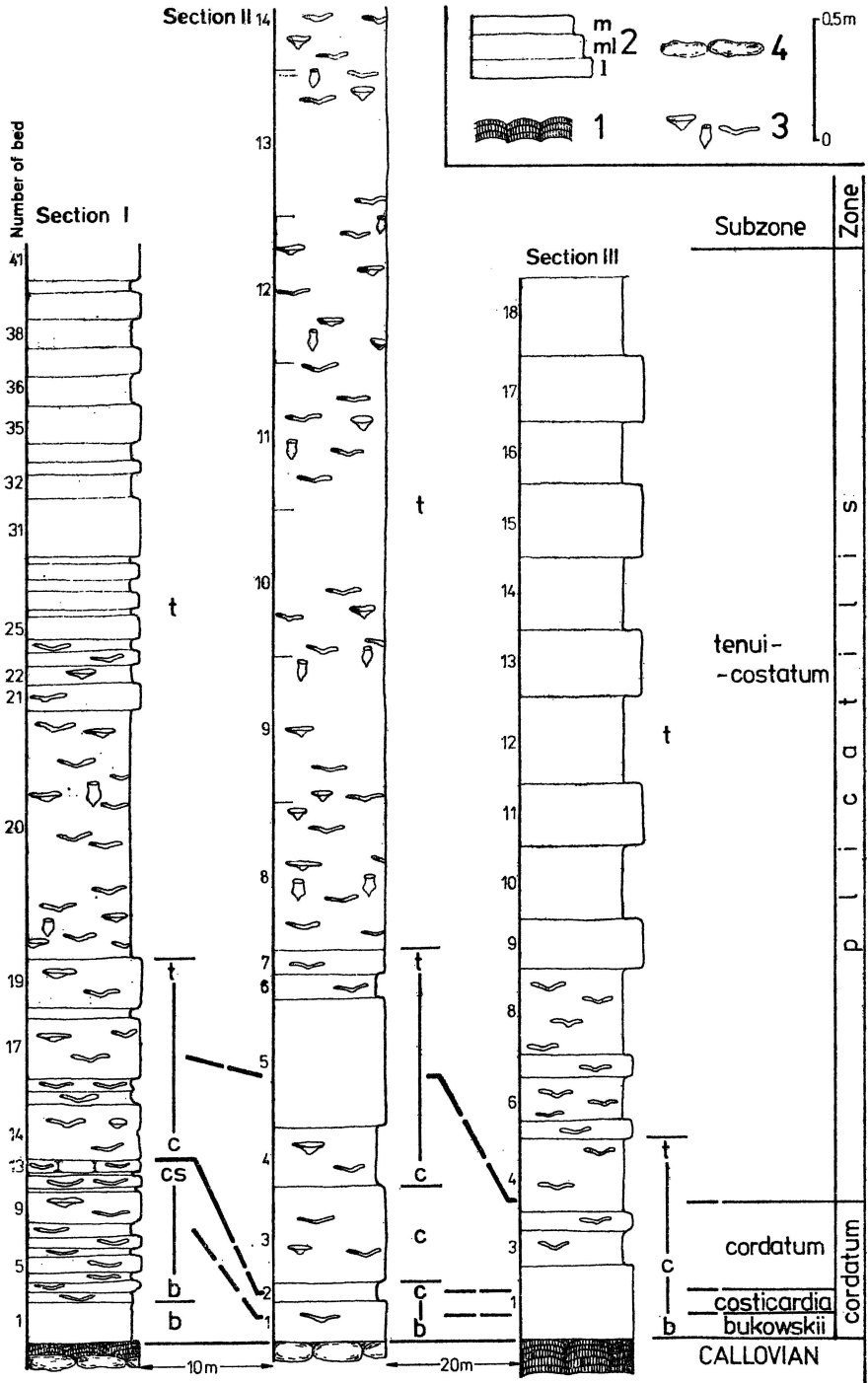


Fig. 3. Oxfordian sections at the Zalas quarry (cf. Text-fig. 2)
 Letters on the right side of sections indicate the ammonite subzones: b — bukowskii Subzone, cs — costicardia Subzone, c — cordatum Subzone, t — tenuicostatum Subzone
 1 stromatolite, 2 lithology (l limestones, ml marly limestones, m marls), 3 sponges, 4 nodules

The uppermost part of the section III is represented by a set of grey-colored limestones interbedded with calcareous marls (beds 9—18). The limestone beds display sharp boundaries and are recognizable over a considerable distance (Pl. 1, Fig. 2). Sponges occur rather infrequently, but ammonites abound; in addition, brachiopods are common in the topmost part of the set (beds 17—18). The following ammonites have been identified:

- bed 9 — *Nebrodites (Enayites) czenstochowiensis* (Siem.), *Perisphinctes* sp.;
 bed 10 — abundant *Lissoceratoides erato* (d'Orb.), *Neocampylites delmontanus delmontanus* (Oppel), *N. delmontanus helveticus* (Jeannel), *N. thirriai* (Petitclerc & Maire), *N. villersi* (Rollier), abundant *Cardioceras (Plasmatoceeras) tenuicostatum* (Nik.), abundant *C. (P.) tenuistriatum* Bor., *C. (Vertebriceras)* sp.;
 bed 11 — *Neocampylites thirriai* (Petitclerc & Maire), *Perisphinctes* sp.;
 bed 12 — *Lissoceratoides erato* (d'Orb.), *Cardioceras (Plasmatoceeras) tenuicostatum* (Nik.), *Perisphinctes* sp.;
 bed 13 — *Cardioceras (Scoticardioceras) serrigerum* (Buck.), *Perisphinctes* sp.;
 bed 14 — *Lissoceratoides erato* (d'Orb.), *Neocampylites villersi* (Rollier), *Cardioceras (Plasmatoceeras) tenuicostatum* (Nik.), *C. (P.) tenuistriatum* Bor., *C. (Subvertebriceras) densiplicatum* Boden var. *anglicum* var. n., *Perisphinctes* sp.;
 bed 16 — abundant *Lissoceratoides erato* (d'Orb.), *Neocampylites delmontanus helveticus* (Jeannel), *N. thirriai* (Petitclerc & Maire), *Cardioceras (Plasmatoceeras) tenuicostatum* (Nik.), *C. (P.) tenuistriatum* Bor., *C. (Scoticardioceras) excavatum* (Sow.), *Perisphinctes* sp.;
 bed 18 — *Lissoceratoides erato* (d'Orb.), *Neocampylites thirriai* (Petitclerc & Maire), *Perisphinctes* sp.

In addition to the above listed forms, a large number of ammonites were found in the quarry scree, the stratigraphic position of which can be established after the matrix color.

The yellow-colored strata (= bed 1 in sections I—II and the base of bed 1 in section III) yielded the following ammonites: *Cardioceras (Scarburgiceras) bukowskii* Maire, *Goliathiceras (Pachycardioceras) globulus* Arkell, *Peltomorphites interscissus* (Uhlig), and *Lissoceratoides erato* (d'Orb.).

The red-colored strata (= beds 2-13 in section I and the top of bed 1 in section III) yielded the following ammonites: *Holcophylloceras zignodianum* (d'Orb.), *Sowerbyceras tortisulcatum* (d'Orb.), *Creniceras renggeri* (Oppel), *Creniceras crenatum* (Brug.), *Lissoceratoides erato* (d'Orb.), *Taramelliceras minax* (Buk.), *T. bukowskii* (Siem.), *T. oculatum* (Phill.), *T. pseudoculatum* (Buk.), *T. polonicum* Malinowska, *Neocampylites delmontanus delmontanus* (Oppel), *Glochiceras (Coryceras) distortum* (Buk.), *Trimarginites eucharts* (d'Orb.), *Cardioceras (Cardioceras) costicardia* Buk., *C. (Scarburgiceras)* sp., *C. (Vertebriceras) sequanicum* Maire, *C. (Vertebriceras)* sp., *C. (Subvertebriceras) costellatum* Buk., *Mirosphinctes* sp., *Parawedekindia arduennensis* (d'Orb.), *P. choffati* (Loriol), *P. stephanowi* Sapunov, *Peltoceratoides constantii* (d'Orb.), *Peltomorphites interscissus* (Uhlig), *Euaspidoceras ovale* (Neum.), *Perisphinctes (Prososphinctes) mazuricus* Buk., and *Nebrodites (Enayites) aff. czenstochowiensis* (Siem.).

BIOSTRATIGRAPHY

The chronostratigraphic subdivision of the Oxfordian Stage in Europe is based on ammonite zones and subzones. The subdivision is somewhat variable among particular parts of Europe because of a variation in spatial distribution of ammonite groups. Nevertheless, the ammonite zones and subzones proposed by Arkell (1941) for the Lower Oxfordian still are in wide use (cf. Cariou, Enay & Tintant 1971; Kniazev 1975; Sykes & Callomon 1979). A somewhat different zonation pattern applied by some authors to the Lower Oxfordian of Poland was discussed by Gizejewska & Matyja (1979).

The zonation patterns become variable in Europe beginning with the Middle Oxfordian. The pattern proposed by Cariou, Tintant & Enay

(1971) is applied in the Submediterranean Province to which a considerable part of Poland belonged during the Oxfordian (Matyja & Giżejewska 1979); whereas a sequence of cardioceratid zones was recently proposed for the Subboreal and Boreal Provinces (Sykes & Callomon 1979).

The Oxfordian strata overlie in the Zalas quarry the Upper Callovian nodular crinoid limestones or stromatolite (Giżejewska & Wiczorek 1977). In the investigated geological sections no ammonites have been found indicative of the lowermost Oxfordian zone, the *mariae* Zone. However, thin lenses of pink-colored marls overlying the stromatolite in the neighboring sections in the quarry did yield (Giżejewska & Wiczorek 1977) the ammonites *Quenstedtoceras mariae* (d'Orb.) and *Cardioceras* (*Scarburgiceras*) *praecordatum* (Douv.) indicative of the *mariae* Zone.

BUKOWSKII SUBZONE

The *bukowskii* Subzone has been recognized after ammonites found in the quarry scree but nevertheless unequivocally attributable to specified strata due to the characteristics of the associated rock. The subzone is indicated by *Cardioceras* (*Scarburgiceras*) *bukowskii* Maire found in association with *Lissoceratoides erato* (d'Orb.), *Goliathiceras* (*Pachycardioceras*) *globulus* Arkell, and *Peltomorphites interscissus* (Uhlig) in yellow calcareous marls. Those marls make up bed 1 in all the investigated geological sections (cf. Text-fig. 3). Ammonites indicative of the *bukowskii* Subzone were found in yellow calcareous marls also in neighboring sections in the Zalas quarry (Garlicka & Tarowski 1980).

The *bukowskii* Subzone ranges up into the set of red-colored marls and marly limestones, the debris of which yielded specifically unidentifiable representatives of the subgenus *Scarburgiceras*.

COSTICARDIA SUBZONE

The *costicardia* Subzone has been recognized after the occurrence of *Cardioceras* (*Cardioceras*) *costicardia* Buck. and *C.* (*Subvertebriceras*) *costellatum* Buck. found in debris of the red marls and marly limestones of beds 2—13 in section I and the top of bed 1 in section III. The red-colored rocks yielded also a number of ammonite species known from the *bukowskii* and *costicardia* Subzones, in particular: *Parawedekindia arduennensis* (d'Orb.), *P. choffati* (Loriot), *Peltoceratoides constantii*

(d'Orb.), *Peltomorphites interscissus* (Uhlig), *Creniceras crenatum* (Brug.), *C. renggeri* (Oppel), *Perisphinctes* (*Prososphinctes*) *mazuricus* Buk., *Taramelliceras oculatum* (Phill.), *T. pseudoculatum* (Buk.), *T. bukowskii* (Siem.), and *T. polonicum* Malinowska.

CORDATUM SUBZONE

The base of the cordatum Subzone is usually defined (Arkell 1935-1948, Wright 1972, Callomon & Cope 1971) by the first appearance of one or more species of the group including *Cardioceras* (*Cardioceras*) *cordatum* (Sow.), *C. (C.) ashtonense* Arkell, *C. (C.) persecans* Buck., *Goliathiceras nitidum* Arkell, and *G. repletum* (Maire). The first three of these species have been recorded in the investigated sections, namely: *Cardioceras* (*Cardioceras*) cf. *persecans* Buck. in bed 14 in section I; *C. (C.) ashtonense* Arkell in beds 15 and 19 in section I and in bed 2 in section III; *C. (C.)* cf. *ashtonense* Arkell in bed 3 in section II; and *C. (C.) cordatum* var. *costicordatum* Arkell also in the latter bed. Furthermore, closely related representatives of the subgenus *Cardioceras*, namely *Cardioceras* (*Cardioceras*) sp. C and *Cardioceras* (*Cardioceras*) sp. D, have been recorded in bed 14 in section I and in bed 4 in section III, respectively.

One may conclude that the cordatum Subzone certainly includes bed 3 in section II and bed 2 in section III, and probably also beds 14-19 in section I and beds 3-4 in section III. Insofar as the latter two sets of strata are concerned, this conclusion must be treated with caution because of the occurrence of *Cardioceras* (*Subvertebriceras*) cf. *densiplicatum* Boden and *C. (S.) densiplicatum* Boden var. *lithuanicum* var. n., the latter form being here regarded (cf. remarks on ammonites) as stratigraphically older than its conspecifics typical of the Middle Oxfordian.

It is also to be noted that *Cardioceras* (*Plasmatoceras*) sp. A abounds in strata that yielded ammonites indicative of the cordatum Subzone, as well as higher up in the section but below the first occurrence of *Cardioceras* (*Plasmatoceras*) *tenuistriatum* Bor., *C. (P.) tenuicostatum* (Nik.), and the subgenus *Scoticardioceras*.

Any representatives of the genera *Parawedekindia*, *Peltoceratoides*, and *Peltomorphites* have not been recorded in strata attributed to the cordatum Subzone and possibly also to the lower part of the tenuicostatum Subzone, which corroborates previous conclusion (Matyja 1977) that these genera do not range above the costicardia/cordatium subzonal boundary.

TENUICOSTATUM SUBZONE

The lower boundary of the tenuicostatum Subzone is here defined by the first appearance of *Cardioceras* (*Plasmatoceras*) *tenuicostatum* (Nik.), *C. (P.) tenuistriatum* Bor., and/or *C. (Scoticardioceras) roemeri* Siegfried. In turn, the upper boundary is defined (cf. Brochwicz-Lewiński 1976) by the appearance of the *Kranaosphinctes promiscuus* group, *Perisphinctes* (*Dichotomosphinctes*) *antecedens* group, and/or *P. (D.) rotoides* Ronch.

The tenuicostatum Subzone is represented in the investigated sections by beds 20—41 in section I, beds 8—14 in section II, and beds 5—18 in section III. In addition to abundant specimens of *Cardioceras* (*Plasmatoceras*) *tenuicostatum* (Nik.) and *C. (P.) tenuistriatum* Bor., the fauna of this subzone includes: *C. (Subvertebriceras) densiplicatum* Boden var. *anglicum* var. n., *C. (Scoticardioceras) serrigerum* Buck., *C. (Scot.) roemeri* Siegfried, *C. (Scot.) excavatum* (Sow.), *C. (?Scot.)* sp. B, and *C. (Vertebriceras) cf. dorsale* Buck. associated with *Lissocera-toides erato* (d'Orb.), *Neocampylites delmontanus delmontanus* (Oppel), *N. delmontanus helveticus* (Jeannet), *N. villersi* (Rollier), *N. thirriai* (Petitclerc & Maire), *Euaspidoceras ovale* (Neum.), *Nebroditis (Enayites) czenstochowiensis* (Siem.), and various unidentifiable perisphinctids.

The antecedens Subzone has not been recognized in the investigated sections in the Zalas quarry.

REMARKS ON SOME AMMONITES

Cardioceras (Cardioceras) cordatum (Sowerby)
var. *costicordatum* Arkell, 1946
(Pl. 3, Fig. 13)

Remarks. — The range of the intraspecific variability of *Cardioceras cordatum* (Sow.) is meant in the present paper as by Arkell (1946, p. 308). In addition to the typical form of the species, which infrequently occurs in Poland, Arkell (1946) distinguished two varieties continuously intergrading with the typical form each. The presently illustrated form is more evolute and flat than the typical form of the species, being attributable to the variety *costicordatum* Arkell. The diagnostic feature of the species *Cardioceras cordatum* (Sow.) is the shell ornamentation, with secondary ribs weakened or even interrupted at the whorl flank, just behind the lateral tubercle. This feature is absent from earlier cardioceratids; while it appears also in *Cardioceras (Cardioceras) ashtonense* Arkell and *C. (C.) persecans* Buck., both of them closely related in morphology to *C. (C.) cordatum* var. *costicordatum* Arkell and characteristic of the cordatum Subzone.

Distribution at Zalas. — Section II, bed 3.

Cardioceras (Subvertebriceras) densiplicatum Boden, 1911
(Pl. 3, Fig. 11 and Pl. 4, Figs 5—6)

1911. *Cardioceras vertebrale* var. *densiplicata* nov. var.; Boden, p. 87, Pl. 1, Fig. 14.

1942. *Cardioceras (Subvertebriceras) densiplicatum* Boden; Arkell, p. 240, Pl. 52, Figs 3–5, Pl. 53, Figs 1, 4, 7–12, and Text-figs 85 (7) and 86.

Remarks. — The species under discussion is widespread in Europe and has been recently recognized as an index form for the lowermost ammonite zone of the Middle Oxfordian in the Subboreal and Boreal Provinces (Sykes & Callomon 1979). The present authors are of the opinion that the morphological variability observed in *Cardioceras (Subvertebriceras) densiplicatum* Boden in the investigated sections in the Zalas quarry permits distinction of two varieties different from each other in their whorl cross section.

One of the two forms, called *C. (S.) densiplicatum* Boden var. *lithuanicum* var. n., shows less prominent shoulders and less depressed shell above the lateral tubercle (Text-fig. 4a–b). This variety is represented by the specimen



Fig. 4. Whorl sections of two varieties *Cardioceras (Subvertebriceras) densiplicatum* Boden discussed in the text

a — var. *lithuanicum* var.n.: the lectotype (taken from Boden 1911, Pl. 1, Fig. 14a)

b — var. *lithuanicum* var. n.: the specimen illustrated in Pl. 3, Fig. 11

c — var. *anglicum* var. n.: the specimen illustrated in Pl. 4, Fig. 5a–b

described by Boden (1911, p. 37, Pl. 1, Fig. 14), as well as by one of the presently illustrated ones (Pl. 3, Fig. 11 and Text-fig. 4b). The other form, called *C. (S.) densiplicatum* Boden var. *anglicum* var. n., shows more angulate whorl cross section, more prominent shoulders, and considerably depressed shell above the lateral tubercle (Text-fig. 4c). It is represented by some specimens illustrated by Arkell (1942, Pl. 52, Fig. 4, Pl. 53, Figs 1, 10, and Text-fig. 86) and Bourseau (1977, Pl. 8, Fig. 10), as well as by the remainder of the presently illustrated specimens (Pl. 4, Figs 5–6).

One can hardly recognize the age relationship of Boden's specimen to those found in England. In the investigated area, however, the variety *lithuanicum* occurs below the first appearance of the variety *anglicum*, in association with ammonites indicative of the cordatum Subzone.

Distribution at Zalas. — Variety *lithuanicum*: section III, bed 3; variety *anglicum*: section I, beds 29, 35, and section III, beds 7 and 14.

Cardioceras (Scoticardioceras) serrigerum (Buckman, 1941)
(Pl. 4, Fig. 2)

1941. *Cardioceras (Scoticardioceras) serrigerum* (S. Buckman); Arkell (1935–1948), p. 226, Pl. 50, Fig. 2 and Text-fig. 79 only.

Remarks. — The presently illustrated form very closely resembles the holotype nucleus figured by Arkell (1941, Pl. 50, Fig. 2). This species differs from its morphologically most close relative, *C. (Scot.) expositum* (Buck.), in having weak shoulders at the inner whorls, as well as in its less distinct keel and ornamentation.

The other specimen illustrated by Arkell (1941, Pl. 49, Fig. 8) under the name *C. (Scot.) serrigerum* (Buck.) belongs to another species. It is more evolute, with a prominent keel and strong shoulders. It is noteworthy that when dealing

with distribution of the considered species Arkell (1941, p. 226) mentioned only a specimen from Marcham in addition to the holotype, not one from Headington where the specimen under discussion was found.

Distribution at Zalas. — Section III, bed 13.

Cardioceras (Plasmatoceras) sp. A
(Pl. 3, Fig. 12)

Material: A dozen or so poorly preserved specimens.

Description. — The specimens do not exceed 20 mm in diameter but nonetheless they most commonly possess a living chamber. The shell is densely ribbed, with convex whorl sides, wide venter, and low and wide keel. The ribs are flexuoid at the inner whorls, but more rectilinear, slightly prorsiradiate at the outer whorls. At the outer whorls the ribs regularly bifurcate at the whorl mid-height or a little below it. They are strongly inclined forwards at the ventral margin, but they incline in opposite direction at the keel and pass it perpendicularly. The keel is consequently covered with a slaty ornamentation (cf. Pl. 3, Fig. 12a).

Remarks. — The considered specimens are intermediate in morphology between *Cardioceras (Plasmatoceras) plastum* Euck. and *C. (P.) tenuicostatum-tenuistriatum* group. They differ from the former species in their less bulgy whorl cross section and more slender venter; while from representatives of the *C. (P.) tenuicostatum-tenuistriatum* group they differ in their wider whorls and lower secondaries to primaries ratio. The considered specimens are intermediate also in their stratigraphic position and may represent a phylogenetic link between *C. (P.) plastum* Buck. and *C. (P.) tenuicostatum-tenuistriatum* group.

Distribution at Zalas. — Section I, beds 14, 15, 18; section II, bed 5; and section III, bed 2.

Cardioceras (?Scoticardioceras) sp. B
(Pl. 4, Fig. 1)

Material: Some thirty variably preserved specimens.

Description. — The specimens do not exceed 30 mm in diameter but nonetheless they most commonly possess a living chamber. The shell is involute, with relatively wide umbilicus ($O/H=0.82$), slender outline, flattish whorl sides, and fine ornamentation. At the inner whorls, a tubercle appears on the primary ribs. It gradually disappears later in ontogeny, being replaced with a flat-like swelling. The secondaries arise from bifurcation of the primaries at the inner whorls. The ribs are arch-like in outline, inclined backwards at the last whorl.

Remarks. — The subgeneric position of the investigated specimens is uncertain because of their immaturity. The fine ornamentation and narrow whorl cross section appear to be indicative of the subgenus *Scoticardioceras*. However, *Scoticardioceras* is characterized by large-sized forms with smooth final living chamber. The attribution of the considered forms to *Scoticardioceras* remains therefore tentative until a complete adult shell will be found.

Distribution at Zalas. — Section II, beds 8, 9, and 10.

Cardioceras (Cardioceras) sp. C
(Pl. 3, Fig. 9)

Material: One specimen (No. RT 111).

Dimensions: D = 47 mm, W/D = 0.42; H/D = 0.32; O/D = 0.33.

Description. — The shell is involute, with wide umbilicus ($O/H=0.82$), sub-rectangular whorl cross section, flat whorl sides, and strong ornamentation. The

primary ribs are onset at the umbilical wall; they are slightly flexuoid and prorsiradiate. They show a high tubercle somewhat above the mid-height of the whorl. They are weakened or even disappear above the tubercle. If present, they further run in the previous direction or bifurcate, also with no change in direction. The secondary ribs arise from bifurcation or intercalation. They are parallel to the primaries at the inner whorls, and somewhat inclined forwards at the outer whorls. They achieve a considerable height at the ventral margin, but this trend gradually declines in ontogeny. The venter is almost flat, with well developed keel, serrated in outline due to the ribs passing over the venter. Sporadically, the secondary ribs are split into tertiary ones at the keel base.

Remarks. — The specimen is to be assigned to the subgenus *Cardioceras* because of its strong ornamentation, well developed lateral tubercles, and ontogenetic decline of the ribbing at the ventral margin. The widely spaced primary ribs and weakened ornamentation at the contact of the primaries and secondaries are suggestive of a relationship to the *Cardioceras (Cardioceras) cordatum* group. However, this is counterevidenced by the whorl cross section. The latter feature resembles, in turn, *Cardioceras biplanum* Maire (see Maire 1938, p. 102, Pl. 15, Figs 3—5) which species, however, does not show any weakening of the ornamentation between the primary and secondary ribs.

Distribution at Zalas. — Section I, bed 14.

Cardioceras (Cardioceras) sp. D

(Pl. 4, Fig. 3)

Material: One specimen (No. RT 118).

Dimensions: D = 45 mm; W/D = 0.40; H/D = ?0.31; O/D = 0.33.

Description. — The shell is involute, with wide umbilicus (O/H=0.83), flat whorl sides, and subrectangular whorl cross section. The primary ribs are onset at the umbilical wall, distinctly bent at the umbilical margin, slightly flexuoid and rectiradiate in outline. They show a low, slate-like tubercle somewhat above the whorl mid-height. At that point they incline backwards, but they are strongly curved forwards at the ventral margin. The venter is weakly convex at the phragmocone, and flat at the living chamber, with distinct and high keel. An intercalary secondary rib appears at the height of the lateral tubercles between each two primaries. All the primaries and secondaries pass over the venter, being sometimes split into tertiary ribs at the base of the keel.

Remarks. — The investigated specimen resembles *Cardioceras (Cardioceras) persecans* var. *fileyense* Arkell from which it differs in its more densely spaced ribs at the inner whorls.

Distribution at Zalas. — Section III, bed 4.

Institute of Geology
of the Warsaw University,
Al. Żwirki i Wigury 93,
02-089 Warszawa, Poland
(B. A. Matyja)

Laboratory of Paleontology and Stratigraphy
of the University of Mining and Metallurgy,
Al. Mickiewicza 30,
30-059 Kraków, Poland
(R. Tarkowski)

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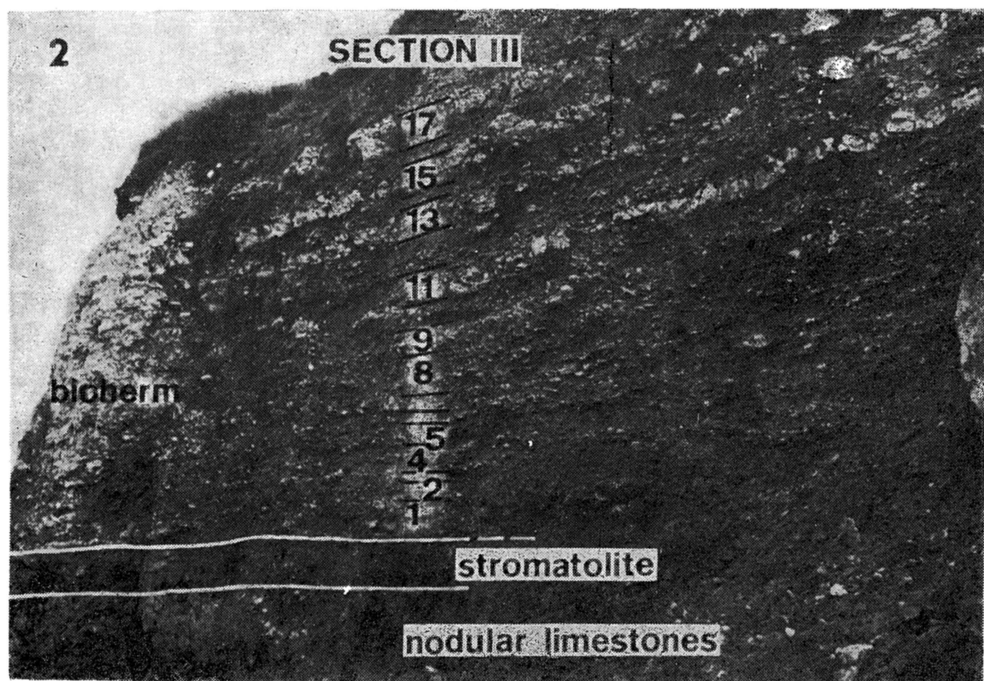
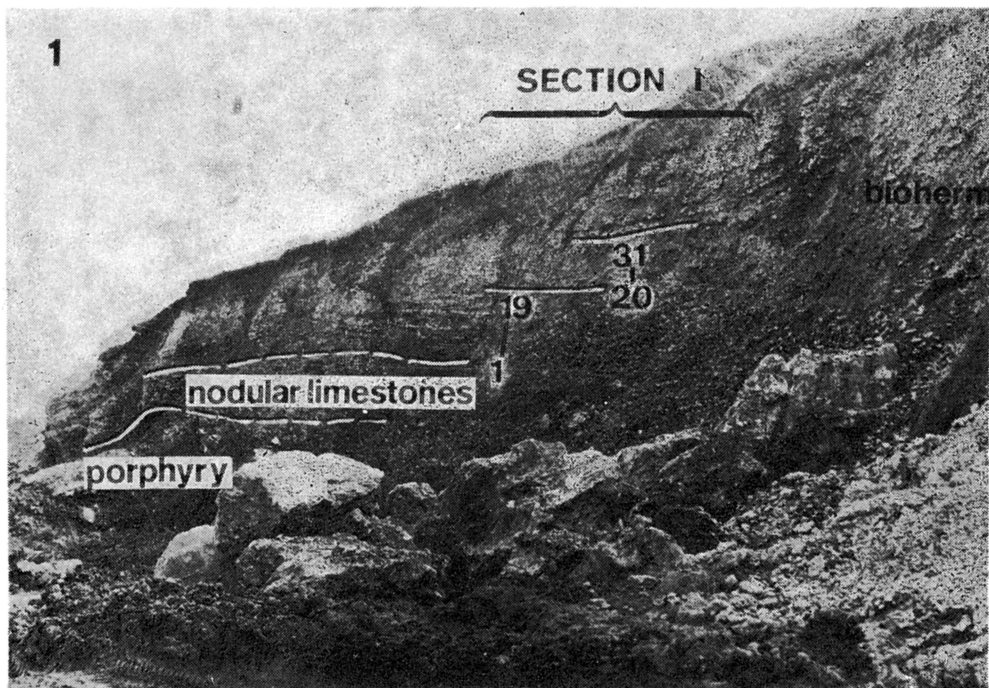
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B. A. MATYJA i R. TARKOWSKI

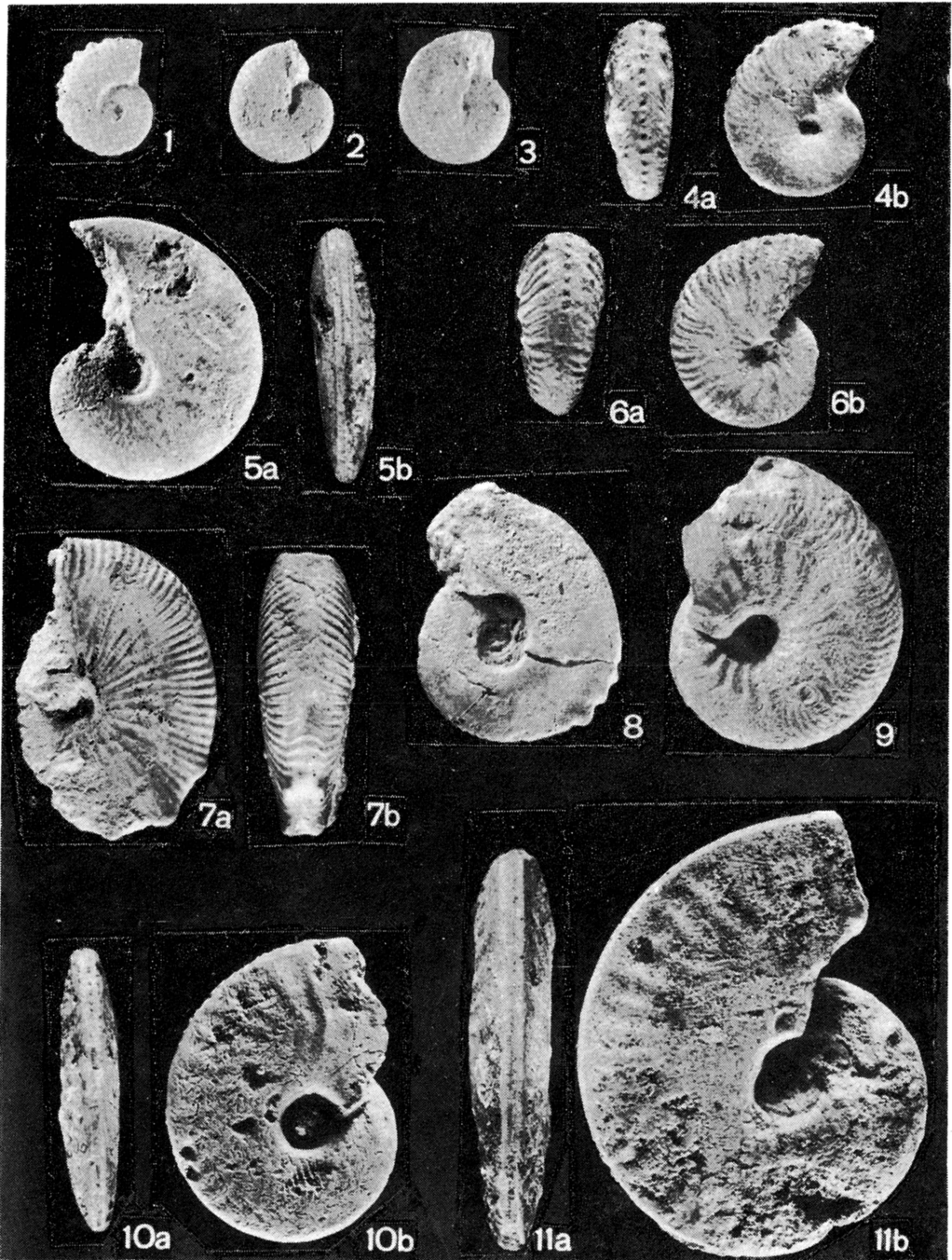
DOLNY I ŚRODKOWY OKSFORD W ZALASIE KOŁO KRZESZOWIC

(Streszczenie)

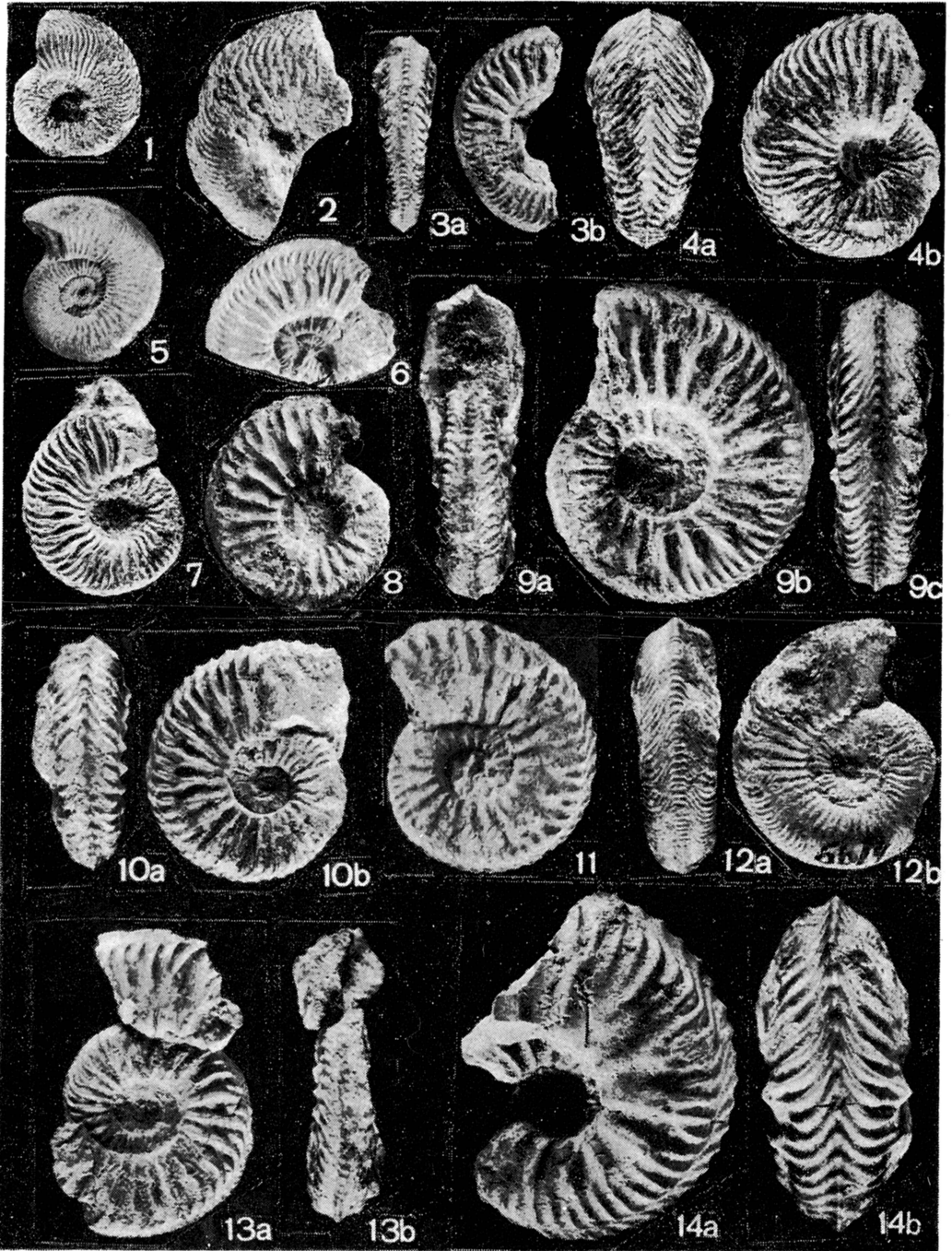
Przedmiotem pracy jest analiza utworów oksfordu odsłaniających się w kamieniołomie Zalas koło Krzeszowic (fig. 1). W trzech sporządzonych blisko siebie profilach (fig. 2—3 oraz pl. 1, fig. 1—2), przedstawiono następstwo występujących amonitów, zbieranych warstwa po warstwie. Bogaty zbiór tych amonitów, z których część przedstawiono na ilustracjach (pl. 2—6), pozwala stwierdzić, że utwory oksfordu dolnego mają zmienną, acz niewielką miąższość. Obecności poziomu *mariae* nie stwierdzono. W obrębie poziomu *cordatum* wyróżniono podpoziomy: *bukowskii*, *costicardia* i *cordatum*. Szczególnie interesujące amonity zebrano z warstw pogranicznych dolnego i środkowego oksfordu. W pracy przedyskutowano także kwestię zróżnicowania morfologicznego niektórych istotnych stratygraficznie gatunków amonitów, oraz opisano kilka form nie znanych dotychczas w literaturze, a należących do podrodzajów: *Cardioceras*, *Plasmatoceras* i przypuszczalnie *Scoticardioceras*.



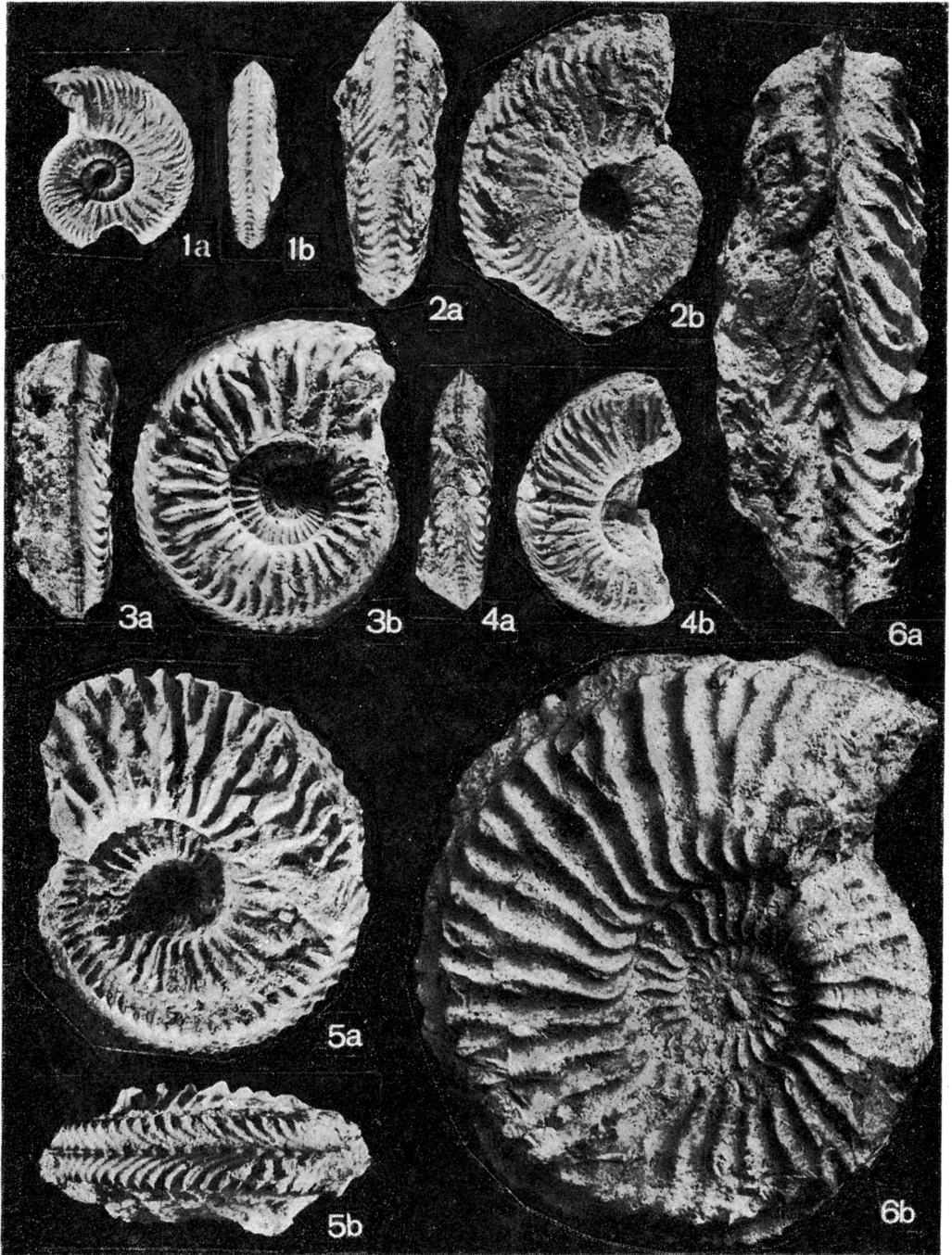
Details of the Jurassic sequence exposed at the Zalas quarry (cf. Text-figs 2—3):
 1 Eastern and middle part of the exposure (area of section I); 2 Middle and western part of the exposure (area of section III)



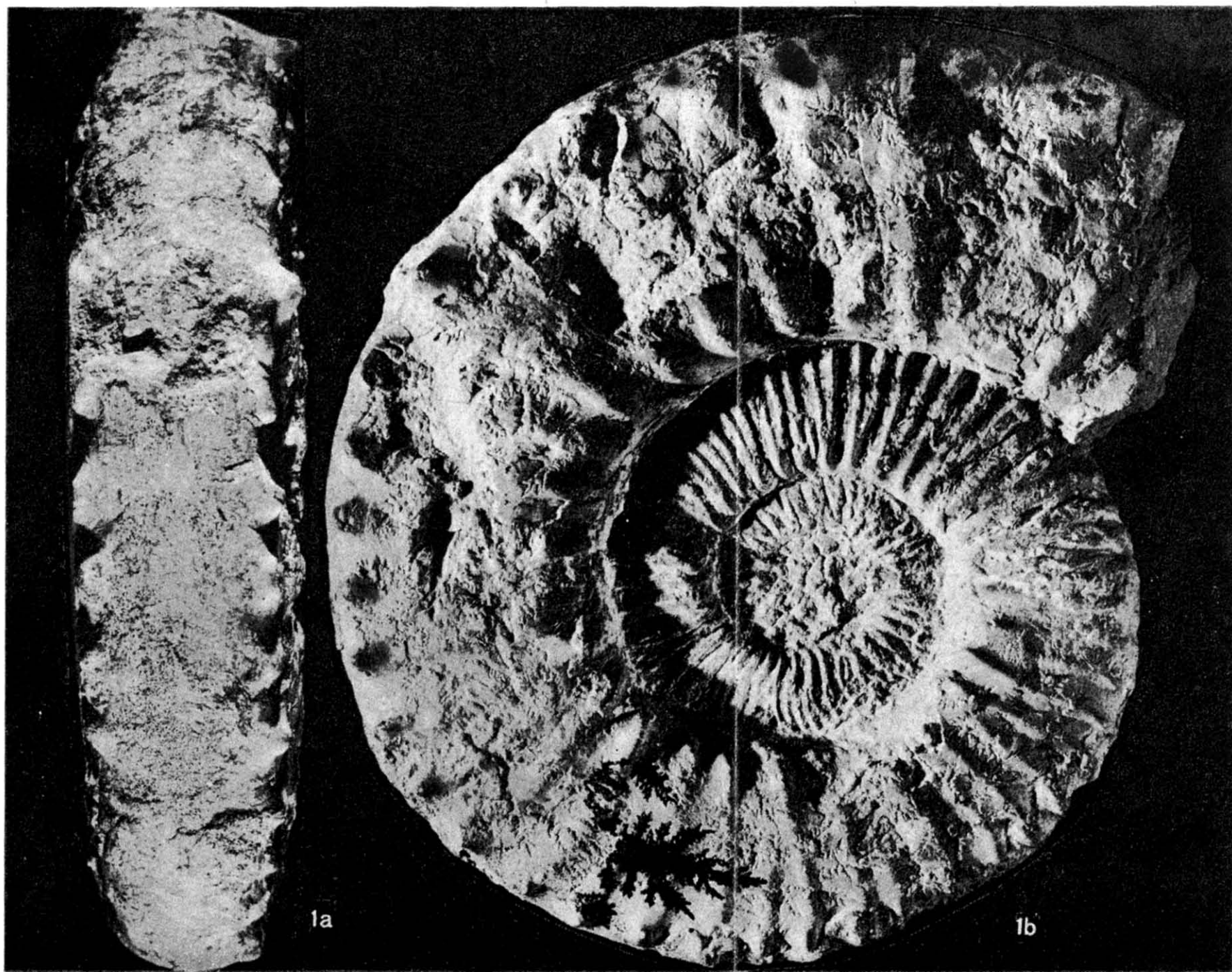
1 — *Creniceras crenatum* (Brug.), specimen No. RT86, red marls; 2-3 — *Popanites paturattensis* (Grepp.); 2 — RT87, 3 — RT88; 4a-b — *Taramelliceras polonicum* Malinowska, RT89, red marls; 5a-b — *Neocampylites thirriai* (Petitclerc & Maire), RT94, grey marls; 6a-b — *Taramelliceras bukowskii* (Siem.), RT90, red marls; 7a-b — *Taramelliceras minax* (Buk.), RT92, red marls; 8 — *Glochiceras* (*Coryceras*) *distortum* (Buk.), RT93; 9 — *Taramelliceras oculatum* (Phill.), RT91, red marls; 10a-b-11a-b — *Neocampylites villersi* (Rollier); 10a-b — RT95, grey marls, 11a-b — RT98, grey marls



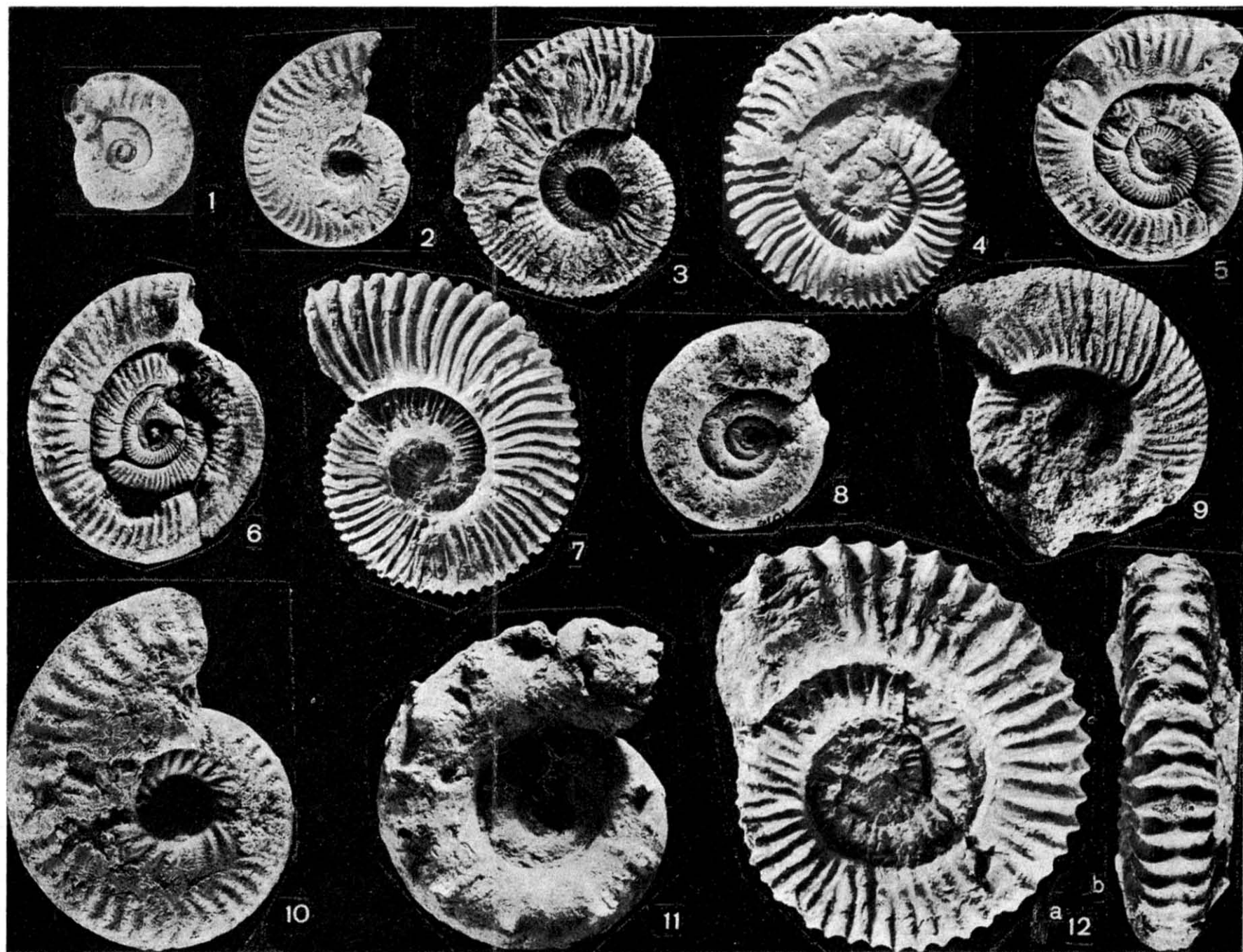
1—2 — *Cardioceras (Scarburgiceras) bukowskii* Maire; 1 — specimen No. RT105, yellow marls, 2 — RT106, yellow marls; 3a—b — *Cardioceras (Cardioceras) cf. ashtonense* Arkell, RT107, section I, bed 16; 4a—b — *Goliathiceras (Pachycardioceras) globulus* Arkell, Mt805, yellow marls; 5a—b *Cardioceras (Plasmacoceras) tenuicostatum* (Nik.), RT108, section III, bed 10; 6 — *Cardioceras (Scotticardioceras) excavatum* (Sow.), RT109, section II, bed 9; 7 — *Cardioceras (Subvertebriceras) costellatum* Buck., RT110, red marls; 8 — *Cardioceras (Subvertebriceras) cf. densiplicatum* Boden, Mt806, section I, bed 14; 9a—c — *Cardioceras (Cardioceras) sp. C*, RT111, red marls; 10a—b — *Cardioceras (Vertebriceras) sequanicum* Maire, RT112, red marls; 11 — *Cardioceras (Subvertebriceras) densiplicatum* Boden var. *lithuanicum* var., n., RT113, section III, bed. 3; 12a—b — *Cardioceras (Plasmacoceras) sp. A*, RT114, section I, bed 13, X2; 13a—b — *Cardioceras (Cardioceras) cordatum* var. *costicordatum* Arkell, RT115, section II, bed 3; 14a—b — *Cardioceras (Cardioceras) costicardia* Buck., Mt807, red marls



1a—b — *Cardioceras* (?*Scoticardioceras*) sp. B, specimen No. RT116, section II, bed 9; 2a—b — *Cardioceras* (*Scoticardioceras*) *serrigerum* (Buck.), Mt808, section III, bed 13; 3a—b — *Cardioceras* (*Cardioceras*) sp. D, RT118, section III, bed 4; 4a—b — *Cardioceras* (*Scoticardioceras*) *roemeri* Siegfried, RT117, section III, bed 5; 5a—b — *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden var. *anglicum* var. n., Mt697, section III, bed 14; 6a—b — *Cardioceras* (*Subvertebriceras*) *densiplicatum* Boden var. *anglicum* var.n., Mt809, grey marls



1a—b — *Peltoceratoides constantii* (d'Orb.), specimen No. RT119, red marls



1 — *Mirosphinctes bukowskii* (Choffat), specimen No. RT99; 2 — *Neocampylites delmontanus helveticus* (Jeannet), RT96; 3 — *Parawedekindia choffati* (Loriol), RT100, red marls; 4 — *Parawedekindia stephanovi* Sapunow, Mt810, red marls; 5 — *Nebroditis* (*Enayites*) *czenstochowiensis* (Siem.), Mt811, section III, bed 9; 6 — *Nebroditis* (*Enayites*) aff. *czenstochowiensis* (Siem.), RT103, red marls; 7 — *Parawedekindia arduennensis* (d'Orb.), Mt812, red marls; 8 and 11 — *Aspidoceras* (*Euaspidoceras*) *ovale* Neum.; 8 — RT101, section III, bed 6, 11 — RT102, red marls; 9 — *Perisphinctes* sp., RT104, section I, bed 35; 10 — *Neocampylites delmontanus delmontanus* (Oppel), RT97, grey marls; 12a—b — *Peltomorphites interscissus* (Uhlig), Mt813, red marls