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The highest Kimmeridgian and Lower Volgian in Central Poland; their ammonites and biostratigraphy

ABSTRACT: The Upper Kimmeridgian Eudoxus and Autissiodorensis Zones, with the Fallax Subzone at the top of the latter zone, as well as the Lower Volgian Klimovi, Sokolovi, Pseudoscythica, and Tenuicostata Zones, can be recognized in several expanded and continuous sections of the Pałuki Formation in Central Poland. There can be reconstructed a Subboreal lineage of the Perisphinctaceae, leading from *Discosphinctoides subborealis* sp.n. and *Sarmatisphinctes* gen.n. in the Autissiodorensis Zone, through *Ilowaiskya* and *Pseudovirgatites* in the Lower Volgian, to *Zaraiskites* in the Middle Volgian. The ammonite assemblages of the Pałuki Formation, which also include *Aulacostephanus* and *Amoeboceras* in the Upper Kimmeridgian, are predominantly of Subboreal type, but Mediterranean/Submediterranean ammonites, chiefly the Haplocerataceae, are also represented at some stratigraphic levels. Interregional stratigraphic correlations are discussed in the paper, especially those between the Tithonian and Volgian Stages. The new biostratigraphic material permits *e.g.* to correlate the top of the Klimovi Zone with the top of the Tithonian Hybonotum Zone, and the top of the Sokolovi Zone with a level situated slightly beneath the base of the Middle Tithonian in Franconia.

INTRODUCTION

The Pałuki Formation (DEMBOWSKA 1979), a formation which is chiefly composed of argillaceous limestones and calcarous shales, and displays some similarity to the British Kimmeridge Clay, extends over vast areas of the Polish Lowland. Ammonites occur in profusion in most parts of the Pałuki Formation, which encompasses some upper part of the Eudoxus Zone and the Autissiodorensis Zone of the Upper Kimmeridgian, the Klimovi, Sokolovi, Pseudoscythica, and Tenuicostata Zones of the Lower Volgian, and three horizons of the Middle Volgian Scythicus Zone. However, even in the areas were this formation is not overlain by younger Mesozoic and/or Tertiary sediments, there never existed good natural exposures of the Pałuki Formation, because of the soft nature of its rocks, and an almost omnipresent cover of Quaternary sediments. To the authors' know -ledge, no exposure of the Pałuki Formation exists at present. Nevertheless, a clay-pit at Brzostówka near Tomaszów Mazowiecki, the classic locality of Poland's Volgian stratigraphy (Text-figures 1 and 2), and several other occasional exposures, that existed some years ago, made it possible to investigate the ammonite assemblages occurring in some high portions of the Pałuki Formation, notably in the topmost part of the Tenuicostata Zone, and in the Quenstedti, Scythicus, and Regularis Horizons of the Scythicus Zone. These assemblages were described comprehensively by KUTEK & ZEISS (1974) and KUTEK (1994a); the latter paper includes also a description of still younger Volgian ammonites, found within the Kcynia Formation in the Zarajskensis Horizon of the Scythicus Zone. These ammonites from the Kcynia Formation appear to be the youngest Jurassic ammonites hitherto found in the Jurassic of cratonic Poland.

The present study, chiefly based on paleontologic material from boreholes, is concerned with the ammonites and biostratigraphy of the Kimmeridgian and Lower Volgian portions of the Pałuki Formation. It thus provides, in conjunction with the two earlier papers published in the same journal (KUTEK & ZEISS 1974, KUTEK 1994a), a complete description of the succession of ammonites in the Pałuki Formation in Central Poland.

The present paper is a result of joint work carried out by the authors over twenty years with the basic aim to make the stratigraphic correlations between the Volgian and Tithonian Stages more precise, exploring the possibilities provided by the Subboreal and Submediterranean ammonites which do co-occur in Central Poland (KUTEK & ZEISS 1974, 1975, 1988, 1994).

The paleontologic material was made available by J. KUTEK, who is also responsible for the regional aspects of this paper. The paleontologic work on the Submediterranean ammonites was chiefly done by A. ZEISS, and that on the Subboreal ones by J. KUTEK, but both writers should be regarded as the authors of the new taxa established herein. The last draft of this paper was written by J. KUTEK.

GENERAL GEOLOGIC SETTING

In Permian and Mesozoic time, Central Poland was included in the Central (Northwest) European Basin, and also in the Polish Rift Basin; the Laramide inversion of the proximal part of the latter basin gave rise to the Mid-Polish Anticlinorium (KUTEK 1994b).

During the Permian and Mesozoic, the Central European Basin was usually separated structurally, and sometimes also paleogeographically, from the basins of the Carpathian Tethyan domains by the Meta-Carpathian Arch. However, in the late Middle Jurassic, the Oxfordian and the Kimmeridgian, the area of that arch experienced strong subsidence, so that most of cratonic Poland was transformed into a part of the northern shelf of the European Tethys. As a result, the Oxfordian, and most of the Kimmeridgian, ammonite assemblages of cratonic Poland are predominantly of the Submediterranean type (KUTEK & *al.* 1984, KUTEK 1994b, MATYJA & WIERZBOWSKI 1995). In the Tithonian, the Meta-Carpathian Arch began again to rise. As a consequence of this uplift, sedimentation in the latest Tithonian was restricted in cratonic Poland to the Central European Basin, where a Purbeck-type facies developed, ranging from the Middle Volgian to the Middle Berriasian. In the context of the present paper the most important point is that, as a result of the Tithonian/Berriasian and later uplift of the Meta-Carpathian Arch, no sediments of latest Kimmeridgian and Volgian age were preserved in southern cratonic Poland just north of the Carpathians, and that the occurrences of the Kimmeridgian and Volgian sediments of the Pałuki Formation are confined to Central and Northern Poland.

Kimmeridgian and Volgian sediments were also removed by erosion from some, but not all, parts of the Mid-Polish Anticlinorium, as a result of its Laramide uplift. This tectonic event is also reflected in the present-day distribution of Volgian sediments in Poland (Text-fig. 1). No similar map depicting the distribution of sediments of latest Kimmeridgian age (upper Eudoxus, and Autissiodorensis Zones) is available. However, the latter sediments usually extend but slightly beyond the limits of those of the Lower Volgian (for instance, less than 10 km in the western margin of the Mid-Polish Anticlinorium south of Stobnica; KUTEK 1961, 1962).

The limits of the present-day occurrences of the highest Kimmeridgian and Volgian sediments in cratonic Poland are largely the result of post-Volgian erosion, so that their restricted distribution does not preclude the existence, in latest Kimmeridgian and/or Volgian times, of marine connections to the east with the Russian Platform, to the south with Tethyan domains, and to the west and north-west with regions of Northwest Europe.

Some Upper Jurassic carbonates of Tithonian but probably also Late Kimmeridgian age, reminiscent to some extent of the Stramberk Limestone Formation of the Outer Carpathians, still occur in a small area in south-eastern cratonic Poland, south-east of Lublin, and also in the western Ukraine.

INVESTIGATED SECTIONS

As previously stated, no exposures of the Kimmeridgian and Volgian sediments of the Pałuki Formation are presently available in Central Poland. Still, some paleontologic material could be collected at the locality of Brzostówka, now a suburb of Tomaszów Mazowiecki, and at Stobnica (Text-fig. 2).

At Brzostówka, a section encompassing the uppermost portion of the Lower Volgian Tenuicostata Zone, about 6m thick, and some younger strata representing the Middle Volgian Scythicus Zone (the Scythicus Subzone), could be made accessible in a disused claypit (Text.-fig. 3*C*). This section was described by KUTEK & ZEISS (1974), and the collected ammonites illustrated in 32 plates. This section was discussed again by KUTEK (1994a), and it will be briefly summarized in the present paper.

Several Upper Kimmeridgian and Lower Volgian ammonites from Stobnica (Text-fig. 2) were collected, and figured in 10 plates, mostly under wrong names, by KUTEK (1961). At Stobnica there

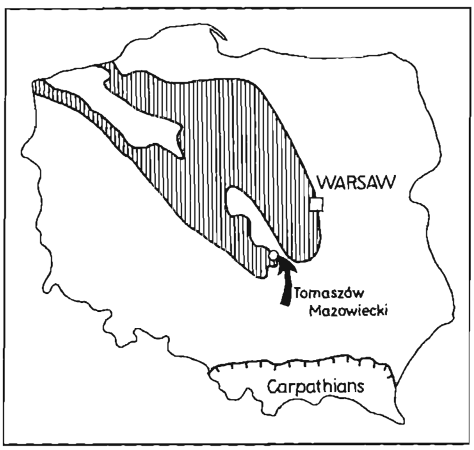


Fig. 1. Distribution of Volgian deposits in Poland (taken *from* KUTEK 1994a)

existed some exposures of the Coquina Formation (*see below*), but identifiable ammonites of the Pałuki Formation could only be collected from three farmers wells, and a few shallow test-pits; the numbers given by KUTEK (1961) to these exposures are used unchanged in this paper. The part-sections provided by the exposures have been pieced together in a composite section (Text-fig. 3*A*), taking into account the available biostratigraphic, and local geologic, data. At Stobnica 37 and 39, the ammonites which were collected from rock material excavated from the wells probably represent only the lowest portions of these two part-sections.

The paleontologic material provided by the sections of Brzostówka and Stobnica is important because it comprises several large ammonites, with dimensions often amounting considerably over those of the specimens obtained from core-samples of the borehole-sections.

Two continuous sections of Kimmeridgian and Volgian sediments of the Pałuki Formation were provided by the wholly-cored boreholes Zarzęcin *IG-1* and Zarzęcin *IG-3* (Text-figs 2 and 3*A*). The lithologic

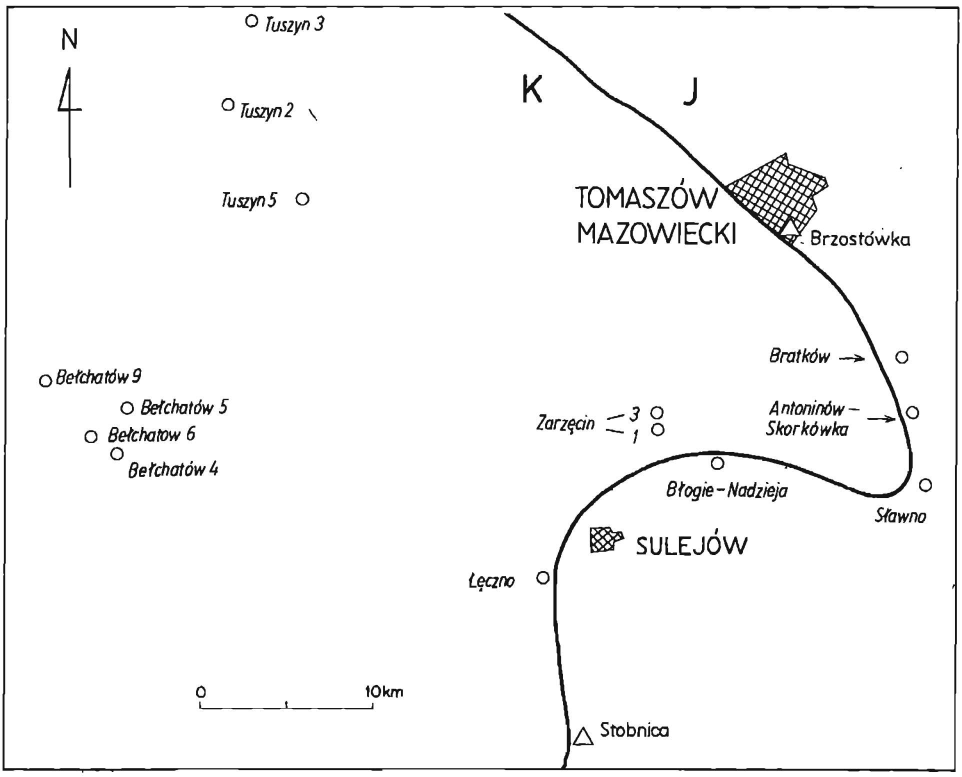


Fig. 2. Location map of the studied area; circles – boreholes, triangles – exposures

succession in these sections was described by A. WITKOWSKI, who also collected the ammonites yielded by these boreholes. The sections of Zarzęcin *1* and 3 were interpreted biostratigraphically in a brief paper by KUTEK & WITKOWSKI (1963). No ammonites were illustrated in that paper, and some of the biostratigraphic interpretations presented therein require revision.

Continuous sections of the Kimmeridgian and Volgian sediments of the Pałuki Formation were also provided by the wholly-cored boreholes Błogie-Nadzieja, Sławno, Antoninów-Skorkówka, and Bratków (Text-figs 3*B*-*C*). The paleontologic material from these sections is here published for the first time. The lithology of the section was described by B.A. MATYJA and A. WIERZBOWSKI (*in* MATYJA & *al.* 1988), while fossils were collected chiefly by J. KUTEK, and in part also by B.A. MATYJA. Data concerning the CaO content in the borehole sections were made available by the *Geological Enterprise* at Cracow.

The Volgian strata are directly overlain by Albian sediments at Stobnica, by Neocomian ones at Zarzęcin, and by Tertiary or Quaternary sediments at Błogie-Nadzieja, Sławno, Antoninów-Skorkówka, and Bratków.

All the exposures and boreholes listed above are situated at the western margin of the Mid-Polish Anticlinorium, chiefly around or within the Tomaszów Syncline (Text-fig. 2). Some additional paleontologic material considered in this paper was obtained from the boreholes Bełchatów *4*, *5*, *6* and *9*, and Tuszyn *2*, *3* and *5*, situated in the Łódź Depression (Text-figs 2 and 4-5); these were but partially cored boreholes of the oil industry. The lithologic successions in these boreholes were described in unpublished reports by T. WEYDLING and K. MROZEK, and some information about the borehole sections can be found in a publication by MROZEK (1975).

The fossils collected in the latter boreholes were given for identification to Professor C. PACHUCKI, of the University of Lublin, who presented a biostratigraphic interpretation of the sections of Bełchatów 5, and Tuszyn 2 and *5*, in a brief paper (PACHUCKI 1963), including 5 plates with illustrations of ammonites; several of the taxonomic interpretations of these ammonites require revision. After the death of Professor C. PACHUCKI, the paleontological material was offered by his co-workers to J. KUTEK. However, the transferred collection does not contain all the fossils collected from the boreholes here considered, although photographs of some of the lost specimens are still available; in a few cases, these photographs are reproduced in the present paper.

The loss of a part of the collected specimens may explain why some coeval intervals from the closely spaced boreholes reveal apparently some differences in faunal content (for instance, the collection contains numerous specimens of *Aulacostephanus* from the borehole Bełchatów *9*, and nearly none such specimens from the borehole Bełchatów *6*).

The boreholes situated in the Łódź Depression yielded some valuable paleontologic material from Upper Kimmeridgian strata, and the junction of the Kimmeridgian and the Volgian was cored in some of the boreholes. However, these boreholes, having been but partly cored, provided less continuous sections, especially in the Lower Volgian, than the boreholes in the region of Tomaszów Mazowiecki.

LITHOLOGY

In the investigated sections, the Pałuki Formation is composed of alternating calcarous shales and limestones, more or less argillaceous; the carbonate content is very variable. Some minor admixture of silt may occur especially in the Lower Volgian. The shales are usually greenish in the Kimmeridgian portion of the formation, and blackish in its Lower Volgian portion. However, the base of the Volgian defined biostratigraphically as the base of the Klimovi Zone, has no clearly distinctive lithological expression. No distinctive lithologic marker beds, readily recognizable over great distances, occur in the Pałuki Formation.

The lithologic successions in the sections here considered were described by different workers in a different way. Different terms were often given to similar rocks. Furthermore, particular sections were described by different authors with a different degree of precision: intercalations only some 10 or 20 cm thick were indicated by some authors, whereas lithologic interval some 10 or 20 m thick were characterized collectively by others. As the lithologic descriptions of different authors are not directly comparable, lithology is not indicated in the stratigraphic columns shown herein (Text-figs 3-5). However, the CaO content, which can be regarded to be an objective measure of lithologic variability, is indicated in the sections of the boreholes Bratków, Antoninów-Skorkówka, Sławno, and Błogie-Nadzieja (Text-fig. 3*B*-*C*). The primary data, which are presented somewhat generalized in these figures, referred to the average content of CaO at one meter intervals.

In the investigated sections, the dip of Upper Jurassic strata is very small, amounting only to a few degrees. Therefore, the thickness of strata is given with no correction for their dip.

No sedimentologic nor paleontologic indications of stratigraphic condensation, and no erosional structures, have been observed in the Pałuki Formation. On the other hand, shell concentrations on bedding surfaces can be interpreted as indicative of omission surfaces, and a few shellbeds, up to several tens of centimeters thick in extreme cases, were encountered in some sections. Nevertheless, there are no indications of significant stratigraphic discontinuities in the Pałuki Formation, so that the sections provided by this formation can be regarded as continuous in terms of usual stratigraphic standards.

PALEONTOLOGIC MATERIAL

Ammonites occur in great numbers in most of the Upper Kimmeridgian and Lower Volgian strata of the Pałuki Formation, where they usually are not accompanied by any other macrofossils. Some other macrofossils, chiefly bivalves (*Nanogyra*, or *Buchia*), or gastropods (*Scurria*), were encountered only at a few levels. Highly diversified assemblages of bivalves appear in the Middle Volgian portion of the Pałuki Formation, as demonstrated in a classical monograph by LEWIŃSKI (1923). However, this part of the Pałuki Formation is beyond the scope of the present paper.

All the ammonites from the Pałuki Formation, which are preserved as shells, molds, imprints, or in a mixed fashion, are crushed. As a consequence, septal sutures are not preserved in the specimens. The dimensions of ammonites were affected by crushing in the usual way; for instance, the height of whorls became enlarged with respect to the diameter of umbilicus. The measurements given in this paper, if not otherwise stated, refer to uncorrected dimensions of crushed specimens.

It is worth to emphasize that the investigated collection includes a fairly large portion of specimens obliquely crushed, or otherwise asymmetrically distorted. For instance, whorls removed from the umbilicus can be observed in some specimens, or parts of the shells thrusted upon other parts. Some artefacts of preservation can thus be produced, especially in small specimens, which may readily lead to erroneous taxonomic interpretations.

Several ammonites obtained from cored boreholes are incomplete because of the limited dimensions of core-samples. However, in the sediments of the Pałuki Formation, a gradation can often be observed from intact specimens, with apertures preserved, through nearly complete and fragmentary specimens (nuclei, fragments of whorls), to shell debris of different size. As a consequence, what should be called a specimen is often a matter of convention; and in some cases, *e.g.* in that of the shellbeds with *Amoeboceras volgae* (Pl. 11), picking up fragments of shells meriting to be classified as specimens would make little sense. Moreover, what might be classified as merely shell debris can still, in some cases, be identifiable taxonomically on the species level, whereas some apparently much better specimens cannot be identified even on genus level. Hence, it can only be stated with much reservation that the present paper is based on about 600 reasonably good specimens of ammonites.

The distribution of ammonites in the investigated sections is indicated in the APPENDIX to this paper. When interpreting these data, it should be taken into acount that several ammonites may be assembled on one bedding surface, and that the levels or narrow intervals, indicated by the collectors, may comprise several such surfaces.

The levels of occurrence of the ammonites are indicated in meters, except for the boreholes situated in the Łódź Depression. In the latter case, the cored interval is first indicated in meters, then, by Roman numerals, the successive core-boxes (of one meter length), and then the position of the core-sample within the boxes in centimeters; from this, the level of occurrence can be deduced. For instance, the indication Bełchatów *6*, 545.0-550.0 m II 30 cm corresponds to a depth of 546.30m, assuming complete coring. In some cases, only the cored interval and the numbers of the core-boxes, or only the interval, were indicated by the collectors.

The ammonites described in this paper are retained in the Museum of the Faculty of Geology, University of Warsaw, as the collections IGPUW/A/31 and IGPUW/A/32. In these collections, the numbers given to specimens refer directly only to rock-samples or core-samples, and not necessarily to individual ammonites; so several ammonites may be contained in one sample. Only reasonably well preserved ammonites were included in these collections.

Where suitable paleontologic material is available, the ammonites from the Kimmeridgian and Lower Volgian strata of the Pałuki Formation, especially those of the family Virgatitidae, are interpreted taxonomically in accordance with the broad, horizontal concept of species, as advanced by CALLOMON (1985), and applied by KUTEK

(1994a) to species of the genus *Zaraiskites* from the Middle Volgian of Central Poland. This means that ammonites revealing a continuous range of morphologic variability, and found in restricted stratigraphic intervals, are interpreted as conspecific.

THE COQUINA FORMATION

In the area here considered, the Pałuki Formation is underlain conformably by the formation of Kimmeridgian age with no formal name, called the Coquina Formation by KUTEK (1974b). It consists of calcarous mudstones and shales intercalated with coquinas, which are chiefly built up by shell hash of *Nanogyra*. In contrast to the Pałuki Formation, the Coquina Formation extends southwards to the Carpathians, being still preserved in the south-western margin of the Mid-Polish Anticlinorium and some parts of the Łódź and Miechów Depressions. It could be demonstrated in the outcrops of the south-western margin of the Holy Cross Mountains, a region included in the Mid-Polish Anticlinorium, that the base of the Coquina Formation is situated high in the Hypselocyclum Zone, or low in the Divisum Zone, in particular sections. The ammonite assemblages of these zones are clearly Submediterranean in type, as evidenced *e.g.* by *Ataxioceras* and *Crussoliceras*. In the southern regions, where the Coquina Formation is directly overlain by mid-Cretaceous sediments, some upper portions of this formation were removed by erosion. In contrast, no part of the Coquina Formation is missing in Central Poland, where in the regions here considered its thickness usually ranges between 50 and 100 m (MROZEK 1975, MATYJA & *al.* 1988). The boundary between the Coquina Formation and the Pałuki Formation can be interpreted as a boundary of tectonically-controlled (transgressive-regressive) sequences; more information about the Coquina Formation is given in papers by KUTEK (1961, 1968, 1969, 1994b).

At Stobnica (Text-fig. 3*A*), several specimens of *Aulacostephanus* were found in the highest coquina layer of the Coquina Formation, at the very top of this formation; some of them were figured by KUTEK (1961, Pls 11-12; Pl. 13, Figs 1-2; Pl. 15, Fig. 1). These specimens, having been subjected to some taxonomic revision (ZIEGLER 1962, KUTEK 1962), can be referred to as *Aulacostephanus eudoxus* (D'ORBIGNY), *A. pseudomutabilis* (DE LORIOL), and *A. pinguis* DURAND. These are diagnostic species of the Eudoxus Zone, and their stratigraphic distribution is not restricted to the upper part of this zone (ZIEGLER 1962, CALLOMON & COPE 1971, HANTZPERGUE & LAFAURIE 1983, HANTZPERGUE 1989). Consequently, it can be expected that some part of the overlying Pałuki Formation still belongs to the Eudoxus Zone.

The upper boundary of the Coquina Formation is usually drawn in particular sections at the top of the highest coquina layer. Accordingly, this boundary can be drawn at 77.0m at Bratków, at 104.0m at Sławno, at 97.0m at Błogie-Nadzieja, at 591.0-596.0m II 30 cm at Bełchatów *4*, at 811.0-817.7m I 20 cm at Bełchatów *5*, presumably at 570.0-576.6m at Bełchatów *6*, and possibly at 982.3-988.5m I 0-100 cm at Tuszyn *2* (see Text-figs 3*A*-*C*, and 4-5). However, the coquina layers differ in thickness, and also in development, representing detrital or non-detrital, and more or less densely shell-repleted, varieties. For instance, the highest coquina layer is about 4.9m thick in the borehole Bratków, 1.0m thick in the borehole Sławno, and 1.8m thick in the borehole Błogie-Nadzieja; and at deeper levels, different numbers of coquina intercalations appear in particular sections (MATYJA & *al.* 1988). These observations indicate, supported by other lithological and biostratigraphic data (Text-figs 3*B*-*C* and Appendix), that the coquina layers here considered form lithosomes of limited lateral extent and appear at different levels in particular sections; hence the topmost coquina layers encountered in different sections are interpreted as presumably more or less diachronic.

This makes the boundary between the Coquina and Pałuki Formations somewhat diffuse. This also seems to be partly the reason why the thickness of the Kimmeridgian portion of the Pałuki Formation, measured from the top of the Coquina Formation to the base of the Volgian, is different in particular sections. This stratigraphic interval is about 72m thick at Bratków, 64m at Sławno, 57m at Błogie-Nadzieja, about 40m in the very closely spaced boreholes Bełchatów *4*, *5* and *6*, and possibly about 80m thick at Tuszyn *2* (Text-figs 3*B*-*C*, and 4-5). It can be estimated to be about 40m thick at Stobnica (Text-fig. 3*A*).

UPPER EUDOXUS ZONE

The lowest strata of the Pałuki Formation yielded only a few, mostly poorly preserved specimens of ammonites (*see* Appendix and Text-figs 3*B*-*C*, 4-5). Nevertheless, these ammonites, when taken together, form a quite distinctive assemblage composed of *Glochiceras* *modestum* ZIEGLER, *Discosphinctoides* ex gr. *stenocyclus – roubyanus* (FONTANNES), *Sutneria eumela* (D'ORBIGNY), *Sutneria* cf. *lorioli* ZEISS, and *Aspidoceras bispinosum* (ZIETEN).

The Polish specimens assigned to *Glochiceras modestum* (Pl. 1, Fig. 6) agree quite well with those described and figured by ZIEGLER (1958a, p. 139, Pl. 14, Figs 3-5). Following ZEISS (1979, pp. 269, 272), the forms of *Sutneria eumela* (D'ORBIGNY) are kept distinct from the more coarsely ornamented forms of *Sutneria lorioli* ZEISS. Accordingly, the two Polish specimens of *Sutneria* are compared with *S. eumela* (Pl. 1, Fig. 5) and *S. lorioli* (Pl. 1, Figs 3-4). The name of *Aspidoceras bispinosum* (ZIETEN) traditionally applied to forms from the Malm Delta of South Germany is retained for the two Polish specimens here considered (Pl. 1, Figs 1-2), so more as they are closely comparable with the well known figures of QUENSTEDT (1887, Pl. 118, Figs 1-2, 4-5).

Of the few specimens of *Discosphictoides* found in the Eudoxus Zone, two are here illustrated (Pl. 1, Figs 6-7). Their relatively dense ribbing (Pl. 1, Fig. 8) and the presence of numerous triplicate ribs (Pl. 1, Fig. 7) permits to accomodate these specimens in the group of *Discosphinctoides stenocyclus – roubyanus* (*see* FONTANNES 1879, pp. 56, 58, Pl. 8, Fig. 6, Pl. 9, Fig. 2; BANTZ 1970, pp. 39-40, Pl. 5, Figs 1, 3), and also to keep them distinct from the representatives of *Discosphinctoides subborealis* sp.n., that occur in profusion in the Autissiodorensis Zone of Central Poland (*see below*).

The ammonite assemblage here considered has clearly its counterpart in the Eudoxus Zone (Malm delta 3 + 4) of South Germany (ZIEGLER 1958b, BANTZ 1970). The occurrences of *Sutneria eumela* (D'ORBIGNY) and *S. lorioli* ZEISS are restricted to the Eudoxus Zone in South Germany, England, and France (ZIEGLER 1962, 1977; CALLOMON & COPE 1971; CONTINI & HANTZPERGUE 1975; ZEISS 1975). Also *Glochiceras modestum* ZIEGLER is a diagnostic fossil of the Eudoxus Zone (ZIEGLER 1958a, b; HÖLDER & ZIEGLER 1959, BANTZ 1970). Accordingly, in the Łódź Depression, the strata ranging up to the level 946.5-952.8m I in the Tuszyn 2 borehole, and the level 805.6-811.0m III in the Bełchatów 5 borehole (Text-figs 4-5) are assigned to the Eudoxus Zone. In the region of Tomaszów Mazowiecki, the level of occurrence of *Glochiceras modestum* at 90.80m in the Sławno borehole (Text-fig. 3*B*) is taken as indicating the top of the strata that can still be assigned with certainty to the Eudoxus Zone.

In the boreholes Bratków, Sławno, and Błogie-Nadzieja, some poorly preserved specimens of small ameboceratids were found just below and/or

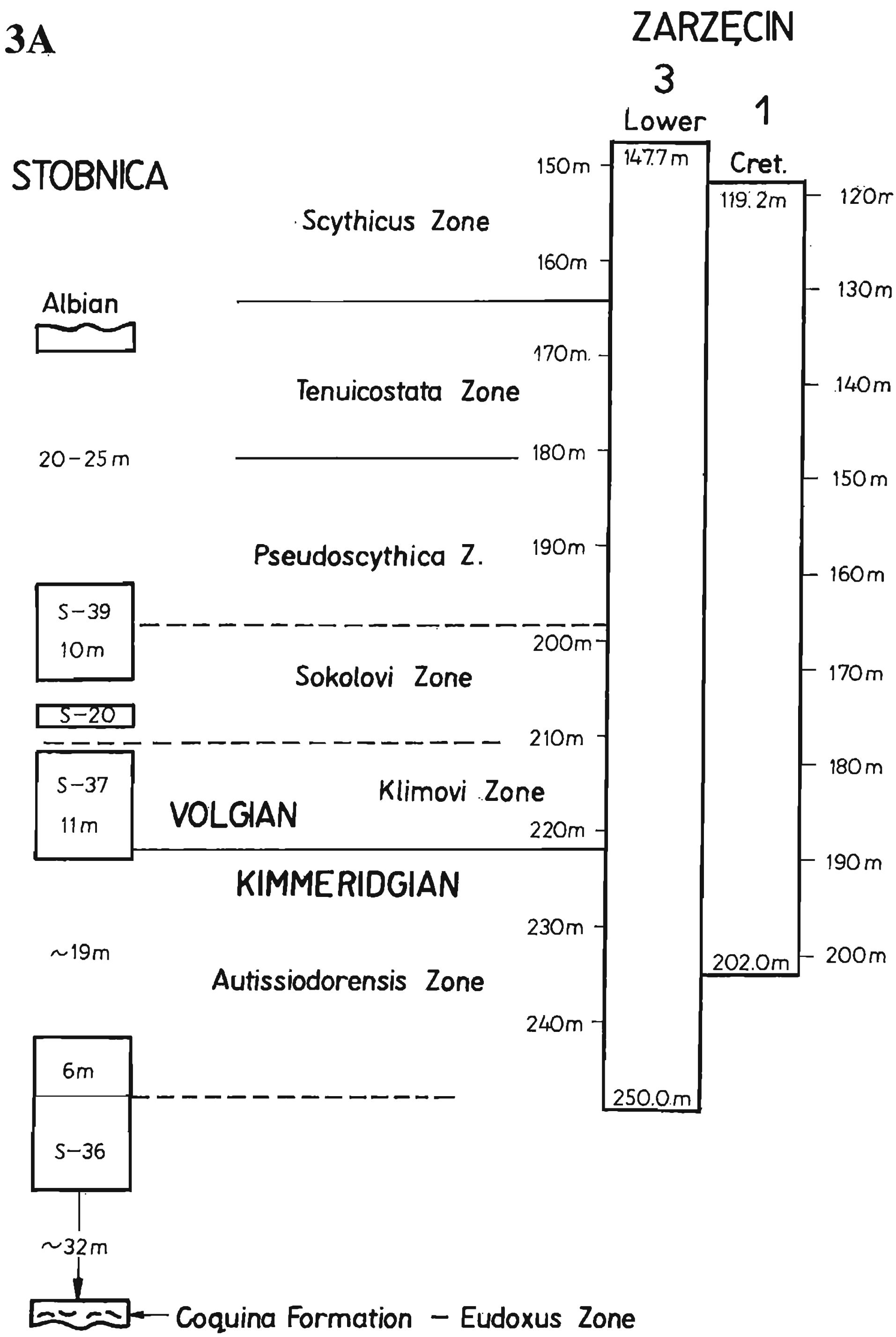


Fig. 3A. Stratigraphic sections of Kimmeridgian and Volgian deposits at Stobnica (exposures) and in the boreholes Zarzęcin *1* and *3*

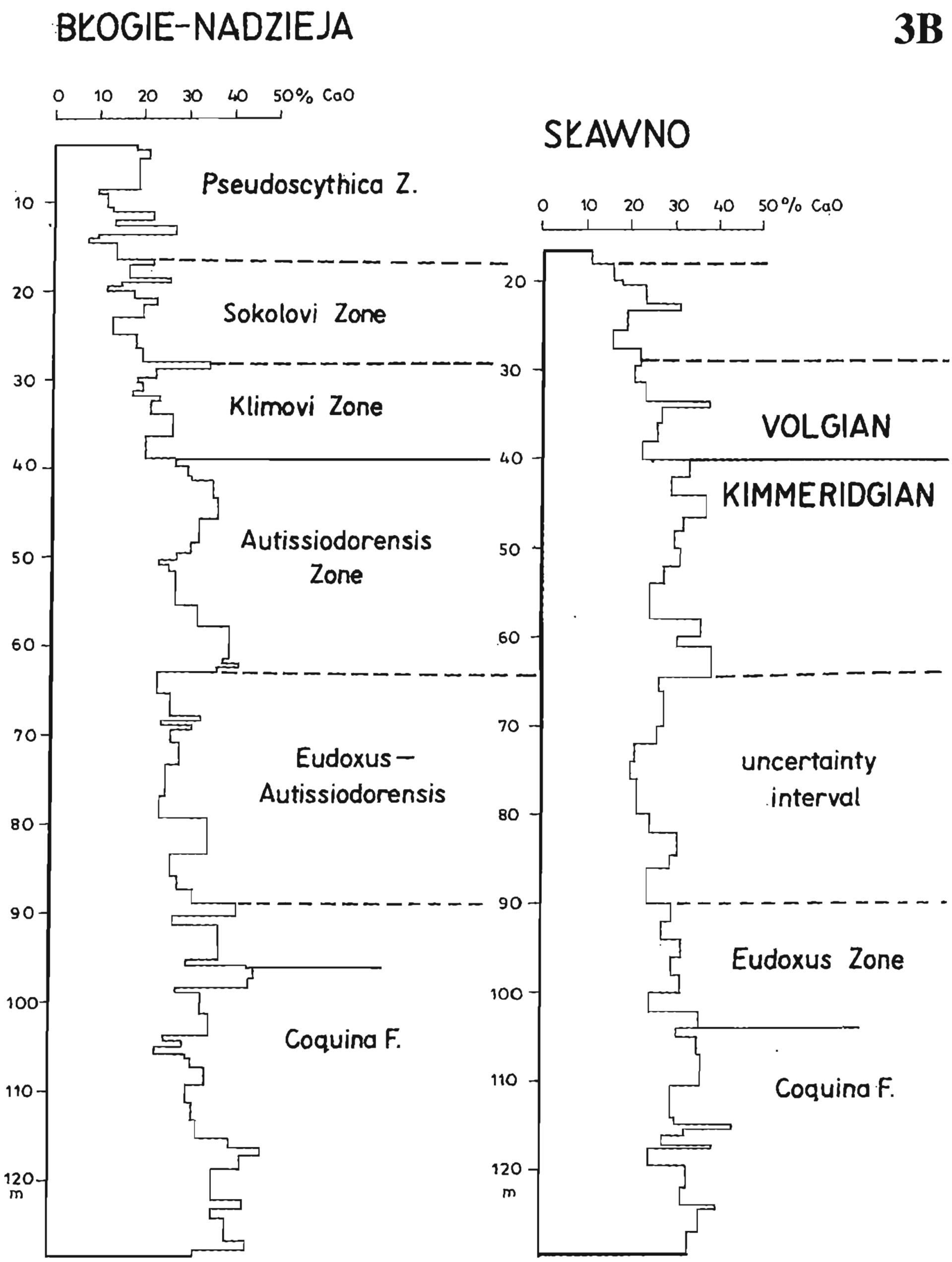
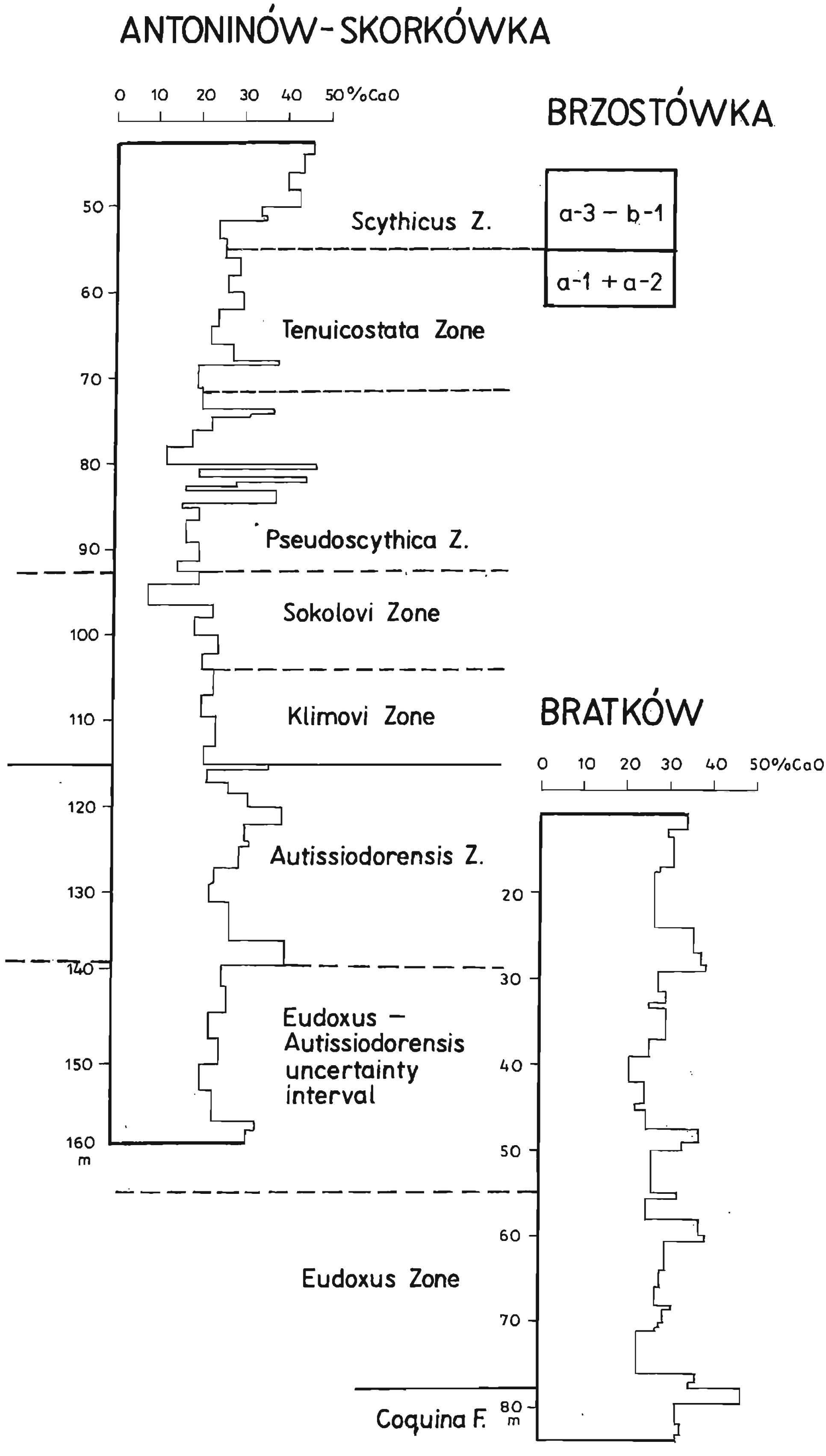


Fig. 3B. Stratigraphic sections of highest Kimmeridgian and Volgian deposits in the boreholes Błogie-Nadzieja and Sławno

Fig. 3C. Stratigraphic sections of highest Kimmeridgian and Volgian deposits in the boreholes Antoninów-Skorkówka and Bratków


ANTONINÓW-SKORKÓWKA
0 10 20 30 40 50%CaO
BRZOSTÓWKA
a-3 – b-1
a-1 + a-2
Scythicus Z.
Tenuicostata Zone
Pseudoscythica Z.
Sokolovi Zone
Klimovi Zone
Autissiodorensis Z.
Eudoxus – Autissiodorensis uncertainty interval
50
60
70
80
90
100
110
120
130
140
150
160 m
BRATKÓW
0 10 20 30 40 50%CaO
20
30
40
50
60
70
80 m
Eudoxus Zone
Coquina F.

a little above the top af the strata assigned to the Eudoxus Zone (Appendix and Text-figs 3*B*-*C*). Most probably they represent microchonchs of *Amoeboeceras* and, presumably, they could be identified with more precision if found in association with better paleontologic material.

Interestingly, no specimens of *Aulacostephanus* have been found in the lowest portion of the Pałuki Formation. This is in marked contrast with the ammonite assemblage found in the topmost layer of the Coquina Formation at Stobnica, which assemblage, comprising over ten specimens (KUTEK 1961), is composed exclusively of species of *Aulacostephanus*.

THE EUDOXUS-AUTISSIODORENSIS UNCERTAINTY INTERVAL

An interval, devoid of diagnostic species of *Aulacostephanus*, and situated between the strata assigned with certainty to the Eudoxus Zone

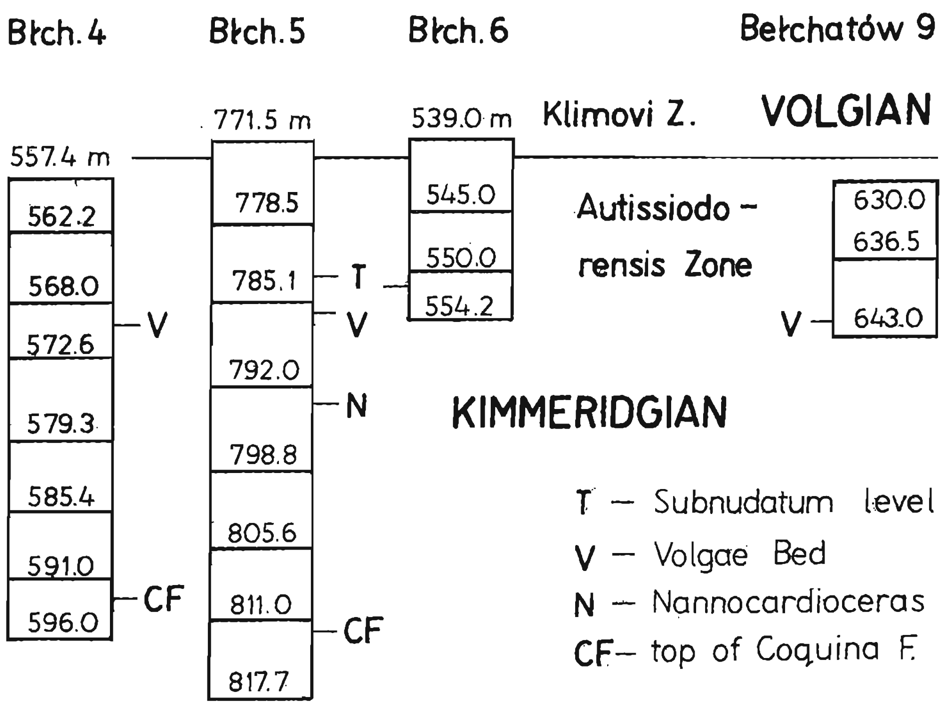


Fig. 4. Stratigraphic sections of highest Kimmeridgian and lowest Volgian deposits in the boreholes Bełchatów *4*, *5*, *6*, and *9*

and the Autissiodorensis Zone (*see below*), will be referred to as the Eudoxus-Autissiodorensis uncertainty interval. Its thickness amounts to about 25m in the borehole sections in the region of Tomaszów Mazowiecki (Text-figs 3*B*-*C*). The corresponding strata are also about 25m thick in the region of Tuszyn (Text-fig. 5), and possibly about 15m thick in the region of Bełchatów (*see* Text-fig. 4 and Appendix). Ammonites are still not very common in the interval here considered, and appear only at some levels.

Occurrences of *Aulacostephanus* are restricted to the topmost part of that interval, which yielded a specimen of *A. volgensis* (VISCHNIAKOFF) at 64.3-7m in the borehole Błogie-Nadzieja (Pl. 3, Fig. 3), and a specimen identified as *A.* cf. *volgensis* at Stobnica 36 (lower part of this part-section, *see below*). Ammonites referrable to *Aulacostephanus volgensis* are known to occur in both the Eudoxus and Autissiodorensis Zones (ZIEGLER 1962, CALLOMON & COPE 1971).

As stated above, some specimens representing microconchs of *Amoeboceras* were found very low in the Eudoxus-Autissiodorensis uncertainty interval (Appendix and Text-figs 3*B*-*C*). Several specimens of *Amoeboceras* (*Nannocardioceras*) *krausei* (SALFELD) were found in the topmost part of of this interval at Bratków (Appendix and Text-fig. 3*C*) and at Stobnica 36, lower interval (Text-fig. 3*A*).

Representatives of *Amoeboceras elegans* SPATH were found as single specimens at 78.8m at Sławno and at 44.7m at Bratków (Text-figs 3*B*-*C*), and at 1169.7-1172.2m II at Tuszyn *3* (Text-fig. 5).

In the specimen from Tuszyn *3* (Pl. 13, Fig. 2), evenly projected clavi are well displayed in the ventrolateral region, and long, nearly straight primary ribs are visible on the flanks of whorls. The specimen can be readily accommodated in the variability range of *A. elegans*, as defined by the specimens figured by SPATH (1935, Pl. 4, Figs 1-3), SYKES & SURLYK (1976, Fig. 7C), BIRKELUND & CALLOMON (1985, Pl. 5, Figs 1-7; Pl. 6, Figs 1-8), WIERZBOWSKI (1989, Pl. 20, Figs 1-7; Pls 21-22), and WIERZBOWSKI & ARHUS (1990, Figs 6 G-H).

The two specimens from Sławno at Bratków (Pl. 13, Figs 3-4) are more poorly preserved, but they agree very well morphologically with the specimen from Tuszyn *3*; accordingly, they are also assigned to *Amoeboceras elegans*.

The species *Amoeboceras elegans* SPATH was reported from the Eudoxus Zone, but not from higher strata, from several Boreal regions (SURLYK & SYKES 1976, MESEZHNIKOV 1984, BIRKELUND & CALLOMON

1984, WIERZBOWSKI 1989, WIERZBOWSKI & ARHUS 1990). This suggests that, in the Polish sections, the lower part of the Eudoxus-Autissiodorensis uncertainty interval, as delimited by the occurrences of *A. elegans*, still represents the Eudoxus Zone.

Only a few specimens of *Discosphinctoides* were found in the interval here discussed (Appendix, and Text-figs 3*B-C* and 4); three of them are figured herein (Pl. 14, Figs 2-4). So far as preservation permits, the specimens are closely comparable with the ammonites that occur in profusion at higher levels in the Autissiodorensis Zone, and are described in this paper as *Discosphinctoides subborealis* sp.n. However, as the scanty paleontologic material concerning the earlier forms does not permit to define their range of variability, it seems better to refer them to as *Discosphinctoides* cf. or aff. *subborealis*.

A very poor specimen of *Aspidoceras*, showing some tubercles on the flank of a whorl fragment, was found at Błogie-Nadzieja, at 64.3m.

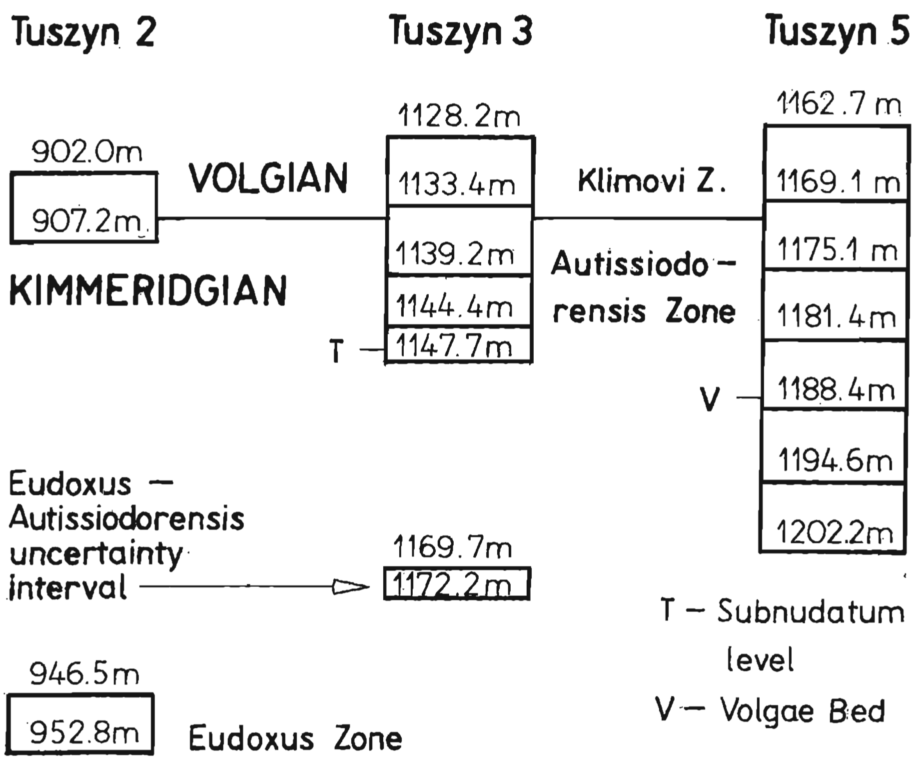


Fig. 5. Stratigraphic sections of highest Kimmeridgian and lowest Volgian deposits in the boreholes Tuszyn *2*, *3*, and *5*

THE AUTISSIODORENSIS ZONE

The Autissiodorensis Zone is here understood as a zone characterized by the ammonites of the group of *Aulacostephanus autissiodorensis* (COTTEAU), similarly as in Northwest Europe (ZIEGLER 1962, CALLOMON & COPE 1971) and in Russia (MESEZHNIKOV 1982, 1988); accordingly, the base of this zone is defined as the level of appearence of those ammonites. However, following the Russian usage, the upper boundary of the Autissiodorensis Zone is identified with the lower boundary of the Klimovi Zone which, by definition, is also the base of the Volgian Stage. Thus, as *Aulacostephanus* does not range up to the base of the Klimovi Zone (*see below*), the Autissiodorensis Zone, as here defined, is not exactly a range zone of the ammonites of the group od *A. autissiodorensis*. However, in terms of thicknesses, the difference is not great: in Central Poland, these ammonites are absent only from the topmost part of the Autissiodorensis Zone, about or less than 1m thick, and are well represented in underlying strata some 20 to 25m thick.

A very narrow subzone, the Fallax Subzone, with a thickness of about 3m, is separated out in the topmost part of the Autissiodorensis Zone; *Aulacostephanus* still occurs in the lower part of this subzone. The Fallax Subzone will be described in another section of this paper. The following description is chiefly concerned with the underlying strata which form the bulk of the Autissiodorensis Zone.

The ammonites of the genera *Aulacostephanus, Amoeboceras*, and *Discosphinctoides* are the most important constituents of the ammonite assemblages of the bulk of the Autissiodorensis Zone. These ammonites are described in the following sections of this paper, and only their stratigraphic distribution is here summarized.

Of special interest is a section which was provided by a farmer's well at Stobnica 36 (KUTEK 1961). In this section, an upper interval 5m thick, consisting of argillaceous limestones, could be distinguished above a lower interval composed of calcarous shales, about 11m thick. Several specimens representing *Aulacostephanus autissiodorensis* (COTTEAU), *A. jasonoides* (PAVLOW), and *A. volgensis* (VISCHNIAKOFF) were collected from debris of the argillaceous limestone, This is clearly an assemblage typical of the Autissiodorensis Zone. Accordingly, the base of the upper interval of Stobnica 36 is taken as the base of the strata that can be assigned with certainty to the Autissiodorensis Zone. It can be estimated that the base of that upper interval is situated some 25m below the top of the Kimmeridgian (Text-fig. 3*A*).

In the boreholes Bratków, Antoninów-Skorkówka, Sławno, and Błogie-Nadzieja, a corresponding package composed of argillaceous limestones was clearly revealed both by the CaO content (Text-figs 3*B*-*C*) and the lithology (MATYJA & *al.* 1988). The base of that interval, which is also taken as the base of the strata assigned to the Autissiodorensis Zone, is situated at 29.1m at Bratków; at 138.1m at Antoninów-Skorkówka; at 64.4m at Sławno, and at 63.6m at Błogie-Nadzieja. From this it follows that the strata referrable with certainty to the Autissiodorensis Zone are also about 25m thick in these boreholes.

In the Łódź Depression, occurrences of species of *Aulacostephanus* and/or *Discosphinctoides subborealis* sp.n. permit to regard the following intervals as the lowest intervals attribuable with certainty to the Autissiodorensis Zone (Appendix, and Text-figs 4-5): Bełchatów *4* – 572.6-579.3m (down to III); Bełchatów *5* – 785.1-792.0m; Bełchatów *6* – 550.0-554.2m; Bełchatów *9* – 636.5-643.0m; Tuszyn *3* – 1444.4-1447.7m; and Tuszyn *5* – 1181.4-1188.4m. From this it can be concluded that the Autissiodorensis Zone is at least about 20m thick in the regions of Bełchatów and Tuszyn.

In Central Poland, ammonites of the genus *Aulacostephanus* are fairly common in the Autissiodorensis Zone (Appendix, and Text-figs 3*A*-*C*, 4 and 5); with *A. autissiodorensis* (COTTEAU), *A. jasonoides* (PAVLOW), *A. volgensis* (VISCHNIAKOFF), and *A. undorae* (PAVLOW), they form an assemblage typical of this zone.

In the boreholes Bratków and Antoninów-Skorkówka, *Amoeboceras (Nannocardioceras) krausei* (SALFELD) was found near the base of the strata ascribed to the Autissiodorensis Zone (Appendix and Text-fig. 3*C*). Specimens of this species were also found, presumably in a similar stratigraphic position, in the borehole Bełchatów *5*, at 792.0-798.8m I 50 cm (Text-fig. 4)

A very narrow, and most probably synchronous, interval crowded with specimens of *Amoeboceras volgae* (PAVLOW) was encountered at Bełchatów *4*, 568.0-572.6m II 30-35 cm; at Bełchatów *9*, 636.5-643.0m V 80 cm to VI 35 cm; and at Tuszyn *5*, 1181.4-1188.4m VI. Forming a useful marker bed, this interval is worth to be separated out as the Volgae Bed (Text-figs 4 and 5).

Single specimens of *Amoeboceras volgae* (PAVLOW) and *A. pristiophorum* (KRAUSE) were found at Bełchatów *5*, 785.5-792.0m I 90 cm and II 90 cm, at levels corresponding to those at which the Volgae Bed occurs at Bełchatów *4* and *9* (Text-fig. 4). This permits to regard these occurrences of *Amoeboceras* at Bełchatów *5* as a less spectacular development of the Volgae Bed. Another specimen of *A. pristiophorum* was collected in the borehole Tuszyn *5* from the interval 1181.4-1188.4m (more precise stratigraphic position unknown), in which the Volgae Bed was also encountered.

The ammonites included in the new species *Discosphinctoides subborealis* occur throughout the bulk of the Autissiodorensis Zone (Appendix, and Text-figs 3*A-C*, 4, 5), where they are the most common ammonites, clearly outnumbering those belonging to *Aulacostephanus*. In this respect, the numbers of labelled specimens given in the following sections of this paper may be misleading because, when ammonites were being collected by one of the authors (J. KUTEK) from some of the borehole sections here considered, much poorly preserved material concerning *Discosphinctoides* was left in the rock, while even very poor specimens of other ammonites were carefully collected. This is an example indicating that frequency spectra of ammonites entirely based on collection material may substantially differ from those carefully established during field work.

Ammonites of the genus *Aspidoceras* appear to be quite rare in the Autissiodorensis Zone of Central Poland; the collection described herein contains only four specimens found in the bulk of this zone, mostly at low levels (*see* Appendix). Three of these specimens are very poorly preserved and can be identified only as *Aspidoceras* sp. The fourth specimen, which is figured herein (Pl. 14, Fig. 1), is referred to as *Aspidoceras* ex gr. *caletanum* (OPPEL). This incomplete specimen shows two rows of paired tubercles, joined by swells. It can be easily accomodated in the species *A. caletanum* (OPPEL), as broadly interpreted by CHECA GONZALEZ (1989, p. 94). Morphologically, it is also comparable with three species defined in a different way by HANTZPERGUE (1989, pp. 330, 337 and 343), notably with *A. caletanum* (OPPEL), *A. quercynum* HANTZPERGUE, and *A. catalaunicum* (DE LORIOL). Stratigraphically, the Polish specimen compares best with *Aspidoceras catalaunicum,* which is known to occur in the Autissiodorensis Zone of France and the Beckeri Zone of South Germany (HANTZPERGUE 1989, pp. 343 and 348).

Specimens of *Taramelliceras* (Pl. 28) were found in the Autissiodorensis Zone at 124.1-7m at Antoninów-Skorkówka; at 45.5-7m and 47.7m at Błogie-Nadzieja; at 197.0-198.0m at Zarzęcin *1*; at 778.5-785.1m V at Bełchatów *5*; at 550.0-554.2m II 70 cm at Bełchatów

6; and at 1144.4-1147.7m at Tuszyn *3*; thus all these specimens appear to have been collected from the same, or about the same, stratigraphic level. The specimens are strongly involute (Pl. 28, Figs 3-4 and 6-8), and reveal no ornamentation at diameters that can be thought to correspond to the phragmocon. At greater diameters, some feeble falcoid ribbing is discernible in some specimens (Pl. 28, Figs 1-3); in these specimens, the primary ribs are strongly prorsoradiate, but straight, or but slightly flexuous. Some weak external ribs, but no distinct tubercles, can be seen in the ventrolateral region of whorls in some specimens (Pl. 28, Figs 7-8). All the discussed specimens, which were found at comparable stratigraphic levels, seem to be conspecific.

These specimens of *Taramelliceras* can be compared, generally, with the species *T. franciscanum* (FONTANNES, 1879), *T. rebouletianum* (FONTANNES, 1879), *T. subnudatum* (FONTANNES, 1879), and *T. acallopistum* (FONTANNES, 1879). All these species, which were described and figured by FONTANNES (1879, pp. 41-45, Pl. 6, Figs 1-5), BERCKHEMER & HÖLDER (1959, pp. 81-85, Pl. 19, Figs 90-97; Pl. 20, Figs 98-99; Abb. 53-59), and BARTHEL & SCHAIRER (1977, p. 106, Pl. 9, Fig. 1), are strongly involute and display feeble ornamentation with more or less reduced external tubercles. The Polish forms, revealing feeble ornamentation, and no external tubercles, are most closely comparable with *T. subnudatum* (FONTANNES). They will be referred to as *Taramellicaras* cf. or aff. *subnudatum* (FONTANNES).

A specimen, found at Zarzecin *1*, at 201.0-202.0m (Pl. 31, Figs 8-9), can safely be identified as *Glochiceras solenoides* (QUENSTEDT, 1849). This specimen, which shows a median groove, and some concave ribbing both in the dorsolateral and ventrolateral region of the last part of the uppermost whorl, appears to be nearly complete. The specimen compares well with the specimens of *G. solenoides* described and figured by ZIEGLER (1958a, p. 145, Pl. 15, Figs 1-5).

The interval 201.0-202.0m at Zarzęcin *1* yielded several other, very poorly preserved specimens of the Haplocerataceae. They cannot be safely identified taxonomically with more precision, but they appear to represent also some other ammonites, in addition to *Glochiceras solenoides* (QUENSTEDT). For instance, one specimen from that interval might be interpreted as a *Taramelliceras* comparable with *T. subnudatum* (FONTANNES).

As yet, the known occurrences of the Haplocerataceae in the Autissiodorensis Zone are restricted in the investigated area to the levels or narrow intervals, indicated above.

AULACOSTEPHANUS IN THE AUTISSIODORENSIS ZONE

Ammonites of the genus *Aulacostephanus* are fairly common at some levels in the upper part of the bulk of the Autissiodorensis Zone, some 15m thick; they are less abundant in the lower strata assigned to this zone. Some 80 specimens of this genus were collected in the investigated sections, supplemented by much shell debris still recognizable as *Aulacostephanus*, due to the distinctive fasciculate ribbing, and the furrow on the ventral side of whorls discernible in some of the crushed material. Some specimens of *Aulacostephanus* were also found in the lower part of the very thin Fallax Subzone. They are here described together with those from the bulk of the Autissiodorensis Zone.

The representatives of *Aulacostephanus* from the Autissiodorensis Zone will be described with reference to the taxonomy of this genus established by ZIEGLER (1962) but, following CALLOMON & COPE (1971), two group of species will be distinghished: the group of *Aulacostephanus volgensis*, a group of microconchs which includes the species *A. volgensis* (VISCHNIAKOFF) and *A. undorae* (PAVLOW), and the group of *Aulacostephanus autissiodorensis*, a group of macroconchs comprising *A. autissiodorensis* (COTTEAU), *A. fallax* ZIEGLER, *A. jasonoides* (PAVLOW), and *A. kirghisensis* (D'ORBIGNY).

In the collection here considered, some microconchs have lappets preserved, or show characteristic periapertural modification of ribbing. Most of the demonstrably adult specimens fall into two clearly distinct size groups, what allows to classify them separately as *A. volgensis* and *A. undorae*, respectively (*see* ZIEGLER 1962, pp. 76 and 90).

A few specimens of *Aulacostephanus undorae* (PAVLOW) with lappets preserved are illustrated herein (Pl. 2, Figs 1-2 and 4-5); in one of these specimens (Pl. 2, Fig. 1) the lappet is about 2 cm long. A narrow constriction is developed at the aperture, and the periapertural region is marked by smoothing or weakening of ribbing, or its modification expressed by development of irregular rib units The end size of the specimens here discussed can be estimated to be about 50-60 mm. This places them at the lower limit of the size range of *Aulacostephanus undorae*, as defined by ZIEGLER (1962, p. 76) on the basis of but a few specimens.

In the specimens here considered, the last whorl displays a relatively distant and predominantly biplicate ribbing which, however, is usually disordered by the presence of simple and intercalatory ribs and, occasionally, triplicate ribs. The ribbing of the preceding whorl is also predominantly biplicate (Pl. 2, Figs 1-2 and 4-5). This type of ribbing, when observed at small whorl diameters, allows several incomplete specimens and nuclei to be classified with more or less confidence as *Aulacostephanus undorae* (Pl. 2, Fig. 3; Pl. 8, Figs 3-4). Such specimens are referred to in the Appendix as *A. undorae* or *A.* cf. *undorae*. It is worth of note that the description of the ammonites here classified as *A. undorae* is based on specimens found in the upper part of the bulk of the Autissiodorensis Zone, and in the Fallax Subzone.

In the investigated collection there are 5 specimens with lappets preserved that can be ascribed to *Aulacostephanus volgensis* (VISCHNIAKOFF). Four of them (Pl. 3, Figs 1 and 3-5; Pl. 4, Figs 1, 4) have end diameters ranging from *c.* 80 to *c.* 100 mm, falling thus within the typical size range of *A. volgensis*, as defined by ZIEGLER (1962, p. 90). All these specimens display biplicate ribbing on the last whorl. In the specimens that were collected in the upper part of the bulk of the Autissiodorensis Zone (Pl. 3, Figs 1 and 4-5), the SR/PR ratio arises to about 3 or more on the outer half of the preceding whorl, and similar values can be observed in incomplete specimes attributable with more or less certainty to *A. volgensis*, that were found in the same part of this zone (Pl. 3, Fig. 2).

Of special interest are some coarse-ribbed microconchs of *Aulacostephanus* found together with a coarsely ribbed variety of *A. autissiodorensis* at Stobnica 36. All these specimens were collected from debris of the argillaceous limestone representing the upper 5 metres of this part-section, as previosly commented in this paper, and thus they come from an interval situated some 20-25m beneath the top of the Autissiodorensis Zone.

The collection from Stobnica contains two specimens with lappets preserved (Pl. 4, Figs 1, 4). An adult form is most probably also represented by a specimen (Pl. 4, Fig. 3) that displays crowding of ribs interpretable as a periapertural modification of ribbing. All these specimens show biplicate ribbing on the last whorl, with quite densely spaced ribs, and similar biplicate ribbing can be seen on the last part of the preceding whorl. The same type of ribbing is displayed by some other specimens, of which one is figured (Pl. 4, Fig. 2). The largest of the specimens here discussed (Pl. 4, Fig. 1) has an end diameter of *c.* 100 mm and thus falls within the size range of *Aulacostephanus volgensis*. The end diameters of the two other (slightly crushed) adult specimens (Pl. 4, Figs 3-4) can be estimated to have been about 70 and 60 mm, which corresponds to the size range of *A. undorae*, as recognized by ZIEGLER (1962). This size, together with the relatively numerous biplicate ribs, and the very long lappet preserved in one of the specimens (Pl. 4, Fig. 4), makes the Polish specimens quite closely comparable with the specimen that was figured by PAVLOW (1886, Pl. 5, Fig. 2) as *Hoplites subundorae* and subsequently included in *Aulacostephanus undorae* by ZIEGLER (1962, Pl. 6, Fig. 10). However, the same type of ribbing displayed by the adult three forms found at the same horizon at Stobnica strongly suggests that they represent but one species. Hence, they are all referred to as *A. volgensis*.

The same interval yielded also a specimen (Pl. 5, Fig. 1) in which strong distant biplicate ribs can be seen on the last whorl, and coarse triplicate ribs on the preceding whorl. This specimens, as well as another specimen displaying strong distant biplicate ribbing on the last whorl (Pl. 5, Fig. 3), are interpreted as very coarsely ribbed variants of *A. volgensis*. They seem to be comparable with a coarse-ribbed specimen of *A. volgensis* from the British Kimmeridge Clay figured by ZIEGLER (1962, Pl. 9, Fig. 1).

The coarsely-ribbed microconchs from Stobnica have their counterpart in the same interval at Stobnica 36 in a large specimen (Pl. 4, Fig. 1), which is interpreted as a macroconch and assigned to *Aulacostephanus autissiodorensis*. This incomplete specimen preserved to a diameter of about 100 mm displays coarse and distant ribbing; the ratio of secondary to primary ribs is about 3 on the outer half of the last preserved whorl, and triplicate ribs alternating with biplicate ones are visible on the inner whorls. This specimen resembles a strongly evolute and coarse-ribbed variety of *A. autissiodorensis* from the British Kimmeridge Clay illustrated by ZIEGLER (1962, Pl. 13, Fig. 1). Another specimen from Stobnica, a coarsely ribbed fragment of whorl (Pl. 5, Fig. 2), is thought to represent a whorl of *A. autissiodorensis* at a diameter somewhat exceeding the diameter of the other specimen from Stobnica (Pl. 4, Fig. 1)

Only a few specimens of *Aulacostephanus* were collected in boreholes from the lower part of the Autissiodorensis Zone. Interestingly, most of them represent coarse-ribbed varieties, as shown by the two specimens illustrated herein (Pl. 6, Figs 1 and 3). These two specimens, which were found in the boreholes Bełchatów *9*, at 643.0-649.0m V 80-90 cm, and Zarzęcin *3*, at 240.0m, presumably represent inner whorls of *A. autissiodorensis*.

However, fine-ribbed varieties of *Aulacostephanus* were also found at deep levels in the Autissiodorensis Zone. An involute fine-ribbed specimen from the argillaceous limestone of Stobnica 36 (Pl. 6, Fig. 4) is assigned to *Aulacostephanus jasonoides* (compare PAVLOV 1886, Pl. 4, Fig. 1 and Pl. 6, Fig. 2; and ZIEGLER 1962, p. 98, Abb. 48). Some fine-ribbed debris of *Aulacostephanus* was also found in that limestone.

Several fragmentary specimens of large forms of *Aulacostephanus* were found in the upper part of the bulk of the Autissiodorensis Zone, giving the impression that macroconchs of *Aulacostephanus* are equally well represented as microchons in that interval. The macrochons appear to display a continuous spectrum of morphologic variability. An extreme case is represented by a strongly involute form with a SR/PR ratio amounting to about 4 at diameter of about 100 mm (Pl. 6, Fig. 5); it is ascribed to *A. jasonoides* (compare CALLOMON & COPE 1971, Pl. 9, Fig. 1). Most other Polish forms are less involute, and have a lower SR/PR ratio. Some (Pl. 7, Figs 1; Pl. 8, Fig. 5) appear to be closely comparable with a variety of *A. autissiodorensis* from the British Kimmeridge Clay (CALLOMON & COPE 1971, Pl. 8, Fig. 1). Other specimens of macroconchs here considered are merely referred to as *Aulacostephanus* ex gr. *autissiodorensis* (Pl. 7, Figs 2-3; Pl. 8, Figs 1-2, 6). In the range of morphologic variability displayed by the macroconchs of *Aulacostephanus* in the investigated area another extreme case is presented by the evolute specimen of *A. autissiodorensis* from Stobnica (Pl. 5, Fig. 4). However, such forms with coarse and distant ribbing were not found in the upper part of the bulk of the Autissiodorensis Zone.

In the described collection, the range of morphologic variability displayed by the microconchs assigned to *A. volgensis* appears to correspond fairly well to that revealed by the macroconchs of the group of *A. autissiodorensis* (compare Pls 3-4; Pl. 5, Figs 1, 3 and Pl. 6, Fig. 2 with Pl. 5, Fig. 4; Pl. 6, Figs 1, 3, 5; Pl. 7; and Pl. 8, Figs 1-2 and 5-6). Hence, it can be said the role of a dimorphic counterpart of the macroconchs of the group of *A. autissiodorensis* is played efficiently by *A. volgensis*. However, there also arises the question of the position of *A. undorae* as a dimorphic constituent of *Aulacostephanus*, so more as some forms from Stobnica 36 referrable to *A. volgensis* have unusually small end diameters. Presumably, the explanation should be sought in the concept of developmental polymorphism in ammonites, as advocated by MATYJA (1986, 1994).

A large proportion of the fragmentary specimens of *Aulacostephanus* found in the Autissiodorensis Zone cannot be classified with desirable precision. They are listed in the Appendix using open nomenclature, in a manner indicating the possibilities of their taxonomic interpretation. Nevertheless, the paleontologic material leaves no doubt the assemblage of *Aulacostephanus* of the Polish Autissiodorensis compares very well with the assemblages recognized in the Autissiodorensis Zone in Britain (ZIEGLER 1962, CALLOMON & COPE 1971, COX & GALLOIS 1981) and Russia (MESEZHNIKOV 1982, 1984, 1988).

The genus *Aulacostephanus* is still represented in the lower part of the Fallax Subzone. The three specimens here illustrated as *A. undorae* (Pl. 8, Figs 3-4), *A. autissiodorensis* (Pl. 8, Fig. 5), and *A.* ex gr. *autissiodorensis* (Pl. 8, Fig. 6) were found associated with much debris of *Aulacostephanus* in the boreholes Sławno, 40.8-9m, and Zarzęcin *1*, 191.3m. The general impression is that *Aulacostephanus* is still common in the lower part of the Fallax Zone, forming an assemblage that does not differ substantially from that in the upper part of the bulk of the Autissiodorensis Zone.

As stated above, two specimens comparable with *Aulacostephanus volgensis* were found in the lower interval of Stobnica 36 and in the borehole Błogie-Nadzieja at 64.3-7m, at levels corresponding to the topmost part of the Eudoxus/Autissiodorensis uncertainty interval.

AMOEBOCERAS (NANNOCARDIOCERAS) KRAUSEI (SALFELD)

Specimens of *Nannocardioceras* were collected in the boreholes Bratków, Antoninów-Skorkówka, and Bełchatów *5*, and also in the lower interval of Stobnica *36*, in the lowest part of the strata assigned to the Autissiodorensis Zone, and in the topmost part of the Eudoxus/Autissiodorensis uncertainty interval (Appendix, and Text-figs 3*A*, *C* and 4). In most cases *Nannocardioceras* occurs in profusion, forming ammonite plasters. Most of the collected specimens are incomplete, but there are about 75 specimens in the collection that permit the development of shell to be observed at different diameters. This mode of occurrence, in conjunction with well-displayed morphologic gradation, leaves no doubt that all the specimens of *Nannocardioceras* are conspecific.

In some specimens the type of ribbing usually found in *Nannocardioceras* can be recognized (*see* KRAUSE 1909, Pl. 3, Figs 1-5;

SALFELD 1915, Pl. 20, Figs 1-10; *and* CALLOMON & COPE 1971, Pl. 11, Fig. 5). To a diameter of about 15 or 20 mm, there occur slightly flexuous ribs, chiefly simple or biplicate, that thicken in the ventro-lateral region (Pl. 9, Figs 2, 5, 7, 9; Pl. 10, Figs 1-2). It can be observed in some specimens that at diameters of some 15 to 20 mm that type of ribbing is gradually replaced by more approximated and faint ribbing which, in turn, fades out, leaving the flanks of whorls ornamented only by less or more discernible striation (Pl. 9, Fig. 2; Pl. 10, Fig. 2). However, the collected specimens show much variability: the ribbing is more or less pronounced, and more or less densely spaced, and in several specimens the striated stage of development appears to set in at diameters well below 15 mm (Pl. 9, Figs 2, 4-5, 7-8).

The ventral side of of whorls can be observed in some specimens. At relatively small diameters, distinct projected ribs can be seen to reach the keel which is not differentiated by sulci (Pl. 9, Fig. 9). At somewhat greater diameters (Pl. 9, Figs 6-7) this ribbing, and the crenulation of the keel, are but faintly expressed.

The investigated collection includes several specimens with diameters amounting to over 20 mm (*see* Pl. 9, Figs 1-2, 3-4, 8; Pl. 10, Fig. 2). The largest relatively well-preserved specimen (Pl. 9, Fig. 1), which attains a diameter of 50-55 mm, has a part of the aperture intact, and its last whorl seems to uncoil, suggesting that the specimen is adult. However, two fragments of still greater striated whorls were found in association with unmistakable specimens of *Nannocardioceras*. At least these unusually large specimens appear to represent macroconchs of *Nannocardioceras*. Such large macroconchs of *Nannocardioceras* had not been reported previously in literature (CALLOMON 1985). Not much more can be said about dimorphism on the basis of the crushed paleontologic material here discussed. The mostly incomplete specimens of the collection do not show a distinct bimodal size distribution, so that there is no evidence that the collection includes both micro- and macroconchs.

Two species are usually assigned to the subgenus *Nannocardioceras*, namely *Amoeboceras* (*N.*) *anglicum*, the type species of this subgenus (SPATH 1939, p. 13), and *A.* (*N.*) *krausei*. Both these species were established by SALFELD (1915, pp. 199, 201), who included in the latter species, in addition to specimens from England, some specimes that had been collected by KRAUSE (1909, Pl. 3, Figs 1, 3-4) from the borehole Heilsberg (= Lidzbark Warmiński) in the region of Warmia in northern Poland (= Emsland, in former East Prussia), and described by him as *"Cardioceras" Volgae* PAVLOW. The ranges of variability of *A.* (*N.*) *anglicum* and *A.* (*N.*) *krausei* are still poorly known, although it was suggested that these species should be kept distinct (CALLOMON & COPE 1971, p. 159). The Polish specimens here discribed are referred as *Amoeboceras* (*Nannocardioceras*) *krausei* (SALFELD) chiefly because they compare very well with those figured by KRAUSE. In this context it is worth to recall SALFELD's (1915, p. 202) observation that these specimens, attaining a greater size, display some differences with respect to the English forms also assigned by him to the species *Amoeboceras krausei*.

AMOEBOCERAS VOLGAE (PAVLOW)

All the specimens of *Amoeboceras volgae* here described were collected at comparable levels from very narrow intervals in the boreholes Bełchatów *4* (568.0-572.6m II 30-50 cm), Bełchatów *9* (636.5-643.0m V 80 cm to VI 35 cm) and Tuszyn *5* (1181.4-1188.4m VI); they thus form a distinctive local marker bed which is called the Volgae Bed (Text-figs 4-5, and Appendix). Presumably, a narrow interval crowded with *A. volgae* described by MALINOWSKA (1976) from the borehole Tuszyn *1* (972.20 – 927.35m) represents the same bed.

The Volgae Bed comprises several shellbeds which are chiefly composed of incomplete shells and debris of *Amoeboceras volgae* (Pls 11-12; Pl. 13, Fig. 7), but some shells or debris of *Aulacostephanus, Discosphinctoides*, and bivalves may appear occasionally.

The specimens here described display, at diameters to about 20 mm or somewhat greater, the characteristic features of *Amoeboceras volgae*, as emphasized by SALFELD (1915, p. 195) and SPATH (1935. p. 27). The fine falcoid ribbing consists of strongly flexuous simple ribs, and intercalatory ribs that do not reach the ventral edge can be recognized in some specimens (*e.g.* Pl. 11, Figs 6-7; Pl. 12, Fig. 3). With increasing diameters, the ribs tend to thicken in the ventro-lateral region. The ventral side can be observed in several specimens, revealing strongly projected ribs and a well-differentiated keel. The morphologic variability displayed by the assemblage of *A. volgae* is expressed *e.g.* by more or less dense and fine ribbing, and more or less pronounced sinuosity of the falcoid ribs. Undoubtedly, the photographs (Pls 11-12) may give a better impression of this variability, than any description.

Highly variable are also the specimens from the Volgae Bed of Tuszyn *1* described and superbly illustrated by MALINOWSKA (1976, Pls 1-6). As a consequence, it was suggested by her that that paleontologic material permits to distinguish, in addition to *Amoeboceras (Amoebites) volgae* (PAVLOW), ten other species. Some forms were described as potentially new species referrable to the subgenus *Amoebites*, or generally to the genus *Amoeboceras*, but some other specimens were interpreted as *Amoeboceras (Nannocardioceras)* cf. *anglicum* (SALFELD) and *A.* (*N.*) cf. *krausei* (SALFELD). Very small specimens, with a keel not well-differentiated on the ventral side, were ascribed to *Nannocardioceras*. However, as remarked by SALFELD (1915, p. 187), the keel is not yet markedly differentiated on early whorls of the group of *Amoeboceras cricki*, which includes *A. volgae*. Taking into account the enormous morphologic variability displayed by several species of the Cardioceratidae (CALLOMON 1985, WIERZBOWSKI 1989, BIRKENMAJER & WIERZBOWSKI 1991), the assemblage of *Amoeboceras* described by MALINOWSKA (1976) is to be interpreted as representing only the species *Amoeboceras volgae* (PAVLOW).

The species *Amoeboceras volgae* was monographed by SALFELD (1915, p. 195), who based the description on his own specimens from Russia (1915, Pl. 20, Figs 11-13), those figured by PAVLOV (1886, Pl. 8, Figs 5a-c), and a specimen from Pomerania figured by SCHMIDT (1905, Pl. 10, Fig. 7). These were specimens with diameters of about 20 mm at most. Hence, several specimens of *Amoeboceras volgae* contained in the collection here considered, which can be estimated to correspond to diameters in the range between 20 and 40 mm, are of special interest. Some specimens with diameters amounting to over 20 mm were also illustrated by MALINOWSKA (1976).

At diameters over 20 mm the falcoid ribbing is also very variable (Pl. 11, Figs 1-5; Pl. 12, Figs 1, 3-5, 7-9 and 12; Pl. 13, Fig. 7). In some, but not all, of the greater specimens it can be seen that the falcoid ribbing becomes more fine or more dense, or tends to be turned into striae; in some cases still well pronounced ribs can be observed to alternate with sets of very fine ribs or striae (*e.g.* Pl. 12, Figs 4-5 and 8). The ribs usually thicken in the vetro-lateral region, displaying a tendency to form prorsoradiate clavi or less elongated tubercles (Pl. 12, Figs 4, 7, 9). Looped ribs can be seen in some specimens (Pl. 12, Figs 4, 6, 10).

The paleontologic material composed of crushed and fragmentary specimens is not suitable to be discussed in terms of dimorphism, but it is perhaps significant that no specimens corresponding to diameters over 40 mm have been found in the Volgae Bed.

OTHER SPECIMENS OF *AMOEBOCERAS*

Some representatives of *Amoeboceras* were found as single specimens fairly high in the Autissiodorensis Zone.

One specimen (Pl. 13, Fig. 1) was found in the borehole Belchatów 5, at 785.5-792.0m I 90 cm. This is a relatively large distorted specimen, with a diameter of some 35 mm. It displays fine and dense, flexuous ribbing, which is chiefly composed of simple ribs, and pointed ventro-lateral clavi that can be seen well beyond the latest preserved portion of the whorl-flank. The large specimen is associated with some shell debris, revealing again markedly flexuous ribbing. A small shell fragment shows three pointed tubercles and indistinct ribbing that seems to have included some looped ribs. The paleontologic material here considered agrees well with the morphologic characters displayed in the Volgae Bed of other boreholes by the assemblages of *Amoeboceras volgae* (PAVLOW), and is ascribed to this species.

Two peculiar specimens from the Autissiodorensis Zone were figured by PACHUCKI (1963, Pl. 1, Figs 8 and 9) as "*Hybonoticeras* nov. sp. aff. *mundulum striatulum* BERCKH. & HÖLDER" and "*Hybonoticeras* nov. sp. indet.", respectively. One of these specimens, found at Bełchatów 5, 785.5-792.0m II 90 cm, is still contained in the collection, and it is refigured herein (Pl. 10, Fig. 3; Pl. 13, Fig. 5); it is supplemented in the collection by another specimen showing the opposite side of the same ammonite. The second specimen illustrated by PACHUCKI is lost; it is here refigured using original photographs of PACHUCKI, twice and thrice enlarged (Pl. 10, Figs 4-5). The latter specimen was found at Tuszyn 5, 1181.4-1188.4m (PACHUCKI 1963, p. 5).

One of these specimens (Pl. 10, Fig. 3; Pl. 13, Fig 5) is distorted, so that the last preserved whorl is shifted away from the umbilicus. Flexuous striation is visible on the flanks of the last preserved whorl, and strong pointed tubercles are developed in the ventro-lateral region. The orientation of the striae is affected by distortion, but in the latest preserved portion of the whorl the striation is clearly falcoid.

The other specimen (Pl. 10, Figs 4-5) is a whorl with striate flanks and strong ventro-lateral tubercles; some of the tubercles seem to have been developed as projected spines. The venter clearly displayes a well-differentiated crenulated keel (but not two keels!). Faint projected ribs can be recognized to occur between the keel and the row of ventro-lateral tubercles.

The three specimens show distinctive characters of *Amoeboceras*, and cannot be ascribed to *Hybonoticeras*. They will be referred to as *Amoeboceras pristiophorum* (KRAUSE) because this is a name available for Late Kimmeridgian amoeboceratids, developing striation and strong ventro-lateral tubercles at very small whorl-diameters. This species, based on a single specimen from the Heilsberg (Lidzbark Warmiński) borehole, was established by KRAUSE (1909, p. 244, Pl. 3, Figs 10-11) as "*Hoplites pristiophorus*" because that specimen, displaying an artefact of preservation, was interpreted as a Jurassic hoplitid (= *Aulacostephanus*) with two keels (sic !). This specimen was re-examined by SALFELD (1915, p. 196) who demostrated that it represented a cardioceratid. However, it is tempting to consider the possibility that the specimens referred to as *Amoeboceras pristiophorum* (KRAUSE) represent but an extreme variety of *A. volgae* (PAVLOW). In this context it is significant that one of the ammonites ascribed to *A. pristiophorum* was found at about the same level as *A. volgae* in the borehole Bechatów 5, at 785.5-792.0m II 90 cm, and that in the Heilsberg borehole *A. pristiophorum* was found associated with a specimen which was figured by KRAUSE (1990, Pl. 3, Fig. 4) as "*Çardioceras Volgae* PAVLOW". Despite SALFELD's (1915, p. 196, 201) opinion to the contrary, that specimen does appear to be referrable to *Amoeboceras volgae* (PAVLOW), taking into account the wide range of variability of this species.

The two specimens found in the Upper Kimmeridgian in the Borehole Łowicz *IG-1* in Central Poland that were figured, but not described, by MALINOWSKA (1989, Pl. 5, Figs 3-4) as *Hybonoticeras hybonotum autharis* (OPPEL), also appear to belong to the genus *Amoeboceras*. The name *A. pristiophorum* (KRAUSE) seems also to be applicable to these specimens with diameters of about 45 – 55 mm, showing striate whorls and strong development of ventro-lateral tubercles; however, these specimens deserve a more precise interpretation. Another Late Kimmeridgian specimen from the same borehole, that was figured by MALINOWSKA (1989, Pl. 5, Fig. 7) as *Hybonoticeras pressulum* subsp. BERCKHEMER & HÖLDER, is obviously deformed and presents an artefact of preservation that can be re-interpreted as a microconch of *Aulacostephanus*. In this context it worth of note that the relatively small ammonite with a lappet, figured herein (Pl. 13, Fig. 6) also shows some similarity with *Hybonoticeras*. This specimen, which belonged to PACHUCKI's collection, is lost, but it can be seen on the still available photograph that one furrow is developed on the venter of the ammonite between slightly thickened ribs. Hence, the specimen is clearly an *Aulacostephanus* which, being a small microconch from the Autissiodorensis Zone, can be assigned to *A. undorae* (PAVLOW).

The five fragmentary specimens from the Łódź Depression that were figured by PACHUCKI (1963, Pl. 1, Figs 3-7) as *Hybonoticeras* aff. *beckeri harpephorum* (NEUMAYR), *Hybonoticeras* cf. *pressulum* (NEUMAYR) and *Hybonoticeras mundulum* (OPPEL) can be re-interpreted as poorly preserved specimens of *Aulacostephanus*.

From the above the conclusion can be drawn that the alleged occurrences of *Hybonoticeras* in cratonic Poland have as yet not been evidenced by unequivocal paleontologic material.

It is worth emphasizing that, in the Polish sections here considered, no representatives of *Amoeboceras* were found above the occurrences of *A. volgae* and *A. pristiophorum*.

As in other regions, the genus *Amoeboceras* does not range up to the top of the Autissiodorensis Zone in the sections of Central Poland here considered. In these sections, forms assigned to *Amoeboceras (Nannocardioceras) krausei* (SALFELD) occur near the base of the strata ascribed to the Autissiodorensis Zone, whereas the forms assigned to *Amoeboceras volgae* (PAVLOW) and *A. pristiophorum* (KRAUSE) occur at a higher level within this zone. An interesting point is that in all these amoeboceratids the ornamentation of the shell tends to fade out at variable, but generally small, diameters.

DISCOSPHINCTOIDES SUBBOREALIS SP.N.

Discosphinctoides (*Discosphinctoides*) *subborealis* sp.n. (Pls 15 – 18)

1961. *Divisosphinctes* cf. *submagistri* ILOV. & FLOR.; J. KUTEK, p. 145, Pl. 16, Fig. 1.

1963. *Subplanites klimovi* (ILOVAJSKI & FLORENSKI); C. PACHUCKI, p. 9, Pl. 3, Fig. 1.

1963. *Epivirgatites* cf. *nikitini* (MICHALSKY); C. PACHUCKI, p. 10, Pl. 3, Fig. 3.

1979. *Ilowaiskya tenuicostata* (MICHAILOV, 1964); J. MAŁECKI, p. 38, Pl. 1, Figs 2-3.

1980. *Virgataxioceras magistri* (ILOVAISKY & FLORENSKY, 1941); L. MALINOWSKA, p. 476, Pl. 150, Fig. 7.

1988. *Virgataxioceras magistri* (ILOVAISKY & FLORENSKY, 1941); L. MALINOWSKA, p. 342, Pl. 150, Fig. 7.

HOLOTYPE: The specimen IGPUW/A/32/305, presented in Pl. 15, Fig. 5.

TYPE LOCALITY: Sławno (Text-figs 1 and 2).

TYPE HORIZON: The Autissiodorensis Zone (Upper Kimmeridgian), below the Fallax Subzone; Pałuki Formation.

DERIVATION OF THE NAME: In reference to the occurrence in cratonic Poland which was included in the Subboreal Province in the latest Kimmeridgian.

DIAGNOSIS: Dimorphic, microconchs with lappets; biplicate and relatively distant ribbing at all stages of development.

MATERIAL: About 100 labelled specimens retained in the collection, supplemented by much fragmentary material and shell debris.

DESCRIPTION: Although the collected material consists of fragmentary specimens, it is sufficiently plentiful to reconstruct the successive stages of ontogenic development (Pls 15-18).

A few specimens have lappets preserved, or display a characteristic development of ribbing near the aperture (Pl. 18). These specimens indicate that the microconchs of *Discosphinctoides subborealis* beared lappets, and that this species had microconchs attaining a size of some 80-100 mm.

The specimens of still greater size (Pls 16-18) can be interpreted as macroconchs. In some of these, the heigth of the preserved whorls amounts to about or over 50 mm (Pl. 17); the corresponding whorl diameters may be estimated as about 200 mm.

The ribbing is chiefly composed of biplicate ribs at all stages of ontogenic development. It is complicated be less or more numerous constrictions, which are usually followed by a simple rib, and preceded by a compound rib, which may be developed as a triplicate rib. Occasional triplicate ribs, not connected directly with constrictions, were observed in only a few specimens (Pl. 16, Fig. 1, Pl. 18, Fig. 4). Occasional intercalatory ribs are still more rare (Pl. 17, Fig. 2).

The ribs are rursiradiate at the umbilical edge, but are usually rectiradiate, or nearly so, on the whorl-flanks (if not affected by distortion of specimens). The constrictions, and some associated ribs, tend to be prorsoradiate.

The ribs furcate relatively low on the whorl-sides, forming a narrow angle of furcation. Individual ribs may furcate in a symmetrical or asymmetrical fashion; in the latter case, the anterior secondary rib follows approximately the course of the primary rib, whereas the anterior ribs diverge backwards from this direction. The furcation pattern is more or less distorted in some specimens. However, the unstable mode of furcation appears to be a primary character of the ribbing of *Discosphinctoides subborealis*, as neihgbouring ribs can be seen to furcate differently in several specimens.

As the collection does not contain well-preserved complete specimens of *Discosphinctoides subborealis* sp.n., several equally good (or poor) specimens could have been chosen as the type. A specimen from Sławno (Pl. 15, Fig. 5; Text-fig. 3*B*) is designated as the holotype because it displays well the style of ribbing, and because it was found associated with two other specimens (Pl. 15, Figs 1-2) of different diameters at practically the same level in the same borehole. The holotype has a (crushed) diameter of 68 mm, with both the corresponding whorl-height and diameter of umbilicus of 24 mm. There are approximately 43 primary ribs on the last preserved whorl of the holotype, and 20 primary ribs on the last half of this whorl.

The amount of intraspecific variability of the new species appears to be moderate in respect to the density of ribbing. The number of primary ribs per whorl increases with ontogeny, but not in a linear fashion. In several specimens, the number of primary ribs per half a whorl is 16-20 at diameter of 50 mm (but, in a few specimens, 14-20 at diameters of 35-40 mm). The available material reveals that the number of primary ribs per half a whorl is approximately 20-22 at diameter of 60 mm, and 18-20 at 70 mm. It can be estimated that this number increases to about 25 at diameters of 90 – 100 mm.

The inner whorls of *Discosphinctoides subborealis* are involute, the height of whorl being greater than the corresponding diameter of the umbilicus. The whorls become evolute at diameters of about 70 mm. As the studied material consists of incomplete and crushed specimens, it does not permit to investigate this aspect of ontogeny more precisely.

The original sections of whorls are strongly distorted in the crushed specimens. Still, what can be observed is consistent with the interpretation that the whorls of *Discosphinctoides subborealis* sp.n. had nearly flat or but moderately convex flanks, and an arched venter.

Although *Discosphinctoides subborealis* sp.n. ranges through strata some 20-25 m thick, no systematic morphologic changes relevant to stratigraphic position within this interval could be recognized. A few specimens with some triplicate ribs, not connected with constrictions, were found near the top of the bulk of the Autissiodorensis Zone but, as discussed below, they can be interpreted as conservative morphologic variants of *Sarmatisphinctes* (gen.n.) *fallax* (ILOVAISKY).

DISCUSSION: The species *Discosphinctoides subborealis* sp.n. can be readily accomodated in the genus *Discosphinctoides* OLÓRIZ SÁEZ, 1978, and the subgenus *Discosphinctoides,* as defined by its author (OLÓRIZ SÁEZ 1978, pp. 481-485). The species *D. roubyanus* (FONTANNES) is the type species of *Discosphinctoides*.

The rib-style of *Discosphinctoides subborealis* sp.n. is also displayed by the ammonites of the group of *D. roubyanus* (FONTANNES) and *D. stenocyclus* (FONTANNES), which were figured and described *e.g.* by FONTANNES (1879, pp. 56, 58; Pl. 8, Fig. 6; Pl. 10, Fig. 2), BANTZ (1970, pp. 39-40; Pl. 5, Figs 1, 3), OLÓRIZ SÁEZ 1978, pp. 485-486; Pl. 39, Fig. 6), and SAPUNOV (1979, p. 96; Pl. 22, Fig. 3, Pl. 23, Fig. 1); interestingly, this group includes microconchs with lappets, which attain a diameter of about 90 mm (OLÓRIZ-SÁEZ 1978, p. 486). Most of these ammonites differ from *D. subborealis* sp.n. by markedly more dense ribbing, and/or by the appearance of a significant number of triplicate ribs at great whorl-diameters. Moreover, less numerous constrictions seem to be developed in most ammonites of the *roubyanus-stenocyclus* group. Still, some forms of *D. stenocyclus* (FONTANNES) with relatively distant ribbing would be hard to distinguish, on purely morphological grounds, from some varieties of *D. subborealis* with weekly developed constrictions.

Hence, it is reasonable to seek the ancestor of *Discosphinctoides subborealis* sp.n. in the group of *Discosphinctoides roubyanus – stenocyclus* (FONTANNES), which occurrences are centered over the Eudoxus Zone, so more as this group is also represented in the upper Eudoxus Zone in Central Poland (where representatives of *Discosphinctoides* also occur in the Eudoxus-Autissiodorensis uncertainty interval). Ammonites of the group of *D. roubyanus – D. stenocyclus* have hitherto been reported from the Mediterranean or Submediterranean regions of Spain, France, South Germany, and Bulgaria (FONTANNES 1879, BANTZ 1970, OLÓRIZ-SÁEZ 1978, SAPUNOV 1979), whereas the known occurrences of *D. subborealis* sp.n. are restricted to the Autissiodorensis Zone of cratonic Poland. From this it follows that, in accordance with the interpretation presented above, *Discosphinctoides subborealis* sp.n. is a Subboreal species of Submediterranean origin.

The newly established species displays some similarity with some Russian ammonites assigned by ILOVAISKY to *Divisosphinctes*, and discussed by him in ILOVAISKY & FLORENSKY (1941). In that paper, as clearly stated in the preface, ILOVAISKY is the sole author of the sections concerning Kimmeridgian and Volgian ammonites and stratigraphy, and hence also the sole author of the new taxa established therein. When referring to the sections written by ILOVAISKY, the paper of ILOVAISKY & FLORENSKY (1941) will be usually cited as ILOVAISKY (1941)

The newly established species is comparable to some extent with the specimen which was described and figured by ILOVAISKY (1941, p. 48, Pl. 4, Fig. 9) as "*Divisosphinctes magistri* sp.n". This is a specimen from the Ural River region, and so from a peri-Tethyan region which was included in the Subboreal Province in the Late Kimmeridgian, as evidenced (*see* ILOVAISKY 1941, ZIEGLER 1962) by the occurrences of ammonites of the group of *Aulacostephanus autissiodorensis*. As *Divisosphinctes* is a synonym of *Dichotomoceras*, a name used at subgeneric level for some Oxfordian ammonites (*see* ENAY 1966, p. 502), some other name has to be applied to the species of ILOVAISKY; it can readily be accommodated in the genus and subgenus *Discosphinctoides*. The specimen of ILOVAISKY, on which the description of his species was chiefly based, was found *extra situ*, so that the range of variability of this species is not known, nor is its precise stratigraphic position, though, as indicated by the stratigraphic context, it is certainly of Late Kimmeridgian age.

In the Russian specimen here discussed, only the ribbing of the last whorl is well displayed. It is predominantly biplicate but, as emphasized by ILOVAISKY, it includes some triplicate ribs; the ribs furcate in a symmetric fashion. As suggested by this author, his specimen was adult, and might have had lappets. If so, it would be a microconch od *Discosphinctoides* with an fairly large end-diameter of 144 mm.

The species *D. magistri* (ILOVAISKY) was based on only two specimens: on that discussed above, and on a specimen figured by PAVLOV (1886, p. 66, Pl. 7, Fig. 4) as "*Perisphinctes* sp. ind. cf. *simoceroides* FONT". Again, the precise stratigraphic position of the latter specimen, found at Gorodishthe on the Volga in "strata with *Aspidoceras acanthicum*", is not known. The specimen figured by PAVLOV, having numerous triplicate ribs, markedly differs from *Discosphinctoides subborealis*.

Altogether, there are good reasons to keep *Discosphinctoides subborealis* sp.n. distinct from *D. magistri* (ILOVAISKY).

Another Russian specimen from the "strata with *Aspidoceras acanthicum*", which was described and figured by PAVLOV (1986, p. 65, Pl. 7, Fig. 3) as "*Perisphinctes virguloides* WAAG.", was renamed by ILOVAISKY (1941, p. 50) as "*Divisosphinctes submagistri* sp.n.". This specimen markedly differs from *Discosphinctoides subborealis* sp.n. in having much more dense biplicate ribbing.

Of special interest are the specimens from the Ural River region which were described by ILOVAISKY as "*Divisosphinctes sublacertosus* sp.n". This species was based, as emphasized by its author, on fragmentary, mostly very poor, specimens; one of them was figured (ILOVAISKY & FLORENSKY 1941, p. 42, Pl. 1, Fig. 3). The information about the stratigraphic position of *D. sublacertosus* is somewhat unclear. Three specimens assigned to this species were found in the Istek-Ultay Ravine in Kimmeridgian sandstones which also yielded several specimens of *Aulacostephanus*, which can be interpreted as an assemblage indicative of the Autissiodorensis Zone, taking into account the taxonomic revision of the aulacostephanids from the Ural River region presented by ZIEGLER (1962). However, at the locality of Khanska Gora, at the Bedranka River, specimens ascribed to *D. sublacertosus* were only found below the strata with *Aulacostephanus* (ILOVAISKY 1941, pp. 24, 26). Accordingly, it was suggested by ILOVAISKY that *D. sublacertosus*, which shows some morphological similarity with "*Ammonites*" *lacertosus* DUM. & FONT., 1876, is a species of Early Kimmeridgian age, corresponding to the comprehensive Zone of *Oppelia tenuilobata*, or even to the Platynota Zone.

The species of ILOVAISKY can readily be accomodated in *Discosphinctoides*, and its biplicate ribbing, as seen in the sole figured specimen (ILOVAISKY 1941, Pl. 1, Fig. 3), is comparable with that found in *Discosphinctoides subborealis* sp.n. However, the outer whorls of *Discosphinctoides sublacertosus* (ILOVAISKY) are not known, nor are the range of its morphologic variability, and its exact stratigraphic range. Hence, there are not sufficient reasons for interpreting the Russian ammonites assigned to *D. sublacertosus* (ILOVAISKY), and the Polish ammonites included in *D. subborealis* sp.n., as conspecific.

The new species *Discosphinctoides subborealis* sp.n. shows some similarity with *Propectinatites websteri* COPE, 1968, from the upper Autissiodorensis Zone of England. The ribbing is biplicate in both these species, which have lappeted microconchs of similar size. However, the ribbing in *P. websteri* is more distant, and the ribbing-style more irregular; these differences can be clearly seen when the specimens figured by COPE (1968, Pl. 1, Figs 1-2) are compared with the holotype of *D. subborealis* (Pl. 15, Fig. 5). Moreover, these two species belong to different phyletic lineages. The species *Propectinatise websteri* gave rise to the genus *Pectinatites*, and shows affinity with the Kimmeridgian ammonites of the genus *Subdichotomoceras*. It was even suggested by BIRKELUND & *al.* (1983, p. 302) that the generic name *Propectinatites* should be regarded as a junior synonym of *Subdichotomoceras*. In contrast, *Subdiscosphinctoides subborealis* sp.n., a species of Submediterranean origin, gave rise, through *Sarmatisphinctes* gen.n., to the genus *Ilowaiskya* (see below).

THE FALLAX SUBZONE

In the investigated sections, the topmost part of the Autissiodorensis Zone is separated out as the **Fallax Subzone**. The lower boundary of this subzone can be defined as the level of appearance of *Sarmatisphinctes fallax* (ILOVAISKY), and its upper boundary as coinciding with the base of the Klimovi Zone. A significant point is that this species is here interpreted paleontologically as a species that evolved from *Discosphinctoides subborealis* sp.n. and gave rise to *Ilowaiskya klimovi* (ILOVAISKY). Accordingly, the lower boundary of the Fallax Subzone is identified as the level where the assemblages of ammonites assigned to *Discosphinctoides subborealis* sp.n. are replaced by assemblages interpreted as representing *S. fallax*, and its upper boundary as the level where the latter assemblages are replaced by those ascribed to *I. klimovi*. From this it follows that the Fallax Subzone can also be interpreted as a range zone of *Sarmatisphinctes fallax*. However, though there are two possible definitions of the Fallax Subzone, the stratigraphic range of this subzone remains the same in any case. The paleontologic description of the species *Sarmatisphinctes fallax* (ILOVAISKY) is postponed to another section of this paper.

Several specimens of this species were found in each of the sections of the boreholes Antoninów-Skorkówka, Błogie-Nadzieja, Sławno, and Zarzęcin *1* and *3* (Appendix). In these sections, the intervals delimited, in each case, by the lowest and the highest specimen of *S. fallax*, are 2.5m, 2.7m, 2.3m, 2.0m and 1.7m thick, respectively. From this it can be concluded that the Fallax Subzone is about 3m thick in these sections. Some specimens of *S. fallax* were also found in the boreholes Bełchatów *5* and *6* and Tuszyn *2*, *3* and *5*; they also suggest a very small thickness of the Fallax Subzone (Appendix). This very narrow subzone was not indicated in the topmost part of the Autissiodorensis Zone in the enclosed diagramatic columns (Text-figs 3*A-C* and 4-5), where the subzone whould be represented by a narrow band amounting but little above 1mm.

Ammonites of the genus *Aulacostephanus* were encountered in several sections above the level of the first appearance of *Sarmatisphinctes fallax* (Appendix, and Text-figs 3*A-C* and 4), leaving no doubt that *Aulacostephanus* is still represented in a considerable portion of the Fallax Subzone. In this context, the most significant is the section of the Sławno borehole, where the lowest specimen of *S. fallax* was found at 43.0m, specimens of *Aulacostephanus* at 40.8-9m, and the highest specimen of *S. fallax* at 40.7m. At Bełchatów *5*, *Aulacostephanus* was even found a little above the single specimen of *S. fallax* (Appendix). However, no section yielded *Aulacostephanus* found just below the base of the Klimovi Zone, nor within this zone, so that all available data are consistent with the interpretation that the genus *Aulacostephanus* does not range up to the base of the Klimovi Zone, leaving the highest portion of the Fallax Subzone, about or less than 1m thick, devoid of *Aulacostephanus*.

As previously stated, the ammonites representing the genus *Aulacostephanus* appear to be so common and diversified in the lower part of the Fallax Subzone, as in the underlying strata of the Autissiodorensis Zone. Hence, the Polish sections suggest that the extinction of the genus *Aulacostephanus* was an abrupt event.

No other ammonites were found in the investigated sections in the Fallax Subzone.

SARMATISPHINCTES GEN.N.

TYPE SPECIES: *Divisosphinctes fallax* ILOVAISKY, 1941; illustrated *in* ILOVAISKY & FLORENSKY (1941, p. 45, Pl. 2, Fig. 5 and Pl. 3, Figs 6-8).

DIAGNOSIS: Dimorphic, microconchs with lappets. Biplicate ribbing on inner whorls; irregular, typically virgataxioceratoid, ribbing on greater whorls; outer whorls of macroconchs with triplicate and biplicate ribs.

DERIVATION OF THE NAME: From Sarmatia, a Latin name applied by ancient historians to regions situated north of the Black and Caspian Seas, and also to Poland; the name *Sarmatisphinctes* thus refers to the occurrence of the type species of the new genus in southern and central regions of the Russian Platform, and in Poland.

SPECIES INCLUDED: *S. fallax* (ILOVAISKY, 1941), *S. dividuum* (MESZHNIKOV, 1973).

REMARKS: The genus *Virgataxioceras* was established by ARKELL (1953, p. 39), with *Virgatosphinctes setatus* SCHNEID (1914, p. 165; Pl 5, Fig. 5; Pl. 6, Fig. 4) as the type species. In addition to *Virgataxioceras setatum* (SCHNEID) and some allied species from the Beckeri Zone of South Germany, also the Subboreal species *V. fallax* (ILOVAISKY) from the Russian Platform was included in the new genus. Several species of *Virgataxioceras* from the Beckeri Zone of Submediterranean or Mediterranean regions of South Germany and Bulgaria have hitherto be established and/or described by SCHNEID (1914-1915, pp. 164-165), BERCKHEMER & HÖLDER (1959, pp. 46-51), and SAPUNOV (1979, pp. 123-124); their list includes *V. comatus* (SCHNEID, 1914), *V. setatus* (SCHNEID, 1914), *V. subsetatus* (SCHNEID, 1914), *V. supinus* (SCHNEID, 1914), *V. setatoides* (BERKCHEMER, 1959), and *V. setatulus* (BERCKHEMER & HÖLDER, 1959).

The new genus *Sarmatisphinctes* is here established for the species *S. fallax* (ILOVAISKY), because it differs in many respects from the Submediterranean/ Mediterranean species of *Virgataxioceras*. As discussed in more detail in the following section of this paper, the ribbing is more regular, and more virgatotome, than "virgataxioceratoid", in the latter species, which appears to have macrochons with lithacoceratoid ribbing on outer whorls, whereas such whorls of *S. fallax* have only biplicate and triplicate ribs. The biogeographic occurrences of the species here compared are different, *S. fallax* having hitherto been reported only from Subboreal regions of Russia and Poland. Moreover, as demonstrated below, *S. fallax* evolved from *Discosphinctoides subborealis* sp.n. and gave rise to *Ilowaiskya klimovi* (ILOVAISKY), whereas the Mediterranean/Submediterranean species of *Virgataxioceras* show affinity with *Lithacoceras* and *Subplanites*. Finally, although all the species of the restricted genus *Virgataxioceras* occur in the Beckeri Zone, and *Sarmatisphinctes fallax* in the (roughly ?) equivalent Autissiodorensis Zone, there are some indications that their exact stratigraphic position is not the same.

Although the dimorphic and phylogenetic relationships of the species *Virgataxioceras dividuum* MESEZHNIKOV, 1973, remain to be established, *Sarmatisphinctes* is no doubt a better place than *Virgataxioceras* for this species, which known occurrences are restricted to the Arctic regions of Russia (*see* MESEZHNIKOV 1973, 1984).

SARMATISPHINCTES FALLAX (ILOVAISKY, 1941)

1941. *Divisosphinctes fallax* sp.n.; D.I. ILOVAISKY, p. 45, Pl. 2, Fig. 5; Pl. 3, Figs 6-8.

1963. *Virgataxioceras fallax* (ILOV. & FLOR.); J. KUTEK & A. WITKOWSKI, p. 161.

1979. *Ilowaiskya klimovi* ILOVAISKY & FLORENSKY, 1941; J. MAŁECKI, p. 39, Pl. 1, Fig. 1.

1979. *Zaraiskites quenstedti* (ROULLIER, 1849); J. MAŁECKI, p. 39, Pl. 4, Fig. 9.

1979. *Zaraiskites scythicus* (VISCHNIAKOFF, 1882); J. MAŁECKI, p. 40, Pl. 4, Figs 1, 3-5.

1979. *Isterites* cf. *spurius* (SCHNEID, 1915); J. MAŁECKI, p. 39, Pl. 4, Fig. 8.

1980. *Virgataxioceras fallax* (ILOVAISKY & FLORENSKY, 1941); L. MALINOWSKA, p. 476, Pl. 149, Fig. 5.

1988. *Virgataxioceras fallax* (ILOVAISKY & FLORENSKY, 1941); L. MALINOWSKA, p. 342, Pl. 149, Fig. 5.

REMARKS: The Russian specimens of *Sarmatisphinctes fallax* described and figured by ILOVAISKY (1941, p. 45, Pl. 2, Fig. 5; Pl. 3, Figs 6-8) show biplicate ribbing on inner whorls, which is replaced at highly variable diameters by irregular virgataxioceratoid ribbing (in the specimen shown in his Pl. 3, Fig. 8, the biplicate ribbing stage persists only to a diameter of about 30 mm). The largest specimen figured by ILOVAISKY (1941, Pl. 2, Fig. 5), with a diameter of 145 mm, shows biplicate and triplicate ribs on the last preserved whorl. The ribbing is more or less distant in different specimens (compare Fig. 6 and 7 in his Pl. 3)

All the perisphinctacean ammonites of the Polish Fallax Subzone, except those belonging to *Aulacostephanus,* can be ascribed to the (broadly interpreted) species *Sarmatisphinctes fallax* (ILOVAISKY). This species occurs in profusion in this subzone (*see* Appendix), forming several shellbeds, *e.g.* at Sławno at 41.10-15m and at Zarzęcin *3*, 220.0-3m (Text-figs 3*A-B*). The collection includes about 55 labelled specimens.

A large proportion of these specimens compare morphologically well with the Russian specimens of *S. fallax (*compare *e.g.* Pl. 19, Fig. 5, and Pl. 20, Figs 3-4 of this paper with Pl. 3, Figs 7-8 of ILOVAISKY & FLORENSKY, 1941). In some of the Polish specimens, triplicate ribbing appears already at diameters of some 30 mm (Pl. 20, Figs 3-4). Several specimens display the characteristic virgataxioceratoid type of ribbing, that includes more or less numerous ataxioceratoid compound ribs, composed of two biplicate ribs, and occasionally of biplicate and triplicate ribs (Pl. 19, Fig. 5), which join at or near the umbilical edge (Pl. 20, Fig. 1), or high on the whorl-flanks (Pl. 19, Figs 3, 5). There also occur virgatotome (polygyrate) ribs, with three, and occasionally four, secondary ribs, and with more or less closely spaced points of furcation; in some ribs all the secondaries furcate from but one point, thus presenting an intermediate case between the ataxioceratoid and the polygyrate rib style (Pl. 19, Figs 1, 3 and 5). In some triplicate and biplicate ribs the anterior secondary rib follows the course of the umbilical rib, in other ribs the secondaries furcate more symetrically, the anterior secondary rib diverging forwards from the course of the umbilical rib. Well-developed constrictions occur in variable, but significant, numbers in different specimens (Pl. 19, Figs 1, 3-5); they are preceded by a compound rib, and followed by a simple rib. Intercalatory ribs appear only in a few specimens (Pl. 19, Fig. 5; Pl. 21, Fig. 2); they contribute little to the irregular aspect of the virgataxioceratoid ribbing. Much intraspecific variability can be observed at this stage of ribbing. For instance, ataxioceratoid rib-units are well represented in some specimen (see Pl. 19, Fig. 5), while virgatotome/polygyrate ribs prevail in others (*see* Pl. 19, Fig. 1).

A fragment of whorl with a short lappet (Pl. 21, Fig. 3a) was found associated with unmistakable specimens of *Sarmatisphinctes fallax.* Hence, this specimen can be thought to represent a microconch of this species, with an estimated diameter of some 70-80 mm. Fragmentary specimens with whorls of greater size were also encountered (Pl. 19, Figs 2, 4; Pl. 20, Fig. 5; Pl. 21, Figs 2- 3b). These whorls show only biplicate and triplicate ribs; no large whorls with a higher ratio of secondary to primary ribs were encountered. Hence it can be concluded that *S. fallax* had macroconchs with biplicate and triplicate ribs on whorls of great diameter. The largest specimen of *S. fallax* figured by ILOVAISKY (1941, p. 45, Pl. 2, Fig. 5), which also shows biplicate and triplicate ribs on the last whorl and can also be interpreted as a macroconch, is an incomplete specimen with a diameter of 145 mm, with a part of the body chamber preserved. From this it can be concluded that the macroconchs of *S. fallax* attained a still greater size.

In addition to the specimens that can be assigned to *Sarmatisphinctes fallax* on purely morphological grounds, and can be referred to as typical, the Polish Fallax Subzone also yielded some other specimens testifying to the broad range of the variability of *Sarmatisphinctes fallax* as a biospecies. One case is represented by two complete microconchs with lappets (Pl. 21, Figs 1, 4), with different diameters (about 50 and 90-100 mm, respectively). The ribbing of these specimens is essentially biplicate, so that they could readily be accommodated in *Discosphinctoides subborealis* sp.n., if found in the bulk of the Autissiodorensis Zone, below the Fallax Subzone. Nevertheless, the specimens are interpreted as conservative variants of *S. fallax,* in accordance with the horizontal concept of species adopted herein. This interpretation is supported by the co-occurrence in the Fallax Subzone of forms with a variable proportion of biplicate ribs, and also by the fact that in species of the genus *Ilowaiskya* which, as argued below, evolved from *Sarmatisphinctes fallax*, the range of intraspecific variability also includes biplicate varieties.

Still other specimens (Pl. 20, Figs 1, 6), with fairly regular ribbing, are reminiscent of *Ilowaiskya klimovi* (ILOVAISKY), although triplicate ribs appear in these specimens at smaller diameters. Most specimens representing such a morphological variety were found at very high levels in the Fallax Subzone.

It thus appears that the species *Sarmatisphinctes fallax* (ILOV.) can be interpreted as a set of densely spaced successive populations, with a broad spectrum of intraspecific variability at each level, which form an evolutionary link between *Discosphinctoides subborealis* sp.n. and *Ilowaiskya klimovi* (ILOVAISKY). Nevertheless, there are good reasons for distinguishing *Sarmatisphinctes fallax* as a separate taxon, as it represents a distinctive stage in the evolution of a phylogenetic lineage, and as it permits to separate out a narrow interval, of high correlation value, at the top of the Autissiodorensis Zone.

The position of boundaries of biostratigraphic units depends on the paleontologic interpretation of their diagnostic fossils, and some special problems may arise from the application of a horizontal (not purely morphological) concept of species. However, in practice, no such problems are posed by the Polish sections here discussed. In these sections, the lower boundary of the Fallax Subzone is marked by the massive and quite abrupt appearance of forms of *Sarmatisphinctes fallax* which can be distinguished from *Discosphinctoides subborealis* sp.n. on purely morphologic grounds. On the other hand, specimens with exclusively biplicate ribbing (such as those shown in Pl. 21, Figs 1, 4) were encountered only sporadically at still higher levels.

A good example is provided by the interval 902.0-907.2m IV of the borehole Tuszyn 2, which yielded, in addition to much shell debris, nine better specimens of *Sarmatisphinctes fallax*; seven of them are here illustrated (Pl. 22). These specimens display much intraspecific variability, *e.g.* a different proportion of biplicate ribs. Nevertheless, even specimens with predominantly biplicate ribbing (*e.g.* Pl. 22, Fig. 2) can be kept distinct morphologically from *Discophinctoides subborealis* sp.n. because of the presence of several triplicate, or ataxioceratoid, ribs.

As remarked above, several species of *Virgataxioceras* from Submediterranean or Mediterranean regions of South Germany and Bulgaria, notably *V. comatum* (SCHNEID), *V. setatum* (SCHNEID), *V. subsetatum* (SCHNEID), *V. supinum* (SCHNEID), *V. setatoides* (BERCKHEMER), and *V. setatulum* (BERKHEMER & HÖLDER), were described and illustrated by SCHNEID (1914, pp. 164-165, Pl. 1, Fig. 7; Pl. 5, Figs 5-7; Pl. 6, Figs 3-4), BERCKHEMER & HÖLDER (1959, pp. 46-51, Pl. 7, Fig. 34; Pl. 8, Figs 39-43; Pl. 9, Figs 44-47, 49; Abb. 26-27, 29-31) and SAPUNOV (1979, pp. 123-124, Pl. 26, Figs 2-3; Pl. 27, Fig. 1). This group of species, which will be referred to as the group of *Virgataxioceras setatum* (SCHNEID), includes lappeted microconchs of different size. Occurrences of forms intermediate morphologically between the particular species of this group was emphasized both by SCHNEID (1914) and BERKHEMER & HÖLDER (1959), so that, for instance, *V. comatum* (SCHNEID) was interpreted as conspecific with *V. setatum* (SCHNEID) by BERCKHEMER & HÖLDER (1959, p. 47).

Although it would be difficult to characterize in a concise fashion the morphologic variablity of the ammonites of the group of *Virgataxioceras setatum*, the figured specimens of those ammonites leave no doubt that their range of variability markedly differs from that of *Sarmatisphinctes fallax,* as defined *e.g.* by the specimens illustrated by ILOVAISKY & FLORENSKY (1941, Pls 2-3), and in the present paper (Pls 19-22). In the former ammonites, the ribbing is usually more regular, and less affected by constrictions; and virgatotome ribbing (with up to six secondaries to one primary rib in some extreme cases) prevails in most forms, whereas, as emphasized by BERCKHEMER & HÖLDER (1959, p. 47), the ataxioceratoid style of ribbing appears but exceptionally.

However, the most important point is that large ammonites of the group of *Virgataxioceras setatum,* interpretable as macroconchs (BERCKHEMER & HÖLDER 1959, p. 47, Pl. 8, Fig. 39), show a "virgatolitacoceratoid" style of ribbing, with a high ratio of secondary to primary ribs on outer whorls; this is in marked contrast with the ribbing of *Sarmatisphinctes fallax*, which consists of biplicate and triplicate ribs at comparable whorl-diameters. The type of dimorphism displayed by the group of *Virgataxioceras setatum* is thus closely comparable with that shown in South Germany, at somewhat higher stratigraphic levels (OHMERT & ZEISS 1980), by the lappeted microconchs of *Lithacoceras* assigned at the subgeneric level to *Subplanites*, and the corresponding macroconchs of *Lithacoceras* assigned to *Virgatolithacoceras*.

From the above it follows that the group of *Virgataxioceras setatum* comprises a Submediterranean/Mediterranean assemblage (or assemblages) of ammonites, showing affinity with *Lithacoceras* and *Subplanites*. On the other hand, *Sarmatisphinctes fallax* is a Subboreal species forming an evolutionary link between *Discosphinctoides* and *Ilowaiskya*. Accordingly, the opinion that the group of *Virgataxioxeras setatum* (SCNEID) and *Sarmatisphinctes fallax* (ILOVAISKY) should be kept distinct at generic level, is supported both by the differences in their morphologic development, and by their different phylogenetical positions.

The species *Virgataxioceras dividuum* (MESEZHNIKOV, 1973) has been reported from an Arctic (or peri-Arctic) region of Russia (the northern Trans-Uralian region, MESEZHNIKOV 1984), and its hitherto known occurrences do not overlap with those of *Sarmatisphinctes fallax* (ILOVAISKY), the latter being restricted to south-eastern and central regions of the Russian Platform (ILOVAISKY 1941; MIKHAILOV 1964; GERASSIMOV & MIKHAILOV 1966; MESEZHNIKOV 1982, 1984, 1988), and cratonic Poland. The species *V. dividuum* (MESEZHNIKOV) differs from *S. fallax* (ILOVAISKY) in having numerous intercalatory ribs, and less pronounced constrictions; the description and figures of *V. dividuum* presented by MESEZHNIKOV (1973) leave no doubt that these two species have different ranges of morphologic variability. The phylogenetic relationships of *V. dividuum* remain unclear. Nevertheless, taking into account the irregular ribbing and the Arctic occurrences of *Virgataxioceratoides dividuum* (MESEZHNIKOV), it seems more reasonable to accommodate for the time being this Boreal species together with the Subboreal species *Sarmatisphinctes fallax* (ILOVAISKY) in the new genus *Sarmatisphinctes*, than in the restricted genus *Virgataxioceras* encompassing Submediterranea/Mediterranean species.

LOWER VOLGIAN AMMONITES AND ZONATION OF THE RUSSIAN PLATFORM

Because of the similarity of the relevant ammonite succession of both regions, the zonation established in the Lower Volgian of the

Russian Platform can also be applied, to a large extent, to the Lower Volgian of Poland.

The classical region of the Lower Volgian of the Russian Platform is situated in the south-eastern part of that area. In literature, it was called the region of Orenburg, the basin of the Ural and Ilek rivers, or the Ural Basin (ILOVAISKY & FLORENSKY 1941, MIKHAILOV 1964, MESEZHNIKOV 1988).

The Lower Volgian ammonites of that region were monographed by ILOVAISKY (*in*: ILOVAISKY & FLORENSKY 1941), who assigned all these ammonites to, or compared with, several new species established by him. In Ilovaisky's monograph, all these species were included in the genus *Ilowaiskya* of VIALOV, 1941, which name was spelled "*Ilovaiskya*". The Zone of *Ilowaiskya sokolovi* and the Zone of *Ilowaiskya pseudoscythica* were distinguished by ILOVAISKY (1941) in the Lower Volgian strata of the investigated region.

A broad concept of species was applied by ILOVAISKY (1941), who emphasized the wide ranges of intraspecific variability of several species of *Ilowaiskya*. That this was a valuable taxonomic approach is corroborated by the fact that, as discussed in the following sections of this paper, several of the species established by ILOVAISKY (1941), and regarded by him as coeval, were found to occur in different stratigraphic intervals, as successive monospecific assemblages of *Ilowaiskya*, in the expanded sections of the Polish Volgian.

The Lower Volgian ammonites from the same region were also monographed by MIKHAILOV (1964), who was able to distinguish the Klimovi, Sokolovi, and Pseudoscythica Zones. The Lower Volgian ammonites, for which a few new species were established by MIKHAILOV, were assigned by him to the two genera, *Subplanites* and *Pectinatites*. However, no microconchs with lappets typical of *Subplanites*, nor any microconchs with ventral horns characteristic of *Pectinatites*, have been demonstrated to occur in the ammonite assemblages of the Lower Volgian of the Russian Platform.

The Lower Volgian strata of the region of the Ural River are variable lithologically, rich in glauconite and phosphatic nodules, and usually very thin. The thickness of the Lower Volgian amounts to *c*. 9m only in a section on the Vetlanka River; in some other sections the Lower Volgian strata are less than 1 meter thick. For instance, in the It-Chashkan anf Kokbulak sections, the Lower Volgian is represented only by the Pseudoscythica Zone, which thicknesses amount only to 35 and 75 cm, respectively (MIKHAILOV 1964). Hence, as pointed out by KUTEK

(1994a), the available data are indicative of stratigraphic condensation and discontinuities in several sections. Accordingly, it can be expected that some of the ammonites found associated in some beds of the sections here considered may represent different biostratigraphic horizons.

In other biostratigraphic sections of the Russian Platform, described in detail, the Lower Volgian is also fairly thin. It encompasses strata about 6m thick (Klimovi, Sokolovi, and Pseudoscythica Zones) in the stratotype of the Volgian Stage at Gorodishche on the Volga River, and about 8m thick (Klimovi and Sokolovi Zones) at Kashpirovka, also on the Volga (MIKHAILOV 1964; GERASSIMOV & MIKHAILOV 1966; MESEZHNIKOV 1982, 1988). Moreover, to the knowledge of the present authors, no Lower Volgian ammonites from the latter sections have ever been figured. Therefore, most important information about the Lower Volgian ammonites succession of the Russian Platform is still provided by the sections from the region of the Ural River.

THE KLIMOVI ZONE

The base of the Klimovi Zone is here defined as the level of the first appearance of *Ilowaiskya klimovi* (ILOVAISKY), and its upper boundary as coinciding with the base of the Sokolovi Zone. The base of the Klimovi Zone is by definition the base of the Volgian Stage (GERASSIMOV & MIKHAILOV 1966).

The Polish sections here considered yielded several specimens of *Ilowaiskya klimovi*, which are described in the following section of this paper.

In the boreholes situated around and within the Tomaszów Syncline (Text-fig. 3*A*-*C*), specimens of *Ilowaiskya klimovi* were found at lowest levels at 113.8m at Antoninów-Skorkówka, at 38.7m at Sławno, at 36.7m at Błogie-Nadzieja, and at 189.1m at Zarzęcin *1*; and a specimen (Pl. 24, Figs 1-2), with an aperture showing features intermediate between those characteristic of *Sarmatisphinctes fallax* (ILOVAISKY) and *Ilowaiskya klimovi* , was encountered at Zarzęcin 1 at 189.4 m. Most of these specimens were found (*see* Appendix) at levels but slightly higher than those of the highest specimens of *S. fallax*. The lower boundary of the Klimovi Zone can thus be drawn with fairly good precision, so more as it is possible to correlate some sections also on a lithological basis (Text-figs 3*B*-*C*). However, as commented below, some paleontologic problems are connected with the distinction between *Sarmatisphinctes fallax* and *Ilowaiskya klimowi*.

The highest specimens of *Ilowaiskya klimovi* were found at 104.9m at Antoninów-Skorkówka, and at 29.25m at Błogie-Nadzieja.

The lowest specimen of *Ilowaiskya sokolovi* (ILOVAISKY), the species indicative of the Sokolovi Zone, was found at Antoninów-Skorkówka at 104.1m, and at 27.5m at Błogie-Nadzieja. This permits to estimate the thickness of the Klimovi Zone as 10-11 m (Text-figs 3A-C).

At Stobnica, several specimens of *Ilowaiskya klimovi* were collected from the debris provided by the well *37* (KUTEK 1961, Pl. 16, Fig. 2; Pl. 17, Figs 1-2; *and* Pl. 23, Fig. 5 in this paper) together with a specimen (KUTEK 1961, Pl. 19, Fig. 2) which can be assigned with some reservation to *Sarmatisphinctes fallax*. This suggests that the part-section of Stobnica *37* extents a little down into the Kimmeridgian.

Only a few specimens of *Ilowaiskya klimovi* were collected from the boreholes situated in the Łódź Depression (*see* Appendix). The stratigraphic position of the base of the Klimovi Zone can be indicated with more or less precision in some sections (Text-figs 4-5), but the upper boundary of this zone cannot be directly indicated. Still, the available data are consistent with the interpretation that the thickness of the Klimovi Zone is about the same in the latter sections and in those of the region of Tomaszów Mazowiecki.

Specimens of *Neochetoceras* were also collected from the Klimovi Zone (*see* Appendix); they are described in another section of this paper. Here it is worth of note that a few specimens of *N. steraspis* (OPPEL) were found at some distance above the base of the Klimovi Zone, and that *N. steraspis* was found associated with *N. mucronatum* BERCKHEMER & HÖLDER in the upper part of this zone (Appendix, and Text-figs 3*A*, *C* and 4).

Poorly preserved specimens of the Haplocerataceae, which cannot be safely identified with more precision, were found at some levels in the Klimovi Zone (*see* Appendix). Some of them might be interpreted as belonging to *Glochiceras* or *Haploceras*. In any case, the available paleontologic material suggests that the superfamily Haplocerataceae is represented not only by the genus N*eochetoceras* in the Klimovi Zone of Central Poland.

Also a few specimens of *Sutneria* were found in the Klimovi Zone, at 106.8m and 108.5m at Antoninów-Skorkówka (Pl. 31, Figs 1-3), and at 765.5-771.5m at Bełchatów *5* (Pl. 31, Fig. 4). The former specimens are precisely located high in the Klimovi Zone. Two complementary specimens from Antoninów-Skorkówka (Pl. 31, Figs 1-3) represent an adult individual with lappets, with a (crushed) diameter of 11 mm, and distinct falcoid ribbing visible on what can be thought to be the body chamber. Similar ornamentation is displayed by a specimen from

Bełchatów 5 (Pl. 31, Fig. 4), about 10 mm large. A few other specimens of *Sutneria* were also found at Antoninów-Skorkówka at the levels indicated above. They are all incomplete, and have diameters not exceeding 10 mm.

These Polish specimens appear to be comparable with the species *Sutneria bracheri* BERCKHEMER, which was described and/or illustrated by BERCKHEMER (1922, p. 75, Pl. 1, Fig. 11), BERCKHEMER & HÖLDER (1959, p. 62, Pl. 12, Fig. 60), BARTHEL (1959, p. 56, Pl. 6, Figs 13-14), and GEYER (1969, Fig. 1). However, the Polish specimens seem to be smaller than the South German ones, which attain diameters to about 25 mm. Therefore, the Polish specimens will be referred to as *Sutneria* cf. or aff. *bracheri* BERCKHEMER.

ILOVAISKA KLIMOVI (ILOVAISKY)

Specimens of *Ilowaiskya klimovi* (ILOVAISKY) from the Russian Platform were described and illustrated by ILOVAISKY (1941, pp. 100-105, Pl. 21, Fig. 40; Pl. 22, Fig. 41), and MIKHAILOV (1964, pp. 44-46; Pl. 1, Fig. 1; Pl. 2, Fig. 3; Pl. 3, Figs 2, 4). The occurrences of this species are restricted to the Klimovi Zone (MIKHAILOV 1964, GERASSIMOV & MIKHAILOV 1966). In the Russian specimens, biplicate ribbing persists to a whorl diameter of about 70 mm, according to MIKHAILOV (1964), or to variable diameters, according to ILOVAISKY (1941). At greater diameters, biplicate and triplicate ribs occur in variable proportions (ILOVAISKY 1941, p. 104; MIKHAILOV 1964, p. 45). The largest Russian specimens of *I. klimovi* have diameters amounting to over 250 mm; the outer whorls of such large specimens, that can be interpreted as macroconchs, bear biplicate and triplicate ribs (*see* Mikhailov 1964, p. 45).

All the perisphinctacean ammonites found in the Klimovi Zone in the investigated Polish sections can readily be accommodated in *Ilowaiskya klimovi* (ILOVAISKY); they compare closely with the Russian specimens of this species.

The inner whorls of the Polish specimens show biplicate ribbing (Pl. 23, Figs 2-3; Pl. 24, Fig. 4). At somewhat variable diameters (*compare* Pl. 23, fig. 3 *with* Pl. 24, Fig. 6), which can be estimated to range from some 50 to about 70 mm, triplicate ribs appear which, at greater diameters, are associated with more or less numerous biplicate ribs. In most specimens (Pl. 23, Figs 1-2, 4-5; Pl. 24, Figs 6-7), the number of triplicate ribs is greater, or about the same, as that of biplicate ribs. For instance, in the specimen from Stobnica 37, figured here for the first time (Pl. 23, Fig. 5), there occur about 55 secondary ribs and 21 primary ribs on a half whorl at diameter of about 120 mm, so that the ratio of secondary to primary ribs is about 2.6.

However, there are exceptions to this rule. For instance, of the three specimens from Stobnica 37, figured formerly (KUTEK 1961, Pl. 16, Fig. 2; Pl. 17, Figs 1-2) under different names, and re-interpreted herein as belonging to *Ilowaiskya klimovi* (ILOVAISKY), one specimen (KUTEK 1961, Pl. 16, Fig. 2) has only a few triplicate ribs on the last preserved whorl, so that the ratio of secondary to primary ribs amounts to only about 2.1 at a whorl-diameter of about 90 mm. And a specimen from Zarzęcin *1* (Pl. 24, Fig. 3), which shows ribbing composed exclusively of biplicate ribs, is here interpreted as an extreme morphologic variant of *I. klimovi*. In this context it is worth of note that a Russian specimen interpreted as belonging to, or close to, *I. klimovi* by ILOVAISKY (1941, p. 104), displays biplicate ribbing complicated only by a few occasional triplicate ribs.

In the Polish specimens, the ribs, if not distorted, are mostly rectiradiate, and they usually do not show a distinct forward bent on the ventral side (Pls 23-24) Constrictions are usually slightly prorsoradiate; they are followed by a simple rib, and preceded by a triplicate, or compound, rib. The Polish specimens of *Ilowaiskya klimovi* compare well with the Russian specimens also in that they display the mixed type of ribbing, as emphasized by ILOVAISKY (1941), who stated that most ribs in *I. klimovi*, both the biplicate and triplicate ones, show a "forked", and only some o them a "backwards one-sided" mode of furcation. In the first case, the anterior secondary rib diverges forwards from the course of the primary rib, so that this mode of furcation is not markedly asymmetric. In the second case, the anterior secondary rib follows the course of the primary rib, and the posterior secondary ribs diverge backwards from this course (this mode of furcation is *e.g.* represented by the "perfect" virgatotome ribbing found in some species of *Zaraiskites* and *Virgatites*). Using other terminology, it can be said that most triplicate ribs in *I. klimovi* (ILOVAISKY) should be classified as polygyrate rather than virgatotome.

A specimen, showing chiefly the ventral side of a large whorl attributable to *Ilowaiskya klimovi*, is here illustrated (Pl. 24, Fig. 5). This specimen, interpretable as a macroconch, is suggestive of ribbing composed of biplicate, triplicate and, possibly, simple ribs.

Only a few fragmentary specimens of *Ilowaiskya klimovi* were found in the lowest strata, some 2-3m thick, overlying the Fallax Subzone; one of them is here illustrated (Pl. 24, Fig. 7). These specimens reveal the morphologic characters of *I. klimovi* equally well as other incomplete specimens found at somewhat higher levels (*compare*

Pl. 24, Fig. 7 *with* Pl. 23, Fig. 2 and Pl. 24, Fig. 6). Still, some doubt might be cast on the taxonomic identification of some of the specimens from the lower strata, as incomplete specimens of some morphologic variants of *Sarmatisphinctes fallax* (ILOVAISKY) may also display the type of ribbing found in *I. klimovi* (see *e.g.* Pl. 20, Fig. 2). In this context, the observation of ILOVAISKY (1941) is worth recalling that often fragments of whorls of *I. klimovi* cannot be distinguished morphologically from those of *S. fallax.* Nevertheless, the discussed Polish specimens found in the lowest strata overlying the Fallax Subzone are assigned to *Ilowaiskya klimovi*, as no other specimens, recognizable unequivocally as representing *Sarmatisphinctes fallax*, were encountered in that stratigraphic interval.

The species *Sarmatisphinctes fallax* (ILOVAISKY) is followed by the species *Ilowaiskya klimovi* (ILOVAISKY) in the sections of both cratonic Poland and the Russian Platform. In Poland, the ammonites belonging to *S. fallax* occur massively in the Fallax Subzone, where the superfamily Perisphinctaceae is represented only by this species and *Aulacostephanus.* Some morphologic variants of *S. fallax* are closely comparable with *I. klimovi*, and in both these species the outer whorls of large specimens interpretable as macroconchs, bear biplicate and triplicate ribs. All this strongly suggests that *Ilowaiskya klimovi* evolved directly from *Sarmatisphinctes fallax.*

The polygyrate/virgatotome ribbing of *Ilowaiskya klimovi* is reminiscent of that found in several species of *Subplanites.* Consequently, *I. klimovi* was ascribed to *Subplanites*, for instance, by ARKELL (1956) and MIKHAILOV (1964), who regarded the name *Ilowaiskya* as a junior synonym of *Subplanites.* Moreover, a phylogenetic link between *Subplanites* and *Ilowaiskya* was suggested by KUTEK & ZEISS (1974), and KUTEK (1990). These interpretations require revision. .

The genus (or subgenus) *Subplanites* comprises microconchs with lappets, whereas the corresponding macroconchs with lithacoceratoid (or virgatolithacoceratoid) ribbing on outer whorls are usually accommodated (*see* OHMERT & ZEISS 1980) in the genus *Lithacoceras.* On the other hand, the outer whorls of macroconchs of *Ilowaiskya klimovi* show a different morphologic development, bearing biplicate and triplicate ribs. Moreover, no lappeted microconchs of *I. klimovi* have hitherto been observed. More generally, no perisphinctacean ammonites with lappets, or with ventral horns reminiscent of *Pectinatites*, have hitherto been found in the Lower Volgian strata of Poland and the Russian Platform.

From this the conclusion can be drawn that *Ilowaiskya klimovi* (ILOVAISKY) is not related phylogenetically with *Subplanites* and *Lithacoceras*, and that the genus *Ilowaiskya* should be retained for this species (and for several other Lower Volgian species). Instead, as advocated above, *Sarmatisphinctes fallax* (ILOVAISKY) can be regarded to be the ancestor of *Ilowaiskya klimovi*. However, in this case, it should be kept in mind that *S. fallax* has microconchs with lappets, whereas *I. klimovi* has not. Hence, the latter interpretation implies that the transformation of *S. fallax* into *I. klimovi* was connected with loss of lappets in microconchs.

In this context, a specimen (Pl. 24, Figs 1-2), found just at, or very close to, the boundary between the Fallax Subzone and the Klimovi Zone (Text-fig. 3*A* and Appendix), is of special interest. In this specimen, the ribbing in the peri-apertural region is very irregular, and the aperture is preceded by a strong constriction. This suggests that the specimen represents an adult individual. The aperture itself can equally well be characterized as strongly flexuous, or as bearing an extremely reduced lappet. The specimen here discussed thus appears to testify to the loss of lappets in microconchs during the transformation of *S. fallax* into *I. klimovi*.

In accordance with the evidence discussed above, it is here accepted that the species *Sarmatisphinctes fallax* (ILOVAISKY) gave rise to the species *Ilowaiskya klimovi* (ILOVAISKY), and thus to the genus *Ilowaiskya*.

THE SOKOLOVI ZONE

The base of the Sokolovi Zone is here defined as the level of the first appearance of *Ilowaiskya sokolovi* (ILOVAISKY), and its upper boundary as coinciding with the base of the Pseudoscythica Zone.

The Polish sections yielded several specimens of *Ilowaiskya sokolovi* (ILOVAISKY), and a few specimens of *Ilowaiskya pavida* (ILOVAISKY), which are described in the following section of this paper. In sections of the Russian Platform, the occurrences of *I. sokolovi* and *I. pavida* are restricted to the Sokolovi Zone (MIKHAILOV 1964).

As already stated, the lowest specimens of *Ilowaiskya sokolovi* were found at 104.1m at Antoninów-Skorkówka, and at 27.5m at Błogie-Nadzieja, at levels but slightly higher than those from which the highest specimens of *Ilowaiskya klimovi* were collected. Thus the boundary of between the Klimovi and Sokolovi Zones can be drawn with reasonably good precision (Text-figs 3*B*-*C*). On the other hand, it should be pointed out that specimens of *Ilowaiskya sokolovi* were obtained only from the sections of the boreholes Antoninów-Skorkówka, Błogie-Nadzieja and Zarzęcin *1*, from Stobnica *20*, and possibly also from Stobnica *39* (Appendix).

Specimens of *Ilowaiskya sokolovi* were collected from relatively low levels of the Sokolovi Zone (Appendix and Text-figs 3*A*-*C*). Specimens representing *Ilowaiskya pavida* were found, in a higher stratigraphic position, at 92.3m, and possibly also at 94.3m, at Antoninów-Skorkówka (Pl. 27, Figs 1-3). The level 92.3m at Antoninów-Skorkówka is taken as the level indicating the top of the strata that can be assigned with certainty to the Sokolovi Zone (Text-figs 3*A*-*C*). Hence this zone can be estimated to be more than 10m, but less than 15m, thick.

The available material suggests that what might be called the Pavida Subzone, or the Pavida Horizon, is individualized at the top of the Sokolovi Zone. Of course, it would not be reasonable to establish a new biostratigraphic unit based only on two closely identifiable specimens found at one level in one section. Still, the Sokolovi Zone appears to have some potential left for further biostratigraphic subdivision.

Haploceratacea appear at several levels in the Sokolovi Zone (Appendix and Figs 3*A*-*C*). A large proportion of them belong to the genus *Neochetoceras*, which is represented in the Sokolovi Zone only by the broadly interpreted species *Neochetoceras mucronatum* BERCKHEMER & HÖLDER (*see* Appendix). The specimens of *Neochetoceras* are described in another section of this paper. Identifiable specimens of *N. mucronatum* were found in the highest stratigraphic position at 100.5m at Antoninów-Skorkówka, at 23.7m at Sławno, at 23.25m at Błogie-Nadzieja, and at 173.0m at Zarzęcin *1*.

The Sokolovi Zone yielded three specimens of the Haploceratacea, with strong arched ribs in the dorsolateral region of the flanks. Two specimens were found at Błogie Nadzieja, at 18.9-19.0m and 22.05m (Pl. 31, Figs 6-7). The third specimen was found, associated with *Neochetoceras mucronatum*, at Stobnica *39* (Pl. 31, Fig. 5). These specimens, which defy closer taxonomic identification, may represent *Ochetoceras* or *Taramelliceras*. The illustrations of these specimens, which might be supplemented by some forms reminiscent of *Glochiceras*, suggest that the assemblages of the

Haploceratacea which are represented in the Polish Sokolovi Zone chiefly by very poorly preserved specimens, may be fairly well diversified, comprising not only the genus *Neochetoceras*.

Specimens of the Haploceratacea were found in the highest stratigraphic position at 95.2m at Antoninów-Skorkówka, at 18.9-19.0m at Błogie-Nadzieja, and at 198.5 m at Zarzęcin *3*. From this it follows that the Haploceratacea still appear near, but not above, the top of the strata classified as the Sokolovi Zone (Text-figs 3*A*-*C*). No representatives of the Haploceratacea were found at higher stratigraphic levels in Lower and Middle Volgian strata in the sections here considered. There also are no reports of any occurrences of the Haploceratacea above the Sokolovi Zone from any other region of cratonic Poland.

SPECIES OF *ILOWAISKYA* FROM THE SOKOLOVI ZONE

The species *Ilowaiskya sokolovi* was established by ILOWAISKY (1941, pp. 71-85, Pl. 7, Fig. 19; Pl. 8, Fig. 18; Pl. 9, Figs 20-22; Pl. 10, Figs 23-24; Pl. 11, Figs 24a, 25; Pl. 12, Fig. 26; Pl. 13, Fig. 27), who distinghished the varieties *typica, pavida,* and *juvenilis* within this species, and described some additional paleontologic material, separating out two cf.-forms and four aff.-forms. This species was split into two species, *I. sokolovi* and *I. pavida*, by MIKHAILOV (1964); the variety *typica* of ILOWAISKY was left in the former species (MIKHAILOV 1964, p. 40; Pl. 5, Fig. 1), whereas the varieties *pavida* and *juvenilis* were included in the latter species (MIKHAILOV 1964, p. 49, Pl. 1, Fig. 2; Pl. 2, Fig. 1; Pl. 8, Fig. 3). This taxonomic decision, which was based on purely morphological grounds, finds additional support in the Polish sections, where forms attributable to the restricted species *Ilowaiskya sokolovi* (ILOVAISKY), and to *Ilowaiskya pavida* (ILOVAISKY), were found in different stratigraphic horizons. Hence, the forms referrable to *I. sokolovi* sensu MIKHAILOV, and to *I. pavida*, will be kept distinct at specific level.

It is open to debate whether a very large ammonite, with a diameter of 360 mm, which was figured by MIKHAILOV (1964, Pl. 4, Fig. 1) as *Subplanites sokolovi*, should be assigned to this species, and to the genus *Ilowaiskya*. This specimen, with a high ratio of secondary to primary ribs persisting to a very large diameter, might be compared, for instance, with *Pseudovirgatites*.

The collection here described includes only about 15 reasonably good specimens of *Ilowaiskya sokolovi*. They were provided only by the boreholes Antoninów-Skorkówka, Błogie-Nadzieja and Zarzęcin *1*, by Stobnica *20*, and possibly also by Stobnica *39* (Appendix and Text-fig. 3*A*-*C*). Still, three different morphological varieties of *I. sokolovi* can be distinguished.

A few specimens show triplicate ribbing on relatively large whorls, with a significant proportion of intercalatory ribs (Pl. 25, Fig. 3; Pl. 26, Fig. 1). This type of ribbing is commonly found in the Russian specimens assigned to *Ilowaiskya sokolovi* var. *typica* (ILOVAISKY, 1941), or to the restricted species *I. sokolovi* as understood by MIKHAILOV (1964). It corresponds to the fourth stage of ontogenic development of *I. sokolovi,* as distinguished by ILOVAISKY (1941) in the variety *typica*.

Another set of specimens (Pl. 25, Fig. 1; Pl. 26, Figs 2 and 4) shows densely spaced triplicate virgatotome ribbing on relatively large whorls (the biplicate ribbing of inner whorls can be seen in the specimen shown in Pl. 26, Fig. 4). The furcation points of the triplicate ribs are situated relatively low on the whorl-flanks, and are often not much removed from each other, so that characteristically long virgatotome bundles are formed. Occasional intercalatory ribs have been observed only in some of these specimens (Pl. 25, Fig. 1).

The triplicate ribbing of this set of specimens corresponds to the third stage of ontogenic development of *I. sokolovi,* as distinghished by ILOVAISKY (1941). It can be observed that in the Polish collection both the third and fourth stage of the ontogenic development of ribbing in *I. sokolovi,* that is ribbing with or without a significant proportion of intercalatory ribs, is represented by specimens of comparable size (Pl. 25, Figs 1, 3; Pl. 26, Figs 1-2). This, however, is in accordance with the observation by ILOVAISKY (1941) that in *I. sokolovi* successive stages of ribbing may appear at variable whorl-diameters, and that some of these stages may be entirely suppressed in some specimens.

The morphologic variety described above is represented by the three ammonites (Pl. 26, Fig. 4) found at Antoninów-Skorkówka at 104.1m. This level is taken to define the base of the strata assigned with certainty to the Sokolovi Zone in the sections of the western margin of the Mid-Polish Anticlinorium. In those ammonites, the ribs are distinctively more densely spaced, as usually in specimens of *I. klimovi* of comparable size (*compare* Pl. 26, Fig. 4 *with* Pl. 23, Fig. 5).

Another group of specimens comprises forms showing distant, and predominantly triplicate ribbing, on middle whorls (Pl. 25, Fig. 2; Pl. 26, Fig. 3). The triplicate ribs are virgatotome with wide furcation angles, and in some specimens (Pl. 25, Fig. 2) the furcation points are situated relatively high on the whorl flanks. Thus this rib-style resembles that found in some species of *Zaraiskites*, especially in *Z. scythicus* (VISCHNIAKOFF). These Polish specimens appear to have their morphologic counterparts in the Russian specimens described by ILOVAISKY (1941, p. 81, Pl. 13, Fig. 28) as "*Ilowaiskya* cf. *sokolovi* f. B (var. nova ?)". In the latter specimens, which also display a distinctively distant ribbing, triplicate ribs appear at variable diameters of whorls.

The three morphologic variants of *Ilowaiskya sokolovi* described above (Pls 25-26) were found only in relatively low portions of the Polish Sokolovi Zone (Appendix and Text-fig 3*A-C*). Of special interest are the three specimens (Pl. 25), which represent all these variants. They were found at Stobnica *20* in a section only about 1m thick, and thus can be regarded to be unequivocally coeval forms.

A fragment of a large whorl with strong biplicate ribs, and simple ribs bordering a constriction, was also found in the lower part of the Polish Sokolovi Zone (Pl. 27, Fig. 5). The ribbing of this specimen, which is also assigned to *Ilowaiskya sokolovi*, and can be interpreted as a macroconch, resembles to some extent the ribbing seen in a part of the outermost whorl of a large specimen of *I. sokolovi*, figured by MIKHAILOV (1964, Pl. 5, Fig. 1).

When regarded as a whole, the assemblages of *Ilowaiskya sokolovi* from the lower part of the Sokolovi Zone differ distinctively from the earlier assemblages of *Ilowaiskya klimovi* (ILOVAISKY). However, some morphologic variants of *I. sokolovi* with distant and fairly regular ribbing do not differ markedly from forms of *I. klimovi*. Some morphologic affinities of *I. sokolovi* with *I. klimovi* were also emphasized by MIKHAILOV (1964). This supports the interpretation that the species *Ilowaiskya sokolovi* (ILOVAISKY), which appears both in Poland and the Russian Platform in strata directly overlying those with *Ilowaiskya klimovi* (ILOVAISKY), evolved from the latter species.

The species *Ilowaiskya pavida* (ILOVAISKY) is represented by two specimens (Pl. 27, Figs 1-2) found, very high in the Sokolovi Zone, at 92.3m at Antoninów-Skorkówka. The ribbing in these specimens is characteristically dense, and essentially biplicate, though some occasional triplicate ribs not connected with constrictions, which are strongly prorsoradiate, appear in one of the specimens (Pl. 27, Fig. 2). These Polish specimens compare closely with the Russian specimens described as *Ilowaiskya sokolovi* var. *juvenilis* by ILOVAISKY (1941, pp. 76; Pl. 13, Fig. 27), which were assigned to the species *Ilowaiskya pavida* by MIKHAILOV (1964, p. 49). A fragment of a whorl with dense biplicate ribs, found at a slightly deeper level at Antoninów-Skorkówka at 94.3m (Pl. 27, Fig. 3), presumably also belongs to *I. pavida*.

The level 92.3m at Antoninów-Skorkówka is taken as the level indicating the top of the strata referrable with certainty to the Sokolovi Zone in the sections of the region of Tomaszów Mazowiecki.

NEOCHETOCERAS

The succession of species of *Neochetoceras*, as recognized in South Germany in Franconia (ZEISS 1968), can be summarized as follows. The species *N. praecursor* ZEISS, 1968, appears deep in the Hybonotum Zone, in which it is followed by *N. steraspis* (OPPEL, 1863). At high levels in this zone, the latter species is associated with *N. mucronatum* BERCKHEMER & HÖLDER, 1959. In the Lower Tithonian above the Hybonotum Zone, *Neochetoceras* is represented by microconchs assigned to *N. mucronatum* BERKHEMER & HÖLDER, and macroconchs accommodated in *N. usselense* ZEISS.

Specimens of *N. praecursor* were described by ZEISS (1968, p. 124; Pl. 26, Figs 1-2); those of *N. steraspis* by OPPEL (1864, pp. 251-252; Pl. 69, Figs 1-3, 5-7; Pl. 70, Fig. 1), BARTHEL & SCHAIRER (1977, p. 107; Pl. 9, Figs 5-7; Pl. 10, Figs 1-7; Abb. 1-2), OLÓRIZ SÁEZ (1978, p. 60; Pl. 5, Fig. 2), and OHMERT & ZEISS (1980, p. 41; Pl. 13, Figs 4-5); those of *N. mucronatum* by BERCKHEMER & HÖLDER (1959, p. 106; Pl. 27, Figs 145-146; Abb. 82-86), ZEISS (1968, p. 123; Pl. 26, Figs 3-4), OLORIZ SAEZ (1978, p. 61), and OHMERT & ZEISS (1980, p. 42; Pl. 13, Fig. 6); and specimens of *N. usselense* by ZEISS (1968, p. 124; Pl. 26, Figs 1-2). The species *Neochetoceras steraspis* includes both microconchs and macroconchs. Following BARTHEL & SCHAIRER (1977, p. 107), "*Ammonites Bous*" of OPPEL (1863, p. 252, Pl. 70, Fig. 1) is included in *N. steraspis*.

The succession of species of *Neochetoceras* in the Lower Volgian of Central Poland appears to mirror, to some extent at least, that recognized in Franconia.

A very poorly preserved specimen (Pl. 29, Fig. 1) was found at 38.1m at Sławno, near the base of the Klimovi Zone. This specimen is strongly involute, and shows only some hardly discernible traces of feeble, probably falcoid, ribbing. This specimen can be interpreted, with some reservation, as a *Neochetoceras*, and compared *e.g.* with *N. prae-*

cursor ZEISS. This, however, is little more than a guess, and the specimen might be interpreted equally well as a *Taramelliceras* close to *T. subnudatum* (FONTANNES). Therefore, no interregional correlations should be based on this specimen, despite its very attractive stratigraphic position just about the base of the Volgian.

A few specimens, found at higher levels in the Klimovi Zone (Appendix, and Text-figs 3*A*, *C*, and 4), are attributable to *Neochetoceras steraspis* (OPPEL).

One of these specimen (Pl. 29, Fig. 4) shows falcoid ribbing, with ribs thickened in the dorsolateral and mid-flank regions of the whorl-side; only faint traces of feeble ribs are discernible in the ventro-lateral region. This specimen appears to be closely comparable with some of the specimens of *N. steraspis* figured by BARTHEL & SCHAIRER (1977, Pl. 10, Figs 4-5), and also, so far as the state of preservation permits, with the forms described as *Neochetoceras steraspis nodolusum* by BERCKHEMER & HÖLDER (1959, p. 104, Abb. 81; Pl. 20, Fig. 107).

Another specimen (Pl. 29, Figs 2-3) shows falcoid ornamentation which is comparable with that displayed, usually at greater whorl-diameters, by some of the specimens of *N. steraspis* figured by OPPEL (1863, Pl. 69, Figs 1-2 and 6-7; *see also* BARTHEL & SCHAIRER 1977, Pl. 10, Fig. 1)

Several ammonites assembled on a bedding surface were provided by a core-sample from Antoninów-Skorkówka, 106.8m (Pl. 29, Fig. 5). All these ammonites are strongly involute, and none of them has distinct ventrolateral edges. They are all assigned to *Neochetoceras steraspis*. More or less feebly developed falcoid ribbing is still clearly visible in some specimens (Pl. 29, Figs 6-7), but hardly discernible in others (Pl. 29, Fig. 8).

One of the specimens of *Neochetoceras,* found also in the Klimovi Zone (Pl. 29, Fig. 9), shows some falcoid ribbing, and a distinct ventrolateral edge. Because of the latter distinctive feature, that specimen is assigned to *N. mucronatum* BERCKHEMER & HÖLDER.

Representatives of *Neochetoceras* appear to be remarkably more common in Central Poland in the Sokolovi Zone, than in the Klimovi Zone. All the specimens of *Neochetoceras* from the Sokolovi Zone can be assigned to the broadly interpreted species *Neochetoceras mucronatum* BERCKHEMER & HÖLDER, comprising both the microconchs usually placed in the restricted species *N. mucronatum*, and the macroconchs accommodated in *N. usselense* ZEISS.

These dimorphs cannot be distinghished in most of the paleontologic material from the Sokolovi Zone, but some specimens (Pl. 30, Figs 1-4), showing fine falcoid ribbing at whorl-diameters that can be estimated to have amounted well over 50 mm, can safely be interpreted as macroconchs. The available paleontologic material is suggestive of a higher proportion of macroconchs of *Neochetoceras* in the Polish Sokolovi Zone, than in the coeval strata in Franconia (*compare* ZEISS 1968).

In several specimens, feeble falcoid ornamentation is visible only in some parts of the whorl-flanks (Pl. 30, Figs 8-10), and in some other specimens no ornamentation is discernible (Pl. 30, Fig. 7). This appears to be in part an expression of the morphologic variability of *Neochetoceras mucronatum*, but may also be due to the state of preservation. An interesting example is provided by two complementary specimens (Pl. 30, Figs 5-6), which permit to observe that the falcoid ribs are thickened in the mid-flank region only on one side of the same ammonite.

Significantly, the presence of prominent ventro-lateral edges, which is a distinctive character of *Neochetoceras mucronatum*, can be still recognized in some of the crushed specimens of *Neochetoceras* from the Sokolovi Zone (Pl. 30, Figs 4-7 and 10).

The investigated collection contains about 20 specimens which can be safely assigned to *Neochetoceras mucronatum*; some other specimens from the Sokolovi Zone with no ornamentation preserved, that are referred to in the Appendix merely as the Haplocerataceae, may also belong to this species. All the specimens attributable with certainty to *N. mucronatum* were found in lower and middle parts of the Sokolovi Zone, and, of these specimens, the highest precisely located in particular sections were found at about the same level at 100.5m at Antoninów-Skorkówka, at 23.7m at Sławno, at 23.25m at Błogie-Nadzieja, and at 173.0m at Zarzęcin *1* (Text-fig. 3*A-C*). Specimens of the Haplocerataceae not identifiable more precisely were also found at somewhat higher levels, in particular at 18.9-19.0m at Błogie-Nadzieja and at 198.5m at Zarzęcin *3*, and it cannot be excluded that some of these specimens also belong to *N. mucronatum*. However, also in this case this species would not extend above the top of the Sokolovi Zone (Appendix and Text-fig. 3*A-B*).

THE PSEUDOSCYTHICA ZONE

The base of the Pseudoscythica Zone is here defined as the level of the first appearance of *Ilowaiskya pseudoscythica* (ILOVAISKY) or *I. ianschini*

(ILOVAISKY), and its upper boundary as coinciding with the base of the Tenuicostata Zone. The definition of the base of the Pseudoscythica Zone is left open to some extent, because *Ilowaiskya ianschini* seems to appear somewhat earlier than *I. pseudoscythica* in the sections of Central Poland.

Only the species *Ilowaiskya pseudoscythica* (ILOVAISKY, 1941), *I. ianschini* (ILOVAISKY, 1941), and *I. schaschkovae* (ILOVAISKY, 1941) are usually reported from the restricted Russian Pseudoscythica Zone (*i.e.* from sections that do not contain *Ilowaiskya tenuicostata*; *see below*). Descriptions and illustrations of these three species were supplied by ILOVAISKY (1941, pp. 87-100; Pls 16-20, Figs 31-39) and MIKHAILOV (1964, pp. 51-56 and 64-66; Pl. 2, Figs 1-2; Pl. 3, Fig. 1; Pl. 4, Fig. 3; Pl. 5, Fig. 3; Pl. 6, Fig. 3; Pl. 8, Figs 1-2, 4; Pl. 9, Figs 1-2; Pl. 10, Fig. 2; Pl. 11, Fig. 3; Pl. 12, Figs 1-2; Pl. 13, Figs 2-3; Pl. 14, Fig. 2; Pl. 17, Fig. 2; Pl. 20, Fig. 3).

The paleontological material obtained from the Pseudoscythica Zone in the sections here considered is very scanty. It comprises only about 15 reasonably good specimens, and was obtained chiefly from the boreholes Antoninów-Skorkówka, Zarzęcin *1* and *3*, and Błogie-Nadzieja (Text-fig. 3*A-C*); the section of the latter borehole encompasses only some lower part of the Pseudoscythica Zone.

Four specimens, which were found deep in the Pseudoscythica Zone at comparable levels, notably at 16.3m and 13.6m at Błogie-Nadzieja (Pl. 32, Figs 3-4), and at 196.5m at Zarzęcin *3* (Pl. 32, Figs 1-2), are closely comparable with the Russian species *Ilowaiskya ianschini*, as characterized by ILOVAISKY (1941). In these specimens, the ribbing is relatively distant, and biplicate; the triplicate ribs not connected with constrictions appear but occasionally (Pl. 32, Figs 1, 4). The mode of furcation of ribs is mostly of the "backwards one-sided" type. Some constrictions are deep, and more or less flexuous (Pl. 32, Fig. 3, and especially Fig. 1). The discussed forms appear to be relatively evolute.

The specimens identified as *Ilowaiskya ianschini* (ILOVAISKY) appear to be the earliest ammonites occurring in the Pseudoscythica Zone in the sections here considered (Text-fig. 3*A-C*). Correlations between the sections of Antoninów-Skorkówka and Błogie-Nadzieja suggest that *Ilowaiskya sokolovi* extends at Antoninow-Skorkówka to about the same level as that at which *I. ianschini* appears at Błogie-Nadzieja. This permits to draw the boundary between the Sokolovi and Pseudoscythica Zone with reasonably good precision.

Two specimens found at Błogie-Nadzieja, at 8.45 m and 9.1 m (Pl. 33, Figs 2-3), are assigned to *Ilowaiskya pseudoscythica* (ILOVAISKY).

In both these specimens, the biplicate ribbing of the inner whorls is not very dense. On the last whorls preserved, there is a fairly large number of triplicate ribs, which alternate with biplicate ones. Most of the ribs display the "backwards one-sided" mode of furcation, and reveal a slight forward sweep on the venter. These specimens compare well with the less densely ribbed variants of *Ilowaiskya pseudoscythica*, figured by ILOVAISKY (1941, Pl. 15, Fig. 32; Pl. 17, Fig. 35) and MIKHAILOV (1964, Pl. 8, Fig. 1; Pl. 13, Fig. 3).

The two specimens described above were found at Błogie-Nadzieja only a few meters above the occurrences of *Ilowaiskya ianschini*, still relatively deep within the Pseudoscythica Zone (Text-fig. 3*B*). As previously stated, the specimens of *I. ianschini* were found but slightly above the occurrences of the species *Ilowaiskya pavida*, sensu MIKHAILOV. In this context, the opinion of ILOVAISKY (1941, p. 94), based on purely morphologic grounds, is worth of note that *I. ianschini* displays affinity with *I. pseudoscythica* on one hand, and with the varieties *pavida* and *juvenilis* of *I. sokolovi*, sensu ILOVAISKY, on the other.

A specimen of *Ilowaiskya pseudoscythica*, found at Antoninów-Skorkówka, at 84.5m (Pl. 33, Fig. 1), displays dense ribbing on the inner whorls, and relatively densely spaced, alternating biplicate and triplicate ribs on the last preserved whorl. Several other specimens, both those figured (Pl. 33, Fig. 4; Pl. 34, Fig. 1), and a few not figured, represent the same morphologic variant, revealing relatively densely spaced and fine ribbing. All these specimens are closely comparable with the lectotype of *Ilowaiskya pseudoscythica* (ILOVAISKY & FLORENSKY 1941, Pl. 26, Fig. 31), designated by MIKHAILOV (1964, p. 55). It is reasonable to assume that such forms with dense and fine ribbing of the inner whorls, and relatively densely spaced ribs on larger whorls, gave rise to the species *Ilowaiskya tenuicostata* (MICHAILOV) from the Tenuicostata Zone.

The specimens representing the densely-ribbed variety of *Ilowaiskya pseudoscythica* were collected from several levels in the Pseudoscythica Zone. However, they were not found in the lowest part of this zone, nor in its topmost part (Appendix and Text-fig. 3*A-C*).

An interesting specimen (Pl. 34, Fig. 3) was found at 181.6m at Zarzęcin *3* very high in the Pseudoscythica Zone (Text-fig. 3*A*), only about 1.5m below the base of the strata assigned to the Tenuicostata Zone. This specimens displays the diagnostic features of *Ilowaiskya schaschkovae*, as emphasized by ILOVAISKY (1941, p. 96): both the biplicate and triplicate ribs furcate high on the flanks of the last whorl preserved, and the triplicate ribs represent the "zaraiskoid" rib-style. The Polish specimen compares well with the Russian specimens of *I. schaschkovae* figured by ILOVAISKY (1941, Pls 19-20, Figs 36-39) and MIKHAILOV (1964, Pl. 5, Fig. 3; Pl. 9, Fig. 2; and Pl. 12, Fig. 2).

Two poorly preserved specimens identified as *Ilowaiskya* cf. *schaschkovae* were found at Antoninów-Skorkówka at 75.6m and 77.5m (Text-fig. 3*C*), at about the same level as a densely-ribbed specimen of *Ilowaiskya pseudoscythica* (77.6m).

So far as permitted by the limited number of the specimens collected from the Polish Pseudoscythica Zone, the distribution of ammonites in this zone can be summarized as follows. The species *Ilowaiskya pseudoscythica* (ILOVAISKY) appears to occur in most parts of the Pseudoscythica Zone, except for its lowest part, which yielded only specimens of *Ilowaiskya ianschini* (ILOVAISKY). In contrast to the densely-ribbed variety of *I. pseudoscythica,* the more coarsely ribbed forms of this species seem to be restricted to some relatively low levels in the Pseudoscythica Zone. The species *Ilowaiskya schaschkovae* (ILOVAISKY) appears to be represented only in the upper part of this zone.

The occurrences of these three species, when pieced together, permit to separate out, in the Polish sections, the Pseudoscythica Zone with a stratigraphic range that can be thought to correspond to the range of the Russian (restricted) Pseudoscythica Zone. The available biostratigraphic data, especially those from Antoninów-Skorkówka, Błogie Nadzieja and Zarzęcin *3* (Appendix and Text-fig. 3*A-C*), permit to estimate that the Pseudoscythica Zone is about 20m thick in the region of Tomaszów Mazowiecki.

TENUICOSTATUM ZONE: THE SECTION AT BRZOSTÓWKA

The base of the Tenuicostata Zone is here defined as the level of appearance of *Ilowaiskya tenuicostata* (MICHAILOV), and its upper boundary as coinciding with the base of the Scythicus Zone, which is also the base of the Middle Volgian Substage. The species *I. tenuicostata*, which still occurs at high levels in the Tenuicostata Zone, does not extend to its upper boundary. Thus the Tenuicostata Zone is not a range zone of *Ilowaiskya tenuicostata*.

A disused clay-pit at Brzostówka (Text-fig. 2) permitted to make accessible a section encompassing the uppermost part of the

Tenuicostata Zone, and the Scythicus Subzone of the Scythicus Zone. This section was described by KUTEK & ZEISS (1974), who illustrated 97 ammonites in 32 plates. The collection obtained at Brzostówka (the collection KB.1 in the Museum of the Faculty of Geology, University of Warsaw) includes several large ammonites with diameters amounting to 150-200 mm. The section of Brzostówka has recently been discussed again in a paper by KUTEK (1994a).

The succession of ammonites in the Brzostówka section, as described by KUTEK & ZEISS (1974) using a purely morphologic concept of species, can be summarized as follows (the beds *a-1* and *a-2* represent the Tenuicostata Zone, whereas the beds *a-3*, *a-4* and *b-1* the Scythicus Subzone).

Bed a-1 (40 cm, argillaceous limestone) – *Ilowaiskya tenuicostata* (MICHAILOV, 1964); *Pseudovirgatites passendorferi* KUTEK & ZEISS, 1974; *Pseudovirgatites puschi puschi* KUTEK & ZEISS, 1974; *P. puschi simplicior* KUTEK & ZEISS, 1974; *P. puschi zaraiskoides* KUTEK & ZEISS, 1974; *Isterites subpalmatus* (SCHNEID, 1915); *I. spurius* (SCHNEID, 1915); *Lemencia*(?) *lewinskii* KUTEK & ZEISS.

Bed a-2 (c. 6m, shales) – *Pseudovirgatites passendorferi*, *P. puschi puschi*, *P. puschi simplicior*, *P. puschi zaraiskoides*, *Isterites subpalmatus*, *I. spurius*, *Lemencia*(?) *lewinskii*.

Bed a-3 (c. 1.5m, argillaceous limestone) – *Isterites masoviensis* KUTEK & ZEISS, 1974; *Zaraiskites quenstedti* (ROUILLIER, 1849), *Zaraiskites scythicus* (VISCHNIAKOFF, 1882).

Bed a-4 (7-8m, shales) – no ammonites.

Bed b-1 (50 cm, argillaceous limestone) – *Zaraiskites scythicus*, *Zaraiskites stschukinensis* (MICHALSKI, 1890), *Zaraiskites tschernyschovi* (MICHALSKI, 1890).

The possibilities of interpreting the ammonite assemblages from Brzostówka in terms of biospecies were discussed by DZIK (1985), who suggested that all the ammonites from any one bed might be interpreted as belonging to but one biospecies, and also, in a less extreme way, by KUTEK (1994a). In the latter paper, all the ammonites from Bed *a-3* formerly assigned to the morphologically interpreted species *Zaraiskites quenstedti* (ROUILLIER), or identified as early morphological variants of *Zaraiskites* scythicus (VISCHNIAKOFF), were interpreted as belonging to *Zaraiskites quenstedti* (ROUILLIER) biospecies. In turn, all the late morphologic variants of *Zaraiskites scythicus* (VISCHNIAKOFF) from Bed *b-1*, together with the forms of *Zaraiskites stschukinensis* (MICHALSKI) from this bed, were interpreted as representing the biospecies *Zaraiskites scythicus* (VISCHNIAKOFF). Moreover, a broader morphologic definition of *Z. quenstedti* (ROUILLIER), and a more restricted morphologic definition of *Z. scythicus* (VISCHNIAKOFF) were proposed, so as to achieve the possibility to include the same forms, respectively, in *Zaraiskites quenstedti* (ROUILLIER) and *Zaraiskites scythicus* (VISCHNIAKOFF), interpreted as both morphospecies and biospecies. These taxonomic interpretations permitted to establish the Quenstedti and Scythicus Horizons within the Scythicus Subzone of the Scythicus Zone. In the same paper (KUTEK 1994a), the Regularis and Zarajskensis Horizons were established within the Zarajskensis Subzone of the Scythicus Zone. The latter horizons are based on *Zaraiskites regularis* KUTEK, 1994, and *Zaraiskites zarajskensis* (MICHALSKI, 1890), interpreted as both morphospecies and biospecies.

Within the Early Volgian species *Pseudovirgatites puschi* three subspecies were established by KUTEK & ZEISS (1974), notably *P. puschi puschi*, *P. puschi simplicior* and *P. puschi zaraiskoides*, to accomodate forms with predominantly fasciculate, polygyrate or imperfect virgatotome ribbing on middle whorls. The forms assigned to these subspecies can be interpreted as mere segments in a continuous spectrum of intraspecific variability. Moreover, the forms referred to by KUTEK & ZEISS (1974) to *Lemencia*(?) *lewinskii* can be readily accomodated in *Pseudovirgatites* (and even in *Pseudovirgatites puschi*, assuming a very broad range of intraspecific variability in this species). However, in the case of the ammonites from the Tenuicostata Zone, it would not be justified, at present, to replace the established morphologic nomenclature by another one, referring to biospecies. The main obstacle is that, reasonably good paleontologic material being still available only from the uppermost part of this zone exposed at Brzostówka, the stratigraphic ranges of particular morphologic variants are not precisely known. Moreover, little is known about dimorphism in the representatives of the Virgatitidae in the Tenuicostata Zone.

In any case, the ammonites assigned to *Ilowaiskya tenuicostata*, *Pseudovirgatites passendorferi*, and *Pseudovirgatites puschi* appear to form a phylogenetic entity, as already suggested by KUTEK & ZEISS (1974). They all have inner whorls characterized by dense and fine biplicate ribbing, which persists to remarkable whorl-diameters. The species *Ilowaiskya tenuicostata*, which ribbing remains biplicate at all stages of development, already displays a feature, also observed in *Pseudovirgatites* and *Zaraiskites*; namely, during ontogeny, the ribbing becomes remarkably more distant not gradually, but abruptly across constrictions (*see* KUTEK & ZEISS, 1974, Pls 1-8; *and* Pl. 35, Fig. 2 in this paper). In *Pseudovirgatites passendorferi* ribs branching into several secondaries are developed on the middle whorls, but the ribbing of the outer whorls remains essentially biplicate, as in *Ilowaiskya tenuicostata* (*see* illustrations *in* KUTEK & ZEISS 1974; *and* Pl. 35 in this paper). In *Pseudovirgatites puschi* a broad spectrum of polygyrate, fasciculate and virgatotome ribbing is displayed by the middle whorls, and triplicate ribs alternate with biplicate ones on outer whorls (*see* KUTEK & ZEISS 1974).

It could be demonstrated in the section of Brzostówka (KUTEK & ZEISS 1974) that ammonites of the genus *Pseudovirgatites* gave rise to the genus *Zaraiskites*. The forms from the Bed *a-2* assigned to the subspecies *Pseudovirgatites puschi zaraiskoides*, which represents the most progressive morphological variant of *Pseudovirgatites puschi*, show much similarity with the most conservative forms of *Zaraiskites quenstedti* from the Bed *a-3* (see KUTEK & ZEISS 1974; KUTEK 1994a; *and* Pl. 38 in this paper).

Ten specimens found in the Beds *a-1* and *a-2* were assigned to *Isterites subpalmatus* (SCHNEID) and *Isterites spurius* (SCHNEID) by KUTEK & ZEISS (1974, pp. 525-526; Pl. 18, Figs 1-4; Pl. 19, Figs 1-2; Pl. 20, Figs 2 and 4; *see also* Pl. 37, Fig. 1 in this paper). The Polish specimens appear to be closely comparable with the specimens of *I. subpalmatus* and *I. spurius* described from the Neuburg Formation of South Germany by SCHNEID (1915, pp. 381, 383; Pl. 26, Fig. 5; Pl. 29, Fig. 2). For the specimens of *Isterites* from Bed *a-3* a new species, *Isterites masoviensis*, was established by KUTEK & ZEISS (1974, p. 526; Pl. 17, Fig. 3; Pl. 20, Fig. 1; Pl. 22, Figs 1-3; Pl. 23, Figs 1-2; Pl. 24, Figs 2-3; *see also* Pl. 37, Figs 2-4 in this paper).

It is of interest that a specimen of *Ilowaiskya schaschkovae* (ILOVAISKY) was found at Zarzęcin *3* (Pl. 34, Fig. 3) very high in the Pseudoscythica Zone, and that, as described in the following section of this paper, specimens of *Isterites* were encountered low in the Tenuicostata Zone in several borehole sections. In this context the opinion of ILOVAISKY (1941) is worth of note that *Ilowaiskya schaschkovae*, a species with "zaraiskoid" ribbing, stands morphologically apart from other species of *Ilowaiskya*. Another interesting point is that the species *Isterites austriacus* KUTEK & ZEISS, described by ZEISS (1977, p. 375, Pl. 2, Fig. 5), from the Tithonian Klentnice Beds of Austria and Moravia, reveals striking similarity with *Ilowaiskya schaschkovae*; in the Austrian species, the biplicate ribbing of the inner whorls is also moderately dense, and a "zaraiskoid" rib-style can be observed on the last preserved whorl.

The name *Isterites* was first used when ammonites referrable to this genus were known only from South Germany. Accordingly, it appeared self-evident that this genus evolved from some Submediterranean ancestors. This opinion was also retained by the authors of the present paper in KUTEK & ZEISS (1974). As *Isterites* is now known to be well represented at several stratigraphic levels in the Volgian of Central Poland, this genus cannot further be regarded as exclusively Submediterranean. Moreover, the data presented above suggest that at least some of the ammonites hitherto ascribed to *Isterites* may have had ancestors in the family Virgatitidae, in some forms currently assigned to *Ilowaiskya*.

As several fragmentary specimens of ammonites collected from the Tenuicostata Zone in borehole sections can be identified taxonomically only with reference to the better specimens obtained at Brzostówka, several specimens figured formerly (KUTEK & ZEISS 1974) are herein refigured (Pls 35-38).

TENUICOSTATA ZONE: BOREHOLE SECTIONS

Complete sections of the Tenuicosta Zone were provided by the boreholes Antoninów-Skorkówka and Zarzęcin *1* and *3* (Text-fig. 3*A*, *C*), where this zone can be estimated to be nearly 20m thick. As revealed by these sections, ammonites appear to be as common in the lower part of this zone as in its uppermost part that was exposed at Brzostówka. However, mostly fragmentary specimens and shell debris could be collected from the borehole sections. The number of collected specimens cannot be indicated precisely, because it is a matter of convention whether some remains of ammonites (as those shown in Pl. 41, Fig. 3) are classified as specimens.

Three large specimens of *Ilowaiskya tenuicostata* (MICHAILOV) were found at Antoninów-Skorkówka at 71.5m (Pl. 34, Fig. 4; Pl. 39, Figs 1-2). These are fragments of large whorls with densely spaced biplicate ribs. In two specimens (Pl. 39, Figs 1-2) biplicate ribbing can also be observed on the whorl preceding the last preserved whorl. The level 71.5 m at Antoninow-Skorkówka is taken as the level indicating the base of the strata referrable with certainty to the Tenuicostata Zone.

The species *Ilowaiskya tenuicostata* (MICHAILOV) seems to be common at several levels in the Tenuicostata Zone, except for its uppermost part (this species does not occur in the Bed Ia-2, about 6m thick, of the Brzostówka section). However, fragmentary specimens of *I. tenuicostata* are usually hard to identify unequivocally, because this species shares the dense and fine ribbing of the inner whorls with all forms of *Pseudovirgatites*, and the biplicate ribbing of the outer whorls with *P. passendorferi*. Some of the specimens, indicated in the Appendix as belonging to *I. tenuicostata* or *P. passendorferi*, may represent the former species.

A specimen, found at Zarzęcin *3* at 172.5m (Pl. 41, Fig. 4), can be safely identified as *Pseudovirgatites passendorferi* KUTEK & ZEISS. In this specimen, the ribbing is essentially biplicate on the last preserved whorl, and includes ribs branching into several secondaries on the preceding whorl. This is the lowest specimen found in the investigated sections in the Tenuicostata Zone, that can be assigned with certainty to the genus *Pseudovirgatites*.

Several poorly preserved specimens, found at higher levels in the Tenuicostata Zone, can be assigned with more or less certainty to *Pseudovirgatites*. For instance, the fragments of whorls which display biplicate, polygyrate and virgatotome ribbing (*see* Pl. 41, Fig. 3), can be assigned to *Pseudovirgatites*, when interpreted together; this assemblage of forms presumably represents *Pseudovirgatites puschi*. Another example is provided by a specimen (Pl. 39, Fig. 3) with very fine and dense biplicate ribbing, that seems belong to *Pseudovirgatites*, rather than to *Ilowaiskya tenuicostata*.

A specimen collected at Zarzęcin *3*, at 179.0m (Pl. 40, Fig. 1), includes two fragments of whorls with dense biplicate ribbing, which can be assigned to *I. tenuicostata*, taking into account that this species, and not *Pseudovirgatites*, can be demonstrated to occur in the basal strata of the Tenuicostata Zone. The specimen also includes a quite different ammonite. This is an evolute form that displays moderately dense ribbing on the inner whorls, and relatively distant biplicate ribbing on the last preserved whorl, which has a diameter of about 60 mm. This specimen cannot be assigned to *Pseudovirgatites*, nor to *Ilowaiskya tenuicostata* or the late forms of *I. pseudoscythica*, which all have more densely ribbed inner whorls. On the other hand, the specimen can be readily accommodated in *Isterites*. Several specimens of *Isterites* found (at higher stratigraphic levels) at Brzostówka reveal similar biplicate ribbing at comparable diameter (*see* KUTEK & ZEISS 1974; *and* Pl. 37, Fig. 3 in this paper). Another example is provided by the Franconian specimens of *Isterites spurius*, in which fairly distant biplicate ribbing persists to a diameter of about 65 mm (SCHNEID 1915, p. 384).

A peculiar specimen was found at Zarzęcin *3* at 180.2m (Pl. 40, Fig. 3). It shows virgatotome ribs with up to four secondaries, intercalatory ribs, and a deep constriction on the last preserved whorl, and presumably biplicate ribbing on the preceding whorl. At first glance, this specimen is reminiscent of *Pseudovirgatites*. However, such a combination of distant virgatotome ribbing with a high ratio of secondary to primary ribs, with biplicate ribbing on the preceding whorl, has not been observed in any species of *Pseudovirgatites* from the Tenuicostata Zone (*see* KUTEK & ZEISS 1974, Pls 8-17). Hence, the discussed specimen is interpreted, with some reservation, as an early form of *Isterites*.

The ammonites encountered at Zarzęcin *3*, at 179.0 and 180.2m, form a distinctive assemblage that has no counterpart in the underlying Pseudoscythica Zone. Hence the level 180.2m is taken to indicate the base of the strata assigned with certainty to the Tenuicostata Zone in the section of Zarzęcin *3*.

Several fragments of whorls, found at different levels in the Tenuicostata Zone, can be assigned, with less or more confidence, to *Isterites* (Pl. 40, Fig. 2; Pl. 41, Figs 1-2). The large whorls of *Isterites*, that provide support for these taxonomic interpretations, were presented formerly (KUTEK & ZEISS 1974; *see also* Pl. 37, Figs 2 and 4, in this paper).

Although the paleontologic material obtained from the borehole sections leaves much to be desired, it permits several conclusions to be drawn.

The most important point is that the whole Tenuicostata Zone, which encompasses in addition to the strata exposed at Brzostówka also some deeper strata, is characterized by a distinctive assemblage of ammonites. This assemblage includes *Ilowaiskya tenuicostata* (MICHAILOV), *Isterites* and, in some upper part of the zone, also *Pseudovirgatites*. On the other hand, the species *Ilowaiskya pseudoscythica* (ILOVAISKY), *Ilowaiskya ianschini* (ILOVAISKY), and *Ilowaiskya schaschkovae* (ILOVAISKY), which are indicative of the Pseudoscythica Zone, were not found in the Tenuicostata Zone. It is worth pointing out that even very poor paleontologic material from the latter Zone, which usually includes numerous nuclei with dense and fine biplicate ribbing, and fragments of large whorls, is often so distinctive that it permits to distinguish the Tenuicostata Zone from the underlying Pseudoscythica Zone. Hence, no doubt is leaved that the Tenuicostata Zone merits to be separated out as a zone of the Lower Volgian Substage.

A striking feature is the large proportion of large whorls of ammonites in the material obtained from the Tenuicostata Zone in the borehole sections. This is consistent with what could be observed in the exposure at Brzostówka (KUTEK & ZEISS 1974). This is of interest because large whorls of ammonites were but occasionally encountered in older Volgian strata in the Polish sections, despite the fact that large macroconchs of *Ilowaiskya* are known to occur in Russia in the Klimovi, Sokolovi, and Pseudoscythica Zones (*see* MIKHAILOV 1964).

In contrast to *Ilowaiskya tenuicostata* and *Isterites*, which are represented in the basal strata of the Tenuicostata Zone, *Pseudovirgatites* seems to be absent from the lowest part of this zone. As yet, however, this is a matter of conjucture. In any case, the available data suggest a possibility of distinguishing a subzone, or some horizons, based on *Pseudovirgatites*, in the upper part of the Tenuicostata Zone.

THE BASE OF THE MIDDLE VOLGIAN

As problems of Middle Volgian stratigraphy are beyond the scope of this paper, only the boundary between the Lower and Middle Volgian (that between the Tenuicostata and Scythicus Zones) will be discussed briefly.

The base of the Middle Volgian, which is paleontologically marked by the transformation of *Pseudovirgatites* into *Zaraiskites*, was exposed at Brzostówka (KUTEK & ZEISS 1974), and in a farmer's well at Sławno (KUTEK 1994a). It is also located within the sections of the bore-holes Zarzęcin *1* and *3*, and Antoninów-Skorkówka (Text-figs 3*A*, *C*).

In the latter section, two specimens representing *Zaraiskites quenstedti* (ROUILLIER) msp. and bsp. were found at 54.7m (Pl. 42, Figs 1-2). One of these specimens (Pl. 42, Fig. 1) reveals the fine and dense, and persisting to a remarkable diameter, ribbing of the inner whorls. The characteristic ribbing of the middle whorls, consisting of virgatotome ribs with up to six secondaries, with some intercalatory ribs, can be seen in both specimens. These specimens also correspond to the species *Zaraiskites quenstedti* (ROUILLIER) as understood by VISCHNIAKOFF (1882).

At Zarzęcin *1*, two specimens of *Zaraiskites quenstedti* (ROUILLIER) morphospecies and biospecies (*sensu* KUTEK 1994a), were found at 130.0 and 131.6m (Pl. 42, Figs 3-4). One of these specimens (Pl. 24, Fig. 3) displays virgatotome ribs with up to four secondaries, and some intercalotory ribs, on the last whorl preserved. Another specimen (Pl. 42, Fig. 4) includes an ammonite in which the biplicate ribbing is less dense, and less prolonged, than in the other specimens (Pl. 34, Figs 3-4). These two ammonites correspond to the early morphologic variants of *Zaraiskites scythicus* (VISCHNIAKOFF), as understood by

MICHALSKI (1890), which in the section of Brzostówka are restricted to the Bed *a-3* (KUTEK & ZEISS 1974, KUTEK 1994a). Significantly, two more densely ribbed fragments of inner whorls are also included in one of the illustrated specimens (Pl. 34, Fig. 4).

Both the biospecies and the re-interpreted morphospecies *Zaraiskites quenstedti* (ROUILLIER) are indicative of the Quenstedti Horizon, which is the lowest horizon of the Scythicus Zone. As this horizon is very thin in the region of Tomaszów Mazowiecki (KUTEK 1994a), the levels, at which *Zaraiskites quenstedti* was found at Antoninów Skorkówka (54.7 m), Zarzęcin *1* (130.0 and 131.6m) and Zarzęcin 3 (163.5m; Appendix), can be thougt to be located close to the base of the Middle Volgian. From this it can be deduced, in conjunction with the assumed position of the base of the Tenuicostata Zone at 71.5m at Antoninów-Skorkówka, and at 180.2m at Zarzęcin *3*, that the Tenuicostata Zone is about 17m thick at Antoninów-Skorkówka, and about 18m thick at Zarzęcin *1* and *3* (Text-figs 3*A*, *C*). At Zarzecin 3, this thickness cannot be much greater, as a specimen of *Ilowaiskya schaschkovae* (ILOVAISKY), indicative of the Pseudoscythica Zone, was found at 181.6m. All these data are consistent with the estimation that the Tenuicostata Zone is nearly 20m thick in the region of Tomaszów Mazowiecki. From this it follows that the Lower Volgian portion of the Brzostówka section (*c*. 6.5m) represents about one third of the thickness of the Tenuicostata Zone.

The available biostratigraphic data (Appendix and Text-fig. 3*A*-*C*) indicate that the Lower Volgian is about 60m thick in the section of Antoninów-Skorkówka, and also in those of Zarzęcin *1* and *3*.

Specimens of *Zaraiskites regularis* KUTEK were found at 44.3-4 m at Antoninów-Skorkówka, at 120.2-7m at Zarzęcin *1*, and at 148.0m at Zarzęcin *3* (*see* KUTEK 1974a, Pl. 10, Figs 2-3). The specimens are indicative of the Regularis Horizon of the Scythicus Zone. Their stratigraphic position in the sections supports the opinion (KUTEK 1994a) that the next-lower Scythicus Horizon is very thin in the region of Tomaszów Mazowiecki.

LOWER VOLGIAN IN THE SECTIONS OF THE ŁÓDŹ DEPRESSION

The investigated collection includes only a small number of specimens obtained from the Lower Volgian intervals of the sections of the boreholes Bełchatów *4*, *5*, *6*, *9*, and Tuszyn *2*, *3*, *5*, which were very poorly cored in most cases (hence, with but a few exceptions, not indicated in Text-figures 4-5). Some specimens from the Klimovi Zone are indicated in the Appendix. A specimen of *Ilowaiskya pseudoscythica* (ILOVAISKY), found at Tuszyn *3*, at 1091.1-1096.7m III, about 40m above the base of the Volgian, is figured herein (Pl. 34, Fig. 1).

Of special interest are several specimens obtained from the cored interval 842.4-848.1m, I and II, at Tuszyn *2*. All these specimens represent *Zaraiskites scythicus* (VISCHNIAKOFF) morphospecies and biospecies, as defined by KUTEK (1994a), and are indicative of the Scythicus Horizon of the Scythicus Zone. From this, an estimated thickness of the Lower Volgian of about 60m can be deduced in conjunction with the data provided by the cored interval 902.0-907.2m (Appendix and Text-fig. 5). Thus, the thickness of the Lower Volgian at Tuszyn *2* appears to be closely comparable with that estimated in the sections of the region of Tomaszów Mazowiecki.

UPPER KIMMERIDGIAN AND LOWER VOLGIAN AMMONITES IN OTHER SECTIONS

Occurrences of Upper Kimmeridgian and Lower Volgian ammonites were reported from a fairly large number of boreholes located in Central Poland (*see e.g.* DEMBOWSKA 1973). Some of these ammonites were figured in several papers (*e.g.* PACHUCKI 1963; DEMBOWSKA 1973; MAŁECKI 1979; BARWICZ & TARKOWSKI 1984; MALINOWSKA 1988, 1989), and the enclosed illustrations leave no doubt that a large proportion of the taxonomic identifications need revision. In this respect, two examples are provided by the synonimies of *Discosphinctoides subborealis* sp.n. and *Sarmatisphinctes fallax* (ILOVAISKY), presented in this paper. A former paper on the ammonites from Stobnica (KUTEK 1961), in which most of the figured ammonites require revision, may serve as another example.

Only some of the occurrences of ammonites will be commented below.

The corrected list of figured specimens from Stobnica (KUTEK 1961), presented below, includes:

Pl. 11; Pl. 12; Pl. 13, Fig. 1 – *Aulacostephanus pinguis* DURAND

Pl. 13, Fig. 2 – *Aulacostephanus eudoxus* (D'ORBIGNY)

Pl. 13, Fig. 3 – *Aulacostephanus autissiodorensis* (COTTEAU)
Pl. 14, Fig. 1 – *Aulacostephanus jasonoides* (PAVLOW)
Pl. 14, Fig. 2 – *Aulacostephanus volgensis* (VISCHNIAKOFF) and *A. autissiodorensis* (COTTEAU)
Pl. 14, Fig. 3 – *Aulacostephanus volgensis* (VISCHNIAKOFF)
Pl. 14, Fig. 4 – *Aulacostephanus* cf. *volgensis* (VISCHNIAKOFF)
Pl. 15, Fig. 1 – *Aulacostephanus pseudomutabilis* (DE LORIOL)
Pl. 15, Figs 2-4 – *Amoeboceras (Nannocardioceras) krausei* (SALFELD)
Pl. 16, Fig. 1 – *Discosphinctoides subborealis* sp.n.
Pl. 16, Fig. 2; Pl. 17, Figs 1-2 – *Ilowaiskya klimovi* (ILOVAISKY)
Pl. 18, Figs 1-2 – *Ilowaiskya* cf. *sokolovi* (ILOVAISKY)
Pl. 19, Figs 1, 3 – *Ilowaiskya sokolovi* (ILOVAISKY)
Pl. 19, Fig. 2 – ? *Sarmatisphinctes* cf. *fallax* (ILOVAISKY)
Pl. 20, Fig. 1 – *Ilowaiskya sokolovi* (ILOVAISKY)
Pl. 20, Fig. 2 – *Neochetoceras mucronatum* BERCKHEMER & HÖLDER
Pl. 20, Fig. 3 – ? *Ochetoceras* and *Neochetoceras mucronatum* BERCKHEMER & HÖLDER.

As discussed by KUTEK (1994a, p. 25), several specimens of ammonites from boreholes, that were figured by DEMBOWSKA (1973), in part under wrong names, are indicative of the Tenuicostata Zone. Their list includes *Ilowaiskya tenuicostata* (MICHAILOV), *Pseudovirgatites puschi simplicior* KUTEK & ZEISS, *P. puschi zaraiskoides* KUTEK & ZEISS, *Pseudovirgatites* sp., and *Isterites* cf. *subpalmatus* (SCHNEID).

A very interesting set of specimens was provided by a cored interval, about 17m thick, of the borehole Zosin *54/52* (DEMBOWSKA 1973, p. 12, Fig. 3), situated about 150 km northwest of Warsaw. This interval yielded specimens which were identified, but not figured, by DEMBOWSKA as *Subplanites* cf. *pseudoscythicus* (ILOVAISKY & FLORENSKY) and *Pectinatites* cf. *tenuicostatus* (MICHAILOV). This suggests that the interval encompasses parts of the Pseudoscythica and Tenuicostata Zones. Moreover, seven specimens, referred to as *Subplanites schaschkovae* (ILOVAISKY & FLORENSKY), *Subplanites* cf. *schaschkovae*, *Subplanites klimovi* (ILOVAISKY & FLORENSKY), *Subplanites kokeni* BEHRENDSEN, *Subplanites* cf. *kokeni*, and *Subplanites* sp., and collected from a narrow horizon at Zosin, between 99.1 and 103.1m, were figured by DEMBOWSKA (1973, Pl. 1, Figs 1, 3-6; Pl. 2, Figs 1, 5). All these specimens appear to be conspecific, and can readily be accommodated in *Ilowaiskya schaschkovae* (ILOVAISKY).

The reasonably good specimens figured by DEMBOWSKA suggest that *Ilowaiskya schaschkovae* is quite common in the Lower Volgian of Central Poland. They also may provide a support for the opinion that this species should be transferred from *Ilowaiskya* to the genus *Isterites*.

Several very densely ribbed nuclei and fragments of whorls, and a larger specimen with densely spaced triplicate and biplicate ribs on the last whorl preserved, which were found between 226.2 and 226.8m in the borehole Zgierz *IG-1* near Łódź, were figured as *Usseliceras siliceum* (QUENSTEDT), *Usseliceras* sp. and *Subplanites postrueppellianus*

OHMERT & ZEISS by MALINOWSKA (1989, Pl. 1, Fig. 4; Pl. 3, Figs 1-6; Pl. 4, Figs 1-2). However, these specimens do not reveal the distinctive features of *Usseliceras* and *Subplanites*. On the other hand, all these specimens can readily be accommodated in *Pseudovirgatites*. After such a taxonomic re-interpretation, there is no need to assume that the Klimovi Zone attains an unusual thickness of about 100m at Zgierz, as suggested by MALINOWSKA (1989, Fig. 3).

In general, it can be concluded that the Lower Volgian ammonites collected by several authors from boreholes reveal, after having been subjected to taxonomic revision, a succession comparable with that recognized in the region of Tomaszów Mazowiecki. In particular, the Tenuicostata Zone is represented distinctively in several sections. However, it should be pointed out that a large proportion of fragmentary specimens collected from boreholes cannot be closely identified taxonomically, especially if such specimens were found not associated with other, more diagnostic specimens.

In the present authors' opinion, the published paleontological evidence does not permit to demonstrate the presence of amonites of the genera *Hybonoticeras*, *Subplanites*, *Pectinatites*, *Usseliceras*, *Danubisphinctes*, and *Torquatisphinctes* in the highest Kimmeridgian or Lower Volgian deposits of cratonic Poland, despite several opinions to the contrary scattered in literature.

SUMMARY OF ZONATION

The Eudoxus Zone, and the Autissiodorensis Zone with the Fallax Subzone at the top, were recognized in the Kimmeridgian portion of the Pałuki Formation. Also the Eudoxus-Autissiodorensis uncertainty interval had to be separated out because of the absence of *Aulacostephanus* in some intermediate strata. The Klimovi, Sokolovi, Pseudoscythica, and Tenuicostatat Zones were distinguished in the Lower Volgian part of the Pałuki Formation. The next-higher Scythicus Zone, which is the basal zone of the Middle Volgian, could be subdivided into the Scythicus Subzone with the Quenstedti and Scythicus Horizons, and the Zarajskensis Subzone with the Regularis and Zarajskensis Horizons (KUTEK 1994a). The first three horizons are still encompassed by the Pałuki Formation; the Zarajskensis Horizons belongs to the Kcynia Formation.

In the region of Tomaszów Mazowiecki, the thicknesses of the successive biostratigraphic units can be estimated as follows (Text-fig. 3*A-C*): Autissiodorensis Zone (above the Eudoxus-Autissiodorensis uncertainty interval) – 20-25m; Fallax Subzone – about 3m; Klimovi Zone – 10-11m; Sokolovi Zone – 10-15m; Pseudoscythica Zone – about 20m; Tenuicostata Zone – nearly 20m ; Scythicus Subzone (Quenstedti and Scythicus Horizons) – about 10m; Regularis Horizon – about 20m; Zarajskensis Horizon (incomplete) – about 40m.

The biostratigraphic units of the Polish Volgian were distinguished at different levels of classification (as zones, subzones or horizons) so as to achieve a correspondence with the zonation of the Volgian of the Russian Platform. Accordingly, the Polish Scythicus Zone corresponds to the Russian Panderi Zone (*see* KUTEK 1994a). However, it should be borne in mind that some of the units established at different levels of classification may not differ in what might be called their paleontologic status. For instance, the Klimovi Zone is based on a single species, *Ilowaiskya klimovi* (ILOVAISKY), and seems not to be further subdivisable biostratigraphically. In this respect, this zone does not differ from the four horizons of the Polish Scythicus Zone (*see* KUTEK 1994a). In this context it is also worth of note that the thickness of the Regularis Horizon (about 20m) is greater than that of the Klimovi Zone (about 10m) developed in the same lithofacies of the Pałuki Formation in the region of Tomaszów Mazowiecki.

As previously stated, the Sokolovi, Pseudoscythica, and Tenuicostata Zones appear to have some potential left for further biostratigraphic subdivision. It is an open question whether the species *Ilowaiskya schaschkovae* (ILOVAISKY), which occurrences seem to be restricted to the topmost part of the Pseudoscythica Zone, should be left in the genus *Ilowaiskya,* or be transferred to the genus *Isterites*.

EVOLUTION OF THE VIRGATITIDAE

The expanded and continuous sections of the Pałuki Formation of Central Poland permit to reconstruct the phylogenetic lineage leading from *Discosphinctoides subborealis* sp.n. through *Sarmatisphinctes*, *Ilowaiskya*, and *Pseudovirgatites* to *Zaraiskites*. As demonstrated by the Russian sections, the latter genus gave rise to *Virgatites*. With but a few exceptions, the occurrences of the ammonites of this lineage are restricted to what may be called the East European (Polish – Russian) Subboreal Subprovince. The species *Discosphinctoides subborealis* was individualized in the Subboreal region of cratonic Poland in the latest Kimmeridgian. However, the ancestors of this species are to be sought in the Eudoxus Zone in representatives of the genus *Discosphinctoides*, which is known from several Tethyan and Peri-Tethyan regions (OLÓRIZ SÁEZ 1978). Thus the discussed lineage is a Subboreal lineage of Mediterranean-Submediterranean origin.

The transformation of *Sarmatisphinctes fallax* (ILOVAISKY) into *Ilowaiskya klimovi* (ILOVAISKY) was connected with loss of lappets in microconchs. On the other hand, *Sarmatisphinctes fallax* has macroconchs which, similarly as those of *Ilowaiskya klimovi*, bear biplicate and triplicate ribs on outer whorls. A reduction of the ratio of secondary to primary ribs, with respect to the ribbing of middle whorls, can also be observed in the outer whorls of *Pseudovirgatites*, *Zaraiskites*, and *Virgatites* (*see* MICHALSKI 1890, ILOVAISKY 1941, MIKHAILOV 1964, KUTEK & ZEISS 1974, KUTEK 1994a).

However, the evolution of the lineage here considered was not linear. This is expressed in most spectacular fashion by the fact that virgatotome ribbing was produced twice during that evolution: first during the transformation of the biplicate species *Discosphintoides subborealis* into *Sarmatisphinctes*, and the second time during the transformation of the biplicate species *Ilowaiskya tenuicosta* (MICHAILOV) into *Pseudovirgatites*.

A very fine and dense biplicate ribbing of the inner whorls, persisting to a remarkable diameter, can be observed in *Ilowaiskya tenuicostata* and *Pseudovirgatites*, and also in the earliest representatives of *Zaraiskites* assigned (KUTEK & ZEISS 1974) to *Zaraiskites quenstedti* (ROUILLIER). This ribbing becomes less dense, and less prolonged, in successive species of *Zaraiskites*. The reduction of the biplicate ribbing stage of inner whorls was first observed in Russian specimens from condensed deposits by MICHALSKI (1890), and was demonstrated (KUTEK 1994a) in species of *Zaraiskites* from successive horizons of the Polish Scythicus Zone. The biplicate stage of ribbing is totally suppressed in the inner whorls of several species of the genus *Virgatites* (see MICHALSKI 1890).

As proposed by CALLOMON (*in*: DONOVAN & *al.* 1981), the subfamilies Ilovaiskyinae, Pseudovirgatitinae, and Virgatitinae are assigned to the family Virgatitidae. Thus the genera *Ilowaiskya*, *Pseudovirgatites*, *Zaraiskites*, and *Virgatites* are accommodated in this family. It may be a matter of discussion whether the new genus *Sarmatisphinctes* should also be included in the Virgatitidae. The type species *Sarmatisphinctes fallax* (ILOVAISKY) has microconchs with lappets, a character commonly found in genera of the Perisphinctidae and Ataxioceratidae. On the other hand, *Sarmatisphinctes* belongs to the same phylogenetic lineage, and the same biogeographic subprovince, as the Volgian genera of the Virgatitidae. Moreover, there is some morphologic affinity between *Ilowaiskya klimovi* (ILOVAISKY) and its ancestor, *Sarmatisphinctes fallax* (ILOVAISKY). In any case, the family Virgatitidae is to be regarded as a Subboreal family of Tethyan origin.

As previously discussed, there is some evidence suggestive of a Subboreal origin of the genus *Isterites*. This makes this genus also a possible candidate to the family Virgatitidae.

CORRELATIONS WITH NORTHWEST EUROPE

The Eudoxus and Autissiodorensis Zones of cratonic Poland are readily comparable with the Eudoxus and Autissiodorensis Zones of Britain and France. In all these regions the Autissiodorensis Zone contains closely comparable assemblages of the group of *Aulacostephanus autissiodorensis* (see ZIEGLER 1962, CALLOMON & COPE 1971, COX & GALLOIS 1981, HANTZPERGUE & LAFAURIE 1983, HANTZPERGUE 1989). In Poland, as well as in Britain, *Amoeboceras* is represented in the Autissiodorensis Zone, but does not range up to the top of this zone (CALLOMON & COPE 1971, COX & GALLOIS 1981).

An interesting point is that both in England (CALLOMON & COPE 1971) and in Central Poland *Aulacostephanus* is absent from some strata intermediate between those assigned to the Eudoxus and Autissiodorensis Zones. In England the stratigraphic ranges of *Aulacostephanus* and *Pectinatites* overlap a little (CALLOMON & COPE 1979), as do those of *Aulacostephanus* and *Sarmatisphinctes* in the Polish sections (in an interval of about 2m).

As ammonites of the genus *Pectinatites*, on which the zonation of the lower part of the British Upper Kimmeridge Clay is based, are absent from Poland, the base of the British Elegans Zone (COPE 1967, CALLOMON & COPE 1971) cannot be correlated directly with the base of the Polish Klimovi Zone. What can be correlated is the upper boundary of the strata with *Aulacostephanus*. In the assumption, that this boundary is synchronous in Northwest Europe and in Poland, the supposition is involved that the extinction of *Aulacostephanus* was a coeval and abrupt event on an interregional scale. The available evidence appears to be consistent with the latter supposition.

As yet, none of the ammonites reported from the British Upper Kimmeridge Clay (COPE 1967, 1978) have been found in Poland. Hence, the ammonite zones of the Lower Volgian of Poland cannot be correlated directly with those of the Upper Kimmeridge Clay.

CORRELATIONS WITH THE RUSSIAN PLATFORM

The zonation of the highest Kimmeridgian and Lower Volgian of Poland can be readily correlated with that applied to coeval strata of the Russian Platform, where the Eudoxus Zone and the Autissiodorensis Zone, with the Fallax Subzone in its upper part, were distinguished in the uppermost Kimmeridgian, and the Klimovi, Sokolovi, and Pseudoscythica Zones in the Lower Volgian (MIKHAILOV 1964; GERASSIMOV & MIKHAILOV 1966; MESEZHNIKOV 1982, 1988). The Panderi Zone (MIKHAILOV 1962), which is the lowest zone of the Middle Volgian of Russia, corresponds to the Polish Scythicus Zone. In the expanded sections of the Polish Volgian, the latter Zone could be subdivided into two subzones and four horizons (KUTEK 1994a).

The only difference between the Polish and Russian zonations is that the Tenuicostata Zone, which is a stratigraphic reality in Poland, was not distinguished in the Russian sections of the Lower Volgian Substage. This problem was discussed in detail by KUTEK (1994a), who summarized several data indicating that a stratigraphic gap exists at the base of the Middle Volgian in most of the classical sections of the Volgian of the Russian Platform.

Only in one of the sections of the region of the Ural River, in that of Vetlanka (MIKHAILOV 1964, p. 20), ammonites indicative of the restricted Pseudoscythica Zone, notably *Ilowaiskya pseudoscythica* (ILOVAISKY) and *I. ianschini* (ILOVAISKY), were found together with *Ilowaiskya tenuicostata* (MICHAILOV) in a sandstone 4.5m thick. This sandstone also yielded several forms that were described and figured by MIKHAILOV (1964, pp. 66, 69-71, Pl. 11, Fig. 2; Pl. 13, Fig. 1; Pl. 14, Fig. 1; Pl. 15, Figs 1-2; Pl. 16, Figs 1-2; Pl. 17, Figs 1) as *Pectinatites* (*Pectinatites*) aff. *pectinatus* (PHILLIPS), *Pectinatites* (*Wheatleyites*) aff. *eastlecottensis* (SALFELD), *P.* (*W.*) *arkelli* MICHAILOV and *P.* (*W.*) *spathi* MICHAILOV. All these forms seem to be comparable with *Isterites*, *Pseudovirgatites*, or *Ilowaiskya tenuicostata*. The re-interpreted specimens form, together with *Ilowaiskya tenuicostata*, of which the holotype comes from Vetlanka (MIKHAILOV 1964, p. 67), an assemblage of ammonites reminiscent to some extent of that found in the Polish Tenuicostata Zone.

As indicated in the paleontologic description of *Ilowaiskya tenuicostata* by (MIKHAILOV 1964, p. 68), specimens of this species were found in two sections, in that of Vetlanka, and in the section of Zubotshistenka 2 in the same region. However, *Ilowaiskya tenuicostata* is not indicated in the description of the latter section (MIKHAILOV 1964, p. 26). To the present authors' knowledge, this species has not been reported from any other section in Russia.

The sandstone interval, 4.5m thick, of the Vetlanka section was assigned to the Pseudoscythica Zone by MIKHAILOV (1964, p. 20), but the ammonites yielded appear to represent a stratigraphic interval that corresponds to the (restricted) Pseudoscythica Zone, and the Tenuicostata Zone, of Central Poland.

The Tenuicostata Zone appears to correspond to a distinct biostratigraphic interval, which should be taken into account when correlating the zonation of the Tithonian stage with that of the Volgian.

CORRELATIONS WITH SOUTH GERMANY: TITHONIAN

A subdivision of the Tithonian Stage into three substages will here be applied for reasons of commodity. In terms of the zonation established in Spain (ENAY & GEYSSANT 1975, OLÓRIZ SÁEZ 1978, TAVERA 1985) the Lower Tithonian, as here understood, corresponds to the Hybonotum and Darwini Zones (ENAY & GEYSSANT 1975), or to the equivalent set of the Hybonotum and Albertinum Zones (OLÓRIZ SÁEZ 1978). The Middle Tithonian corresponds to the Semiforme, Fallauxi, and Ponti Zones (ENAY & GEYSSANT 1975) or to the Verruciferum, Richteri, Admirandum-Biruncinatum, and Burckhardticeras Zones (OLÓRIZ SÁEZ 1978), and the Upper Tithonian to the Simplisphinctes, Transitorius and Durangites Zones (TAVERA 1985).The latter two zones correspond to the Calpionellid Zone *A*.

In South Germany, sections encompassing the whole Lower Tithonian are provided by the Jurassic outcrops of Franconia. The ammonites zonation of the Lower Tithonian strata of Franconia can be summarized, in a simplified fashion, as follows (ZEISS 1968, 1975, 1977b): Hybonotum Zone – Malm zeta 1-3; Tagersheimense Zone – Malm zeta 4a; Triplicatus Zone – Malm zeta 4b-d and Malm zeta 5a (part); Parvinodosum Zone – Malm zeta 5a (part); Vimineus Zone – Malm zeta 5b; and Palatinum Zone – Malm zeta 5c (Text-fig. 6). The base of the Neuburg Formation (Malm zeta 6) is commonly regarded as the base of the Middle Tithonian in South Germany (ZEISS 1968, 1975, 1977a; BARTHEL & GEYSSANT 1973; BARTHEL 1975; ENAY & GEYSSANT 1975; KUTEK & ZEISS 1974).

Although the Subboreal assemblages of ammonites of the Lower Volgian in Poland markedly differ from the Submediterranean assemblages of the Lower Tithonian of Franconia, some correlation possibilities are provided by some ammonites, chiefly by *Neochetoceras*.

In Franconia (ZEISS 1968), the genus *Neochetoceras* is represented by *N. praecursor* ZEISS in the lower part of the Hybonotum Zone (Malm zeta 1, Geisental Formation), and by *N. steraspis* (OPPEL) in the middle part of the Hybonotum Zone (Malm zeta 2, Solnhofen Formation) and in its upper part (Malm zeta 3, Moernsheim Formation), where this species is associated with *N. mucronatum* BERCKHEMER & HÖLDER. To some extent, a similar succession of *Neochetoceras* can be observed in Swabia (SCHLAGERT 1996). Higher up, *Neochetoceras* is represented in the Lower Tithonian of Franconia only by the broadly interpreted species *N. mucronatum* BERCKHEMER & HÖLDER (*i.e.* as a dimorphic species including the macroconchs referred to *N. usselense* ZEISS). This species ranges up into the Malm zeta 5b (Vimineus Zone), being common only in Malm zeta 4 and 5a (Tagersheimense, Triplicatus, and Parvinodosum Zones). No specimens of *Neochetoceras*, nor any other representatives of the Haploceratacea, have been found in Malm zeta 5c (Palatinum Zone).

In the Polish Klimovi Zone, *Neochetoceras steraspis* appears at some distance above the base of this zone, and is associated with *N. mucronatum* in its upper part. A specimen that can, with much reservation, be interpreted as *N. praecursor*, was found just above the base of the Klimovi Zone. In the Sokolovi Zone *Neochetoceras* is only represented by *N. mucronatum*. This species has been recorded at several levels in the Sokolovi Zone, but it seems to be absent from it uppermost part. Some representatives of *N. mucronatum* may be included in the poorly preserved specimens from the uppermost part of the Sokolovi Zone, which are referred to as Haploceratacea in the Appendix. However, these specimens were found close to, but never above, the upper boundary of the Sokolovi Zone. No representatives of *Neochetoceras*, or other Haploceratacea, were encountered at higher levels in the Volgian of Poland.

From these data the following conclusions can be drawn. The boundary between the Klimovi and Sokolovi Zones can be regarded as equivalent to the upper boundary of the Hybonotum Zone. Some upper part of the Klimovi Zone, where *N. steraspis* is associated with *N. mucronatum*, corresponds to the upper part of the Klimovi Zone (Malm zeta 3, Moernsheim Formation). As a whole, the Klimovi Zone may correspond to the Hybonotum Zone. However, there is no good evidence indicating that the base of the Klimovi Zone corresponds precisely to the base of the Hybonotum Zone.

The species *Sutneria bracheri* BERCKHEMER was reported from the Liegende Bankkalke and the Cement Marl of Swabia (BERCKHEMER & HÖLDER 1959, ZIEGLER 1977), which both appear to be of latest Kimmeridgian age (SCHWEIGERT 1996). In the Polish sections, a few specimens identified as *Sutneria* aff. *bracheri* BERCKHEMER were found high in the Klimovi Zone. At the time being, no firm stratigraphic conclusions can be based on these Polish specimens, which may not be conspecific with the German specimens of *Sutneria bracheri*.

The Polish Sokolovi Zone, which yielded specimens of *Neochetoceras mucronatum*, but none of *N. steraspis*, is of of Early Tithonian, post-Hybonotum age. The simplest interpretation, based on the distribution of *Neochetoceras* in the Lower Tithonian of Franconia and in the Lower Volgian of Poland, is that the Sokolovi Zone (possibly except for its uppermost part), corresponds to the Malm zeta 4 and Malm 5a-b of Franconia, and thus to the Tagersheimense, Triplicatus, Parvinodosum, and Vimineus Zones.

It is also of interest that a specimen, referred to as *Ilowaiskya* aff. *pavida juvenilis* ILOVAISKY & FLORENSKY, and a specimen identified as *Ilowaiskya* cf. *pseudoscythica* ILOVAISKY & FLORENSKY, which represents the coarsely ribbed variety of this species, were found in the Malm 5 c (the Palatinum Zone) in Franconia (ZEISS 1968, pp. 116-118; Pl. 22, Fig. 4). These forms are comparable, respectively, with the specimens of *Ilowaiskya pavida*, found in the uppermost part of the Polish Klimovi Zone, and with the less densely ribbed forms of *Ilowaiskya pseudoscythica* found relatively low in the Pseudoscythica Zone (Appendix, and Text-fig. 3*B-C*). This suggests that the boundary between the Sokolovi and Pseudoscythica Zones corresponds to some level within the Franconian Palatinum Zone. Of course, this interpretation, as based on single specimens, may be disputable, but it is consistent with the suggested correlation based on the distribution of species of *Neochetoceras* in the sections of Franconia and Central Poland.

The data considered above suggest that the boundary between the Sokolovi and Pseudoscythica Zones corresponds to a level situated in Franconia within the Palatinum Zone, or near the boundary of the Vimineus and Palatinum Zones (Text-fig. 6). In any case, the Klimovi and Sokolovi Zones correspond to the bulk of the Lower Tithonian of Franconia, in which little place is left to accommodate the Pseudoscythica Zone. This indirectly supports the opinion that a part of the Pseudoscythica Zone, and the Tenuicostata Zone, are post-Early Tithonian in age.

CORRELATIONS WITH SOUTH GERMANY: KIMMERIDGIAN

The new biostratigraphic material from Central Poland adds little to the correlations between the latest Kimmeridgian strata of Subboreal and Submediterranean regions.

Only some limited conclusions can be drawn from the occurrences of *Glochiceras solenoides* (QUENSTEDT) and *Taramelliceras* cf. or aff. *subnudatum* (FONTANNES) at relatively high levels in the Polish Autissiodorensis Zone (Appendix, and Text-figs 3-5). The species *Glochiceras solenoides* is known to occur in South Germany (in Swabia) in the Setatum Beds, the *Liegende Bankkalke* (Ulmensis-Schichten), the Cement Marl, and the *Hangende Bankkalke* (BERCKHEMER & HÖLDER 1959, ZIEGLER 1977). The species *Taramelliceras subnudatum* was reported from the *Liegende Bankkalke* and the Cement Marl (BERCKHEMER & HÖLDER 1959). The stratigraphic position of the *Liegende Bankkalke* and the Cement Marl is high in the Beckeri Zone, above the Setatum Subzone, and thus still in the Kimmeridgian; the *Hangende Bankkalke* belong to the

<table>
<tr><th colspan="2">FRANCONIA</th><th colspan="2">CENTRAL POLAND</th></tr>
<tr><td rowspan="2">M. TITH.</td><td rowspan="2">Neuburg Formation (part)</td><td>Tenuicostata Zone</td><td rowspan="6">LOWER VOLGIAN</td></tr>
<tr><td rowspan="2">Pseudoscythica Zone</td></tr>
<tr><td rowspan="4">LOWER TITHONIAN</td><td rowspan="2">Palatinum Zone</td></tr>
<tr><td rowspan="2">Sokolovi Zone</td></tr>
<tr><td>Vimineus Zone
Parvinodosum Zone
Triplicatus Zone
Tagersheimense Zone</td></tr>
<tr><td>Hybonotum Zone</td><td>Klimovi Zone</td></tr>
</table>

Fig. 6. Correlation of the Lower Tithonian of Franconia in South Germany with the Lower Volgian of Central Poland

Hybonotum Zone of the Lower Tithonian (SCHWEIGERT 1993a,b, 1994, 1996). All these data are consistent with the (quite trivial) interpretation that some upper part of the Polish Autissiodorensis Zone corresponds to an upper part of the South German Beckeri Zone.

The most important conclusion that can be drawn from the new Polish biostratigraphic material is a negative one. Namely, as the species *Sarmatisphinctes fallax* (ILOVAISKY), previously assigned to the genus *Virgataxioceras*, belongs to a different phylogenetic lineage, this species may not be, and most probably is not, coeval with the South-German group of *Virgataxioceras setatum* (SCHNEID). Hence, these ammonites provide no evidence for the time equivalence of the South German Setatum Subzone, based on the group of *Virgataxioceras setatum* and situated relatively deep in the Beckeri Zone (SCHWEIGERT 1993a, b, 1994, 1996), and of the Polish Fallax Subzone, based on *Sarmatisphinctes fallax,* and developed at the very top of the Polish Autissiodorensis Zone. Accordingly, these biostratigraphic data do not contradict the wide-held opinion that the top of the Mediterranean/Submediterranean Beckeri Zone corresponds to the top of the Subboreal Autissiodorensis Zone (ZIEGLER 1962; HANTZPERGUE 1989; SCHWEIGERT 1993a,b, 1994, 1996).

CORRELATIONS BETWEEN THE VOLGIAN AND TITHONIAN STAGES

The Volgian of Poland offered several possibilities to make the correlations between the Volgian and Tithonian Stages more precise. As most of the relevant topics were discussed in previous papers (KUTEK & ZEISS 1974, 1988, 1994; ZEISS 1977a, 1983; KUTEK & WIERZBOWSKI 1986; KUTEK 1994a), only a brief summary is given herein.

As discussed above, the Polish biostratigraphic material permits to conclude that the boundary between the Klimovi and Sokolovi Zone corresponds to the upper boundary of the Hybonotum Zone. It also permits to conclude that the base of the Pseudoscythica Zone corresponds to a level within, or near the base, of the Palatinum Zone. This is a level situated very high in the Lower Tithonian of Franconia, only a short distance beneath the base of the Middle Tithonian Neuburg Formation (Text-figs 6-7).

The ammonites assigned to *Isterites subpalmatus* (SCHNEID) and *I. spurius* (SCHNEID), which were found at Brzostówka in the uppermost part of the Tenuicostata Zone (KUTEK & ZEISS 1974, KUTEK 1994a), have their counterparts in the group of *Isterites palmatus*, which occurs high in the Neuburg Formation, but still below a horizon with calpionellids of the Calpionellid Zone A. This fact, in conjunction with correlations of the Neuburg Formation with several zones of the Tithonian Stage, gave rise to the opinion that the boundary between the Lower and Middle Volgian (that between the Tenuicostata and Scythicus Zones) corresponds approximately to the boundary between the Middle and Upper Tithonian (KUTEK & ZEISS 1974, 1988, 1994; ZEISS 1977a, 1983).

Several occurrences of *Pseudovirgatites* and *Zaraiskites* in the Carpatho-Balkan area, associated with calpionellids of the Calpionellid Zone A in some sections, provided support for the conclusion that some mid-Upper Tithonian strata, representing a part of the Calpionellid Zone

<table>
<tr><th colspan="3">Tithonian zonation</th><th colspan="3">Polish Volgian zonation</th></tr>
<tr><td rowspan="4">UPPER TITHONIAN</td><td rowspan="3">Calp. Zone A</td><td rowspan="2">Durangites Zone</td><td colspan="2">No ammonites</td><td rowspan="4">MIDDLE VOLG.(part)</td></tr>
<tr><td>Zarajskensis Horizon</td><td rowspan="3">Scythicus Zone</td></tr>
<tr><td>Transitorius Zone</td><td>Regularis Horizon</td></tr>
<tr><td colspan="2">Simplisphinctes Zone</td><td>Scythicus Horizon
Quenstedti Horizon</td></tr>
<tr><td rowspan="2">MIDDLE TITH.</td><td colspan="2" rowspan="2">Burckhardticeras Zone
through
Verruciferum Zone</td><td colspan="2">Tenuicostata Zone</td><td rowspan="5">LOWER VOLGIAN</td></tr>
<tr><td colspan="2" rowspan="2">Pseudoscythica Zone</td></tr>
<tr><td rowspan="3">LOWER TITH.</td><td colspan="2" rowspan="2">Albertinum Zone</td></tr>
<tr><td colspan="2">Sokolovi Zone</td></tr>
<tr><td colspan="2">Hybonotum Zone</td><td colspan="2">Klimovi Zone</td></tr>
</table>

Fig. 7. Correlation of the Tithonian with the Lower and Middle Volgian in Central Poland

A, correspond to the Zarajskensis Subzone of the Scythicus Zone (KUTEK & WIERZBOWSKI 1986, KUTEK & ZEISS 1988), and more precisely to the Regularis Horizon of this subzone (KUTEK 1994a).

Some biostratigraphic data provided by the Polish Volgian have an indirect bearing on the correlations between the Volgian and Tithonian Stages.

The data presented in this paper indicate that, in Central Poland, the aggregate thickness of the Pseudoscythica and Tenuicostata Zones (35-40m) is greater than that of the Klimovi and Sokolovi Zones (20-25m), which are developed in the same lithofacies of the Pałuki Formation (Text-fig. 3*A-C*). Not only the Sokolovi Zone, but also the Pseudoscythica and Tenuicostata Zones, appear to be further divisible biostratigraphically. All this suggests that a considerable span of time, and a considerable interval within the Tithonian Stage, may correspond to the Pseudoscythica and Tenuicostata Zones. This, in turn, supports the interpretation that the Middle Tithonian Substage should be correlated with the Pseudoscythica and Tenuicostata Zones (Text-fig. 7).

The Polish Scythicus Zone, which includes two subzones and four horizons, is about 70m thick in Central Poland; of this, 40 meters correspond to the Quenstedti, Scythicus, and Regularis Horizons, which all are developed in the lithofacies of the Pałuki Formation. This suggests a considerable span of time corresponding to the Scythicus Zone. On the other hand, the Regularis Horizon, which is the third of the four horizons of the Scythicus Zone (Text-fig. 7), corresponds to a stratigraphic interval representing a part of the Calpionellid Zone A, and thus situated relatively high in the Upper Tithonian. Accordingly, very little place is left in the Upper Tithonian to accomodate the higher portions of the Volgian Stage (the Virgatus, Nikitini, and Opressus Zones of the Middle Volgian, and the Upper Volgian; *see* MESEZHNIKOV 1988). This indirectly supports the interpretations according to which a post-Tithonian age should be attributed to the Upper Volgian (*e.g.* ZEISS 1983, HOEDEMAEKER 1987, SEY & KALACHEVA 1993).

However, it should be borne in mind that the biostratigraphic units of the Volgian and the Tithonian can be correlated directly only at a few stratigraphic levels, with more or less accuracy. Moreover, in some cases, two steps of correlation are involved: the correlation of the Volgian of Central Poland with the Tithonian of Franconia, and the correlation of the Franconian sections with other Tithonian sections (*see e.g.* ENAY & GEYSSANT 1975, KUTEK & ZEISS 1988). Hence, the enclosed correlation chart given (Text-fig. 7) should be regarded only as an approximation.

BIOGEOGRAPHIC REMARKS

In Eudoxus time, the provincialism of ammonites faunas was not yet so pronounced as in Autissioderensis time, so that the Eudoxus Zone can be distinguished in Northwest Europe, cratonic Poland and the Russian Platform, and also in South Germany. As stated above, the ammonite assemblages of the Eudoxus Zone in Central Poland are still closely comparable with those from the Eudoxus Zone of South Germany, as are the earlier Late Jurassic assemblages of these regions (KUTEK & *al.* 1984; KUTEK 1994a,b; MATYJA & WIERZBOWSKI 1995).

The same assemblages of *Aulacostephanus* occur in the Autissiodorensis Zone in Northwest Europe, cratonic Poland and the the Russian Platform. However, the East-European (Polish-Russian) Subboreal Subprovince was already individualized in Autissiodorensis time, as *Amoeboceras volgae* (PAVLOW), *Discosphinctoides* and *Sarmatisphinctes* are known to occur in the Autissiodorensis Zone only in Poland and Russia.

Quite different ammonite faunas developed in Early Volgian and early Middle Volgian time in Poland and Northwest Europe, which had then no ammonites in common. On the other hand, ammonites of the family Virgatitidae developed both in cratonic Poland and on the Russian Platform, following in these regions the same path of evolution. The ammonite faunas of the Klimovi, Sokolovi, and Pseudoscythica Zones are closely comparable in both regions, and some similarity is also revealed by the ammonites representing the Tenuicostata Zone. The same species of *Zaraiskites* occur in the Scythicus/Panderi Zone of Poland and Russia, but only the Russian Panderi Zone is also characterized by *Dorsoplanites* and *Pavlovia* (no specimens of *Dorsoplanites*, and only a few disputable specimens of *Pavlovia*, were found in Poland; KUTEK 1994a).

In the latest Kimmeridgian (Beckeri and Autissiodorensis Zones) and in the Tithonian/Volgian, the Subboreal assemblages of Central Poland markedly differ from the Submediterranean assemblages of South Germany. On the other hand, Haplocerataceae, which include several species known from South Germany, occur at several levels in the Autissiodorensis, Klimovi, and Sokolovi Zones of Central Poland, where *Neochetoceras mucronatum* seems to be as common as in Franconia. Significantly, no Haplocerataceae were found in cratonic Poland above the Sokolovi Zone.

Ammonites of the genus *Isterites* are known to occur in Franconia and cratonic Poland, and they are possibly also represented in the Lower Volgian of the region of the Ural River in Russia. Representatives of *Isterites* seem to be quite common in Poland, where they possibly appear earlier in stratigraphic sections than in Franconia. Such an interpretation may become quite obvious, if *Ilowaiskya schaschkovae* (ILOVAISKY), a fossil of the Pseudoscythica Zone, is re-interpreted as a species of *Isterites*.

As previously remarked in this paper, doubt can be cast on the alleged Submediterranean origin of *Isterites*. In this context, it is worth of note that a southerly (not very efficient) spread of the Virgatitidae took place in latest Early and earliest Middle Volgian time (in the Middle Tithonian). This is testified by the fact that representatives of *Ilowaiskya tenuicostata*, *Pseudovirgatites*, and *Zaraiskites* were found, mostly as single specimens, and associated with *Buchia* at some localities, in the Polish Carpathians, Slovakia, Bulgaria, Hungary, Moravia, and Austria, as listed by ZEISS (1977a), KUTEK & WIERZBOWSKI (1986), KUTEK & ZEISS (1988), and KUTEK (1994a).

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APPENDIX

The APPENDIX contains the location data (exposures, and/or borehole depths) of the ammonite taxa discussed in the text, and listed hereafter in alphabetic order.

Amoeboceras elegans SPATH — Sławno: 78.8m. Bratków: 44.7m. Tuszyn 3: 1169.7-1172.2m II.

Amoeboceras (Nannocardioceras) krausei (SALFELD) — Stobnica 36, lower interval. Błogie-Nadzieja: 64.3m. Antoninów-Skorkówka: 131.6m, 136.8-137.0m, 137.5m. Bratków: 26.5m, 26.6m, 26.7m, 26.5-7m, 26.8m, 27.3m, 27.7m, 27.8m, 34.5m. Bełchatów 5: 792.0-798.8m I 50 cm.

Amoeboceras pristiophorum (KRAUSE) — Bełchatów 5: 785.5-792.0m II 90 cm. Tuszyn 5: 1181.4-1188.4m.

Amoeboceras volgae (PAVLOW) — Bełchatów 4: 568.0-572.6m II 30-35 cm, 35-40 cm, 35-45 cm, 40-50 cm. Bełchatów 5: 785.5-792.0m I 90 cm. Bełchatów 9: 636.5-643.0m V 80-100 cm, VI 10-25 cm, 10-35 cm. Tuszyn 5: 1181.4-1188.4m VI.

Amoeboceras sp. (microconchs) — Bratków: 34.7m, 51.4-9m, 51.7-9m, 53.1-2m, 54.0m, 54.3-4m, 54.4m, 54.5m, 55.3m, ? 61.5m. Sławno: 89.2m, 91.4m. Błogie-Nadzieja: 84.8m.

Aspidoceras bispinosum (ZIETEN) — Błogie-Nadzieja: 96.2m.

Aspidoceras cf. *bispinosum* (ZIETEN) — Tuszyn 2: 946.5-952.8m.

Aspidoceras ex gr. *caletanum* (OPPEL) — Antoninów-Skorkówka: 131.6m.

Aspidoceras sp. — Stobnica 36, upper interval. Błogie-Nadzieja: 64.3m. Bratków: 39.3m. Bełchatów 5: 785.1-792.0m III 29-30cm.

Aulacostephanus autissiodorensis (COTTEAU) — Stobnica 36, upper interval. Zarzęcin 1: 191.3m. Bełchatów 9: 630.0-636.5m III 30-38 cm.

Aulacostephanus cf. *autissiodorensis* (COTTEAU) — Zarzęcin 3: 240.0 m. Bełchatów 9: 630.0-636.5 m V 40-60 cm; 643.0-649.0 m V 80-90 cm.

Aulacostephanus ex gr. *autissiodorensis* (COTTEAU) — Stobnica 36, upper interval. Błogie-Nadzieja: 49.2m. Sławno: 40.80-85m, 49.2 m, 49.5m. Antoninów-Skorkówka: 118.7m, 124.0m, 124.2m, 124.5m. Zarzęcin 3: 227.0m. Bełchatów 5: 771.5-778.5m II. Bełchatów 6: 550.0-554.2m II. Bełchatów 9: 630.0-636.5m III 30-39 cm, IV 60-70 cm, V 0-15 cm, 40-60 cm; 636.5-643.0m V 45-50 cm; 643.0-649.0m II 60 cm. Tuszyn 3: 1144.4-1147.7m III.

Aulacostephanus ex gr. *autissiodorensis* or *A. volgensis* (VISCHNIAKOFF) — Błogie-Nadzieja: 49.20m. Sławno: 40.80-85m, 47.20m, 47.95m. Antoninów-Skorkówka: 124.5m, 126.3m, 126.1-7 m. Bełchatów 9: 630.0-636.5m II 60-70 cm; 643.0-649.0 II 60 cm.

Aulacostephanus jasonoides (PAVLOW) — Stobnica 36, upper interval. Bełchatów 9: 630.0-636.5m V 0-60 cm.

Aulacostephanus undorae (PAVLOW) — Błogie-Nadzieja: 45.5-7m. Sławno: 40.8-9m. Antoninów-Skorkówka: 124.0m, 124.2m, 124.3m. Zarzęcin 1: 197.0-198.0m. Bełchatów 4: 557.4-562.0m II. Bełchatów 5: 771.5-778m VI 80 cm. Bełchatów 9: 630.0-636.5m I 80 cm, IV 60-70 cm, V 0-30 cm. Tuszyn 3: 1144.4-1147,7m I.

Aulacostephanus cf. *undorae* (PAVLOW) — Antoninów-Skorkówka: 118.8m, 124.0m. Bełchatów 5: 771.5-778.5m VI 80 cm, VII 40 cm. Bełchatów 9: 630.0-636.5m II 60-70 cm.

Aulacostephanus volgensis (VISCHNIAKOFF) — Stobnica 36, upper interval.

Błogie-Nadzieja: 44.5-7m, 48.8m, 64.3-7m. Antoninów-Skorkówka: 124.5m. Tuszyn 5: 1181.4-1188.4m III 70 cm.

Aulacostephanus cf. *volgensis* (VISCHNIAKOFF) — Stobnica 36, lower and upper interval. Błogie-Nadzieja: 49.2m, 57.85m. Sławno: 52.30m. Antoninów-Skorkówka: 123.9m. Zarzęcin 3: 227.0m, 240.0m.

Aulacostephanus undorae (PAVLOW) or *A. volgensis* (VISCHNIAKOFF) — Błogie-Nadzieja: 45.5-7m. Antoninów-Skorkówka: 118.7m. Bełchatów 5: 785.1-792.0m III 29-30 cm.

Aulacostephanus sp. — Błogie-Nadzieja: 45.2m, 45.5-7m, 49.2m. Sławno: 40.80-85m, 47.55m. Antoninów-Skorkówka: 118.5-7m, 123.9m, 124.0m, 124.3m, 124.1-7m, 126.1-7m. Zarzęcin 1: 193.4m, 198.0m. Bełchatów 4: 568-576.6m II 40-50 cm. Bełchatów 5: 771.5-778.5m VI 80 cm; 785.1-792.0m III 20-30 cm, 29-30 cm. Bełchatów 9: 630.0-636.5m I 80 cm, II 60-70 cm, V 45-50 cm, IV 60-70 cm; 636.5-643.0m VI 10-25 cm. Tuszyn 3: 1144.4-1147.7m II. Tuszyn 5: 1169.1-1175.1m VI 60 cm.

Discosphinctoides ex gr. *stenocyclus - roubyanus* (FONTANNES) — Bełchatów 5: 805.6-811.0m III 20-30 cm, IV 10 cm. Tuszyn 2: 946.5-952.8m II.

Discosphinctoides subborealis sp.n. — Stobnica 36, upper interval. Błogie-Nadzieja: 44.2m, 44.4m, 45.2m, 46.5-7m, 47.2m, 47.2m, 48.6-7m, 49.1m, 49.2m, 49.3m, 49.4m, 49.9m, 51.2m, 51.9m. Antoninów-Skorkówka: 119.10-15m, 121.8m, 121.8-9m, 123.9m, 124.9m, 125.5m, 125.9m, 126.7-8m, 129.5m. Sławno: 43.1m, 47.3m, 47.50m, 47.55m, 49.1m, 49.2m, 49.5-7m, 49.8m, 51.6m, 51.8m, 53.5m, 57.1m, 58.7m. Bratków: 10.9m, 11.85-12.0m, 11.3m, 26.2m. Zarzęcin 1: 193.4m, 196.0m, 196.5m, 197.6m, 198.1m. Zarzęcin 3: 230.0m, 230.4m, 231.0-5m, 232.0m, 232.5m, 233.0m. Bełchatów 4: 557.4-562.2m III; 562.2-568.0m III; 568.0-572.6m I 0-30 cm, 30-50 cm, 80 cm, 85 cm, II 0.25 cm, 40 cm, III 75 cm; 572.6-579.3 m I 0-30 cm, 80 cm, II 0-25 cm, 40 cm, III 0-10 cm, 75 cm; 572.6-579.3m III 0-40 cm, 60 cm. Bełchatów 5: 771.5-778.5m III 80 cm, 90 cm, V 10-15 cm, 50 cm, 60 cm, 80 cm, 90 cm; 778.5-785.1m I 60 cm, 80 cm, 90 cm, II 10 cm, 80 cm, IV 30 cm, VI 80 cm. Bełchatów 9: 630.0-636.5m I 0 cm, 20-25 cm, 60 cm, 70 cm, 80 cm, 90 cm, II 50 cm, 60 cm, 60-70 cm, 70 cm, III 30 cm, 30-35 cm, 60-70 cm, IV 32-40 cm, 60-70 cm; 636.5-643.0m I 0-30 cm, 20-25 cm, II 56-60 cm, 60-70 cm, 80-100 cm, III 80-100 cm, IV 80-100 cm, V 40-45 cm. Tuszyn 3: 1144.4-1447.7m II, III. Tuszyn 5: 1169.1-1175.1m VI (?); 1181.4-1188.4 VI.

Discosphinctoides cf. or aff. *subborealis* sp.n. — Błogie-Nadzieja: 70.5-6m, 73.0m. Bratków: 40.2m, 40.35m 49.4m, 49.5m. Bełchatów 4: 579.3-585.4m VI 70 cm.

Glochiceras modestum ZIEGLER — Sławno: 90.8m. Tuszyn 2: 946.5-952.8m I

Glochiceras cf. *modestum* ZIEGLER — Tuszyn 2: 946.5-952.8m I.

Glochiceras solenoides (QUENSTEDT) — Zarzęcin 1: 201.0-202.0m.

Haploceratаceae — Stobnica 39. Antoninów-Skorkówka: 95.2m, 95.5m, 104.1m, 106.3m, 107.2m. Sławno: 23.8m. Błogie-Nadzieja: 18.9-19.0m, 19.0m, 20.05m, 23.25m, 24.3m, 29.8m, 29.9m. Zarzęcin 1: 181.0m, 201.0-202.0m. Zarzęcin 3: 198.5m. Bełchatów 4: 551.4-557.4m II 90 cm. Bełchatów 5: 765.5-771.5m II 90 cm. Bełchatów 6: 550.0-554.2 m.

Ilowaiskya ianschini (ILOVAISKY) — Błogie-Nadzieja: 13.6m, 16.3m. Zarzęcin 3: 196.5 m.

Ilowaiskya cf. *ianschini* (ILOVAISKY) — Antoninów-Skorkówka: 87.4m.

Ilowaiskya klimovi (ILOVAISKY) — Antoninów-Skorkówka: 104.9m, 106,1m, 107.5m, 109.2-8m, 109.3m, 110.4-5m, 111.4m, 113.3m, 113.8m. Sławno: 31.3m, 32.25m, 33.0m, 35.2m, 36.7m, 38.7m. Błogie-Nadzieja: 29.25m, 31.3m, 32.45m, 33.0m, 36.7m. Zarzęcin 1: 181.0m, 183.7m, 184.0m, 185.0m, 185.9m, 189.1m, 189.4m. Zarzęcin 3: 217.0m, 220.0m. Bełchatów 5: 771.5-778.5m. Tuszyn 3: 1133.4-1139.3m I. Tuszyn 5: 1156.5-1162.7m, 1162.7-1169.1m, 1169.1-1175.1 m I 80 cm.

Ilowaiskya pavida (ILOVAISKY) — Antoninów-Skorkówka, 92.3m

Ilowaiskya cf. *pavida* (ILOVAISKY) — Antoninów-Skorkówka, 94.3m.

Ilowaiskya pseudoscythica (ILOVAISKY) — Antoninów-Skorkówka: 77.6m, 83.2m, 84.5m, 87.4m. Błogie-Nadzieja: 8.45m, 9.1m. Zarzęcin 1: 154.0m. Tuszyn 3: 1091.1-1096.7m III.

Ilowaiskya cf. *pseudoscythica* (ILOVAISKY) — Antoninów-Skorkówka: 83.4m, 87.4m. Tuszyn 5: 1137.7-1144.0m I 60-70 cm.

Ilowaiskya schaschkovae (ILOVAISKY) — Zarzęcin 3: 181.6m.

Ilowaiskya cf. schaschkovae (ILOVAISKY) — Antoninów-Skorkówka: 75.6m, 77.5m.

Ilowaiskya sokolovi (ILOVAISKY) — Stobnica 20. Antoninów-Skorkówka: 101.2m, 103.2m, 104.1m. Błogie-Nadzieja: 24.4m, 25.5m, 27.5m. Zarzęcin 1: 174.5-175.5m.

Ilowaiskya cf. *sokolovi* (ILOVAISKY) — Stobnica 39.

Ilowaiskya tenuicostata (MICHAILOV) — Brzostówka, bed a-1. Antoninów-Skorkówka: 71.5m. Zarzęcin 3: 179.0m.

Ilowaiskya tenuicostata (MICHAILOV) or *Pseudovirgatites passendorferi* KUTEK & ZEISS — Antoninów-Skorkówka: 63.3 m. Zarzęcin 1: 144.1 m. Zarzęcin 3: 179.0 m.

Isterites masoviensis KUTEK & ZEISS — Brzostówka, bed a-3.

Isterites spurius (SCHNEID) — Brzostówka, beds a-1 and a-2.

Isterites subpalmatus (SCHNEID) — Brzostówka, beds a-1 and a-2.

Isterites sp. — Antoninów-Skorkówka, 68.8m. Zarzęcin 3: 179.0m.

? *Isterites* sp. — Zarzęcin 1: 142.5m. Zarzęcin 3: 170.0 m, 180.2m.

Isterites sp. or *Ilowaiskya tenuicostata* (MICHAILOV) — Zarzęcin 3: 179.0m.

Neochetoceras steraspis (OPPEL) — Antoninów-Skorkówka: 106.8m, 107.2m, 108.5m. Zarzęcin 1: 183.0m, 183.1m. Bełchatów 5: 765.5-771.5 m II 30 cm.

Neochetoceras mucronatum BERCKHEMER & HÖLDER (*N. mucronatum* s.s. + *N. usselense* ZEISS) — Stobnica 39. Antoninów-Skorkówka: 100.5m, 101.7m. Sławno: 23.7m, 25.7m. Błogie-Nadzieja: 23.25m, 23.6-8m, 24.3m, 24.35-45m, 23.5m, 25.6-9m, 27.3m, 28.8-9m. Zarzecin 1: 173.0m, 174.3m, 183.1m.

? *Neochetoceras* sp. — Sławno: 38.1m.

Pseudovirgatites passendorferi KUTEK & ZEISS — Brzostówka, beds a-1 and a-2. Zarzęcin 3: 172.5m.

Pseudovirgatites puschi KUTEK & ZEISS — Brzostówka, a-1, a-2.

Pseudovirgatites cf. or aff. *puschi* KUTEK & ZEISS — Antoninów-Skorkówka: 61.2-4m. Zarzęcin 1: 140.4m. Zarzęcin 3: 180.2m.

Pseudovirgatites sp. — Antoninów-Skorkówka: 58.5m, 61.2m, 67.0m. Zarzęcin 1: 140.5m. Zarzęcin 3: 170.0m.

Sarmatisphinctes fallax (ILOVAISKY) — Antoninów-Skorkówka: 115.25-30m, 115.35m, 117.0m, 117.2-3m, 117.7m. Błogie-Nadzieja: 39.1m, 39.2m, 39.3m, 39.5m, 39.7m, 39.9m, 41.7m, 41.8m. Sławno: 40.7m, 41.10-15m, 41.4m, 42.2m, 42.2-3m, 43.0m. Zarzęcin 1: 190.0m, 191.1m, 191.8m, 192.0m. Zarzęcin 3: 222.0-2m, 222.0-3m, 222.2-3m, 223.7m. Bełchatów 5: 771.5-778.5m III 0-40 cm. Bełchatów 6: 539.0-545.0 m I 70 cm. Tuszyn 2: 902.0-907.2 m IV, IV 60 cm. Tuszyn 3: 1133.4-1139.3m. Tuszyn 5: 1169.1-1175.1m III 50 cm, VI 60 cm.

Sarmatisphinctes cf. *fallax* (ILOVAISKY) — Stobnica 37.

Sutneria cf. of aff. *bracheri* BERCKHEMER — Antoninów-Skorkówka: 106.8m, 108.5m. Bełchatów 5: 765.6-771.5m.

Sutneria eumela (D'ORBIGNY) — Tuszyn 2: 946.5-952.8m.

Sutneria cf. *lorioli* ZEISS — Bratków: 64.2m.

Taramelliceras cf. or aff. *subnudatum* (FONTANNES) — Antoninów-Skorkówka: 124.1-7m. Błogie-Nadzieja: 45.5-7m, 47.7m. Zarzęcin 1: 197.0-198.0m. Bełchatów 5: 778.5-785.1m V. Bełchatów 6: 550.0-554.2m II 70 cm. Tuszyn 3: 1144.4-1147.7m II.

Zaraiskites regularis KUTEK — Several outcrops and boreholes in the region of Tomaszów Mazowiecki (*see* KUTEK 1994a). Antoninów-Skorkówka: 44.3-4m. Zarzęcin 1: 120.2-7m. Zarzęcin 3: 148.0m.

Zaraiskites quenstedti (ROUILLIER) — Brzostówka, bed a-3. Sławno, exposure (*see* KUTEK 1994a). Antoninów-Skorkówka: 54.7 m. Zarzęcin 1: 130.0m, 131.6m. Zarzęcin 3: 163.5m.

Zaraiskites scythicus (VISCHNIAKOFF) — Brzostówka, bed b-1. Tuszyn 2: 842.2-848.1m I, II.

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PLATES 1 – 42

PLATE 1

Ammonites from the upper Eudoxus Zone

1 — *Aspidoceras bispinosum* (ZIETEN); Specimen IGPUW/A/32/596, × 1; Błogie-Nadzieja, 96.2 m

2 — *Aspidoceras* cf. *bispinosum* (ZIETEN); Specimen IGPUW/A/32/473, × 1; Tuszyn 2, 946.5-952.8 m

3 — *Sutneria* cf. *lorioli* (D'ORBIGNY); Specimen IGPUW/A/32/591, × 2; Bratków, 64.2 m

4 — Same specimen, × 1

5 — *Sutneria* cf. *eumela* (D'ORBIGNY); Specimen IGPUW/A/32/473, × 1 (*refigured from* PACHUCKI 1963, Pl. 2, Fig. 7; *and* ZEISS 1979, Pl. 2, Fig. 2); Tuszyn 2, 946.5-952.8 m

6 — *Glochiceras modestum* ZIEGLER; Specimen IGPUW/A/32/141, × 2; Sławno, 90.8 m

7 — *Discosphinctoides* ex gr. *stenocyclus* – *roubyanus* (FONTANNES); Specimen IGPUW/A/32/569, × 1; Tuszyn 2, 946.5-952.8 m II

8 — *Discosphinctoides* ex gr. *stenocyclus* – *roubyanus* (FONTANNES); Specimen IGPUW/A/32/382, × 1; Bełchatów 5, 805.6-811.0 m IV 10 cm

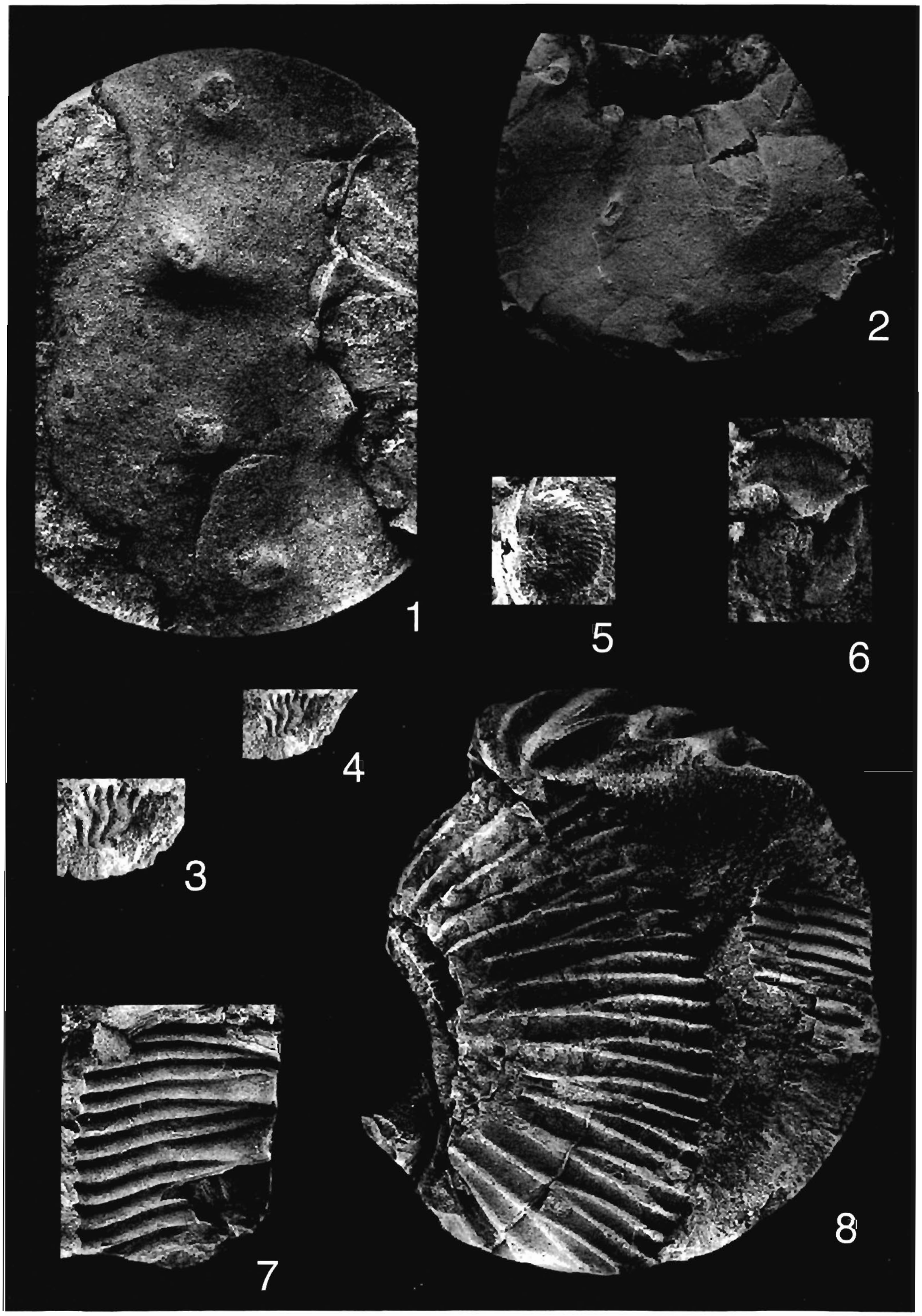
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PLATE 2

Aulacostephanus undorae (PAVLOW); Autissiodorensis Zone

1 — Specimen IGPUW/A/32/72; Antoninów-Skorkówka, 124.3 m
2 — Specimen IGPUW/A/32/99; Błogie-Nadzieja, 45.5-7 m
3 — Specimen IGPUW/A/32/128; Tuszyn 3, 1444.4-1447.4 m I
4 — Specimen IGPUW/A/32/119; Bełchatów 9, 630.0-636.5 m IV 60-70 cm
5 — Specimen IGPUW/A/32/117; Bełchatów 9, 630.0-636.5 m IV 60-70 cm
6 — Specimen lost; Bełchatów 9, 630.0-636.5 m V 0-30 cm

All figures of natural size

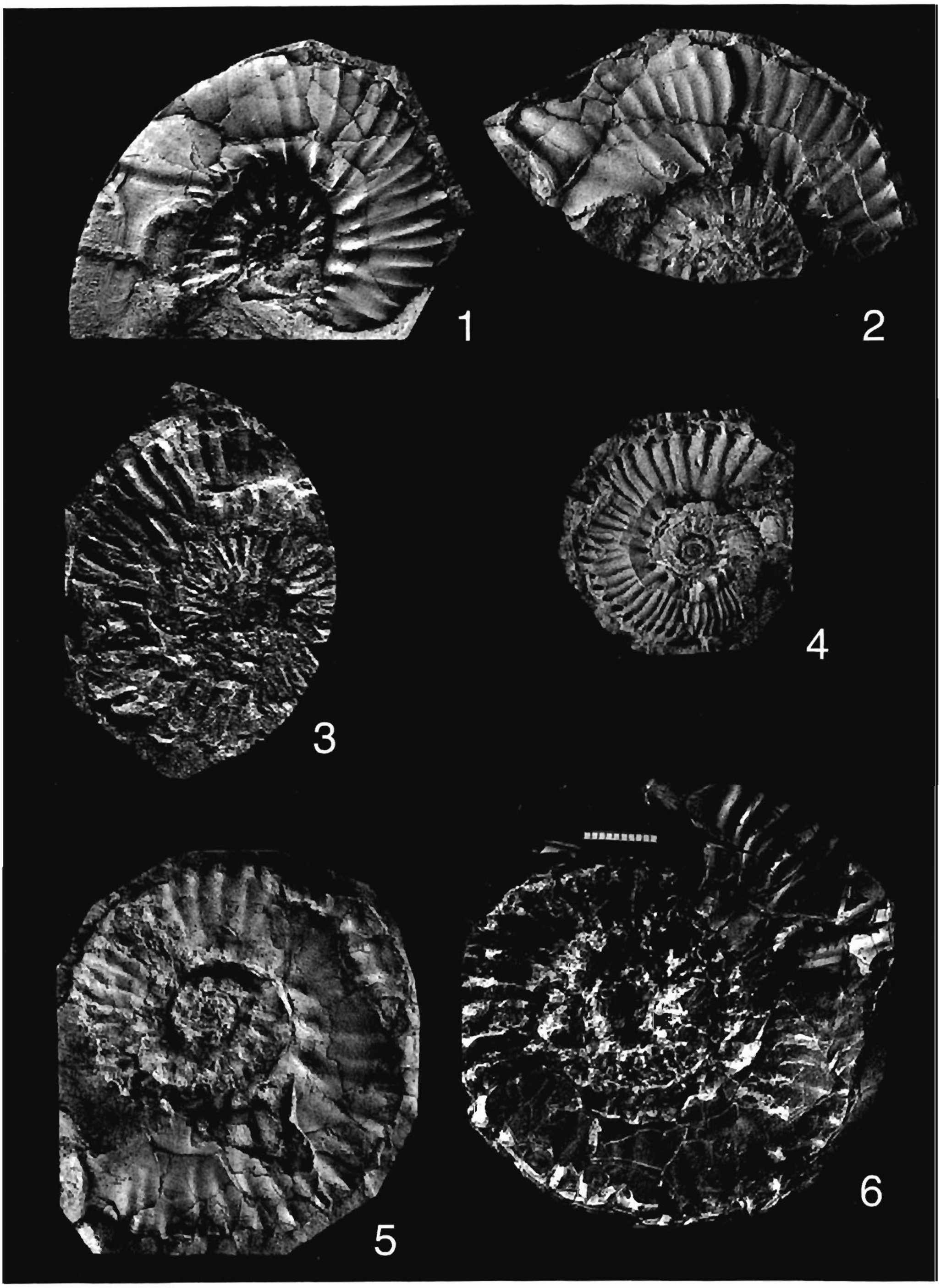
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PLATE 3

Aulacostephanus volgensis (VISCHNIAKOFF); Autissiodorensis Zone

1 — Specimen IGPUW/A/32/81; Autissiodorensis Zone; Błogie-Nadzieja, 48.8 m

2 — Specimen IGPUW/A/32/130; Autissiodorensis Zone; Tuszyn 5, 1181.4-1188.4 m III 70 cm

3 — Specimen IGPUW/A/32/374; Eudoxus-Autissiodorensis uncertainty interval; Błogie-Nadzieja, 64.3-7 m

4 — Specimen IGPUW/A/32/83; Autissiodorensis Zone; Antoninów-Skorkówka, 124.5 m

5 — Specimen IGPUW/A/32/78 (counterpart of specimen IGPUW/A/32/83)

All figures of natural size

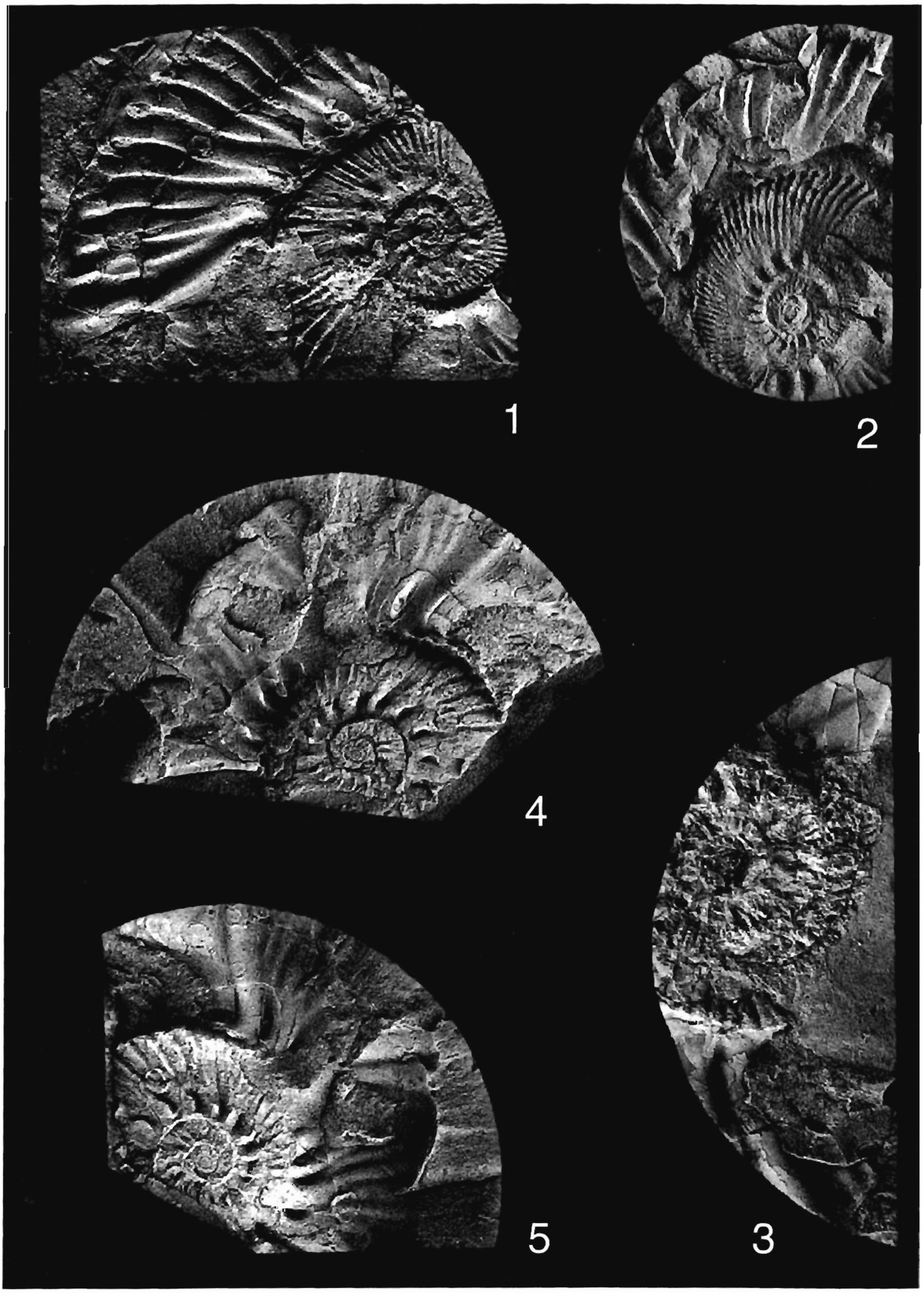
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PLATE 4

Aulacostephanus volgensis (VISCHNIAKOFF); Autissiodorensis Zone; Stobnica 36, upper interval

1 — Specimen IGPUW/A/31/4 (*refigured from* KUTEK 1961, Pl. 14, Fig. 3)
2 — Specimen IGPUW/A/31/11
3 — Specimen IGPUW/A/31/4
4 — Specimen IGPUW/A/31/15

All figures of natural size

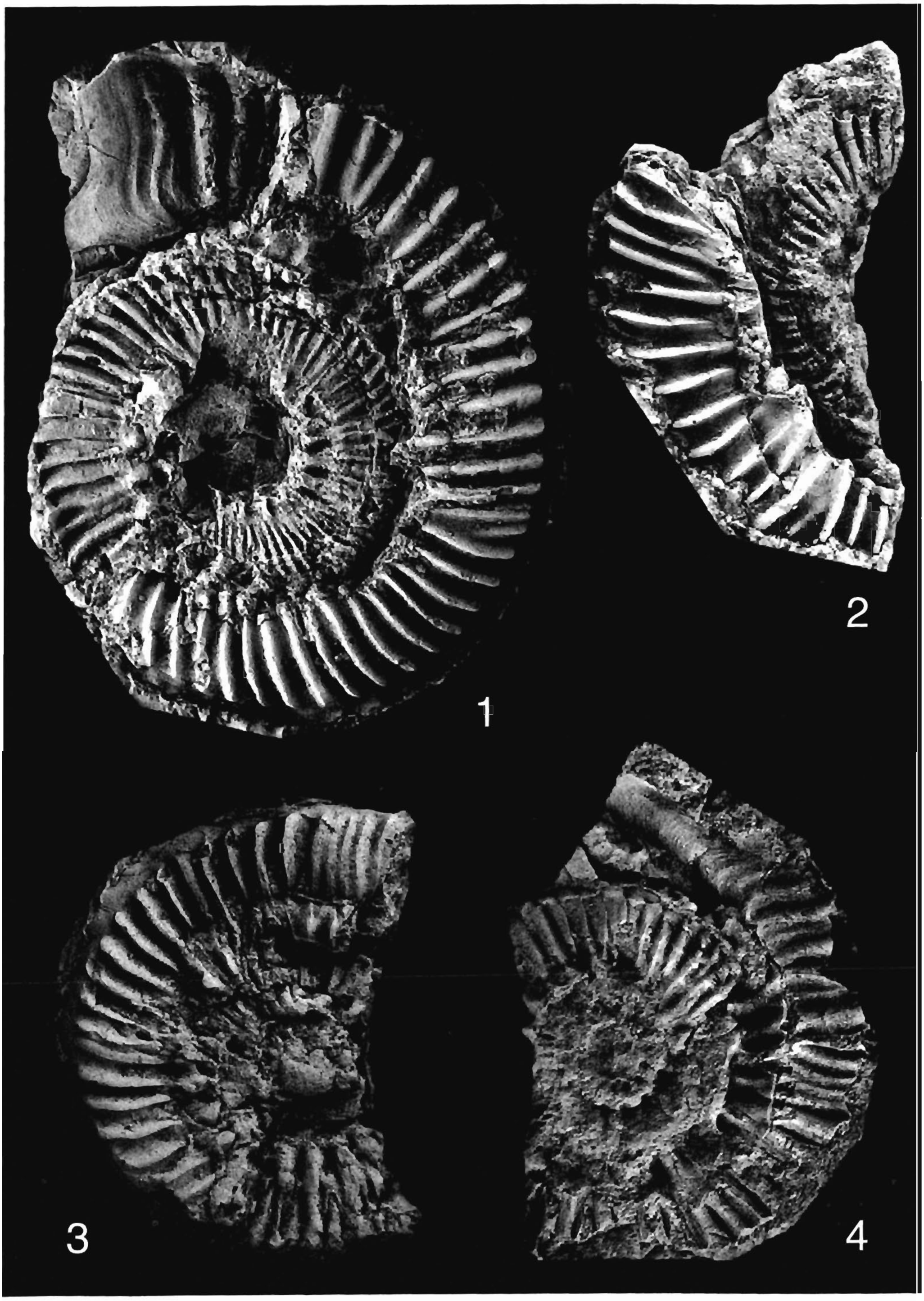
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PLATE 5

Aulacostephanus; Autissiodorensis Zone; Stobnica 36, upper interval

1 — *Aulacostephanus volgensis* (VISCHNIAKOFF); Specimen IGPUW/A/31/1

2 — *Aulacostephanus autissiodorensis* (COTTEAU); Specimen IGPUW/A/31/14, pars (*refigured from* KUTEK 1961, Pl. 14, Fig. 2)

3 — *Aulacostephanus volgensis* (VISCHNIAKOFF); Specimen IGPUW/A/31/14, pars (*refigured from* KUTEK 1961, Pl. 14, Fig. 2)

4 — *Aulacostephanus autissiodorensis* (COTTEAU); Specimen IGPUW/A/31/3 (*refigured from* KUTEK 1961, Pl. 13, Fig. 3)

All figures of natural size

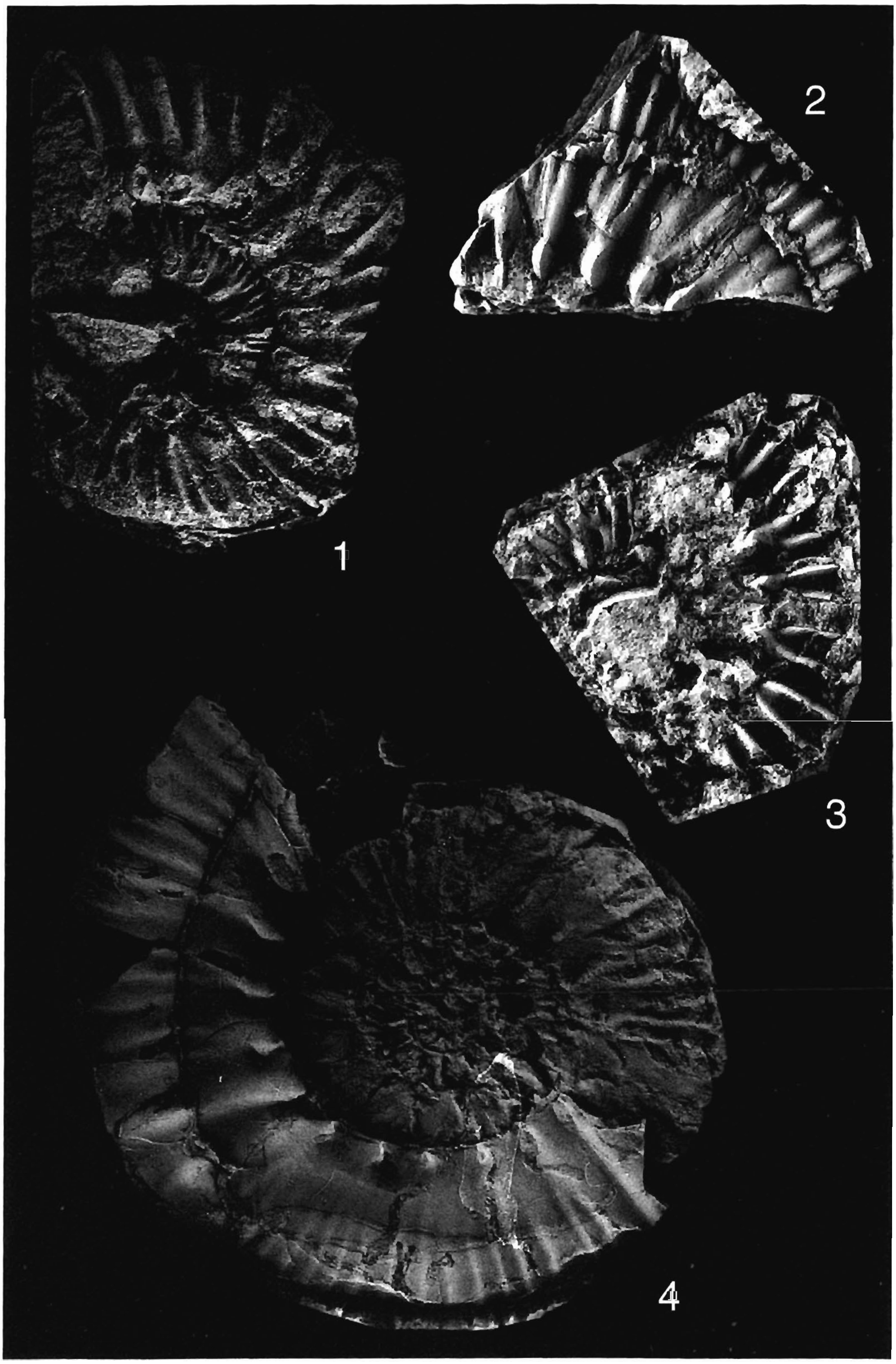
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PLATE 6

Aulacostephanus; Autissiodorensis Zone

1 — *Aulacostephanus* cf. *autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/121; Bełchatów 9, 643.0-649.0 m V 80-90 cm

2 — *Aulacostephanus* cf. *volgensis* (VISCHNIAKOFF); Specimen IGPUW/A/31/8 (*refigured from* KUTEK 1961, Pl. 14, Fig. 4); Stobnica 36, upper interval

3 — *Aulacostephanus* cf. *autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/71; Zarzęcin 3, 240 m

4 — *Aulacostephanus jasonoides* (PAVLOW); Specimen IGPUW/A/31/7 (*refigured from* KUTEK 1961, Pl. 14, Fig. 1); Stobnica 36, upper interval

5 — *Aulacostephanus jasonoides* (PAVLOW); Specimen IGPUW/A/32/118; Bełchatów 9, 630.0-636.5 m V 0-60 cm

All figures of natural size

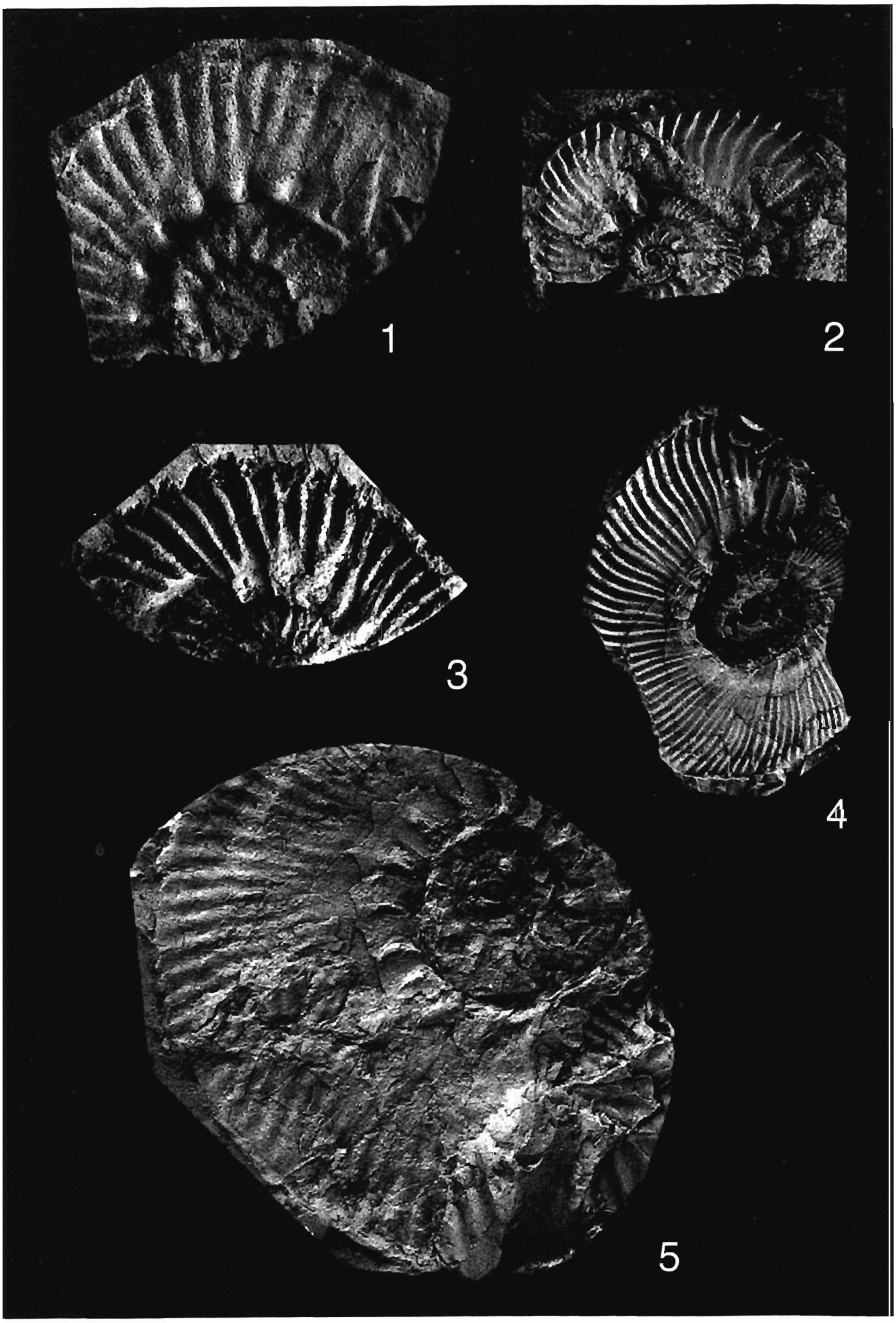
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PLATE 7

Aulacostephanus; Autissiodorensis Zone

1 — *Aulacostephanus autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/120; Bełchatów 9, 630.0-636.5 m III 30-38 cm

2 — *Aulacostephanus* ex gr. *autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/115; Bełchatów 9, 630.0-636.5 m V 40-60 cm

3 — Specimen IGPUW/A/32/116 (counterpart of specimen IGPUW/A/32/115)

All figures of natural size

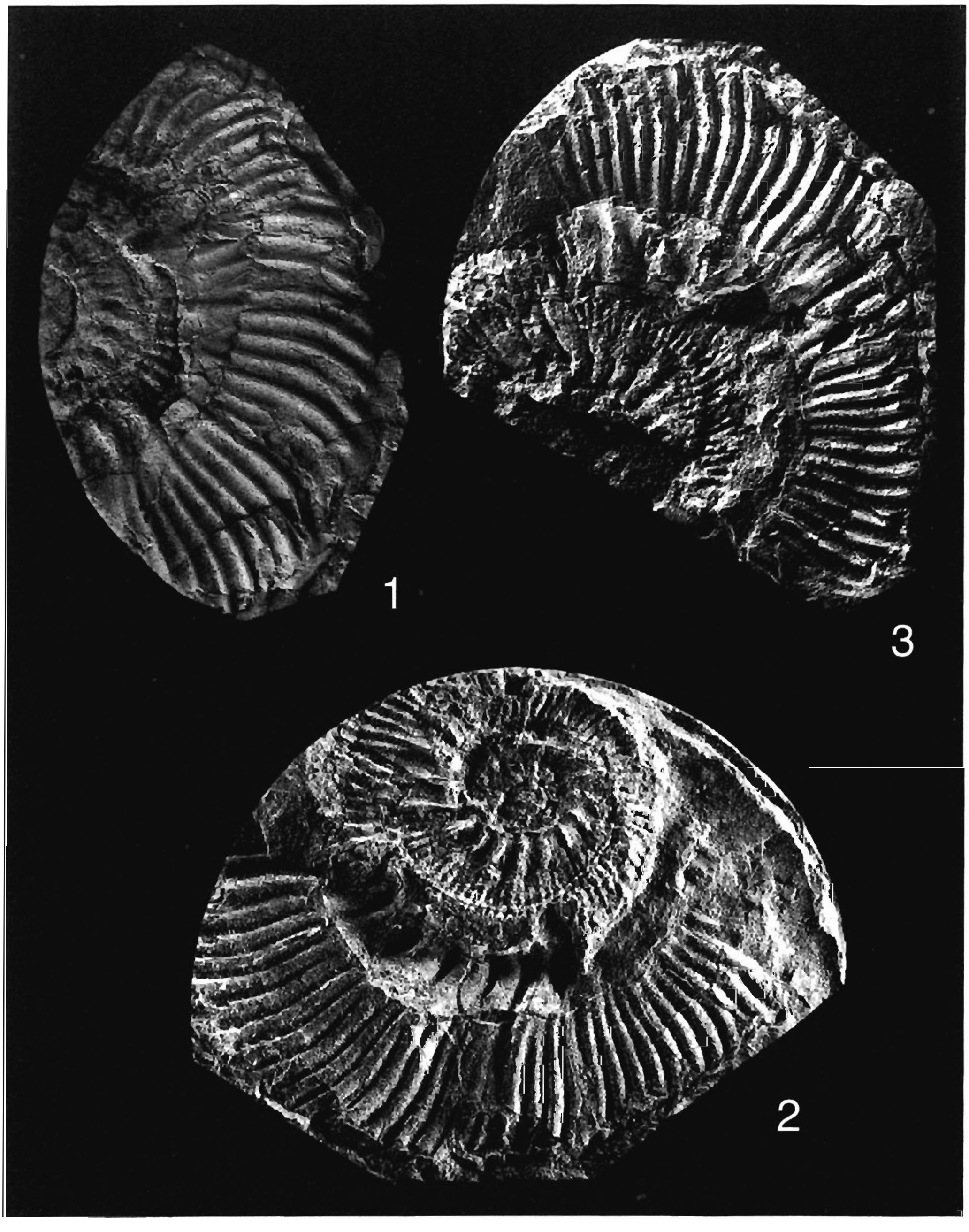
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PLATE 8

Aulacostephanus; Autissiodorensis Zone

1 — *Aulacostephanus* ex gr. *autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/79; Antoninów-Skorkówka, 118.7 m

2 — Specimen IGPUW/A/32/88 (counterpart of specimen IGPUW/A/32/79)

3 — *Aulacostephanus undorae* (PAVLOW); Specimen IGPUW/A/32/93; Fallax Subzone; Sławno, 40.8-9 m

4 — Specimen IGPUW/A/32/94 (counterpart of specimen IGPUW/A/32/93)

5 — *Aulacostephanus autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/67; Fallax Subzone; Zarzęcin 1, 191.3 m

6 — *Aulacostephanus* ex gr. *autissiodorensis* (COTTEAU); Specimen IGPUW/A/32/73; Fallax Subzone; Sławno, 40.80-85 m

All figures of natural size

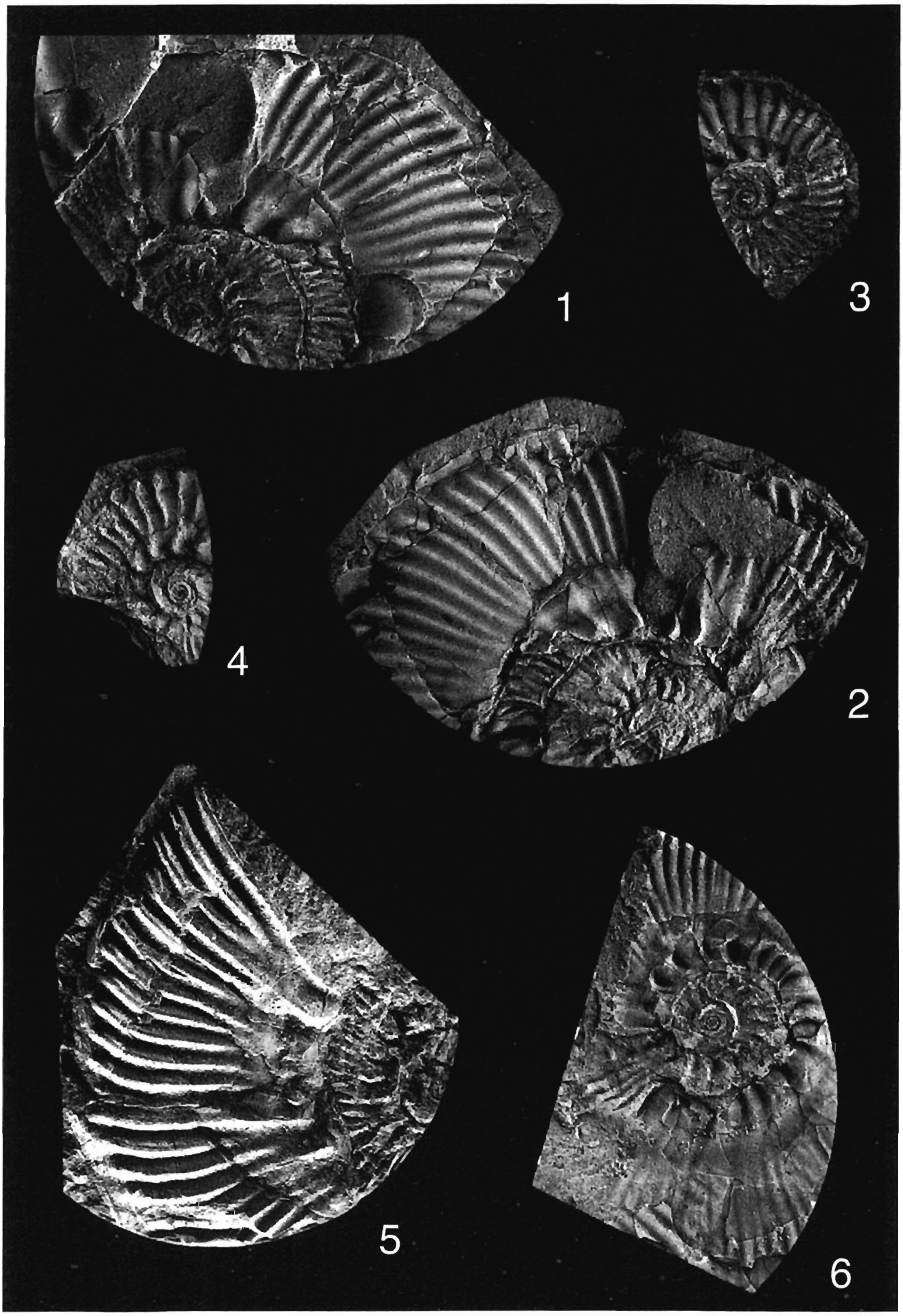
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PLATE 9

Amoeboceras (*Nannocardioceras*) *krausei* (SALFELD)

1 — Specimen IGPUW/A/31/3; Eudoxus-Autissiodorensis uncertainty interval; Stobnica 36, lower interval
2 — Specimen IGPUW/A/32/27; Autissiodorensis Zone; Bratków, 26.5 m
3 — Specimen IGPUW/A/32/30; Autissiodorensis Zone; Bratków, 26.7 m
4 — Specimen IGPUW/A/32/34; Autissiodorensis Zone; Bratków, 26.8 m
5 — Specimen IGPUW/A/32/35; Autissiodorensis Zone; Bratków, 27.3 m
6 — Specimen IGPUW/A/32/38; Autissiodorensis Zone; Bratków, 27.8 m
7 — Specimen IGPUW/A/32/39; Autissiodorensis Zone; Bratków, 27.8 m
8 — Specimen IGPUW/A/32/36; Autissiodorensis Zone; Bratków, 27.3 m
9 — Specimen IGPUW/A/31/39; Eudoxus-Autissiodorensis uncertainty interval, Stobnica 36, lower interval

All figures of natural size

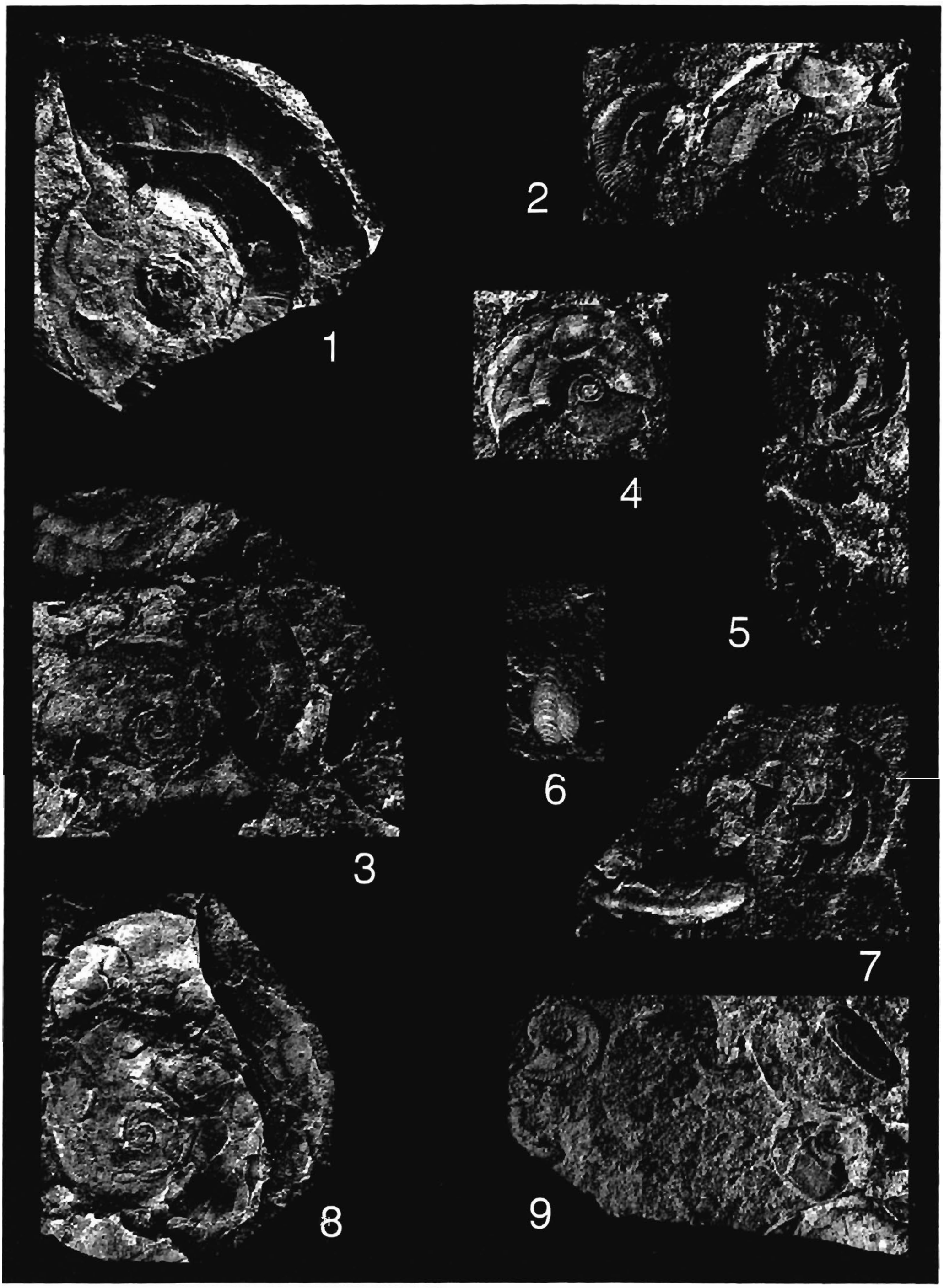
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PLATE 10

Amoeboceras; Autissiodorensis Zone

1 — *Amoeboceras (Nannocardioceras) krausei* (SALFELD); Specimen IGPUW/A/32/27, × 2; Bratków, 26.5 m

2 — *Amoeboceras (Nannocardioceras) krausei* (SALFELD); Specimen IGPUW/A/32/27, × 2; Bratków, 26.5 m

3 — *Amoeboceras pristiophorum* (KRAUSE); Specimen IGPUW/A/32/612, × 2; Bełchatów 5, 785.5-792.0 m II 90 cm

4 — *Amoeboceras pristiophorum* (KRAUSE); Specimen lost (*refigured from* PACHUCKI 1963, Pl.1, Fig. 5), × 2; Tuszyn 5, 1181.4-1188.4 m

5 — Same specimen, × 3

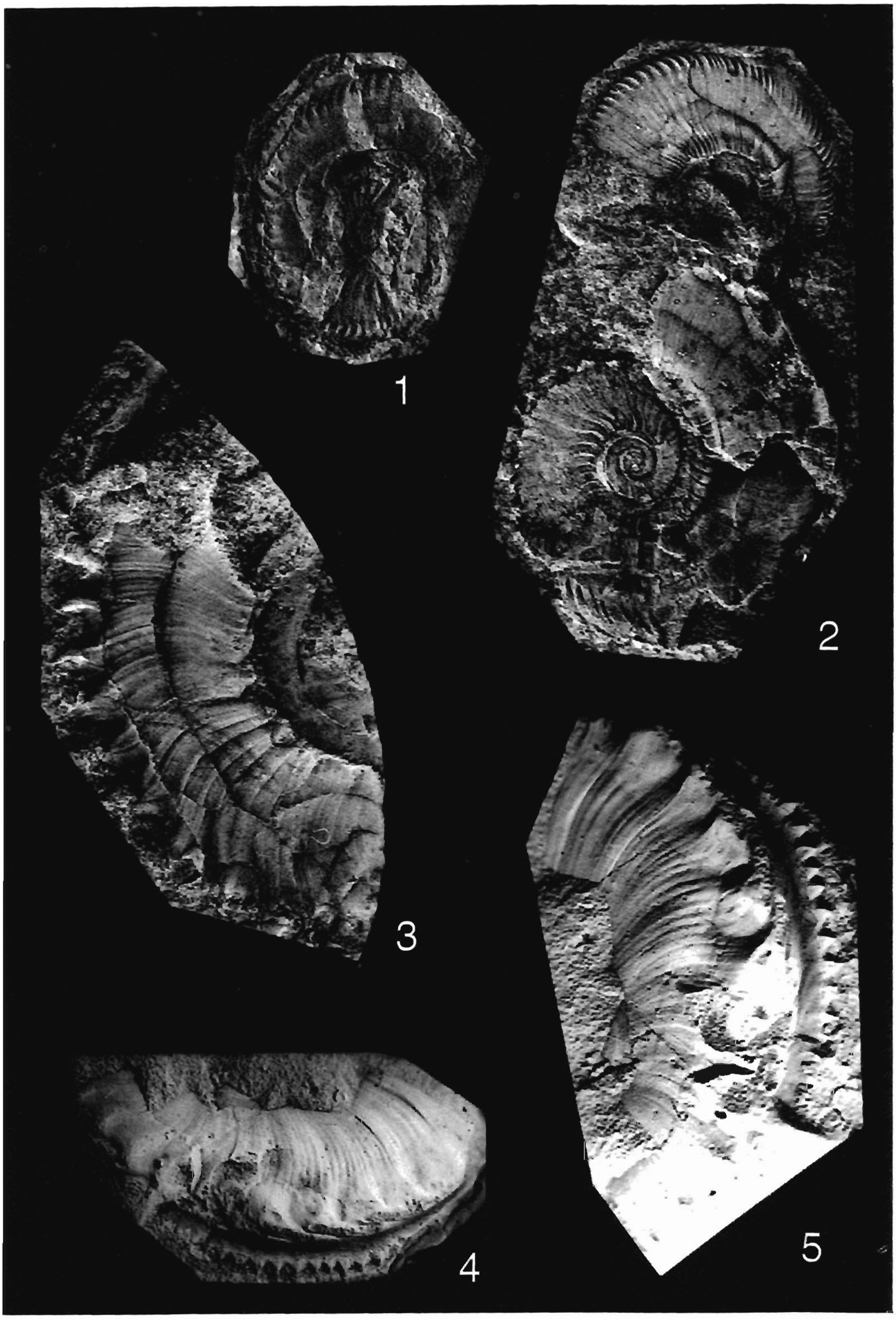
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PLATE 11

Amoeboceras volgae (Pavlow); Autissiodorensis Zone

1 — Specimen IGPUW/A/32/4, × 1.5; Bełchatów 9, 636.5-643.0 m VI 10-35 cm

2 — Specimen IGPUW/A/32/1, × 1.5; Tuszyn 5, 1181.4-1188.4 m VI

3 — Specimen IGPUW/A/32/2 (counterpart of specimen IGPUW/A/32/1), × 1.5

4-6 — Specimen IGPUW/A/32/4, × 1.5; Bełchatów 9, 636.5-643.0 m VI 10-35 cm

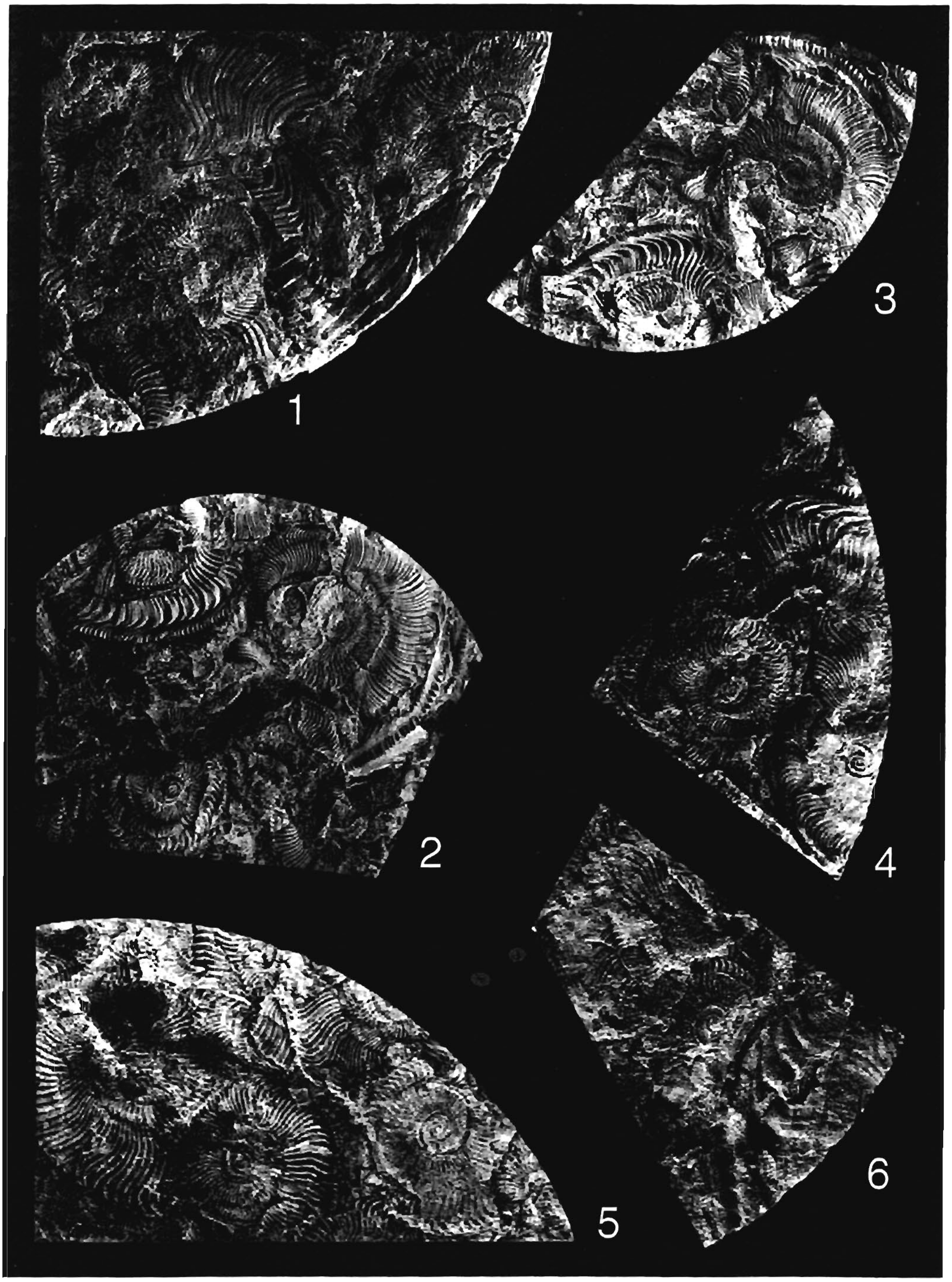
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PLATE 12

Amoeboceras volgae (PAVLOW); Autissiodorensis Zone

1-2 — Specimen IGPUW/A/32/2, × 2; Tuszyn 5, 1181.4-1188.4 m VI

3-4 — Specimen IGPUW/A/32/1, × 2; Tuszyn 5, 1181.4-1188.4 m VI

5-7 — Specimen IGPUW/A/32/4, × 2; Bełchatów 9, 636.5-643.0 m VI 10-35 cm

8-12 — Specimen IGPUW/A/32/3, × 2; Bełchatów 9, 636.5-643.0 m VI 10 - 35 cm

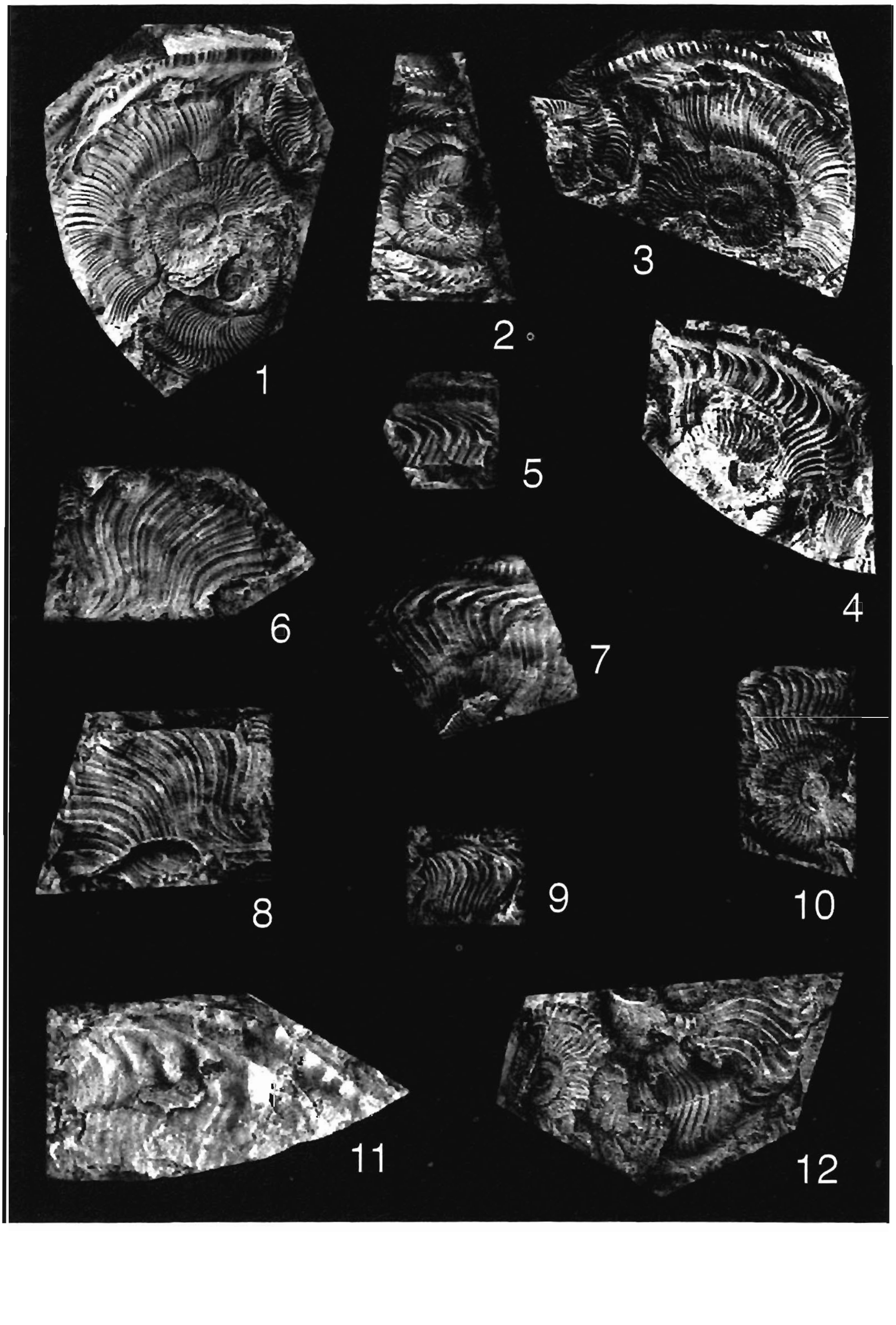

PLATE 13

Amoeboceras and *Aulacostephanus*

1 — *Amoeboceras volgae* (PAVLOW); Specimen IGPUW/A/32/593; Autissiodorensis Zone; Bełchatów 5, 785.1-792.0 m I 90 cm

2 — *Amoeboceras elegans* SPATH; Specimen lost; Eudoxus-Autissiodorensis uncertainty interval; Tuszyn 3, 1169.7-1172.2 m II

3 — *Amoeboceras elegans* SPATH; Specimen IGPUW/A/32/64; Eudoxus-Autissiodorensis uncertainty interval; Sławno, 78.8 m

4 — *Amoeboceras elegans* SPATH; Specimen IGPUW/A/32/65; Eudoxus-Autissiodorensis uncertainty interval; Bratków 44.7 m

5 — *Amoeboceras pristiophorum* (KRAUSE); Specimen IGPUW/A/32/612; Autissiodorensis Zone, Bełchatów 5, 785.5 -792.0 m II 90 cm

6 — *Aulacostephanus undorae* (PAVLOW); Specimen lost; Autissiodorensis Zone; Bełchatów 4, 557.4-562.0 m II

7 — *Amoeboceras volgae* (PAVLOW); Specimen IGPUW/A/32/2; Autissiodorensis Zone; Tuszyn 5, 1181.4-1188.4 m VI

All figures of natural size

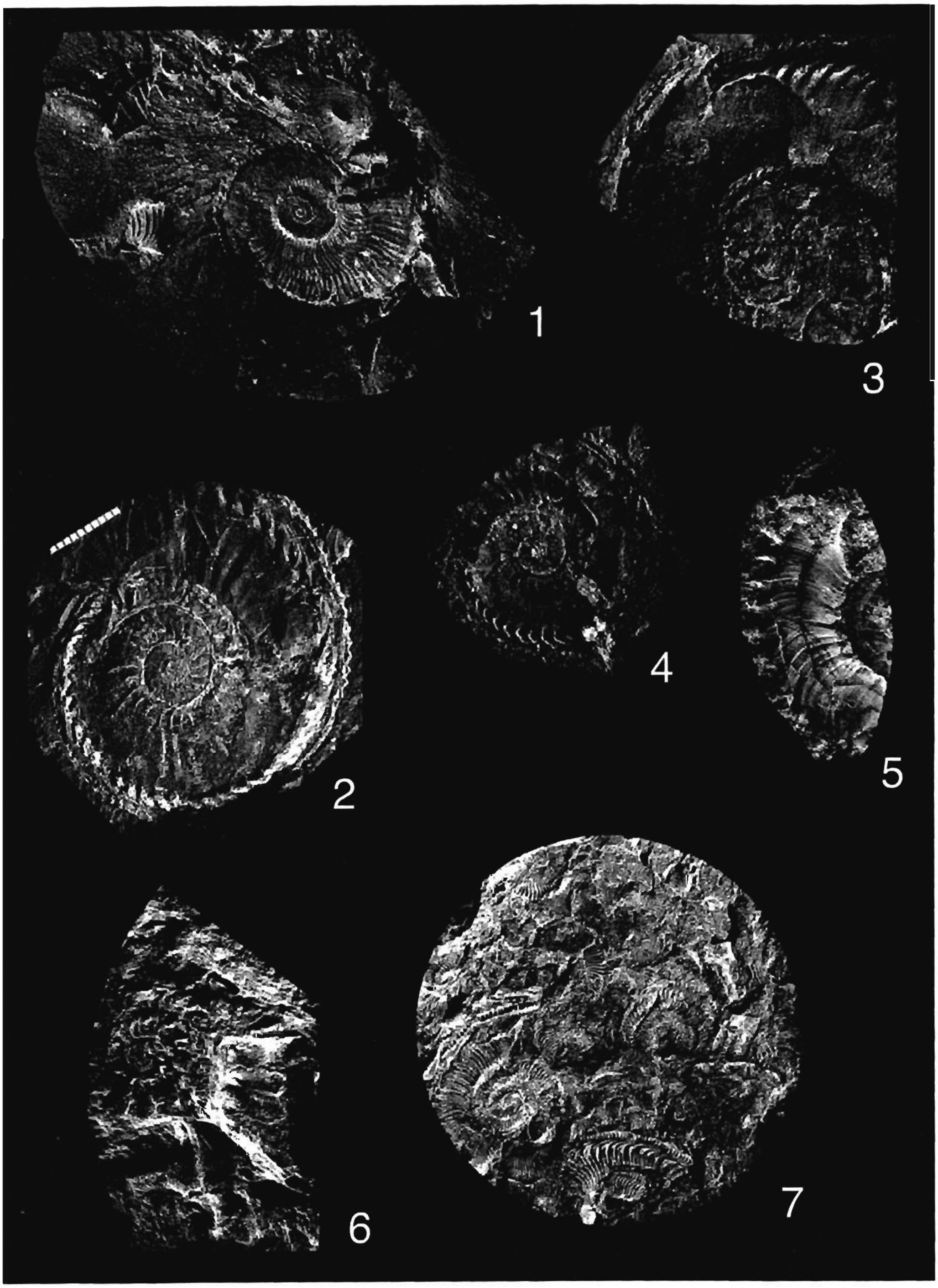
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PLATE 14

Aspidoceras and *Discosphinctoides*

1 — *Aspidoceras* ex gr. *caletanum* (OPPEL); Specimen IGPUW/A/32/590; Autissiodorensis Zone, Antoninów-Skorkówka, 131.6 m

2 — *Discosphinctoides* cf. or aff. *subborealis* sp.n.; Specimen IGPUW/A/32/376; Eudoxus-Autissiodorensis uncertainty interval; Bratków, 40.35 m

3 — *Discosphinctoides* cf. or aff. *subborealis* sp.n.; Specimen IGPUW/A/32/370; Eudoxus-Autissiodorensis uncertainty interval; Błogie-Nadzieja, 70.5-6 m

4 — *Discosphinctoides* cf. or aff. *subborealis* sp.n.; Specimen IGPUW/A/32/371; Eudoxus-Autissiodorensis uncertainty interval; Błogie-Nadzieja, 73.0 m

All figures of natural size

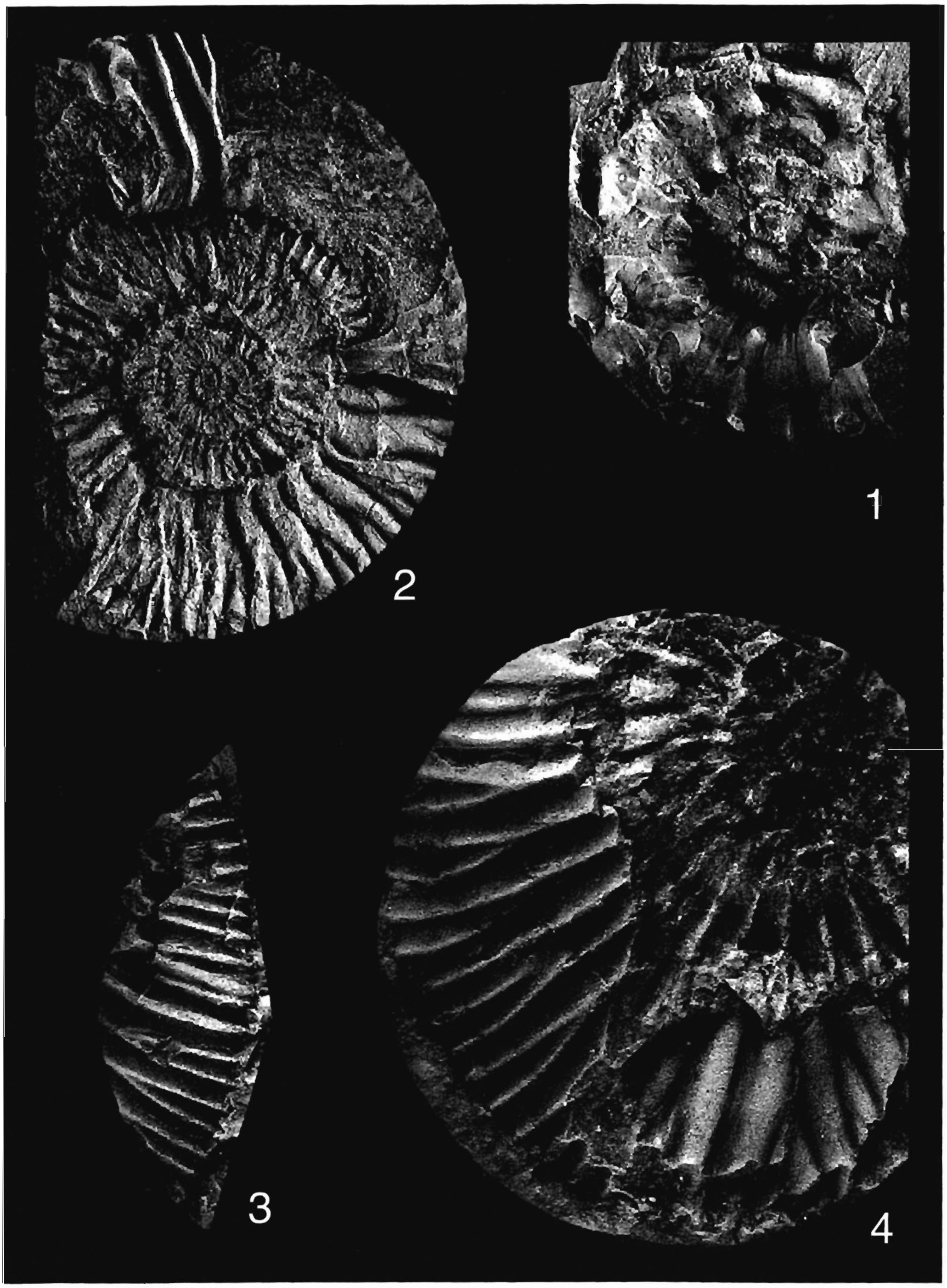
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PLATE 15

Discosphinctoides subborealis sp.n.; Autissiodorensis Zone

1 — Paratype; Specimen IGPUW/A/32/305; Sławno, 47.3 m
2 — Paratype; Specimen IGPUW/A/32/310; Sławno, 47.3 m
3 — Paratype; Specimen IGPUW/A/32/420; Zarzęcin 1, 197.6 m
4 — Paratype; Specimen IGPUW/A/32/412; Bełchatów 5, 778.5-785.1 m I 80 cm
5 — **Holotype**; Specimen IGPUW/A/32/307; Sławno 47.3 m

All figures of natural size

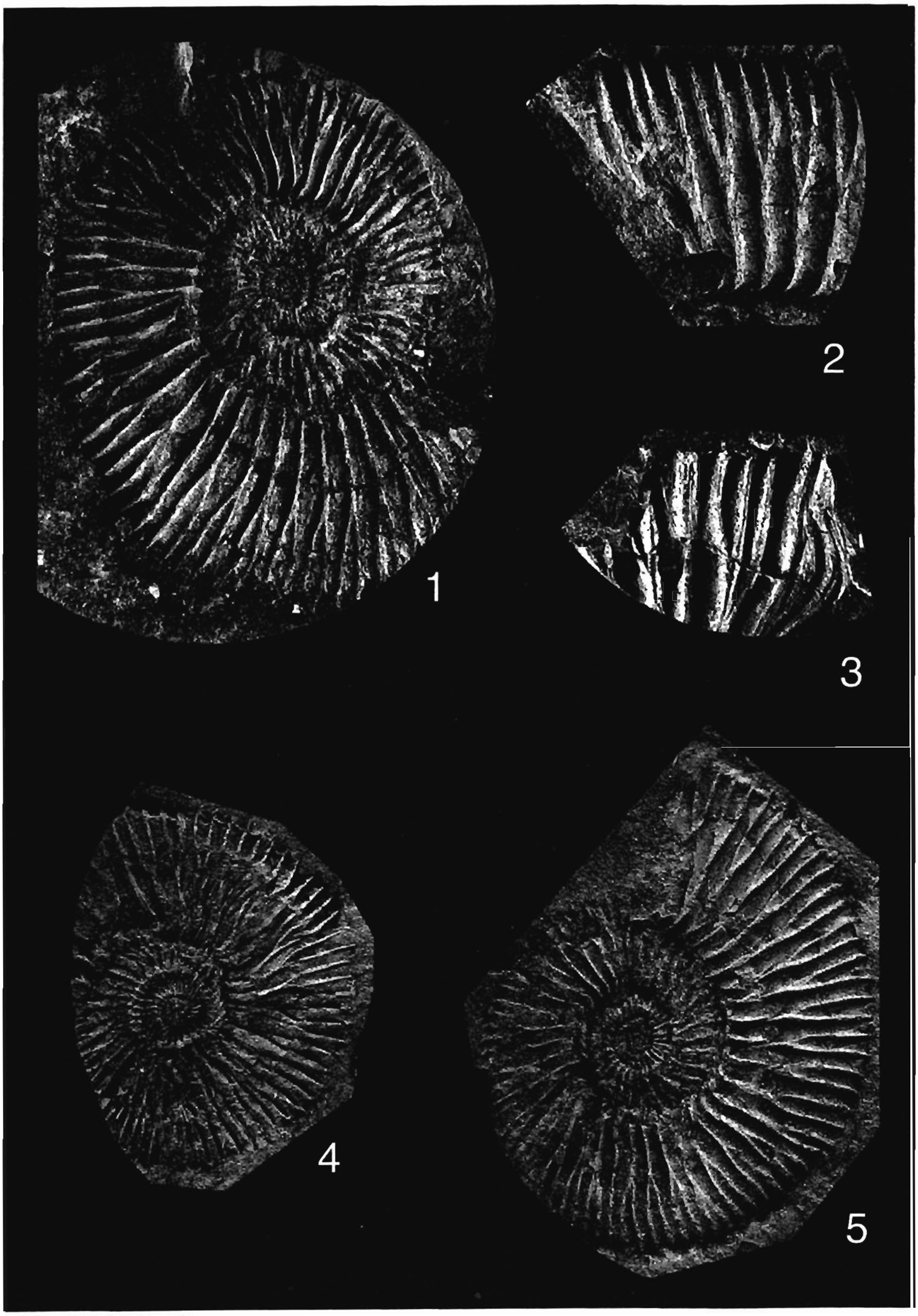
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PLATE 16

Discosphinctoides subborealis sp.n.; Autissiodorensis Zone

1 — Paratype; Specimen IGPUW/A/32/422; Bełchatów 9, 630.0-635.5 m IV 32-40 cm

2 — Paratype; Specimen IGPUW/A/32/389; Bełchatów 4, 557.4-562.2 m III

3 — Paratype; Specimen IGPUW/A/32/206; Zarzęcin 3, 230.0 m

All figures of natural size

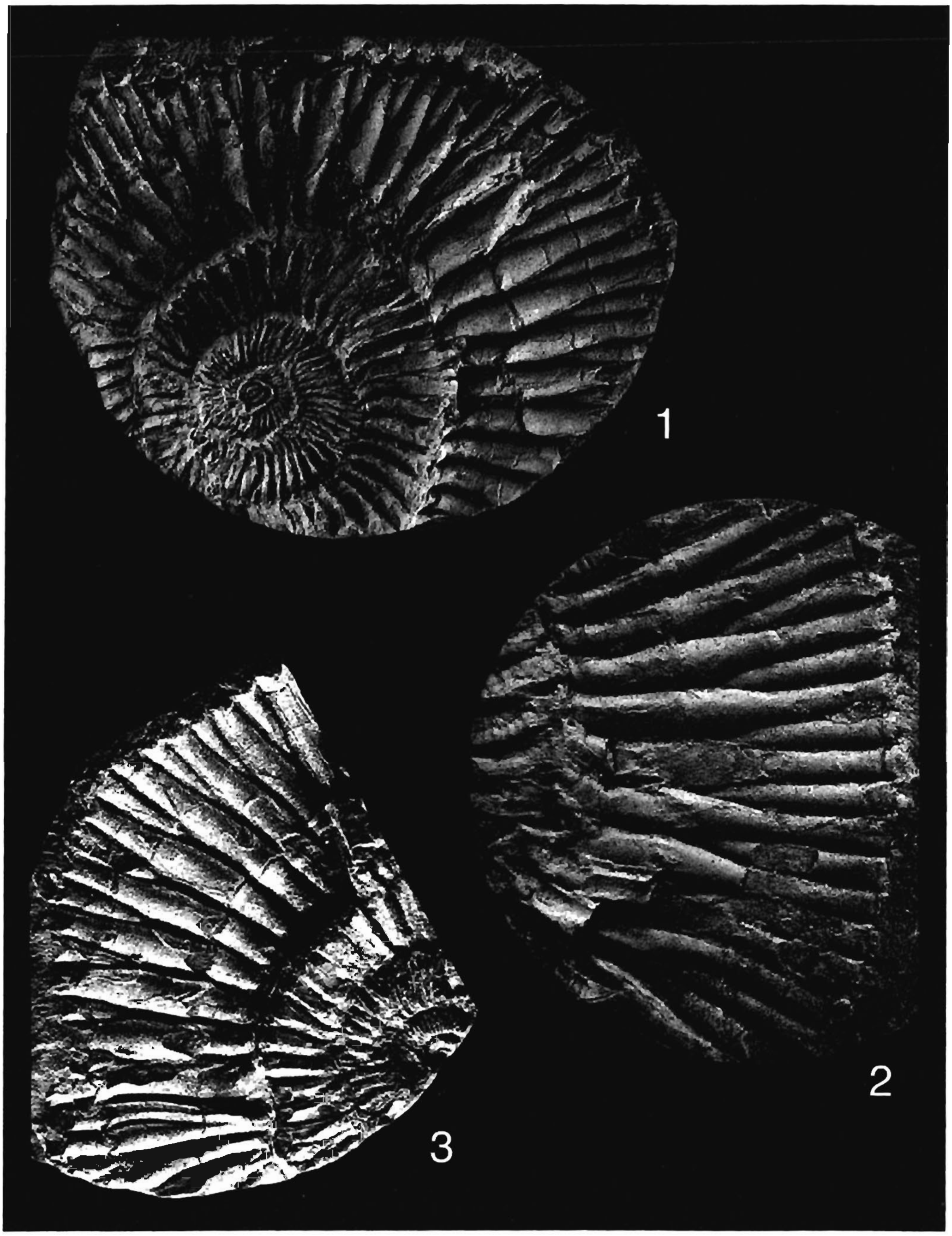
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PLATE 17

Discosphinctoides subborealis sp.n.; Autissiodorensis Zone

1 — Paratype; Specimen IGPUW/A/32/404 (*refigured from* PACHUCKI 1963, Pl. 3, Fig. 1); Bełchatów 5, 771.5-778.5 m V 50 cm

2 — Paratype; Specimen IGPUW/A/32/288; Antoninów-Skorkówka, 129.5 m

All figures of natural size

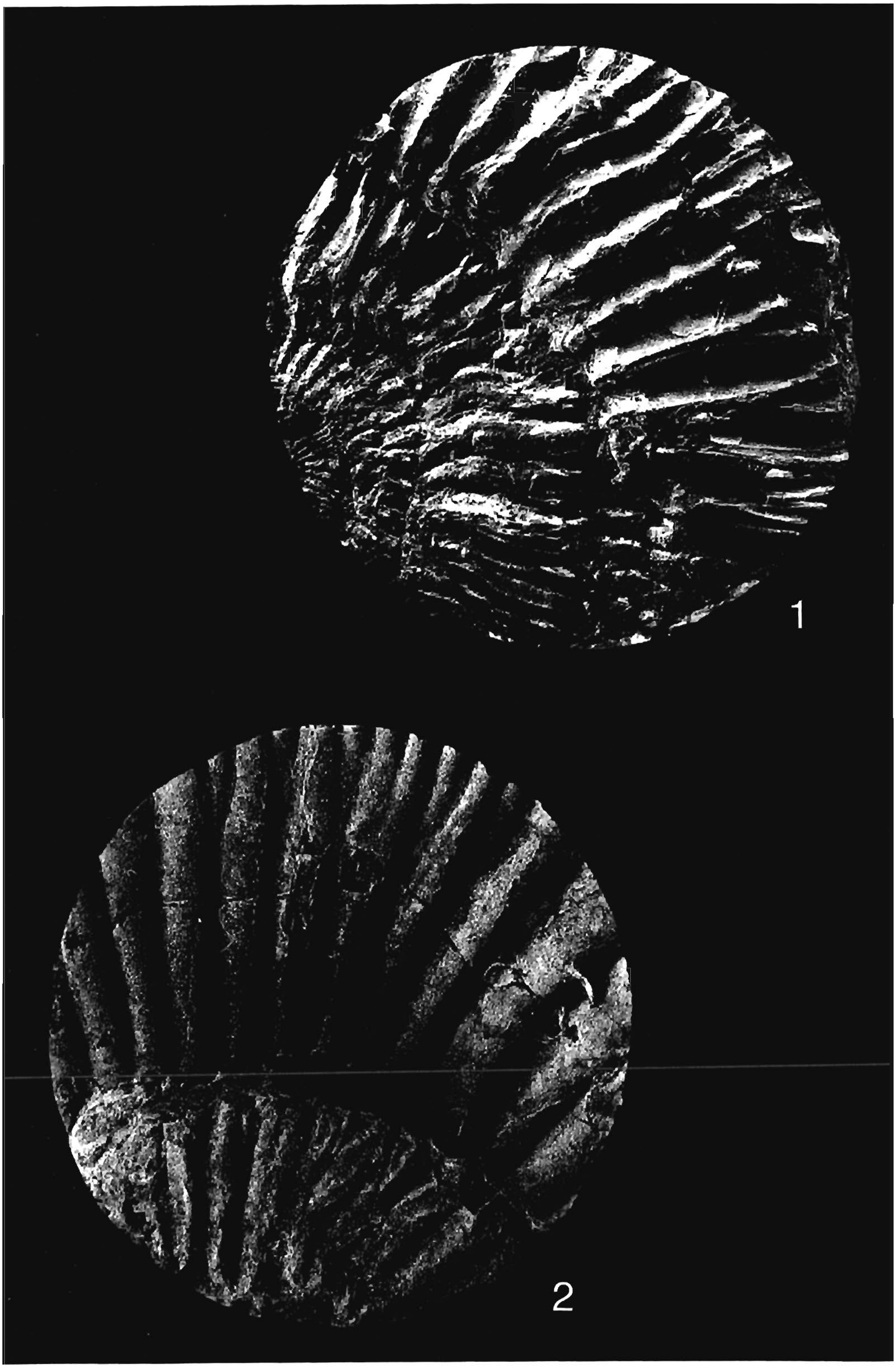
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PLATE 18

Discosphinctoides subborealis sp.n.; Autissiodorensis Zone

1 — Paratype; Specimen IGPUW/A/32/419; Bełchatów 9, 630.0-636.5 m II 60-70 cm

2 — Paratype; Specimen IGPUW/A/32/421; Bratków 26.2 m

3 — Paratype; Specimen IGPUW/A/32/429; Bełchatów 9, 630.0-636.5 m I 90 cm

4 — Paratype; Specimen IGPUW/A/32/409; Bełchatów 5, 771.5-778.5 m III 80 cm

5 — Paratype; Specimen IGPUW/A/32/119; Bełchatów 9, 630.0-636.5 m I 80 cm

All figures of natural size


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PLATE 19

Sarmatisphinctes fallax (ILOVAISKY); Fallax Subzone

1 — Specimen lost; Bełchatów 6, 539.0-545.0 m I 70 cm
2 — Specimen IGPUW/A/32/272; Antoninów-Skorkówka, 117.0 m
3 — Specimen IGPUW/A/32/317; Sławno, 42.2-3 m
4 — Specimen IGPUW/A/32/312; Sławno, 40.7 m
5 — Specimen IGPUW/A/32/235, Zarzęcin 3, 222.0-20 m

All figures of natural size

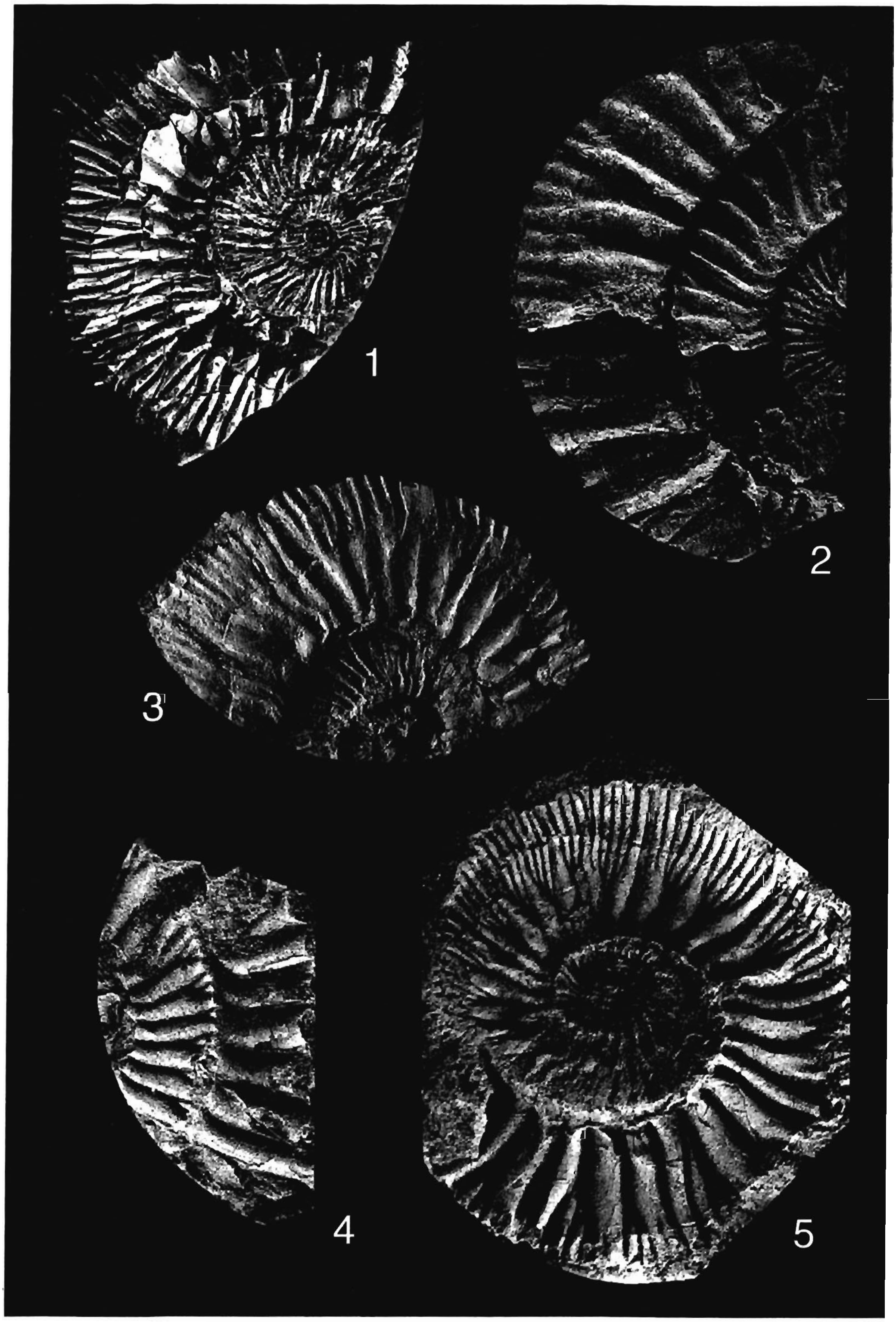
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PLATE 20

Sarmatisphinctes fallax (ILOVAISKY); Fallax Subzone

1 — Specimen IGPUW/A/32/244; Zarzęcin 1, 190.1 m
2 — Specimen IGPUW/A/32/270; Błogie-Nadzieja, 39.5 m
3 — Specimen IGPUW/A/32/241; Zarzęcin 1, 191.8 m
4 — Specimen IGPUW/A/32/240 (counterpart of specimen IGPUW/A/32/241); Zarzęcin 1, 192.0 m
5 — Specimen IGPUW/A/32/342; Błogie-Nadzieja, 39.9 m
6 — Specimen IGPUW/A/32/270; Antoninów-Skorkówka, 115.35 m

All figures of natural size

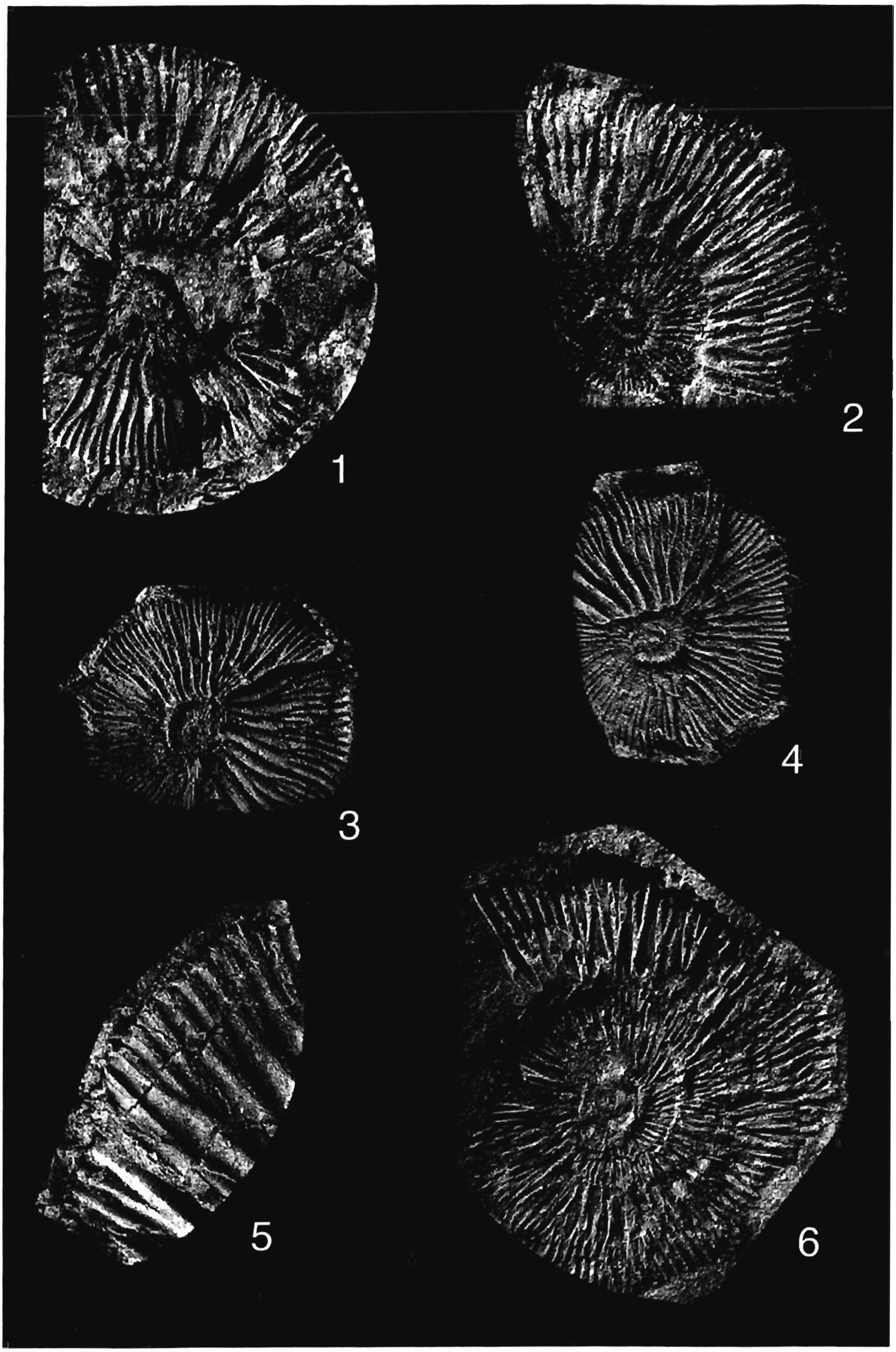
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PLATE 21

Sarmatisphinctes fallax (ILOVAISKY); Fallax Subzone

1 — Specimen IGPUW/A/32/335; Sławno, 41.10-15 m
2 — Specimen IGPUW/A/32/234; Zarzęcin 3, 220.0-30 m
3 — Specimen IGPUW/A/32/237; Zarzęcin 1, 191.0 m
4 — Specimen IGPUW/A/32/333; Błogie-Nadzieja, 39.9 m

All figures of natural size

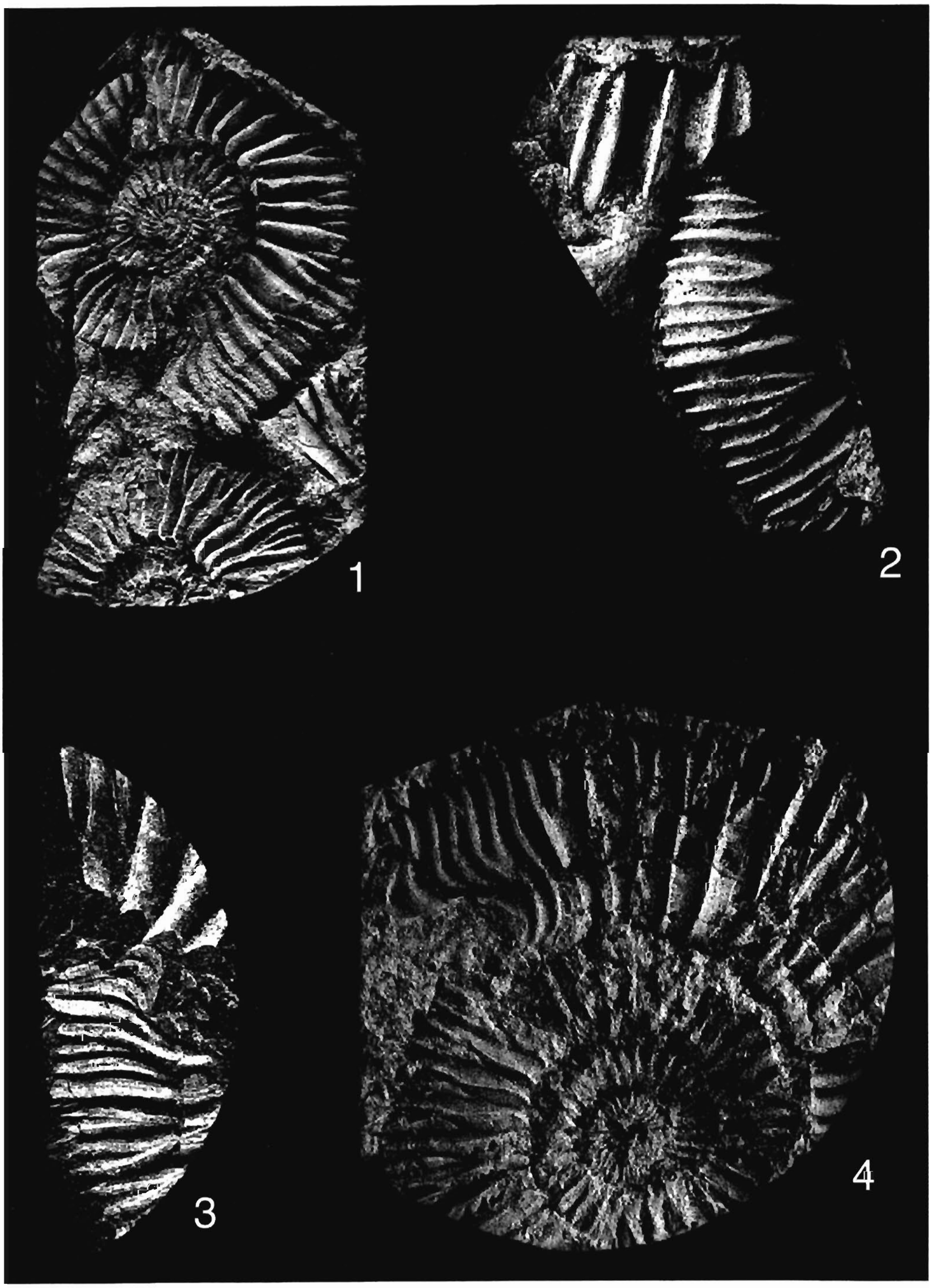
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PLATE 22

Sarmatisphinctes fallax (ILOVAISKY); Fallax Subzone

1 — Specimen IGPUW/A/32/564; Tuszyn 2, 902.0-907.2 m IV
2 — Specimen IGPUW/A/32/570; Tuszyn 2, 902.0-907.2 m IV
3 — Specimen IGPUW/A/32/569; Tuszyn 2, 902.0-907.2 m IV 60 cm
4 — Specimen IGPUW/A/32/565; Tuszyn 2, 902.0-907.2 m IV
5 — Specimen IGPUW/A/32/562; Tuszyn 2, 902.0-907.2 m IV 60 cm
6 — Specimen IGPUW/A/32/570; Tuszyn 2, 902.0-907.2 m IV

All figures of natural size

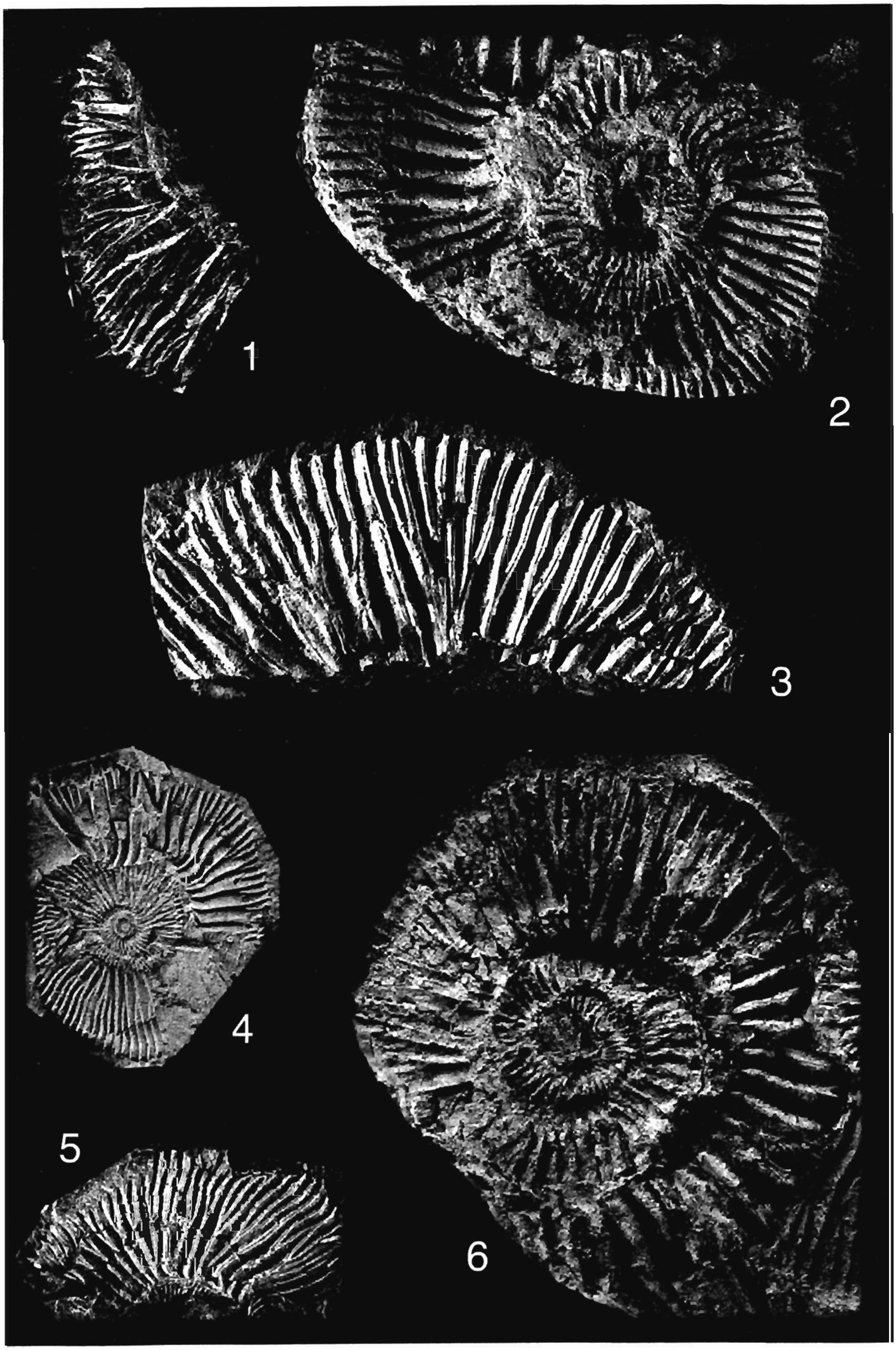
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PLATE 23

Ilowaiskya klimovi (ILOVAISKY); Klimovi Zone

1 — Specimen IGPUW/A/32/326; Sławno, 35.2 m
2 — Specimen IGPUW/A/32/252; Zarzęcin 3, 217.0 m
3 — Specimen IGPUW/A/32/266; Antoninów-Skorkówka, 110.4-5 m
4 — Specimen IGPUW/A/32/258; Antoninów-Skorkówka, 109.3 m
5 — Specimen IGPUW/A/31/17; Stobnica 37

All figures of natural size

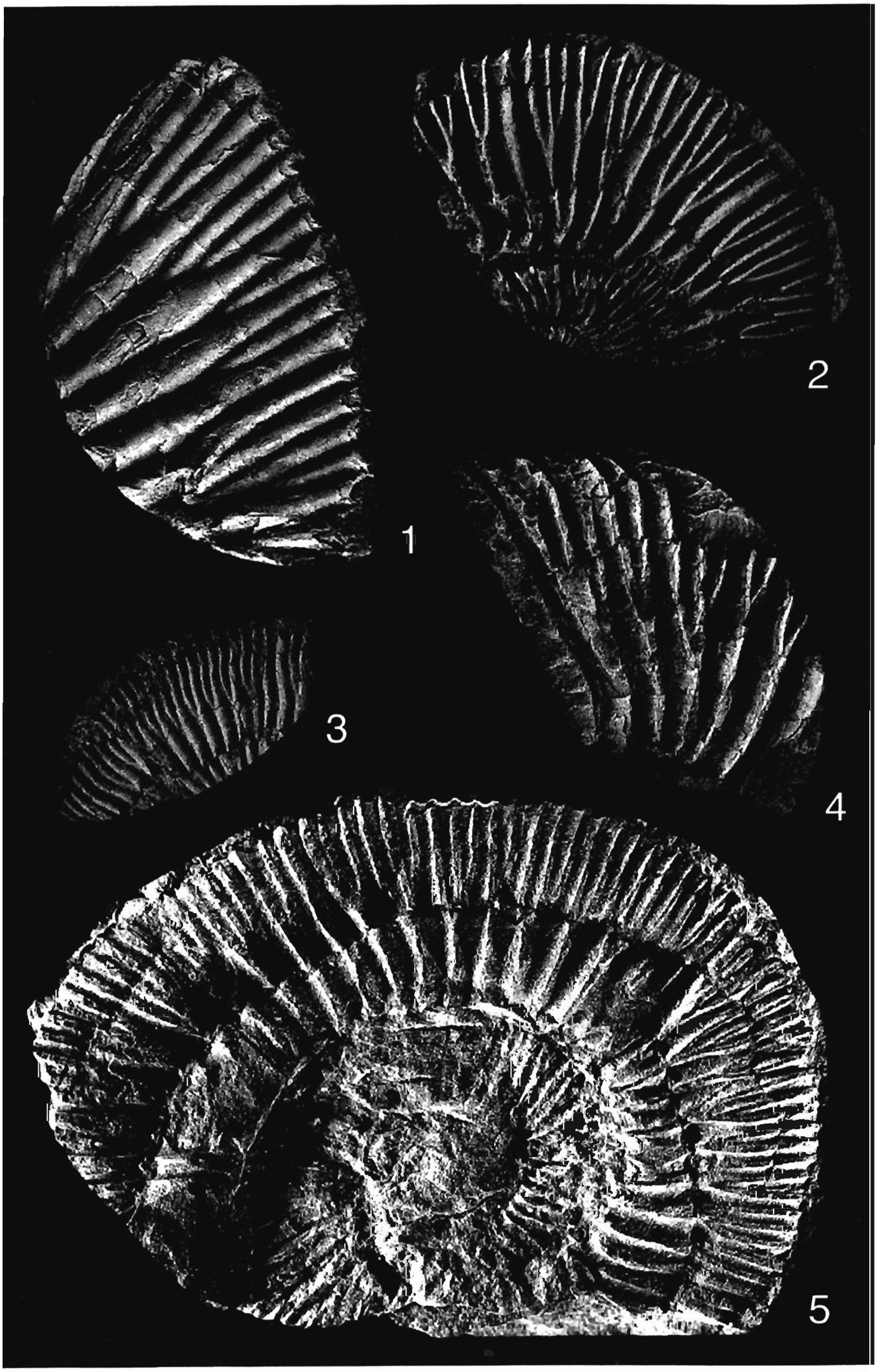
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PLATE 24

Ilowaiskya klimovi (ILOVAISKY); Klimovi Zone

1 — Specimen IGPUW/A/32/282; Zarzęcin 1, 189.4 m
2 — Specimen IGPUW/A/32/228 (counterpart of specimen IGPUW/A/32/282); Zarzęcin 1, 189.4 m
3 — Specimen IGPUW/A/32/248; Zarzęcin 1, 184.0 m
4 — Specimen IGPUW/A/32/263; Zarzęcin 1, 185.9 m
5 — Specimen IGPUW/A/32/263; Antoninów-Skorkówka, 111.4 m
6 — Specimen IGPUW/A/32/266; Antoninów-Skorkówka 110.4-5 m
7 — Specimen IGPUW/A/32/247; Zarzęcin 3, 220.0 m

All figures of natural size

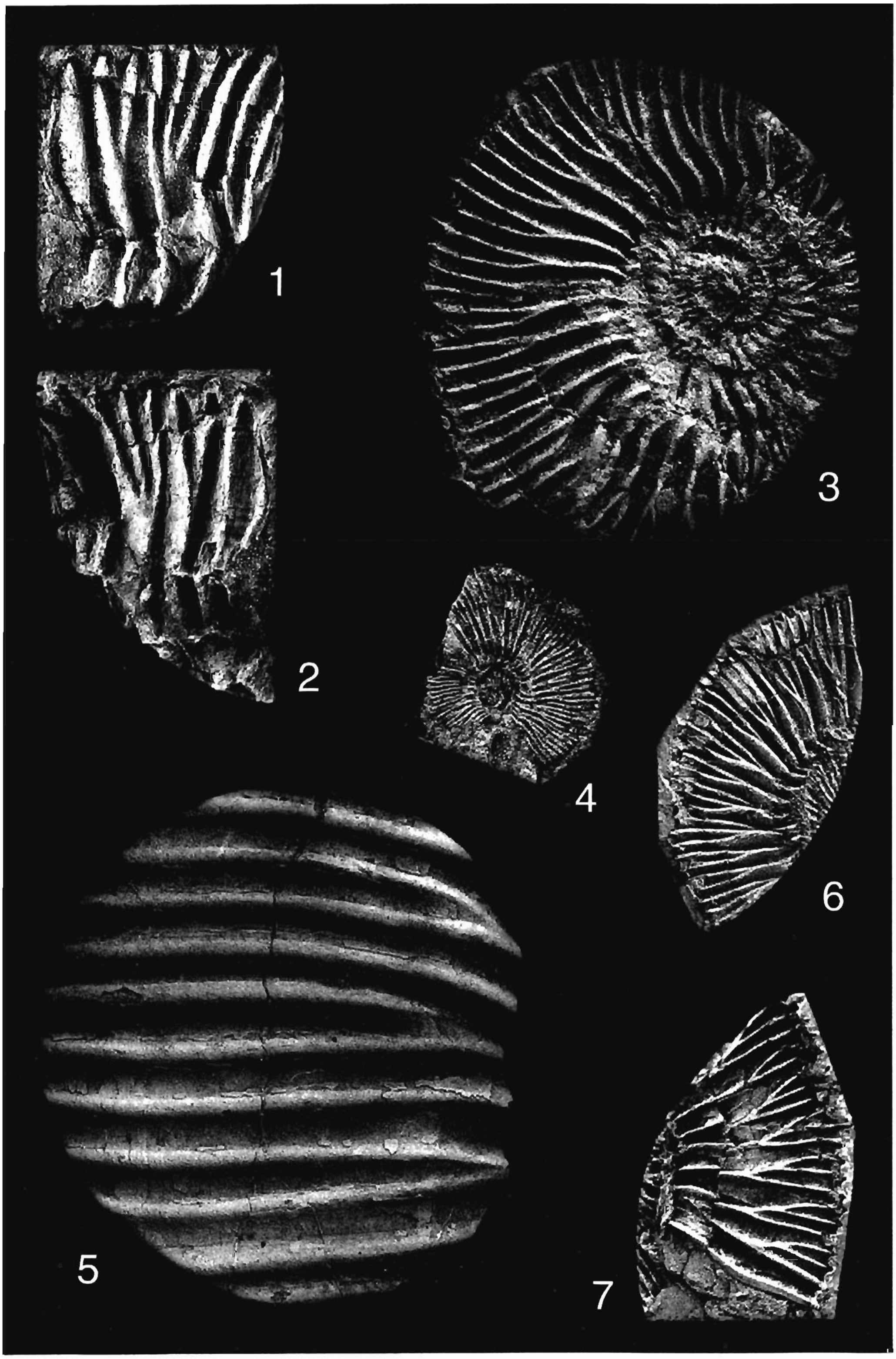
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PLATE 25

Ilowaiskya sokolovi (ILOVAISKY); Sokolovi Zone; Stobnica 20

1 — Specimen IGPUW/A/31/28 (*refigured from* KUTEK 1961, Pl. 19, Fig. 3)

2 — Specimen IGPUW/A/31/33 (*refigured from* KUTEK 1961, Pl. 19, Fig. 1)

3 — Specimen IGPUW/A/31/32 (*refigured from* KUTEK 1961, Pl. 20, Fig. 1)

All figures of natural size

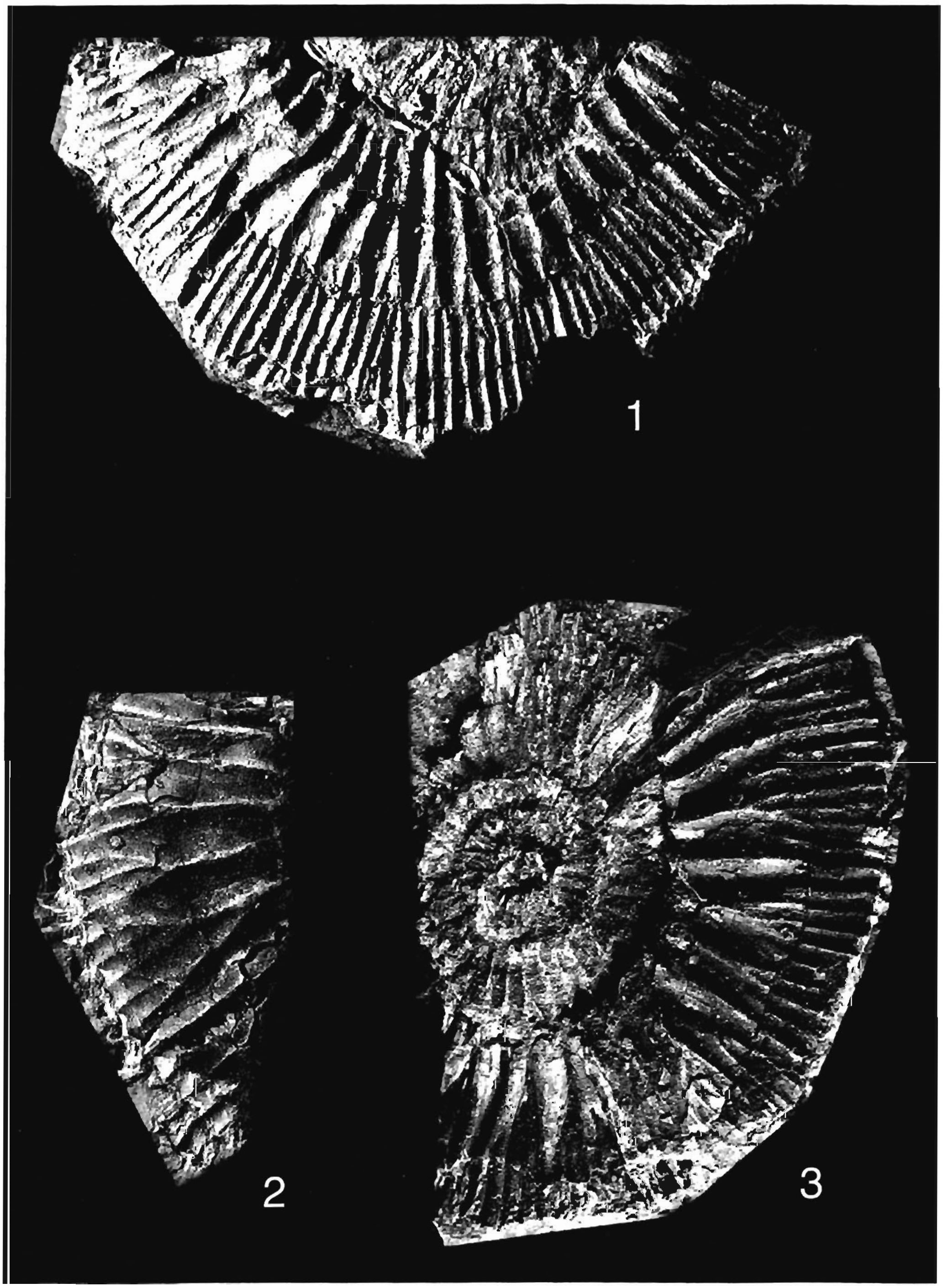
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PLATE 26

Ilowaiskya sokolovi (ILOVAISKY); Sokolovi Zone

1 — Specimen IGPUW/A/32/491; Błogie-Nadzieja, 27.5 m
2 — Specimen IGPUW/A/32/549; Zarzęcin 1, 174.5-175.5 m
3 — Specimen IGPUW/A/32/494; Antoninów-Skorkówka, 103.2 m
4 — Specimen IGPUW/A/32/264; Antoninów-Skorkówka, 104.1 m

All figures of natural size

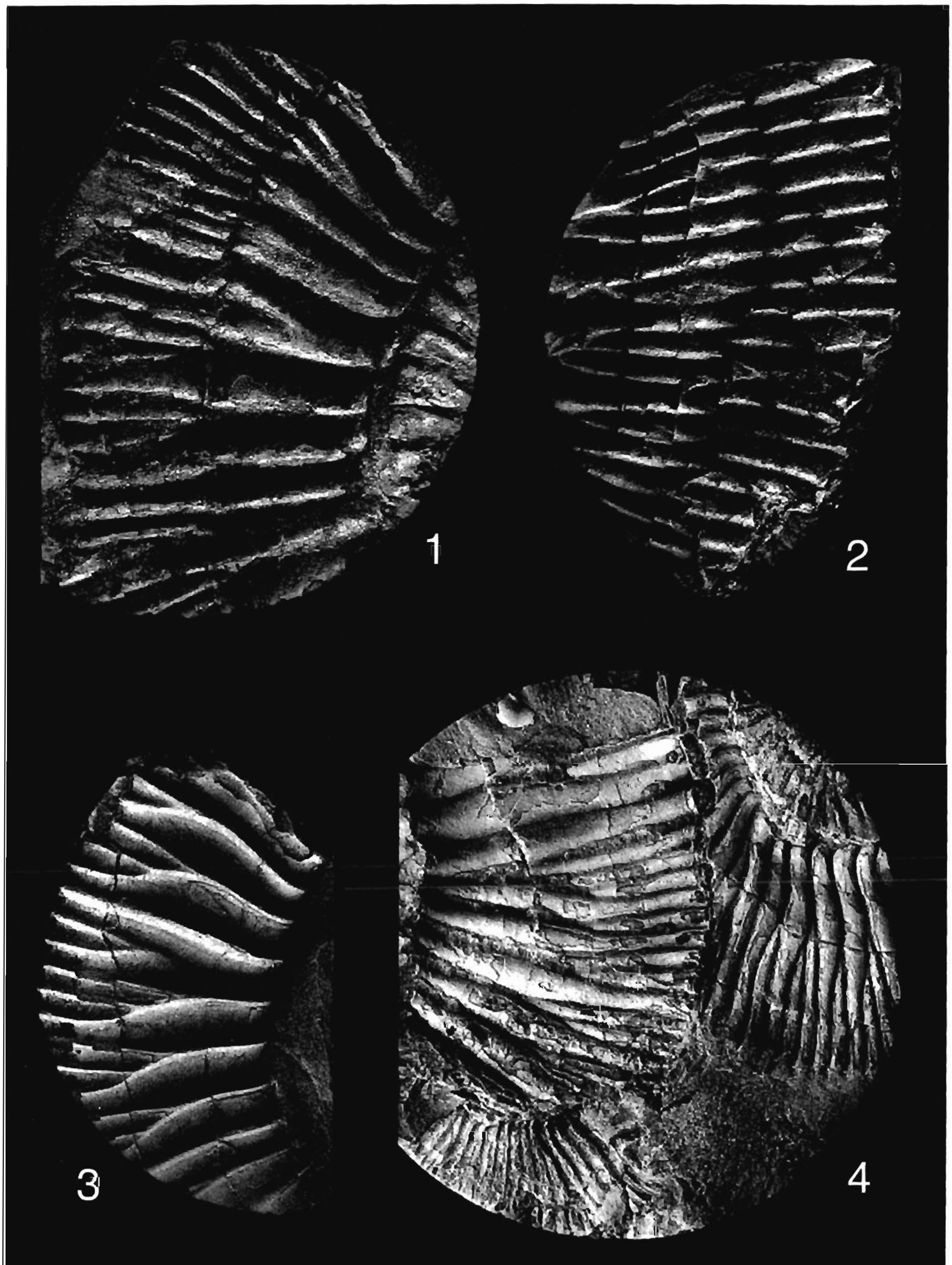
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PLATE 27

Ilowaiskya; Sokolovi Zone

1 — *Ilowaiskya pavida* (ILOVAISKY); Specimen IGPUW/A/32/489; Antoninów-Skorkówka, 92.3 m

2 — *Ilowaiskya pavida* (ILOVAISKY); Specimen IGPUW/A/32/487; Antoninów-Skorkówka, 92.3 m

3 — *Ilowaiskya* cf. *pavida* (ILOVAISKY); Specimen IGPUW/A/32/485; Antoninów-Skorkówka, 94.3 m

4 — *Ilowaiskya sokolovi* (ILOVAISKY); Specimen IGPUW/A/32/482; Błogie-Nadzieja, 25.55 m

All figures of natural size

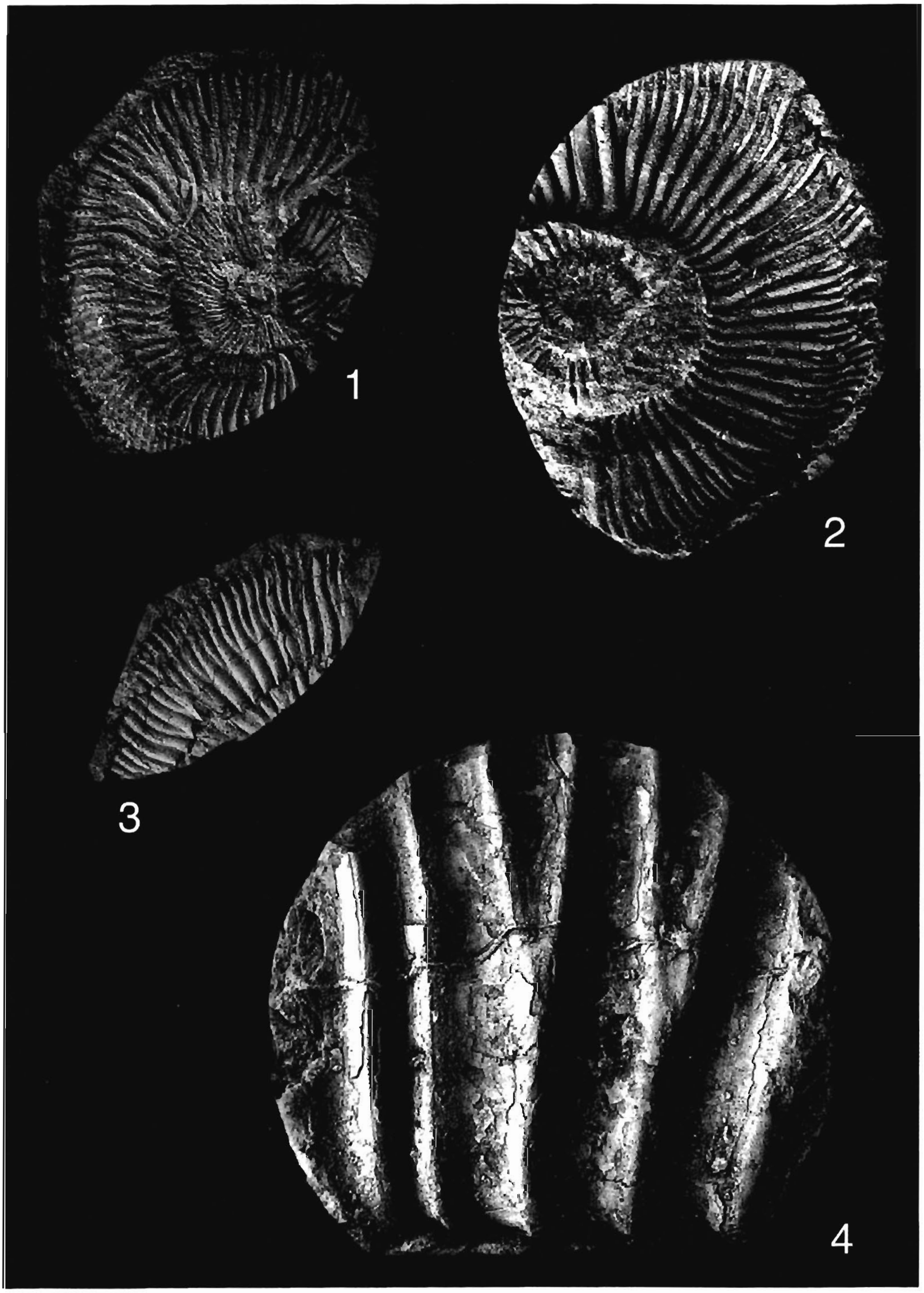
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PLATE 28

Taramelliceras cf. or aff. *subnudatum* (FONTANNES); Autissiodorensis Zone

1 — Specimen IGPUW/A/32/147; Antoninów-Skorkówka, 124.1-7 m
2 — Specimen IGPUW/A/32/153 (counterpart of specimen IGPUW/A/32/153); Antoninów-Skorkówka, 124.1-7 m
3 — Specimen IGPUW/A/32/143; Błogie-Nadzieja, 47.7 m
4 — Specimen IGPUW/A/32/134; Bełchatów 6, 555.0-554.2 m II 70 cm
5 — Specimen IGPUW/A/32/145; Zarzęcin 1, 197.0-198.0 m
6 — Specimen IGPUW/A/32/139; Antoninów-Skorkówka, 124.1-7 m
7 — Specimen IGPUW/A/32/155; Bełchatów 5, 778.5-785.1 m V
8 — Specimen lost; Tuszyn 3, 1144.4-1147.4 m II

All figures of natural size

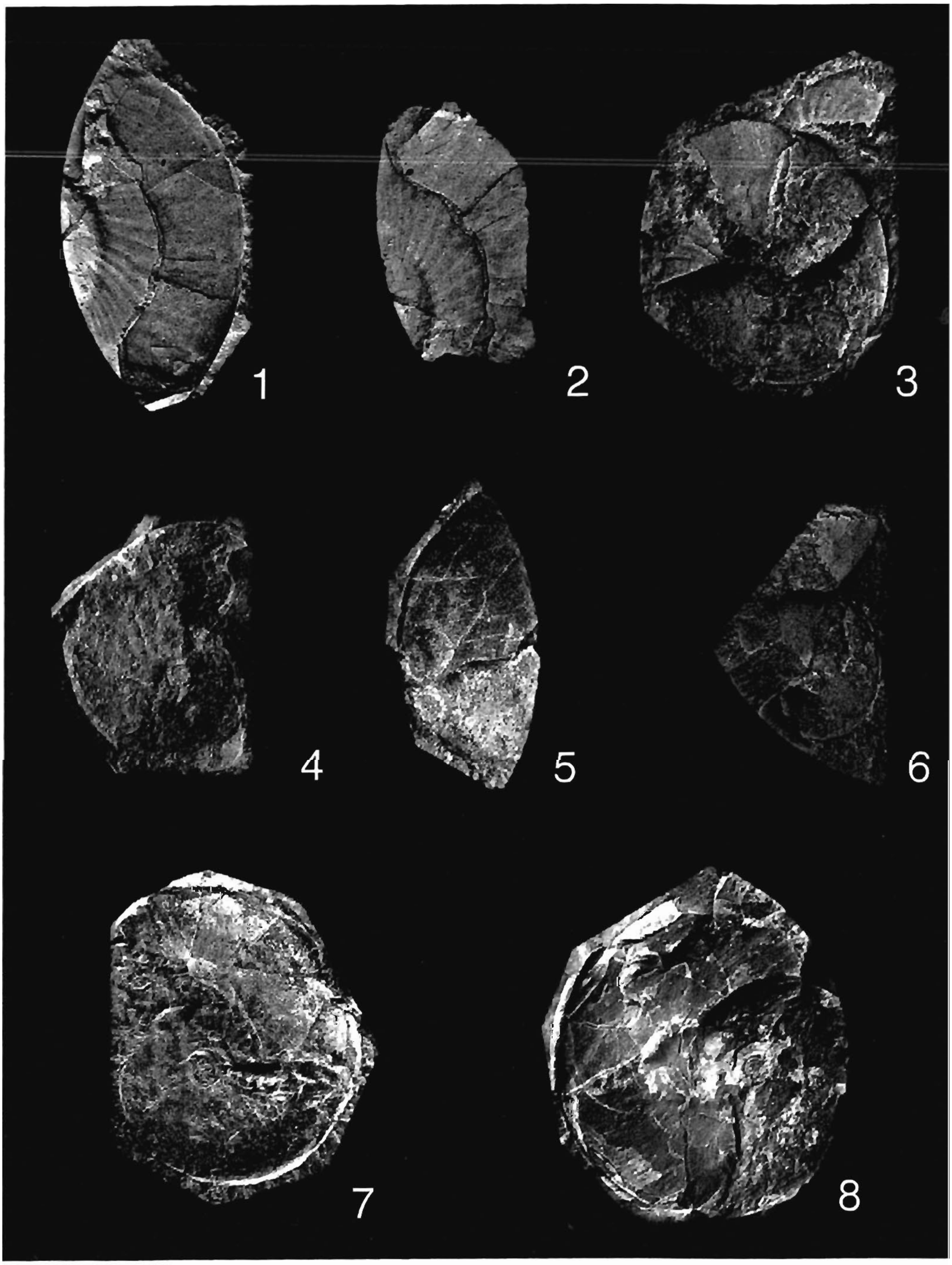

PLATE 29

Neochetoceras; Klimovi Zone

1 — ? *Neochetoceras* sp.; Specimen IGPUW/A/32/175, × 1; Sławno, 38.1 m

2 — *Neochetoceras steraspis* (OPPEL); Specimen IGPUW/A/32/595, × 1; Zarzęcin 1, 183.0 m

3 — Same specimen, × 2

4 — *Neochetoceras steraspis* (OPPEL); Specimen IGPUW/A/32/132, × 1; Bełchatów 5, 765.5-771.5 m II 30 cm

5 — *Neochetoceras steraspis* (OPPEL); Specimen IGPUW/A/32/170, × 1; Antoninów-Skorkówka 106.8 m

6 — *Neochetoceras steraspis* (OPPEL); Specimen IGPUW/A/32/170 (pars), × 2; Antoninów-Skorkówka, 106.8 m

7 — *Neochetoceras steraspis* (OPPEL); Specimen IGPUW/A/32/170 (pars), × 2; Antoninów-Skorkówka, 106.8 m

8 — *Neochetoceras steraspis* (OPPEL); Specimen IGPUW/A/32/170 (pars), × 2; Antoninów-Skorkówka, 106.8 m

9 — *Neochetoceras mucronatum* BERCKHEMER & HÖLDER; Specimen IGPUW/A/32/596, × 1; Zarzęcin 1, 183.1 m

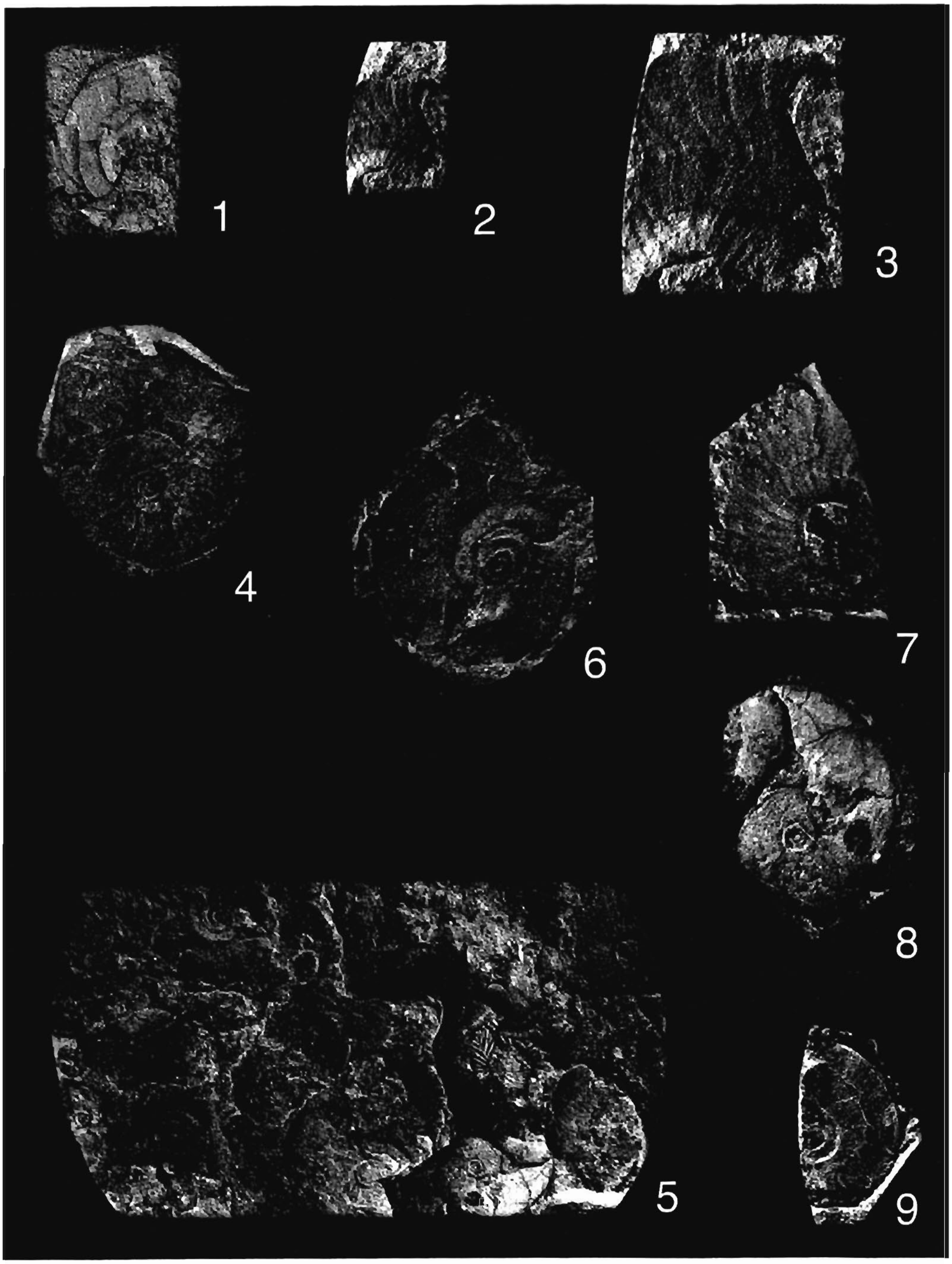
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PLATE 30

Neochetoceras mucronatum BERCKHEMER & HÖLDER; Sokolovi Zone

1 — Specimen IGPUW/A/32/185; Błogie-Nadzieja, 23.6-8 m
2 — Specimen IGPUW/A/32/189; Błogie-Nadzieja, 23.5 m
3 — Specimen IGPUW/A/32/166; Sławno, 23.7 m
4 — Specimen IGPUW/A/32/178; Sławno, 25.7 m
5 — Specimen IGPUW/A/32/184a; Błogie-Nadzieja, 23.6-8 m
6 — Specimen IGPUW/A/32/184b (counterpart of specimen IGPUW/A/32/184a); Błogie-Nadzieja, 23.6-8 m
7 — Specimen IGPUW/A/32/167; Sławno, 25.7 m
8 — Specimen IGPUW/A/32/587; Antoninów-Skorkówka, 101.7 m
9 — Specimen IGPUW/A/32/195; Błogie-Nadzieja, 25.6-9 m
10 — Specimen IGPUW/A/31/3 (*refigured from* KUTEK 1961, Pl. 20, Fig. 3); Stobnica 39

All figures of natural size

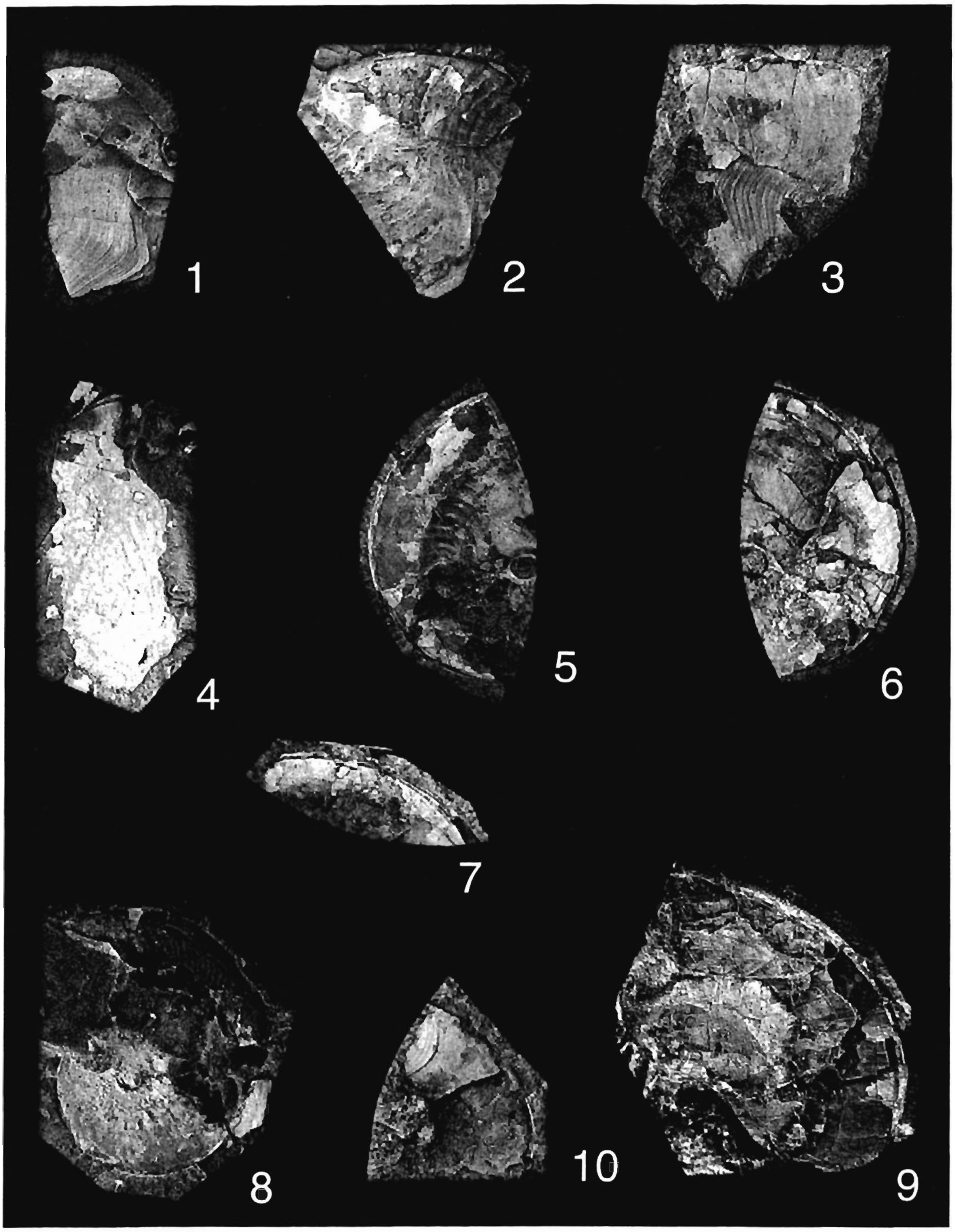
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PLATE 31

Sutneria and Haploceratacea

1 — *Sutneria* cf. or aff. *bracheri* BERCKHEMER; Specimen IGPUW/A/32/133, × 2; Klimovi Zone; Antoninów-Skorkówka, 106.8 m

2 — Same specimen, × 1

3 — *Sutneria* cf. or aff. *bracheri* BERCKHEMER; Specimen IGPUW/A/32/168 (counterpart of specimen IGPUW/A/32/133), × 2; Klimovi Zone; Antoninów-Skorkówka, 106.8 m

4 — *Sutneria* cf. or aff. *bracheri* BERCKHEMER; Specimen IGPUW/A/32/598, × 3; Klimovi Zone; Bełchatów 5, 765.5-771.5 m

5 — *Ochetoceras* or *Taramelliceras* (**5a**); *Neochetoceras mucronatum* BERCKHEMER & HÖLDER (**5b**); Specimen IGPUW/A/31/4 (*refigured from* KUTEK 1961, Pl. 20, Fig. 2), × 1; Sokolovi Zone; Stobnica 39

6 — *Ochetoceras* or *Taramelliceras*; Specimen IGPUW/A/32/188, × 2; Sokolovi Zone; Błogie-Nadzieja, 18.9-19.0 m

7 — *Ochetoceras* or *Taramelliceras*; Specimen IGPUW/A/32/196, × 1; Sokolovi Zone; Błogie-Nadzieja, 20.5 m

8 — *Glochiceras solenoides* (QUENSTEDT); Specimen IGPUW/A/32/142, × 2; Autissiodorensis Zone; Zarzęcin 1, 201.0-202.0 m

9 — Same specimen, × 1

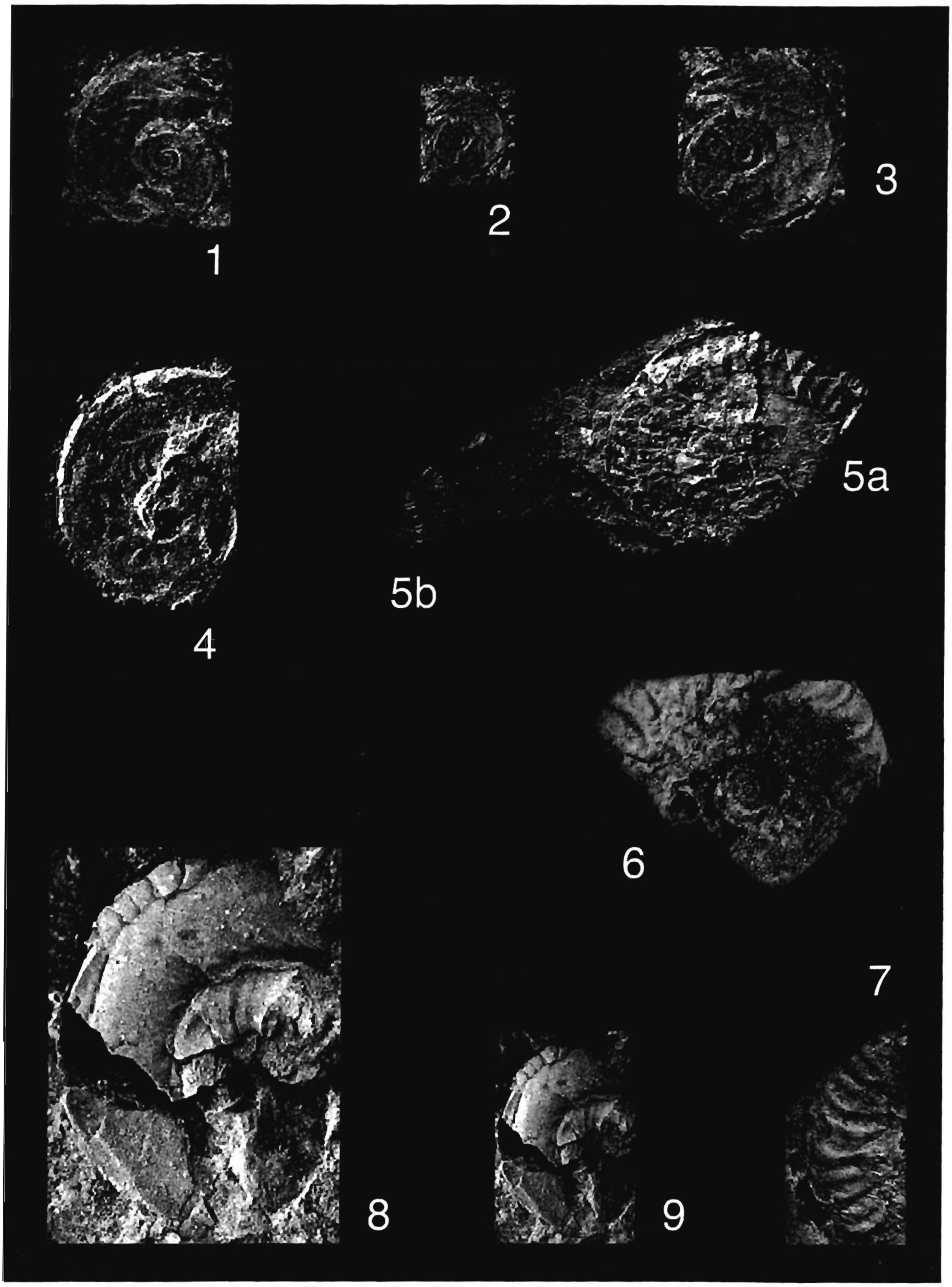
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PLATE 32

*Ilowaiskya ianschini (*ILOVAISKY); Pseudoscythica Zone

1 — Specimen IGPUW/A/32/493; Zarzęcin 3, 196.5 m
2 — Specimen IGPUW/A/32/495; Zarzęcin 3, 196.5 m
3 — Specimen IGPUW/A/32/488; Błogie-Nadzieja, 16.3 m
4 — Specimen IGPUW/A/32/501; Błogie-Nadzieja, 13.6 m

All figures of natural size

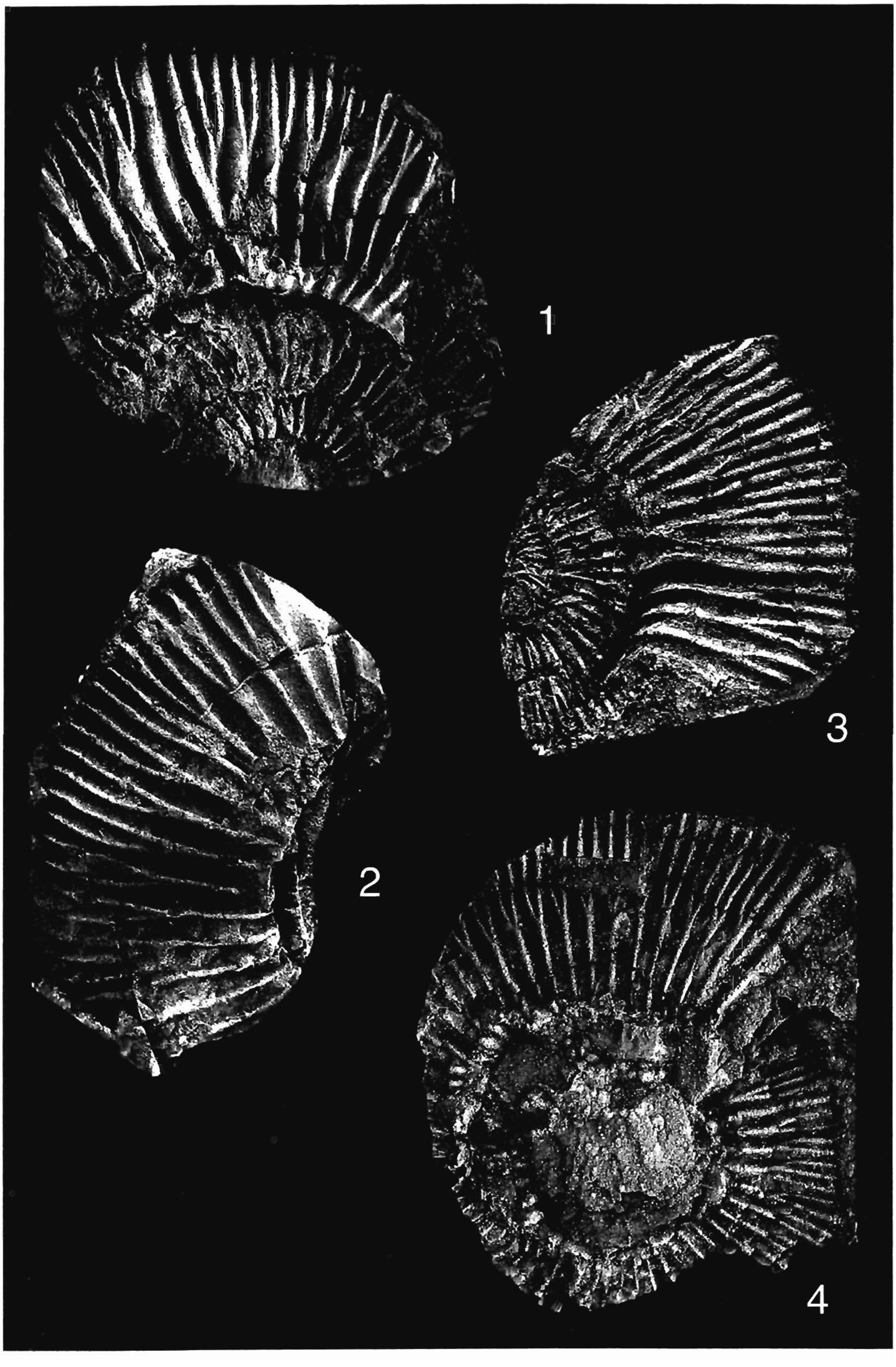
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PLATE 33

Ilowaiskya pseudoscythica (ILOVAISKY); Pseudoscythica Zone

1 — Specimen IGPUW/A/32/536; Antoninów-Skorkówka, 84.5 m
2 — Specimen IGPUW/A/32/480; Błogie-Nadzieja, 9.11 m
3 — Specimen IGPUW/A/32/481; Błogie-Nadzieja, 8.45 m
4 — Specimen IGPUW/A/32/537; Zarzęcin 1, 154.0 m

All figures of natural size

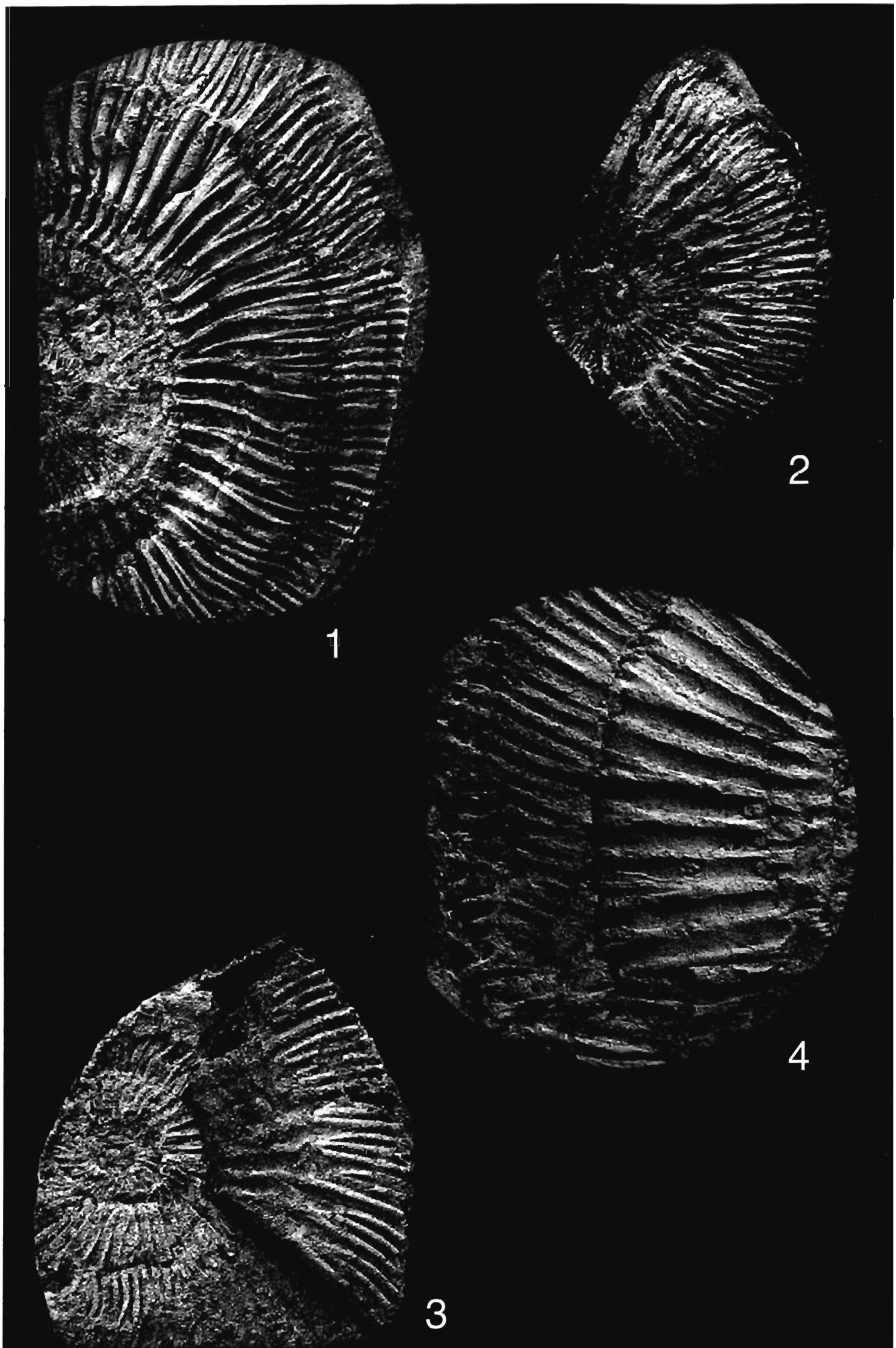
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PLATE 34

Ilowaiskya; Pseudoscythica and Tenuicostata Zones

1 — *Ilowaiskya pseudoscythica* (ILOVAISKY); Specimen lost; Pseudoscythica Zone; Tuszyn 3, 1091.1-1096.7 m III

2 — *Ilowaiskya pseudoscythica* (ILOVAISKY); Specimen IGPUW/A/32/543; Pseudoscythica Zone; Zarzęcin 1, 154.0 m

3 — *Ilowaiskya schaschkovae* (ILOVAISKY); Specimen IGPUW/A/32/561; Pseudoscythica Zone; Zarzęcin 3, 181.6 m

4 — *Ilowaiskya tenuicostata* (MICHAILOV); Specimen IGPUW/A/32/568; Tenuicostata Zone; Antoninów-Skorkówka, 71.5 m

All figures of natural size

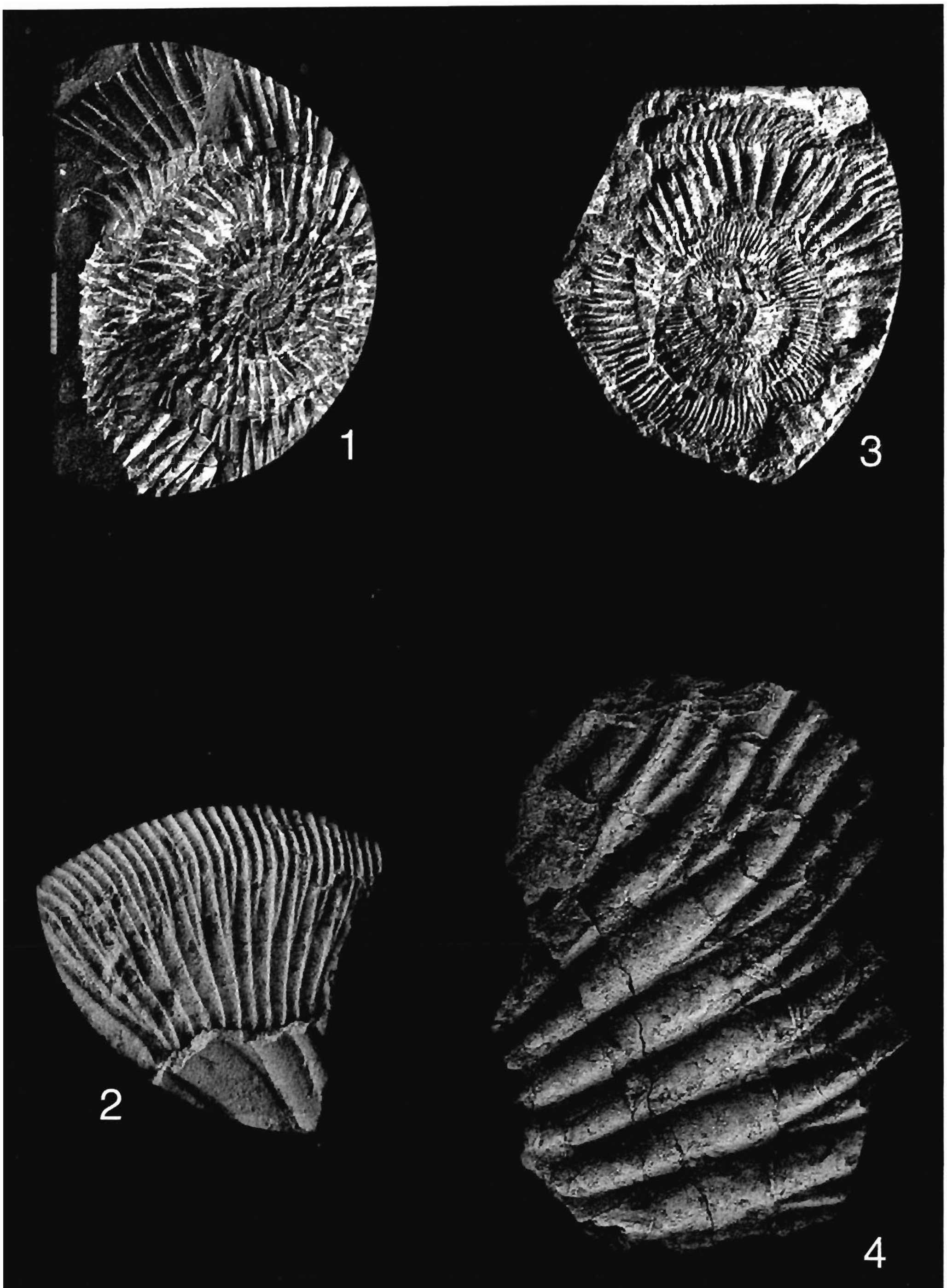
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PLATE 35

Ammonites from the Tenuicostata Zone; Brzostówka, a-1

1 — *Pseudovirgatites passendorferi* KUTEK & ZEISS, refigured from KUTEK & ZEISS (1974, Pl. 8, Fig. 1)

2 — *Ilowaiskya tenuicostata* (MICHAILOV); specimen KB.1.5

All figures of natural size

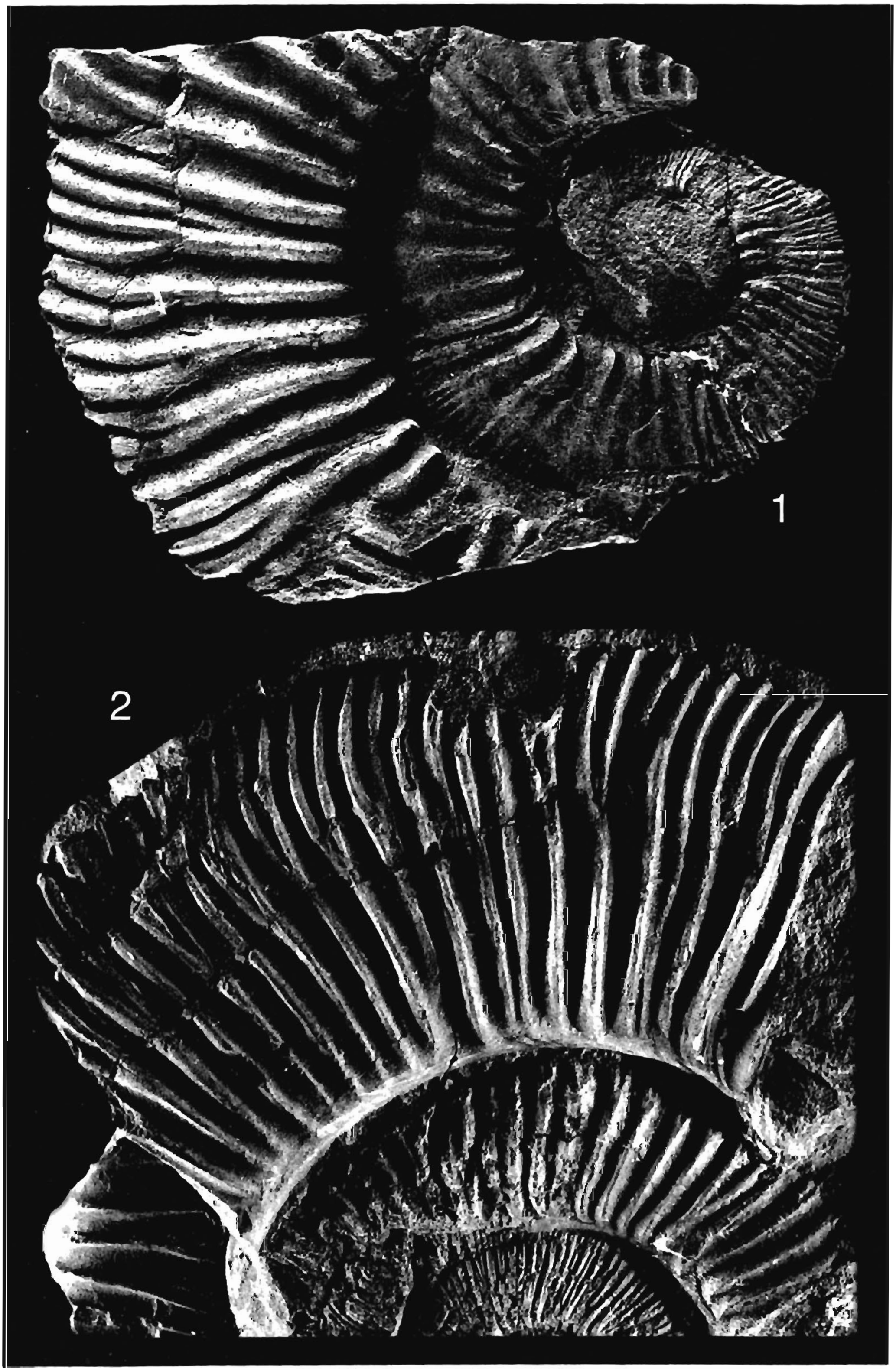
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PLATE 36

Ammonites from the Tenuicostata Zone

1 — *Isterites spurius* (SCHNEID), refigured from KUTEK & ZEISS (1974, Pl. 19, Fig. 2); Brzostówka, a-2

2 — *Ilowaiskya tenuicostata* (MICHAILOV), refigured from KUTEK & ZEISS (1974, Pl. 1); Brzostówka, a-1

All figures of natural size


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PLATE 37

Isterites; Tenuicostata Zone and Quenstedti Horizon

1 — *Isterites subpalmatus* (SCHNEID), refigured from KUTEK & ZEISS (1974, Pl. 18, Fig. 1); Tenuicostata Zone; Brzostówka, a-2

2 — *Isterites masoviensis* KUTEK & ZEISS, refigured from KUTEK & ZEISS (1974, Pl. 20, Fig. 1); Quenstedti Horizon; Brzostówka, a-3

3 — *Isterites masoviensis* KUTEK & ZEISS, refigured from KUTEK & ZEISS (1974, Pl. 21, Fig. 1); Quenstedti Horizon, Brzostówka, a-3

4 — *Isterites masoviensis* KUTEK & ZEISS, refigured from KUTEK & ZEISS (1974, Pl. 22, Fig. 2); Quenstedti Horizon; Brzostówka, a-3

All figures of natural size


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PLATE 38

Pseudovirgatites and *Zaraiskites*; Tenuicostata Zone and Quenstedti Horizon

1 — *Pseudovirgatites zaraiskoides* KUTEK & ZEISS, refigured from KUTEK & ZEISS (1974, Pl. 17, Fig. 1); Tenuicostata Zone; Brzostówka, a-2

2 — *Zaraiskites quenstedti* (ROUILLIER), refigured from KUTEK & ZEISS (1974, Pl. 26, Fig. 4); Quenstedti Horizon; Brzostówka, a-3

3 — *Zaraikites quenstedti* (ROUILLIER), refigured from KUTEK (1994a, Pl. 2, Fig. 1); Quenstedti Horizon, exposure at Sławno

All figures of natural size

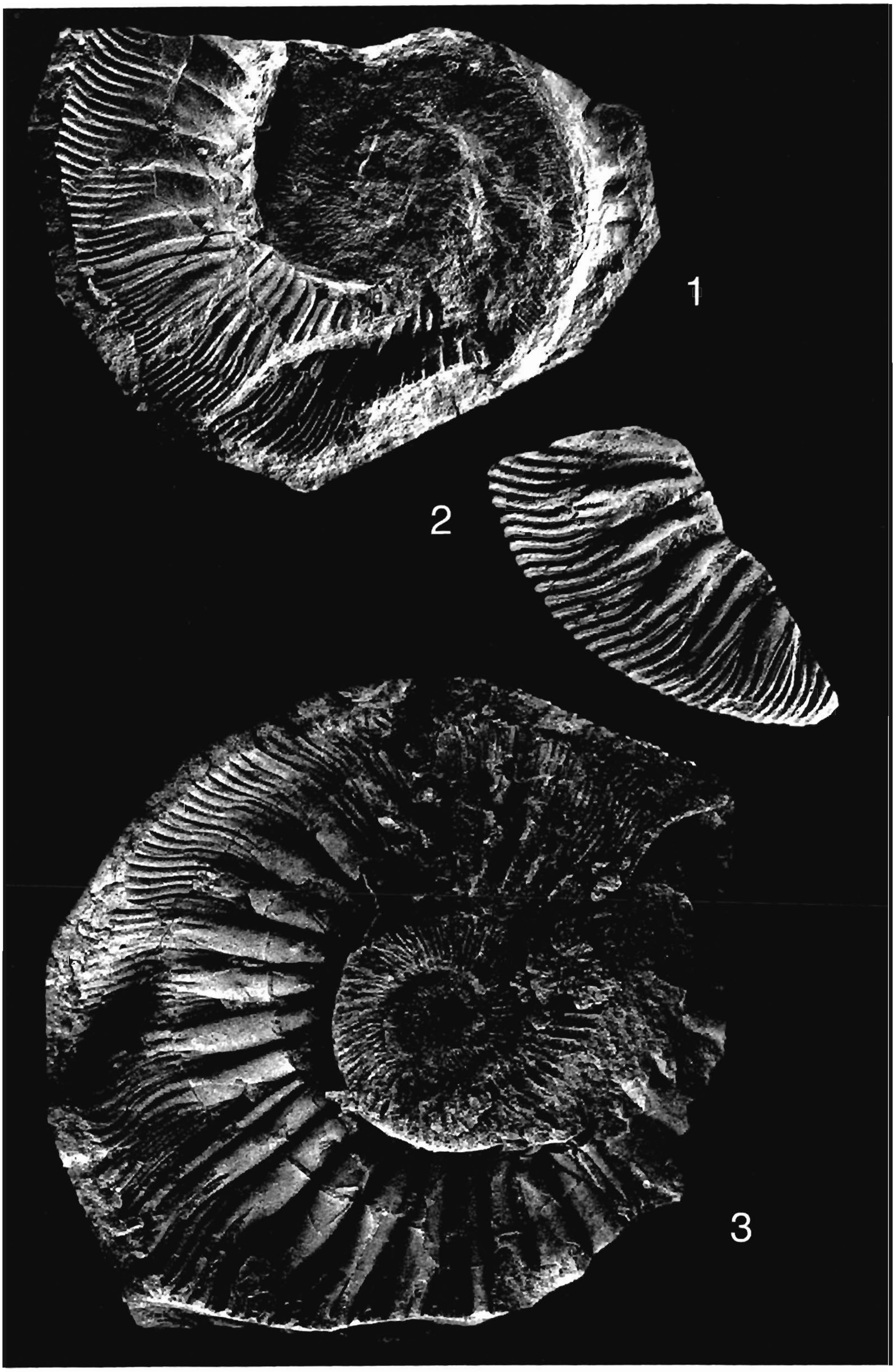
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PLATE 39

Ammonites from the Tenuicostata Zone

1 — *Ilowaiskya tenuicostata* (MICHAILOV); Specimen IGPUW/A/32/562; Antoninów-Skorkówka, 71.5 m

2 — *Ilowaiskya tenuicostata* (MICHAILOV); Specimen IGPUW/A/32/563; Antoninów-Skorkówka, 71.5 m

3 — *Pseudovirgatites* sp.; Specimen IGPUW/A/32/559; Zarzęcin 1, 140.5 m

All specimens of natural size

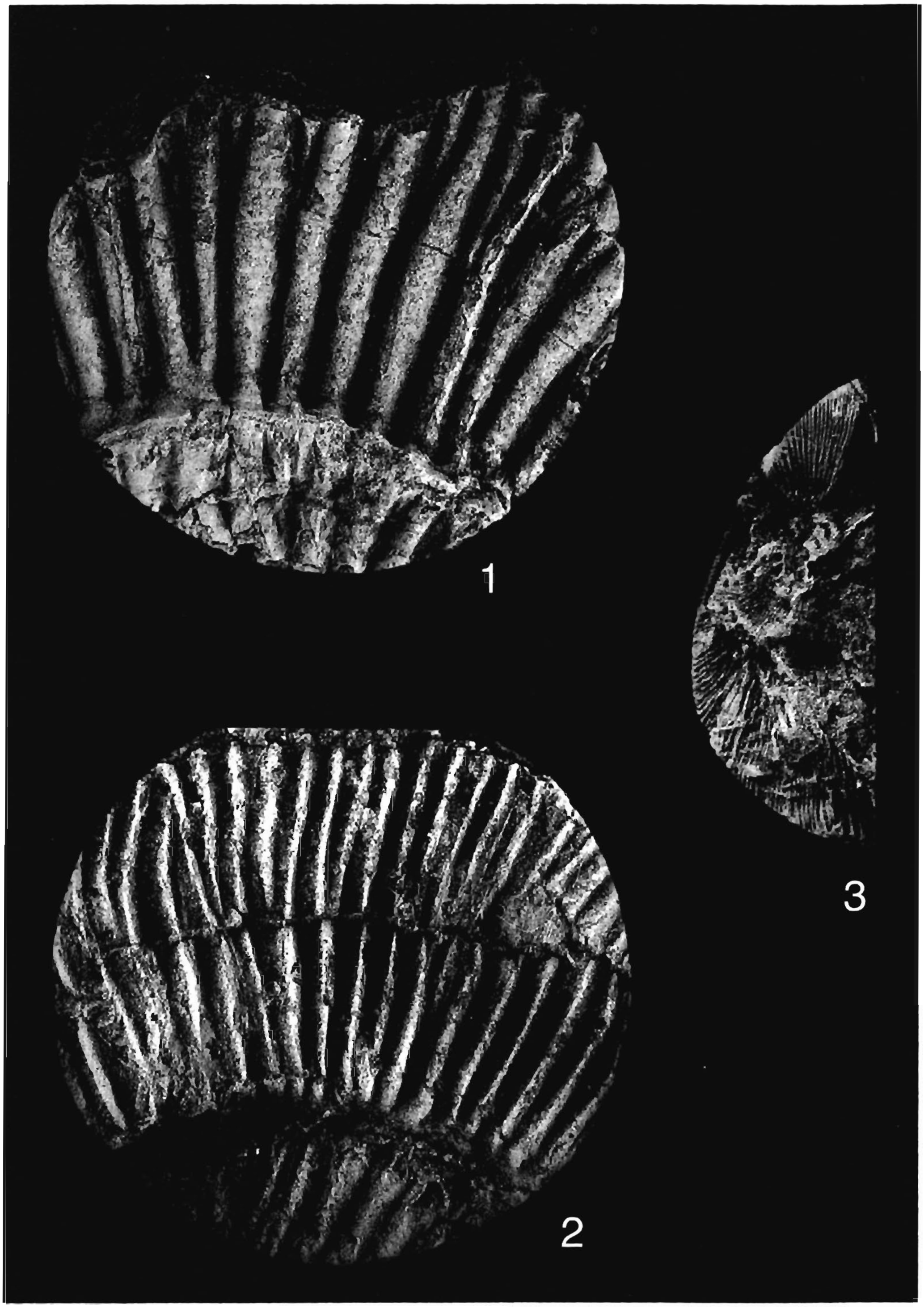

PLATE 40

Ammonites from the Tenuicostata Zone

1 — *Isterites* sp. and *Ilowaiskya tenuicostata* (MICHAILOV); Specimen IGPUW/A/32/566; Zarzęcin 3, 179.0 m

2 — *Isterites* sp.; Specimen IGPUW/A/32/535; Antoninów-Skorkówka, 68.8 m

3 — ? *Isterites* sp.; Specimen IGPUW/A/32/544; Zarzęcin 3, 180.2 m

All figures of natural size

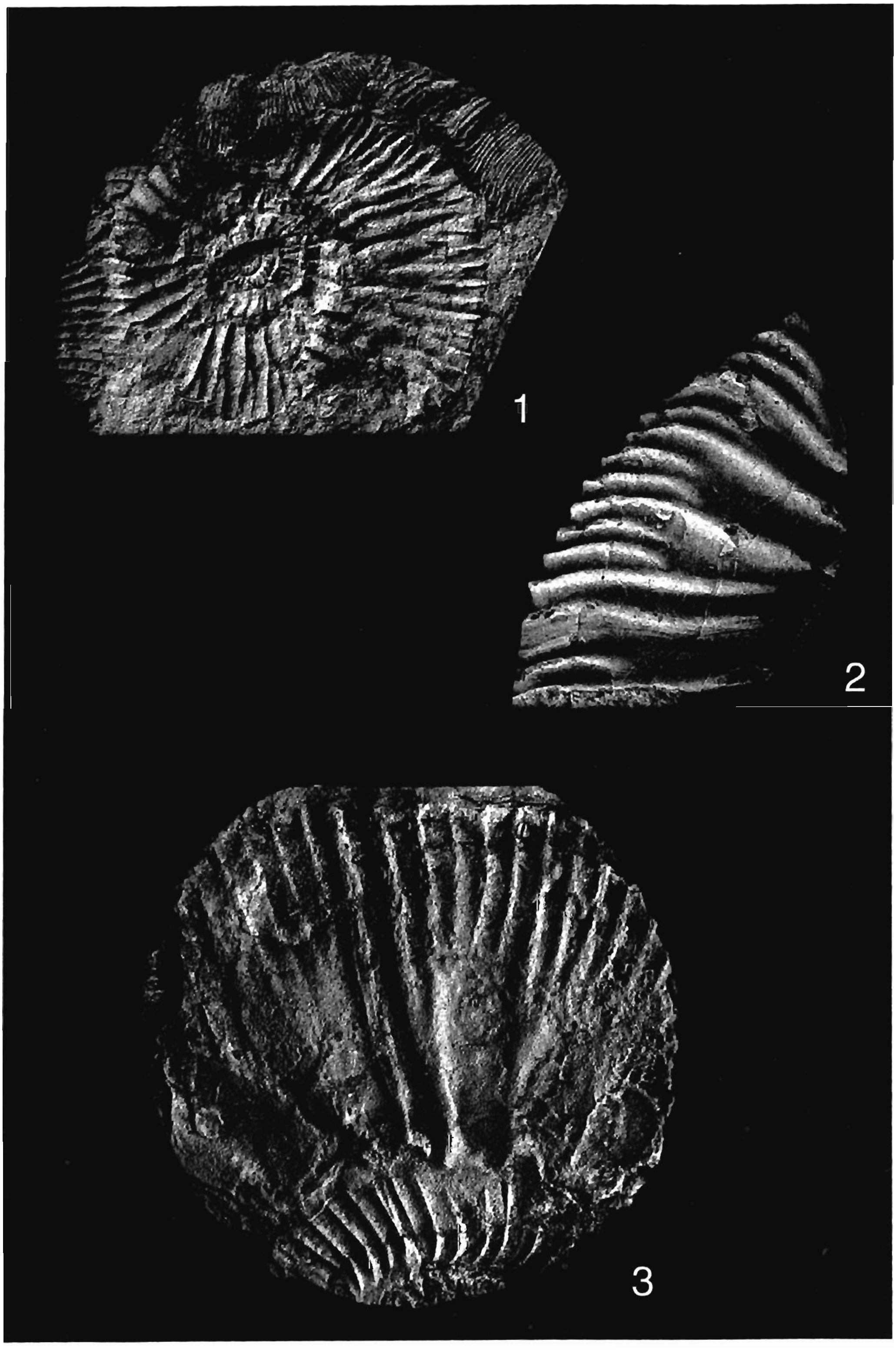
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PLATE 41

Ammonites from the Tenuicostata Zone

1 — ? *Isterites* sp.; Specimen IGPUW/A/32/512; Zarzęcin 3, 170.0 m

2 — ? *Isterites* sp.; Specimen IGPUW/A/32/529; Zarzęcin 1, 142.5 m

3 — *Pseudovirgatites* sp.; Specimen IGPUW/A/32/569; Antoninów-Skorkówka, 61.2 m

4 — *Pseudovirgatites passendorferi* KUTEK & ZEISS; Specimen IGPUW/A/32/550; Zarzęcin 3, 172.5 m

All figures of natural size

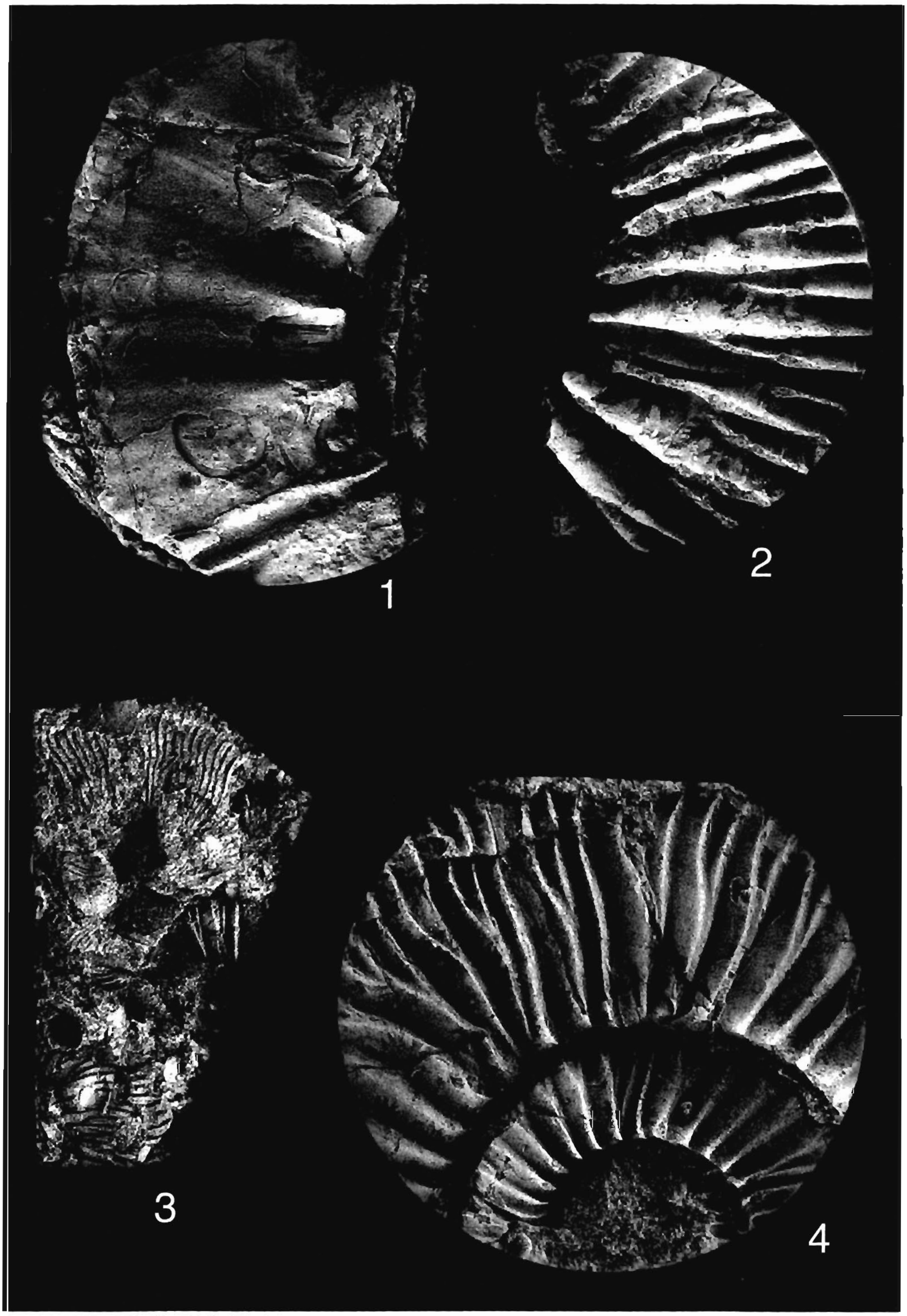
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PLATE 42

Zaraiskites quenstedti (ROUILLIER); Quenstedti Horizon

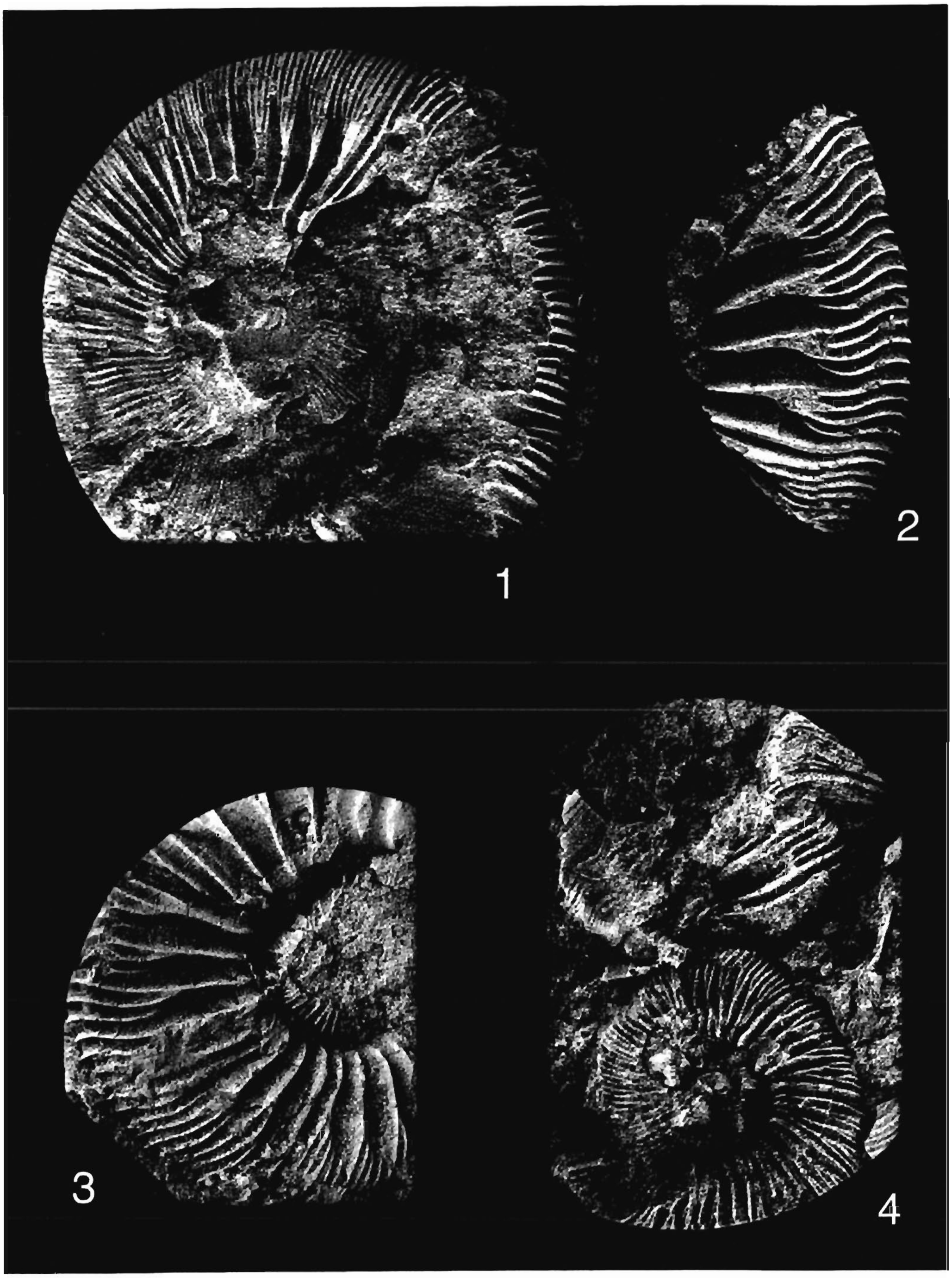
1 — Specimen refigured from KUTEK (1994a, Pl. 3, Fig. 1); Antoninów-Skorkówka, 54.7 m

2 — Specimen IGPUW/A/32/555; Antoninów-Skorkówka, 54.7 m

3 — Specimen IGPUW/A/32/553; Zarzęcin 1, 131.6 m

4 — Specimen IGPUW/A/32/554; Zarzęcin 1, 130.0 m

All figures of natural size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