

Correlation of the zonal schemes at the Middle – Upper Oxfordian boundary (Jurassic) in the Submediterranean Province: Poland and Switzerland

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ABSTRACT:

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Definition of the Oxfordian Elisabethae Subzone of the upper Transversarium Zone, and the Wartae Subzone, is provided. The Wartae Subzone has been absorbed into the overlying Bifurcatus Zone as a basal Subzone. The redefined base of the Bifurcatus Zone lies somewhat below the lower boundary of the Bifurcatus Zone of CARIOU & al. (1997). The boundary between the redefined Transversarium and Bifurcatus zones is now the boundary between the Submediterranean Middle and Upper Oxfordian. Correlation between the zonal schemes of Poland and Western Europe is established by means of the intermediate area of northern Switzerland, where the indexes of the zonal schemes co-occur. The lower boundary of the Wartae Subzone of the Bifurcatus Zone in Poland is approximately coeval with the lower boundary of the Schilli Subzone and Zone in Switzerland. The overlying Rotoides Subzone correlates with the upper part of the Wartae Subzone in Poland. Description of topotypes of *Perisphinctes* (*Dichotomoceras*) *wartae* from Częstochowa, and the accompanying macroconch species, is provided.

Key words: Correlation, Oxfordian, Perisphinctidae, Submediterranean Province, Switzerland, Poland.

INTRODUCTION

The biogeographical differentiation of ammonites during the Oxfordian in the Submediterranean Province led to the various zonal schemes that are currently used in Europe (Text-fig. 1). The present paper is focused on the stratigraphical interval at the Transversarium and Bifurcatus zonal boundary as proposed herein (see below). This interval is subdivided into the Elisabethae Subzone and the Wartae Subzone by means of perisphinctid taxa which are widely distributed in Submediterranean Europe. This

makes the zonation proposed herein applicable in Central and Western Europe. In the interval that is approximately equivalent to the boundary of the Elisabethae and Wartae subzones in Poland, there appear in the south-western part of Europe (France, Spain and Switzerland) ammonites of the genus *Larcheria* TINTANT, which are diagnostic of the Oxfordian Schilli Subzone (e.g. CARIOU & al. 1997). This genus apparently disappears eastward of Switzerland. Consequently, the Schilli Subzone have not been applied in eastern Central Europe, e.g. in Poland.

The present paper provides a correlation between the Oxfordian zonal schemes in the Submediterranean Province. The correlation is based on associations of ammonite species recognized in both Poland and Switzerland (Text-fig. 2a, b), the respective type areas of the index species, *Perisphinctes (Dichotomoceras) wartae* and *Larcheria schilli* (OPPEL). The ammonites studied belong to the collection IGPUW/A/36 housed in the Museum of the Geology Department of the University of Warsaw (Poland), and to the collection of REINHART and SYLVIA GYGI in the Natural History Museum in Basel (Switzerland).

DEFINITIONS OF THE UPPER MIDDLE TO LOWER UPPER OXFORDIAN ZONES AND SUBZONES IN POLAND

The zones and subzones as used in the present paper represent chronostratigraphical units.

Middle Oxfordian

Transversarium Zone (OPPEL 1863)

The *Transversarium Zone* has been recently redefined by GYGI (2000a,b, 2001), and subsequently by GŁOWNIAK (2002a). The two concepts of the *Transversarium Zone* of the previous authors differ from each other in the definitions of the lower and upper zonal boundary. In Switzerland, the lower boundary of the *Transversarium Zone* is drawn at the top of the Lower Oxfordian *Cordatum Zone* (for detailed comments see Gygi 2000b, p. 106) and thus becomes coeval with the lower boundary of the Middle Oxfordian. The *Plicatilis Zone*, distinguished in the lower part of the Middle Oxfordian in the zonation of NW Europe (cf. SYKES & CALLOMON 1979), and in the Submediterranean zonations (e.g. CARIOU & *al.* 1997, GŁOWNIAK 2002a), is not used in Switzerland.

| | Poland | | Switzerland | | West Europe | |
|------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | Zone | Subzone | Zone | Subzone | Zone | Subzone |
| Upper Oxfordian | Bimammatum | Bimammatum | Bimammatum | Bimammatum | Bimammatum | Bimammatum |
| | | Hypselum | | Hypselum | | Hypselum |
| | Bifurcatus | Grossouvrei | Bifurcatus | Grossouvrei | Bifurcatus | Grossouvrei |
| | | Stenocycloides | | Stenocycloides | | Stenocycloides |
| | | Wartae | Schilli | Rotoides | Transversarium | Rotoides |
| | | | Schilli | Schilli | | |
| Middle Oxfordian | Transversarium | Elisabethae | Transversarium | Luciaeformis | Plicatilis | Luciaeformis |
| | | Buckmani | | Antecedens | | Parandieri |
| | Plicatilis | Arkei | Densiplicatum | Densiplicatum | Antecedens | |
| | | Ouatius | | | Vertebrale | |
| | | Paturattensis | | | | |
| L. O. | Cordatum | Cordatum | Cordatum | Cordatum | Cordatum | Cordatum |

Fig. 1. The Submediterranean Oxfordian zonal schemes and their correlation at the Middle-Upper Oxfordian boundary. Numbers indicate the conventional base of the Upper Oxfordian in the Submediterranean Province as used by different authors: 1 – as proposed by CARIOU & *al.* (1971, 1997); 2 – as used by e.g. CARIOU & *al.* (1991); GYGI (2000b). Dashed line indicates the presumable correlation with Western Europe; L.O. = Lower Oxfordian

The upper boundary of the Transversarium Zone, as proposed by GYGI (2000a), is placed at the level of disappearance of the zonal index, *Gregoryceras* (*Gregoryceras*) *transversarium* (QUENSTEDT) in the type area in Canton Aargau (N Switzerland). It is also the level at which *Larcheria schilli* (OPPEL) – the index of the Swiss Schilli Zone (cf. following sections) – appears. The previous definition of the upper boundary of the Transversarium Zone is hardly applicable in Poland, as the two previous taxa, *G. (G.) transversarium* and *L. schilli*, have not been recognized there.

The Transversarium Zone, as used in the present paper, follows the definition proposed by GŁOWNIAK (2002a). The definitions of the zonal boundaries are based on perisphinctid species of a single lineage. The lower boundary of the Transversarium Zone, coeval with the top of the Plicatilis Zone, is drawn at the level of the phyletic first appearance of *Perisphinctes* (*Dichotomosphinctes*) *antecedens* SALFELD and its *Perisphinctes* s. str. macroconch counterpart. The upper boundary of the Transversarium Zone is placed at the level of the appearance of *Perisphinctes* (*Dichotomoceras*) *wartae* BUKOWSKI and its *Perisphinctes* s. str. macroconch counterpart. This level is coeval with the lower boundary of the Wartae Subzone, the basal Subzone of the Bifurcatus Zone (see below). The Transversarium Zone is divided into the lower, Buckmani Subzone and the upper, Elisabethae Subzone. The Buckmani Subzone will be characterised elsewhere. The essential characteristic of the Elisabethae Subzone is as follows:

Elisabethae Assemblage Subzone

INDEX: *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ.

DEFINITION: FO of the index defines the lower boundary of the Subzone; the top is coeval with the base of the Wartae Subzone (see below). The subzone is characterised e.g. by *Perisphinctes* (*Dichotomosphinctes*) *luciae* DE RIAZ, *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis* ENAY and *Perisphinctes* (*Dichotomosphinctes*) *croatalinus* SIEMIRADZKI – taxa which first occur somewhat above the base of the Subzone, and accompany *P. (D.) elisabethae* through the subzone. *P. (D.) elisabethae* and the allied taxa previously mentioned are interpreted as a single biospecies (cf. GŁOWNIAK 1997a). This biospecies ranges up to the top of the subzone, where it disappears, giving rise to the succeeding species, *Perisphinctes* (*Dichotomoceras*) *wartae* BUKOWSKI. The accompanying macroconchs are *Perisphinctes* (*Perisphinctes*) *pumilus* ENAY and *Perisphinctes* (*Perisphinctes*) *andelotensis* ENAY, which are limited exclusively to the Elisabethae Subzone.

In addition to occurrences of the previous taxa, the upper part of the Elisabethae Subzone is marked by the FO of *Subdiscosphinctes kreutzii* (SIEMIRADZKI) as well of members of the genera *Passendorferia* BROCHWICZ-LEWIŃSKI and *Liosphinctes* BUCKMAN. The latter genus is represented in the subzone by *Liosphinctes berlieri* DE LORIO. *Subdiscosphinctes kreutzii* and the two genera mentioned range through the upper part of the Elisabethae Subzone into the overlying Wartae Subzone. The genera *Passendorferia* and *Liosphinctes* are represented in the Wartae Subzone by different species from those in the upper Elisabethae Subzone.

GEOGRAPHICAL RANGE: Poland, Switzerland, Spain, France, northern England. *P. (D.) luciaeformis* is a subzonal index and the guide species of the Luciaeformis Subzone in the standard Oxfordian zonal scheme.

Upper Oxfordian

Bifurcatus Zone (BOONE in PETITCLERC 1922; ENAY 1964)

INDEX: *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (QUENSTEDT).

Redefinition of the lower boundary: The Wartae Subzone is absorbed herein into the Bifurcatus Zone as a basal Subzone (Text-fig. 1). The base of the Bifurcatus Zone as defined herein is coeval with the base of the Wartae Subzone (cf. below). It lies below the lower boundary of the Bifurcatus Zone as used by other authors (cf. ENAY 1964; CARIOU & al. 1991, 1997; GYGI 2001). The base of the redefined Bifurcatus Zone is placed at the FO of *Perisphinctes wartae* BUKOWSKI – the primitive member of the subgenus *Dichotomoceras* BUCKMAN (cf. the systematic account). This level is marked by the LO of members of the subgenus *Dichotomosphinctes* BUCKMAN.

Wartae Assemblage Subzone

INDEX: *Perisphinctes* (*Dichotomoceras*) *wartae* BUKOWSKI. Topotype material of the index is described in the present paper. The Subzone was named by TINTANT (1958), but his definition is not accepted herein.

DEFINITION: The base of the Subzone is marked by the FO of the index. The top of the Subzone is coeval with the base of the Stenocycloides Subzone as defined by CARIOU & al. (1971). *P. (D.) wartae* ranges throughout the Wartae Subzone. It is accompanied in the Subzone by its macroconch counterpart, *Perisphinctes* (*Perisphinctes*) *cautisnigrae* ARKELL (cf. systematic

account) — the species, which first appears approximately at the base of the Wartae Subzone. The two forms range up into the lower Stenocycloides Subzone, where they disappear.

Subdiscosphinctes kreutzi (SIEMIRADZKI) ranges up from the upper part of the Elisabethae Subzone of the Transversarium Zone into the Wartae Subzone of the Bifurcatus Zone, with its LO at the top of the Subzone. In the upper part of the Subzone, *S. kreutzi* is accompanied by other species of *Subdiscosphinctes* MALINOWSKA, e.g. *S. richei* (DE RIAZ). These taxa range up into the Stenocycloides Subzone. Similarly, the species *cracoviensis* (SIEMIRADZKI) – tentatively assigned here to the genus *Liosphinctes* BUCKMAN, as well as members of the genus *Passendorferia* BROCHWICZ-LEWIŃSKI, range throughout the Wartae Subzone up into the Stenocycloides Subzone.

REMARKS: The zonal boundaries of the Oxfordian zonal scheme as proposed herein, are defined by means of evolutionary events at higher than specific rank. The lower boundary of the Wartae Subzone is a suitable level for the zonal boundary, as it is placed at the level of phyletic first appearance of the subgenus *Dichotomoceras* BUCKMAN. Approximately at this level appears also *Perisphinctes* (*Perisphinctes*) *cautisnigrae* – the first macroconch that bears elements of shell morphology typical of *Perisphinctes* s. str. from higher levels in the Bifurcatus Zone. The upper boundary of the Wartae Subzone is marked by evolutionary events of lower, specific rank, and should not be regarded as a zonal boundary. To promote the Wartae Subzone to full zonal rank, following the example of the Schilli Zone as distinguished by GYGI (2001) (see the next section), would not be compatible with the zonal concept used herein (cf. also GŁOWNIAK 2002a).

GEOGRAPHICAL RANGE: Poland, Switzerland, France, Spain, England, Germany.

The Middle - Upper Oxfordian boundary

The boundary between Submediterranean Middle and Upper Oxfordian is now placed at the base of the Wartae Subzone of the Bifurcatus Zone (cf. GŁOWNIAK 2002b). It correlates approximately with the base of the Upper Oxfordian in the Boreal and Subboreal standard Oxfordian zonation as proposed by SYKES & CALLOMON (1979)(cf. GŁOWNIAK 2005). The correlation is substantiated by the appearance of *Amoeboceras transitorium* in the Submediterranean sections of central Poland (ATROPS & al. 1993, MATYJA & WIERZBOWSKI 1994), somewhat below the lower boundary of the Wartae

Subzone in the Bifurcatus Zone. *A. transitorium* is indicative of the lower Upper Oxfordian Glosense Zone in the Boreal zonation.

DETAILS OF THE OXFORDIAN ZONAL SCHEME OF WESTERN EUROPE

The Oxfordian zonation as used in Western Europe has been regarded as the primary standard of reference for the Oxfordian Stage (SYKES & CALLOMON 1979). In the interval equivalent to the upper Transversarium and Bifurcatus Zone in Poland the following zones and subzones are distinguished:

Middle Oxfordian

Upper part of the Transversarium Zone

In the upper part of the Transversarium Zone the Schilli Subzone and the Rotoides Subzone as proposed by CARIOU & al. (1991, 1997) are distinguished (cf. Text-fig. 1 in the present paper).

Schilli Subzone (BOONE in PETITCLERC 1922; CARIOU 1966)

Full characteristics of the Subzone were given by CARIOU & al. (1997). The base of the Subzone is marked by the first appearance of *Larcheria schilli* (OPPEL) – the earliest recognized member of the genus *Larcheria* TINTANT. The genus *Larcheria* is essentially, if not entirely, restricted to this Subzone and is its characteristic element. It is accompanied in the Subzone e.g. by *Perisphinctes* gr. *wartae* BUKOWSKI.

Two successive horizons have been distinguished in the Subzone (MELÉNDEZ & FONTANA 1992): the lower, *Schilli* biohorizon, and the upper, *Subschilli* biohorizon.

Rotoides Subzone (CARIOU & al. 1991)

The characteristic association of the Rotoides Subzone is represented e.g. by *Perisphinctes wartae* BUKOWSKI and *Perisphinctes rotoides* RONCHADZÉ – the two species assigned to the subgenus *Dichotomosphinctes* by CARIOU & al. (1997). *Larcheria* is absent from this Subzone.

The conventional Middle and Upper Oxfordian boundary in the Submediterranean Province

The Middle and Upper Oxfordian boundary currently used in the Submediterranean Province has been interpreted in two different ways, cf. GŁOWNIAK 2005

Text-fig. 1: either at the base of the *Stenocycloides* Subzone of the Bifurcatus Zone, as proposed by CARIOU & *al.* (1971, 1997); or, higher, at the base of the Hypselum Subzone of the Bimammatum Zone, according to some other authors (e.g. CARIOU & *al.* 1991, GYGI 2000b).

THE SWISS SCHILLI ZONE

The Schilli Zone as distinguished by GYGI (2001) has been introduced above the Transversarium Zone and below the Bifurcatus Zone (Text-fig. 1). The redefinition of the boundary between the Transversarium and Schilli zones as given by GYGI (2001) is based on his studies of the type material of the zonal indexes, *Gregoryceras* (*Gregoryceras*) *transversarium* (QUENSTEDT) and *Larcheria schilli* (OPPEL) from Canton Aargau in northern Switzerland (GYGI 2000a).

The base of the Schilli Zone is coeval with the base of the Schilli Subzone, and they both are defined by the first appearance of the index (GYGI 2001, p. 8). The upper boundary of the Transversarium Zone proposed by GYGI (2001) lies below the upper boundary of the Zone proposed by French authors (CARIOU & *al.* 1971, 1997). The Schilli Zone is subdivided into the Schilli Subzone and the Rotoides Subzone, in ascending order. These subzones were used by GYGI (2001) according to their original definitions (cf. previous section). *Perisphinctes rotoides* RONCHADZÉ, the index of the Rotoides Subzone, has been recognised by GYGI in GYGI & PERSOZ (1986, p. 422) to be an early representative of the subgenus *Dichotomoceras* BUCKMAN.

The Transversarium, Schilli and Bifurcatus Zones belong in Switzerland to the Middle Oxfordian, and the base of the Upper Oxfordian is taken at the lower boundary of the overlying Bimammatum Zone (GYGI 2000b).

GEOGRAPHICAL-STRATIGRAPHICAL SETTING AND AMMONITE SUCCESSION OF THE STUDIED SECTIONS

Zawodzie Quarry and Niegowonice Quarry in southern Poland

Geographical-stratigraphical setting

The Zawodzie quarry is located in the eastern suburbs of Częstochowa, and the Niegowonice Quarry lies south of Częstochowa in the Polish Jura Chain (Text-fig.

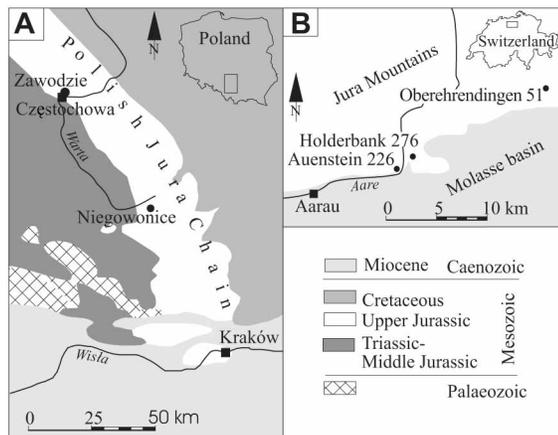


Fig. 2. Locations of the areas studied: a) Polish Jura Chain (central Poland), b) Jura Mountains (Canton Aargau, northern Switzerland)

2a). The Zawodzie Quarry is the type section of *Perisphinctes* (*Dichotomoceras*) *wartae* BUKOWSKI.

The succession exposed in the Zawodzie Quarry (Text-fig. 3) is represented by a continuous, 31 m thick series of thickly-bedded sponge limestones, distinguished as the Zawodzie beds by RÓŻYCKI (1953). Only a lower part, 25 m thick, is shown in Text-fig. 3. The succession in the Niegowonice Quarry is developed as biostromal and biohermal sponge limestones, with a thickness of 25 m. The section was figured by MATYJA & WIERZBOWSKI (1994, Text-fig. 2).

Ammonite succession

The stratigraphical interval under consideration in Zawodzie ranges from the upper Elisabethae Subzone of the Transversarium Zone in the Middle Oxfordian, through the Wartae Subzone and the lower *Stenocycloides* Subzone of the Bifurcatus Zone in the Upper Oxfordian (Text-fig. 3). The full succession also includes the upper part of the *Stenocycloides* Subzone, but this is not considered in the present paper. The interval represented in the Niegowonice Quarry ranges from the upper Elisabethae Subzone to the upper Wartae Subzone.

Perisphinctes (*Dichotomoceras*) *wartae* BUKOWSKI and *Perisphinctes* (*Perisphinctes*) *cautisnigrae* ARKELL of the Wartae Subzone first appear in the Zawodzie Quarry above the levels yielding *P.* (*Dichotomosphinctes*) *elisabethae* DE RIAZ and the allied species of the subgenus *Dichotomosphinctes* of the Elisabethae Subzone (Text-fig. 3, Appendix). *P.* (*D.*) *wartae* and *P.* (*P.*) *cautisnigrae* are accompanied in the Wartae Subzone by ?*Liosphinctes cracoviensis* (SIEMIRADZKI) and *Subdiscosphinctes kreutzii* (SIEMIRADZKI). In the upper part of the Wartae Subzone they are additionally accompanied by other species of the genus

Subdiscosphinctes MALINOWSKA, e.g. *S. richei* DE RIAZ (cf. Appendix).

Perisphinctes (*Dichotomoceras*) *bifurcatoides* ENAY first appears in the Zawodzie Quarry with the last representatives of *P. (D.) wartae* and *P. (P.) cautisnigrae*, and marks the base of the Stenocycloides Subzone (Text-fig. 3, Appendix). *P. (D.) bifurcatoides* co-occurs in the upper part of its range with other species of the subgenus *Dichotomoceras* BUCKMAN and *Perisphinctes* s. str. WAAGEN, as well as with ?*Liosphinctes cracoviensis* and members of the genus *Subdiscosphinctes* (Text-fig. 3, Appendix). The species *Subdiscosphinctes kreutzii* is absent from the levels yielding *P. (D.) bifurcatoides*.

The section in the Niegowonice Quarry yielded *Amoeboceras transitorium* SPATH (cf. MATYJA & WIERZBOWSKI 1994). The species appeared with *P. (D.) elisabethae* and *Perisphinctes* (*Dichotomosphinctes*) *crotaalinus* SIEMIRADZKI (Appendix) in the upper Elisabethae Subzone. The entry of *Perisphinctes* (*Dichotomoceras*) *wartae* higher up-section (Appendix) marks the base of the Wartae Subzone.

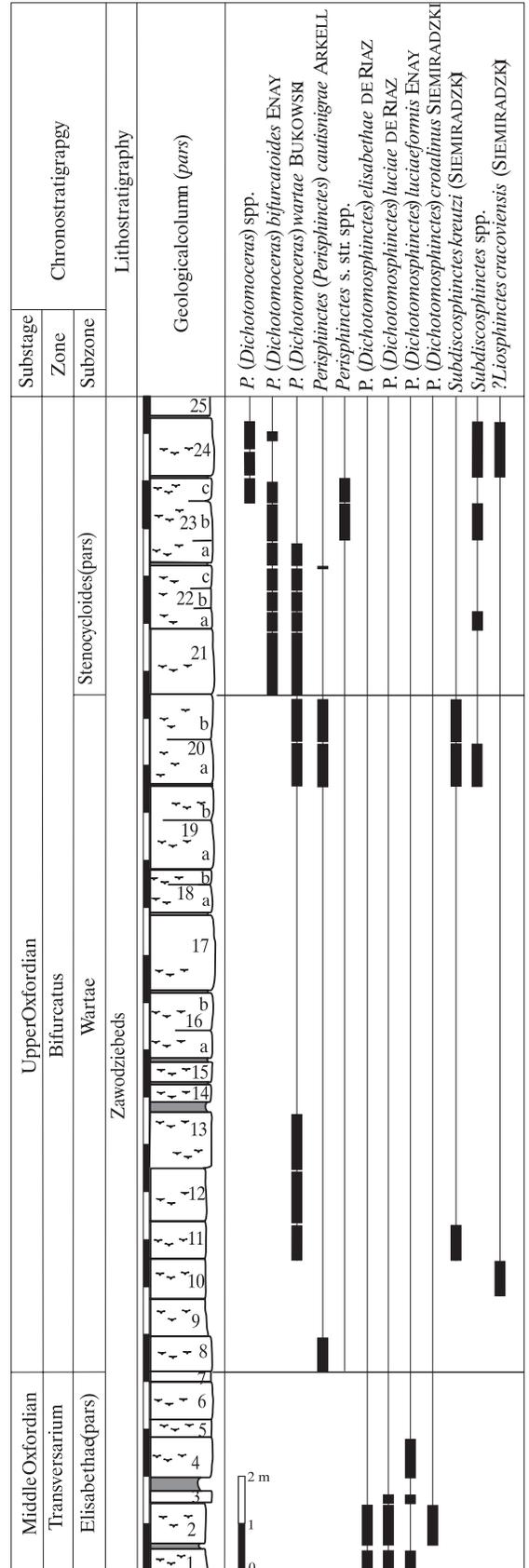
The sections in Canton Aargau in northern Switzerland

Geographical-stratigraphical setting

The sections RG 51, RG 226 and RG 276 are located in the Jura Mountains in Canton Aargau in northern Switzerland (Text-fig. 2b). The section RG 51 (Text-fig. 4) was described in detail and figured by GYGI (1977, Pl. 11, Fig 5); the section RG 226 was described and figured by GYGI (1973, Text-fig. 3), GYGI (1990, p. 60); and the section RG 276 by GYGI & al. (1979). The section RG 276 near Holderbank was designated by GYGI (2001) as the reference section for the Schilli Zone.

The Oxfordian carbonates are represented in the lower part of the sections by sponge limestones with marl intercalations (GYGI 1969), distinguished as the Birnenstorf Member; and, in the upper part, by thick blue-grey marls with intercalated limestone beds, distinguished as the Effingen Member. The Birnenstorf Member ranges in thickness from 0.5 m to nearly 5 m (cf. Text-fig. 4). It rests discontinuously on a condensed iron-oolitic limestone bed of Bathonian Age, and in RG 51 locally also on lenses of ferruginous marly limestones of Middle Callovian Age (MANGOLD & GYGI 1997).

Fig. 3. Late Middle to early Late Oxfordian stratigraphical succession in the Zawodzie quarry; zonation after GŁOWNIAK (1998); for explanations see Text-fig. 4



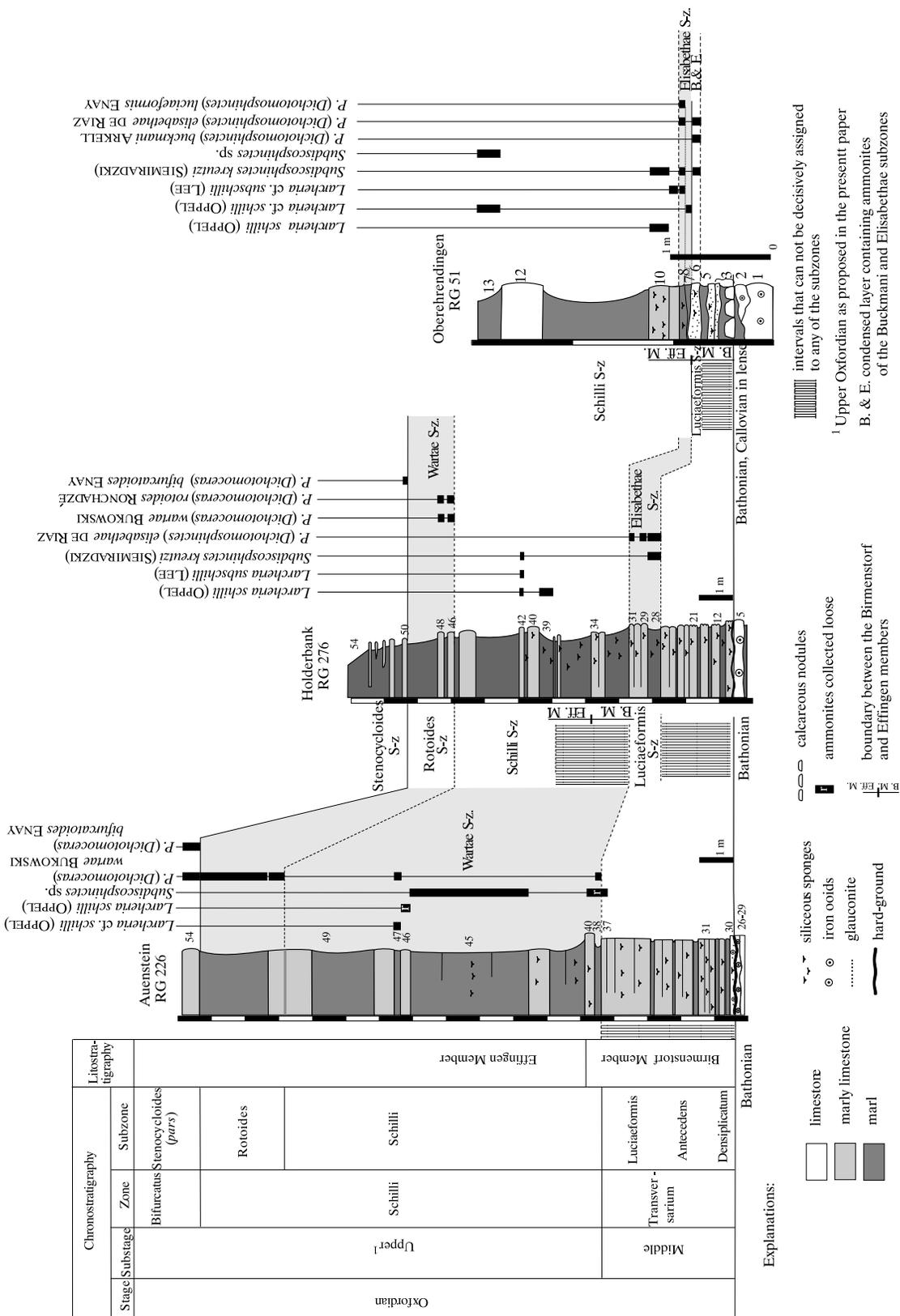


Fig. 4. Geological columns, perisphinctid distribution and the chronostratigraphical correlation of the Oxfordian sections in northern Switzerland; zonation after GYGI (2000a, 2001). Section RG 51 is not at the same scale as the other sections

Ammonite succession

The stratigraphical interval studied in northern Switzerland ranges from the upper Luciaeformis Subzone of the Transversarium Zone throughout the Schilli and Rotoides Subzones of the Schilli Zone, to the basal part of the Stenocycloides Subzone of the Bifurcatus Zone (Text-fig. 4). The zonal and subzonal indexes co-occur in the Swiss sections with species diagnostic of the Elisabethae and Wartae subzones in Poland. The correlation with the Polish zonation is indicated by grey fields in Text-fig. 4.

Members of the genus *Larcheria* first occur in northern Switzerland with the species *Perisphinctes* (*Dichotomosphinctes*) *elisabethae*, *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis* and *Subdiscosphinctes kreutzii* in section RG 51 (Text-fig. 4, Appendix). The base of the Schilli Subzone and Zone lies at the base of the bed 7 in this section. The underlying bed 6 yielded *Perisphinctes* (*Dichotomosphinctes*) *buckmani* ARKELL, *P. (D.) elisabethae* and *S. kreutzii* (Appendix). Since GYGI (2001) recognized *P. (D.) elisabethae* in the Luciaeformis Subzone of the Transversarium Zone, it follows that bed 6 should be correlated with the Luciaeformis Subzone. According to GŁOWNIAK (1997b, 1998), this bed includes ammonites characteristic of the two subzones of the Transversarium Zone in Poland: the Buckmani Subzone is documented in bed 6 by *P. (D.) buckmani*, and the overlying Elisabethae Subzone by *P. (D.) elisabethae* and *S. kreutzii*, species which do not overlap in stratigraphical range with *P. (D.) buckmani* in successions of normal thickness. Bed 6 is therefore condensed.

In the upper part of the Schilli Subzone and Zone, *Larcheria* cf. *schilli* was found in RG 226 in a single bed (bed 47) with *Perisphinctes* (*Dichotomoceras*) *wartae* BUCKMAN, directly above *Larcheria schilli* in bed 46 (Text-fig. 4, Appendix).

P. (D.) rotoides first appears in northern Switzerland above the levels with *Larcheria* (cf. section RG 276: Text-fig. 4). The base of the Rotoides Subzone of the Schilli Zone lies at the base of bed 46 in RG 276 (Text-fig. 4). *P. (D.) rotoides* co-occurs in RG 276 with *P. (D.) wartae* (Appendix).

The uppermost beds in sections RG 226 and RG 276 yielded the first *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* ENAY (Appendix), indicating the Stenocycloides Subzone of the Bifurcatus Zone (Text-fig. 4).

ENAY and *Subdiscosphinctes kreutzii* (SIEMIRADZKI) of the late Elisabethae Subchrone in the Transversarium Chrone, appear in Switzerland with *Larcheria schilli* and *Larcheria subschilli* (Text-fig. 5) of the early Schilli Subchrone and Chrone. Later, *Larcheria schilli* becomes associated with *Perisphinctes* (*Dichotomoceras*) *wartae* BUKOWSKI of the Wartae Subchrone in the Bifurcatus Chrone in Poland. In Poland and in Switzerland, *P. (D.) wartae* continuously succeeds *P. (D.) elisabethae* and the associated forms of *Dichotomosphinctes*, and there is no intermediate perisphinctid assemblage between them. In Switzerland, *L. schilli* disappears at the end of the Schilli Subchrone and there is no direct descendant of it in the study area. *P. (D.) wartae* becomes accompanied by *Perisphinctes* (*Dichotomoceras*) *rotoides* RONCHADZÉ of the Rotoides Subchrone (Text-fig. 5). The first appearance of *P. (Dichotomoceras) bifurcatoides* ENAY is at the beginning of the Stenocycloides Subchrone of the Bifurcatus Chrone in Poland and in Switzerland (Text-fig. 5).

| Poland | | | | Switzerland | | | | |
|-----------|--------|----------------|--------------------|---|----------------|------------|---------------------|----------------|
| Age | Subage | Chrone | Subchrone | Taxa ranges | | | | |
| Oxfordian | Late | Bifurcatus | Stenocycloides | <i>Dichotomosphinctes elisabethae</i> <i>Dichotomosphinctes luciaeformis</i> <i>Dichotomoceras bifurcatoides</i> <i>Larcheria schilli</i> <i>Larcheria subschilli</i> <i>Dichotomoceras rotoides</i> | Stenocycloides | Bifurcatus | Middle Oxfordian | |
| | | | Wartae | | | | | Stenocycloides |
| | Middle | Transversarium | Elisabethae (pars) | | Schilli | Rotoides | | Middle |
| | | | | | Schilli | Bifurcatus | | |

Fig. 5. Biochronological correlation between Poland and Switzerland. Asterisk (*) indicates the level of first occurrence of the Oxfordian Boreal species *Amoeboceras transitorium* SPATH in the Submediterranean sections of central Poland. The interval in question is assigned in Switzerland to the Middle Oxfordian (cf. GYGI 2000b)

BIOCHRONOLOGY: POLAND AND SWITZELAND

Perisphinctes (*Dichotomosphinctes*) *elisabethae* DE RIAZ, *Perisphinctes* (*Dichotomosphinctes*) *luciaeformis*

CHRONOSTRATIGRAPHICAL CORRELATION AT THE MIDDLE AND UPPER OXFORDIAN BOUNDARY IN THE SUBMEDITERRANEAN PROVINCE

Poland and Switzerland

The boundary between the Elisabethae Subzone and the Wartae Subzone in Poland is placed somewhat above the boundary between the Luciaeformis and Schilli subzones in Switzerland (Text-fig. 1). The lower boundary of the Bifurcatus Zone as proposed herein is placed somewhat above the lower boundary of the Schilli Zone as proposed by GYGI (2001). The base of the Rotoides Subzone in the Schilli Zone lies approximately in the upper part of the Wartae Subzone in Poland. The bases of the Stenocycloides Subzone in Poland and in Switzerland are coeval (Text-fig. 1).

The Submediterranean Middle and Upper Oxfordian boundary is coeval with the boundary between the Elisabethae and Wartae subzones in Poland. It correlates approximately with the boundary between the Luciaeformis and Schilli Subzones in Switzerland (Text-fig. 1). In Switzerland, the entire interval studied is assigned to the Middle Oxfordian (cf. GYGI 2000b).

Correlation with Spain and France

The lower boundary of the Schilli Subzone in Spain lies within the upper Elisabethae Subzone of the Transversarium Zone in Poland (Text-fig. 1). This correlation is supported by the association of *Larcheria* in the Schilli Subzone with *Perisphinctes* (*Dichotomosphinctes*) *luciae* and the other densely ribbed perisphinctid species recognized in Spain (ATROPS & MELÉNDEZ 1993). The association of *Larcheria* with the younger species *P.* (*Dichotomoceras*) *wartae* has not been hitherto recognized in Spain. The boundary between the Schilli and Rotoides Subzones is usually marked by a stratigraphical discontinuity and an abrupt change in the perisphinctid succession (MELÉNDEZ & FONTANA 1991); *P.* (*D.*) *wartae* first appears in Spain at the base of the Rotoides Subzone. Additional data are needed for more detailed correlation between Spain and Poland at the boundary between the Schilli and Rotoides subzones.

In France, *Larcheria* is associated with *Perisphinctes* gr. *wartae* in the Schilli Subzone (cf. CARIOU & al. 1997). The levels yielding *Larcheria* in France should therefore be correlated tentatively with the lower part of the Wartae Subzone in Poland. Further studies are required to establish whether *P.* gr. *wartae* of French authors is conspecific with *P.* (*Dichotomoceras*) *wartae* from Poland, which would substantiate this correlation.

The upper part of the Wartae Subzone correlates in France with the Rotoides Subzone, as *Perisphinctes wartae* – assigned by French authors to the subgenus *Dichotomosphinctes* – co-occurs there with *P.* (*D.*) *rotoides*. The other perisphinctid species typically associated with *Larcheria* in the Schilli Subzone in France and in Spain, are small massive forms that are assigned by French authors to the subgenus *Otosphinctes* (CARIOU & al. 1997). These forms are apparently restricted to south-western Europe and cannot be used in the present correlation. Further studies are required to refine the correlation with the Oxfordian zonation of CARIOU & al. (1997).

THE LOWER BOUNDARY OF THE UNIFIED UPPER OXFORDIAN IN THE SUBMEDITERRANEAN PROVINCE

The base of the Wartae Subzone of the Bifurcatus Zone as used in the present paper has been recommended as the boundary between the unified Middle and Upper Oxfordian Substage in the Submediterranean Province (cf. GŁOWNIAK 2002b).

The base of the Wartae Subzone of the Bifurcatus Zone correlates approximately with the base of the Schilli Subzone and Zone as distinguished by GYGI (2001).

The boundary between the Submediterranean Middle and Upper Oxfordian, as defined herein, lies somewhat below the conventional Middle and Upper Oxfordian boundary placed at the base of the Stenocycloides Subzone of the Bifurcatus Zone, as proposed by CARIOU & al. (1971, 1997); it lies well below the Middle and Upper Oxfordian boundary coeval with the base of the Hypselum Subzone of the Submediterranean Bimammatum Zone as recognized by many other authors (e.g. MELÉNDEZ & al. 1985, CARIOU & al. 1991, GYGI 2000b) (Text-fig. 1, cf. GŁOWNIAK 2005).

SYSTEMATIC ACCOUNT

Repositories

Museum of the Geology Department of the University of Warsaw, collection no IGPUW/A/36. Natural History Museum in Basel, collection of R. & S. GYGI.

Terminology of shell-dimensions

Symbols used in the text for shell description are as follows: **D** – diameter; **D:D_i** – shell diameter compared to

the diameter of phragmocone; **W/U** – whorl height as fraction of umbilical width; **U/D** – umbilical width as fraction of diameter; **W/D** – whorl height as fraction of diameter; **D: r** – rib number (r) per whorl counted at a given shell-diameter (D).

Systematic description

Superfamily Perisphinctaceae STEINMANN, 1890

Family Perisphinctidae STEINMANN, 1890

Genus *Perisphinctes* WAAGEN, 1869

Subgenus *Perisphinctes* WAAGEN, 1869

Perisphinctes (Perisphinctes) cautisnigrae ARKELL, 1935
(Text-fig. 6)

1935. *Perisphinctes (Perisphinctes) cautisnigrae* sp. nov.; ARKELL, p. 14, text-figs 3, 5; pl. 1, fig. 1a-b, 2 (=holotype), pl. 3, figs 1-2.

1937. *Perisphinctes (Perisphinctes) cautisnigrae* ARKELL; ARKELL, p. 57; pl. 13, figs 1-3.

1966. *Perisphinctes (Perisphinctes) cautisnigrae* ARKELL; ENAY, p. 390, text-fig. 109 (*pars*); pl. 13, fig. 2.

1970. *Perisphinctes (Perisphinctes) cautisnigrae* ARKELL; BROCHWICZ-LEWIŃSKI, pl. 3.

MATERIAL: Three specimens from Zawodzie Quarry: IGPUW/A/36/697 comes from bed 20 a-b; the two other specimens come from bed 8 and the top of bed 22 (Text-fig. 3).

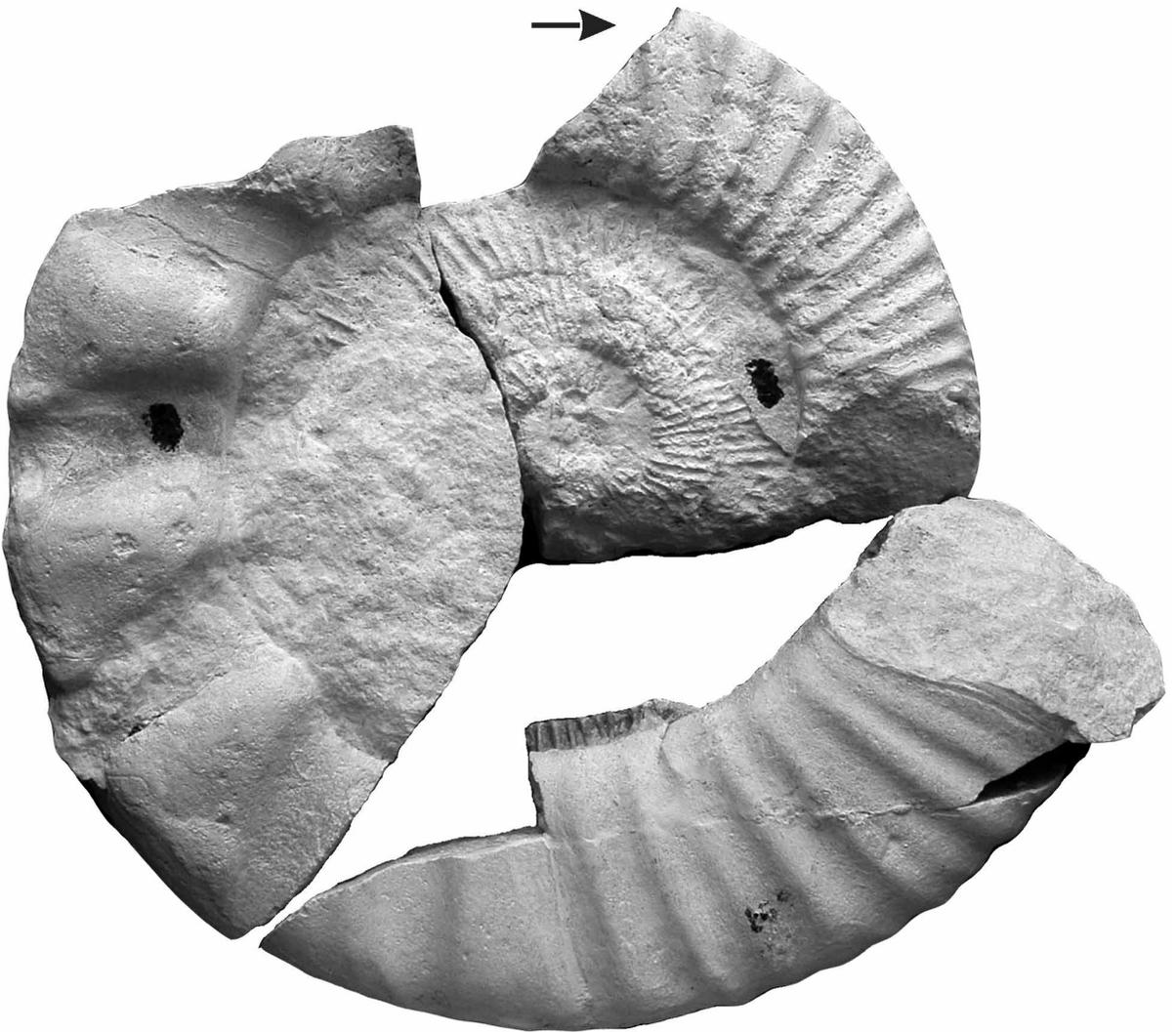


Fig. 6. *Perisphinctes (Perisphinctes) cautisnigrae* ARKELL, 1935; IGPUW/A/36/697; Zawodzie Quarry, bed 20 a-b; reduced x 0.5. Arrow indicates end of phragmocone

DESCRIPTION: IGPUW/A/36/697 (Text-fig. 6) is an incomplete specimen, with the inner whorls fragmentarily preserved. It represents a full grown individual. The specimen is c. 300 mm in diameter; the phragmocone is c. 220 mm in diameter. At this diameter the whorl is broken away. The whorl-section of the phragmocone is subrectangular. The primary ribs on the phragmocone are moderately thick and straight. In the final part of the phragmocone they become somewhat thicker. The ribs on the body-chamber are cuneiform and flat-sided. The last few ribs are approximated. The peristome is simple-shaped.

The other two specimens in the collection are immature individuals. They range in diameter from ca. 190 mm to 210 mm. One of the specimens comprises the phragmocone and a part of the body-chamber which is 1/8 whorl long; the other one is an incomplete specimen with half of the whorls broken away. The last preserved half-whorl is occupied by the body-chamber.

REMARKS: In *Perisphinctes* (*Perisphinctes*) *cautisnigrae* ARKELL first appear features of shell ornamentation characteristic of the macroconch species of the subgenus *Perisphinctes* s. str. of the higher subzones of the Bifurcatus Zone. The characters in common are as follows: 1) abrupt change in the primary ribs, from straight ridges to massive cuneiform ribs; 2) first appearance of the variocostate ribs not earlier than on the adult body-chamber, i.e. not as in the members of *Perisphinctes* s. str. from the subzones of the underlying Transversarium Zone, in which the first appearance of the variocostate ribs occurs already on the phragmocone and continues on the body-chamber; 3) cuneiform shape of the ribs which protrude distinctly over the whorl-flank and are flat sided. The affinity of *P. (P.) cautisnigrae* with the *Perisphinctes* s. str. from the upper subzones of the Bifurcatus Zone gives additional support for the redefinition of the status of the Wartae Subzone as the basal Subzone of the Bifurcatus Zone.

P. (P.) cautisnigrae co-occurs in Poland with *P. (Dichotomoceras) wartae* BUKOWSKI. The two species presumably represents macro- and microconch counterparts. *Perisphinctes* (*Perisphinctes*) *cuneicostatus* ARKELL, the macroconch counterpart of *P. (D.) wartae* suggested by ENAY (1966), has not been recognized so far from the type area of *P. (D.) wartae* in the Polish Jura Chain. *P. (P.) cuneicostatus* is a French form from Haute Marne, with unknown type locality and type horizon (ENAY 1966). *P. (P.) cautisnigrae* comes from southern England, from the Red Bed of the Trigonina Clavellata Member of Osmington (WRIGHT 2001).

Further support that *P. (P.) cautisnigrae* and *P. (D.) wartae* appear in their respective type areas at approximately the same time is the time-relation to the early

species of the Oxfordian Boreal genus *Amoeboceras*, *A. transitorium* and *A. glosense*. The two latter species span the early and late times, respectively, of the Boreal Glosense Chron (SYKES & CALLOMON 1979). In addition, *Amoeboceras transitorium* first appears in central Poland directly below the FO of *P. (D.) wartae* (cf. MATYJA & WIERZBOWSKI 1994, ATROPS & al. 1993), whereas *Amoeboceras glosense* occurs in southern England somewhat below *P. (P.) cautisnigrae* (WRIGHT 2001). The appearance of *P. (D.) wartae* and *P. (P.) cautisnigrae* in Poland, and the appearance of *P. (P.) cautisnigrae* in southern England, thus occur approximately at the transition between the early and late Glosense Chron.

P. (P.) cautisnigrae co-occurs in the type horizon in southern England with *Perisphinctes cautisruffae* ARKELL, 1936 (ARKELL 1936, pl. 10, figs 1a-c, 2a, 2b) – which is close to, if not conspecific with, *P. (D.) wartae* from Poland. If the above two taxa could be proved to be conspecific, the co-occurrence of *P. (P.) cautisnigrae* and *P. (D.) wartae*, which has hitherto only been recognized in Poland, would also be valid in areas of NW Europe.

Subgenus *Dichotomoceras* BUCKMAN, 1919

Perisphinctes (*Dichotomoceras*) *wartae* BUKOWSKI, 1887
(Text-figs. 7a-b; 8)

1887. *Perisphinctes wartae* n. f.; BUKOWSKI, p. 140; pl. 27, fig. 1a-c.

1966. *Perisphinctes* (*Dichotomosphinctes*) *wartae* BUKOWSKI; ENAY, p. 486, text-fig. 147 (topotype).

1970. *Perisphinctes* (*Dichotomosphinctes*) *wartae* BUKOWSKI; BROCHWICZ-LEWIŃSKI, pl. 7 (topotype).

MATERIAL: The collection comprises twenty-six topotypes from beds 11-13, and 20a-23a in Zawodzie Quarry (Text-fig. 3). The topotype IGPUW/A/36/641 (Text-fig. 7a, b) comes from bed 12.

DESCRIPTION: The topotype IGPUW/A/36/641 (Text-fig. 7a-b) is an adult microconch showing approximation of the last ribs. Final constrictions appear at the end of the body chamber. The specimen is of $D=190$ mm, septate to $D_i=120$ mm. The body chamber is 7/8 whorl long. The coiling is moderately evolute. The whorl-section is oval and flat-sided. The primary ribs are sharp. They are thin and densely spaced on the inner whorls, and they become moderately thin and moderately densely spaced on the middle and outer whorls. The ribs bifurcate; simple ribs occur occasionally. The bifurcation points are sharp. The secondary ribs sweep forward slightly on the body-chamber (Text-fig. 7b).

The topotypes vary in the rib number per whorl: the difference between the more and the less densely ribbed specimens in the collection studied reaches c. 20 ribs per whorl at comparable diameters (Text-fig. 8), and up to c. 15 ribs per whorl in the specimens coming

from a single bed. The rib-number per whorl increases gently at small and medium diameters, and somewhat more markedly at large diameters. The rib-density curves are somewhat concave at small and medium diameters (Text-fig. 8).

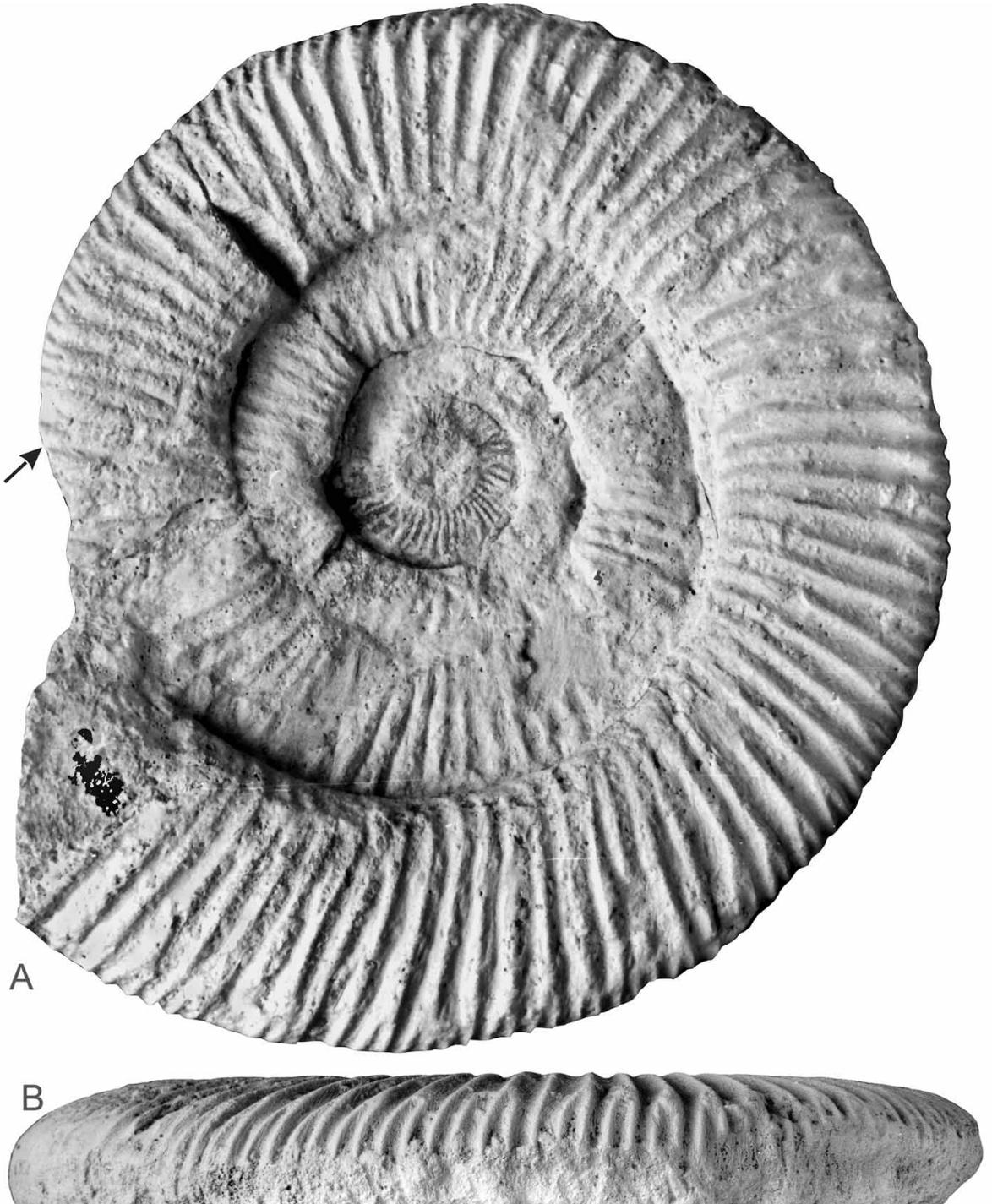


Fig. 7. *Perisphinctes (Dichotomoceras) wartae* BUKOWSKI, 1887; IGPUW/A/36/641; Zawodzie quarry, bed 13: a) lateral view, b) ventral side; natural size. Arrow indicates end of phragmocone

DIMENSIONS:

| IGPUW/A/36/641 | | | | | |
|------------------|----|------|------|------|--|
| D:D _f | D | W/D | U/D | W/U | D:r |
| 190:120 | 90 | 0.29 | 0.48 | 0.59 | 37:45; 90:54; 105:58; 118:60; 134:65; 156:69; 175:73; 190:80 |

REMARKS: *Perisphinctes wartae* BUKOWSKI has been commonly regarded as a member of the subgenus *Dichotomosphinctes* BUCKMAN (ENAY 1966; BROCHWICZ - LEWIŃSKI 1970, 1976; MELÉNDEZ 1989; CARIOU & *al.* 1997). The species shows primitive characters of the subgenus *Dichotomoceras* BUCKMAN, to which it is assigned herein. It possesses a rib-density curve which is somewhat concave at small and medium diameters (Text-fig. 8). This character of shell ornamentation never occurs in members of the subgenus *Dichotomosphinctes*, in which the rib-density-curves are somewhat convex upward. Concavity of the rib-density curve is a diagnostic character of the subgenus *Dichotomoceras* (cf. IGPUW/A/36/674 on the Text-fig. 8), but in *P. (D.) wartae* it is not yet particularly pronounced. *P. (D.) wartae* shows a forward sweep of the secondary ribs on the venter (Text-fig. 7b), which is also found in members of the subgenus *Dichotomoceras*.

P. (D.) wartae, before its final disappearance, co-occurs with *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY in the upper part of its range. Transitional forms exist between these two species.

OCCURRENCE: The FO of the species is at the lower boundary of the Wartae Subzone of the Bifurcatus Zone. It ranges throughout the Wartae Subzone into the lower

part of the overlying Stenocycloides Subzone of the Bifurcatus Zone, where it has its LO.

CONCLUDING REMARKS

Biogeography. The standard Oxfordian zonal scheme for the Submediterranean Province of West Europe, and the zonal scheme in Switzerland, is based partly on the endemic genus *Larcheria* TINTANT. This genus has not yet been recognized in Poland. The Schilli Subzone, defined by *Larcheria*, therefore possesses limited application in Poland.

Alternative biochronological scale. The upper Middle to lower upper Oxfordian zonal scheme, as proposed in the present paper, is based on the ammonite succession in central Poland. It is defined by species that are widely distributed in the Submediterranean Province. The newly defined Elisabethae Subzone and Wartae Subzone are characterized by successive species which are phylogenetically linked. The boundary between these sub-zones is taken at the level of the phyletic first appearance of the subgenus *Dichotomoceras* BUCKMAN, represented by the primitive member *Perisphinctes wartae*. It is now the boundary between the redefined Transversarium Zone and Bifurcatus Zone, and the base of the Upper Oxfordian in the Submediterranean Province.

The base of the unified Submediterranean Upper Oxfordian Substage. The boundary between the Middle and Upper Oxfordian, coeval with the boundary between

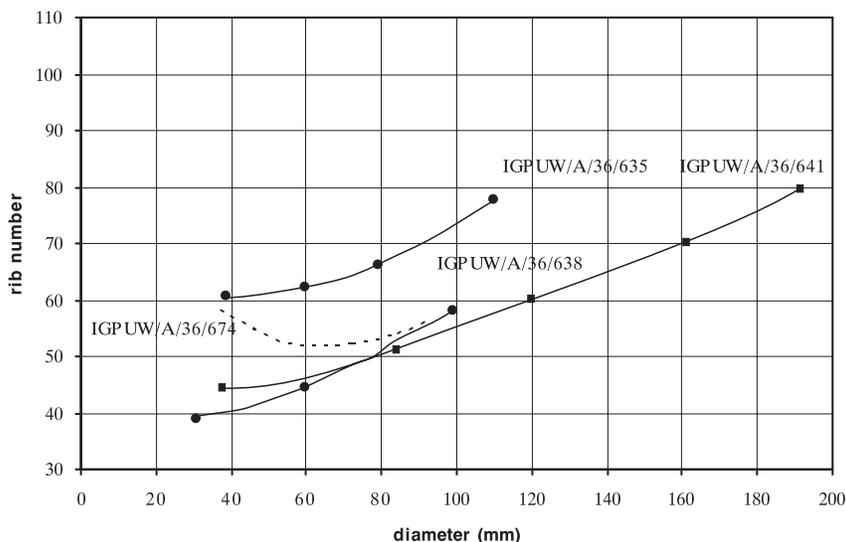


Fig. 8. Rib-density curves of *Perisphinctes (Dichotomoceras) wartae* BUKOWSKI (continuous lines); The specimens come from Zawodzie quarry (Text-fig. 3), from the Wartae Subzone; IGPUW/A/36/635 is from bed 11; IGPUW/A/36/641 is from bed 12; IGPUW/A/36/638 is from bed 13. *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY (dashed line, IGPUW/A/36/674) comes from the Stenocycloides Subzone, from bed 23b in Zawodzie quarry

the Elisabethae and Wartae subzones, correlates with the lower boundary of the Upper Oxfordian in the Boreal and Subboreal zonal scheme, and it is proposed herein as the base of the unified Upper Oxfordian Substage in the Submediterranean Province. The conventional Substage boundary is defined at two different levels, both of which lie higher than the level under discussion.

Correlation in the Submediterranean Province. The boundary between the Elisabethae and Wartae subzones correlates approximately with the boundary between the Submediterranean Luciaeformis and Schilli subzones, which is taken in Switzerland as the base of the Schilli Zone. The correlation is based on co-occurrences of species first recognized in the sections of northern Switzerland: *Perisphinctes (Dichotomoceras) wartae* co-occurs there, in the lower part of its range, with *Larcheria schilli*, and in the upper part of its range, with *Perisphinctes (Dichotomoceras) rotooides*. The first appearance of *L. schilli* is with the last members of the subgenus *Dichotomosphinctes*, e.g., *P. elisabethae*.

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APPENDIX

Distribution of the perisphinctid species in the studied sections

Zawodzie Quarry (Text-fig. 3)

Elisabethae Subzone of the Transversarium Zone:

- bed 1 (the base of the section): *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ (six specimens), *Perisphinctes (Dichotomosphinctes) luciae* DE RIAZ (three specimens), *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY;
 bed 2: *P. (D.) elisabethae*, *P. (D.) luciae* (five specimens), *P. (D.) crotalinus* SIEMIRADZKI;
 bed 3: *P. (D.) luciaeformis*, *P. (D.) luciae* (two specimens);
 bed 4: *P. (D.) luciaeformis*;

Wartae Subzone of the Bifurcatus Zone:

- bed 8: *Perisphinctes (Perisphinctes) cautisnigrae* ARKELL;
 bed 10: ?*Liosphinctes cracoviensis* (SIEMIRADZKI);
 bed 11: *Perisphinctes (Dichotomoceras) wartae* BUKOWSKI (three specimens), *Subdiscosphinctes kreutzii* (SIEMIRADZKI);
 bed 12: *Perisphinctes (D.) wartae* (Text-fig. 7a-b);
 bed 13: *P. (D.) wartae* (three specimens);
 bed 20a-b: *P. (D.) wartae*, *Perisphinctes (Perisphinctes) cautisnigrae* ARKELL, *S. kreutzii*;
 bed 20 b: *P. (D.) wartae* (two specimens), *P. (P.) cautisnigrae*, *S. kreutzii*, *Subdiscosphinctes richei* DE RIAZ;

Stenocycloides Subzone of the Bifurcatus Zone:

- bed 21: *P. (D.) wartae*, *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY (two specimens);
 bed 22a: *P. (D.) wartae* (three specimens), *P. (D.) bifurcatoides*, *Subdiscosphinctes* sp.;
 bed 22b: *P. (D.) wartae*, *P. (D.) bifurcatoides*;
 bed 22c: *P. (D.) wartae*, *P. (D.) bifurcatoides*;
 bed 22/23: *P. (P.) cautisnigrae*;
 bed 23a: *P. (D.) wartae*, *P. (D.) bifurcatoides*;
 bed 23b: *P. (D.) bifurcatoides*, *Subdiscosphinctes* sp., *Perisphinctes (Perisphinctes) spp.*;
 bed 23c: *P. (D.) bifurcatoides* (two specimens), *Perisphinctes (Dichotomoceras) spp.*, *Perisphinctes (Perisphinctes) spp.*;
 bed 24 (the upper part of the section): *P. (D.) bifurcatoides*, ?*Liosphinctes cracoviensis*, *Subdiscosphinctes* sp.

Niegowonice Quarry (for the geological column see Text-fig. 2 in MATYJA & WIERZBOWSKI 1994)

Elisabethae Subzone of the Transversarium Zone:

- bed 25 (the base of the section): *P. (D.) luciae* DE RIAZ (two specimens);
 bed 23: *P. (D.) luciae*;
 bed 20: *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ;
 bed 18: *P. (D.) elisabethae*;
 bed 17: *P. (D.) elisabethae* (two specimens), *Perisphinctes (Dichotomosphinctes) crotalinus* SIEMIRADZKI,
Amoeboceras transitorium SPATH;
 bed 14: *P. (Dichotomosphinctes) sp.*, *Subdiscosphinctes kreutzii* (SIEMIRADZKI) (two specimens);

Wartae Subzone of the Bifurcatus Zone:

- bed 13: *P. (Dichotomoceras) wartae* BUKOWSKI;
 bed 12: *S. kreutzii*;
 bed 7: *P. (D.) wartae*;
 bed 6: *P. (D.) wartae*;
 bed 5: *S. kreutzii* (two specimens);
 bed 4: *S. kreutzii*;
 bed 2: *P. (D.) wartae*, *S. kreutzii*;
 bed 1 (the top of the section): *P. (D.) wartae* (five specimens), *S. kreutzii* (six specimens).

Auenstein, section RG 226 (Text-fig. 4)

Luciaeformis Subzone of the Transversarium Zone or Schilli Subzone of the Schilli Zone:

- bed 37-40 (lower part of the section): *Subdiscosphinctes* sp. (collected loose);

Schilli Subzone of the Schilli Zone:

- bed 38: *Perisphinctes (Dichotomoceras) wartae* BUKOWSKI;
 bed 45: *Subdiscosphinctes* sp.;
 bed 46: *Larcheria schilli* (OPPEL) (GYGI 2000b, Pl. 8, Fig. 2) (collected loose, probably from bed 46);
 bed 47: *Larcheria* cf. *schilli* (GYGI 2000b, Pl. 5, Fig. 5), *P. (D.) wartae*;

Rotoides Subzone of the Schilli Zone:

- bed 52: *P. (D.) wartae*;
 bed 53: *P. (D.) wartae*;

Stenocycloides Subzone of the Bifurcatus Zone

- bed 54 (top of the section): *P. (D.) wartae*, *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY.

Holderbank, section RG 276 (Text-fig. 4)

Luciaeformis Subzone of the Transversarium Zone:

- bed 28: *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ; *Subdiscosphinctes kreutzii* (SIEMIRADZKI);
 bed 29: *P. (D.) elisabethae*;
 bed 31: *P. (D.) elisabethae*;

Schilli Subzone of the Schilli Zone:

- bed 39: *Larcheria schilli* (OPPEL);
 bed 42: *L. schilli*; *Larcheria subschilli* (LEE); *S. kreutzii* (four specimens);

Rotoides Subzone of the Schilli Zone:

- bed 46: *Perisphinctes (Dichotomoceras) rotooides* RONCHADZÉ; *P. (D.) wartae*;
 bed 48: *P. (D.) rotooides*; *P. (D.) wartae*;

Stenocycloides Subzone of the Bifurcatus Zone

- bed 50 (top of the section): *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY.

Oberehrendingen, section RG 51 (Text-fig. 4)

Luciaeformis Subzone of the Transversarium Zone:

- bed 6: *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ, *Perisphinctes (Dichotomosphinctes) buckmani* ARKELL, *Subdiscosphinctes kreutzii* (SIEMIRADZKI);

Schilli Subzone of the Schilli Zone:

- bed 7: *Larcheria* cf. *schilli* (OPPEL);
 bed 8: *Larcheria* cf. *subschilli* (LEE), *P. (D.) elisabethae*, *Perisphinctes (Dichotomosphinctes) luciaeformis* ENAY;
 bed 9: *L.* cf. *subschilli*;
 bed 10: *L. schilli* (two specimens), *S. kreutzii*;
 bed 13 (top of the section): *L.* cf. *schilli*, *Subdiscosphinctes* sp.