BULLETIN DE L'ACADÉMIE
POLONAISE DES SCIENCES
Série des Sciences de la Terre
Volume XXII, No 2, 1974
Publié en février 1975

Time Changes of Oxfordian Ammonite Fauna of the Polish Jura Chain; Some Reflections

by

W. BROCHWICZ-LEWIŃSKI and Z. RÓŻAK

Presented by Z. KIELAN-JAWOROWSKA on April 23, 1974

Summary. Reversible and irreversible time changes in an ammonite shell size, dimensions, ornamentation and presumably sutures, known to occur in *Glochiceras* [34], are also found in contemporaneous Oxfordian groups, such as perisphinctids. Periods of the maximum size reduction, the *Tenuicostatum-Antecedens* and *Bifurcatus-Bimammatum* junction beds, coincide with the sharpest changes in the composition of ammonite faunas, whereas the changes appear markedly smaller or almost none in periods of limited shell-size oscillations. Changes in the shell size and morphology appear at least partly related to external factors. The changes may partly explain the "overweight" of the taxa of the Submediterranean and Subboreal provinces in comparison with other provinces.

Introduction

The paper deals with ammonite fauna of the Oxfordian of the Polish Jura Chain. In the last few years it has been possible to collect well-preserved material from several horizons of the Oxfordian. In the course of the study of the specimens some interesting observations concerning time changes in this ammonite fauna could be made. The studies were greatly facilitated by Enay's [13] monograph of Oxfordian perisphinctids from France and by papers on contemporaneous ammonite fauna of the Polish Jura Chain recently published by Malinowska [25—26].

The study on time changes in any fauna greatly depends on the time scale available. The Submediterranean and NW-European zonations recently applied in France [12—14], England [8, 10, 32], FRG [33], Spain [4] and in Poland [5, 21] appeared useful for the present purpose.

Previous studies on time changes in Jurassic Ammonite faunas

In attempts to explain time changes in Jurassic Ammonite faunas Waagen, Gemmellaro and Neumayr began to look for the succession of similar species and to connect these species into lineages, i.e. to trace evolutionary changes [34]. Further studies showed that the situation was much more complex. Besides changes of this type Siemiradzki [29] found changes in the ammonite spectrum, which result fr the recruitment of new elements from other provinces, e.g. Cardioceratidae fr more northerly areas to the Oxfordian basin of southern Poland.

The problem of the dependence of ammonite ornamentation on environmen conditions was touched by Spath [31], according to whom "like other mollus shells these ornamented ammonites often bear the stamp of their local habit although the animals inhabitating these shells may be assumed to have been id tical". If it is the case, then certain simultaneous trends in changes of ammon shells of different ammonite groups inhabitating the same region may be expect

A number of authors have noted remarkable differences in the mean size ammonite shells of different ages [3]. It was Różycki [28] who reported a cert tendency for the mean size of shells to increase during the Neuvisian and Argovi Arkell [1] regarded the adult maximum size of shell as a good specific characterist which forced him to interpret the appearance of the Oxfordian giant perisphinc fauna in Submediterranean Europe in terms of migration from more southe areas [2]. The possibility of an increase of the maximum shell size and the resulti or accompanying changes in ornamentation were evidenced in *Creniceras-Gloc ceras* and *Perisphinctes* faunas by Ziegler [34] and Enay [13], respectively. T former study showed that these size changes may be reversible, on the contra to some changes in the shell morphology.

Thus, it may be stated that changes in a given ammonite community may resu from: (1) evolution of species, (2) immigration of new elements from other are and (3) the influence of environmental factors on a number of morphological fe tures, including the shell size, the length of the final body chamber, the complexi of sutures, the whorl outline [34] and the density and strength of the sculptu [13]. It should be noted that there is a possibility to distinguish artificial specie genera or series on the basis of changes induced by factors (2) and (3).

Sexual dimorphism in ammonites [23, 9] gave an invaluable clue to the analys of changes in ammonite faunas, as recognition of dimorphic pairs makes it necessa and possible to analyse changes in both micro- and macroconchs and to appl tests of mutual consistency. This was already shown by Enay [13].

Changes in Oxfordian perisphincted faunas of Polish Jura Chain

The lowermost Oxfordian from the Częstochowa-Żarki area, Polish Jura Chai (the *Cordatum* and lower *Plicatilis* Zones) yields numerous small microconchs o the *Prososphinctes mazuricus* groups and their macroconchs, *P. claromontanu* group. There also occur some microconchs of *Alligaticeras* and fragments of fairl large macroconchs representing the ancestors or early *Kranaosphinctes*.

The *Kranaosphinctes promiscuus* group first appear at the base of the *Anteceden* Subzone, where they are represented by forms attaining ca. 180 mm in size and with body chamber over a whorl long. They are accompanied by some marcoconchs already referable to *Arisphinctes* and *iscosphinctes*. Microconchs are reprented by minute *Otosphinctes* and early *Dichotomosphinctes*, 40—100 mm in dia-eter. and minute *Passendorferia czenstochovensis* (Siem.). Generally, the sculpture id shape of these specimens are strictly similar to those of perisphinctids from e *Bifurcatus-Bimammatum* junction beds. All the specimens are relatively small-zed. with very long body chambers moderately to markedly evolute and ornamented ith innumerous, coarse, round-crested ribs. On purely morphological premises is possible to place some of them in species and genera known from the upper-ost *Bifurcatus*-lowermost *Bimammatum* beds, such as *Microbiplices*, *Orthos-hinctes*, *Progeronia*, and vice versa.

From the base of the *Antecedens* Subzone, there is a distinct trend of the ultimate ze of microconchs to increase [8, 13]. This is shown best by the series proposed y Enay ([8], p. 857; the maximum shell size given in brackets): *Otosphinctes ouatius* r *O. Monfalconensis* (ca. 60 mm) → *O. magnouatius* (80 mm) → *Dichotomosphinctes otoides* (ca 100 mm) → *D. antecedens* (150—180 mm) → *D. wartae* (160—180 mm). Close to the end of the *Antecedens* Subzone there appear giant microconchs, *D. uckmani* and *D. dobrogensis*, about 200 mm or more in diameter. A similar trend eems to be observable in macroconchs. Macroconchs of the *Kranaosphinctes pro-niscuus* group increase in size up to 220—240 mm and are soon followed by *K. rifidus*, over 400 mm in size. References in the literature and fragmentary speci-nens indicate that soon appear giant *Kranaosphinctes*, *Arisphinctes* and early *Peri-sphinctes* s. st., up to 500 mm in size or more. The size increase is accompanied by tendency to develop finer and denser ribbing of microconchs and inner whorls of macroconchs [13], a shorter final body chamber, and an increased complexity of sutures.

That *Perisphinctes* s. st. originate from *Arisphinctes* was shown by Enay [13] and Hauerstein [18]. Most probably the former evolved from the *Arisphinctes maximus-ingens* group via the transitient *Perisphinctes chloroolithicus-parandieri* group. Early *Arisphinctes* are known from the lower *Antecedens* Subzone, charac-terized by rich and differentiated *Kranaosphinctes* fauna. However, the Polish early *Kranaosphinctes* appear very close to the *Kranaosphinctes cyrilli-methodii* group comprising Mediterranean species roughly referable to the English genus *Kranaos-phinctes* Buckman (see [13], p. 590). Microconchs of these Mediterranean *Kranaos-phinctes* may be assumed to belong or are closely allied to the *Passendorferia czen-stochovensis-birmensdorfensis* group, comprising late representatives of *Mutations-reihe des P. alligatus* of Siemiradzki [30]. These groups, Mediterranean *Kranaos-phinctes* and early *P. czenstochovensis-birmensdorfensis* are assumed to give rise to the *Passendorferia* group including idoceratids of the late *Plicatilis-Bifurcatus* zones [7]. If it is the case then the ancestors of *Arisphinctes* should be looked for elsewhere. It was mentioned above that the basal part of the *Antecedens* Subzone yields numerous *Otosphinctes-Dichotomosphinctes*. The evolutionary series of Enay (see above) clearly show that this fauna gave rise to later giant *Dichotomosphinctes*, which are sexual counterparts of *Arisphinctes* and the *Perisphinctes* proper. There-fore, macroconchs of these early *Otosphinctes-Dichotomosphinctes* were to give rise to the [illegible]*sphinctes-Perisphinctes* faunas. These ancestral macroconchs may be

Comment to the ammonites illustrated

Some ammonites of paleontological importance are shown in Plates I—IV. In their descriptions the following abbreviations were used: *D* — diameter, *D Ph* — diameter of phragmocone, *H* — height of whorl, *T* — whorl thickness, *U* — umbilical diameter

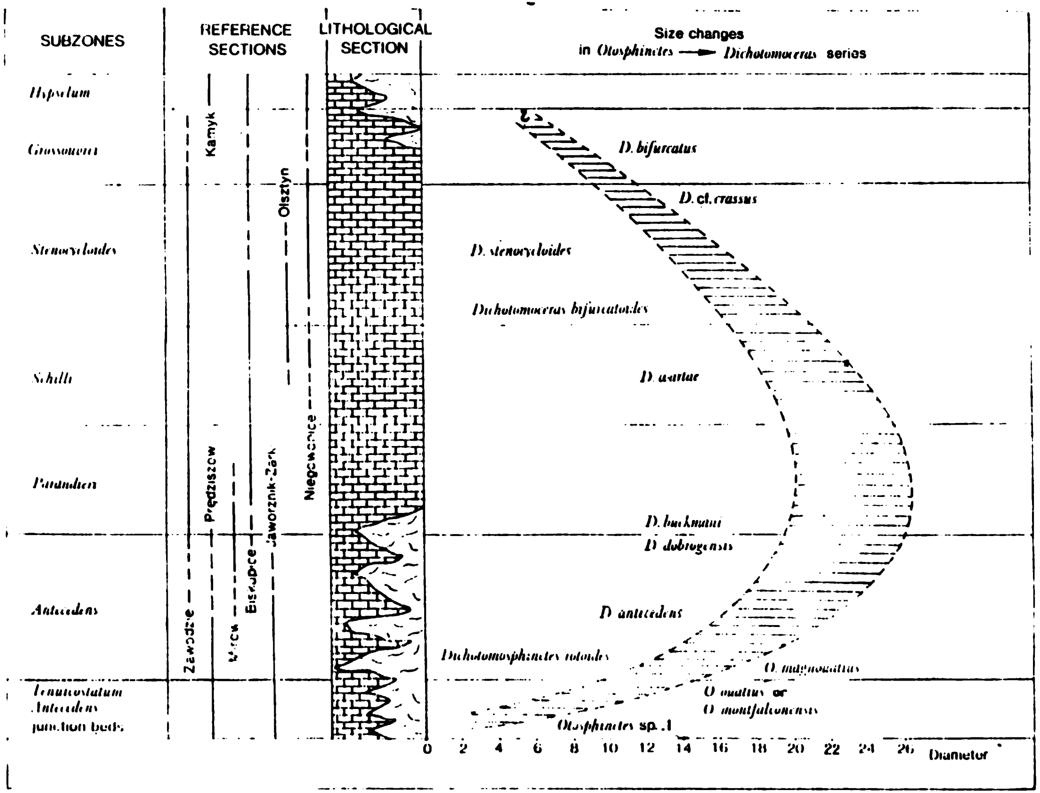


Figure. Time changes in the shell size of ammonites of the [redacted] referable to the English (proper) stock of *Kranaosphinctes* or, which seems more probable, represent early *Arisphinctes*. In either case, in the late *Plicatilis* Zone (or even earlier) Mediterranean and Submediterranean lineages were well separated.

The *Transversarium-Bifurcatus* zones seem to display a trend to reduce the shell size gradually. Such conclusion may be drawn from the analysis of the sequence of microconchs. The late *Transversarium* (*Schilli* Subzone) yields microconchs of the *D. wartae* group, 180—160 mm in size, i.e. smaller than the *D. buckmani-dobrogensis* fauna. The early *Bifurcatus* (*Stenocycloides* Subzone) yields descendants of the former, *Dichotomoceras bifurcatoides-stenocycloides* group, 180—150 mm or less in size. This group is gradually replaced by smaller forms of the *D.* cf. *crassus* group ca. 120 mm, and those in turn by still smaller forms of the *D. bifurcatus* group (100—70 mm, and even less than 50 mm at the end of the *Bifurcatus* Zone). The macroconch fauna of this age is still little known, but a similar trend may be noted. Sexual dimorphs of the *D. wartae* group (*P. cuneicostatus* — ? *martelli* — ? *cautisnigrae*), attaining 350—460 mm in size, are replaced by dimorphs of the *D. bifurcatoides-stenocycloides* group (*P.* cf. *panthieri*), some of which are smaller than their ancestors. The *Dichotomoceras* cf. *crassus* fauna presumably matches macroconchs of the *P. variocostatus* group which are less than 300 mm in size. And finally the presumable macroconchs of *D. bifurcatus* attain about 220 mm in size. Here presumably belong small-sized macroconchs recently placed by Malinowska [26] in *P.* (*Dichotomoceras*) *crassus* Enay. It should be noted that this trend to reduce the shell size in faunas of the *Bifurcatus* Zone was independently found by R. Enay's team (Enay, pers. inf.).

Along with the phenomenon of the size reduction there are distinct changes in the whorl shape and ornamentation. The most distinct change takes place at the base of the *Bifurcatus* Zone, where rib-curves of microconchs and of inner whorls of macroconchs become U-shaped. Such rib-curves are typical of the *Dichotomoceras* and *Perisphinctes variocostatus* groups (i.e., the type specimen of *Perisphinctes* s. st. and its close allies). This change results from ribs being more crowded on the innermost whorls and somewhat more loosely spaced thereafter. It is accompanied by some decrease in the number of ribs and a change in their appearance — they become more prominent and sharper-crested [13]. A forward sweep of secondaries, typical of *D. wartae*, is retained in *D. bifurcatoides-stenocycloides* and even emphasized in *D. bifurcatus*. From the base of the *Grossouvrei* Subzone there is a further reduction in the number of ribs and an increase in their strength. It seems possible to distinguish two principal types of sutures in the *Dichotomoceras* fauna of the *Bifurcatus* Zone: one closer to *Dichotomosphinctes*, and the other, bifurcatus-type, markedly simplified (Cariou, pers. inf.). It is of vital importance to state whether or not these types represent stages of simplification of sutures. It should be noted that the small-sized conchs of *D. bifurcatus* also display markedly simplified sutures.

The decrease in the shell size is also accompanied by changes in its shape. The transition from *Arisphinctes* to *Perisphinctes* s. st. [1, 13] seems to be related to a more sudden transition from ornamentation common for both micro- and macroconchs to that typical of macroconchs. This seems to result from the shell size reducti and along with a further progress of this phenomenon anomalous forms appe Such are some small-sized macroconchs of the *P. variocostatus* group, havi the final body chamber of the width, height and ribbing which look as if tak from a macroconch twice as large. However, along with a further decrease in si the proportions are restored. The problem whether or not the smallsized macroconc of *Perisphinctes* s.st., cited from the *Antecedens* Subzone [13], correspond to a earlier phase of the size reduction is of vital importance here.

Changes in the shell size and remodelling of the sculpture of this *Arisphincte Perisphinctes* fauna are accompanied by similar changes in cooccurring perisphincti The changes are well-marked in microconchs *Subdiscosphinctes.* Close to the low *Bifurcatus* boundary there is a transition from the *Subdiscosphinctes kreutzi-rich* group (*m*) to *S. cracoviense* (*m*), which is marked by a change from isocostate variocostate ribbing. This is reflected by a change from steeply rising rib curv of the former [13, 6] to the initially even steeper rising and thereafter broadly conv rib curves of the latter group (*S. cracoviense* (Siem.), *S.* sp. ex. gr. *rhodanicus* Dumo *S.* sp. *A*; see [6], Figs. 3—4). It may also be noted that the ribbing of *Subdisco phinctes* recorded from the *Stenocycloides* Subzone is somewhat sharper and le densely spaced than that of its earlier representatives. Close to the end of this subzo this genus recedes; none of its representatives has been found either in th *Grossouvrei* Subzone or in the early *Bimammatum* Zone in Poland so far.

Several problems concerning this *Subdiscosphinctes* fauna remain open. Th *Schilli* and/or *Stenocycloides* Subzones yield macroconchs not exceeding 300 m in diameter and microconchs having 140—160 mm and occasionally less in di meter. Recently Malinowska [25] described a number of macroconchs of *Subdi cosphinctes* markedly exceeding 300 mm in size. Two such forms are at the autho disposal. Although their accurate position is not known, it may be inferred th they are derived from the lower *Transversarium* or the uppermost *Plicatilis* Zon This would be confirmed by the find of giant microconchs of that genus in the low part of Zawodzie section, in strata older than the *Schilli* Subzone. The proble of the origin of *Subdiscosphinctes* (formerly *Lithacoceras*) was previously discuss [6]. Subsequent studies on the faunas of the *Plicatilis* Zone gave some early macr conchs and a number of small, relatively highly evolute microconchs of *Subdis cosphinctes*. However, it is still an open question whether or not there is a co tinuity between *P. mazuricus-consociatus* and the above *Subdiscosphinctes* faun

The *Transversarium* and *Bifurcatus* Zones also yield some late *Arisphincte* (of the *pickeringius* group) and *Liosphinctes*. These specimens also display the abov phenomena of the size reduction and sculpture changes. However, dimorphis in these genera is still poorly known. *Arisphinctes* seems to pass the *Bifurcatu Bimammatum* boundary giving rise to *Pseudorthosphinctes*. One of us (W.B.-L. [6]) is not so sure as he used to be about dimorphism in *Liosphinctes*. He had followe Enay [13] regarding *Platysphinctes* as a microconch, whereas it may represent a smal sized macroconch. Similarly, the forms identified as microconchs of *Liosphinct decipiens* (see [5], Pl. VIII, Fig. 2; Pl. XV) are characterized by the final bod amber over a whorl long and may represent "dwarvish" macroconchs. This see be also the case of *Decipia decipiens* in Malinowska [26]. Thus the microcon(*Liosphinctes* are still to be identified. Moreover, it remains an open questi rether these presumable miniature macroconchs from the *Tenuicostatum-An dens* and late *Bifurcatus-Bimammatum* series represent ancestors and descendai the *Liosphinctes* proper, respectively. Such an interpretation seems plausib Malinowska [24] reports "*Platysphinctes*" from the *Bimammatum* Zone of t lish Jura Chain. The fate of this evolutionary line appears difficult to assess b is not improbable that along with a new phase of an increase in the shell size ves *Lithacoceras* sensu Geyer [15].

It should be noted that these tendencies are also displayed by Mid-Oxfordi: oceratids. They (*Passendorferia ziegleri* and *P.* cf. *uptonoides*) are markedly larg an the early *Kranaosphinctes promiscuus* group and the small-sized *Passendorfer* *'esiformis* known from the late *Bifurcatus* Zone, but much smaller than the gia *'anaosphinctes* from the late *Antecedens* times. An analysis of ribbing shows th is finest and most densely spaced in the case of *P. ziegleri* and becomes progress ly coarser and more loosely spaced towards the end of the *Bifurcatus* Zone. On few complete microconchs of this group were found. Recently A. Bittner foun complete megalomorph (76 mm in size) with all the features of *P. birmensdo, nsis* Moesch at Zawady, Polish Jura Chain (see cooccurring fauna in [26]) in th *'hilli-Stenocycloides* junction beds. This megalomorph is almost twice as larg *P. czenstochovensis* and *P. birmensdorfensis* known from the lower *Anteceden* d ? *Grossouvrei* Subzones, respectively. Recent collecting gave also a numbe perisphinctids referable to "*Perisphinctes*" *birmensdorfensis* Oppenheimer (no: oesch) from the uppermost *Bifurcatus*-lower *Bimammatum* strata (Pl. IV, Photo –2). These are small-sized microconchs with loosely spaced, coarser, round-creste(os and relict parabolic nodes-resembling swellings spaced along the final bod amber. Their macroconchs are still to be identified.

In the case of aspidoceratids, some fragments of giant macroconchs (*Parawede ndia*) and accompanying microconchs (*Peltoceratoides*; about a dozen centimeter: diameter) were recorded in the *Cordatum* Zone. However, they soon disappeai d the *Tenuicostatum-Antecedens* junction beds reveal almost no aspidoceratids. iant aspidoceratids are reported again from the late *Antecedens*-early *Parandieri* nes (*Euaspidoceras paucituberculatum* and its allies, over 400 mm in size). Towards e end of the *Bifurcatus* Zone smaller (up to 300 mm in size) *E. oegir* and small, avy tuberculated forms transitional to *E. hypselum* begin to prevail. The lower rt of the *Bimammatum* Zone yields small (up to 150 mm in size) *E. hypselum* d *E. schwabi* and their allies.

The *Bifurcatus-Bimammatum* junction beds yield an assemblage of small peris-inctids, which is still poorly known. This assemblage comprises "dwarvish" *risphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.), less than 50 mm in size, ancestors early *Microbiplices*, early *Orthosphinctes*, some involute perisphinctids roughly ferable to *Ringsteadia*, highly evolute "*Perisphinctes*" *birmensdorfensis* Oppenh. on Mo[illegible]) and its allies, a.o. The genus *Perisphinctes* s. st. undoubtedly disappears but the question remains open whether or not it gives rise to any other one. A tr sition from *P. bifurcatus* to *Microbiplices* [13] seems improbable, but this sho be verified by the taxonomic position of the sexual dimorphs of the latter, wl are still to be identified. Generally, this perisphinctid assemblage represents a m mum reduction in the shell size and from the base of the *Bimammatum* Zone a cer trend to increase the shell size is marked again.

After a time, large perisphinctids begin to prevail once more. Higher horiz of the *Bimmatum* Zone yield large macroconchs of *Decipia* sensu Enay [13], *Li coceras* sensu Geyer [15], *Pseudorthosphinctes* sensu Enay [13], micro- and ma conchs referable to *Progeronia*, various *Orthosphinctes*, *Ringsteadia*, "*Perisphinc* cf. *acer* Neumayr, and others. The large forms are generally close in appearanc those from the upper *Plicatilis-Transversarium* zones and some specimens easily be placed in taxa typical of these zones. *Platysphinctes* of Malinowska and *Perisphinctes wartae* of Koerner [19] are good examples. There are no reli records of macroconchs with cuneicostate ribbing of the final body chamber, ty of the *Perisphinctes* proper, and microconchs with highly densicostate, fine ribbin *Subdiscosphinctes kreutzi-richei* (*m*) group. And a morphological type appea here for the first time is that of *Ringsteadia*.

The above trends should be also reflected by changes in other ammonite gro but, unfortunately, the data are still insufficient. The genus *Glochiceras*, tha to the pioneer study of Ziegler [34], is the only exception here. Its representati with the mean size of 30 (22—43) mm in the *Transversarium* Zone decrease in with time, attaining 24 (18—28) mm on the average in the *Bimammatum* Z [34]. The size reduction in *Glochiceras* is correlated with an increase in the len of the final body chamber (from 2/3 to 7/8 of the whorl) with some changes in sub-peristomal whorl section and with a simplification of sutures.

To sum up, the *Tenuicostatum-Antecedens* junction beds seem to display a per of size reduction in perisphinctids. From the base of the *Antecedens* Subz perisphinctids increase in size to attain their maximum in late *Antecedens-Parano* times. This is followed by another period of initially gradual reduction in the s size, which becomes fairly rapid since the beginning of the *Grossouvrei* Subzo The second period of the minimum shell size is attained close to the end of *Bifurcatus* Zone and is followed by another period of an increase in the shell s This phenomenon of changes in the shell size seems to be of oscillatory nat and the above-outlined main phases presumably represent the net result of a num of smaller-scale oscillations.

The phenomenon of the shell-size changes presumably results in or is accompa by changes in the shell shape and ornamentation and in the complexity of sutu hence it appears to be of remarkable importance for the taxonomy of ammoni Generally, ammonites from different periods of miniaturization are very sim to one another in shell size, shape, dimensions, ornamentation and in simpli sutures. This seems to be also the case with ammonites from different periods gigantism. Thus the phenomenon appears to be a potential source of serious stacles, particularly for attempts to restore evolutionary series.

Previous studies [34, 13] and the above analysis imply a reversibility of some anges in the shell morphology, size, ornamentation and in the complexity of tures. This phenomenon makes it difficult to distinguish between possible immi-ants from other ammonite provinces and "endemic" elements of the Submedi-ranean province. Some remarks on the possible paleobiogeographic importance the above phenomena are given below.

Previous analyses [18, 13] showed "accelerated" evolution of perisphinctids the *Plicatilis* Zone. Recently Kutek *et al.* ([21]), p. 575) found "a very abrupt ange in ammonite faunas, marked by the appearance of new genera, subgenera "groups of species" at the base of the *Bimammatum* Zone. It follows that these o most abrupt changes in the composition of the Oxfordian ammonite faunas incide with the above-discussed periods of size reduction. In turn, the changes composition of ammonite faunas appear markedly smaller or almost none during riods of limited oscillations in shell size — as, for example, changes at the *Plica-lis-Parandieri* and *Bimammatum-Planula* boundaries.

Paleobiogeographic reflections

The first contribution to the problem of the paleobiogeography of the Oxfordian erisphinctid faunas was made by Siemiradzki [29], according to whom the Polish, wabian and French basins were the center of evolution of a number of series of erisphinctids and the difficulties in the recognition of the series resulted from ee migration of open-ocean ("Indian") and other species into these basins. More aborated evolutionary series were subsequently given by the same author [30], onchadzé [27] and others.

The opposite interpretation was given by Arkell ([2] p. 610), who, assuming the ltimate shell size as a specific characteristic, interpreted the appearance of Oxfor-ian faunas of large perisphinctids in Central and Northern Europe as the result f "a return of Tethyan faunas". This was questioned by Callomon, according to hom in the time of the Callovian-Oxfordian Boreal Spread "there was an unusually xtensive northward migration of some Tethyan elements" (Callomon, fide [17], . 134) as far as East Greenland. Subsequently, the analysis of Cariou [11] showed hat "it is exaggerated to speak of a Tethyan migration, as the *Perisphinctidae* (and ther Tethyan families) were rather autochtonous in Central and North Europe... and he large movements of ammonite faunas have mostly been made by the Boreal amilies which transgress towards the south". In this way we returned to Siemiradzki 29, 30], who tried to distinguish continuous Callovian-Kimmeridgian evolutionary eries of perisphinctids and found southward migration of cardioceratids.

The extent of migration of perisphinctids within the Tethyan Realm remains ontroversial. Recent paleobiogeographic analyses (see [11] and the references therein) howed remarkable provinciality of Oxfordian perisphinctids, but boundaries between he provinces are of gradational nature [17].

The Oxfordian assemblage of the Polish Jura Chain mostly consists of Sub-nediterranean elements, with some admixtures of Tethyan, Subboreal and Boreal ones. There seem to be no greater differences with respect to assemblages kno from southern France, FRG and southern USSR [20]. The above changes in pe phinctid assemblages presumably took place on the whole area of the Subme terranean province and certainly in SE France (Enay, pers. inf.).

The most characteristic Submediterranean and Subboreal forms include *Pe phinctes* s. st., *Decipia, Ringsteadia*, etc. Accurate relationships of such a perisphinc assemblage with those known from other provinces are still difficult to assess beca of the time scales for the latter regions being far less detailed. Despiting mod stratigraphic works in a number of extra-Submediterranean areas the Subme terranean zonation still comprises the maximum number of easily distinguisha zones and subzones (especially for the Oxfordian). This is related to the appar "overweight" of the Submediteranean taxa. This relative enrichment of the Subn diterranean ammonite assemblage and (? resulting) apparent dissimilarity of t assemblage may be interpreted in terms of environmental effects on the shell m phology if the above premise of Spath [31] and the above conclusions are va A time sequence of environmental changes would lead to a sequence of chan in the environmentally dependent shell morphology. Different sequences of envir mental events would of course lead to a different "ornamentational" sequence, i to the origin of different "morpho-" fauna.

Immigrants to the Submediterranean province were presumably also affected the changes. There is a relative enrichment of "Submediterranean-Subborea cardioceratid assemblages in numbers of both genera and species in comparis with the Boreal assemblages. Quantitatively, there are a few times more cardiocera taxa in the former than in the latter region.

It seems possible to distinguish two principal lineages among the Submed terranean perisphinctids: (1) series of idoceratids, comprising the Mediterrane *Kranaosphinctes* group, descendant *Passendorferia*, and forms transitional to *Nebr dites herbichi-teres* and some *Idoceras* [7], and (2) series of Submediterranea Subboreal perisphinctids, comprising *Perisphinctes* s. st., its ancestors, *Arisphinct* and descendants, if any, as well as the corresponding microconchs (*Dichotom ceras, Dichotomosphinctes* and *Otosphinctes*). There are some more troubleson genera and species groups, such as Mediterranean *Arisphinctes* and *Dichotomo phinctes* of [13], presumably closer to the 1st series, and some Submediterrane *Liosphinctes* and *Arisphinctes pickeringius*, closer to the 2nd group rather.

It appears difficult to restore the actual position of such groups as *Arisphinct plicatilis* or the genus *Subdiscosphinctes*. Their affiliation will not be known unt their origin is explained but they seem to be closer to the 1st series.

The *Arisphinctes-Perisphinctes* s.st. (M) assemblage appears to be limited the Submediterranean and Subboreal provinces and any extra-Submediterranea Subboreal records of it should be tested by identifying the corresponding micr conchs. However, there are numerous records of microconchs or even series microconchs outside these regions, e.g. [4]. The actual position of the microconc should be verified by the position of their macroconchs. Such an analysis ma nable one to estimate the extent to which the ornamentation of micro- and macroonchs has been susceptible to environmental factors.

Anyhow, the origin of the genus *Perisphinctes* s. st. appears to result from certain hanges in the Oxfordian perisphinctid assemblage, taking place over the areas f Submediterranean and Subboreal provinces. It seems to be a final result of a cycle f size changes. If a narrow interpretation of this genus is accepted, this name should e applied to *Perisphinctes variocostatus* (Buckl.) and its allies, characterized by U-shaped initial part of the rib-curve, prominent, loosely-spaced, very sharp-rested ribs on inner whorls, etc., and to the corresponding microconchs. In such case, the stratigraphic range of this genus would be confined to the *Bifurcatus* Zone, and all the earlier *Perisphinctes* sensu Arkell and Enay would be placed in *Martelliceras* Schindewolf. It should be noted that the ornamentation of the final body chamber of the *Perisphinctes* type is nothing unusual among Upper Jurassic perisphinctids and it is repeated by some unrelated early Kimmeridgian forms of he genus *Progeronia* Arkell ([36], Pl. 8, Fig. 3, Pl. 9).

Possible causes of time changes

The causes of spreads of Boreal faunas are still unknown. The Boreal elements, as cardioceratids, appear to be independent of climate, as these Boreal forms could live in areas of carbonate deposition situated within the Oxfordian coral belt.

The faunal differences between Oxfordian subzones were partly related by Callomon [8] to some ecological factors. Subsequently, changes in the share of particular families in the ammonite spectrum were shown by Ziegler [35] to be dependent on a number of environmental factors including the depth and tempeture of water (but see the objections of Geyer [16]).

Changes of the ultimate shell size were previously linked by Ziegler with some inherent trends as "the sediments involved give no clues concerning the changes" ([34], p. 231). However, the fact that the changes may take place simultaneously in unrelated groups makes it difficult to accept such an explanation and seems to emphasize the importance of some external stresses.

The coincidence of the "replacement" of Boreal elements by giant Tethyan perisphinctids with the appearance of coral reefs, i.e., with an amelioration of climate was noted by Callomon ([8], p. 198). Actually, the earlier phase of gigantism coincides with the development of large fringe reefs from NE margins of the Holy Cross Mts. [22], which are undoubtedly older than the late *Bifurcatus* Zone (*Perisphinctes bifurcatus* Qu. was recently found in a direct encapping of the reef at Bałtów, the Holy Cross Mts.). However, the Częstochowa (Polish Jura Chain) sections and particularly *Bifurcatus-Bimammatum* sections displaying the phase of ammonite-shell-size reduction show no changes in lithology (here we are indebted to Dr. A. Gaździcki and Dr. J. Liszkowski for microfacial analyses).

Thus it may be tentatively concluded that the size changes in ammonite faunas appear to be at least partly related to some hitherto unidentified environmental factors, which were changing over the large part of the Submediterranean and Subboreal provinces.

The manuscript was kindly revised by J. H. Callomon, E. Cariou, R. Enay a J. Liszkowski. Thanks are due to W. C. Kowalski, J. Kutek, H. Makowski, L. M linowska, K. Pożaryska, A. Wierzbowski and A. Zeiss for discussions. Any erro in interpretation are entirely due to the authors.

DEPARTMENT OF GEOLOGY, WARSAW UNIVERSITY, AL. ŻWIRKI I WIGURY 93, 02-089 WARSA
(WYDZIAŁ GEOLOGII, UNIWERSYTET WARSZAWSKI)

REFERENCES

[1] W. J. Arkell, Paleont. Soc. Mon. Pts., **1—14**, (London) (1935—1948).

[2] — , *Jurassic geology of the world*, Edinburgh-London, 1965.

[3] — in; R. C. More (ed.), *Treatise on invertebrate paleontology, Part L, Mollusca*, *Cephalopoda, Ammonoidea*, Univ. Kansas Press, New York 1957.

[4] H. Behmel, N. Jb. Geol. Paläont. Abh., **137** (1970), 1.

[5] W. Brochwicz-Lewiński, Bull. Acad. Polon. Sci., Sér. Sci. de la Terre, **18** (1970)

[6] — , Acta Geol. Pol., **22** (1972), 473—497.

[7] — , Acta Palaeont., Pol., **18** (1973), 299—320.

[8] J. H. Callomon, Proc. Geol. Ass., **71** (1960), 177—208.

[9] — , Trans. Leicester lit. phil. Soc., **57** (1963), 1—36.

[10] — , Colloque Int. du Jurassique, Luxemburg 1962, C.r. Me., Luxembou 1964, 269—291.

[11] E. Cariou, in: A. Hallam (ed.), *Atlas of palaeobiogeography*, Elsevier Sci. Publ. Co Amsterdam-London-New York, 1973, 287—295.

[12] E. Cariou, R. Enay, H. Tintant, C. R. Somm, Seances Soc. Geol. Fr., **6** (1971), 18—2

[13] R. Enay, Nouv. Arch. du Museum d'Hist. Nat. de Lyon, **7** (1966), 1—624.

[14] R. Enay, H. Tintant, E. Cariou, Coll. Int. du Jurassique, Luxembourg, 1967 [preprint

[15] O. F. Geyer, Palaeontographica, **117**, Abt. A (1961), 1—157.

[16] — , Palaeogeography, Palaeoclimatol., Palaeoecol., **10** (1971), 265—172.

[17] A. Hallam, in: F. A. Middlemiss, P. F. Rawson & G. Newall (eds.), *Faunal provinc in space and time*, Geol. J. Spec. Issue, **4** (1971), 129—152.

[18] G. Hauerstein, *Perisphinctes (Arisphinctes) aus der Plicatilis-Zone (Mittel-Oxfordium von Blumberg/Südbaden (Taxonomie, Stratigraphie)*, Fotodruck: Mikrokopie GmbH, Münche 1966, 1—112.

[19] U. Koerner, Jh. geol. Landesamt Basen-Württemberg, **6** (1963), 337—394.

[20] G. Krimholz (ed.), *Jurskaja sistema, Stratigrafia SSSR v chetyrnadcati tomakh*, Nedra Moscow (1972), 1—524.

[21] J. Kutek, B. A. Matyja, A. Wierzbowski, Acta Geol. Pol., **23** (1973), 547—575

[22] J. Liszkowski, Przegląd Geol., **10** (1962), 655—658.

[23] H. Makowski, Palaeontologia Polon., **12** (1962), 1—92.

[24] L. Malinowska, Rocz. P. T. Geol., **40** (1970), 177—182.

[25] — , Acta Palaont. Pol., **17** (1972), 167—242.

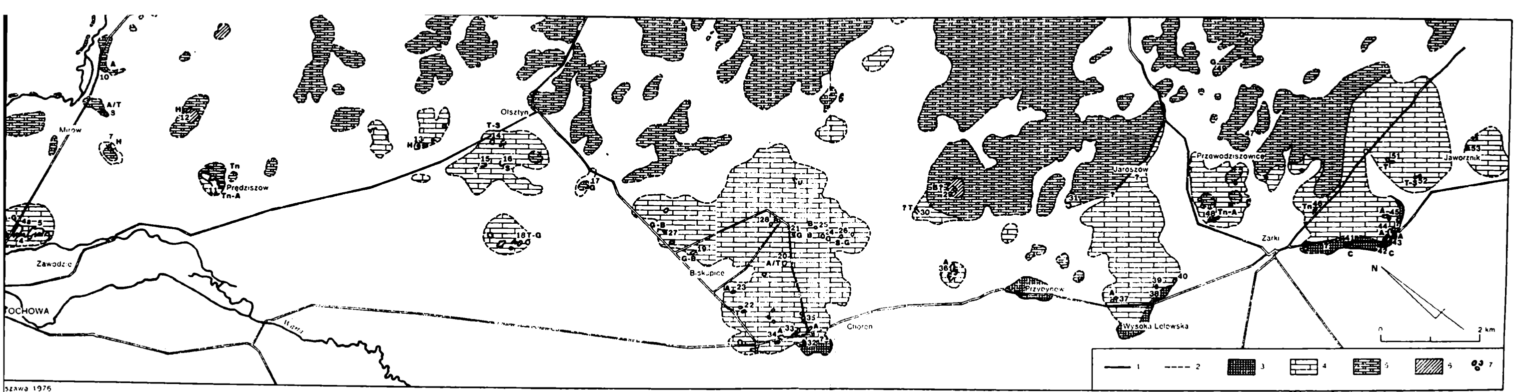
[26] — , Biul. Inst. Geol., **233** (1972), 5—67.

[27] J. Ronchadze, Mem. Soc. Paleont. Suisse, **42** (1917], 1—70.

[28] S. Z. Różycki, Prace Inst. Geol., **17** (1953), 1—335.

[29] J. Siemiradzki, Akad. Umiej. Pam. wydz. mat.-przyr., **18** (1891), 1—92.

Species	Stratigraphic range of the ammonites								Locality
			Antecedens			Bifurcatus			
	Cordatum	Tenuicostatum	P. rotoides	P. buckmani	Transversarium	Stenocycloides	Grossouvrei	Bimammatum	
1	2	3	4	5	6	7	8	9	10
Glochiceras subclausum (Opp.)									
G. cornutum Ziegler				+	+			+	3, 6, 7, 10, 11, 20, 22
G. cf. *canale* (Qu.)							+		20
G. cf. *distortum* (Buk.)							?+	?+	19
Lissoceratoides erato (d'Orb.)				+					3
L. rollieri (de Lor.)		+	+	+					10—11, 34, 43—44, 46
Creniceras crenatum (Brug.)		+	+						11, 46
Trimarginites arolicus (Opp.)	+	+	+			?+	?+		3, 11, 22, 26, 42
T. stenorhynchus (Opp.)		+	+			+	+		2, 20, 26, 35, 43
Neocampylites delmontanus (Opp.)		+			+				11, 15, 46
N. henrici (d'Orb.)	+	+							42—43
Ochetoceras canaliculatum (Buch)		?+							32
O. cf. *canaliculatum* (Buch)			?+	+	+	+	?+	?+	2, 6, 11, 18—20, 27, 31
O. hispidum (Opp.)					?+		+	?+	2, 21
Neoprionoceras lautlingensis (Roll.)			+	?+			+		3, 6, 10, 22, 27
Proscaphites anar (Opp.)			+	+				?+	3, 10, 11, 22
Taramelliceras (T.) polonicum Mal.			?+	+					?, 19, 10, 22, 35
T. (T.) sp. aff. *gmelini* (Opp.)	+								42
T. (T.) cf. *pichleri* (Opp.)		+							11
T. (T.) cf. *argoviense* Jean.			+	+			+		6, 17,
T. (T.) bachianum (Opp.)			+						43 or 45
T. (T.) callicerum (Opp.)			+	+	+	+	+		1, 10, 26, 37
T. (T.) costatum (Qu.)				+		+			3, 5, 31
T. (T.) cf. *costatum* (Qu.)								+	7, 13, 19
T. (Strebliticeras) tegulatum (Qu.)						?+	+		2, 16, 31
T. (S.) externnodosum (Dorn)								+	12
Goliathiceras sp. ex gr. *gorgon* Ark.					?+	+	+	+	4—5, 7, 13, 27, 52
G. (? Pachycardioceras) sp.		+							46
Cardioceras (Vertebriceras) spp.		+							48
C. (Subvertebriceras) zenaidae Ilov.	+'	+							11, 42
C. (S.) spp.		+	+						11, 43, 45, 48
C. (Scarburgiceras) bukowskii Maire	?+	+	+	+					3, 11, 45
C. (Plasmatoceras) tenuistriatum Bor.	+								42
C. (P.) tenuicostatum (Nik.)		+	+						11, 44, 48
C. (P.) popilaniense Bod.		+	+						43—44, 46, 48, 11
C. (Scoticardioceras) cf. *gallicum*		+							11
Amoeboceras alternans-ovale group		+	+						43, 46, 48
Amoeboceras sp. *A*						+	+	+	5, 7, 12, 27
Parawedekindia, Peltoceratoides,					+				2
Peltomorphites	+								41—42
Gregoryceras sp.									
Epipeltoceras spp.				+					11
Euaspidoceras paucituberculatum Ark.								+	12
E. oegir (Opp.)				+	+	?+			1, 2, 5, 22, 31, ?36
E. cf. *babeanum* (d'Orb.)					?+	+	+	+	2—3, 12, 24, 31
E. wildenbergense (Dorn)							+		2, 17
E. sublongispinum (Dorn)							+		26
E. cf. *depereti* (Col.) or *E.* sp. n. Sequeiros [35]							?+	?+	21
							+		5
Pseudowaagenia sp.									
Kranaosphinctes promiscuus (Buk.)								+	19
K. trifidus (Sow.)			+						11, 23, 37, 44, 48
K. cf. *decurrens* (Buck.)			+						43 or 44
K. spp.			+						44, 48
Perisphinctes (Arisphinctes) maximus (Young and Bird)		?+	+	?+					48, 10, 43, 44
P. (A.) pickeringius (Y, and B.)			+						11
P. (A.) sp. ex. gr. *tenuis* Enay					+	+			2, 5
P. (Perisphinctes) martelli (Opp.)							+		24
P. (P.) cautisnigrae Ark.					+				2, 5, 18, 31
P. (P.) cf. *multicostatus* Malin.					+				2, 5, 31
P. (P.) variocostatus (Buckl.)					+				15
P. (P.) cf. *panthieri* Enay						?+	+		2, 5, 24
P. (P.) malinowskae B.-L.						+			1—2, 5, 14
P. (? P.) sp. *A*							+		2, 24
P. (Otosphinctes) cf. *magnouatius* Ark.				?+					36
P. (O.) cf. *sorlinensis* de Lor.			+						43—44
P. (O.) sp. *A*		+							11
P. (O.) spp.		+							11
P. (Dichotomosphinctes) rotoides Ronch.		+	+	+					10—11, 32—34, 37, 44, 4
P. (D.) cf. *antecedens* Salf.			+						11, 36, 43
P. (D.) cf. *buckmani* Ark.			+	+					3, 11, 33, 43, 45
P. (D.) cf. *dobrogensis* Sim.			+	+					3. 11, 32
P. (D.) elisabethae Riaz			+	+					11, 44
P. (D.) cf. *elisabethaeformis* Riaz				?+	+				5, 8, 18, 51
P. (D.) cf. *luciaeformis* Enay					+				5, 18
P. (D.) wartae Buk.				+					10
P. wartae tr. *P. (Dichotomoceras) bifurcatoides-stenocycloides* gr.					+				1, 2, 5, 14—15, 18, 22
P. (D.) bifurcatoides-stenocycloides group						+			2, 5, 31
P. (D.) bifurcatus (Qu.)					?+	+	?+		2, 4—5, 14, 16, 18, 26,
P. (D.) cf. *crassus* Enay							+		2, 4—5, A4, 17, 19, 24, 49, 50
? Orthosphinctes sp.						+	?+		14, 21
Orthosphinctes spp.							+		A4
Ringsteadia sp.								+	7, 12, 13
Microbiplices microbiplex (Qu.)								+	27—28, 12, 7
Microbiplices sp. *A*								+	7, 12—13, 19, 21, 27, 28
Liosphinctes laevipickeringius (Ark.)							+		5
L. cf. *berlieri* (Lor.)			+	+	+				2, 10, 34
L. bonarelli (Siem.)				+	+				2, 5, 10, 22
Subdiscosphinctes (S.) kreutzi (Siem.)							+		2, 18
S. (S.) richei (Riaz)				+	+				2, 26, 31
S. (S.) sp.					+				2, 51
S. cracoviensis (Siem.)				+	+				1—5, 6, 11, ?36, 51
S. sp. ev gr. *rhodanicus* (Dum.)					+				15, 31
S. cf. *aeneas* (Gemm.)					+				51
S. (Aureimontanites) cf. *boreale*						?+			5
Malin.					+				51
S. A. carioui B.-L.									
S. (A.) spp.			+						44
Nebrodites (Passendorferia) ziegleri B.-L.			?+	+	+	+			2, 10, 30, 34
N. (P.) teresiformis B.-L.					+	+			1, 3, 18
N. (P.) cf. *uptonoides* (Enay)						?+	+		2, 24
N. (P.) birmensdorfensis (Moesch)							+	+	2, 5
N. (P.) czenstochovensis (Siem.)									5
N. (P.) birmensdorfensis (Oppenh. non	+		+						48
Moesch.)					+	+	?+		
"P" sp. cf. *regalmicensis* (Gemm.)								+	7
Larcheria cf. *latumbilicata* Tint.				+					10
Larcheria spp.					+				2
Prososphinctes mazuricus-claromontanus gr.					+				1, 31?, 51
"*Perisphinctes*" *matheyi-mairei* gr.	+								41—42
	+								41—42.



szawa 1976

1- outcrops

Figure. Oxfordian of the Częstochowa area, Polish Jura Chain (outline of outcrops and main lithological types, partly after S. Z. Różycki, Z. Mosoczy and others)

/ of Callovian, 2 — outcrops of Oxfordian; main lithological types: 3 — spongy limestones with marly intercalations, 4 — platy limestones, 5 — massive limestones, 6 — chalky limestones; 7 — quarries, zones and subzones of Oxfordian: C — Cordatum Zone, Tn — Tenuicostatum beds, A — Antecedens Zone, T — Transversarium Zone, S — Stenocycloides Subzone of Bifurcatus Zone, G — Grossouvrei Subzone of Bifurcatus Zone, B — Bimammatum Zone

[30] — , Paleontographica, **45** (1899), 69—352.
[31] L. F. Spath, Mem. Geol. Surv. India Paleont. Indica, N.S., **9** (1931—1933), 2.
[32] J. K. Wright, Proc. Yorkshire Geol. Soc., **39** (1972), 225—266.
[33] A. Zeiss, Erlangen geol. Abh., **62** (1966), 104—111.
[34] B. Ziegler, Evolution, **13** (1959), 229—235.
[35] — , Geol. Rundschau, **56** (1967), 439—464.
[36] J. Kutek, Acta Geol. Pol., **18** (1968), 493—586

Брохвич-Левиньски, З. Ружак, **Замечания о временной изменчивости аммонитовой фауны [ок]сфорда на территории Польской Юры**

[Со]держание. Обратимые изменения в максимальном диаметре раковины, размерах, орна[ме]нтации и степени осложнения лопастной линии, известные у аммонитов рода *Glochiceras* [(с]м. [34]), обнаружены также у их одновременников из семейства *Perisphinctidae*. Периоды [ма]ксимальной редукции величины, соответствующие переходным слоям между биозонами: [*Te*]*nuicostatum* и *Antecedens*, а также *Bifurcatus* и *Bimammatum*, совпадают с периодами най[бо]льших изменений в составе аммонитовой фауны оксфорда. Одновременно периодам нез[на]чительных изменений величин раковины соответствуют незначительные изменения в [со]ставе аммонитовой фауны. В некоторой степени эти изменения являются вероятно вызван[н]ыми внешними факторами. Независимо, рассматриваемые изменения, хотя бы частично [м]огут выяснить причину резкого преобразования количества оксфордских таксонов известных [в] Субмедитерранской и Суббореальной провинции над количеством таксонов обнаруже[нн]ых в других провинциях.

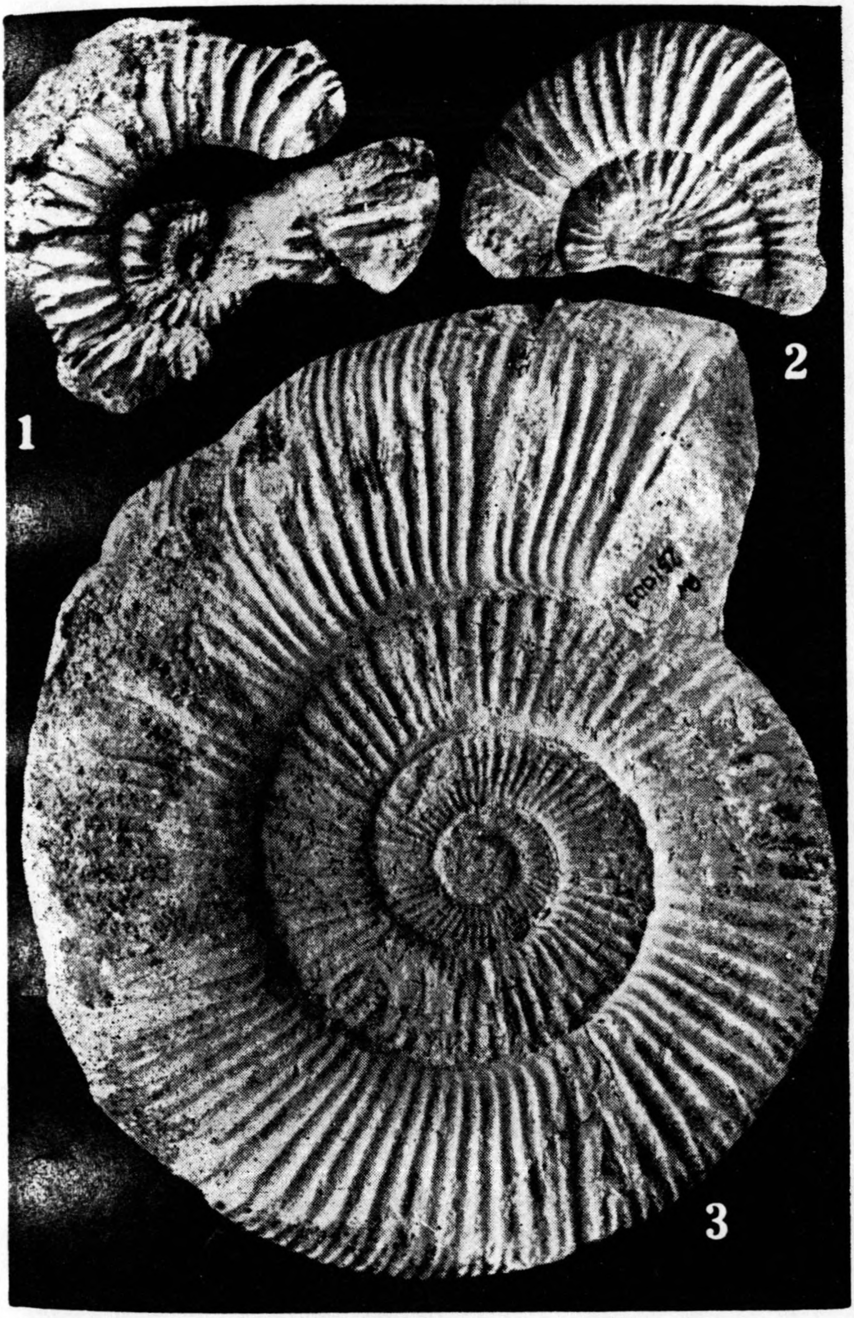


Photo 1. *Microbiplices* sp.; Br 05/273, Zawodzie at Częstochowa, the *Bifurcatus* Zone, *Grossouvrei* Subzone; D_{max} — 55 mm, H/D — 0.28, T/D — ca. 0.34, U/D — 0.49

Photo 2. *Perisphinctidae* (? *Idoceratinae* sp. et gen. indet.); Br 05/045, Zawodzie at Częstochowa, the *Transversarium* Zone, *Grossouvrei* Subzone; D_{max} — 66 mm, ? complete

Photo 3. *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* Enay; Br 25/003, Skrajnica near Olsztyn, Częstochowa [illegible]; D_{max} — 145, D Ph — 90 mm, H/D — 0.30, U/D — 0.48, D — 109 mm, H/D — 0.30, T/D — 0.20, U/D — 0.47, [illegible]

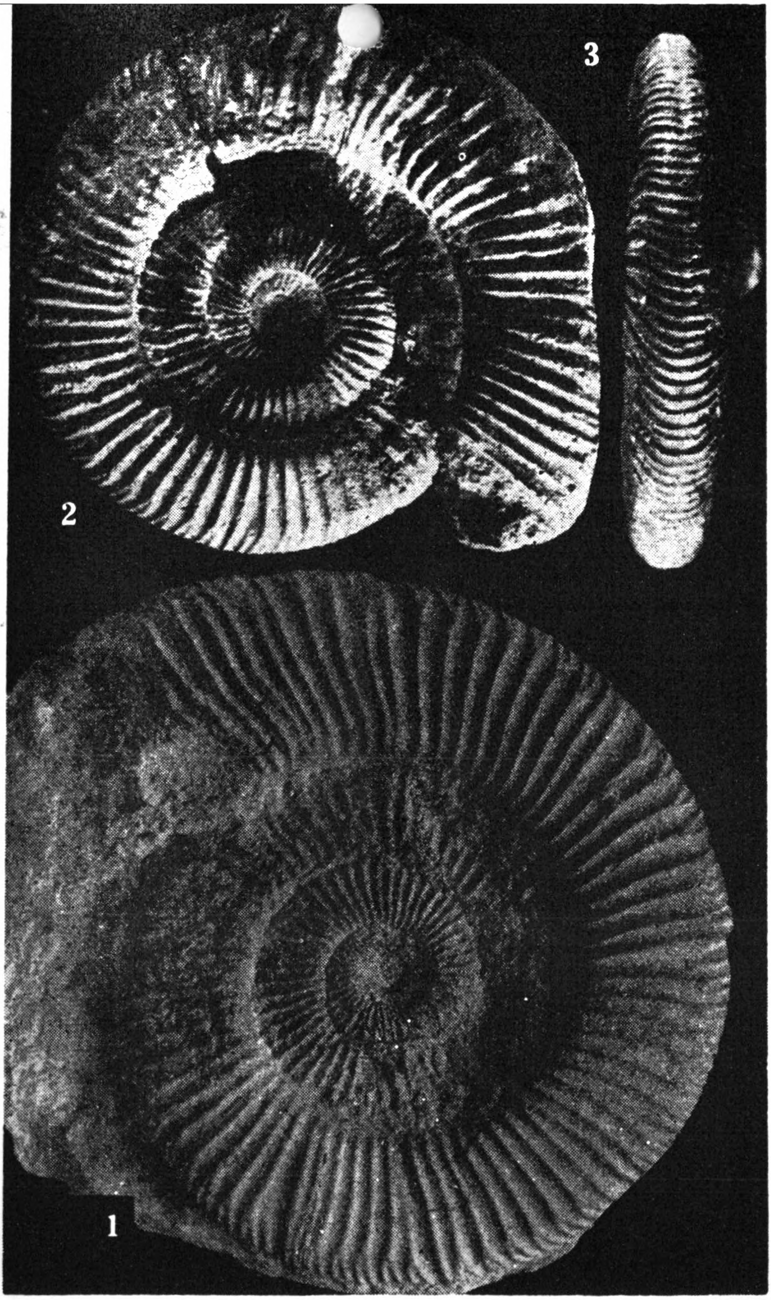


Photo 1. *Perisphinctes* (*Dichotomosphinctes*) *wartae* Buk.; Br 02/208, Zawodzie at Częstocho[...] the *Transversarium* Zone, *Schilli* Subzone; D_{max} — 162 mm; almost complete

Photo 2. *Perisphinctes waehneri* Siemiradzki (type specimen) = *recte P.* (*D.*) *stenocyclo*[...] Siemiradzki; D_{max} — 137 mm, Δ *Ph* — 82 mm, *D* — 111 mm, *H*/*D* — 0.29, *T*/*D* — 0.22, *U*/*D* 0.50, *D* — 85 mm, *H*/*D* — 0.28, *T*/*D* — 0.22, *U*/*D* — 0.50; almost complete

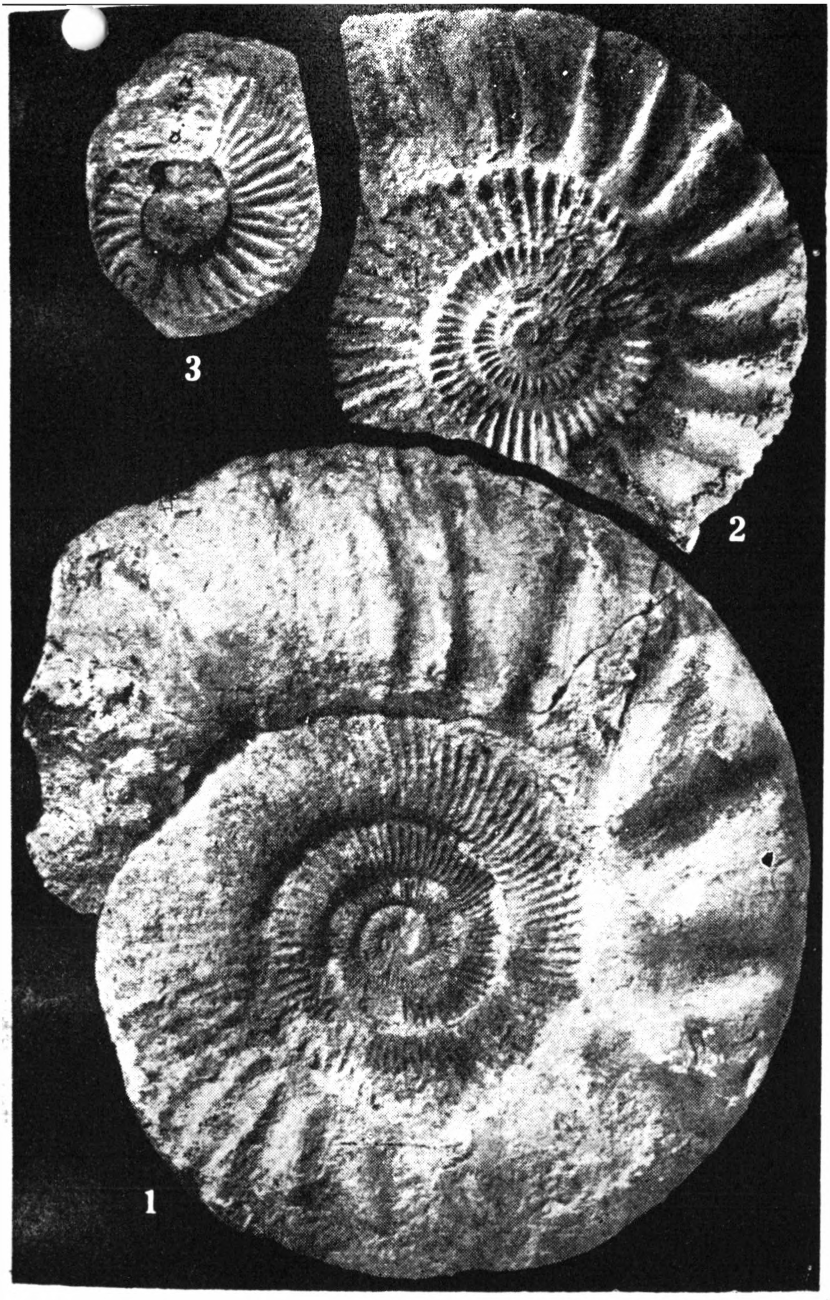


Photo 1. *Perisphinctes* (*Perisphinctes*) *cuneicostatus* Arkell; Br 05/202, Zawodzie at Częstochowa, the *Transversarium* Zone, *Schilli* Subzone; D_{max} — 365 mm, *D Ph* — 255 mm; complete, with peristome

Photo 2. *Perisphinctes* (*Perisphinctes*) sp.; Br 02/003, Zawodzie at Częstochowa, the *Bifurcatus* Zone, *Grossouvrei* Subzone; D_{max} — ca. 216 mm, *D Ph* — 140—160 mm, *D* — 192 mm, *H*/*D* — 0.30, *U*/*D* — 0.49, *D* — 87 mm, *H*/*D* — 0.30, *U*/*D* — 0.49; almost complete dwarvish macroconch, presumable sexual counterpart of *P.* (*Dichotomoceras*) *bifurcatus* (Qu.)

Photo 3. *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (Qu.); Ha 24/7a, the *Bifurcatus* Zone, *Grossouvrei* Subzone, upper most part of*Bifurcatus-Bimammatum* junction beds; D_{max} — 48 mm;

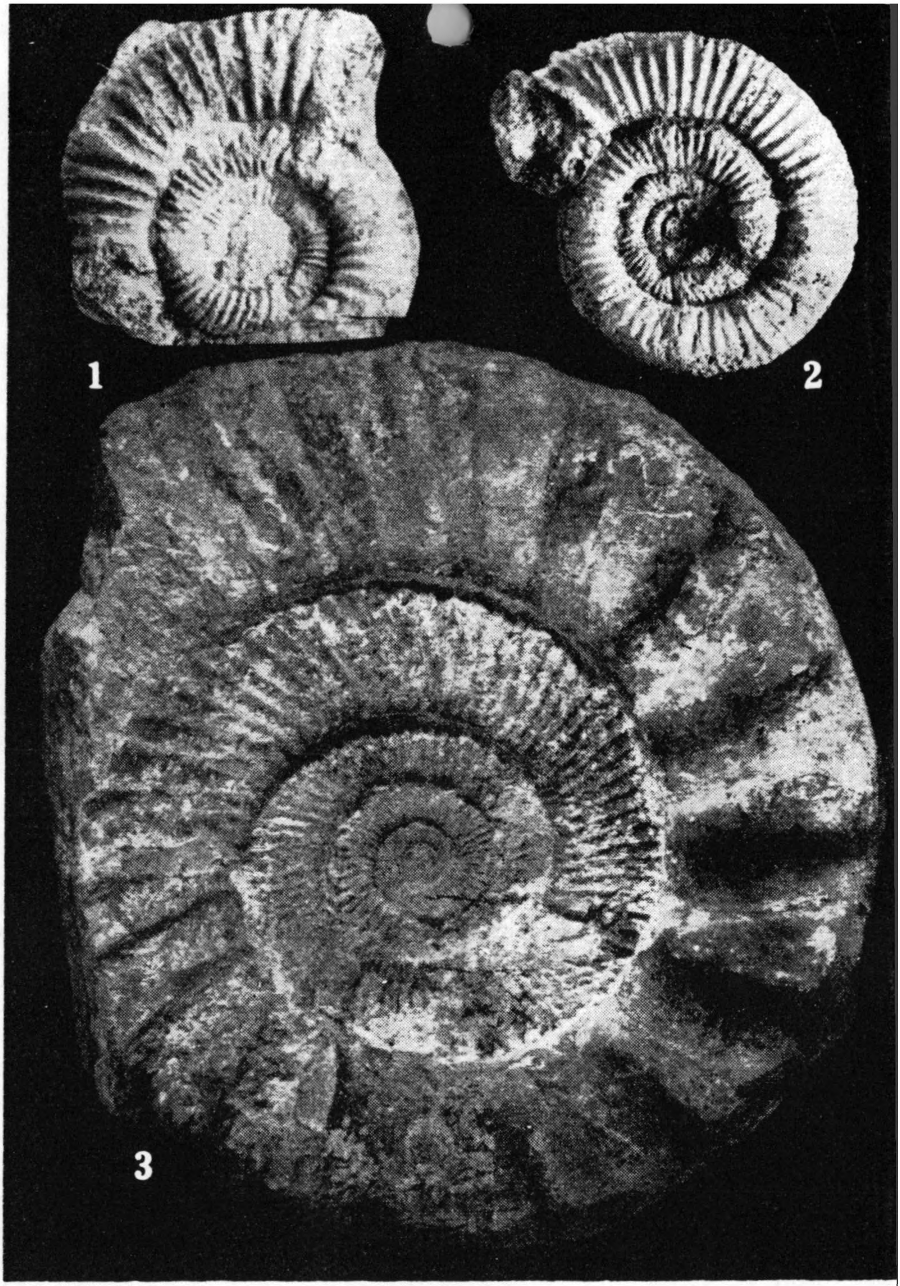


Photo 1. *Passendorferia* cf. *birmensdorfensis* (Oppenh. non Moesch); Br 7/21, Kamyk at Cz stochowa, *Bimammatum* Zone, *Hypselum* Subzone; D_{max} — 52 mm, D — 47 mm, H/D — 0.2 T/D — 0.30, U/D — 0.50; note swellings-resembling parabolic nodes marked along the fin body chamber

Photo 2. *Passendorferia birmensdorfensis* (Oppenh. non Moesch); Br A19/006, Olsztyn ne Częstochowa, *Bimammatum* Zone, *Hypselum* Subzone; D_{max} — 76 mm, H/D — 0.28, U/D — 0.52; complete

Photo 3. *Perisphinctes* (*Perisphinctes*) *cautisnigrae* Arkell; Br 05/201, Zawodzie at Częstochow fallen block, the *Transversarium* Zone, *Schilli* Subzone or lowermost *Bifurcatus* Zone; D_{max} –