POLSKA AKADEMIA NAUK · KOMITET NAUK GEOLOGICZNYCH

PAŃSTWOWE WYDAWNICTWO NAUKOWE • WARSZAWA

acta geologica polonica

Vol. 35, No. 3-4 Warszawa 1985

To the Memory of Professor Edward PASSENDORFER

RYSZARD MARCINOWSKI & JOST WIEDMANN

The Albian ammonite fauna of Poland and its paleogeographical significance

ABSTRACT: The taxonomical and ecological analysis of the ammonite assemblages, as well as the general paleogeographical setting indicate that the Albian deposits within the Polish part of the Central European Basin accumulated under shallow or extremely shallow-marine conditions, and those of the High-Tatra Swell in an open sea environment. The Boreal character of the ammonite faunas in the epicontinental area of Poland, and the Tethyan one in the Tatra Mts are well displayed by the composition of the analyzed assemblages. During Middle Albian time the Boreal hoplitids migrated to the Polish areas from the west or north-west, and they gradually spread, through the western Ukraine, towards the High-Tatra Swell located far within the Tethyan Realm (Alpino--Carpathian geosyncline). In the Upper Albian, in spite of an increasing marine transgression, a distinct provincialism became evident both in the Boreal and in the Tethyan ammonite assemblages. This distinction apparently resulted from the *depth/distance filter* which had separated the High-Tatra Swell from the platform areas of Poland, a filter which worked more efficiently than it had during Middle Albian time. This event was of regional character in Europe, and was caused by change in climatic and bathymetrical conditions rather than by the development of physical barriers (lands or cordilleras).

INTRODUCTION

The aim of the present paper is to announce the results of investigation and/or revision of the Albian ammonites of Poland. This ammonite fauna, a paleontological monograph of which will soon be published separately (MARCINOWSKI & WIEDMANN 1985), has its occurrences confined primarily to the two regions, *viz.* the Central Polish Uplands (Polish Jura, and Holy Cross Mountains) and the high-tatric series of the Tatra Mountains, Inner Carpathians (*see* Text-fig. 1). The geotectonic settings of these two regions during Albian time were different, just as they were throughout the entire Mesozoic. The Central Polish Uplands were a part of the southern, marginal part of the epicontinental Central European Basin (*see* MARCINOWSKI & RADWAŃSKI 1983), and the Tatra Mountains were embraced by the Alpino-Carpathian geosyncline (*see* Text-fig. 2). This difference in geotectonic setting has evidently controlled a pronounced faunistic differentiation: a Boreal character of the ammonite fauna in the Central Polish Uplands, and a Mediterranean one in the Tatra Mountains.

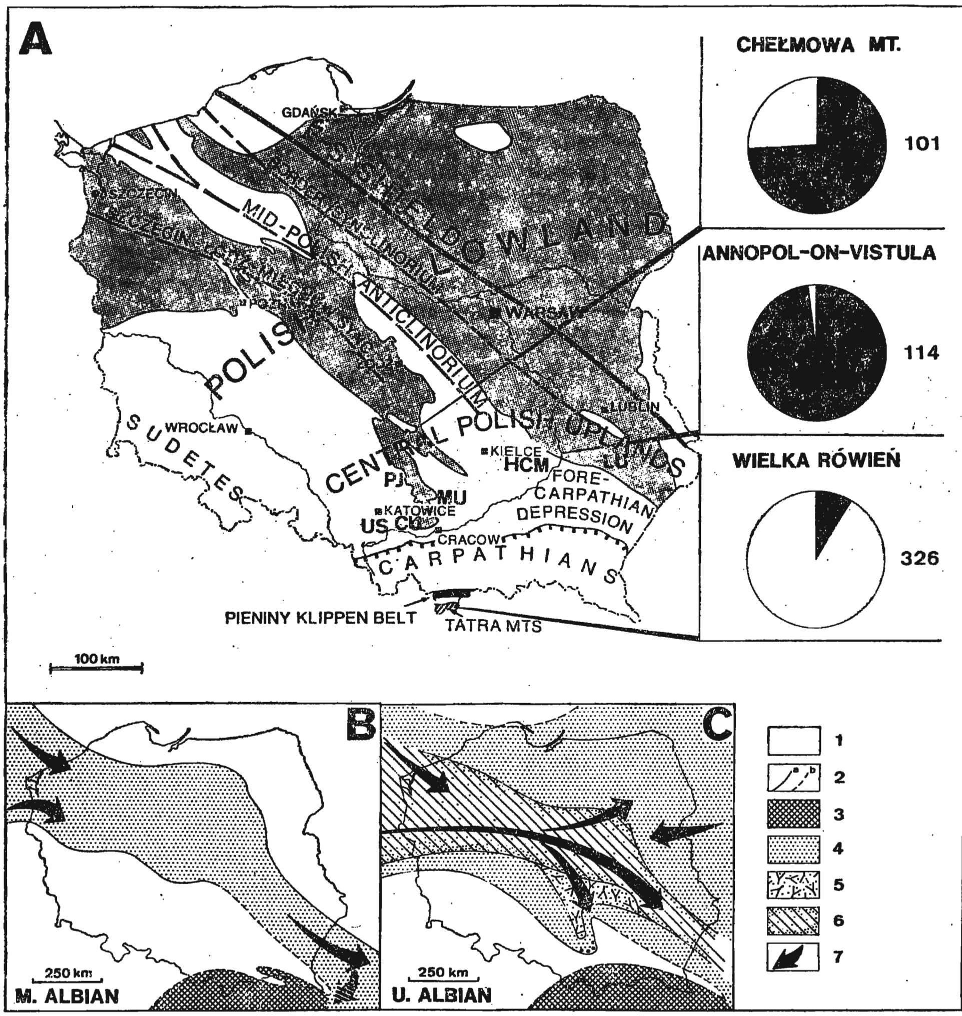


Fig. 1. The Albian of Poland

A — Tectonic sketch map of Poland (without Cenozoic and Upper Cretaceous cover), to show distribution of the Albian deposits (*stippled*)

The main Laramide tectonic units are indicated by their axial zones; thick line (labelled *F-S Shield*) indicates a general outline of stable margins of the Fenno-Sarmatian Shield; northern margin of the Carpathians is overthrust (Albian deposits within the Carpathians are omitted)

CHARACTERISTICS OF THE AMMONITE-BEARING DEPOSITS

The diversified pattern of the Albian ammonite faunas in Poland is the result of the general paleogeographical conditions of the two above-indicated regions. Because the areas of the present-day Central Polish Uplands were closely connected with those of the present-day Polish Lowland, the latter will also be shortly characterized.

POLISH LOWLAND

During post-Variscan time, from the Zechstein throughout the Mesozoic, the areas of the Polish Lowland belonged to the Central European Basin which embraced the geotectonic structure of the Danish-Polish Trough and was shouldered by the Fenno-Sarmatian Shield to the east (*see* KUTEK & GŁAZEK 1972, MARCINOWSKI & RADWAŃSKI 1983). The maximum thickness of the post-Variscan sedimentary sequence (about 7.5 km) occurs in the Kujawy region where the latitudinal subsidence axis of the Central European Basin intersects that of the NW-SE running Danish-Polish Trough. At the Upper Cretaceous decline, during the Laramide phase of the Alpine orogeny, an inversion of the Danish-Polish Trough took place; it resulted in the formation of the Mid-Polish Anticlinorium associated with two neighboring synclinorial zones (*see* Text-fig. 1*A*; *cf. also* KUTEK & GŁAZEK 1972, MARCINOWSKI & RADWAŃSKI 1983). The Albian deposits in the Polish Lowland, available only through boreholes, are overlain by cover of Upper Cretaceous (up to 2.5 km), and Tertiary (up to 200 m) plus Quaternary deposits. They begin with the Middle Albian — Lower Turonian transgressive sequence (*cf.* SAMSONOWICZ 1925; CIEŚLIŃSKI 1959b; RACZYŃSKA & CIEŚLIŃSKI 1960; MARCINOWSKI & RADWAŃSKI 1983, 1985) and rest, with a stratigraphic gap, upon the marine sequence of Neocomian age (Berriasian — Lower Hauterivian).

The Middle Albian deposits of the Polish Lowland consist primarily of sands and/or sandstones, commonly glauconitic, while sandy-glauconitic marls or marly glauconitic sandstones containing phosphatic nodules, as well as gaizes and spongiolites occur more extensively in the Upper Albian (*see* Text-fig. 1*B*—*C*). An average thickness of the Albian deposits ranges between 50 and 70 meters, reaching a maximum value of about 200 meters. These deposits thin out both towards the Fenno-Sarmatian Shield, and southwardly in the direction of the present-day Central Polish Uplands.

Within the Central Polish Uplands indicated are areas discussed in the text: US — Upper Silesia, PJ — Polish Jura, CU — Cracow Upland, MU — Miechów Upland, HCM — Holy Cross Mountains, LU — Lublin Upland

Location of the profiles with the percentage content of the Boreal hoplitid fauna (*black*) and number of specimens are given for particular sections:

Mt. Chełmowa — auritus-Subzone
Annopol-on-Vistula — eodentatus up to altonense-Subzone
Wielka Rówień — floridum up to altonense-Subzone

B-C — Middle and Upper Albian paleogeography of Poland; compiled after the reference data (CIEŚLIŃSKI 1959b, 1965, 1976; KSIĄŻKIEWICZ 1961, 1962; JASKOWIAK-SCHOENEICHOWA 1979; RACZYŃSKA 1979) and own observations in the Central Polish Uplands

1 — land areas, 2 — boundaries between land and sedimentary areas (*a* high probable, *b* speculative), 3 — flysch, 4 — shallow water sands (mostly glauconitic), 5 — sands with sponge-originated content (gaizes and spongiolites), 6 — sandy marls and marly sands (mostly with phosphatic nodules and glauconite), 7 — routes of migration of the Boreal hoplitid fauna

Table 1

Standard biostratigraphic zonation of the Albian sequence in Poland (*adopted from* OWEN 1971; KENNEDY, HANCOCK & CHRISTENSEN 1981)

Substage	Ammonite Zones	Ammonite Subzones
UPPER ALBIAN	Stoliczkaia dispar	Mortoniceras (Mortoniceras) perinflatum Stoliczkaia (Stoliczkaia) blancheti
	Mortoniceras inflatum	Mortoniceras (Mortoniceras) altonense Callihoplites auritus Hysteroceras varicosum Hysteroceras orbignyi Dipoloceras (Dipoloceras) cristatum
MIDDLE ALBIAN	Euhoplites lautus	Anahoplites daviesi Euhoplites nitidus
	Euhoplites loricatus	Euhoplites meandrinus Dipoloceras (Dipoloceroides) subdelaruei Dimorphoplites niobe Anahoplites intermedius
	Hoplites dentatus	Hoplites (Hoplites) spathi Lyelliceras lyelli Hoplites (Isohoplites) eodentatus
LOWER ALBIAN /upper part/	Douvilleiceras mammillatum	Protohoplites puzosianus Otohoplites raulinianus Cleoniceras floridum Sonneratia kitchini

CENTRAL POLISH UPLANDS

The Central Polish Uplands, a hilly belt of which repeats the outline of the Carpathian border and the Fore-Carpathian Depression, make up a circum-Carpathian zone which was uplifted in isostatic response to the Miocene subsidence of the foredeep, regardless of the Laramide folded structures of the Danish-Polish Trough (*see* MARCINOWSKI & RADWAŃSKI 1983). Epicontinental Albian deposits occur at the surface along this zone, and only these deposits are ammonite-bearing (*see* Text-fig. 1*A*). During Albian time, the area of the Central Polish Uplands was a part of a more or less hypothetical meta-Carpathian arch which separated the Carpathian geosyncline from the epicontinental Central European Basin situated to the north (*see* Text-figs 1*B—C* and 2). The Albian deposits are represented, just as in the Polish Lowland, by sands and sandstones which are commonly glauconitic; in the higher parts of the sequence to the north there occurs a lithofacies composed of gaizes, spongiolites, and sandy-glauconitic marls. The thickness of the Albian sequence reaches about 180 meters towards the Polish Lowland, and it decreases southwardly where the thickness ranges from nil to some tens of meters, being dependant on both the pre-Albian topography and the sub--Hercynian (Cenomanian-Santonian) synsedimentary tectonics (*cf.* DŻUŁYŃSKI 1953; ALEXANDROWICZ 1954; MARCINOWSKI 1970, 1974; GŁAZEK, MARCINOWSKI & WIERZBOWSKI 1971; MARCINOWSKI & SZULCZEWSKI 1972; MARCINOWSKI & RADWAŃSKI 1983, 1985).

The key sections which have yielded well definied ammonite assemblages are those at Mt. Chełmowa near Przedbórz in the north-western part of the Holy Cross Mountains, and Annopol-on-Vistula in the easternmost outskirts of the Holy Cross Mountains, a place located formally in the neighboring Lublin Upland (*see* Text--fig. 1).

CARPATHIANS

The Inner Carpathians in Poland embrace the Tatra Mts and the Pieniny Klippen Zone. The Outer, *i. e.* the Flysch Carpathians include only the Beskides Mts. which have been folded and thrust northward (at least as far as 50—70 km) in the younger Tertiary (Miocene). Within the Pieniny Klippen Belt, these younger Tertiary movements followed those of the Laramide age; the Tatra Mts have been folded in the sub-Hercynian (post-Turonian) phase (KSIĄŻKIEWICZ 1956, 1972; ANDRUSOV 1965).

The opinions offered recently on the geotectonic nature of the basement of the Flysch Carpathians are diverse. Geophysical data (*cf.* SZÉNÁS 1973, ČECH 1982) indicate a continental-type of crust during both the Mesozoic and Tertiary sedimentation (*cf. also* KSIĄŻKIEWICZ 1977). The same is indicated by the huge amounts of sialic material during the flysch sedimentation and by the moderate depths of the basin, not exceeding the value of 2500 meters (KSIĄŻKIEWICZ 1975, 1977), and thus corresponding to the depths of the modern continental slope. Therefore the opinions (DEWEY & *al.* 1973; SIKORA 1976; MAHEL 1978, 1983) on the oceanic-type of the discussed basement are not justified.

FLYSCH CARPATHIANS

Within an immense sequence of the flysch deposits (at least 6 km thick) which was continuously deposited during the Tithonian through the Lower Miocene, the Albian deposits (up to 500 m thick) occur in many tectonic units (nappes), and display an evident lithological differentiation. The Lower and Middle Albian is represented primarily by sandstones and shales, whereas the Upper Albian is dominated by shales with gaizes and spongiolites (*cf.* Text-fig. 2).

PIENINY KLIPPEN BELT

Within the Pieniny Klippen Belt, the Albian deposits are uniform, both in regard to facies and thickness in particular tectonic units (nappes); they are represented by marls intercalated with shales and radiolarites (total thickness of about 10 to 20 m). Noteworthy is the presence (*see* BIRKENMAJER & KOKOSZYŃSKA 1958) of the heteromorphs of the genus *Hamites* within these pelagic deposits. In the southernmost unit (the Manin Series) the Albian deposits reach a much greater thickness (up to 400 m) and these are developed in the facies of marly-sandy flysch with scarce ammonites (ANDRUSOV 1965).

TATRA MTS

In the high-tatric facies-tectonic zone (the High-Tatra Swell *in* Text-fig. 2), dark-green glauconitic limestones (up to 0.5 m thick) with stromatolites and rich ammonites and associated fauna of Albian age rest upon eroded and locally karstified Urgonian reefoid limestones, and are covered by sandy-glauconitic mudstones and marly mudstones intercalated by sandstones over 50 meters thick (PASSENDORFER 1921, 1930).

The key section is exposed at Wielka Rówień, a small alp on the northern slopes of Mt. Giewont featuring the landscape of the northern parts of the Tatra Mts, and widely known due to the classical description and paleontological monograph presented by PASSENDORFER (1930).

In the sub-tatric facies-tectonic zone (the Sub-Tatra Trough *in* Text-fig. 2), the Albian deposits (up to 150 m thick) are dominated by marls and mudstones intercalated with sandstones, and they conformably overlie the Aptian and older Neocomian pelagic deposits (*see* WIGILEW 1914).

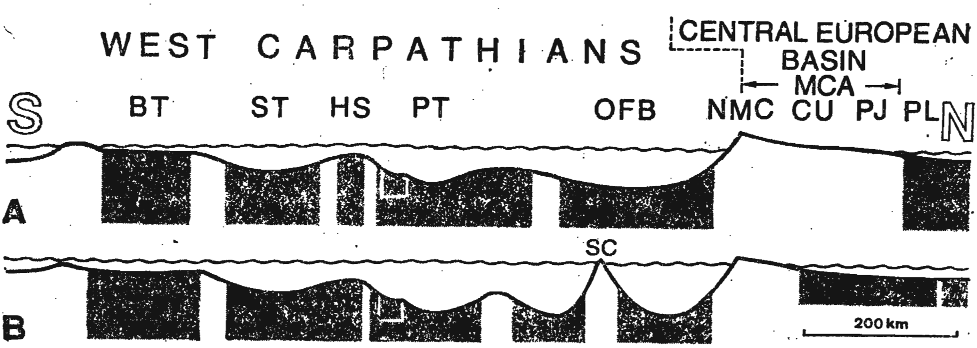


Fig. 2. The West Carpathians geosyncline and the southern part of the Central European Basin during the Middle (A) and Upper (B) Albian

Distribution of facies and the relationships between particular regions based on the reference data (KSIĄŻKIEWICZ 1958, 1961, 1962, 1977; BIRKENMAJER 1960, 1977; ANDRUSOV 1965; ŚLĄCZKA 1976; CSÁSZÁR & HAAS 1979)

BT — Bakony Trough, ST — Sub-Tatra Trough, HS — High-Tatra Swell, PT — Pieniny Trough, OFB — Outer Flysch Basin, SC — Silesian Cordillera, NMC — North-Margin Cordillera, MCA — Mata-Carpathian Arch, CU — Cracow Upland, PJ — Polish Jura, PL — Polish Lowland

SHELF FACIES: 1 — shallow water organodetrital and reef limestones, 2 — shallow water sands and sandstones, mostly glauconitic, 3 — open shelf glauconitic limestones stratigraphically condensed, 4 — open shelf marls

CONTINENTAL SLOPE FACIES: 5 — mesopelagic marls and mudstones intercalated by sandstones, 6 — bathypelagic marls with siliceous cherts and radiolarites, 7 — flysch (*a* sandstones and shales, *b* mainly shales with spongiolites and gaizes)

The terms meso- and bathypelagic are used as defined in "*The Encyclopedia of Oceanography*", edited by R. W. FAIRBRIDGE (1966), but relative depths of the facies are determinated in connection to the modern subdivisions of the stable (Atlantic type) continental margins (*cf.* BOILLOT 1981)

AMMONITE SPECTRA AND STRATIGRAPHY IN THE KEY SECTIONS

Mt. CHEŁMOWA

The sandy deposits of Upper Albian age (*see* CHLEBOWSKI, HAKENBERG & MARCINOWSKI 1978; MARCINOWSKI & RADWAŃSKI 1983) attain a thickness of some 180 meters, and they contain ammonites only within the middle (20 m thick) portion of the section. This portion consists of by medium- to coarse-grained quartz sandstones, locally cross-bedded, with irregular inliers of quartz gravels (pebbles 2—10 mm in diameter). Silicified wood fragments bored by bivalves and trace fossils of the *Chondrites*-type are common, whilst inoceramids and sponges are less frequent. Rarely noted are fragments of reed buried in life position.

Within the discussed deposits the ammonites are very scarce. During a twenty-yeared period only about one hundred specimens have been collected. These consist primarily of normally-coiled shells corresponding to the adult stages of very large or even huge individuals (*see* Table 2). The phragmocones and juveniles of some forms are completely missing.

Table 2

Ammonite content in the Mt. Chełmowa section (auritus-Subzone)

Families and genera	Percentage	Max. diameter in mm
HOPLITIDAE Douvillé, 1890	72.28	
Callihoplites Spath, 1925	44.56	219.5
Anahoplites Hyatt, 1900	27.72	190
BRANCOCERATIDAE Spath, 1933		
Mortoniceras (Mortoniceras) Meek, 1876	23.76	428
DESMOCERATIDAE Zittel, 1895		
Puzosia (Puzosia) Bayle, 1878	1.98	215
HAMITIDAE Hyatt, 1900		
Hamites (Plesiohamites) Breistroffer, 1947	1.98	Wh=56

The ammonite assemblage is characterized by the presence of forms displaying a pronounced ornamentation of the shell (*Callihoplites*, *Anahoplites*, *Mortoniceras*), and which thus correspond to the trachyostraceous group. Accessory are the ammonites with weakly ornamented shells, thus corresponding to the leiostraceous group (*Puzosia*), and finally the heteromorphs (*see* Table 2 and Text-fig. 3). This assemblage is dominated by the hoplitids of Boreal provenance (*see* Table 2 and Text-fig. 1*A*), and its taxonomic composition is as follows:

Hamites (Plesiohamites) multicostatus BROWN, *H. (P.)* sp. ?*multicostatus* BROWN, *Puzosia (Puzosia) mayoriana* (d'ORBIGNY), *Anahoplites planus planus* (MANTELL), *A. planus inflatus* SPATH, *A. planus fittoni* (d'ARCHIAC), *A. planus compressus* SPATH, *A. planus sulcatus* SPATH, *A.* aff. *picteti* SPATH, *A.* aff. *asiaticus* GLASUNOVA, *Calihoplites catillus* (SOWERBY), *C. patella* SPATH, *C. potternensis* SPATH, *C. auritus* (SOWERBY), *Mortoniceras (Mortoniceras) inflatum* (SOWERBY), *M. (M.) pricei* (SPATH), *M. (M.) kiliani* (LASSWITZ), and *M. (M.)* aff. *gracilis* (HAAS).

The presented assemblage evidences the auritus-Subzone of the Mortoniceras inflatum Zone (CHLEBOWSKI, HAKENBERG & MARCINOWSKI 1978). This position is confirmed by the large-sized (up to 190 mm in diameter) representatives of the genus *Anahoplites* HYATT, which are sometines provided with smooth body chambers of the Callihoplites catillus-type. These features are characteristic of the forms of the genus *Anahoplites* HYATT from the auritus-Subzone (*see* SPATH 1927, p. 202). The presence of *Mortoniceras (Mortoniceras) kiliani* (LASSWITZ), a species which is hitherto known in Europe exclusively from the altonense and blancheti-Subzones (*see* SPATH 1932, BREISTROFFER 1947, KENNEDY & HANCOCK 1978), may be explained in the two ways: either it appears here earlier than in other regions of Europe, or this species comes from the successive stratigraphic horizon. The latter possibility seems to be highly probable, because the ammonites at Mt. Chełmowa quarries have not been collected bed by bed.

The sedimentary environment yielding the discussed assemblage is thought to have been extremely shallow-marine as indicated by cross-bedding, gravels, fragments of wood and reed. The large-sized empty ammonite shells were certainly carried by wind towards the shallows, supposedly distant to the mainland (*cf.* MARCINOWSKI & RUDOWSKI 1980). An extremely shallow-marine environment is also inferred, partly at least, by the virtual absence of the heteromorphs, whose benthic or epibenthic mode of life required less agitated waters.

ANNOPOL-ON-VISTULA

The Albian sequence, which overlies the Kimmeridgian limestones, begins with poorly glauconitic sands (2 m thick) overlain by compact sandstones, locally quartzitic (up to 3 m thick). These sandstones (unit A_3 in lithostratigraphical subdivision of CIEŚLIŃSKI 1959a; *see* MARCINOWSKI & RADWAŃSKI 1983, (Fig. 6) have yielded some rare ammonites (22 specimens), such as *Hoplites* (*Hoplites*) e gr. *dentatus* (SOWERBY), *H. (Isohoplites)* spp., *H. (Otohoplites) normanniae* (DESTOMBES, JUIGNET & RIOULT). Associated fossils are represented by the large-sized nautiloids *Cymatoceras*, inoceramids, and trace fossils of the *Chondrites*-type (impregnated with phosphates, and commonly occurring in the topmospart of the unit). All the body fossils are preserved as quartzitic moulds impregnatted with phosphates, and they are a taphonomical remnant of the original community: *i. e.* only these organic remains persisted which had been phosphatized prior to the diagenetic dissolution and silification.

The age of the indicated ammonite assemblage is documented (*see* MARCINOWSKI & RADWAŃSKI 1983, 1985; MARCINOWSKI & WALASZCZYK 1985) by the presence of *Hoplites (Isohoplites)*, the subgenus confined to the Hoplites (Isohoplites) eodentatus Subzone of the Hoplites dentatus Zone (*cf.* OWEN 1971; DESTOMBES, JUIGNET & RIOULT 1973; DESTOMBES 1979). Noteworthy is the occurrence of *Hoplites (Otohoplites) normanniae* (DESTOMBES, JUIGNET & RIOULT) which has formerly been reported from here under the name "*H. (Dimorphoplites) hilli* SPATH" and the item "*Hoplites (Dimorphoplites)*" in Table 3 should be *Hoplites (Otohoplites)*, as kindly indicated by Dr. H. G. OWEN, London.

The discussed sandy deposits, were certainly accumulated in a shallow-marine environment comparable to that recognized at the Mt. Chełmowa section. Large-sized ammonite shells could also have floated into the shallow areas, and the absence of heteromorphs could have resulted from the unfavorable environmental conditions.

The upper part of the Albian sequence is developed as a bipartite Phosphorite Bed (units A_5—A_8 in lithostratigraphical subdivision of CIEŚLIŃSKI 1959a).

The lower part of the Phosphorite Bed (units A_5—A_7 of CIEŚLIŃSKI 1959a; *see* MARCINOWSKI & RADWAŃSKI 1983, 1985; *and* MARCINOWSKI & WALASZCZYK 1985), which is about 20 cm thick, is highly condensed, as evidenced by the abrasion of all diversified fossils and by the post-depositional reworking of phosphatic lumps and the contained fossils (*cf.* SAMSONOWICZ 1925; MARCINOWSKI & RADWAŃSKI 1983, 1985; MARCINOWSKI & WALASZCZYK 1985). The fossil assemblage consists of normally coiled ammonites, sponges, decapods, inoceramids, bony material (shark and sauropterigian teeth), as well as frequent pieces of wood bored by the bivalve "*Gastrochaena*" *amphisbaena* GEINITZ. All these fossil remains are preserved as phosphatic moulds or as phosphatized parts of skeletons, the wood fragments included. The ammonites (92 specimens) are represented by: *Puzosia (Puzosia) mayoriana* (d'ORBIGNY), *Hoplites (Hoplites) dentatus dentatus* (SOWERBY), *H. (H.) dentatus robustus* SPATH, *H. (H.) vectenensis* SPATH, *H. (H.) escragnollensis* SPATH, *H. (H.) baylei* SPATH, *H. (H.) rudis* PARONA & BONARELLI, *Hoplites (Hoplites)* spp., *Euhoplites* cf. *ochetonotus* (SEELEY), *Euhoplites* sp., *Anahoplites planus* cf. *fittoni* (d'ARCHIAC), *Anahoplites* sp., *Callihoplites auritus* (SOWERBY), and *Mortoniceras (Mortoniceras)* cf. *inflatum* (SOWERBY).

The age of this assemblage spans the full stratigraphical range from the lyelli- and spathi-Subzones of the Hoplites dentatus Zone, through the two successive Middle Albian zones (Euhoplites loricatus and Euhoplites lautus), up to the low-Upper Albian Mortoniceras inflatum Zone (*see* MARCINOWSKI & RADWAŃSKI 1983, 1985; MARCINOWSKI & WALASZCZYK 1985).

The Middle to low-Upper Albian ammonite assemblage, collected from the quartzitic sandstones and the lower part of the Phosphorite Bed, is composed almost exclusively of the hoplitids, whereas the puzosids and brancoceratids are here quite accessory (*see* Table 3).

The mass-occurrence of the fossils in the lower part of the Phosphorite Bed was due to an early phosphatization and redeposition. The phosphatization took place beneath the sediment surface, and this process concerned primarily the or-

Table 3

Ammonite content in the Annopol-on-Vistula section (eodentatus through altonense-Subzone)

Families and genera	Percentage
HOPLITIDAE Douvillé, 1890	98.24
Hoplites (Hoplites) Neumayr, 1875	76.31
Hoplites (Dimorphoplites) Spath, 1925	9,65
Hoplites Neumayr, 1875	5.26
Anahoplites Hyatt, 1900	3.51
Euhoplites Spath, 1925	1.75
Hoplites (Isohoplites) Casey, 1954	0.88
Callihoplites Spath, 1925	0.88
DESMOCERATIDAE Zittel, 1895	
Puzosia (Puzosia) Bayle, 1878	0.88
BRANCOCERATIDAE Spath, 1933	
Mortoniceras (Mortoniceras) Meek, 1876	0.88

ganic remains, the bottom-settled wood fragments included. It was certainly interrupted several times, and then followed by exhumation and redeposition of the more or less phosphatized remains, as evidenced by damage of the ammonite moulds, as well as of the phosphatic lumps containing different fossils (*cf.* SAMSONOWICZ 1925; MARCINOWSKI & RADWAŃSKI 1983, 1985). The formation of the condensed sequence is thus thought to have developed in a high-energy environment, whereas the phosphatization was possible only during periods of lower hydrodynamic activity. The changes of the water dynamics were here connected with synsedimentary tectonic movements which, however, did not lead to an emersion because of the coeval eustatic rise of the global sea level (*cf.* HANCOCK 1975, NAIDIN & *al.* 1980).

The upper part of the Phosphorite Bed (unit A_8 of CIEŚLIŃSKI 1959a) is less condensed, and it contains only two specimens of *Stoliczkaia (Stoliczkaia)* cf. *notha* (SEELEY), indicative of the uppermost Albian Stoliczkaia dispar Zone (CIEŚLIŃSKI 1959a). The upper part of the Phosphorite Bed completes the Albian sequence which is conformably overlain by the lowermost Cenomanian strata (MARCINOWSKI & WALASZCZYK 1985).

WIELKA RÓWIEŃ

A band of unstratified, dark green glauconitic limestone (0.5 m thick) which begins the Albian sequence at Wielka Rówień and which is replete with a diversified fauna (*see* PASSENDORFER 1921, 1930, 1983), contains numerous ammonites, usually preserved as more or less phosphatized moulds. The ammonite assemblage includes:

Phylloceras (Hypophylloceras) velledae velledae (MICHELIN), *Ph. (H.) velledae aschiltaense* BREISTROFFER, *Ph. (H.) subalpinum subalpinum* (d'ORBIGNY), *Ph. (H.) moreti* (MAHMOUD), *Ph. (H.) cypris cytherae* WIEDMANN, *Protetragonites aeolus aeolus* (d'ORBIGNY), *Tetragonites nautiloides* (PICTET), *T. rectangularis* WIEDMANN, *Tetragonites* spp., *Jauberticeras*? *majorcense* WIEDMANN, *Eogaudryceras (Eogaudryceras) vatonnei* (COQUAND), *E. (E.) shimizui gaonai* WIEDMANN, *Kossmatella (Kossmatella) schindewolfi* WIEDMANN & DIENI, *K. (K.) oosteri oosteri* BREISTROFFER, *K. (K.) oosteri passendorferi* WIEDMANN & DIENI, *K. (K.) romana* WIEDMANN, *K. (Kossmatella)* sp., *Hamites (Hamites) attenuatus* SOWERBY, *H. (H.) virgulatus* BRONGNIART, *H. (H.) rotundus* d'ORBIGNY, *H. (H.) rectus* BROWN, *H. (H.) incurvatus* BROWN, *H. (H.) maximus* BROWN, *H. (Hamites)* spp., *H. (Metahamites)* [the species which will be described as a new one by MARCINOWSKI & WIEDMANN (=*Hamites* sp. of Passendorfer 1930, pp. 662—663, Text-fig. 20 and Pl. 4, Fig. 78)], *Hemiptychoceras subgaultinum* BREISTROFFER, *Anisoceras (Prohelicoceras) moutonianum* (d'ORBIGNY), *Anisoceras (Protanisoceras)* cf. *flexuosum* (d'ORBIGNY), *A. (P.)* aff. *flexuosum* (d'ORBIGNY), *A. (Protanisoceras)* sp., *Anisoceras* spp., *Hamitoides rusticus* SPATH, *Pseudhelicoceras convolutum* (QUENSTEDT), *P.* cf. *robertianum* (d'ORBIGNY), *Pseudhelicoceras* spp., *Turrilitoides emericianus* (d'ORBIGNY), *T. astierianus* (d'ORBIGNY), *T. intermedius* (PICTET & CAMPICHE), *T. hugardianus* (d'ORBIGNY), *T. densicostatus* (PASSENDORFER), *Turrilitoides* spp., "*Eoscaphites*" [the species which will be described as a new one by MARCINOWSKI & WIEDMANN], *Puzosia (Puzosia) mayoriana mayoriana* (d'ORBIGNY), *P. (P.) mayoriana quenstedti* (PARONA & BONARELLI), *P. (P.) mayoriana lata* SEITZ, *P. (P.) mayoriana furnitana* PERVINQUIÈRE, *P. (P.) mayoriana provincialis* (PARONA & BONARELLI), *P. (P.) mayoriana* (d'ORBIGNY) *sensu lato*, *P. (Puzosia)* spp., *Uhligella rebouli* JACOB, *U. walleranti* JACOB, *Beudanticeras beudanti* (BRONGNIART), *Desmoceras (Desmoceras) latidorsatum latidorsatum* (MICHELIN), *D. (D.) latidorsatum inflatum* BREISTROFFER, *D. (D.) latidorsatum complanatum* JACOB, *D. (D.) convergens* JACOB, *D. (D.)* ?*paronai* (KILIAN), *D. (Desmoceras)* spp., *Parasilesites kilianiformis* (FALLOT), *Douvilleiceras* sp. [juv.], *Hoplites (Hoplites) dentatus dentatus* (SOWERBY), *H. (H.) escragnollensis* SPATH, *Anahoplites splendens* (SOWERBY), *Brancoceras (Eubrancoceras) versicostatum* (MICHELIN), *Hysteroceras orbignyi* (SPATH), *H. varicosum binodosum* (STIELER), *Dipoloceras (Dipoloceras) cristatum* (DELUC), *D. (D.)* cf. *bouchardianum* (d'ORBIGNY), *Dipoloceras (Dipoloceroides) delaruei* (d'ORBIGNY), and *Dipoloceras* sp.

This assemblage is dominated by forms of the leistraceous group (desmoceratids, phylloceratids, gaudryceratids, and tetragonitids), whereas the trachyostraceous group is subordinate (*see* Text-fig. 3 and Table 4). Noteworthy is the relatively great number of heteromorphs (34.35%). All these features serve to distinguish the discussed assemblage from the assemblage of similar age of Annopol-on-Vistula, and from the Upper Albian assemblage of Mt. Chełmowa (*see* Text-figs 1*A* and 3, and Tables 2—4).

The age of the discussed assemblage is indicative of the full stratigraphical range from the floridum-Subzone of the Douvilleiceras mammilatum Zone through the altonense-Subzone of the Mortoniceras inflatum Zone. Its lower limit is determined by the appearance of the subgenera *Anisoceras (Prohelicoceras)* and *Anisoceras (Protanisoceras)*, as well as by the species *Uhligella walleranti* JACOB.

The upper limit can be established only at the neighboring section at Mała Łąka, where the glauconitic limestones are overlain, with a sedimentary break, by sandy-glauconitic mudstones containing, among others, such ammonite species as *Hamites (Hamites) attenuatus* SOWERBY, *Anisoceras (Anisoceras) saussureanum* (PICTET), *Mortoniceras (Mortoniceras) pricei* (SPATH), *M. (M.) inflatum* (SOWERBY), and *M. (M.) pachys* (SEELEY). The latter ammonites are preser-

Table 4

Ammonite content in the Wielka-Rówień section (floridum through altonense-Subzone)

	Families and genera	Percentage
normal-coiled ammonites 65.65%	DESMOCERATIDAE Zittel, 1895	36.81
	Puzosia (Puzosia) Bayle, 1878	16.87
	Desmoceras (Desmoceras) Zittel, 1884	9.51
	Uhligella Jacob, 1907	4.29
	Beudanticeras Hitzel, 1902	3.37
	Parasilesites Imlay, 1959	2.76
	HOPLITIDAE Douvillé, 1890	8.59
	Hoplites (Hoplites) Neumayr, 1875	7.97
	Anahoplites Hyatt, 1900	0.61
	PHYLLOCERATIDAE Zittel, 1894	
	Phylloceras (Hypophylloceras) Salfeld, 1924	7.36
	GAUDRYCERATIDAE Spath, 1927	5.21
	Kossmatella (Kossmatella) Jacob, 1907	3.68
	Eogaudryceras (Eogaudryceras) Spath, 1927	0.92
	Jauberticeras Jacob, 1907	0.61
	TETRAGONITIDAE Hyatt, 1900	
	Tetragonites Kossmat, 1895	3.68
	BRANCOCERATIDAE Spath, 1933	2.76
	Brancoceras (Eubrancoceras) Breistroffer, 1952	0.61
	Dipoloceras (Dipoloceras) Hyatt, 1900	0.61
	Hysteroceras Hyatt, 1900	0.61
	Brancoceras (Brancoceras) Steinmann, 1881	0.31
	Dipoloceras (Dipoloceroides) Breistroffer, 1947	0.31
	Dipoloceras Hyatt, 1900	0.31
	LYTOCERATIDAE Neumayr, 1875	
	Protetragonites Hyatt, 1900	0.92
	DOUVILLEICERATIDAE Parona & Bonarelli, 1897	
	Douvilleiceras de Grossouvre, 1894	0.31
heteromorphs 34.35%	TURRILITIDAE Meek, 1876	16.56
	Turrilitoides Spath, 1923	13.80
	Pseudhelicoceras Spath, 1922	2.76
	HAMITIDAE Hyatt, 1900	12.27
	Hamites (Hamites) Parkinson, 1811	10.43
	Hamites (Metahamites) Spath, 1930	1.23
	Hemiptychoceras Spath, 1925	0.61
	ANISOCERATIDAE Hyatt, 1900	3.68
	Anisoceras Pictet, 1854	1.23
	Anisoceras (Prohelicoceras) Spath, 1925	1.23
	Anisoceras (Protanisoceras) Spath, 1923	0.92
	Hamitoides Spath, 1925	0.31
	SCAPHITIDAE Meek, 1876	
	Eoscaphites Breistroffer, 1947	1.84

ved as fragmentary moulds, more or less eroded, particularly when regarding the large-sized forms (PASSENDORFER 1930, pp. 526, 656). The surface of these moulds is glauconitized, but the interiors are composed of the glauconitic limestone. This state of preservation clearly indicates the redeposition of the ammonites derived from the glauconitic limestone. The eroded glauconitic limestone had to include *M. (M.) inflatum* (SOWERBY) and *M. (M.) pachys* (SEELEY), the species which evidence the altonense-Subzone. Consequently, the sandy-glauconitic mudstone with redeposited ammonites at Mała Łąka is interpreted as an equivalent of the blancheti-Subzone. The stratigraphic gap associated with this redeposition represents a very short interval. The presence of *H. (H.) attenuatus* (SOWERBY), the species known exclusively from the Middle Albian, and of *M. (M.) pricei* (SPATH) ranging only up to the auritus-Subzone indicates a lack of stratification within underlying sediments and therefore it confirms a stratigraphically condensed nature of the glauconitic limestone. The sandy glauconitic mudstones pass conformably into the marly mudstones with ammonites (*see* PASSENDORFER 1930), indicative of the perinflatum-Subzone of the Stoliczkaia dispar Zone.

ALBIAN PALEOGEOGRAPHY IN POLAND

The mid-Cretaceous transgression progressed from the NW part of the Central European Basin onto the epicontinental (platform) areas of Poland in the eodentatus-Subzone of the Middle Albian (*cf.* SAMSONOWICZ 1925; CIEŚLIŃSKI 1959a, b; MARCINOWSKI & RADWAŃSKI 1983). The sea inundated the whole Danish-Polish Trough and partly covered the Fenno-Sarmatian Shield to the east (Text-fig. 1*A*—*B*). The transgression reached the north-eastern Holy Cross region earlier than the Polish Jura (especially its southern parts) due to the greater subsidence along the axial zone of the Danish-Polish Trough. Along this axial zone, and more southwardly troughout the Lwow region, there existed a narrow seaway between the Central European Basin and the Carpathian geosyncline (Text-fig. 1*B*). The southern parts of the present-day Central Polish Uplands remained emergent in the Middle Albian, and the southernmost tips underwent the strongest upheaval (the North Margin Cordillera), and subsequently supplied clastic material both southwardly, to the Outer Flysch Basin (Lgota Beds), as well as northwardly to the Central European Basin (*cf.* Text-fig. 2*A*). In the northern Polish Lowland, the clastic material in the Central European Basin was derived from the western part of the Fenno-Sarmatian Shield, where the paeneplanation was more advanced, thus resulting in finer clastic material. In the Middle Albian, the shallow-marine glauconitic sand facies was dominant, significant amounts of fine clastic material (clay-silty inliers) being present in the axial part of the basin. The region which comprises the Annopol-on-Vistula section then became (lyelli-Subzone) a submarine swell, the origin of which was associated with a stratigraphical condensation and development of phosphate-bearing deposits (SAMSONOWICZ 1925, 1934; POŻARYSKI 1947; CIEŚLIŃSKI 1959a, 1976; MARCINOWSKI & RADWAŃSKI 1983; MARCINOWSKI & WALASZCZYK 1985).

During Albian time the basement spreading of the Carpathian geosyncline ceased, and the geosyncline itself attained its greatest width (KSIĄŻKIEWICZ 1977, p. 340). The West Carpathian geosyncline, excluding the Bakony Trough and High-Tatra Swell, was the site of pelagic and deep-sea sedimentation in the Middle Albian, and bottom undulations involved the facies diversity (Text-fig. 2*A*). The High-Tatra Swell, after a short-period of emersion, became in the uppermost Lower Albian (floridum-Subzone) an area of sedimentation again, displaying however (*see* Text-fig. 2*A*), a stratigraphical condensation and the development of glauconitic and phosphate-bearing deposits (PASSENDORFER 1930; KRAJEWSKI 1981, 1985).

In the Upper Albian, due to the progression of the transgression, the Central European Basin acquired broad seaway connections with the epicontinental seas covering the Fenno-Sarmatian Shield (Text-fig. 1*B*—*C*). The transgression embraced the areas of the Polish Jura and the Cracow Upland, but the only seaway to the Carpathian geosyncline was realized along the Lwow region (Text-fig. 1*C*). Although the facies of shallow-marine glauconitic sands remained dominant during Upper Albian time, the open sea environments continued as indicated by marly sediments (sandy marls and marly sandstones) or carbonate-siliceous ones (gaizes and spongiolites). Also more common were the phosphorites which mark a correlation horizon just beneath the Albian/Cenomanian boundary. The Annopol-on--Vistula region still persisted as a submarine swell, featuring condensed, phosphate--bearing deposits. The littoral structures, *eg.* various burrows and borings, noted in the basal sands of the Polish Jura, are thought to indicate that this region was the externmost, marginal part of the Central European Basin during Upper Albian time (MARCINOWSKI 1974).

In the West Carpathian geosyncline a general deepening of the sea bottom took place during Upper Albian time. In the Bakony Trough, this led to the disappearance of reefoid deposits which were overlain by open-sea marls rich in ammonites. On the High-Tatra Swell during M. inflatum time a condensed sedimentation continued, and this was followed during S. dispar time by silty-marly deposits with inliers of flysch-like sandstones (PASSENDORFER 1930, KRAJEWSKI 1985). In the Pieniny Trough bathypelagic marls were still deposited, whereas the Outer Flysch Basin underwent a deepening and a subdivision into two basins separated by the Silesian Cordillera (*cf.* Text-fig. 2*B*; *and* KSIĄŻKIEWICZ 1961, 1962, 1975)[1].

The Upper Albian deepening of the discussed basins and their extension (both in the Central European Basin and in the Carpathian geosycline) are comparable with the general pattern of eustatic changes of the global ocean (*cf.* HANCOCK 1975, NAIDIN & *al.* 1980).

---

[1] The maximum depth of the Albian flysch sedimentation in the Outer Flysch Basin ranges from 600—1000 m (KSIĄŻKIEWICZ 1975, Fig. 4). The bathypelagic marls and associated radiolarites in the Pieniny Trough were deposited at a comparable depth where clastic material had a smaller influence. The moderate depth of the Pieniny Trough sediments is indicated by the presence (*see* BIRKENMAJER & KOKOSZYŃSKA 1958) of benthic and epibenthic mollusks such as the ammonite *Hamites*, and bivalves *Aucellina* and *Pycnodonte*.

AMMONITE BIOGEOGRAPHY

The Central European Basin was a part of the European Zoogeographic Realm (NAIDIN 1959, 1969, 1981), the limits of which during Albian and Cenomanian time coincided with the Hoplitinid Faunal Province (OWEN 1971, 1976, 1979; MARCINOWSKI 1980, 1983; SAVELEV 1981). This province was comprising eastern Greenland, Spitsbergen, the North Sea Basin, the London-Paris Basin, the Central European Basin, the Russian Platform, as well as Crimea and northern Caucasus, the Aral region, Mangyshlak, Kopet-dag, and northern Iran. The presence of the hoplitids in the Lower Albian of eastern Greenland, Spitsbergen, eastern England, northern France, northern Germany, and Bornholm (OWEN 1971, 1979; KENNEDY, HANCOCK & CHRISTENSEN 1981), and their subsequent appearance throughout the platform areas of Poland during Middle Albian time clearly indicate a migration of these ammonites from the north and north-west (*see* Text-fig. 1*B*). The Middle Albian ammonite assemblage from Annopol-on--Vistula is almost exclusively composed of Boreal hoplitids (*see* Text-fig. 1*A* and Table 3). Although the percentage of hoplitids within the Mediterranean assemblage from the High-Tatra Swell is as low as 8.59%, they are nevertheless the second most abundant component of the counted families. Mediterranean influences are unknown throughout the platform areas of Poland, and the migration is therefore thought to have progressed unidirectionally from the Danish-Polish Trough, through the Lwow region, towards the Carpathian geosyncline. During Middle Albian time, the hoplitids migrated from western Europe to the Russian Platform and the mid--Asia regions; at that time there was no direct connection[2] between the Central European Basin and the middle of Russia (*see* Text-fig. 1*B*). In Podolia as well as on the Moesian Platform, the Mediterranean influences recognizable within the Albian ammonite assemblages, are indicative of an area close to the Carpathian geosyncline (*see* NOWAK 1917, PASTERNAK & *al.* 1968, MUTIU 1984).

During Upper Albian, the Central European Basin and the sea which was spreading over the Russian Platform acquired wide connections due to the further advance of the mid-Cretaceous transgression (*see* Text-fig. 1*C*). The Boreal hoplitids could then migrate from western Europe to the mid-Asiatic regions along a direct seaway which clearly was much shorter than that along the southern regions bordering the Carpathian geosyncline. The disappearance of the Boreal forms within the Upper Albian ammonite faunas of the High-Tatra Swell can easily be explained by such a paleogeographical setting. The Boreal character of the Upper Albian ammonite faunas is still well pronounded in the Polish part of the Central European Basin, although heavily ornamented Mediterranean brancoceratids represented solely by the genus *Mortoniceras*, had already appeared. The latter genus is relatively common at the Mt. Chełmowa section, but it vanishes in the south-

[2] In the Lower Cretaceous, up to the Aptian, a direct connection of the Boreal seas with the Alpine geosyncline existed along the western slopes of the Urals. This connection ceased at Albian time, and then a latitudinal basin developed on the Russian Platform uniting it with the Central European Basin via the Polesie region and eastern Poland at least by the Upper Albian (*see* Text--fig. 1*C*; *and* SAZANOV & SAZANOV 1967, NAIDIN & *al.* 1980, NAIDIN 1981).

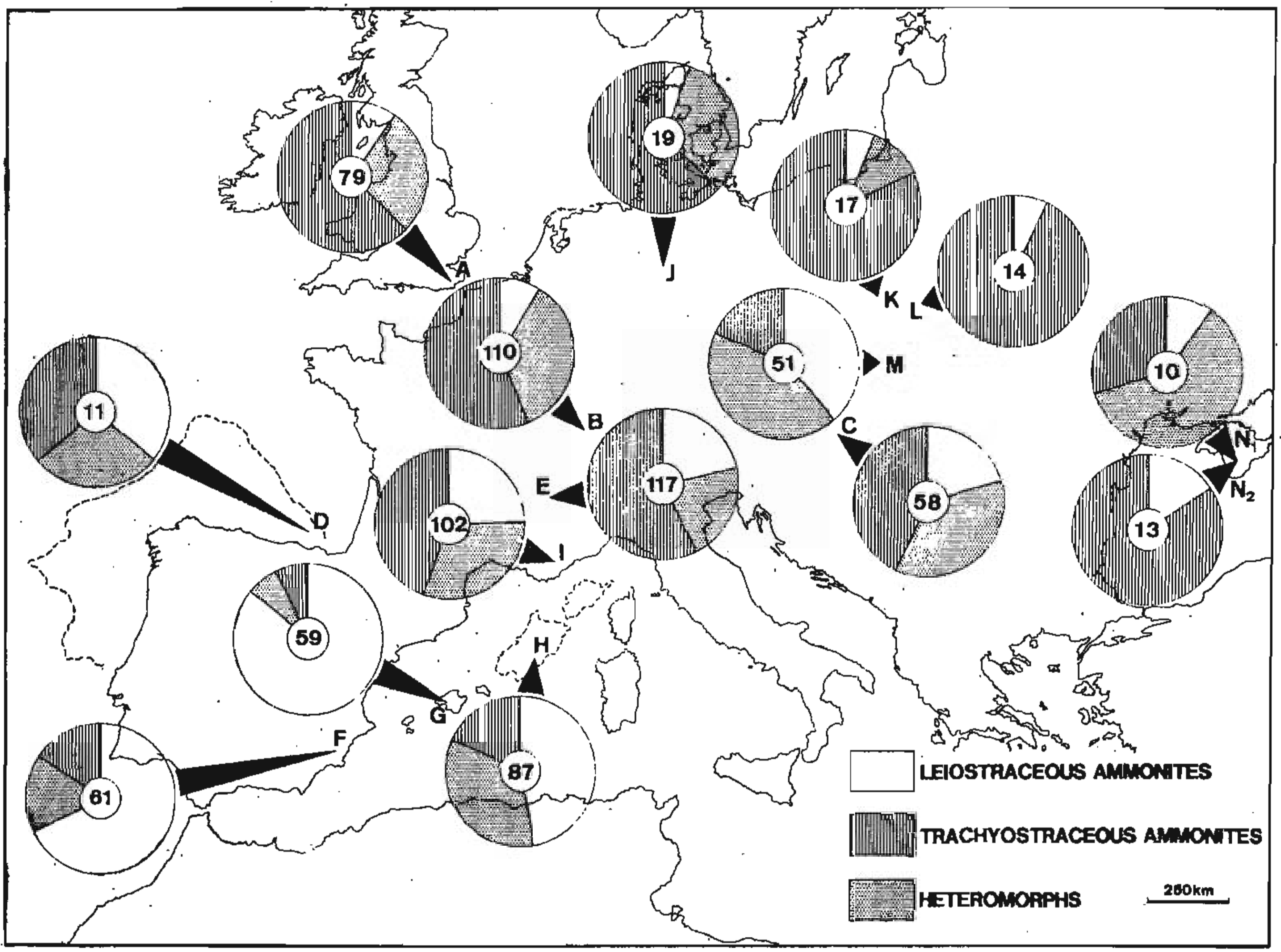
-eastern areas (Annopol-on-Vistula section; *see* Tables 2—3), a fact which excludes the possibility of its migration from the Carpathian geosyncline through the Lwow region. A general eastward migration of the family Brancoceratidae is thus well exemplified by the Polish occurrences which are therefore compatible with the former observations (OWEN 1976, 1979) concerning the spreading of the Upper Albian brancoceratids from the Alpine geosyncline to the Central European Basin via the London-Paris Basin. The lack of Boreal influences in the High-Tatra Swell and of Mediterranean forms (originated in the Carpathian geosyncline) in the platform areas of Poland is thought to have resulted from an advanced provincialism which distinguished the Boreal and the Tethyan realms in Poland more efficiently than it had during the Middle Albian. This provincialism was certainly favored by a regional deepening of the West Carpathian geosyncline which then acquired its maximum width (in meridional extent, precisely). Consequently, the *depth/distance filter* phenomenon was increasing and it both hampered further migration of the ammonite faunas, and separated the High-Tatra Swell from the platform areas of Poland more effectively than during Middle Albian time. The landmass barriers, which included a part of the Meta-Carpathian Arch and the Silesian Cordillera within the Outer Flysch Basin (*see* Text-figs 1*C* and 2), certainly played no decisive role in the ammonite provincialism. This latter interpretation is supported by the fact that the Mediterranean influences in the Berriasian and Valanginian ammonite faunas in platform areas of Poland were much greater than in the Upper Cretaceous epoch when the Central European Basin, throughout the Central Polish Upland, possessed wide and direct seaway connections (since the Cenomanian) with the Carpathian geosyncline. An increasing provincialism in the Upper Albian ammonite faunas is also recognizable in Spain (WIEDMANN 1962a, 1982) and in the sub-Alpine chains of southeastern France. In the latter region, distinct boreal influences were still evident in the Middle Albian (*cf.* PARONA & BONARELLI 1897, GEBHARD 1983).

The presented data lead to an unexpected conclusion: an increase of provincialism in the Upper Albian ammonite faunas was associated with a further advance of the mid-Cretaceous transgression which was responsible for the elimination of the isolationism between particular basins and their ecosystems. The decisive role controlling distribution of the ammonites can therefore be ascribed to the climate and bathymetry (*see also* WIEDMANN 1973, 1982; SCHOLZ 1979a; KLINGER & WIEDMANN 1983). The latter factors were also decisive, during the Upper Creaceous spoch, for the separation of the Central European Bioprovince from the Tathyan Bioprovince, although good seaway connections were than in action.

REMARKS ON ECOLOGICAL AND BATHYMETRICAL REQUIREMENTS OF THE ALBIAN AMMONITES

The Albian ammonite assemblages of Mt. Chełmowa and Annopol-on-Vistula are dominated by the trachyostraceous forms (the hoplitids and the brancoceratids) whereas the leiostraceous forms and the heteromorphs are practically missing (*see*

Ammonite eco-morphotypes in the European Middle and Upper Albian



Dash-lined contour indicates the Iberian Peninsula and the Corsardinian microplate before rotation to their actual position

The number of species (or subspecies) is given in the center of the spectrograme

Leiostraceous ammonites — phylloceratids, gaudryceratids, tetragonitids, and desmoceratids; **Trachyostraceous ammonites** — hoplitids, brancoceratids, and lyelliceratids; **Heteromorphs** — turrilitids, hamitids, anisoceratids, and scaphitids

AMMONITE LOCALITIES:

A — Stoliczkaia dispar Zone of Folkestone, SE England (SPATH 1923—1943)
B — Stoliczkaia dispar Zone of Sainte-Croix, Switzerland (RENZ 1968)
C — Stoliczkaia dispar Zone of the Bakony Mts, Hungary (SCHOLZ 1979a)
D — Stoliczkaia dispar Zone of the Vascogotic Ranges, northern Spain (WIEDMANN 1962a)
E — Stoliczkaia dispar Zone of Salazac, Gard, southern France (BREISTROFFER 1940, 1947)
F — Upper Albian of the Subbetic of Caravaca, Murcia, southern Spain (Wiedmann, *unpublished data*)
G — Upper Albian of Mallorca (WIEDMANN 1962b, 1964)
H — Stoliczkaia dispar Zone of the Orosei area, eastern Sardinia (WIEDMANN & DIENI 1968)
I — Hoplites dentatus up to Stoliczkaia dispar zones (condensed sequences) of the sub-Alpine chains, SE France (GEBHARD 1983)
J — Mortoniceras perinflatum Subzone of the Stoliczkaia dispar Zone of Salzgitter, northern Germany (SCHOLZ 1979b)
K — Callihoplites auritus Subzone of the Mortoniceras inflatum Zone of Mt. Chełmowa, Poland
L — Hoplites dentatus up to Mortoniceras inflatum zones (mostly condensed sequence) of Annopol-on-Vistula, Poland
M — Douvilleiceras mammillatum up to Mortoniceras inflatum zones (condensed sequence) of Wielka Rówień, Tatra Mts. Poland
N — Upper Albian of the SW Crimea Highland, Soviet Union (MARCINOWSKI & NAIDIN 1976): N_1 — Mortoniceras inflatum Zone in clay facies, N_2 — uppermost Mortoniceras inflatum and Stoliczkaia dispar zones in sandy facies

Text-fig. 3 and Tables 2—3). When the type of ornamentation of these ammonites is taken into account, they evidently coincide with the group *A* of TANABE, OBATA & FUTAKAMI (1978). The dominance of the leiostraceous forms (group *C* — the desmoceratids, phylloceratids, gaudryceratids, tetragonitids) and the high percentage of heteromorphs (group *B*) in the ammonite assemblage of Wielka Rówień indicate either an offshore environment and greater depths (*cf.* WIEDMANN 1973; TANABE, OBATA & FUTAKAMI 1978) or a boundary between the lower neritic and the upper bathyal zone in the classic model of SCOTT (1940).

The Albian heteromorphs usually occur in the clay and marly facies rather than in the sandy facies (*cf.* SPATH 1934—1943, MARCINOWSKI & NAIDIN 1976, SCHOLZ 1979a, b). A similar situation is also known from the Middle Jurassic deposits of the Swabian Alb in West Germany, where the heteromorphs are remarkably frequent in the clay facies which, due to its quiet-water nature, provided optimum biotope conditions (*see* DIETL 1976).

Generally, the Albian ammonite assemblages of the Boreal Realm are dominated by the trachyostraceous forms associated with heteromorphs, whereas in the Tethyan Realm the leiostraceous forms and the heteromorphs are dominant. Such a general feature clearly indicates the low tendency to provincialism displayed by the heteromorphs, whose mode of life was benthic or epibenthic. This has certainly resulted from a high tolerance of the larval stages of these ammonites with respect to the environment, as well as from a considerable resistance to environmental changes during their juvenile stages when they settled, after a pelagic larval spread, in various geographic zones (MARCINOWSKI 1974, 1980; *cf. also* KENNEDY & COBBAN 1976).

The mass occurrences of the Albian ammonites both in the platform and in geosynclinal areas of Europe are usually connected with stratigraphically condensed deposits which developed on submarine swells, under environmental conditions corresponding to the present-day open shelf. Extremely shallow marine environments and those beyond the neritic zone were never favored by the mid-Cretaceous and younger ammonites (*see* WIEDMANN 1973).

Acknowledgements

The authors offer their most sincere and cordial thanks to the late Professor E. PASSENDORFER, University of Warsaw, for his kindness in providing his paramount collection of Albian ammonites from the Tatra Mountains for use in this research and for his encouragement on the subject. Thanks are also extended to Docent S. CIEŚLIŃSKI, Geological Survey of Poland, for making available his collection from Annopol-on-Vistula. Special thanks are due to Jeff GEE, temperarily at the University of Tübingen, for improvement of the language, and to Dr. H.-D. BERGNER, of the same University, for preparing the text drawings.

The first of the authors, R. MARCINOWSKI, wishes to acknowledge the Alexander von HUMBOLDT-Stiftung, Bonn, for providing financial support during his stay at the University of Tübingen.

Institute of Geology
of the University of Warsaw,
Al. Żwirki i Wigury 93
02-089 Warszawa, Poland

(R. Marcinowski)

Institut und Museum
für Geologie und Paläontologie
der Universität Tübingen,
Sigwartstrasse 10,
7400 Tübingen, Bundesrepublik Deutschland

(J. Wiedmann)

REFERENCES

ALEXANDROWICZ, S. 1954. Turonian deposits of the southern part of the Cracow Upland. *Acta Geol. Polon.*, **4** (3), 361—390. Warszawa.

ANDRUSOV, D. 1965. Geologie der Tschechoslowakischen Karpaten; *II*, Kreide, 264—415. Bratislava.

BIRKENMAJER, K. 1960. Geology of the Pieniny Klippen Belt of Poland. *Jb. Geol. B. A.*, **103**, 1—36. Wien.

— 1977. Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland. *Studia Geol. Polon.*, **45**, 7—158. Warszawa.

— & KOKOSZYŃSKA, B. 1958. Revision of Cretaceous fauna collected by L. Horwitz in the Pieniny Klippen Belt of Poland. *I*: Fauna of the so-called "Santonian" in the Dunajec River gorge near Czorsztyn. *Inst. Geol. Biul.*, **135**, 5—26. Warszawa.

BOILLOT, G. 1981. Geology of the continental margins, 1—115. London—New York.

BREISTROFFER, M. 1940. Révision des Ammonites du Vraconien de Salzac (Gard) et considérations générales sur ce sous-étage albien. *Trav. Lab. Géol. Grenoble*, **22** (1938—1939), 71—171. Grenoble.

— 1947. Sur les zones d'ammonites dans l'Albien de France et d'Angleterre. *Trav. Lab. Géol. Grenoble*, **26**, 17—104. Grenoble.

ČECH, F. 1982. Relationship between fuel deposits and deep structure of the Pannonian Basin of the Carpathian Arc. *Západné Karpaty, Sér. Géol.*, **8**, 1—146. Bratislava.

CHLEBOWSKI, R., HAKENBERG, M. & MARCINOWSKI, R. 1978. Albian ammonite fauna from Mt. Chełmowa near Przedbórz (Central Poland). *Bull. Acad. Polon. Sci., Sér. Sci. de la Terre*, **25** (2), 91—97. Warszawa.

CIEŚLIŃSKI, S. 1959a. The Albian and Cenomanian in the northern periphery of the Holy Cross Mountains. *Trav. Inst. Géol.*, **28**, 1—95. Warszawa.

— 1959b. Commencement of Upper Cretaceous transgression in Poland. *Kwartalnik Geol. (Quart. J. Inst. Geol.)*, **3** (4), 943—964. Warszawa.

— 1965. Beitrag zur Kenntnis des Oberkreide-Klimas in Polen. *Geol. Rundsch.*, **54** (1964), 318—328. Stuttgart.

— 1976. Development of the Danish-Polish Furrow in the Holy Cross region in the Albian, Cenomanian and Lower Turonian. *Inst. Geol. Biul.*, **295**, 249—271. Warszawa.

CSÁSZÁR, G. & HASS, J. 1979. Review of the facies and palaeogeography of the Cretaceous in Hungary. *In*: J. WIEDMANN (*Ed.*), *Aspekte der Kreide Europas, IUGS Series A*, **6**, 413—424. Stuttgart.

DESTOMBES, P. 1979. Les Ammonites de l'Albien inférieur et moyen dans le stratotype de l'Albien; Gisements, paléontologie, biozonation. *Les Stratotypes Francais*, **5**, 43—193. Paris.

— , JUIGNET, P. & RIOULT, M. 1973. Ammonites de l'Aptien — Albien du Bec de Caux, Normandie (NW France). *Bull. Soc. Géol. Normandie et Amis Museum du Havre*, **61**, 49—106. Havre.

DEWEY, J. F. & *al.* 1973. Plate tectonics and the evolution of the Alpine system. *Geol. Soc. Amer. Bull.*, **84**, 3137—3180. Boulder.

DIETL, G. 1978. Die heteromorphen Ammoniten des Dogger (Stratigraphie, Taxonomie, Phylogenie, Ökologie). *Stuttgarter Beitr. Naturk., Ser. B*, **33** (1976), 1—95. Stuttgart.

DŻUŁYŃSKI, S. 1953. Tectonics of the southern part of the Cracow Upland. *Acta Geol. Polon.*, **3** (3), 325—440. Warszawa.

FAIRBRIDGE, R. W. (*Ed.*) 1966. The Encyclopedia of Oceanography. New York.

GEBHARD, G. 1983. Stratigraphische Kondensation am Beispiel mittelkretazischer Vorkommen im perialpinen Raum. *Geowissenschaft. Fakult. Eberhard-Karl-Univ. Tübingen (Doctor thesis)*, 1—131. Stuttgart.

GŁAZEK, J., MARCINOWSKI, R. & WIERZBOWSKI, A. 1971. Lower Cenomanian trace fossils and transgressive deposits in the Cracow Upland. *Acta Geol. Polon.*, **21** (3), 433—448. Warszawa.

HANCOCK, J. M. 1975. The sequence of facies in the Upper Cretaceous of northren Europe compared with that in the Western Interior. *In*: W. G. E. CALDWELL (*Ed.*), Cretaceous system in the Western Interior of North America. *Geol. Assoc. Canada Spec. Pap.*, **13**, 83—118. Ottawa.

JASKOWIAK-SCHOENEICHOWA, M. 1979. Paläogeographie des Alb und Cenoman in Polen. *In*: J. WIEDMANN (*Ed.*), *Aspekte der Kreide Europas, IUGS Series A*, **6**, 463—471. Stuttgart.

KENNEDY, W. J. & COBBAN, W. A. 1976. Aspects of ammonite biology, biogeography, and biostratigraphy. *Palaeontology Spec. Pap.*, **17**, 1—94. London.

KENNEDY, W. J. & HANCOCK, J. M. 1978. The mid-Cretaceous of the United Kingdom. Mid-Cretaceous Events, Uppsala 1975 — Nice 1976, *Ann. Mus. Hist. Natur. Nice*, **4** (5), 1—72. Nice.

KENNEDY, W. J., HANCOCK, J. M. & CHRISTENSEN, W. K. 1981. Albian and Cenomanian ammonites from the island of Bornholm (Denmark). *Bull. Geol. Soc. Denmark*, **29**, 203—244. Kobenhavn.

KLINGER, H. C. & WIEDMANN, J. 1983. Palaeobiogeographic affinities of Upper Cretaceous ammonites of Northern Germany. *Zitteliana*, **10**, 413—425. München.

KRAJEWSKI, K. P. 1981. Phosphate microstromatolites in the High-Tatric Albian limestones in the Polish Tatra Mts. *Bull. Acad. Polon. Sci., Sér. Sci. de la Terre*, **29** (2), 175—183. Warszawa.

— 1985. Early diagenetic phosphate cements in the Albian condensed glauconitic limestone of the Tatra Mountains, Western Carpathians. *Sedimentology*, **31** (4), 443—470. Amsterdam.

KSIĄŻKIEWICZ, M. 1956. Geology of the northern Carpathians. *Geol. Rundschau*, **45** (2), 369—411. Stuttgart.

— 1958. Sedimentation in the Carpathian flysch sea. *Geol. Rundschau*, **47** (1), 418—425. Stuttgart.

— 1961. Pre-orogenic sedimentation in the Carpathian geosyncline. *Geol. Rundschau*, **50** (1960), 8—31. Stuttgart.

— 1962 (*Ed.*). Geological Atlas of Poland, **13** — Cretaceous and Early Tertiary in the Polish External Carpathians. Warszawa.

— 1972. Geology of Poland; Tectonics of the Carpathians, **4** (3), 7—228. Warszawa.

— 1975. Bathymetry of the Carpathian Flysch Basin. *Acta Geol. Polon.*, **25** (3), 309—367. Warszawa.

— 1977. Hypothesis of plate tectonics and the origin of the Carpathians. *Ann. Soc. Géol. Pologne*, **47** (3), 329—353. Kraków.

KUTEK, J. & GŁAZEK, J. 1972. The Holy Cross area, Central Poland, in the Alpine cycle. *Acta Geol. Polon.*, **22** (4), 603—653. Warszawa.

MAHEL, M. 1978. Geotectonic position of magmatites in the Carpathians, Balkan and Dinarides. *Západné Karpaty, Sér. Geol.*, **4**, 9—119. Bratislava.

— 1983. Beziehung Westkarpaten — Ostalpen, Position des Übergangs-Abschnittes — Deviner Karpaten. *Geol. Zbor. Geologica Carpathica*, **34** (2), 131—149. Bratislava.

MARCINOWSKI, R. 1970. The Cretaceous transgressive deposits east of Częstochowa (Polish Jura Chain). *Acta Geol. Polon.*, **20** (3), 413—449. Warszawa.

— 1974. The transgressive Cretaceous (Upper Albian through Turonian) deposits of the Polish Jura Chain. *Acta Geol. Polon.*, **24** (1), 117—217. Warszawa.

— 1980. Cenomanian ammonites from German Democratic Republic, Poland, and the Soviet Union. *Acta Geol. Polon.*, **30** (3), 315—325. Warszawa.

— 1983. Upper Albian and Cenomanian ammonites from some sections of the Mangyshlak and Tuarkyr regions, Transcaspia, Soviet Union. *N. Jb. Geol. Paläont. Mh. (1983)* **3**, 156—180. Stuttgart.

— & NAIDIN, D. P. 1976. An Upper Albian ammonite fauna from Crimea. *Acta Geol. Polon.*, **26** (1), 83—119. Warszawa.

— & RADWAŃSKI, A. 1983. The Mid-Cretaceous transgression onto the Central Polish Uplands (marginal part of the Central European Basin). *Zitteliana*, **10**, 65—95. München.

— & — 1985. Basic problems in biostratigraphic subdivision of the mid-Cretaceous sequence developed on the Central Polish Uplands. *Cretaceous Research* (in press). London.

— & RUDOWSKI, S. 1980. Biała Góra — Middle and Upper Albian. *Guide 52 Annual Meeting of the Geological Society of Poland*, 221—226. Warszawa.

— & SZULCZEWSKI, M. 1972. Condensed Cretaceous sequence with stromatolites in the Polish Jura Chain. *Acta Geol. Polon.*, **22** (3), 515—539. Warszawa.

— & WALASZCZYK, I. 1985. Mid-Cretaceous deposits and biostratigraphy of the Annopol section, Central Polish Uplands. *Österreichische Akad. Wissenschaft. Schriftenrheie der Erdwissenschaftlichen Kommissionen* **7**, *27-41*. Wien.

— & WIEDMANN, J. 1985. The Albian ammonites of Poland. *Zitteliana* (in press). München.

MUTIU, R. 1984. Stratigraphie des dépôts Albiens de la Plate-Forme Moesienne (Secteur Roumain). *Ann. Inst. Géol. et Géophys.*, **64**, 283—289. Bucuresti.

NAIDIN, D. P. 1959. On the paleogeography of the Russian Platform during the Upper Cretaceous epoch. *Stockholm Contr. Geol.*, **3** (6), 127—138. Stockholm.

— 1969. Biostratigraphie und Paläogeographie der Oberen Kreide der Russischen Tafel. *Geol. Jb.*, **87**, 157—186. Hannover.

— 1981. The Russian platform and Crimea. *Aspects of Mid-Cretaceous regional geology* (R. A. REYMENT & P. BENGTSON, *Eds*), 29—68. *Academic Press*; London.

— & *al.* 1980. Cretaceous transgressions and regressions on the Russian platform, in Crimea and Central Asia. *Cretaceous Research*, **1**, 375—387. London.

NOWAK, J. 1917. Cephalopoden der mittleren Kreide Podoliens. *Bull. Acad. Sci. Cracovie, Cl. Sci. Math. et Nat., Sér. A.* Cracovie.

OWEN, H. G. 1971. Middle Albian stratigraphy in the Anglo-Paris Basin. *Bull. Br. Mus. Nat. Hist. (Geol.), Suppl.*, **8**, 1—164. London.

— 1976. The stratigraphy of the Gault and Upper Greensand of the Weald. *Proc. Geol. Assoc.*, **86**, 475—498. London.

— 1979. Ammonite zonal stratigraphy in the Albian of North Germany and its setting in the Hoplitinid Faunal Province. *In*: J. WIEDMANN (*Ed.*), *Aspekte der Kreide Europas, IUGS Series A*, **6**, 563—588. Stuttgart.

PARONA, C. F. & BONARELLI, G. 1897. Fossili Albiani d'Escragnolles, del Nizzardo e della Liguaria occidentale. *Palaeontogr. Italica*, **2** (1896), 53—112. Pisa.

PASSENDORFER, E. 1921. Sur le Crétacé hauttatrique de la Tatra. *Bull. Serv. Géol. Pologne*, **1** (2—3), 217—250. Warszawa.

— 1930. Étude stratigraphique et paléontologique du Crétacé de la série hauttatrique dans les Tatras. *Trav. Serv. Géol. Pologne*, **2** (4), 509—676. Warszawa.

— 1983. Jak powstały Tatry; *wyd. VII* [Origin of the Tatra Mts; 7th ed.]. *Wyd. Geol.*; Warszawa.

PASTERNAK, S. I. & *al.* 1968. Stratigrafia i fauna kreidivih vidkladiv zahodu Ukrainy (bes Karpat), 7—272. Kiev.

POŻARYSKI, W. 1947. A phosphate deposit of the north-eastern margin of the Holy Cross Mountains. *Bull. Serv. Géol. Pologne*, **27**, 1—56. Warszawa.

RACZYŃSKA, A. 1979. The stratigraphy and lithofacies development of the younger Lower Cretaceous in the Polish Lowlands. *Trav. Inst. Geol.*, **89**, 5—78. Warszawa.

— & CIEŚLIŃSKI, S. 1960. The Lower Cretaceous terrestrial strata NW from Holy Cross Mts. *Przegląd Geol.*, **10**, 521—525. Warszawa.

RENZ, O. 1968. Die Ammonoidea im Stratotyp des Vraconnien bei Sainte-Croix (Kanton Waadt). *Schweiz. Paläont Abh. (Mém. Suisse Paléont.)*, **87**, 1—99. Basel.

SAMSONOWICZ, J. 1925. Esquisse géologique des environs de Rachow sur la Vistule et les transgressions de l'Albien et du Cénomanien dans le sillon nord-européen. *Bull. Serv. Géol. Pologne*, **3** (1—2), 45—118. Warszawa.

— 1934. Explication de la feuille Opatów, 1—117. *Serv. Géol. Pologne*; Warszawa.

SAVELEV, A. A. 1981. On the zonal ammonite division of the Albian stage in Mangyshlak. *In*; Evolution and biostratigraphy in the middle of the Cretaceous period (D. P. NAIDIN & V. A. KRASSILOV, *Eds*), 41—46. Vladivostok.

SAZONOV, I. G. & SAZONOV, N. T. 1967. Paleogeografija russkoy platformy v jurskije i rannemelovye vremija. *Trudy VNIGNI (Vses. N.-Issled. Gelorazved. Neft. Inst.)*, **62**, 1—260. Leningrad.

SCHOLZ, G. 1979a. Die Ammoniten des Vracon (Oberalb, *Dispar*-Zone) des Bakony-Gebirges (Westungarn) und eine Revision der wichtingsten Vracon-Arten der West-Mediterranen Faunenprovinz; Teil 1—2. *Palaeontographica, Abt. A*, **165** (1—6), 1—136. Stuttgart.

— 1979b. Vracon-Ammoniten (Oberalb, *dispar*-Zone) aus dem Flammenmergel von Salzgitter. *In*: J. WIEDMANN (*Ed.*), *Aspekte der Kreide Europas, IUGS Series A*, **6**, 589—606. Stuttgart.

SCOTT, G. 1940. Paleoecological factors controlling the distribution and mode of life of Cretaceous ammonoids in the Texas area. *J. Paleontol.*, **14** (4), 299—323. Tulsa.

SIKORA, W. 1976. Cordilleres of the Western Carpathians in the light of the plate tectonics theory. *Przegląd Geol.*, **6**, 336—349. Warszawa.

SPATH, L. F. 1923—1943. A monograph of the Ammonoidea of the Gault. *Palaeontogr. Soc. (Monogr.)*, parts **1—16**, 1—787. London.

SZÉNÁS, G. 1973. The Carpathian system and Global tectonics. *Tectonophysics*, **15**, 267—286. Amsterdam—London—New York.

ŚLĄCZKA, A. (*Ed.*). 1976. Atlas of paleotransport of detrital sediments in the Carpathian — Balkan Mountain system. Part *I*, Tithonian — Lower Cretaceous. *Carpathian — Balkan Geological Association, Sedimentological Comission.* Warszawa.

TANABE, K., OBATA, I. & FUTAKAMI, M. 1978. Analysis of ammonoid assemblages in the Upper Turonian of the Manji area, Central Hokkaido. *Bull. Nat. Sci. Mus., Ser. C (Geol. & Paleont.)*, **4** (2), 37—60. Tokyo.

WIEDMANN, J. 1962a. Ammoniten aus der Vascogotischen Kreide (Nordspanien); Phylloceratina, Lytoceratina. *Palaeontographica, Abt. A.* **118** (4—6), 119—237. Stuttgart.

— 1962b. Unterkreide-Ammoniten von Mallorca; 1. Lfg., Lytoceratina, Aptychi. *Abh.Akad. Wiss. Lit. Mainz, Math.-Naturw. Kl.*, **1**, 1—148. Wiesbaden.

— 1964. Unterkreide-Ammoniten von Mallorca; 2. Lfg., Phylloceratina. *Abh. Akad. Wiss. Lit. Mainz, Math.-Naturw. Kl.*, **4**, 155—264. Wiesbaden.

— 1969. The heteromorphs and ammonoid extinction. *Biol. Rev.*, **44** (4), 563—602. Cambridge.

— 1973. Evolution or revolution of ammonoids at Mesozoic System boundaries. *Biol. Rev.*, **48**, 159—194. Cambridge.

— 1982. Grundzüge der kretazischen Subsidenz-Entwicklung im Südatlantik, in Marokko, Nordspanien und im Helvetikum. *N. Jb. Geol. Paläont. Abh.*, **165**, 5—31. Stuttgart.

— & DIENI, I. 1968. Die Kreide Sardiniens und ihre Cephalopoden. *Palaeontogr. Italica*, **64** (*n. ser.*, **34**), 1—171. Pisa.

WIGILEW, B. 1914. Das subtatrische Neokom in der Tatra. *Spraw. Kom. Fizjogr., Ser. III*, **48**, 42—46. Kraków.

R. MARCINOWSKI i J. WIEDMANN

AMONITY ALBU POLSKI I ICH ZNACZENIE PALEOGEOGRAFICZNE

(Streszczenie)

W pracy przedstawione są wstępne rezultaty badań nad amonitami albskimi, występującymi w profilach Góry Chełmowej k. Przedborza, Annopola nad Wisłą, oraz Wielkiej Równi w Tatrach (*por.* fig. 1*A* oraz tab. 2—4). Analiza zespołów amonitowych, jak również ogólne tło paleogeograficzne wskazują, iż osady zawierające amonity w polskiej części basenu contralnoeuropejskiego składane były w warunkach odpowiadających wewnętrznemu szelfowi, natomiast osady serii wierchowej Tatr w środowisku otwartego szelfu i jego granicy ze stokiem kontynentalnym (*por.* fig. 1*B*—*C* oraz 2). Masowe nagromadzenia amonitów w profilach Annopola nad Wisłą i Wielkiej Równi w Tatrach związane były z wyniesieniami dna zbiornika, na których miały miejsce zjawiska kondensacji obejmującej w obu przypadkach zbliżony interwał stratygraficzny albu (*por.* fig. 1*A* oraz tab. 1). Występowanie amonitów w skrajnie płytkomorskich osadach Góry Chełmowej spowodowane zostało napławieniem muszli, które dryfowały z wiatrem w strefę płycizn.

Wpływy borealne w medyterańskim zespole amonitowym serii wierchowej Tatr (*por.* fig. 1*A* oraz tab. 4) umożliwiają stosowanie ,,borealnego" podziału biostratygraficznego zarówno w obszarze platformowym jak i geosynklinalnym Polski (*patrz* tab. 1). W albie środkowym borealne hoplitidy migrowały do Polski z zachodu i północnego zachodu, a następnie poprzez depresję lwowską docierały do geosynkliny karpackiej, w tym również do strefy sedymentacji serii wierchowej (*por.* fig. 1*B* oraz 2*A*). W albie górnym następuje, mimo rozwoju transgresji (*patrz* fig. 1*C*), wzrost prowincjonalizmu zarówno wśród borealnych jak i medyterańskich zespołów amonitowych, spowodowany powstaniem ,,filtru" głębokościowo-odległościowego, który separował Tatry od obszaru platformowego Polski w stopniu znacznie większym niż w albie środkowym. Zjawisko to miało charakter pan-regionalny, a wywołane zostało przede wszystkim czynnikami natury klimatycznej i batymetrycznej, w mniejszym zaś stopniu istnieniem barier fizycznych w postaci lądów, czy też kordylier pojawiających się efemerycznie w geosynklinie alpejskiej. W prowincji borealnej albskie zespoły amonitowe zdominowane są przez formy cechujące się silną ornamentacją muszli, natomiast w medyterańskiej przez formy gładkie i słabo ornamentowane, przy czym heteromorfy nie wykazują związku z żadną z tych prowincji (*por.* fig. 3). Brak prowincjonalizmu wśród wiodących bentoniczny lub epibentoniczny tryb życia heteromorfów powodowany był dużą tolerancją środowiskową ich stadium młodocianego oraz zdolnością zasiedlania różnych stref ekologicznych (*por.* MARCINOWSKI 1974, 1980).