Biostratigraphy of Albian to Turonian Deep-Water Agglutinated Foraminifera calibrated by Planktonic Foraminifera, Radiolaria, and Dinoflagellate Cysts in the Pieniny Klippen Belt, Polish Carpathians

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ABSTRACT

The stratigraphic distribution of selected Albian to Turonian deep-water agglutinated foraminifers is calibrated by means of planktonic foraminifera (from *Ticinella roberti* to *Marginotruncana sigali* zones), dinocysts (*Litosphaeridium siphonophorum, Ovoidinium scabrosum, Epelidosphaeridia spinosa, Oodnadattia alata*) and Radiolaria (*Holocryptocanium barbui - Pseudodictyomitra pseudomacrocephala* and *Holocryptocanium barbui - Hemicryptocapsa prepolyhedra* assemblages). A local zonation based on agglutinated foraminifera is established (*Haplophragmoides nonioninoides, Plectorecurvoides alternans, Bulbobaculites problematicus, Uvigerinammina* ex. gr. *jankoi* interval zones) and compared with planktonic zonations.

INTRODUCTION

The mid- and Upper Cretaceous deposits in the Pieniny Klippen Belt (PKB), Carpathians have been the subject of numerous studies with respect to their biozonation and palaeoecology (see e.g. Birkenmajer & Geroch, 1961; Alexandrowicz, 1966; 1979; Alexandrowicz *et al.*, 1968a,b; Jednorowska, 1979; 1980; Scheibnerová, 1969; Gasiński, 1983; 1988; K. Bąk, 1992; 1993). A detailed study of planktonic foraminifera in all facies and structural zones in the Polish part of the PKB inspired us to attempt tp correlate different groups of microfauna from these deposits. This correlation was achieved for planktonic, benthonic (agglutinated) foraminifera, radiolaria, and dinoflagellate cysts. This work made it possible to calibrate more precisely the stratigraphic ranges of agglutinated taxa found in Albian to Turonian deposits of the PKB.

Generally, the Albian - Turonian deposits belong to pelagic and turbidite facies. Pelagic deposits of the Kapuśnica, Chmielowa, Pomiedznik and Jaworki formations (Skalski Marl Member and Brynczkowa Marl Member; Birkenmajer, 1977) are represented by green, gray, red and dark marls with limestone intercalations (sections: Falsztyn - Fl, Czorsztyn - Cz, Halka - H, Kapuśnica - Kp, Cisowiec - Ci, Stare Bystre - SB) (Figs. 1 & 2). Turbidite facies with intercalations of fine-bedded sandstones and mudstones are characteristic of the deposits of the Trawne Member, Sneżnica Siltstone Member, and partly Macelowa Marl Member (sections: Kietowy - Ki, Niedziczanka - Ni, Orlica - Or, Bukowiny valley - B). Detailed lithological descriptions of the profiles were presented by Alexandrowicz (1966), Gasiński (1988), and K. Bąk (1992; 1993).

MATERIAL & METHODS

Planktonic and agglutinated foraminifera were retrieved from about 140 samples from ten outcrops (Figs. 1 & 3). Radiolaria and dinoflagellate cysts were collected from the same samples. However, these microfossil groups did not occur in every sample.

For foraminiferal analysis, the samples were placed in a solution of sodium sulphate and gently heated several times, then washed through a 63 µm sieve and air-dried. About 300 specimens of agglutinated and planktonic foraminifera were picked from each sample.

Radiolarian skeletons were freed by dissolving the matrix of the host rock in hot acetic acid for about 24 hours. Aliquots of each sample were washed through a 63 µm sieve. These were then dried and all radiolaria were picked from each sample.

Samples for dinoflagellate cyst study were prepared so that each sample was treated with 5% HCl and subsequently with concentrated 48% laboratory grade HF. The residue was then filtered through a 15 µm screen to concentrate the dinocysts, then a slide was prepared from each sample. At least 300 dinocysts were counted to estimate the total number of species in the sample.

Detailed indexes of each microfossil group were presented earlier (see: Gasiński, 1983; 1984; 1988; K. Bąk, 1992, 1993; M. Bąk, 1993a, 1994; Jamiński, 1990).

In: Kaminski, M.A. Geroch, S., & Gasiński, M.A. (eds.), 1995. Proceedings of the Fourth International Workshop on Agglutinated Foraminifera, Kraków Poland, September 12-19, 1993. *Grzybowski Foundation Special Publication* no. 3, pp. 13-27

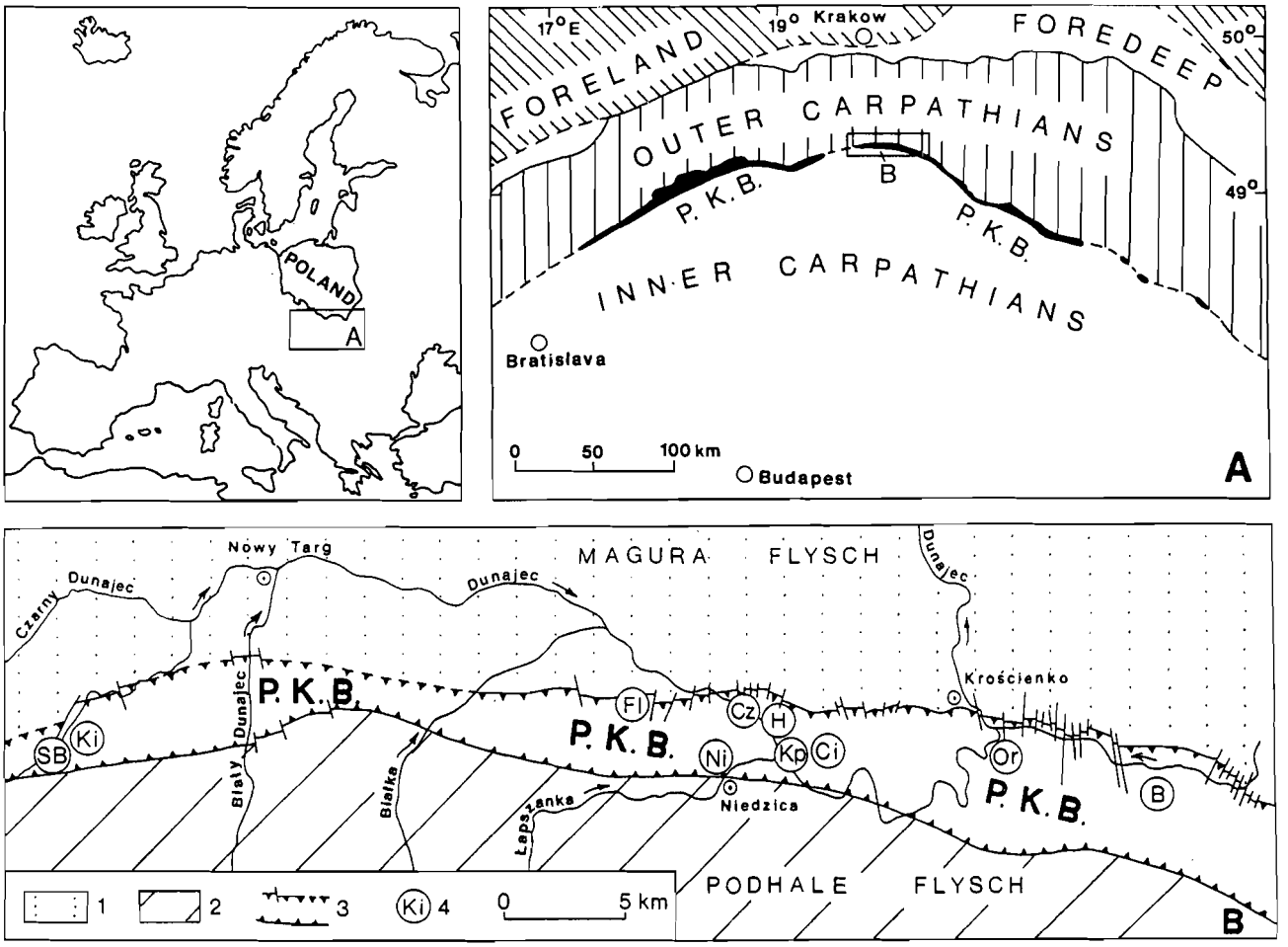

Figure 1. Location of the studied sections. A - Tectonic sketch-map of the Polish Carpathians; B - Detailed location of the studied sections of the Pieniny Klippen Belt (P.K.B.) 1 - Magura Flysch of the Outer Carpathians, 2 - Podhale Flysch of the intramontane basin of the Inner Carpathians, 3 - tectonic borders of the Pieniny Klippen Belt, 4 - names of sections: SB - Stare Bystre, Ki - Kietowy stream, Fl - Falsztyn, Ni - Niedziczanka river, Cz - Czorsztyn, H - Halka, Kp - Kapuśnica, Ci - Cisowiec, Or - Orlica, B - Bukowiny valley.

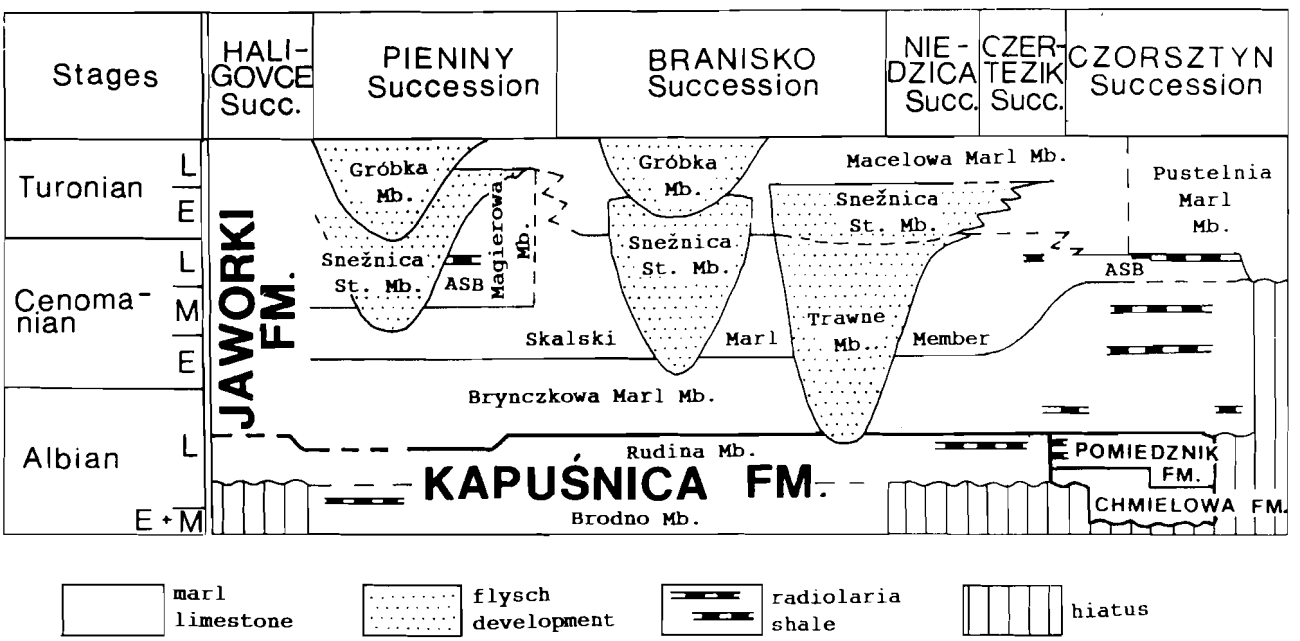

Figure 2. Lithostratigraphic units of the Albian through Turonian deposits of the Pieniny Klippen Belt (Birkenmajer, 1987); ASB - Altana Shale Bed, Sneżnica St. Mb. - Sneżnica Siltstone Member.

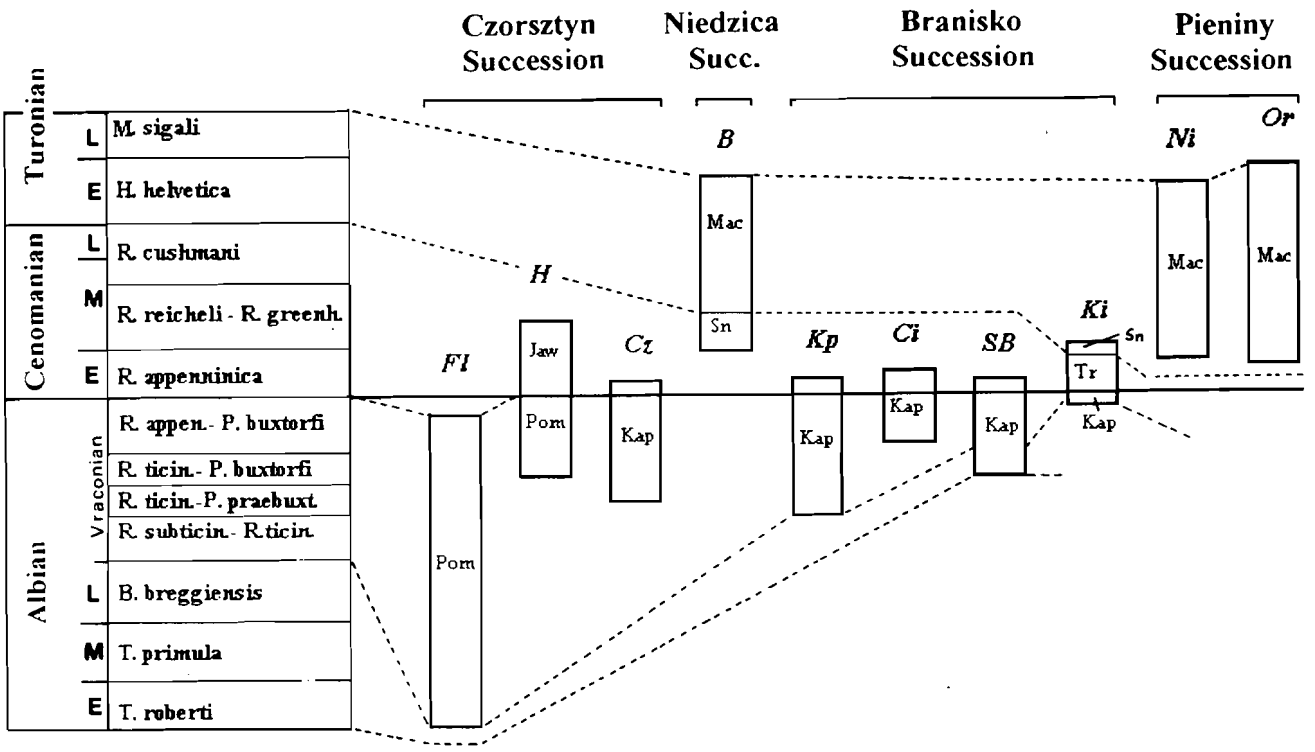

Figure 3. Age of the investigated sections; Pom - Pomiedznik Formation, Kap - Kapuśnica Formation, Jaw - Jaworki Formation, Sn - Sneżnica Siltstone Member, Tr - Trawne Member, Mac - Macelowa Marl Member; for explanations and names of outcrops see Fig. 1

BIOSTRATIGRAPHY

A. Foraminifera

The presence of abundant assemblages of planktonic foraminifera and radiolaria enabled us to calibrate the stratigraphic ranges of agglutinated taxa to existing local zonal schemes. A summary of these ranges is shown in Fig. 4. Three agglutinated assemblages are characteristic for the studied deposits:

1. An assemblage of long-ranging foraminifers, which appeared before the Albian and disappeared after the Turonian. This includes *Ammodiscus cretaceus, Glomospira charoides, G. gordialis, Glomospirella gaultina, Saccammina* cf. *placenta, Pseudonodosinella troyeri, Gaudryina filiformis,* and abundant specimens of *Tritaxia gaultina* and *Dorothia oxycona.* The stratigraphic ranges of *T. gaultina* and *D. oxycona* are longer than those reported by Geroch & Nowak (1984) for the Polish Outer Carpathians.

2. An assemblage of Albian to Cenomanian age with numerous specimens of *Dorothia gradata, Arenobulimina preslii* and, less often, *Haplophragmoides concavus, H. nonioninoides* and *H. gigas minor.* Additionally, the species *Psammosphaera fusca, Hippocrepina depressa, Trochammina globigeriniformis, Textularia foeda, Spiroplectinata annectens, Hyperammina gaultina* and *Plectorecurvoides alternans* occur in this assemblage. The latter two taxa are present also in Turonian deposits.

3. An assemblage of Turonian age with very frequent spherical forms such as *Recurvoides godulensis, R. primus* and planispiral forms such as *Haplophragmoides* cf. *bulloides, H. kirki* and *H.* cf. *walteri.* Specimens of *Trochammina umiatensis, Uvigerinammina* ex gr. *jankoi, Gerochammina lenis, Glomospira irregularis* and *Bulbobaculites problematicus* (appearing since the middle Cenomanian) are very frequent. *Spiroplectinella praelonga* and *Tritaxia subparisiensis* occur sporadically.

A change in the agglutinated assemblages occurs between the upper Cenomanian and lower Turonian. An increased abundance of agglutinated taxa is correlated with the gradual appearance of turbidite sedimentation, from the Cenomanian to the Turonian (Trawne Member, Gróbka Member, Sneżnica Siltstone Member and Macelowa Marl Member). In the Turonian the agglutinated taxa are dominant.

A local biostratigraphical zonation is proposed on the basis of index agglutinated foraminifera. The zones *sensu* Geroch & Nowak (1984) are correlated with planktonic foraminiferal zonations (Fig. 4) established for these deposits by Gasiński (1983; 1988) and K. Bąk (1992; 1993).

1. *Haplophragmoides nonioninoides* Zone (Interval Zone). Lower boundary: first occurrence (FO) of *H. nonioninoides.* Upper boundary: FO of *Plectorecurvoides alternans.* This zone corresponds to the early and middle Albian.

2. *Plectorecurvoides alternans* Zone (Interval Zone). Lower boundary: FO of *P. alternans.* Upper boundary: FO of *Bulbobaculites problematicus.* This zone represents the late Albian through early Cenomanian.

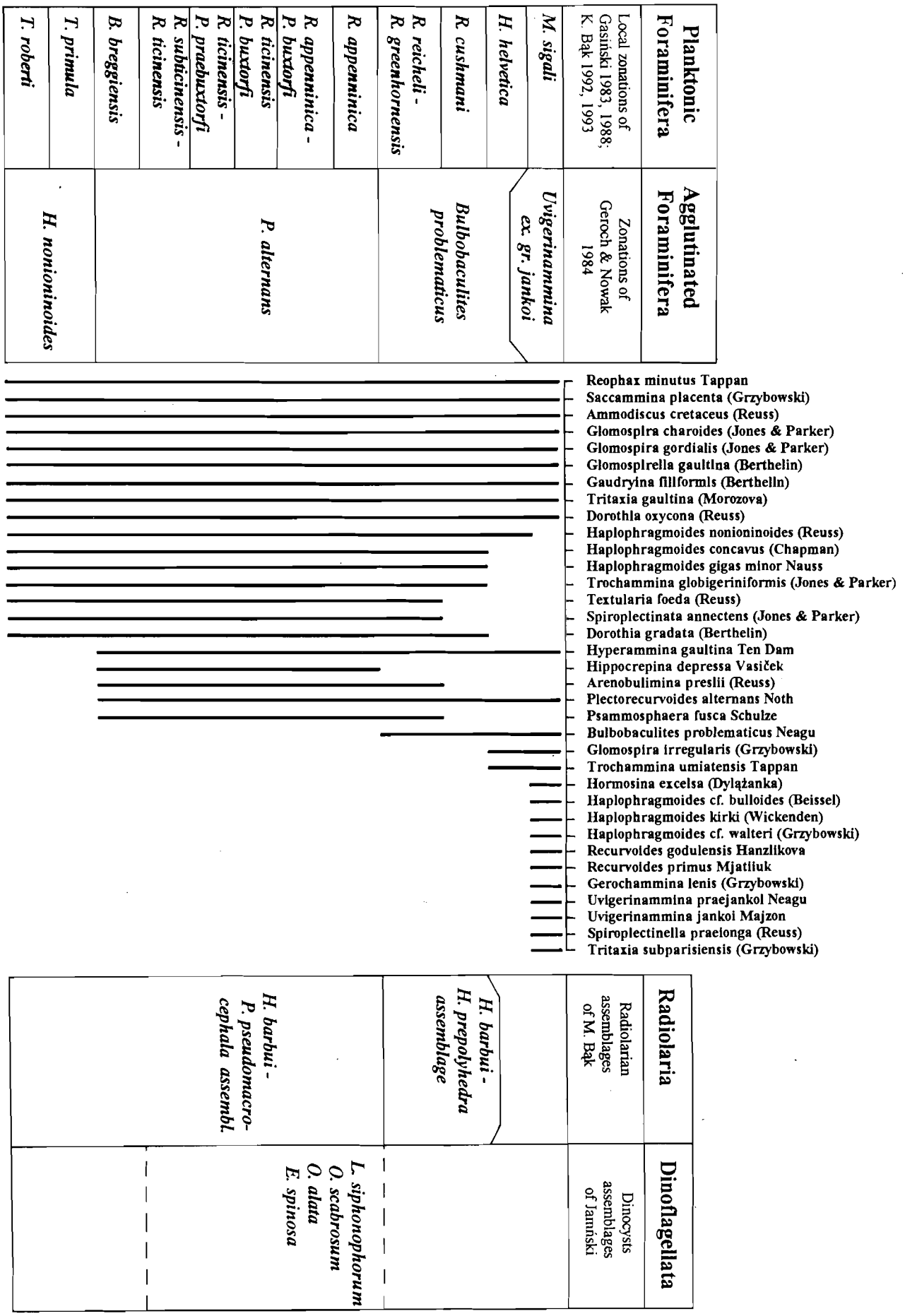

Figure 4. Stratigraphic ranges of agglutinated foraminifera calibrated by planktonic microfossils.

3. *Bulbobaculites problematicus* Zone (Interval Zone). Lower boundary: FO of *B. problematicus*. Upper boundary: FO of *Uvigerinammina* ex gr. *jankoi*. This zone represents the middle Cenomanian through early Turonian.

4. *Uvigerinammina* ex. gr. *jankoi* Zone (Interval Zone). Lower boundary: FO of *U.* ex gr. *jankoi*. Upper boundary: FO of *Goesella rugosa*. The upper boundary of this zone was not recognized in the investigated sections. This zone corresponds to the late Turonian in the studied deposits.

B. Radiolarian Assemblages

A clear-cut correlation between the foraminiferal zones and radiolarian assemblages can be established here because of the co-occurrence foraminifera and radiolaria. In the investigated deposits (Albian - Turonian), the Radiolaria are common and generally well preserved. The radiolarian assemblages are dominated by spherical cryptocephalic cryptothoracic Nassellaria (80-90%), belonging to the genera *Holocryptocanium, Hemicryptocapsa, Cryptamphorella* and *Squinabollum*.

Two local assemblages may be distinguished (Fig. 4) in the analysed Albian to Cenomanian. The first occurrence of *Hemicryptocapsa prepolyhedra* in the investigated deposits, dated as middle Cenomanian (*Rotalipora reicheli - R. greenhornensis* foraminiferal Zone), and its common occurrence, permits division of our radiolarian microfauna into two assemblages.

1. A *Holocryptocanium barbui - Pseudodictyomitra pseudomacrocephala* assemblage corresponding to the foraminiferal zones *T. roberti* (early Albian) - *R. appenninica* (early Cenomanian). It is characterized by a high frequency of the index species *H. barbui* and also of *Cryptamphorella conara, C. macropora, Squinabollum fossilis, Praeconocaryomma globosa, P. copiosa, Protostichocapsa stocki*, and moreover by the co-occurrence of *Pseudodictyomitra pseudomacrocephala, Stichomitra communis, Novixitus weyli, N. maclaughlini* and some multisegmented nassellarians belonging to the genera *Archaeodictyomitra, Alievum, Mita, Stichomitra* and *Thanarla*.

2. A *Holocryptocanium barbui - Hemicryptocapsa prepolyhedra* assemblage corresponding to the foraminiferal zones *R. reicheli - R. greenhornensis* (middle Cenomanian) to *R. cushmani* (late Cenomanian). The index species *H. barbui* is less frequent in this assemblage and is found in co-occurrence with *Hemicryptocapsa prepolyhedra*. The most common species are: *H. prepolyhedra, Hemicryptocapsa tuberosa, Holocryptocanium barbui, Novixitus maclaughlini* and *N. weyli*.

Our local radiolarian assemblages were compared with the radiolarian zonations presented by Dumitrica(1975) and Nakaseko & Nishimura (1981) on the basis of the closest similarity to our radiolarian fauna. Dumitrica (1975) distinguished two radiolarian assemblages in the Cenomanian sequence of the Romanian Carpathians. Our assemblage can be correlated with his lower assemblage (*Holocryptocanium barbui - Holocryptocanium tuberculatum*) as based on the high frequency of the index species, the co-occurrence of other cryptocephalic and cryptothoracic nassellarians (*Holocryptocanium, Hemicryptocapsa, Cryptamphorella, Squinabollum*) and some multisegmented Nasselaria (*Dictyomictra, Stichomitra*). However, *Alievum* was recorded also in our lower assemblage (*H. barbui - P. pseudomacrocephala*).

The investigated radiolarian assemblages, dated as Albian - Cenomanian, correspond to the *H. barbui - H. geysersensis* assemblage of Nakaseko & Nashimura (1981) from southwest Japan. It is based on the co-occurrence of *H. barbui, H. geysersensis, Pseudodictyomitra pseudomacrocephala, Novixitus weyli, Cryptamphorella conara, C. macropora, Hemicryptocapsa tuberosa, Archaeodictyomitra vulgaris, Thanarla veneta, Squinabollum fossillis, Amphipyndax stocki. Holocryptocanium geysersensis* is rare in our assemblage.

C. Dinoflagellate Cyst Stratigraphy

Dinoflagellate cysts from the Pieniny Klippen Belt are well preserved almost exclusively in the Albian - Cenomanian sections. The middle Cenomanian to Turonian sections yield only small quantities of dinoflagellate cysts probably as a result of increased turbidite sedimentation and destruction of the cysts due to oxydising conditions.

The dinoflagellate cysts from the Kapuśnica and Pomiedznik formations described by Jamiński (1990), contain a variety of species diagnostic for the middle Albian to lower Cenomanian in the Tethyan realm, including short-ranging species such as: *Lithosphaeridium siphoniphorum* subsp. *siphoniphorum, Ovoidinium scabrosum, O. verrucosum* and *Oodnadatia alata*. These taxa are characteristic elements of the middle to uppermost Albian (Vraconian) assemblages (Below, 1984; Habib & Drugg, 1987; Williams & Bujak, 1985). *Epelidosphaeridia spinosa, Palaeohystrichopora infusorioides* and *Xenacus ceratioides*, found in the upper parts of these sections, are characteristic of lower Cenomanian assemblages (Below, 1984) but their stratigraphic ranges are disputable. The dinoflagellate cysts may have only limited value in the calibration of foraminifera zones due to the rather low resolution of their stratigraphic record.

The assemblages of dinoflagellate cysts from middle Cenomanian to Turonian sections contain only long-range taxa, such as *Gonyaulacysta cassidata, Odontochitina operculata, Oligosphaeridium complex* and *Spiniferites ramosus*.

CONCLUSIONS

1. The agglutinated foraminiferal zones of Geroch & Nowak (1984) have been recognised in the Albian to Turonian deposits of the Pieniny Klippen Belt.

2. The stratigraphical ranges of selected agglutinated species have been calibrated by planktonic foraminifera, radiolarians, and dinoflagellate cysts.
3. The chronostratigraphic relationships between the Kapuśnica, Pomiedznik, and Jaworki formations are more precisely established herein, based on the planktonic microfossil biostratigraphy.

SYSTEMATIC PART

Only the most frequent taxa of the deep-water agglutinated foraminifera (DWAF) are mentioned below. The classification followed is that of Loeblich & Tappan (1987) and Decrouez (1989). The local planktonic foraminiferal zones of Gasiński (1983; 1988) and K. Bąk (1992; 1993) are used below. Detailed morphological descriptions are omitted because these have already been published. Synonyms are given only for recently published papers.

Order Foraminiferida Eichwald, 1830
Suborder Textulariina Delage & Herourd, 1896
Family Saccamminidae Brady, 1881
Genus ***Saccammina*** Carpenter, 1869

Saccammina cf. ***placenta*** (Grzybowski, 1898)

Plate 1, Fig. c

Reophax placenta Grzybowski, 1898, p. 276, pl. 10, figs. 9-10.
Saccammina placenta (Grzybowski). - Geroch, 1960, pl. 2, figs. 1-6.
Saccammina cf. *placenta* (Grzybowski). - Kuhnt, 1990, p. 325, pl. 2, fig. 2.

Material. About 40 specimens.
Remarks. The same designation was used by Kuhnt & Kaminski (1990) for small, deep-water, mid-Cretaceous specimens from the North Atlantic and Western Tethys.
Locality and horizon. All successions of the Pieniny Klippen Belt; Albian - Turonian.

Family Hippocrepinidae Rhumbler, 1895
Genus ***Hyperammina*** Brady, 1878

Hyperammina gaultina Ten Dam, 1950

Plate 1, Fig. a

Hyperammina gaultina (Ten Dam). - Neagu, 1972, p. 8, pl. 2, fig. 2.
Hyperammina gaultina (Ten Dam). - Geroch & Olszewska, 1990, p. 535, pl. 1, figs. 1-18, 25-27.

Material. 10 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; from upper Albian (*B. breggiensis* Zone) to upper Turonian (*M. sigali* Zone).

Family Haplophragmoididae Maync, 1952
Genus ***Haplophragmoides*** Cushman, 1910

Haplophragmoides cf. ***bulloides*** (Beissel, 1891)

Plate 2, Figs. f-i

Haplophragmium bulloides Beissel, 1891, p. 17, pl. 2, figs. 1-3, pl. 4, figs. 24-30 (*fide* EM Cat.).
Haplophragmoides herbichi Neagu. - Neagu, 1968, p. 238, pl. 1, figs. 9-12.
Haplophragmoides bulloides (Beissel). - Jednorowska, 1980, pl. 2, figs. 1, 2.
Haplophragmoides cf. *bulloides* (Beissel). - Kuhnt & Kaminski, 1990, p. 447, fig. 3.

Material. More than 200 specimens.
Remarks. Specimens are smaller than shallow-water forms described by Beissel (1891). Test is globular, sometimes flattened. Wall is finely agglutinated with much cement. Similar morphotypes of small, deep-water forms have been assigned to *H. herbichi* by Neagu (1990) and to *H.* cf. *bulloides* by Kuhnt & Kaminski (1990).
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Haplophragmoides kirki (Wickenden, 1932)

Plate 2, Fig. e

Haplophragmoides kirki (Wickenden). - Geroch, 1966, p. 476, pl. 10, figs. 6, 7.
Haplophragmoides kirki (Wickenden). - Huss, 1966, p. 83, pl. 4, figs. 25-27.

Material. More than 200 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Haplophragmoides cf. ***walteri*** (Grzybowski, 1898)

Plate 2, Figs. a-d

cf. *Haplophragmium walteri* Grzybowski, 1898, pl. 10, fig. 24.
Haplophragmoides cf. *walteri* (Grzybowski). - Hemleben & Troester, 1984, p. 519, pl. 3, fig. 6.
Haplophragmoides cf. *walteri* (Grzybowski). - Kuhnt, 1990, p. 314, pl. 4, figs. 10-12.

Material. About 50 specimens.
Remarks. Specimens described here are smaller than typical Paleogene forms. They have 6-7 chambers only in the final whorl, circular outline, sutures depressed distinct. Chambers are flattened near ridge. A distinct umbilicus is visible. *Haplophragmoides walteri* has not yet been reported from the Upper Cretaceous in the Carpathians. However, it has been noted as *H.* cf. *walteri* by Hemleben & Troester (1984) from the Atlantic, and by Kuhnt & Kaminski (1990) from the North Atlantic and western Tethys (Southern Spain, Umbrian Apenines).
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Family Lituolidae de Blainville, 1827
Genus ***Bulbobaculites*** Maync, 1952

Bulbobaculites problematicus (Neagu, 1962)

Plate 1, Figs. j-l

Ammobaculites problematicus Neagu. - Birkenmajer *et al.*, 1979, pl. 3, figs. 4-7.
Bulbobaculites problematicus (Neagu). - Kuhnt & Kaminski, 1990, p. 465, pl. 4, figs. A-H.

Material. About 60 specimens.
Locality and horizon. All successions of the Pieniny Klippen Belt; from the middle Cenomanian (*R. reicheli - R. greenhornensis* Zone) to upper Turonian (*M. sigali* Zone).

Family Ammosphaeroidinidae Cushman, 1927
Genus ***Recurvoides*** Earland, 1934

Recurvoides godulensis Hanzliková, 1971

Recurvoides godulensis Hanzliková, 1971, p. 146-148, fig. 2, pl. 4, figs. 1-4.
Recurvoides godulensis Hanzliková. - Jednorowska, 1980, p. 15, figs. 3 (2a, b).

Material. More than 100 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Recurvoides primus Myatlyuk, 1970

Recurvoides primus Myatlyuk, 1970, p. 80, pl. 20, figs. 3a-e, 4a-v, pl. 21, fig. 1.
Recurvoides primus Myatlyuk. - Jednorowska, 1980, figs. 3a-b.

Material. 10 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Family Spiroplectamminidae Cushman, 1927
Genus ***Spiroplectinella*** Kiselman, 1972

Spiroplectinella praelonga (Reuss, 1845)

Plate 1, Figs. m, n

Spiroplectammina praelonga (Reuss). - Scheibnerová, 1976, p. 127, pl. 8, fig. 7, pl. 129, pl. 9, figs. 1-5.
Spiroplectammina praelonga (Reuss). - Geroch & Nowak, 1984, p. 233, pl. 4, fig. 9.

Material. 15 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Family Plectorecurvoididae Loeblich & Tappan, 1964
Genus ***Plectorecurvoides*** Noth, 1952

Plectorecurvoides alternans Noth, 1952

Plate 2, Fig. n, Plate 3, Figs. m, n

Plectorecurvoides alternans Noth, 1952, p. 117-118, figs. 1a-c, 2a, b.
Plectorecurvoides alternans Noth. - Geroch, 1962, p. 285, figs. 3 (11, 15).

Material. 20 specimens.
Locality and horizon. All successions of the Pieniny Klippen Belt; from upper Albian (*B. breggiensis* Zone) to upper Turonian (*M. sigali* Zone).

Family Trochamminidae Schwager, 1877
Genus ***Trochammina*** Parker & Jones, 1859

Trochammina umiatensis Tappan,

Plate 2, Figs. j-l

Trochammina umiatensis Tappan. - Birkenmajer *et al.*, 1979, pl. 3, figs. 9, 10.
Trochammina umiatensis Tappan. - Jednorowska, 1980, pl. 2, figs. 3-5.

Material. About 60 specimens.
Locality and horizon. Pieniny, Branisko and Niedzica successions of the Pieniny Klippen Belt; Turonian.

Family Prolixoplectidae Loeblich & Tappan, 1985
Genus ***Gerochammina*** Neagu, 1990

Gerochammina lenis (Grzybowski, 1896)

Plate 1, Figs. s, t

Spiroplecta lenis Grzybowski, 1896, pl. 9, figs. 24-25.
Gerochammina lenis (Grzybowski). - Neagu, 1990, p. 254, pl. 2, figs. 22-32, pl. 4, figs. 28-31.

Material. More than 60 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Family Verneuilinidae Cushman, 1911
Genus ***Uvigerinammina*** Majzon, 1943

Uvigerinammina praejankoi Neagu, 1990

Plate 3. Fig. j

Uvigerinammina praejankoi Neagu, 1990, pl. 3, figs. 1-33.

Material. Seven specimens.
Remarks. Single specimens of *U. praejankoi* found in the red marls of the Niedzicznka and Bukowiny sections. They are pseudo-biserial in the last whorl. These specimens occur together with *U. jankoi* in the same samples.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Uvigerinammina jankoi Majzon, 1943

Plate 3, Figs. h, i, k, l

Uvigerinammina jankoi Majzon. - Geroch, 1957, pl. 14, figs. 1-16, pl. 15, figs. 1-9.
Uvigerinammina jankoi Majzon. - Geroch & Nowak, 1984, p. 388, pl. 4, fig. 4.

Material. About 70 specimens.

Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Genus ***Spiroplectinata*** Schubert, 1902

Spiroplectinata annectens (Jones & Parker, 1863)

Textularia annectens Jones & Parker. - Jones & Parker, 1863, p. 92, pl. 1, fig. 1 (*fide* EM Cat).
Spiroplectinata annectens (Jones & Parker). - Peryt, 1983, pl. 22, figs. 6, 10.

Material. About 20 specimens.
Locality and horizon. Czorsztyn and Branisko successions of the Pieniny Klippen Belt; from lower Albian (*T. roberti* Zone) to middle Cenomanian (*R. reicheli - R. greenhornensis* Zone).

Genus ***Gaudryina*** d'Orbigny, 1839

Gaudryina filiformis Berthelin, 1880

Plate 1, Figs. h, i

Gaudryina filiformis Berthelin, 1880, p. 25, pl. 24, fig. 8 (*fide* EM Cat.).
Gaudryina filiformis Berthelin. - Hanzliková, 1969, p. 186, pl. 2, fig. 4.
Dorothia filiformis Berthelin. - Riegraf & Luterbacher, 1989, p. 1099, pl. 3, fig. 10.

Material. 40 specimens.
Locality and horizon. All successions of the Pieniny Klippen Belt; Albian through Turonian.

Family Tritaxiidae Plotnikova, 1979
Genus ***Tritaxia*** Reuss, 1860

Tritaxia gaultina (Morozova, 1948)

Plate 1, Figs. o, p

Clavulina gaultina Morozova, p. 36, pl. 1, fig. 4 (*fide* EM Cat.).
Clavulinoides gaultinans (Morozova). - Neagu, 1962, p. 419, pl. 40, figs. 1-7.
Tritaxia gaultina (Morozova). - Gasiński, 1984, pl. 1, figs. 3-5.

Material. About 80 specimens.
Locality and horizon. All successions of the Pieniny Klippen Belt; Albian through Turonian.

Tritaxia subparisiensis (Grzybowski, 1896)

Plate 1, Fig. r

Clavulina subparisiensis Grzybowski, 1896, pl. 9, fig. 30.
Tritaxia subparisiensis (Grzybowski). - Geroch & Nowak, 1984, p. 233, pl. 4, fig. 10.

Material. About 20 specimens.
Locality and horizon. Pieniny and Niedzica successions of the Pieniny Klippen Belt; upper Turonian (*M. sigali* Zone).

Family Eggerellidae Cushman, 1937
Genus ***Dorothia*** Plummer, 1931

Dorothia gradata (Berthelin, 1880)

Plate 3, Fig. b

Dorothia gradata Berthelin, 1880, p. 24, pl. 1, figs. 6a-c (*fide* EM Cat.).
Dorothia gradata (Berthelin). - Gawor-Biedowa, 1972, p. 29, 30, pl. 2, fig. 7.
Dorothia gradata (Berthelin). - Heller, 1975, pl. 2, fig. 2.

Material. 60 specimens.
Locality and horizon. All successions of the Pieniny Klippen Belt; Albian (*T. roberti* Zone) through upper Cenomanian (*R. cushmani* Zone).

Dorothia oxycona (Reuss, 1860)

Plate 3, Figs. d-g

Gaudryina oxycona Reuss, 1860, p. 220, pl. 12, figs. 3a-c (*fide* EM Cat.).
Marsonella oxycona (Reuss). - Riegraf & Luterbacher, 1989, pl. 3, figs. 8-9.

Material. About 60 specimens.
Locality and horizon. All successions of the Pieniny Klippen Belt; Albian through Turonian.

Family Textulariidae Ehrenberg, 1838
Genus **Textularia** Defrance, 1824

Textularia foeda Reuss, 1845

Textularia foeda Reuss, 1845, pp. 109-110, pl. 43, fig. 12 (*fide* EM Cat.).
Textularia foeda Reuss. - Gasiński, 1984, pl. 1. figs. 1-2.

Material. Ten specimens.
Locality and horizon. Czorsztyn and Branisko successions of the Pieniny Klippen Belt; from upper Albian (*R. ticinensis - R. subticinensis* Zone) to upper Cenomanian (*R. cushmani* Zone).

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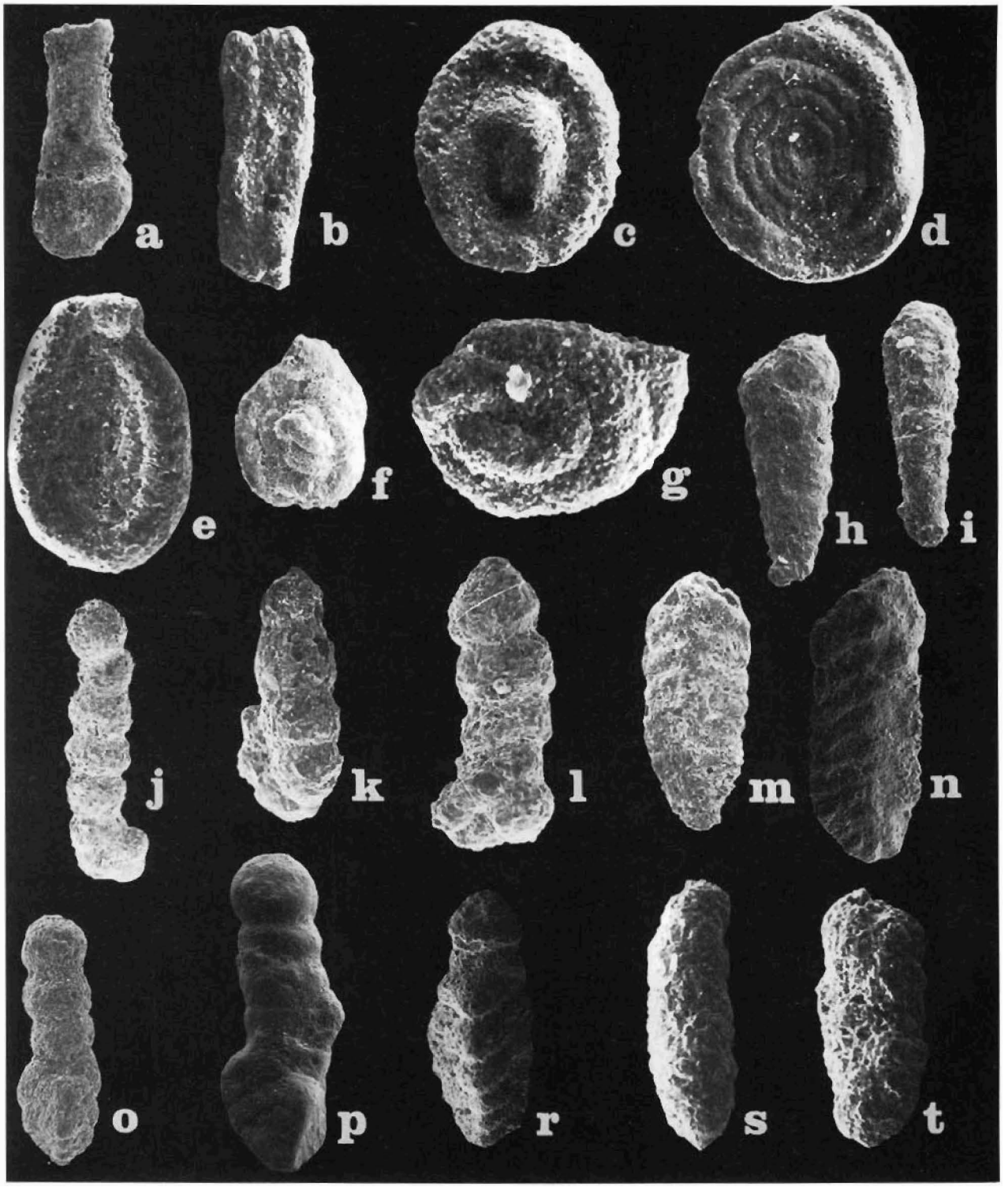

Plate 1. a. *Hyperammina gaultina* Ten Dam; from Niedziczanka, Macelowa Marl Member (a x50, b x60), **b.** *Rhizammina* sp.; Orlica, Macelowa Marl Member (x60), **c.** *Saccammina* cf. *placenta* (Grzybowski); Kietowy Stream, Trawne Member (x60), **d, e.** *Ammodiscus cretaceus* (Reuss); Orlica, Macelowa Marl Member (x60), **f, g.** *Glomospira irregularis* (Grzybowski); Bukowiny valley, Sneżnica Siltstone Member (f. x60, g. x100), **h, i.** *Gaudryina filiformis* (Berthelin); Niedziczanka, Sneżnica Siltstone Member (x50), **j - l.** *Bulbobaculites problematicus* Neagu; Orlica, Macelowa Marl Member (j. x50, k, l. x75), **m, n.** *Spiroplectinella praelonga* (Reuss); Orlica, Macelowa Marl Member (x50), **o, p.** *Tritaxia gaultina* (Morozova); **o.** Niedziczanka (Macelowa Marl Member (x50), **p.** Kapuśnica, Kapuśnica Formation (x50), **r.** *Tritaxia subparisiensis* (Grzybowski); Niedziczanka, Macelowa Marl Member (x50), **s, t.** *Gerochammina lenis* (Grzybowski); Bukowiny valley, Macelowa Marl Member (x60).

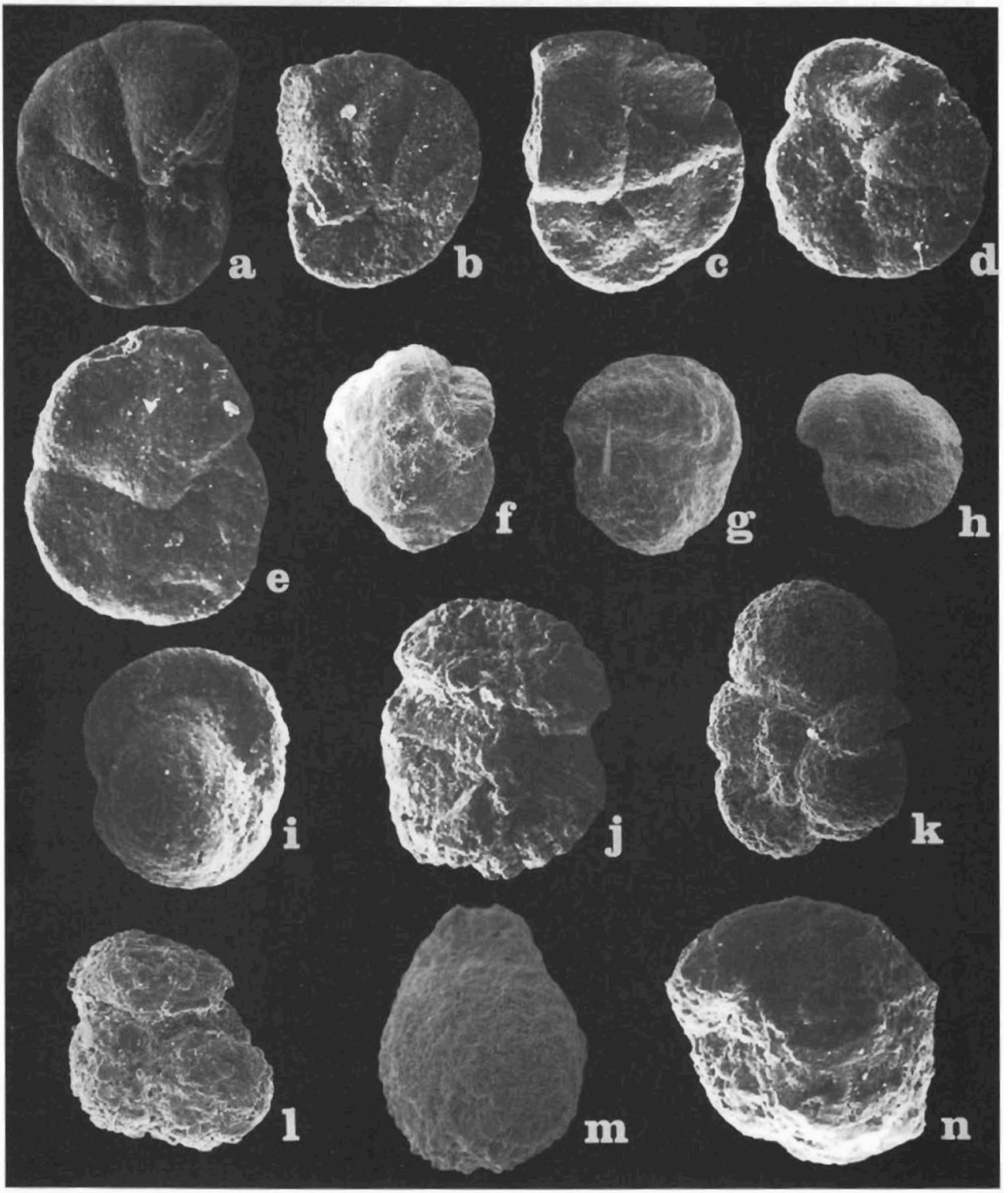

Plate 2. a - d. *Haplophragmoides* cf. *walteri* (Grzybowski); from Bukowiny valley, Macelowa Marl Member (a x60, b x75, c x60, d x75), **e.** *Haplophragmoides kirki* (Wickenden); Orlica, Macelowa Marl Member (x100), **f - i.** *Haplophragmoides* cf. *bulloides* (Beissel); Niedziczanka, Macelowa Marl Member (f, g, h. x50, i x100), **j - l.** *Trochammina umiatensis* Tappan; Orlica, Sneżnica Siltstone Member (x75), **m.** *Thalmannamina* sp.; Niedziczanka, Macelowa Marl Member (x100), **n.** *Plectorecurvoides alternans* Noth; Kietowy, Trawne Member (x50).

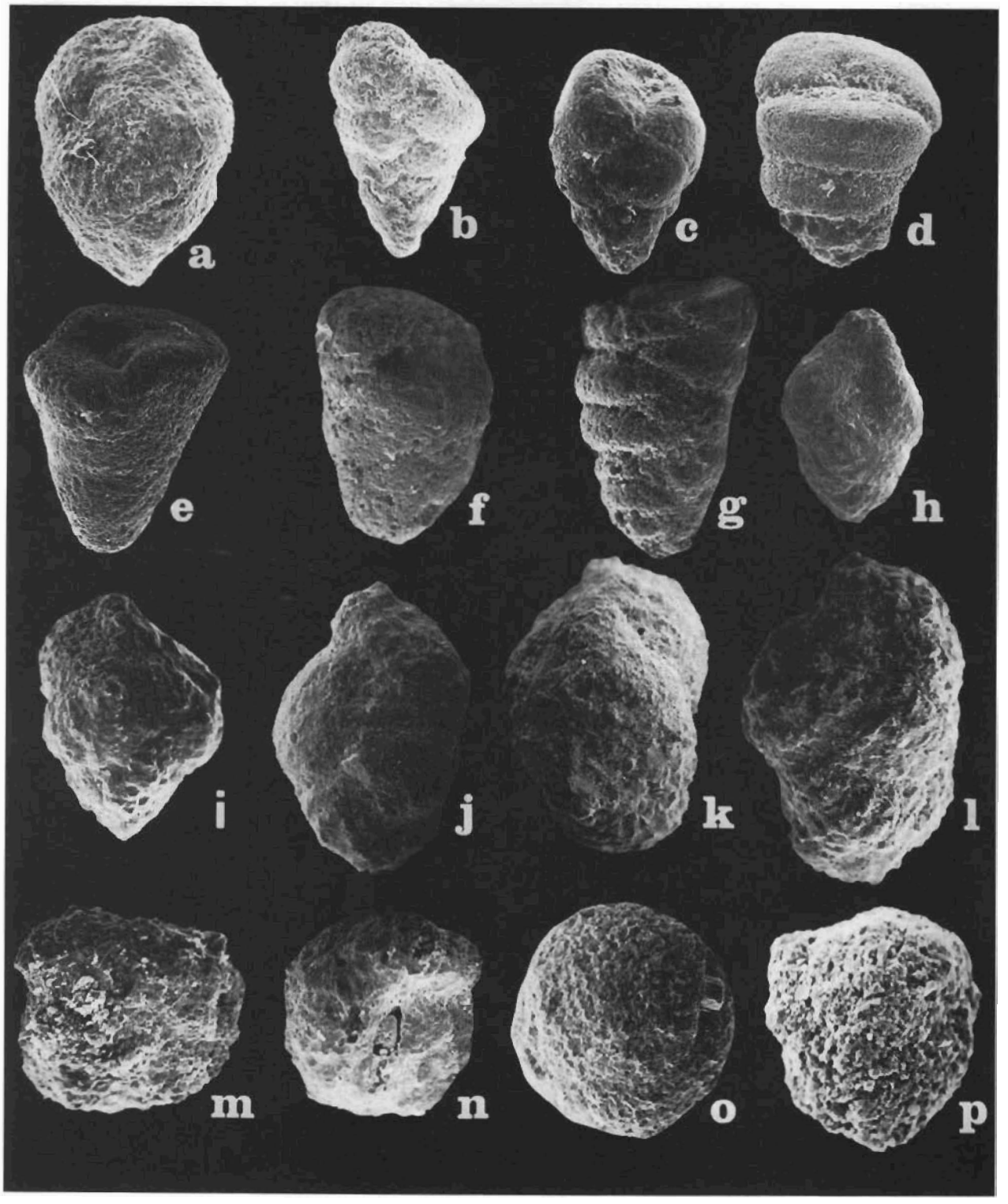

Plate 3. a, c. *Arenobulimina preslii* (Reuss); from Czorsztyn, Pomiedznik Formation (x100), **b.** *Dorothia gradata* (Berthelin); Kapuśnica, Kapuśnica Formation (x50), **d - g.** *Dorothia oxycona* (Reuss); Kietowy, Trawne Member (d, g x60, e, f x90), **j.** *Uvigerinammina praejankoi* Neagu; Orlica, Macelowa Marl Member (x75), **h, i, k, l.** *Uvigerinammina jankoi* Majzon; Orlica, Macelowa Marl Member (x75), **m. n.** *Plectorecurvoides alternans* (Geroch); Niedziczanka, Macelowa Marl Member (x50), **o, p.** *Recurvoides* sp.; Niedziczanka, Macelowa Marl Member (x50).

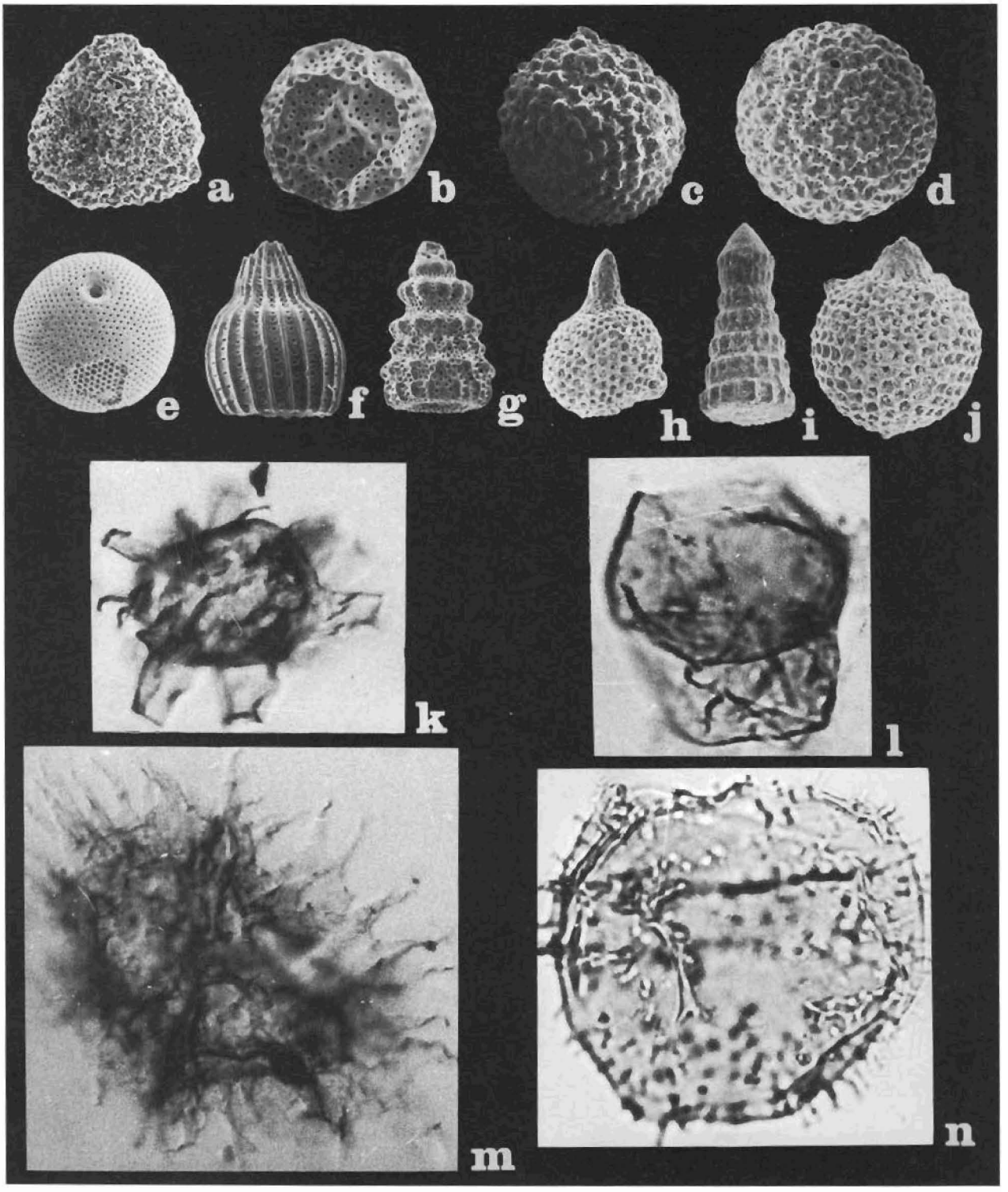

Plate 4. Radiolaria: **a.** *Alievum* sp.; from Falsztyn, Pomiedznik Formation (x150), **b.** *Hemicryptocapsa prepolyhedra* Dumitricá; Kietowy, Sneżnica Siltstone Member (x150), **c.** *Holocryptocanium geysersensis* Pessagno; Falsztyn, Pomiedznik Formation (x150), **d.** *Hemicryptocapsa tuberosa* Dumitricá; Kietowy, Sneżnica Siltstone Formation (x150), **e.** *Holocryptocanium barbui* Dumitricá; Kietowy, Sneżnica Siltstone Member, **f.** *Thanarla elegantissima* (Cita); Kietowy, Sneżnica Siltstone Member (x120), **g.** *Novixitus maclaughlini* Pessagno; Kietowy, Sneżnica Siltstone Member (x120), **h.** *Squinabollum fossilis* (Squinabol), Czorsztyn, Pomiedznik Formation (x120), **i.** *Pseudodictyomitra pseudomacrocephala* (Squinabol); Halka, Pomiedznik Formation (x120), **j.** *Cryptamphorella conara* Foreman; Czorsztyn, Pomiedznik Formation (x150). **Dinoflagellata**: **k.** *Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams, Czorsztyn, Pomiedznik Formation (x400); **l.** *Ovoidinium scabrosum* (Cookson & Hughes) Davey; Czorsztyn, Pomiedznik Formation (x1000) **m.** *Oodnadanattia alata* (Cookson & Eisenack) Below; Halka, Pomiedznik Formation (x1000) **n.** *Epelidosphaeridia spinosa* (Cookson & Hughes) Davey; Czorsztyn, Pomiedznik Formation (x1000).