Slovak Geol. Magazine, 3,4(1997) 315–329

Biostratigraphical and lithological evaluation of the profile „BALCOVÁ“, Šiprúň sequence, Veľká Fatra Mts.

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Abstract. The profile „Balcová“ is located in the Ľubochnianska dolina valley (Veľká Fatra Mts.) north of elevation point Balcová (979). The subject of study was the Poruba Formation as uppermost in the Šiprúň sequence. From the point of view of lithofacial content we take this formation as a complex of marly shales and marlstones, with intercalations of more or less sandy limestones and sporadically sandstone beds. By analysis of foraminifers and nannoplankton assemblages we obtained precised dating of the formation, from Early Albian to Middle Turonian. In the upper horizons of the Poruba Formation we proved the presence of planktonic foraminifers of the Helvetoglobotruncana helvetica Zone (in the sense of Salaj 1986). We established a tectonic break in the succession of strata of the Šiprúň sequence in this area, between the Poruba Formation and underlying formations.

Key words: West Carpathians, Biostratigraphy, Middle Cretaceous, Poruba Formation, Šiprúň sequence, Veľká Fatra Mts., foraminifers, nannoplankton.

Introduction

The paper was prepared on the basis of the research activities under the project: *Regional Geological Research of Slovakia* in the frame of the theme „Biostratigraphy of the Phanerozoic of the Western Carpathians – Biostratigraphical and microfacial evaluation and correlation of selected Cretaceous lithostratigraphic sections“. The aim of this project is to document significant lithostatigraphic profiles in the Western Carpathians and to correlate stratigraphic range of individual groups and/or species of organisms on the basis of this documentation. Besides other, the profile through the Tatric Mesozoic succession of the Veľká Fatra Mts. – the Šiprúň sequence – in the Ľubochnianska dolina valley, north of mount Balcová (979) was chosen for investigation. Attention was paid to the higher part of the bed sequence overlying the Lučivná Formation - the Poruba Formation.

The choice of the section „Balcová“ was also motivated by the results of Bujnovský et al. (1988) and Bujnovský and Gašpariková (1990), which raised the question of the age range of the formation, colliding with the defined lithological content.

The profile „Balcová“ is situated in cuts along the forest road NW of Balcová (979), at the slope of Chmelinec, in altitude between 750 m and 900 m (Fig. 1).

We carried out documentation of the bed sequence, took samples for determination of foraminifers and nannoplankton and also petrographic analyses. The microfauna was evaluated from washings as well as in thin section material.

History of investigations

On the basis of mapping of the Nízke Tatry Mts. and adjacent part of the Veľká Fatra Mts. Matějka (1927, 1930) distinguished the so called „Šiprúň Series“ in the area of Revúca and Ružomberok, with specific bed sequence from the Triassic to Gaultian, considering it as overthrust tectonically to the position above the crystalline Ľubochňa massif of the Veľká Fatra Mts., but below the „lower Subtatric nappe“ (= Krížna nappe). Matějka (l. c.) described the uppermost members of the „Series“ as dark to black limestones with cherts – the marly limestones passing into dark shaly marls. To the top the latter are interbeded with some sandstones, upward passing to the flysch development. Further on, Matějka (op. cit.)

describes dark-grey, light-coloured and yellow marls and sandstones, fine-grained limestones, in places with muscovite sandstones with plant detritus. In the top part he noted thick layers of sandstones and conglomerates. Later Matějka (1931) supposed the age of the sequence range up to the „Gaultian".

Bystrický (1956) has found out that the „Šiprúň Series" is not of the character of particular nappe, but is only a higher part of the normal bed sequence of the Tatricum envelope.

In the General geological map (scale 1:200 000) the area was included in the „Veľká Fatra Series" (= Group) (Maheľ et al. 1964, p. 129), with the youngest member of grey marly shales with layers of sandstones (there „Albian").

Lithofacial and paleogeographical analysis of the Mesozoic of Tatric envelope series was carried out by Polák (1976). He designates the uppermost part of the „envelope sequence" with the term „Albian". In the individual analysed mountain ranges he distinguished various facial varieties of the formation, for the Veľká Fatra Mts. he mentions prevalence of pelitic facies with clayey and sandy marly shales with an amount of sericite, with intercalations of fine-grained sandstones and/or a limited intervals of „flysch character" in the lower part of the complex. The Albian complex is underlain by Aptian dark limestones with cherts and intercalations of black clayey shales. Somewhat later Bujnovský and Polák (1979) acknowledged priority of the name „Šiprúň sequence" for the envelope unit with the bed sequence from the Triassic to Early Cenomanian.

In the year 1985 Bujnovský and Polák published a brief information on the succession of strata of the Šiprúň sequence in the Veľká Fatra Mts. where they mention the find of *Hedbergella roberti* (Gandolfi), *Haplophragmoides nonioninoides* (Reuss) and *Rotalipora* ex gr. *cushmani* (Morrow), proving even an Early Turonian age of the uppermost formation. Similar finding was published previously by Cúlová and Andrusov (1964) from the „High Tatric Series" in the Tichá dolina valley in the Vysoké Tatry Mts. where they found *Praeglobotruncana helvetica* (Bolli) and *Globotruncana renzi* Gandolfi, on the basis of which they shifted the upper boundary of the uppermost Tatric Mesozoic envelope formation to the Early Turonian.

The Poruba Formation was defined by Jablonský (1986) as the uppermost formation of the Krížna nappe bed sequence in the Strážovské vrchy Mts. and Malá Fatra Mts. and of the Tatricum in the Nízke Tatry Mts. and Veľká Fatra Mts. He divided the formation into the Homôlka Marlstones, Čavoj Member, Ludrová and Senkov Members. For „Tatric" localities of the formation he mentions the range of age Albian-Middle Cenomanian, later (Jablonský in Samuel et al. 1988) the age from the Albian to Early Cenomanian, with total thickness of 30-400 m. He defines the lower boundary of the Poruba Formation as unsharp and asynchronous, the upper boundary as erosional and/or tectonic.

In the Krížna nappe between Early Cretaceous micritic limestones and Albian - Cenomanian flysch (thus understand the Poruba Formation) is an extensive complex of olistostromes (Jablonský - Marschalko, 1992), corresponding in its position to the Vlkolínec Breccia, of Aptian - lowermost Albian age (Jablonský in Samuel et al. 1988).

Detailed geological mapping of the surroundings of elevaton point Balcová in scale 1:25 000 was carried out by Bujnovský et al. (1988). In the Šiprúň sequence they distinguished as youngest the Poruba Formation, above the Lučivná Formation, ranging in age from the Aptian to Middle Cenomanian, in total thickness of 120 m.

On the basis of this mapping (l.c.) Bujnovský and Gašpariková (1990) also published data on the surroundings of Balcová. They again mention the position of the Poruba Formation overlying the Lučivná Formation, which range of age is Valangian - Late Barremian. They established the age of the Poruba Formation as Early Aptian to Middle Cenomanian, on the basis of foraminifer associations. Unfortunately, as in the foregoing (Bujnovský et al. 1988), also in this work a more precise localisation of sampling sites and their representation in the profile are missing, not making possible a more detailed analysis and correlation of data. They understand the Poruba Formation as a complex of spotted marls with intercalations of greywacke sandstones.

In a detailed microbiostratigraphical study of formations at the boundary of the Jurassic and Cretaceous in the profile along the forest road-cut NNE of Balcová Boorová (1992) distinguished the Osobitá Formation, overlying the Lučivná Formation. For the Lučivná Formation she stated the upper boundary as the Barremian(?) - Early Aptian (Bedulian). She descirebes the Osobitá Formation as marly dark-grey, in places spotted, predominantly thin platy limestones with thin inerbeds of dark shaly marlstones. Several limestone beds contain black cherty nodules. At the lower level are two beds of limestones with uneven „nodular" divisional surface, at the top of the formation is a bed of black calcarenite, typical of this formation. Thickness of the formation is about 14 m. On the basis of the separated planktonic foraminifers its age was determined as Aptian (Gargasian - Clansay).

In the strata overlying this complex Boorová (l.c.) distinguished an unnamed formation of „Lower Albian dark-grey and black limestones". It is formed by dark-grey to black platy limestones and layered spotted limestones (radiolarian biomicrite), in lower layers with black spotted marlstones. She also records several beds with

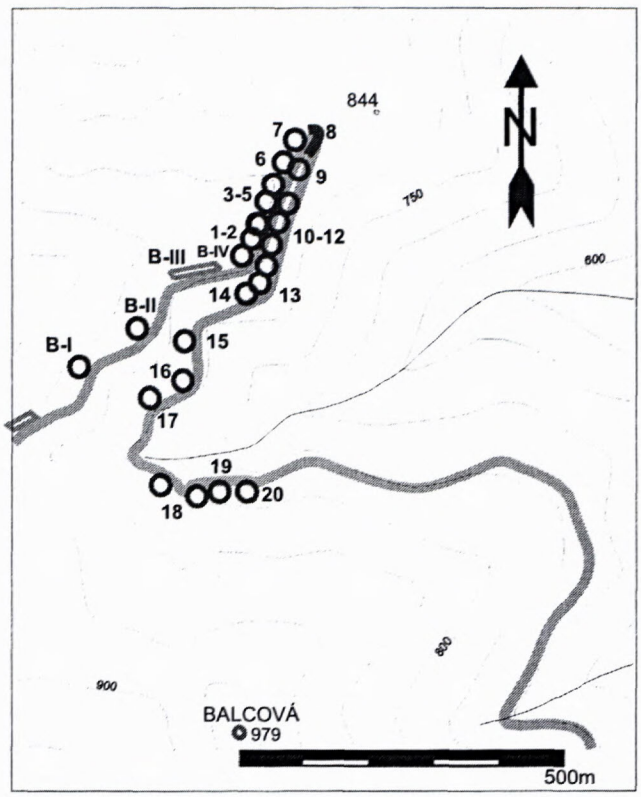

Fig. 1. Localization of profile and situation of documentation points

chert nodules and even continuous beds of cherts. The supposed age of this sequence (about 23 m thick) is Early Albian according to superposition.

Geological situation

For the preliminary geological localisation of our profile we used the map of Bujnovský et al. (1988). In this map the Osobitá Formation has not been plotted yet. With more detailed reconnaissance of the area it has been shown that the boundary of Krížna nappe overthrust in the place of the profile runs more to the west and higher (875 m above sea level) than indicated in the map (l.c.) (compare Fig. 2).

The youngest sediments of envelope (but also Krížna nappe) bed sequences of the Inner Carpathians are deposited atop of the Aptian shales and limestones (in places with cherts). It is mainly a complex of more or less shaly marlstones and marls, acquiring flysch character upwards due to increase of sandstone beds. In some mountain ranges also conglomerates are represented (Malé Karpaty, Žiar, Nízke Tatry, Humenské vrchy Mts. compare Salaj - Samuel 1966, Jablonský 1978, 1986). The age of topmost sediments of bed sequences in the individual mountain ranges was established as Albian (Žiar, Strážovské vrchy, Malá Fatra Mts. - autochtonous units), Albian - Early Cenomanian (Malé Karpaty, Malá Fatra Mts. - Krížna nappe) (Salaj - Samuel 1966, Bujnovský - Gašpariková 1990), even up to the Early Turonian (Vysoké Tatry, Veľká Fatra Mts.) (Cúlová - Andrusov 1964, Bujnovský - Polák 1985).

The lithofacial composition of the whole Poruba Formation is internally quite variegated (Jablonský 1986, also Samuel et al. 1988). Thickness of the formation is considerably variable from several tens of metres to more than 200 m. This results mainly from its position at the top of the bed sequence where it was eroded tectonically by overthrust nappes (unroofing). Its relatively „softer" lithology also plays role in thickness reduction, when squeezed between limestone complexes.

Description of the „Balcová" section

In the lower part of the profile limestones dominate. At the bottom are dark-grey and greenish-black platy limestones with dark spots and shaly intercalations (Pl. V., Fig. 3) (= Osobitá Limestones? - Boorová 1992). Higher up are dark-grey shales and layers of grey limestones. In places also nodules of black cherts are found. Boorová (l.c.) ranged this passage to the „unnamed" formation of the Early Albian.

Following above is the Poruba Formation. It is composed of a shaly limestone and marl beds, 30-200 cm thick. Grey argillaceous limestones are with silt admixture and darker spots after bioturbations (Pl. V., Figs. 1 and 2). Shaly marlstones, claystones and marls in the higher part of the sequence have an admixture of silt and sericite. Sparce thin beds of fine-grained sandstones to siltstones are found. In the upper part of the profile we found a set of irregular sandstone beds, limited lenticularly, interpreted as „channel fill" (Pl. VI., Fig. 1). To a limited degree regularly alternating beds of fine-grained sandstones with calcareous argillaceous shales were found (Pl. IV., Fig. 2). In the uppermost part occur some few cm thick reddish-brown marlstones.

Atop lies poorly outcroped tectonic breccia with fragments of sandstones, marlstones and limestones and layers of grey dolomites, belonging to the Krížna nappe. As a whole the bed sequence forms a flat anticline with NE-SW axis, transversally bent in NW-SE direction.

Documentation of selected parts of the profile

We present here description of the documentation points (from underlying to overlying), which are important from the point of view of general characterisation and from which decisive samples and determinations are coming. Their localisation is shown in Fig. 1. With regard to transversal bending of beds some passages of the profile are overlapping (B-14/-15= B-12/-13 and B-II/B-IV= B-1/B-2). Complete documentation is found in the archival report by Boorová - Potfaj (1996).

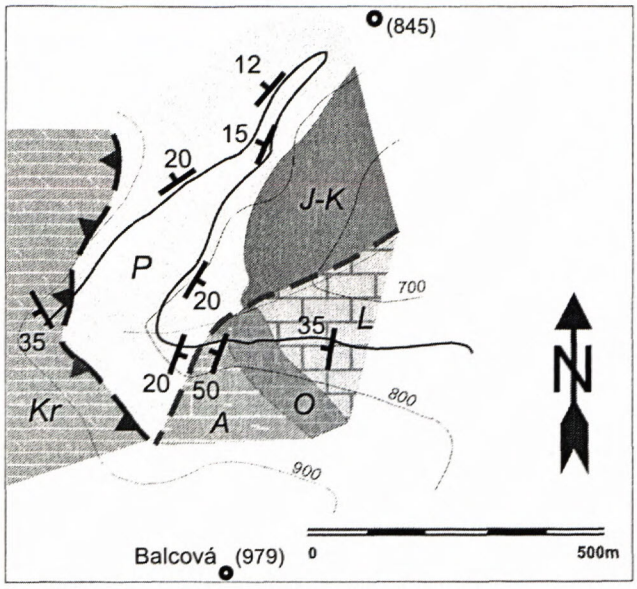

Fig. 2. Geological sketch-map of the profile area
Legend: Kr - Krížna nappe - undifferentiated
Šiprún sequence: P - Poruba formation, A - lower Albian limestones, O -Osobitá formation, L. Lučivná formation, J-K - older Cretaceous and Jurassic formations

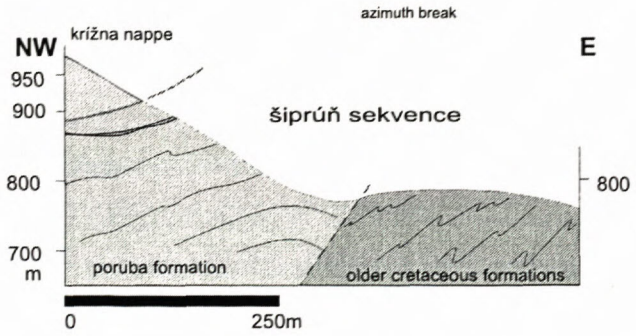

Fig. 3. Geological cross-section

Lower part of the profile - „unnamed" formation of the Early Albian (Boorová 1992):

B-19: Grey platy limestones with Fe-coatings, bedding plane v = 260/32 (Pl. V., Fig. 3). Among limestone beds are dark-grey to black shales up to 10 cm thick. Angulary disintegrating shales (sample B-19, washing 146/94) contain a mixed association of recrystallised plankton and agglutinated benthonic foraminifers:

Glomospirella sp., *Ammodiscus tenuissimus* (Gümbel), *Glomospirella gaultina* (Berthelin), *Lenticulina* sp., *Epistomina* sp., *Anomalina* sp., *Anomalina (Gavelinella) complanata* Reuss, *Ticinella roberti* (Gandolfi). Age: Early Albian.

B-18 (797 m a.s.l.): Dark-grey, dark-green limestones with black spots, layered to platy, at bedding planes are „dendrites" and Fe-coatings. The limestones are relatively massive, at the bottom bioturbated and shaly in places. In the lower part are two beds of light-grey spotted limestones with stylolites, lined by dark-grey shaly marlstones. Dip of beds is 48-30° to the west, cleavage k = ÷ 265/30. Total thickness at the outcrop is about 12 m. In thin section from dark-grey spotted limestones (sample B-18a) are cross sections of *Hedbergella infracretacea* (Glaessner), *Ticinella* sp. (Pl. II., Fig. 1), *Ticinella bejaouaensis* SIGAL, *Ticinella roberti* (Gandolfi) - Age: Early Albian.

The nannoplankton (B 18-99/94) contains the species: *Braarudosphaera africana* Stradner, *Cyclagelosphaera deflandrei* (Manivit) and *Watznaueria barnesae* (Black), being a little representative association. The age may be interpreted as Albian - Early Cenomanian, on the basis of the occurrence of *B. africana.*

Middle part of the profile - Poruba Formation:

B-17 (805 ? m a.s.l.): Greenish-grey marlstones-limestones, thinner beds of shaly marls with boudined intervals. In thin section display the individual components „schlieren-like" structure, with slight lamination. Dip v = 120/20°. The thin section contains *Hedbergella* sp., *Ticinella* sp. - Age: Early Albian.

B-16 (810 m a.s.l.): Shaly marlstones in beds 0,9-6 m at section of 25 m (Pl. V., Fig. 2). Immediately overlying are limestones with plant chaff, with rusty brown coating, highly tectonized. Dip v = 325/18, v_2 = 290/30, s_2 = 95/40. Between the ravines are shaly marlstones - green, dark spotted limestones 30-300 cm, dip v = 110/20. In thin section we identified: *Hedbergella* sp., *Hedbergella delrioensis* (Carsey), *Ticinella primula* Luterbacher, *Thalmanninella* cf. *ticinensis subticinensis* (Gandolfi), *Thalmanninella ticinensis ticinensis* (Gandolfi) - Age: younger part of Middle Albian - older part of the Late Albian.

B-13 (825 m a.s.l.): Greyish-green limestones with black spots and shaly marlstones/claystones (Fig. 4c). Well exposed beds of massive shaly limestone (30-80 cm) with black bioturbation marks. At the base is a laminated dark-grey calcareous sandstone of thickness 13 cm, roughly 3 distinct layers 30 to 50 cm at a section of 4 m. Dip v = 320/30-320/15°. In thin section from the lower part are cross sections of tests: *Planomalina (Planomalina) buxtorfi* (Gandolfi) (Pl. II., Fig. 4), *Hedbergella delrioensis* (Carsey), *Whiteinella gandolfii* Gašpariková et Salaj (Pl. II., Fig. 3), *Thalmanninella appenninica appenninica* (Renz), *Thalmanninella* cf. *brotzeni* (Sigal). Age: latest Albian - earliest Cenomanian.

B-15 (815 a.s.l.): Prevalence of shaly marlstones to green limestones with dark spots with sandy admixture,

banks of 30-100 cm. Interlayered are distinctly cleeved layers up to thickness of 1,5 m. Dip v = 310/18. The nannoplankton (preparation No 96/94) contains the species:

Braarudosphaera cf. *batilliformis* Troelson & Quadros, *Cyclagelosphaera deflandrei* (Manivit), *Cyclagelosphaera margerelii* Noel, *Ellipsagelosphaera* sp., *Manivitella pemmatoidea* (Deflandre), *Watznaueria barnesae* (Black). It is a very poor sample with species of wide range. *B. batilliformis* indicates the age Middle Aptian - Early Cenomanian.

B-14 (820 m a.s.l.): Dark-grey spotted limestone to marlstone. There are several distinct boudined zones up to 2-10 cm (b = 15/10°, axes of minute folds o = 280/30°, extensional joints and extensional veinlets filled up with calcite reach 7-30 cm long, 1 cm width, with dip ž = 60/55° and 30/35°), v = 310/20. This part of the profile appears higher if compared to B-13. In thin section are cross sections of:

Hedbergella delrioensis (Carsey), *Ticinella* sp., *Thalmanninella* sp., *Thalmanninella appenninica appenninica* (Renz) (Pl. II., Fig. 5) - Age: Albian.

B-12: Shales, sandy limestones. Between B-12 and B-13 limestones are more massive and beds attain thickness from 50 cm to 2 m, v = 305/10.

B-11: (± 832 m a.s.l.): Shales, overlain by sandy limestone. Shales dominate, thickness of beds around 0,5 m, v = 310/20°. Joints and faults of dip z = 180/85-44°, with listric bending to 100/05°.

B-11B: (830 m a.s.l.): The same as B-11, v = 290/55, grey sandy shaly marlstones. In the lower part is a bed of fine-grained sandstone. From heavy minerals in thin section we found zircon, pyrite is present. In marlstones we determined cross-sections of foraminifers:

Nodosaria sp., *Hedbergella* sp., *Whiteinella* sp., *Praeglobotruncana stephani* (Gandolfi), *Clavihedbergella simplex* (Morrow), *Thalmanninella* cf. *brotzeni* (Sigal), *Thalmanninella brotzeni* (Sigal) - Age: basal part of the Early Cenomanian.

From the same piece we obtained the nannoplankton association, (preparation No. 130/94):

Braarudosphaera bigelowii (Gran & Braarud), *Cyclagelosphaera deflanderi* (Manivit), *Eifelithus turriseiffelii* (Deflandre), *Watznaueria barnesae* (Black) – abundant is *W. barnesae*, other species sporadically only. It is similar to other samples from Balcová. Age: Late Albian.

B-10: (840 m a.s.l.): Black-spotted layers of limestones and marlstones, 10-40 cm thick, wedging out lenticularly, more or less compact, in places shaly. Calcite veinlets follow schistosity planes in more argillaceous beds. Alternation with 10-15 cm thick beds of shales with fine silty - muscovite admixture. Total thickness of the sequence is 8 m, bedding v = 320/05 - 315/20°. In thin section from overlying limestones we found:

Planomalina sp., *Hedbergella* sp., *Praeglobotruncana* sp., *Thalmanninella* cf. *brotzeni* (Sigal). Age: basal part of the Early Cenomanian.

B-9: In places beds of highly cleaved and folded limestones and/or calcareous shales are jutting out. The thin section from limestones contains the association of foraminifers:

Hedbergella sp., *Praeglobotruncana* sp., *Praeglobotruncana delrioensis* (Plummer), *Thalmanninella deeckei* (Franke). Age: younger part of the Early Cenomanian.

B-7, B-8: Dark-grey shales (sample B-8), cleaved marlstones to shales of light-grey colour (sample B-8/A). On bedding planes are Fe-coatings. The limestones are pale-grey, more-less compact (Fig. 4b). V = 320/10° (above the small saddle before the curve v = 80/30°). At the curve (B-7): shaly claystones in prevalence over marlstones and limestones, v = 80/30°, lot of calcite. Individual components are schlieren-like ordered, in thin sections lamination is visible. In thin sections are present: *Hedbergella* sp., *Praglobotruncana* sp. and *Thalmanninella* sp. - Age: Cenomanian.

B-6: Alternation of shales and limestones and/or marlstones. Washing from grey shales (146/94) contains Cenomanian foraminifers:

Ammodiscus cretaceous (D'Orbigny), *Lenticulina* sp., *Thalmanninella appenninica balernaensis* Gandolfi (Pl. III., Figs. 1 and 2.).

In thin section are: *Dorothia* aff. *oxycona* (Reuss), *Hedbergella* sp., *Praeglobotruncana delrioensis* (Plummer), *Thalmanninella appenninica* (Renz), *Thalmanninella* ex gr. *deeckei* (Franke) - Age: Cenomanian.

B-5: Covered section, in places cleaved limestones and grey shales are jutting out (in alternation). From the substratum of the shales is the sample of dark-grey limestone for thin section, in which we determined:

Hedbergella sp., *Hedbergella planispira* (Tappan), *Whiteinella* sp., *Praeglobotruncana* sp., *Thalmanninella* sp. Age: Cenomanian.

Higher part of the profile

B-4: Alternation of beds of dark-grey cleaved limestones, marlstones with thin beds of grey (sample B-4) and greyish-brownish shales (Fig. 4a). Fine calcite veinlets and polished surfaces are common. The rocks are more compact than in B-3, v = 270/12°. The thin section contains cross sections of planktonic foraminifers:

Hedbergella sp., *Whiteinella* sp., *Sigalitruncana sigali* (Reichel) (Pl. II., Fig. 9), *Dicarinella* sp. Age: Middle Turonian.

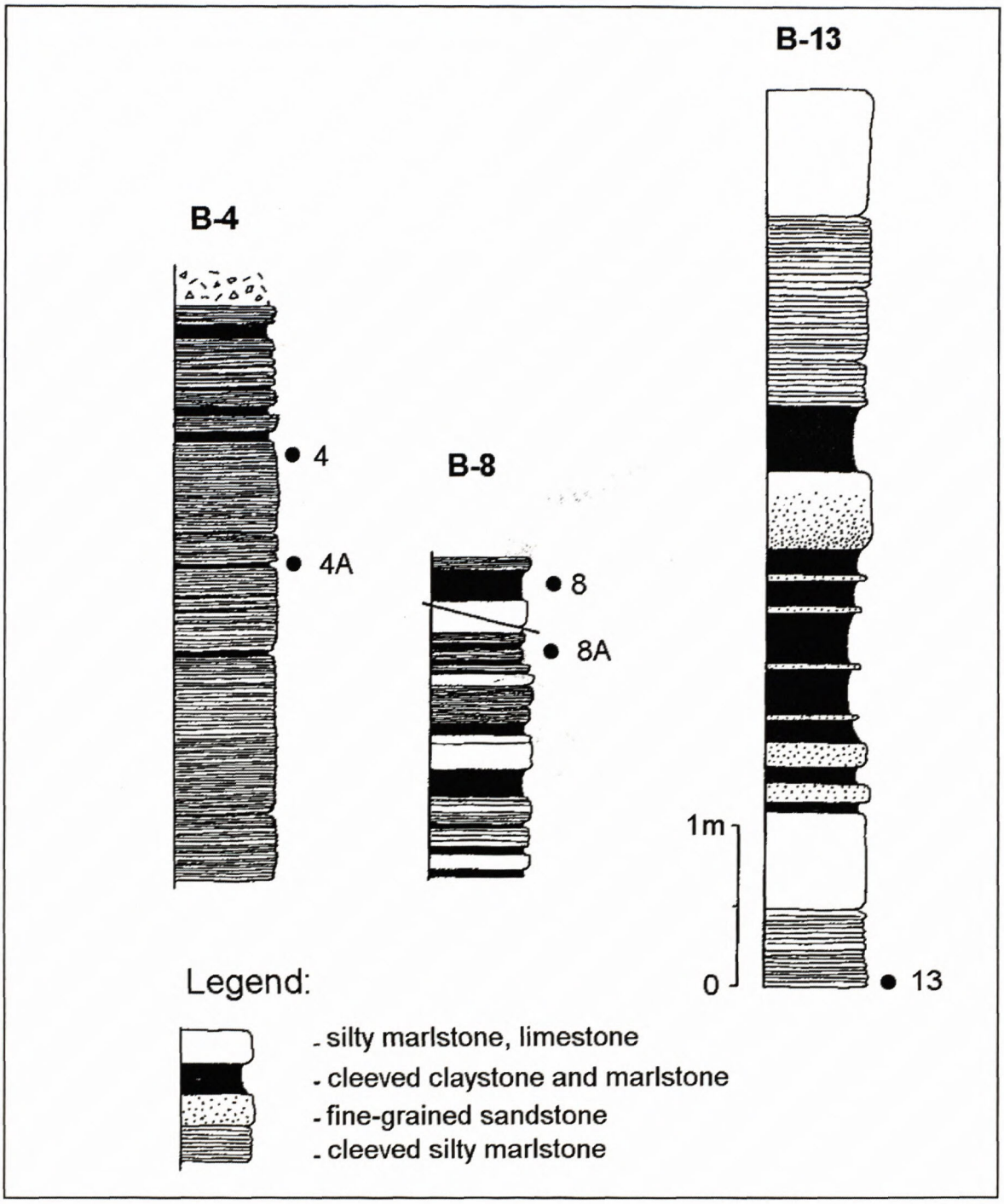

Fig. 4. Lithological profiles of the Poruba formation

In thin section B-4/A from brownish shale with leafy disintegration are found:

Tritaxia sp., *Dorothia* sp., *Nodosaria* sp., *Anomalina* sp., *Hedbergella* sp., *Whiteinella* sp., *Praeglobotruncana* sp., (Pl. I., Fig. 1), *Helvetoglobotruncana helvetica* (Bolli) (Pl. I., Fig. 2), *Dicarinella oraviensis* (Scheibnerová) - Age: Middle Turonian.

B-3: Marlstones in beds of lenticular course, bedding v = 285/18°. The sample for thin section is from grey-greyish-green shaly claystone to dark-grey limestone. We determined here:

Hedbergella sp., *Whiteinella* sp. (Pl: II., Fig. 6), *Praeglobotruncana* sp., *Helvetoglobotruncana helvetica* (Bolli) (Pl. I., Fig. 3), *Dicarinella hagni* (Scheibnerová) (Pl. II., Fig. 8). Age: Middle Turonian.

B-IV/B-1: Marlstones and silty limestones, thin intercalations of fine-grained sandstones, v = 305/10 - 310/12. In thin section are cross sections of *Praeglobo-*

truncana sp., *Sigalitruncana sigali* (Reichel), *Dicarinella* sp. Age: Middle Turonian.

B-I (at the marked tree): Greyish-green, cleaved silty ?marlstones and limestones with dark spots, beds of greyish-green shales (3-10 cm), fine - grained carbonate sandstones. The rocks are dragged out in lenticular form, polished surfaces and calcite veinlets at S-1 planes, bedding v = 330/20°. In sample B-I_3 (2 thin sections) from the uppermost marly horizon – from brownish sandy shaly marlstones around allochems and/or recrystallized parts of rock are „hems", from which some resemble cross-sections of planktonic foraminifers.

Nannoplankton in repeated preparation from grey sandy shaly marls with dark spots:

Braarudosphaera cf. *africana* Stradner, ?*Conusphaera* sp., *Manivitella pemmatoidea* (Deflandre), *Nannoconus* sp., ?*Prediscospahera* sp., *Rucinolithus wisei* Thierstein and coprolites.

On the basis of the presence of *B. africana* we interprete the age of the association as Aptian - Albian.

B-II (870 m a.s.l.): Cleaved greenish-grey, dark-spotted calcareous claystones with muscovite and silty admixture (30-50 cm), laminae of blackish-grey claystones, layers of fine-grained carbonate sandstones, green limestones with fucoids, bedding v = 340/40°. Next 5 m as B-I, mostly scree-covered. The sample is from grey and/or brownish-greyish-green shales.

In thin sections from reddish-brown shaly marlstones (sample B-IIb) planktonic and benthonic foraminifers were established. An association of foraminifers was identified, represented by planktonic forms *Sigalitruncana sigali* (Reichel) (Pl. I., Fig. 5), *Dicarinella* sp. and *Dicarinella hagni* (Scheibnerová) (Pl. I., Fig. 6) which indicate the Middle Turonian.

The washing from the sample contains the association of foraminifers:

Ammodiscus cretaceous (D'Orbigny), *Trochammina* sp., Anomalina (*Gavelinella*) sp., *Sigalitruncana sigali* (Reichel) (Pl. III., Fig. 3), *Dicarinella biconvexa* (Samuel et Salaj) (Pl. III., Figs 10 and 11), *Dicarinella* sp., (Pl. III., Fig. 13), Dicarinella aff. *hagni* (Scheibnerová) (Pl. III., Fig. 5), *Dicarinella hagni* (Scheibnerová), (Pl. III., Fig. 9), *Dicarinella imbricata* (Mornod), *Dicarinella oraviensis* (Scheibnerová) (Pl. III., Figs 6, 7 and 12) - Age: Middle Turonian.

Nannoplankton (118/94) B-II from light-grey silty marly shales:

?*Cyclagelosphaera* sp., *Cyclagelosphaera margerelii* Noel, *Ellipsagelosphaera fossacincta* Black, *Manivitella pemmatoidea* (Deflandre), *Prediscosphaera* sp. - spines, *Prediscosphaera* aff. *cretacea* (Arkhangelsky) s.l., *Stradneria crenulata* (Bramlette & Martini).

This is a relatively poor, little diversified assemblage. Its age is at least Albian. We understand *P.* ex gr. *cretacea* here in widest conception of the group of elliptical Prediscospheras.

B-III/D: About 10 m NE of B-II, 1,5 m below of greyish-green shaly marlstones is a sandstone body 4 m thick, a complex of 8 beds of fine-grained to medium-grained sandstones (5-100 cm). Bedding v = 300/30 - 360/15°. The sandstone body is limited primarily (sedimentary), but from the eastern side also by faults (z = 65/30° and 247/42°). The axis of small boudined SW-vergent fold o = 320/25°.

B-III/C: About 10 m to NE, cleaved greenish-grey argillaceous limestones with laminae of calcareous siltstones up to 5 mm, beds are discontinuous, lenticular, v = 300/30 - 360/15° (Pl. V., Fig. 2).

B-III/B: In the middle part are lenticular laminae of fine-grained sandstones and a bed (13 cm) of fine-grained carbonate sandstone. According to the texture of silt laminae and bedding the rocks they are in normal position. In places the formation is penetrated by a dense network of calcite veinlets and softly boudined (axe of boudines = 230/10° - SW vergency, bedding v = 350/12 - 330/08°.

B-III/A: (865 m a.s.l., at length of about 15 m): Cleaved greenish-grey marls and claystones, fine-sandy admixture with scattered muscovite. Beds up to about 10-50 cm. Intercalations (1-5 cm) of fine-grained carbonate sandstones with pieces of carbonised plant chaff. Structure of the Bouma sequence T(a)c. Sand to shale ratio P < 0,1, bedding index I = ± 5. Dip of the body is to NNW, at angle of 10-45°.

Remarks to foraminifer microfauna and petrography

For microscopic study we took from the Poruba Formation samples of greyish-brown, greyish-green marlstones to limestones and calcareous shales with dark-grey to black spots. From the point of view of texture they belong to biomicrites to biomicrosparites (Folk 1962). According to Dunham's classification they are biogenic wackestones, sporadically packstones. The samples are more or less recrystallized, with variable, in places considerably high content of clayey admixture. Most samples contain a foraminifer microfacies, less radiolarian, foraminifer - radiolarian and/or calcispherule - foraminifer microfacies is found. Of dominant position among biogens are cross sections of recrystallized tests of planktonic foraminifers (see Plts. I. and II.). In some samples a part of the specimen is diagenetically affected by stress. In the sequence (from bottom to top) gradually appear forms of the genera *Hedbergella, Ticinella, Thalmanninella, Whiteinella, Praeglobotruncana, Dicarinella, Helvetoglobotruncana* and *Sigalitruncana* (Fig. 5).

In thin section material of Bujnovský and Gašparikova (1990), which was available to us, we confirmed

the presence of the genus *Rotalipora*. In our samples we were not successful to find this genus. Benthonic forms are found rarely only. The amount of foraminifers in the individual samples is variable. In association with foraminifers are usually rare *Globochaete alpina* LOMBARD, sporadically fragments of thick-walled bivalves, very scarcely „filaments" and Ostracode valves. In samples B-19 and B-18a large amount of radiolarians of *Spumellaria* type are filled up with sparry calcite. Sponge spicules mostly of monaxonic type are in sample B-19. Abundant recrystallized circular cross sections belonging to *Calcisphaerula innominata* Bonnet, are found in samples B-6 and B-5. It is not excluded that some of them can belong to radiolarians of the group *Spumellaria*, mainly in sample B-5. In association of calcispherules *Pithonella ovalis* (Kaufmann) appears (mainly in sample B-6).

Planktonic and benthonic foraminifers are also in thin sections of samples B-IIb from reddish-brown shaly marlstones. The association consists of *Sigalitruncana sigali* (Reichel) (Pl. I., Fig. 5), *Dicarinella* sp. (Pl. I., Fig. 4) and *Dicarinella hagni* (Scheibnerová) (Pl. I., Fig. 6) and indicates the Middle Turonian age.

Only several few horizons are suitable to the study of foraminifers, because of strong recrystallisation. In washings pyrite and/or limonite cores of foraminifers are -except scarce cases- undeterminable (Pl. III., Figs. 1 and 8). Free separated forms were compared with cross sections of tests from thin sections, which mostly provided a better preserved microfauna.

The mineral admixture in marlstones is represented by clastic quartz of aleuritic, scarcely sandy fraction. Its content varies usually around 1%. Hydromicas, sericite and/or muscovite in some places emphasise the oriented structure of sediments and in samples B-17 and B-7 indications of lamination are observable.

Discusion

Establishing of such a wide age range as the Aptian - Middle Turonian for a formation deposited by currents seems to be suspicious. Thus we examined the preceding determinations of foraminifers and nannoplankton at the profile and state the following: The Aptian associations of Bujnovský and Gašpariková (1990) are determined correctly, however, are not original, but probably redeposited, or they are not collected from the Poruba Formation. We cannot confirm this assumption unambiguously, because precise localisation of samples is missing. The Early Cenomanian association mentioned under No. 35 and 36 by Gašpariková (in Bujnovský et al. 1988) with *Thalmanninella* ex gr. *brotzeni* (Early to Middle Cenomanian) may be accepted even when determination of the species is only „ex gr." – even if there could be some similar species, the occurrence of this does not exceed the range of the mentioned one. We have, however, serious remarks to composition of nannoplankton association from doc. point 37 as to its interpretation: *Cribrosphaera (=Cribrosphaerella) ehrenbergi* Arkhangelsky, *Prediscosphaera cretacea* (Black), *Podorhabdus albianus* Black and *Eifelithus turriseiffelii* (Deflandre) are concerned. *C. ehrenbergi* is a species already found in the Late Albian. The first occurrence of *P. albianus* was already recorded also from the Barremian! Thus these two species do not satisfactorily prove the Cenomanian age of the association. The question of the presence of *P. cretacea* is a somewhat different – according to Perch-Nielsen (in Bolli et al. 1985) this species is ranging in the Senonian (Campanian - Maastrichtian). This, however raises the question of correctness of its determination and/or purity of the sample. In case there is no contamination (and if we do not want to admit directly the Cenomanian age of the Poruba Formation), we could consider the determination of *P. cretacea* as erroneous. Probably it could have been mistaked with *P. intercisa* (DEFLANDRE), however, this would imply dating at least to the Late Cenomanian. It is, however, a certain possibility that some of the circular forms *Prediscosphaera* ex gr. *columnata - avitus - cantabrigensis* was concerned, which were found already in the Albian to Early Cenomanian. We, however, have no available documentation material to rewiew, by which we should take the final conclusion. The occurrence of „zonal species" *E. turriseiffelii* has not been recorded in the association (Bujnovský et al., 1988), but is mentioned (Bujnovský - Gašpariková 1990) by a formulation, which arises suspicion of an error in retyping of the original text. If, however, also this species was present in the sample, its occurrence is already in the Late Albian, what means that the association could still belong to the Late Albian.

The lower boundary of the Poruba Formation at the profile „Balcová" is disputable. According to Bujnovský and Gašpariková (1990) the formation starts in the Early Aptian. The foraminifers *Hedbergella infracretacea* (Glaessner), *Anomalina (Gavelinella) sigmoicosta barremiana* (Bettenstaedt) and nannoplankton *Chiastozygus litterarius* (Gorka) established by Boorová (1992), prove the presence of the Osobitá Formation at the profile „Balcová", dated to the Aptian. In the overlying part is still the sequence of limestones with cherty horizons, which, with regard to their lithology, cannot be ranged to the Poruba Formation. This complex is older than the Early Albian. According to description and localisation this part of the formation corresponds to our documentation points **B-18 - B-20**. For them equally an age older than the Early Albian is established. This part of the profile probably still may also be ranged to the Osobitá

Formation.* Therefore the lower boundary of the Poruba Formation at Balcová cannot be older than the Early Albian.

Gašpariková (Bujnovský - Gašpariková, 1990) established the upper age boundary of the Poruba Formation at the profile „Balcová" as Middle Cenomanian, defined by the presence of planktonic foraminifers from the *Rotalipora cushmani montsalvensis* Zone. This sample obviously could have not been collected from the uppermost part of the formation.

Bujnovský - Polák (1985) mentioned that the youngest Mesozoic Tatricum sequence of the Veľká Fatra Mts. are sandstones, sandy limestones and claystones with foraminifers proving stratigraphic range as Albian - Early Turonian: *Hedbergella roberti* (Gandolfi), *Haplophragmoides nonioninoides* (Reuss) and *Rotalipora* ex gr. *cushmani* (Morrow). This we cannot consider as sufficient evidence. According to present-day state of knowledge, *R. cushmani*, on the basis of which the upper age boundary of the Tatricum sequence was established, does not exceed the Cenomanian boundary (Robaszynski - Caron 1979, Caron 1985).

In our material (in washings as well as thin sections), in the upper horizons of the Poruba Formation, the presence of planktonic foraminifers from the *Helvetoglobotruncana helvetica* Zone (in the sense of Salaj 1986) was observed. So the upper boundary of the Šiprúň sequence in the Veľká Fatra Mts. at the locality Balcová can be shifted to the Middle Turonian.

The continuity of bed sequence to underlying formations (Osobitá Formation) is made doubtful at the profile. According to geological settings the Poruba Formation is folded to a slight anticlinal form, the NW limb dipping at angle 10-20° to north-west where it submerges under the Krížna nappe, whereas the SE limb is dipping to southeast, apparently beneath the older - underlying limestone complex (Fig. 3). Therefore it is not possible to confirm continuity of the Šiprúň sequence to the north of Balcová. For this reason it is also problematic to determine the lower boundary of the Poruba Formation at the profile. According to Jablonský (1992) the formation should be underlain by the Vlkolínec Breccia, the equivalent of which we have not found here. The earliest association determined by us (higher Middle Albian in sample **B-16**) also appears too young for the base of the formation, we could consider this part as the middle interval.

Continuity of the bed sequence of the Poruba Formation itself is more vindicable when also not proved directly. The setting and succession of onset of individual species - markers of foraminifer zones testifies in favour of minimum reductions and breaks of the bed sequence in the Poruba Formation.

In nannoplankton associations we have found out a sporadical occurrence of young (Campanian - Maastrichtian) species in several preparations. We consider them as contaminations during the process of sample preparation. This is indicated by the fact that these young species have not been found any more in the repeated preparations from the same sample. In determination of the age we were not taking into consideration contaminated samples. The method of age determination according to nannoplankton associations has not brought satisfying results, preservation of the associations is relatively poor, their reduction and selective diagenetic dissolution were quite possible (compare determinations of associations in the plates).

Conclusion

At the profile north of elevation point Balcová (978,5) in the Šiprúň sequence the Poruba Formation occurs as the uppermost lithostratigraphical unit. According to the lithological content there is an equivalent of the Homôlka Marlstones, only locally in the higher part of the profile also the Senkov flysch Member and Ludrová sandstone Member occur (Jablonský in Samuel et al. 1988). The established thickness of the Poruba Formation is here only a little more than 200 m. The study of planktonic foraminifers of the Poruba Formation at the profile Balcová has brought new knowledge concerning its age. The associations of nannoplankton were not sufficiently conclusive, however, are not in contradiction to the range on the basis of foraminifers.

Our determinations of planktonic foraminifers from the *Helvetoglobotruncana helvetica* Zone (sensu Salaj 1986) unambiguously prove the Middle Turonian age of the uppermost parts of the Poruba Formation.

Although we could not establish foraminifer associations in succession of individual biozones in continuity one after another, we suppose (taking into account the interval of sampling, considerable recrystallization, the results of Bujnovský and Gašpariková (1990)) a more or less continuous bed sequence of the Poruba Formation at the profile Balcová in the range Albian - Middle Turonian. Incidental absence of certain horizons in the bed sequence may be explained as a secondary phenomenon caused by tectonic and not sedimentary reduction.

The lower boundary of the Poruba Formation, after confrontation with the results of Boorová (1992) is Early Albian, that is younger than mentioned by Bujnovský et al. (1988, 1990).

At the profile „Balcová" the continuity of the Šiprúň bed sequence cannot be proved. This is tectonically interrupted between the Poruba and underlying formations.

* We refused the speculation that there could be the Párnica Formation, because this is formed by dark-spotted calcareous shales (marls) of the Late Barremian to Aptian (Andrusov et al. 1985).

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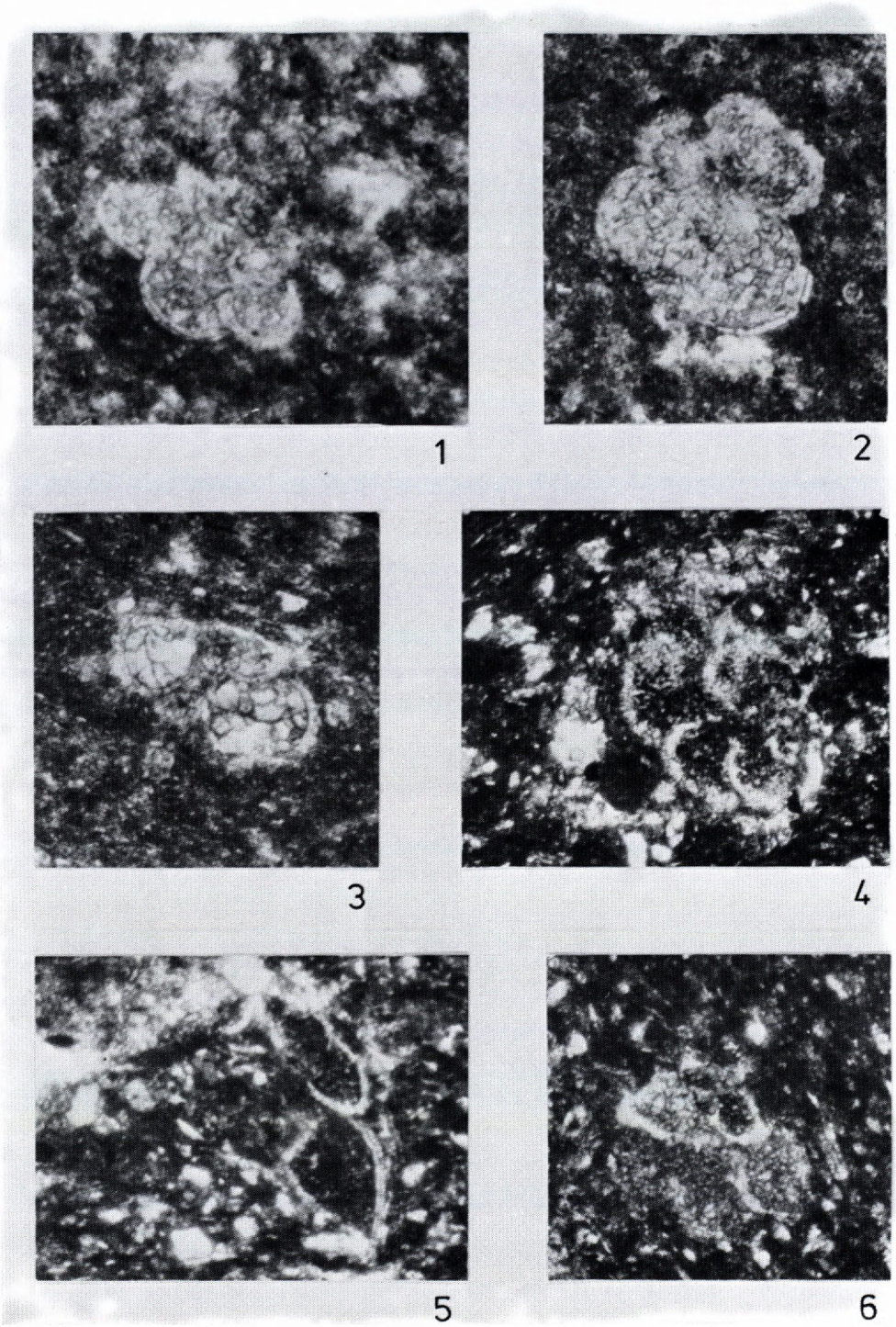
Plate I



Cross sections of recrystallized planktonic foraminifer. Poruba Formation:

Fig. 1: *Praeglobotruncana* sp.; Middle Turonian, sample B-4/A; magnif. 109x
Fig. 2: *Helvetoglobotruncana helvetica* (Bolli); Middle Turonian, s. B-4/A; magn. 103x
Fig. 3: *Helvetoglobotruncana helvetica* (Bolli); Middle Turonian, sample B-3; magnif. 109x
Fig. 4: *Dicarinella* sp.; Middle Turonian, sample B-II_b; magnif. 96x
Fig. 5: *Sigalitruncana sigali* (Reichel); Middle Turonian, sample B-II_b; magnif. 85x
Fig. 6: *Dicarinella hagni* (Schreibnerová); Middle Turonian, sample B-II_b; magnif. 98x

Plate II

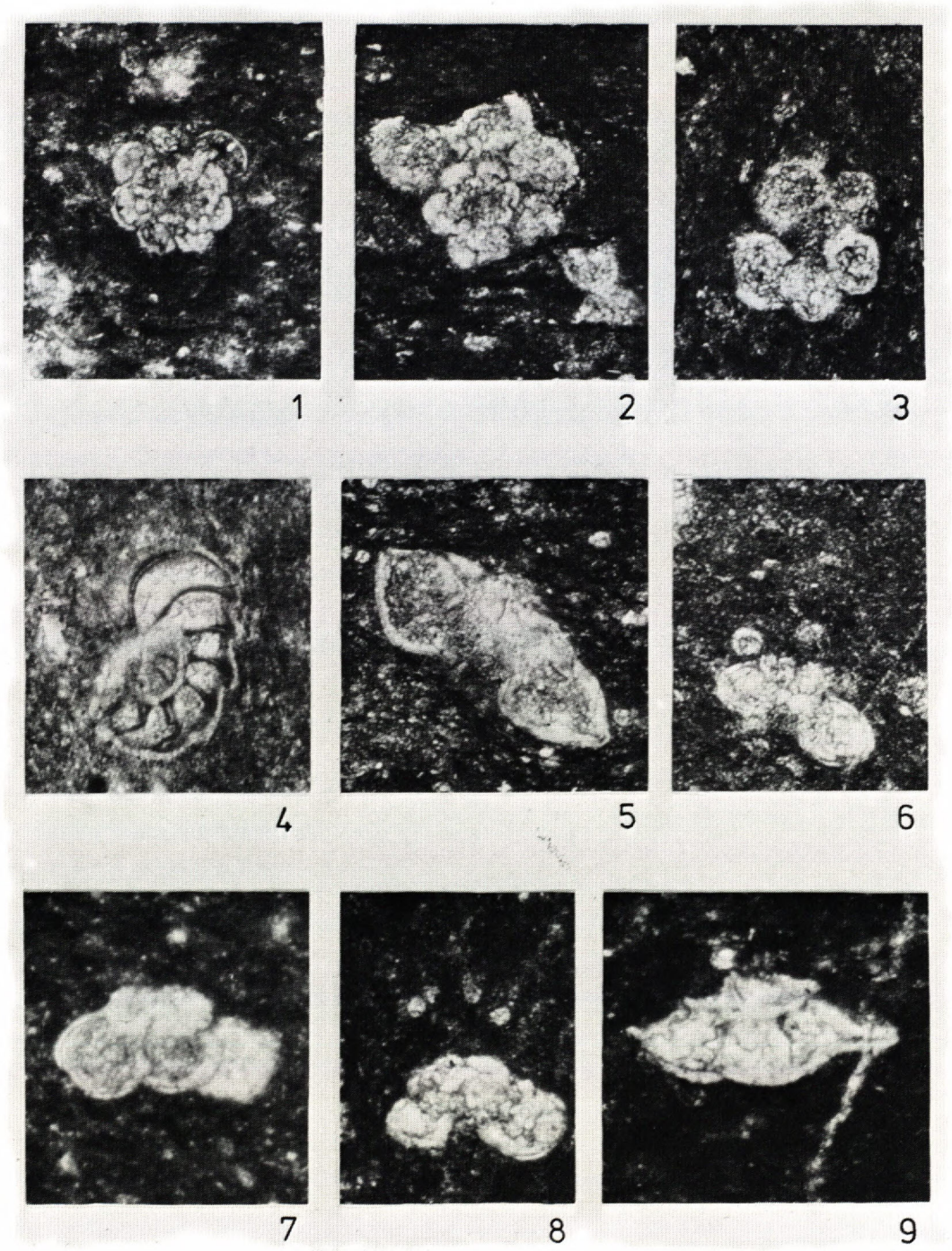


Plate II: Cross sections of recystallized planktonic foraminifers. Poruba Formation:
Fig. 1: *Ticinella* sp.; Early Albian, sample B-18; magnif. 100x
Fig. 2: *Ticinella primula* Luterbacher; younger part of Middle Albian - older part of Late Albian, sample B-16; magnif. 96x
Fig. 3: *Whiteinella gandolfii* Gašpariková et Salaj; Albian - oldest Cenomanian, sample B-13; magnif. 100x
Fig. 4: *Planomalina (Planomalina) buxtorfi* (Gandolfi); the youngest Albian - oldest Cenomanian, sample B-13; magnific. 70x
Fig. 5: *Thalmanninella appenninica appenninica* (RENZ); Albian, sample B-14; magnif. 95x
Fig. 6: *Whiteinella* sp.; Middle Turonian, sample B-3; magnif. 100x
Fig. 7: *Dicarinella hagni* (Scheibnerová); Middle Turonian, sample B-3; magnif. 95x
Fig. 8: *Dicarinella* ex gr. *oraviensis* (Scheibnerová); Middle Turonian, sample B-3; zväčšenie 103x
Fig. 9: *Sigalitruncana sigali* (Reichel); Middle Turonian, sample B-4; magnif. 95x

Plate III

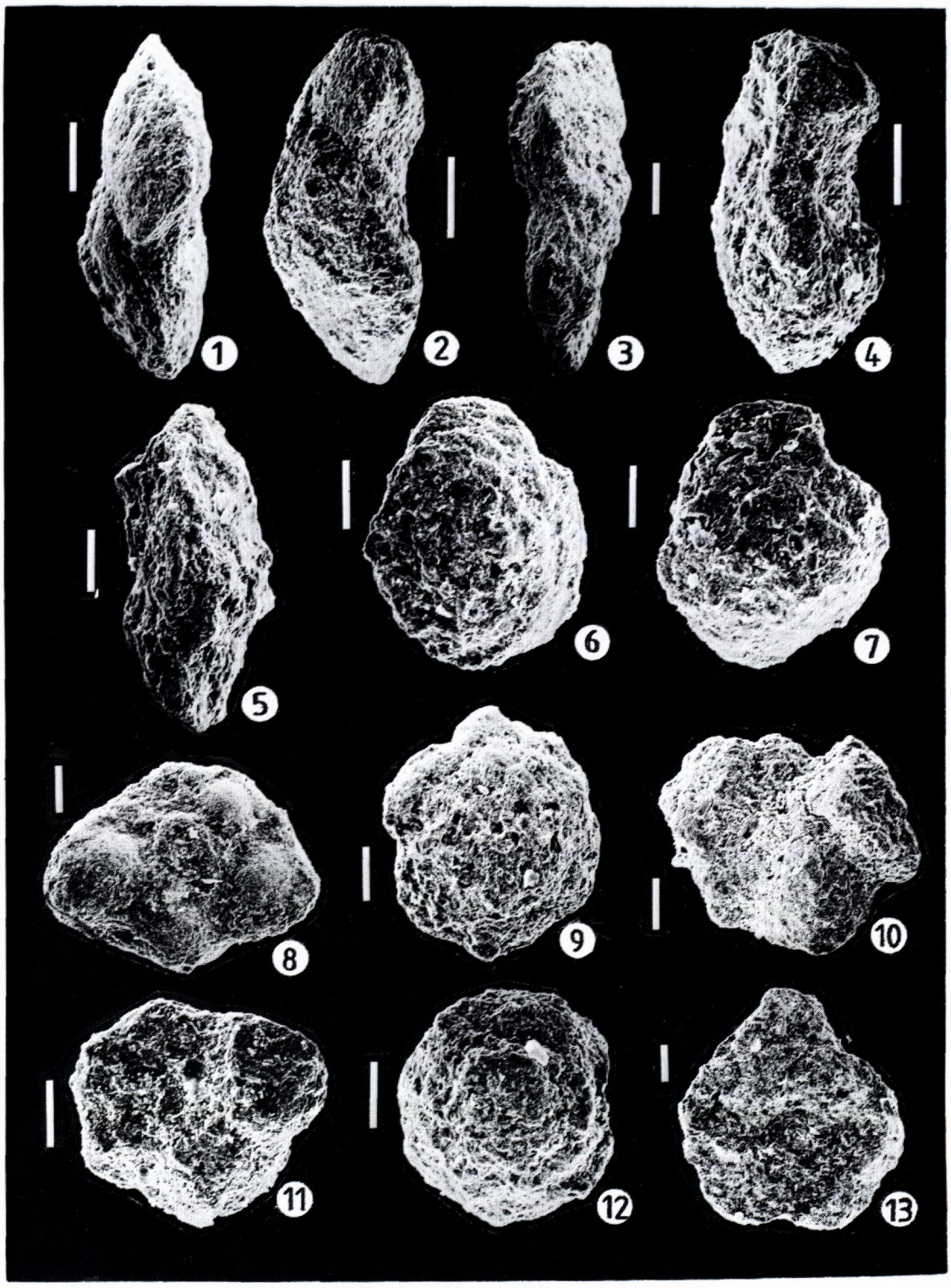


Plate III: Recystallised planktonic foraminifers. Poruba Formation.
Fig. 1, 2: *Thalmanninella appenninica balernaensis* Gandolfi; Cenomanian, Fig. 1. - limonite core. sample B-6; washing 149/94
Fig. 3: *Sigalitruncana sigali* (Reichel); Middle Turonian, sample B-II; washing 285/94
Fig. 4, 9: *Dicarinella hagni* (Scheibnerová); Middle Turonian, sample B-II; washing 285/94
Fig. 5: *Dicarinella* aff. *hagni* (Scheibnerová); Middle Turonian, sample B-II; washing 285/94
Fig. 6, 7, 12: *Dicarinella oraviensis* (Scheibnerová); Middle Turonian, sample B-II; washing 285/94
Fig. 8: *Hedbergella* sp. Limonitové jadro. sample B-2; washing 285/94
Fig. 10, 11: *Dicarinella biconvexa* (Samuel - Salaj); Middle Turonian, sample B-II; washing 285/94
Fig. 13: *Dicarinella* sp.; Middle Turonian, sample B-II; washing 285/94
bar scale = 100 m

Plate IV

1

2

Plate. IV

Fig. 1: Lenticular layers of sandstones, incised supply channel filled up with fine to coarse-grained sandstones. Docum. point B-IIID. View from the south.

Fig. 2: Thin-bedded fine-grained sandstones in greenishgrey silty marlstone. The sandstone beds are discontinuous. Marginal part of the supply channel. Docum. point (B-III/c).

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Plate V

Fig. 1: Shaly greyish-green marlstone. Distinct is alternation of more-less „mylonitized" rocks in 0,5-1,5 m intervals. Docum. point B-11b.

Fig. 2: Layered marlstone with indication of gradation (increasing clastic silt admixture to the top). In the upper part of the outccrop is distinct cleavage. Document. point 16.

Fig. 3: Limestone formation of the Early Albian. Between limestone beds are dark-grey to black shaly marlstones. Docum. point 19.

Plate V

1

2

3