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STRATIGRAPHY AND PALAEOGEOGRAPHIC POSITION OF THE JURASSIC CZERTEZIK SUCCESSION, PIENINY KLIPPEN BELT (WESTERN CARPATHIANS) OF POLAND AND EASTERN SLOVAKIA

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Abstract: The Czertezik Succession has been closely re-examined in its most classical sections of the Pieniny Klippen Belt (Western Carpathians) in Poland and eastern Slovakia. The study revealed the presence of the "lower nodular limestones" (Niedzica Limestone Formation), and resulted in discovery of Early Bajocian ammonite fauna in grey crinoidal limestones of the Smolegowa Limestone Formation/Flaki Limestone Formation, and the latest Bajocian to Early Bathonian ammonite fauna in the Niedzica Limestone Formation. These new data proved closer similarity between the Czertezik Succession and the Niedzica Succession than between the Czertezik Succession and the Czorsztyn Succession as it was suggested up to now. On the other hand, the Czertezik Succession represents deeper palaeogeographical position within the Pieniny Klippen Basin than the Niedzica Succession and it has been deposited near the Branisko/Kysuca Succession.

Key words: Jurassic, Western Carpathians, Pieniny Klippen Belt, Czertezik Succession, stratigraphy, ammonites, palaeogeography.

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INTRODUCTION

The sedimentary basin of the Pieniny Klippen Belt included several facies zones, each characterized by specific sequence of rocks – especially well marked during Jurassic and Early Cretaceous. These zones have been recognized as the Klippen Successions (called earlier series), such as: the Czorsztyn Succession and the Niedzica/Pruské Succession – deposited on the southern slope of the northern ridge (Czorsztyn Ridge), the Branisko/Kysuca Succession, and the Pieniny Succession deposited in the central part of the basin, as well as still fragmentarily known successions deposited on a northern slope of the southern ridge (Andrusov Exotic Ridge) – the Nižna Succession, and the Haligovce Succession (see Andrusov, 1926, 1938; Birkenmajer, 1963, 1977, 1986, 1988, 2001; Scheibner, 1968; Mišík, 1997; Golonka *et al.*, 2003; and other papers cited therein).

The Czertezik Succession was originally established by Birkenmajer (1959). It was characterized by special development of the Middle-Upper Jurassic deposits. This included occurrence of thick white and/or grey crinoidal limestones, sometimes with cherts, corresponding to the Smolegowa Limestone Formation and/or Flaki Limestone Formation, but also development locally of red crinoidal limestones of the Krupianka Limestone Formation. Younger deposits were recognized as follows: the radiolarites attributed to the Czajakowa Radiolarite Formation (green-coloured corresponding to the Podmajerz Radiolarite Member below, and red-coloured of the Buwałd Radiolarite Member above), as well as the overlying red nodular limestones of the ammonitico-rosso type of the Czorsztyn Limestone Formation, and white micritic *Calpionella* limestones (Birkenmajer, 1959, 1976, 1977).

The most characteristic feature of the Czertezik Succession appeared to be the lack of "lower nodular limestones" of the Niedzica Limestone Formation (Birkenmajer, 1959,

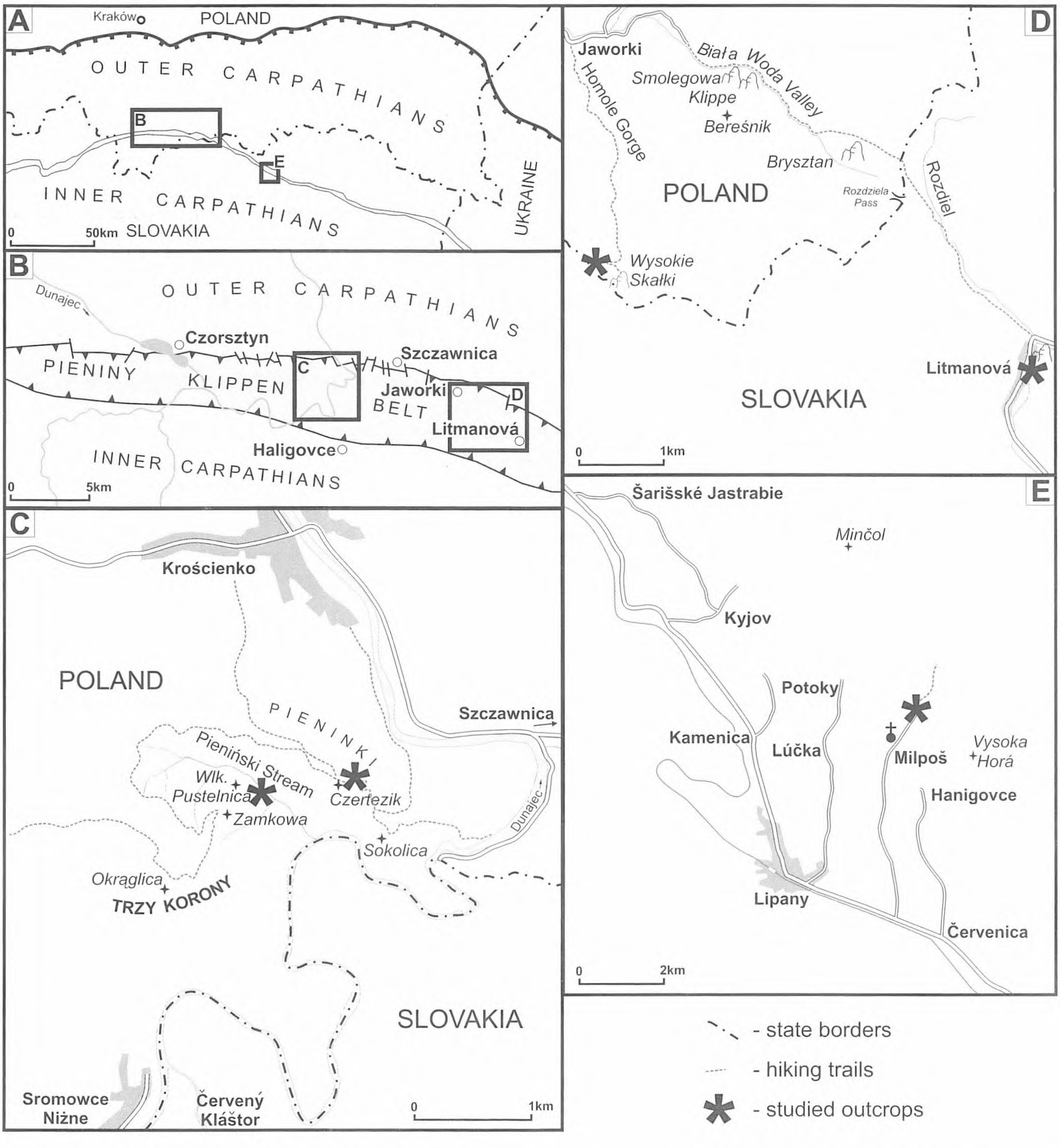

Fig. 1. A and B. Location of the Pieniny Klippen Belt (*in grey*) within the Carpathians. C–E. Location of the studied sections in central and eastern parts of the Pieniny Klippen Belt in Poland (C and D) and in eastern Slovakia (D and E)

1976, 1977). These deposits have been well known in the Niedzica Succession where they occurred directly above crinoidal limestones, and yielded abundant ammonites of the latest Bajocian to Late Callovian/Early Oxfordian age (Birkenmajer & Znosko, 1955; Wierzbowski *et al.*, 1999). On the other hand, the age of radiolarites of the Czertezik Succession, interpreted as directly overlying crinoidal limestones, were regarded as Oxfordian by Birkenmajer (1958, 1977). In consequence, the crinoidal limestones of the Czertezik Succession were classified as representing a very long time-interval from Bajocian till the end of Callovian (Birkenmajer, 1959, 1977), markedly longer than the time of deposition of crinoidal limestones in the other klippen successions (see Wierzbowski *et al.*, 1999).

The palaeogeographical position of the Czertezik Succession in the Pieniny Klippen Basin was always somewhat disputable. Its close relation to the Czorsztyn Succession and the Niedzica – Branisko (Kysuca) successions was already indicated by Birkenmajer (1959). A special mixture of features recognized in deposits attributed to the Czertezik

Succession was treated as typical of a shallower water Czorsztyn Succession (thick crinoidal limestones showing wide stratigraphical range), but also – of a deeper water Niedzica and Branisko successions (well developed radiolarites). This resulted in interpretation of the Czertezik Succession as originated in a fairly deep water, and deposited on the southern slope of the Czorsztyn Ridge between more elevated areas where the Czorsztyn Succession, and the Niedzica Succession were formed (Birkenmajer, 1959, 1977, fig. 5). Somewhat different interpretation gave Aubrecht & Ožvoldová (1994, fig. 3) who suggested facies changes in the basin related to the existence of tectonic escarpment: this brought both the Czorsztyn and the Czertezik successions in direct lateral contact with the Pruské (Niedzica) Succession. Still other interpretation was given by Książkiewicz (1972, pp. 90–92) who interpreted the original position of the Czertezik Succession in the Pieniny Klippen Basin as lying south of that of the Niedzica Succession, and in close proximity of the Branisko Succession. Similar interpretation was given by Golonka & Rączkowski (1984) on the occasion of geological mapping of the eastern part of the Pieniny Klippen Belt in Poland.

New data were gathered by the present authors during field-studies in 2001 to 2003 in the most important sections of the Czertezik Succession in Poland – at Pieniński Stream and Czertezik Mt – treated as the most classical areas of occurrence of the Czertezik Succession (Birkenmajer, 1959), as well as at Wysokie Skałki area, and in Slovakia – at Litmanovské Klippen and at Milpoš village (Fig. 1). These studies resulted in discovery of "lower nodular limestones" (Niedzica Limestone Formation) occurring directly below radiolarites (Czajakowa Radiolarite Formation) in almost all the sections studied, as well as of ammonite faunas of Early Bajocian and latest Bajocian to Early Bathonian age unknown so far from the Czertezik Succession. All these new data make possible a revision of stratigraphical log, and biostratigraphy of the Czertezik Succession, and in consequence the reconstruction of palaeogeographical position of the Czertezik Succession within the Pieniny Klippen Basin.

The ammonites collected are deposited in the Museum of Geology, University of Warsaw (collection number IG-PUW/A/28), and in Department of Geology and Paleontology of the Comenius University in Bratislava.

DESCRIPTION OF SECTIONS OF THE CZERTEZIK SUCCESSION

Pieniński Stream (Figs 1C, 2, 3/1)

The northern slopes of the Wielka Pustelnica Mt at the right side of the Pieniński Stream – a left tributary of Dunajec River, show well exposed deposits of the Czertezik Succession (Birkenmajer, 1977, text-fig. 7 and 21B; see also Birkenmajer, 1958, p. 19).

The oldest deposits crop out in western side of a narrow gorge, about 700 m from the Dunajec River. They consist of crinoidal limestones exposed in overturned position (70/60N) attaining at least (base not exposed) a thickness of 43.90 m (section A; Figs 1C, 2A–C, 3/1), or even about 55–60 m (according to Birkenmajer, 1959, 1977). Some number of smaller scale rock units can be recognized in the sequence on the basis of lithology supported by thin sections study.

Unit 1 (see Figs 2C/1, 3/1) includes beds 1–13 of total thickness 10.2 m (base not exposed). It consists of well bedded (from medium to thick-bedded – 0.25 m to 0.80 m in thicknesses of beds), mostly grey-coloured crinoidal limestones (except a single markedly red-coloured bed no. 5b). The beds differ in size of biogenic particles oscillating from fine-grained to coarse-grained. It may be difficult to recognize bedding planes in weathered rocks, as they show tendency towards splitting into several centimetres thick flags. In thin sections the deposits are crinoidal grainstones, locally with presence of unwashed micrite matrix. In red-coloured variety the grains are stained by dark opaque Fe-Mn oxides. Besides the dominating crinoid ossicles, detritus of bivalves and brachiopods is sometimes present; the siliciclastic sand portion is represented by quartz grains. Edges of crinoidal ossicles are sutured, and the ossicles are twinned, whereas the rock itself contains frequent microstylolites.

Unit 2 (see Figs 2C/2, 3/1) includes beds 14–17 of total thickness 9.10 m. It consists of very thick-bedded grey-coloured crinoidal limestones (bed 14 – 2.45 m, bed 15 – 1.10 m, bed 16 – 2.10 m, bed 17 – 3.45 m). The limestones are crinoidal-spiculitic grainstones, locally with presence of unwashed micrite matrix; the chalcedony cement is developed locally. Crinoid ossicles associated with monaxone spicules (often with chalcedony infillings), and rhaxa spicules are the most common. Rarely encountered are indeterminable foraminifers, and bivalve shell detritus.

Unit 3 (see Figs 2C/3, 3/1) includes beds 18–19 of total thickness 1.10 m (bed 18 – 1.0 m, bed 19 – 0.10 m). It consists of medium-bedded reddish crinoidal limestones. These are crinoidal grainstones with strongly sutured allochems. The grain surfaces, but locally also their interiors, are stained by dark opaque Fe-Mn oxides. Crinoid ossicles are the most common; they are associated with less commonly encountered bryozoans fragments, and foraminifers (*Textularia* sp.); the sandy admixture is strongly dominated by quartz grains with a marked admixture of dolomite clasts (attaining up to 2–3 mm in diameter); single grains of chlorite are also recognized.

Unit 4 (see Figs 2C/4, 3/1) includes beds 20–22 of total thickness 7.70 m. It consists of very thick-bedded grey-coloured crinoidal limestones (bed 20 – 1.55 m, bed 21 – 3.90 m, bed 22 – 2.25 m) with commonly occurring grey cherts from a few centimetres to about 40 cm in length. The rocks are: crinoid-rhaxa grainstone to packstone, and crinoidal packstone with a marked admixture of detrital quartz grains, locally even sandstone. Besides ubiquitous crinoid ossicles sometimes associated with spongy spicules (mostly rhaxa), some other biogenic components occur less commonly: foraminifers (*Lenticulina* sp., nodosarids and nubecularids), ostracodes, and bivalve shell detritus.

Unit 5 (see Figs 2C/5, 3/1) includes beds 23–27 of total thickness of 10.75 m. It consists of thick-bedded and very thick-bedded grey-coloured crinoidal limestones (bed 23 – 1.25 m, bed 24 – 1.10 m, bed 25 – 1.40 m, bed 26 – 5.60 m, bed 27 – 1.40 m). When weathered, the limestone beds split

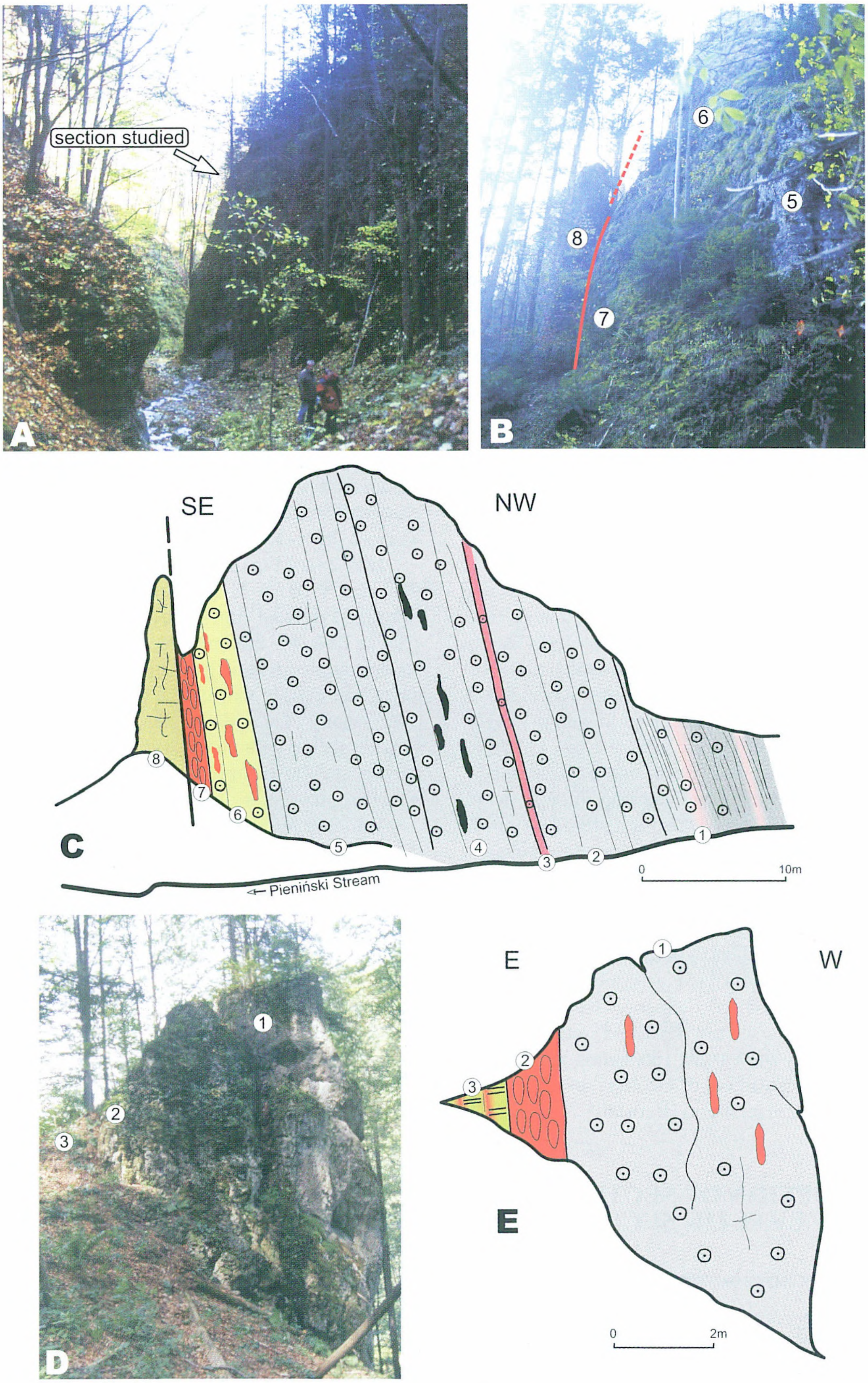

Fig. 2. Pieniński Stream: sections studied. A–C. General (A) and detailed (B) view of the section A and its geological cross-section sketch (C). Explanations: 1–6 – grey, reddish and greenish crinoidal limestones units sometime with cherts (in black) of the Smolegowa and Flaki Limestone formations (numbers of units according to these given in the text); 7 – ammonitico rosso-type nodular limestone of the Niedzica Limestone Formation; 8 – maiolica-type grey micritic limestones of the Pieniny Limestone Formation with sharp, tectonic contact with underlying beds. D–E. General view (D) and geological sketch (E) of the section B. Explanations: 1 – grey crinoidal limestones with cherts of the Flaki Limestone Formation; 2 – ammonitico rosso-type red nodular limestones of the Niedzica Limestone Formation; 3 – variegated, red and green coloured radiolarites of the Czajakowa Radiolarite Formation

into several centimetres thick flags similarly as in unit 1. In thin-sections the rock displays appearance of coarse crinoidal grainstone with strongly expressed pressure-solution condensed fabrics; some microstylolitic zones are filled with residual material – mostly quartz grains. Beside crinoid ossicles, bivalve and brachiopod shell debris is recognized.

Unit 6 (see Figs 2C/6, 3/1) includes beds 28–29 of total thickness 5.05 m. It consists of thick-bedded and very thick-bedded green-coloured crinoidal limestones (bed 28 – 3.55 m, bed 29 – 1.50 m) with commonly occurring green-coloured, and also red-coloured cherts (the latter in the topmost part of the unit). In thin sections the rock appears partly silicified crinoidal grainstone. Crinoid ossicles are the most common (often strongly sutured, and, when silicification is stronger, outlined with chalcedony rims, or even existing as "ghosts" within chalcedony), but some admixture of bivalve and brachiopod shell detritus, sometimes also foraminifers (*Lenticulina* sp., and *Tetrataxis* sp.) and fragments of bryozoans are also recognized. Common arenaceous admixture is dominated by quartz grains (with some minor clasts of micritic carbonates and sandstones with calcareous matrix), but sometimes (intercalations in bed 29) quartz grains occur so commonly that the rock becomes fine-grained sandstone to siltstone with calcareous cement and rare crinoid ossicles. Some better preserved brachiopods from bed 28 include *Septocrurella* cf. *defluxa* (Oppel).

The discussed crinoidal limestones show variable lithology (see Birkenmajer, 1977) – from crinoid grainstones corresponding to the Smolegowa Limestone Formation (rock-units 1, 3 and 5), to crinoid and crinoid-spiculite grainstones with cherts corresponding to the Flaki Limestone Formation (rock-units 2, 4 and 6).

The overlying deposits (see Figs 2C/7, 3/1) are red-cherry to green-cherry coloured highly calcareous ammonitico rosso-type nodular limestones which rest directly on the green-coloured crinoidal limestones with red cherts (bed 29) discussed above. The nodular limestones are well bedded (beds 30a–c, 31) attaining beds thicknesses from about 0.2 m to about 0.5 m. The recorded thickness of nodular limestones is up to 1.25 m, with tectonic upper boundary, marked by an oblique sharp contact with maiolica-type limestones (see Fig. 2C/8). In thin sections nodular limestones display features of packstones and wackestones with prevailing occurrence of filaments. The filament and filament-juvenile gastropod microfacies may be distinguished in the studied deposits. Moreover, some other skeletal remains occur less commonly – such as ostracodes, planktonic foraminifers (*Globuligerina* sp., but still far from mass occurrence), benthic foraminifers (*Lenticulina* sp., nodosarids), siliceous sponges, bivalve and brachiopod shell debris, crinoid ossicles, and echinoid spines. The lithology and stratigraphical position of the discussed nodular limestones in the sequence (see Birkenmajer, 1977; see also Wierzbowski *et al.*, 1999) make possible their attribution to the Niedzica Limestone Formation.

The outcrops of the Czertezik Succession continue north-west from Wielka Pustelnica Mt along the right side of the Pieniński Stream towards its right tributary – the Huliński Stream. Most complete section (section B; Figs 2D–E, 3/1) is exposed in a small klippe (coordinates: N 49° 25' 23'', E 20° 25' 19''), about 50 m above the valley floor. The lower part, a few meters in thickness, consists of massive crinoidal limestones with red cherts identical with topmost part of the crinoidal limestones (rock unit 6 in section A) from a gorge. The crinoidal limestones are overlain by red-coloured nodular limestones attaining 1.25 m in thickness. These are wackestones to packstones rich in filaments (locally very densely packed) with some fragments of crinoid ossicles, and in a places more rich in *Globochaete*; the nodular limestones may be attributed to the Niedzica Limestone Formation (cf. Wierzbowski *et al.*, 1999). Younger are radiolarites of the Czajakowa Radiolarite Formation (Birkenmajer, 1977). The lowermost part of this unit consists of variegated red and green coloured calcareous radiolarian chert bed resting directly on the nodular limestones in the north-western part of the klippe; it is covered by green-coloured and upwards also red-coloured calcareous radiolarian cherts alternating with marly shales, about 1.5 m thick, exposed in south-eastern part of the klippe: they contact along fault plane, steeply inclined toward south (100/80S), with crinoidal limestones and nodular limestones described above from northern part of the klippe.

Czertezik (Figs 1C, 3/1)

Highly deformed deposits of the Czertezik Succession crop out at the tourist trail on the south-eastern slope of the Czertezik mountain (Birkenmajer, 1958, p. 19, fig. 102; Birkenmajer, 1977, fig. 21A). The section studied (Figs 1C, 3/1) shows a few meters of nodular limestones occurring between crinoidal limestones from north-west, and the maiolica-type limestones from south-east. The beds are steeply inclined and placed in overturned position (Birkenmajer, 1958, fig. 102).

The oldest beds consist of grey and red-coloured crinoidal limestones (referred to Smolegowa Limestone Formation, and Krupianka Limestone Formation, respectively; see Birkenmajer, 1977), and grey-coloured crinoidal limestones with cherts corresponding to the Flaki Limestone Formation. Although the detailed sequence is difficult to establish, it could consists of alternation of particular types of crinoidal limestones similarly as in the Pieniński Stream section.

Youngest studied rocks are nodular limestones, which are strongly tectonically reduced; moreover, absence of radiolarites in the sections studied is also of tectonic character (Birkenmajer, 1958, p. 19). The lowermost part of the nodular limestones, about 1 meter thick, directly overlying the crinoidal limestones, consists of packstones rich in filaments and radiolarians with sparsely placed crinoid ossicles. These deposits rich in filaments correspond to the Niedzica Limestone Formation (cf. Wierzbowski *et al.*, 1999). The bulk of nodular limestones, about 3 metres thick consists, however, of wackestones and packestones rich in *Saccocoma* debris, and less commonly occurring radiolarians, and shell fragments; these limestones rich in *Saccocoma* correspond to the Czorsztyn Limestone Formation (cf. Wierzbowski *et al.*, 1999). Such interpretation of the two parts of the nodular limestones in the Czertezik section obviously indicates that there is a tectonic contact between them, along which the radiolarites have been tectonically removed.

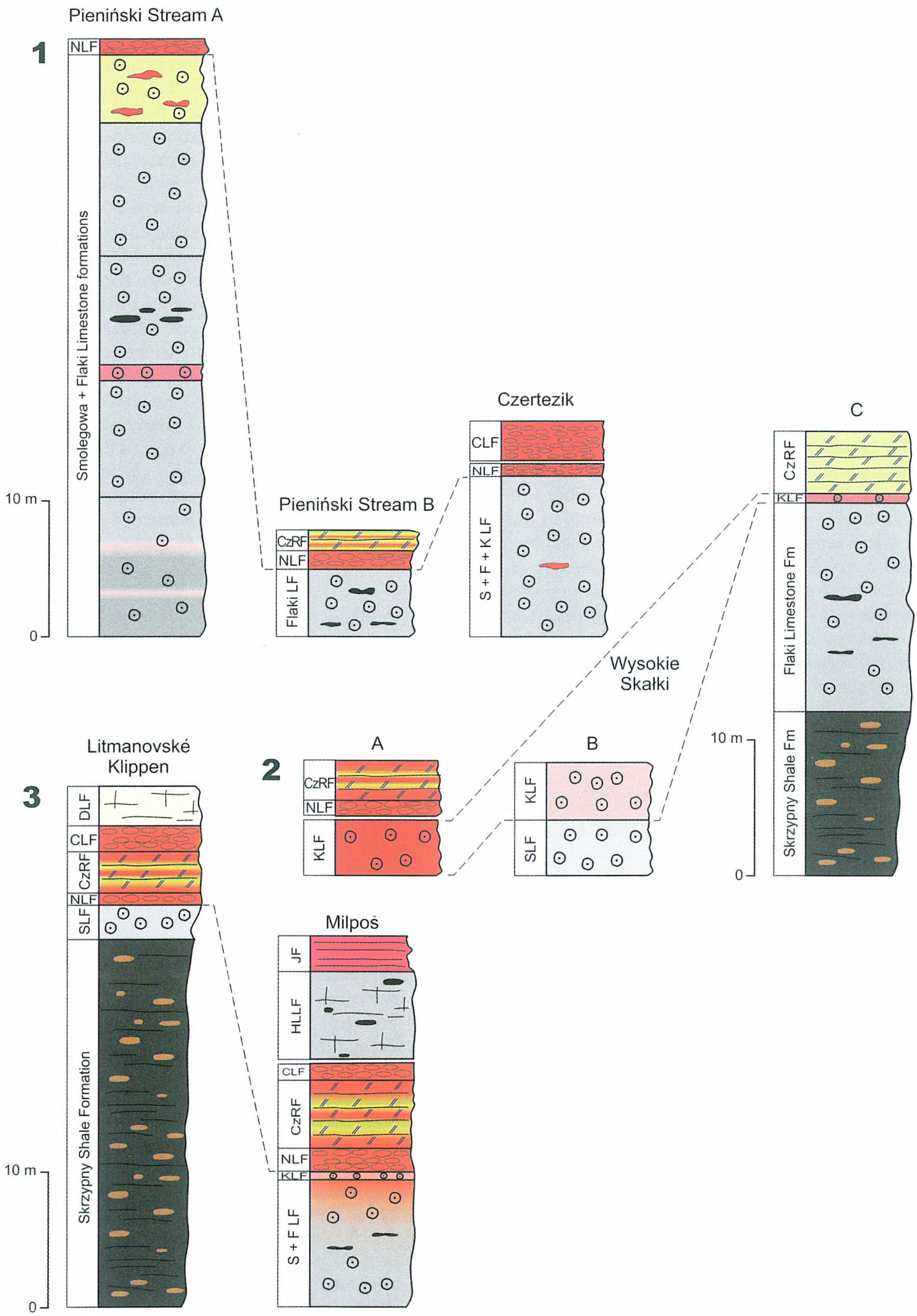

Fig. 3. Lithostratigraphical columns of the sections studied. Abbreviations: S (=SLF) + F(=FLF) – Smolegowa and Flaki Limestone formations (white and grey crinoidal limestones); KLF – Krupianka Limestone Formation (red crinoidal limestones); NLF – Niedzica Limestone Formation (red nodular limestones); CzRF – Czajakowa Radiolarite Formation (red and green radiolarites); CLF – Czorsztyn Limestone Formation (red nodular limestones); DLF – Dursztyn Limestone Formation (white *Calpionella* limestones); HLLF – Horná Lysá Limestone Formation (grey *Calpionella* limestones with cherts); JF – Jaworki Formation (red globotruncana marls)

Wysokie Skałki (Figs 1D, 3/2, 4)

The deposits of the Czertezik Succession are well exposed along the Stachurówka – Wysokie Skałki ridge (Birkenmajer, 1970, 1977) constituting the Polish – Slovak state border.

Three sections in north-western slope of Wysokie Skał-ki (denoted A–C from north-west to south-east) have been studied giving full details of the lateral variability of deposits.

Section A (coordinates N 49° 23' 02.3'', E 20° 32' 58.6'') is exposed in core of a small recumbent fold. The oldest rock-unit 1 (Figs 3/2A, 4A/1) consists of red-coloured, fine-grained, thin-bedded crinoidal limestones with rare red cherts, and a single thin (0.1 m) intercalation of red radiolarian chert; the crinoidal limestones are of packstone character consisting mainly of crinoid ossicles, and not very frequent small-sized detrital quartz grains, whereas radiolarite intercalation contains numerous radiolarian tests (dominant are spumellarians), with some admixture of small detrital quartz grains; a total thickness of discussed rock-unit is unknown, but it exceeds 3 meters. The full thickness of red crinoidal limestones in the area studied may reach elsewhere about 10 meters (Birkenmajer, 1970). The deposits may be attributed to the Krupianka Limestone Formation (Birkenmajer, 1977). Younger (rock-unit 2; see Figs 3/2A, 4A/2) are red indistinctly nodular limestones; their thickness recorded is about 0.4 m, but as the nodular limestones tectonically contact with underlying crinoidal limestones, the overall thickness of the unit may be somewhat larger. In thin section, the bulk of limestones show features of wackestones to packstones rich in filaments, and less commonly occurring shells of juvenile gastropods, tests of foraminifers (mostly benthic, but also planktonic ones) and fragments of crinoid ossicles; but the top of the unit is covered by thin ferrugineous crusts with serpulid encrustations and numerous planktonic foraminifers (*Globuligerina*). According to their lithological character the discussed nodular limestones may be attributed to the Niedzica Limestone Formation (cf. Wierzbowski *et al.*, 1999). The nodular limestones are overlain by calcareous radiolarian cherts alternating with marly shales, constituting rock-unit 3 (see Figs 3/2A, 4A/3), and attributed to the Czajakowa Radiolarite Formation (Birkenmajer, 1977). These deposits are somewhat variegated, red and green coloured in their basal part, but in bulk of the unit the deposits are green· coloured (Podmajerz Radiolarite Member). The deposits are at least about 2.5 m thick, but their upper boundary is not known being covered by scree. According to Birkenmajer (1970) green radiolarite unit attains usually about 5–6 m in thickness in the area of study.

Section B commences with (coordinates: N 49° 22' 59.5'', E 20° 33' 03.6'') grey crinoidal limestones containing dark phosphatic nodules and ammonites (*Lytoceras* sp. – see Fig. 5D; and fragmentary preserved Sonninidae – possibly *Sonninia* sp. – see Fig. 5E), which may be traced in a rubble. Further south-east along the state border (coordinates: N 49° 22' 59'', E 20° 33' 03.8'') younger crinoidal limestones are well exposed. Their lower part (rock-unit 1 – see Figs 3/2B, 4B/1) consists of grey-coloured, coarse to medium-grained crinoidal limestones 4.2 m thick: limestones are very thick-bedded, but when weathered split into 0.1 m to 0.15 m thick flags. Ammonites occur more commonly in the lowermost part of the unit: these include poorly preserved Stephanoceratidae (? *Stemmatoceras* sp. – see Fig. 5F, I). In upper part of the section crinoidal limestones (rock-unit 2 – see Figs 3/2B, 4B/2) become more reddish, and fine-grained: their thickness attains about 5–6 meters. Whereas crinoidal limestones of the rock-unit 1 in thin sections appear mostly to be grainstones with abundant white crinoid ossicles, and numerous detrital quartz grains, the limestones of the unit 2 are grainstones to packstones with sparse calcareous and ferruginous matrix, and show usually dominance of finer crinoid debris, and more diversified detrital material (besides very abundant quartz grains, there occur also lithoclasts of calcareous mudstones). The crinoidal limestones of the lower part of the section B may be attributed to the Smolegowa Limestone Formation, and these of the upper part of the section – to the Krupianka Limestone Formation.

Section C (see Figs 3/2C, 4C) begins at narrow pass directly below the summit part of Wysokie Skałki, where green tourist trail reaches the crest (N 49° 22' 53.7'', E 20° 33' 09.2''). The oldest deposits found here are black shales with spherosiderites representing the Skrzypny Shale Formation (see Figs 3/2C, 4C/1). These are directly overlain by grey crinoidal limestones with grey cherts, black phosphatic nodules and lithoclasts of green micritic limestones; the deposits are found as loose blocks already at the base of the slope. Younger are grey crinoidal limestones with cherts (see Figs 3/2C, 4C/2) well exposed on the north-western slope of Wysokie Skałki. All these crinoidal limestones with cherts may be attributed to the Flaki Limestone Formation (Birkenmajer, 1977); their recorded total thickness attains about 14 m, however, according to Birkenmajer (1970), it may be locally somewhat smaller (10 m).

Crinoidal limestones of the Flaki Limestone Formation in section C are directly covered by thin bed, about 0.4 m thick, of red-coloured, very fine-grained crinoidal limestone (see Figs 3/2C, 4C/3), the rock consists of densely packed debris of crinoid ossicles (particular fragments often corroded and stained by ferro-manganese oxides) with admixture of very small quartz grains. This is succeeded by grey-cherry-coloured fine-grained crinoidal limestones about 0.2 m thick and containing also numerous crinoid ossicles and small quartz grains. These deposits may be possibly attributed to the Krupianka Limestone Formation. Younger are green-coloured calcareous radiolarian cherts alternating with marly shales of the Podmajerz Radiolarite Member of the Czajakowa Radiolarite Formation (see Figs 3/2c, 4C/4) which thickness does not exceed about 5–6 meters (Birkenmajer, 1970, 1977). The youngest are red-coloured radiolarian cherts of the upper part of the Czajakowa Radiolarite Formation (Buwałd Radiolarite Member) overlain by red nodular limestones of the Czorsztyn Limestone Formation, about 4–6 m thick, at the top of Wysokie Skałki (Birkenmajer, 1970, 1977).

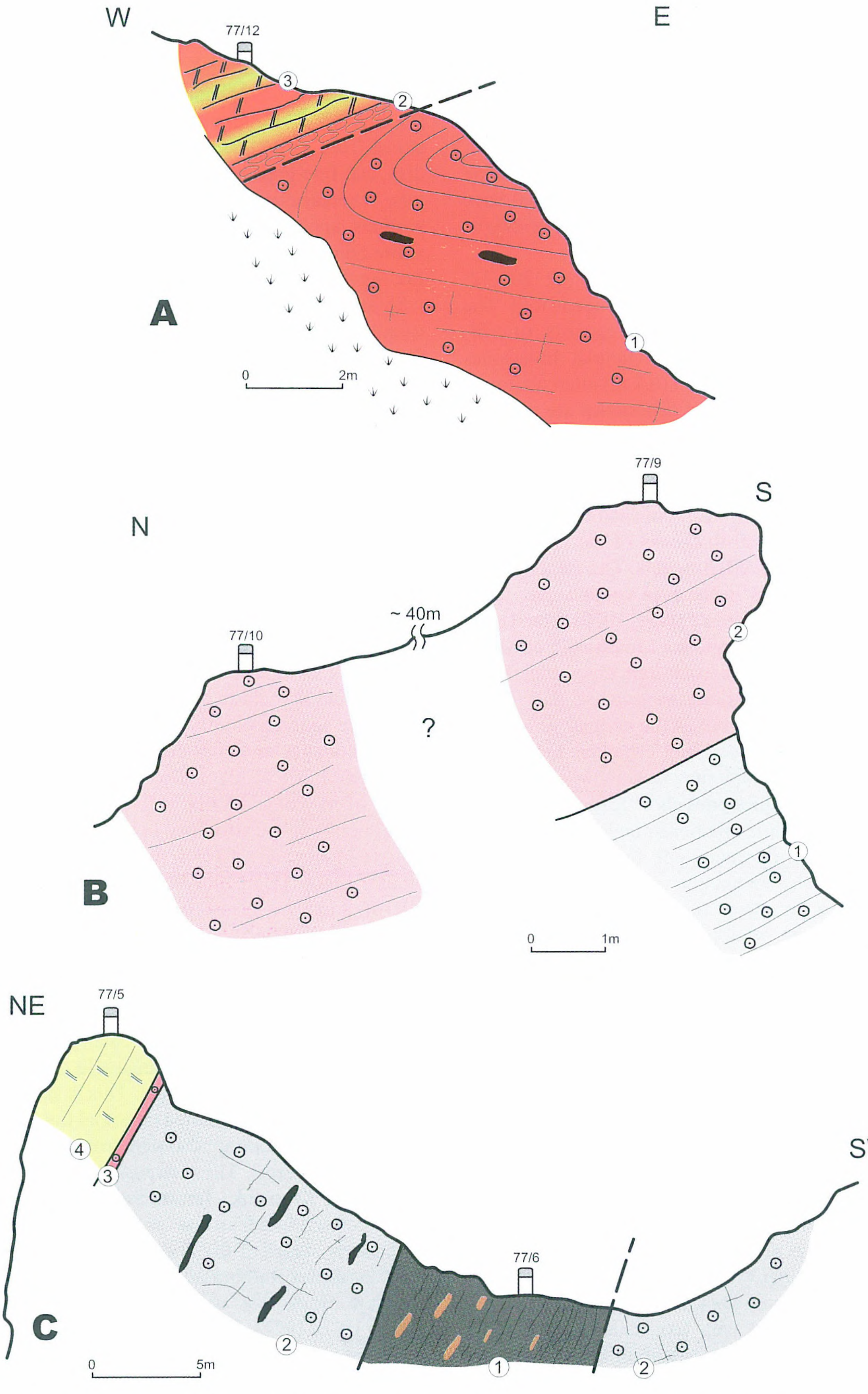

Fig. 4. Wysokie Skałki sections **A–C** described in the text. Explanations: section **A**: 1 – red crinoidal limestones with rare cherts of the Krupianka Limestone Formation; 2 – ammonitico rosso-type red nodular limestones of the Niedzica Limestone Formation with tectonic contact with older deposits; 3 – red and green calcareous radiolarian cherts of the Czajakowa Radiolarite Formation; section **B**: 1 – grey crinoidal limestones of the Smolegowa Limestone Formation; 2 – reddish crinoidal limestones of the Krupianka Limestone Formation; section **C**: 1 – black shales with spherosiderites of the Skrzypny Shale Formation; 2 – grey crinoidal limestones with cherts of the Flaki Limestone Formation; 3 – red crinoidal limestones of the Krupianka Limestone Formation; 4 – green calcareous radiolarian cherts of the Czajakowa Radiolarite Formation (Podmajerz Radiolarite Member). Note the state border stones with original numbering in all figures

Litmanovské Klippen (Figs 1D, 3/3, 6)

The best exposures of the Czertezik Succession occur in the eastern part of the Litmanovské Klippen, at the northern part of Litmanová village. They are located along the Litmanovsky Stream directly above the junction of its two main tributaries – the streams Velky Lipnik and Rozdiel. The locality was denoted as Litmanová klippe Ls2 by Ožvoldová *et al.* (2000, fig. 1 d).

The oldest are black marly shales with discoidal spherosiderite concretions of the Skrzypny Shale Formation. They are inclined about 50 toward North. Their detailed full thickness is not known, as the upper boundary is not exposed. The recorded thickness reaches 19.5 m, but a part of the section – about 15 m thick, including possibly an upper part of the Skrzypny Shale Formation, is covered by scree.

Younger deposits are grey coloured, fine-grained, well-bedded crinoidal limestones of the Smolegowa Limestone Formation. Although the exposed deposits are only 2.40 m thick, the full thickness of the unit seems here also rather small, and it possibly does not exceed a few meters. The lowest bed 1, about 0.80 m thick (base not exposed) consists of crinoidal grainstone rich in crinoid ossicles but with marked admixture of detrital quartz grains; some grains of heavy minerals like zircon, rutile and garnet are also present. The overlying bed 2 shows at its base a thin condensed level marked by occurrence of small dark phosphatic nodules, abundant glauconite grains, and rich fauna of ammonites including *Stephanoceras* (*Skirroceras*) sp. (see Fig. 5G–H), and *Nannolytoceras polyhelictum* (Boeckh) (see Fig. 5A–C), belemnites and brachiopods; here also a single pebble of micaceous gneiss a few centimetres in diameter has been found. The rock appears faintly laminated in thin sections: it is rich in well preserved crinoid ossicles, fragments of bryozoans (sometimes unusually abundant), and less common brachiopod and bivalve detritus, tests of ostracodes and foraminifers (*Lenticulina* sp.), echinoid spines, as well as rare sponge spicules. The crinoidal limestone is a packstone with a marked admixture of detrital quartz grains. The discussed bed 2 is about 1.2 m thick, but when weathered it splits into thin flags with a thickness of 0.1–0.3 m. The highest crinoidal limestone bed 3 is 0.40 m thick and shows indistinctly nodular character. The topmost part of the bed is laminated – the laminae are wackestones and packstones of filamentous-crinoidal microfacies; bioclasts are mostly fine-grained, but a few larger fragments of bivalve shells; sponge spicules and tests of nodosarid foraminifers are also recognized; quartz grains are small and occur randomly.

The upper boundary of the crinoidal limestone unit is placed at the base of overlying single bed (bed 4), 0.55 m thick, consisting of cherry-red coloured nodular limestone with scattered small crinoid fragments (in lower and upper parts of the bed) to cherry-violet coloured more massive limestone (in middle part of the bed). The nodular limestone is wackestone to packstone rich in filaments, and locally also crinoid ossicles – thus, representing filament microfacies, and filament-crinoidal microfacies; small quartz grains are locally observed. More massive limestone from the middle part of bed 4 is mudstone to wackestone with small bioclasts – mostly debris of filaments, as well as some tests of foraminifers (*Lenticulina* sp., and nodosarids), ostracods, crinoid ossicles and echinoid spines. Still higher bed (bed 5) consists of light grey, micritic, indistinctly nodular limestone, about 0.20 m in thickness: it is wackestone rich in calcified radiolarian tests, with very rare planktonic foraminifers. The deposits of beds 4–5 attaining thickness 0.75 m, may be attributed to the Niedzica Limestone Formation.

Overlying deposits are calcareous radiolarian cherts alternating with marly shales, about 3.40 m thick: particular beds thickness ranges from 1.5–3 cm up to about 10–15 cm. The deposits are green-coloured in their lower part (about 2.33 m thick), and red-coloured in upper part (about 1.07 m thick). They correspond to the Czajakowa Radiolarite Formation – the Podmajerz Radiolarite Member, and the Buwałd Radiolarite Member (Ožvoldová *et al.*, 2000).

The youngest studied deposits in the section are red-coloured nodular limestones with nodules up to 10 cm in thickness occurring in marly matrix. These are wackestones, and packstones with abundant *Saccocoma* fragments (*Saccocoma* microfacies) corresponding to the Czorsztyn Limestone Formation (Ožvoldová *et al.*, 2000).

Milpoš (Figs 1E, 3/3, 7)

Good exposures of the Czertezik Succession are found along the Milpoš stream, at northern end of the Milpoš village. The most continuous section is on western side of the stream close to a small dam (coordinates: N 49° 11' 39.4'', E 21° 0' 56.4'') where the beds are steeply inclined (65-85/75-85N). The section was described by Ožvoldová & Frantová (1997, p. 50, fig. 1 f).

The oldest deposits are well-bedded crinoidal limestones, about 24.5 m in thickness, consisting of several rock-units (1–5) which differ mostly in grain size, bed thickness, and presence or absence of cherts (Figs 3/3, 7B/1–5). The limestones are mostly packstones, locally also grainstones, and contain always an admixture of very small detrital quartz grains. The lowest rock unit 1 (base not exposed) consists of thin-bedded, fine-grained, grey coloured crinoidal limestone, about 4 m in thickness. This is overlain by rock-unit 2 consisting of medium-grained, mostly grey coloured, but upwards also grey-reddish coloured, crinoidal limestones with brownish cherts in topmost part of the unit: the unit attains about 6 m in thickness. Overlying deposits, about 10 m in thickness, consist of very thin-bedded, grey-reddish, and also greenish upwards, crinoidal limestones with red and black cherts attaining length about 10 cm, and occurring commonly in upper part of the rock unit (rock-unit 3). Higher up in the sequence grey coloured, thin-bedded crinoidal limestones with brownish cherts of the rock-unit 4 appear, about 4.50 m in thickness. The uppermost unit 5, about 1 m thick, consists of grey coloured massive crinoidal limestones. The bulk of deposits discussed may be attributed to the Smolegowa Limestone Formation, but some parts of the sequence rich in cherts (upper part of rock-units 2 and 3, and rock-unit 4) represent possibly the Flaki Limestone Formation.

The overlying deposits, about 0.9 m in thickness, include dark red-cherry coloured fine-grained crinoidal lime-

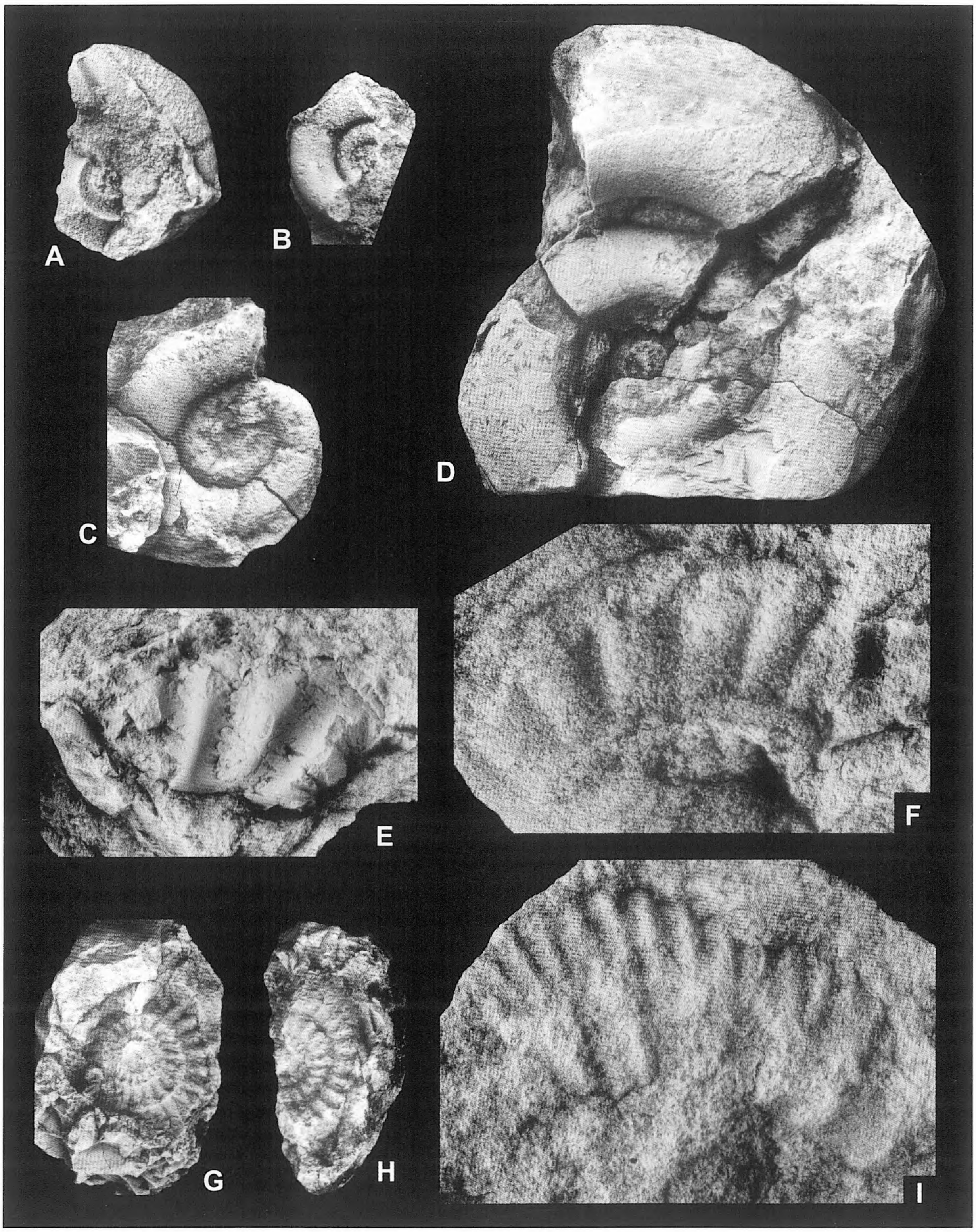

Fig. 5. Ammonites from the Smolegowa Limestone Formation of the Czertezik Succession: **A–C**. *Nannolytoceras polyhelictum* (Boeckh), Litmanovské Klippen; **A–B**: IGPUW/A28/64; **C**: IGPUW/A28/65; **D**. *Lytoceras* sp., Wysokie Skałki, section B, IG-PUW/A28/66; **E**. sonninid ammonite (? *Sonninia* sp.), Wysokie Skałki, section B, IGPUW/A28/67; **F**, **I**. ? *Stemmatoceras* sp., Wysokie Skałki, section B, F: IGPUW/A28/68, I: IGPUW/A28/69; **G–H**. *Stephanoceras* (*Skirroceras*) sp., Litmanovské Klippen, IGPUW/A28/70, all specimens in natural size

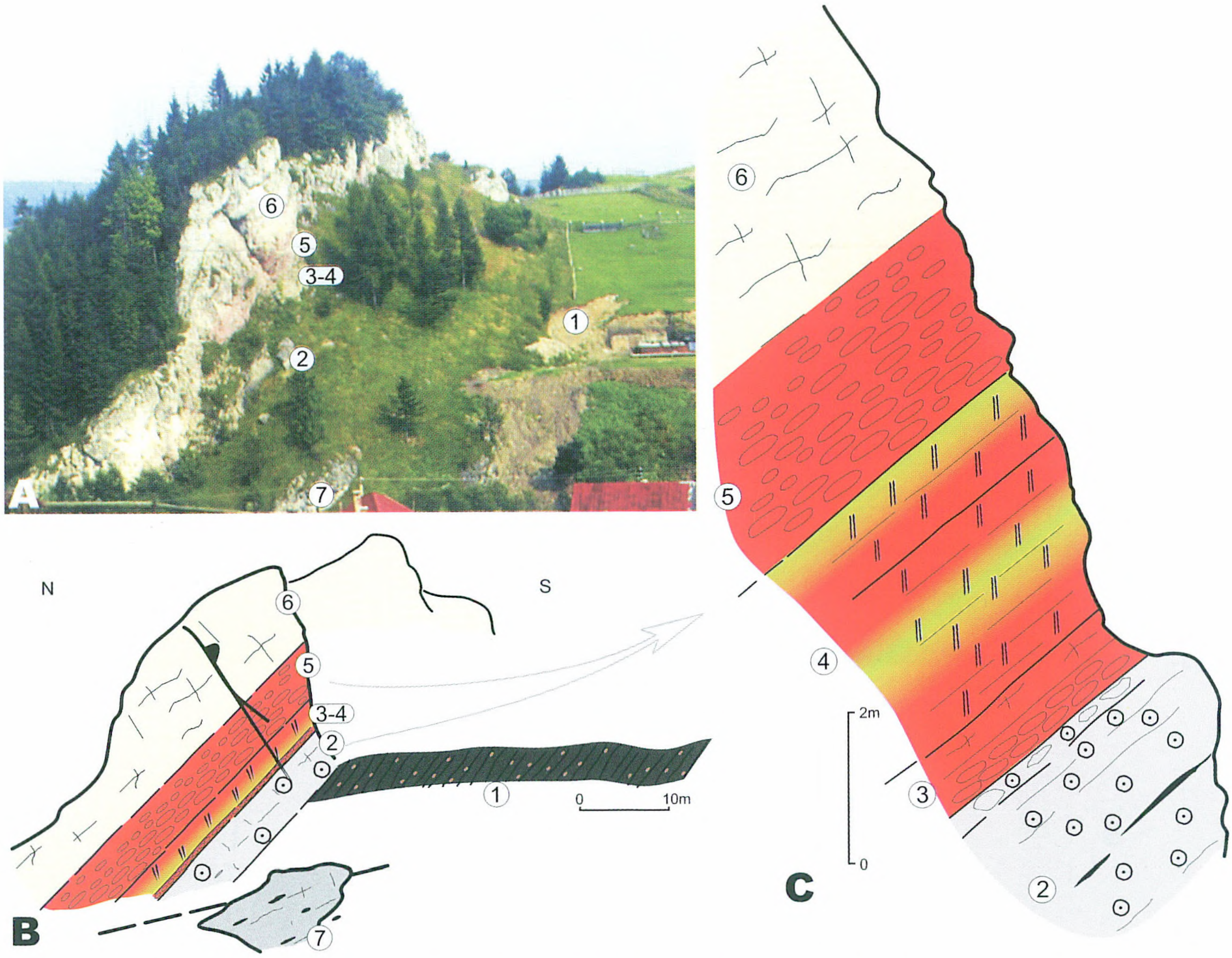

Fig. 6. Litmanovské Klippen section. **A–C**. General view of the klippen (**A**) and (**B–C**) geological cross-section sketches. Explanations: 1 – black shales with spherosiderites of the Skrzypny Shale Formation; 2 – grey crinoidal limestones of the Smolegowa Limestone Formation; 3 – ammonitico rosso-type cherry-red nodular limestones of the Niedzica Limestone Formation; 4 – green (lower part) and red (upper part) calcareous radiolarian cherts of the Czajakowa Radiolarite Formation (Podmajerz and Buwałd Radiolarite members, respectively); 5 – ammonitico rosso-type red nodular limestones of the Czorsztyn Limestone Formation; 6 – *Calpionella*-type white and cream micritic limestones of the Dursztyn Limestone Formation (Sobótka Limestone Member); 7 – maiolica-type grey micritic limestones with cherts of the Pieniny Limestone Formation

stones with haematite-marly matrix (Figs 3/3, 6B/6). They are indistinctly nodular, and thin-bedded. In thin-section rock appears packstone with abundant fragments of crinoid ossicles, and less commonly occurring small-sized fragments of filaments, with marked admixture of detrital quartz grains. The deposits may be attributed to the Krupianka Limestone Formation (see Ožvoldová & Frantová, 1997).

Red nodular limestones with abundant marly matrix (Figs 3/3, 7B/7) are about 1.5 m thick. They consist of packstones, less commonly of wackestones, rich in filaments. At the base, these deposits yielded ammonites such as *Nannolytoceras tripartitum* (Raspail) (Fig. 8E), *Phylloceras* sp., *Cadomites (Candomites)* cf. *daubenyi* (Gemmelaro) (Fig. 8F), *Parkinsonia* (*Parkinsonia*) sp. (Fig. 8G), and fairly numerous ammonites found from about 0.1–0.5 m – *Nannolytoceras tripartitum* (Raspail), *Holcophylloceras zignodianum* (d'Orbigny), *Calliphylloceras disputabile* (Zittel) (Fig. 8D), *Adabofoloceras* ex gr. *adabofolense* (Collignon) (Fig. 8A–C), *Phylloceras* sp., *Oxycerites* sp., *Oecotraustes* sp., *Parkinsonia* (*Parkinsonia*) sp., Perisphinctidae indet., and about 1.0–1.1 m above the base of the unit – *Nannolytoceras tripartitum* (Raspail), *Oxycerites* sp., *Bullatimorphites* (*Bullatimorphites*) cf. *ymir* (Oppel) (Fig. 8H); moreover single specimen of Zigzagiceratinae was found in a rubble. The deposits may be attributed to the Niedzica Limestone Formation.

Red-coloured (but in uppermost 0.9 m thick part, subordinately also green-coloured), calcareous radiolarian cherts with marly intercalations (Figs 3/3, 7B/8), about 5 m thick, are attributed to the Czajakowa Radiolarite Formation (see also Ožvoldová & Frantová, 1997, p. 50). They are capped by dark-brown coloured nodular limestones with poor marly matrix: these are packstones with abundant *Saccocoma* fragments (*Saccocoma* microfacies) corresponding to

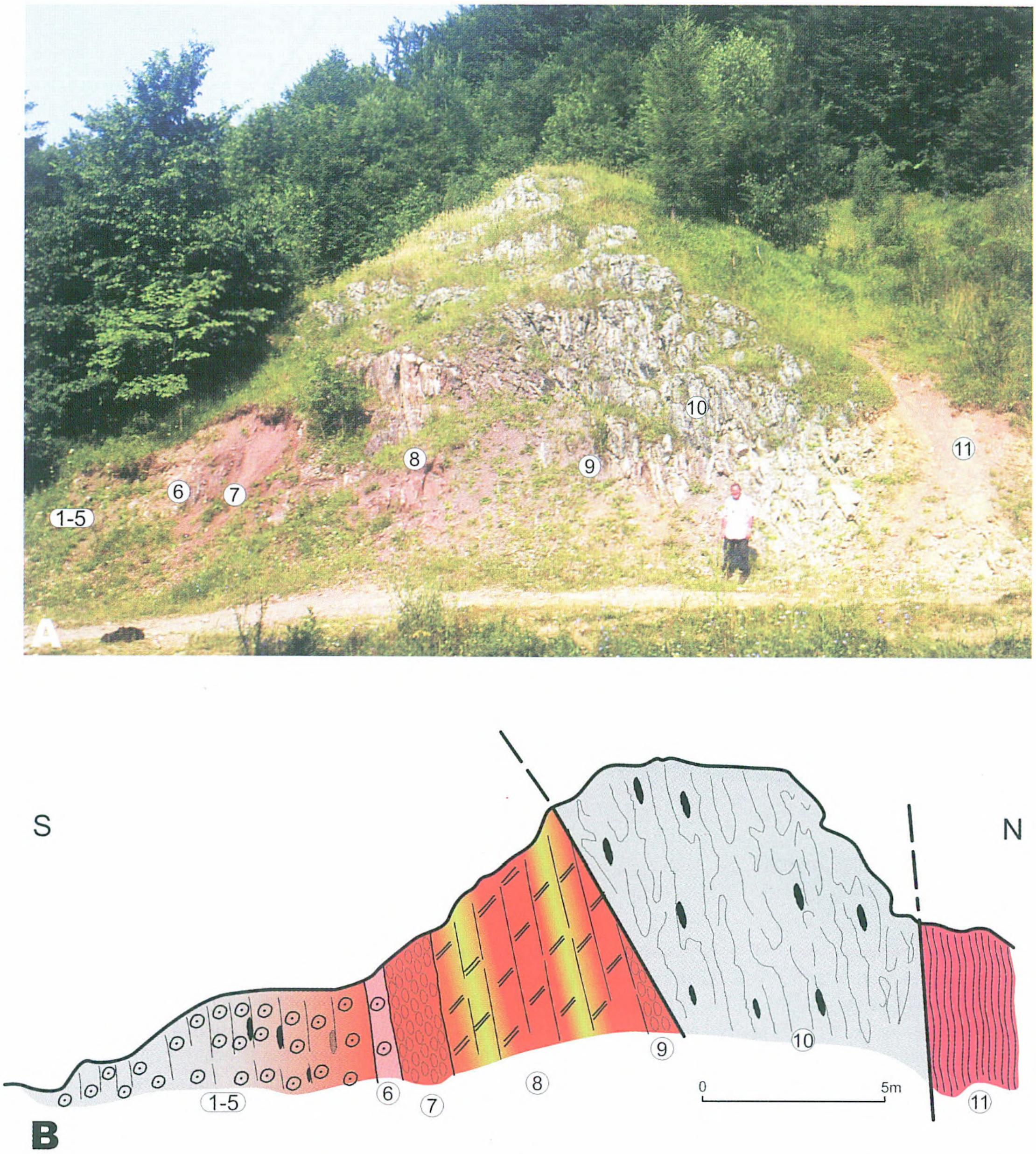

Fig. 7. Milpoš section. **A–B**. General view of the quarry (**A**) and geological cross-section sketch (**B**). Explanations: 1–5 – grey and grey-reddish crinoidal limestones of the Smolegowa and Flaki Limestone formations (numbers of the units according to the text); 6 – red-cherry crinoidal limestones of the Krupianka Limestone Formation; 7 – ammonitico rosso-type red nodular limestones of the Niedzica Limestone Formation; 8 – red calcareous radiolarian cherts of the Czajakowa Radiolarite Formation; 9 – ammonitico rosso-type dark-brown nodular limestones of the Czorsztyn Limestone Formation; 10 – light-grey micritic and crinoidal limestones with cherts of the Horná Lysá Limestone Formation; 11 – Scaglia rosa-type (*Globotruncana*) red-cherry marls

the Czorsztyn Limestone Formation (Figs 3/3, 7B/9). Recorded thickness of these deposits is 0.60 m, but their upper boundary is tectonic.

The youngest deposits discussed (radiolarites in upper part of the outcrop, and nodular limestones in its lower part) contact along steeply inclined fault plane with micritic and crinoidal limestones with lenses of cherts (about 6.10 m in thickness) (Figs 3/3, 7B/10). These deposits contain calpionellids *Tintinopsella longa* (Colom), *Calpionellopsis oblonga* (Cadisch) and *C. simplex* (Colom), and belong to the Horná Lysá Limestone Formation (Mišik *et al.*, 1994), Late Berriasian in age.

JURASSIC STRATIGRAPHY OF THE CZERTEZIK SUCCESSION

The oldest deposits of the Czertezik Succession (Fig. 9) consist of grey marls and marly limestones (Krempachy Marl Formation), and shales with spherosiderite nodules (Skrzypny Shale Formation). Much of these deposits belong to Aalenian (see Birkenmajer, 1977, and earlier papers cited therein), but the upper part of the Skrzypny Shale Formation ranges up into Lower Bajocian. The best known ammonite assemblage comes from the Skrzypny Shale Formation of the Litmanovské Klippen section where it proves the occur-

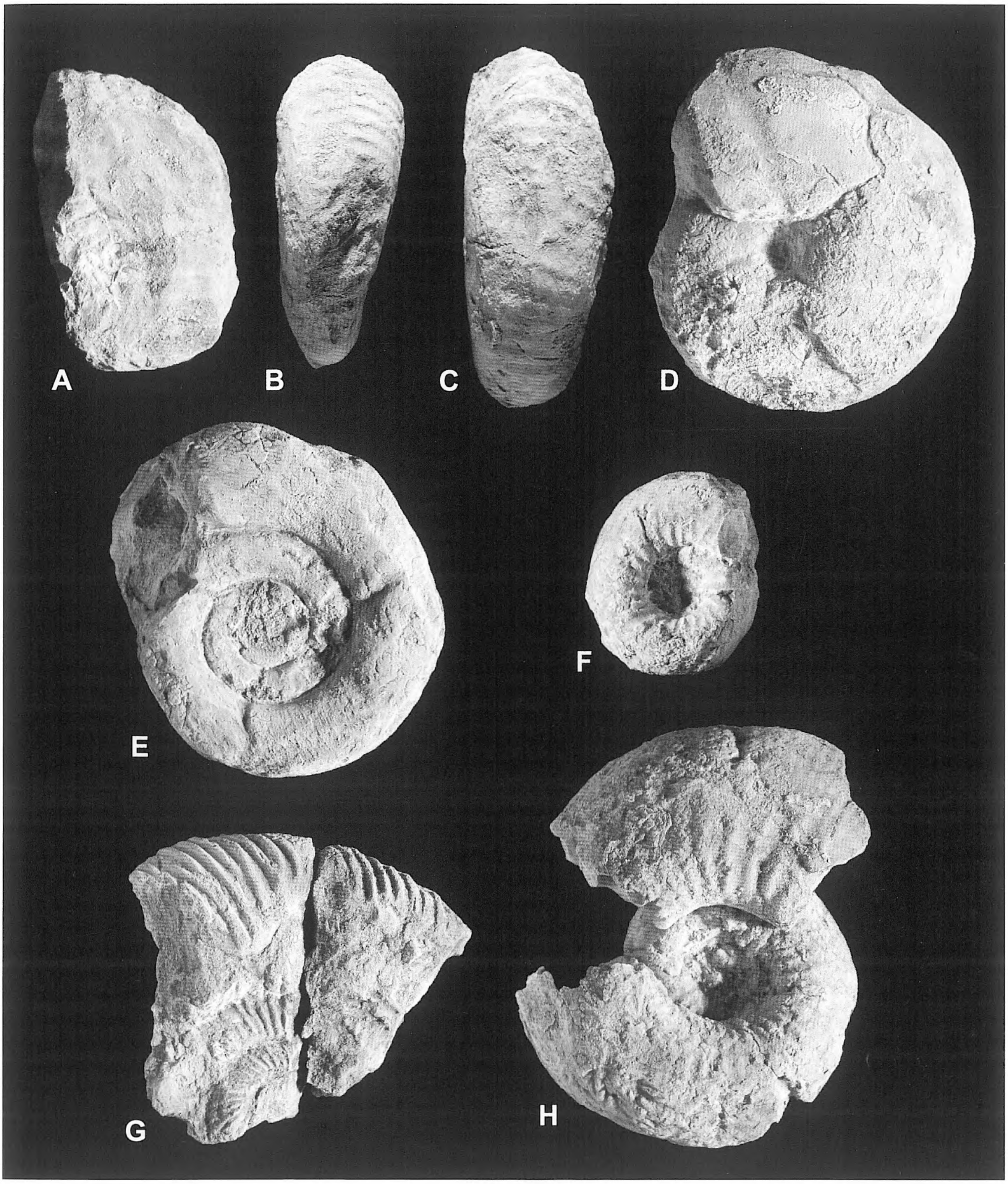

Fig. 8. Ammonites from the Niedzica Limestone Formation of the Czertezik Succession in Milpoš quarry. **A–C**. *Adabofoloceras* ex gr. *adabofolense* (Collignon), 0.1–0.5 m above the base; **D**. *Calliphylloceras disputabile* (Zittel), 0.1–0.5 above the base; **E**. *Nannolytoceras tripartitum* (Raspail), base of the formation; **F**. *Cadomites* (*Cadomites*) cf. *daubenyi* (Gemmelaro), base of the formation; **G**. *Parkinsonia* (*Parkinsonia*) sp., base of the formation; **H**. *Bullatimorphites* (*Bullatimorphites*) cf. *ymir* (Oppel), 1.0–1.1 m above the base, all specimens in natural size; ammonites deposited in Department of Geology and Paleontology of the Comenius University in Bratislava

rence of the Murchisonae and the Concavum zones of the Aalenian, as well as the Discites Zone of the lowermost Bajocian (Scheibner, 1964, 1968). Younger Early Bajocian ammonite faunas are not known from the Skrzypny Shale Formation in this locality, what could be related with stratigraphical gap at the base of the overlying crinoidal limestones marked by well developed discontinuity surface (cf. Scheibner, 1964; see also chapter on correlations herein). The occurrence of a stratigraphical gap at the boundary between the Skrzypny Shale Formation and the overlying crinoidal limestones seems highly probable in the Wysokie Skałki area (see sections B and C in description of the localities): here clasts of micritic limestones and black phosphatic nodules are found commonly in the lower part of the crinoidal limestones.

The crinoidal limestones are developed mostly as interfingering units of grey crinoidal grainstones of the Smolegowa Limestone Formation and crinoidal-spiculitic grainstones with cherts of the Flaki Limestone Formation (Pieniński Stream, Czertezik, Milpoš); but some sections (Wysokie Skałki – section B, Litmanovské Klippen) show the dominance of crinoidal grainstones of the Smolegowa Limestone Formation, whereas some other – of crinoidal grainstones with cherts of the Flaki Limestone Formation (Wysokie Skałki – section C). The youngest beds comprise red-coloured fine-grained crinoidal limestones encountered in some sections only (Czertezik, Wysokie Skałki – mostly in sections A and B, and very reduced in thickness in section C; Milpoš) – which may be referred to the Krupianka Limestone Formation.

The crinoidal limestones yielded not very well preserved, but important for stratigraphy ammonites, found in lower part of the sections at Wysokie Skałki and Litmanovské Klippen. These include *Lytoceras* sp. (filled with crinoidal matrix) (Fig. 5D), and fully phosphatized fragment of a large whorl (still septate) with distant strong blunt ribs fading towards narrow venter representing difficult for closer interpretation Sonninidae (possibly *Sonninia* sp. – Fig. 5E); both these specimens were found in Smolegowa Limestone Formation – at the base of the crinoidal limestones in lowermost part of section B in Wysokie Skałki area. Much better preserved ammonite fauna consisiting of *Stephanoceras* (*Skirroceras*) sp. (Fig. 5G–H), and *Nannolytoceras polyhelictum* (Boeckh) (Fig. 5A–C) was found somewhat above the base of the crinoidal limestones of the Smolegowa Limestone Formation in a condensed level in the Litmanovské Klippen section. The ammonites indicated are typical of Lower Bajocian: the sonninid ammonite (? *Sonninia* sp.) suggests the Propinquans Zone (Sauzei Zone), whereas an assemblage of *Stephanoceras* (*Skirroceras*) and *Nannolytoceras polyhelictum* – indicates the stratigraphical interval from the Propinquans Zone (Sauzei Zone) to lower part of the Humphriesianum Zone (cf. Pavia, 1983; Callomon & Chandler, 1990; Rioult *et al.*, 1997). Somewhat higher, but still in lower part of crinoidal limestones of the Smolegowa Limestone Formation in section B in Wysokie Skałki area, two fragments of whorls of large ammonites of the family Stephanoceratidae were found: both of them show distant strong primary ribs swollen at their end about middle of whorl height, and strongly developed secondary ribs (number of secondaries per one primary is about 3.0). These ammonites may be referred possibly to *Stemmatoceras* (Fig. 5F, I) what indicates stratigraphical interval from the upper part of the Propinquans Zone (Sauzei Zone) to the lower/middle part of the Humphriesianum Zone (cf. Pavia, 1983; Callomon & Chandler, 1990; Rioult *et al.*, 1997).

From the aforegoing, it may be suggested, that after deposition of expanded sequences of marly and shale facies of the Krempachy Marl Formation and Skrzypny Shale Formation – from Aalenian to earliest Bajocian (Discites Chron, only ?), the deposition became highly discontinuous – with periods of "normal" deposition of micritic limestones, very slow deposition (phosphatic nodules) and non-deposition. The upper part of the Skrzypny Shale Formation yields rare small phosphatic concretions: the concretions show gradual decrease in the phosphorus content from the Czorsztyn Succession through Czertezik and Niedzica successions to the Branisko Succession what generally follows the palaeobathymetry of the Pieniny Klippen Basin (Tyszka & Kamiński, 1995; Tyszka, 1999). However, the bulk of deposits corresponding to stratigraphical interval of discontinuous sedimentation discussed has been completely removed in the Czorsztyn, Niedzica and Czertezik successions before deposition of basal beds of crinoidal limestones; reworked clasts of micritic limestones and phosphatic pebbles including phosphatized fragment of ? *Sonninia* sp. suggesting the Propinquans Zone (Sauzei Zone) of the Lower Bajocian found at Wysokie Skałki in the Czertezik Succession are the only evidence of these deposits. The onset of crinoidal sedimentation took place at the end of Early Bajocian (latest Propinquans Chron – to early Humphriesianum Chron). It should be remembered that all the ammonites reported so far from the white and grey crinoidal limestones of the Czertezik Succession (Smolegowa Limestone Formation and Flaki Limestone Formation) are in fact Early Bajocian in age (see e.g. *Stephanoceras scalare* Mascke illustrated by Horwitz, 1937, pp. 203–204, pl. XI, fig. 3 coming from crinoidal limestones of the Pieniński Stream of the Czertezik Succession; cf. also Myczyński, 1973, pp. 12, 17–18).

Biostratigraphical documentation of the upper part of crinoidal limestones is very poor. A distinctive thin radiolarite intercalation within red crinoidal limestones of the Krupianka Limestone Formation in section A of Wysokie Skałki area yielded poorly preserved and indeterminable radiolarian microfauna. It should be remembered, however, that the red nodular limestones directly overlying crinoidal limestones in the Milpoš section are latest Bajocian–earliest Bathonian in age (see comments below). It seems thus clear that the crinoidal limestones of the Czertezik Succession do not range stratigraphically upwards above the top of Bajocian.

The red nodular limestones discussed attain generally very small thickness (0.4 m to 1.5 m). The ammonites found in the unit in the Milpoš section include i.a. *Nannolytoceras tripartitum* (Raspail) (Fig. 8E), *Parkinsonia* (*Parkinsonia*) sp. (Fig. 8G), *Cadomites (Cadomites)* cf. *daubenyi* (Gemmelaro) (Fig. 8F), *Bullatimorphites (Bullatimorphites)* cf. *ymir* (Oppel) (Fig. 8H), and indeterminable fragment of

Zigzagiceratinae. It is an assemblage indicative of the uppermost Bajocian to Lower Bathonian, reported previously from the lowest part of the nodular limestones of the Czorsztyn Succession and the Niedzica Succession in the Pieniny Klippen Belt (Birkenmajer & Znosko, 1955; Rakúš, 1990; Wierzbowski *et al.*, 1999; Schlögl, 2002). Nodular limestones of the Czertezik Succession are characterized by frequent occurrence of fragments (filaments) of thin-shelled bivalves (*Bositra*). This type of microfacies is typical of "lower nodular limestones" (Niedzica Limestone Formation) of the Niedzica Succession and a lower part of the nodular limestones of the Czorsztyn Limestone Formation of the Czorsztyn Succession assigned on the base of ammonites to uppermost Bajocian, Bathonian, and Callovian (Wierzbowski *et al.*, 1999). It is difficult to state, however, whether the whole indicated stratigraphical interval is represented in the "lower nodular limestones" in the Czertezik Succession, especially as the upper part of these deposits did not yield here any diagnostic fossils. Top of nodular limestones in section A at Wysokie Skałki is covered by ferrugineous crusts with serpulid encrustations and abundant planktonic foraminifers *Globuligerina* ("*Protoglobigerina*"), whereas the nodular limestones in other studied sections of the Czertezik Succession are abruptly succeeded by calcareous radiolarian cherts. Both the appearance of the *Globuligerina* microfacies in the Czorsztyn Succession (and locally also in the Niedzica Succession), as well as of the radiolarian microfacies (radiolarites) in the Niedzica Succession took place during latest Callovian/Early Oxfordian (Wierzbowski *et al.*, 1999). Hence, the nodular limestones of the Czertezik Succession could range upwards till end of the Callovian. It should be remembered that in the section C at Wysokie Skałki the "lower nodular limestones" are completely missing, and very fine-grained crinoidal limestones (Krupianka Limestone Formation) are capped directly by green radiolarites. Thus, the section C is intermediate in character between the Czertezik Succession and the Branisko Succession, and it is highly probable, that the radiolarian deposits span here a larger time interval (? latest Bajocian – Callovian, see also chapter on correlation) than the radiolarites in bulk of the sections studied of the Czertezik Succession.

As usually, the radiolarite units of the Czertezik Succession comprise two members of the Czajakowa Radiolarite Formation: green-coloured calcareous radiolarian cherts alternating with marly shales of the Podmajerz Radiolarite Member (but locally underlain by variegated red and green coloured single band of radiolarite – e.g. in section B of Pieniński Stream, and section A of Wysokie Skałki), and red coloured radiolarian cherts alternating with marly shales of the Buwałd Radiolarite Member. In the Milpoš section, the radiolarian cherts are mostly red-coloured, with the exception of several subordinate parts which are green-coloured making their attribution to any of these members more difficult (Buwałd Radiolarite Member after Ožvoldová & Frantová, 1997). The radiolarian microfauna studied so far from the sections of Czertezik Succession in Slovakia (Milpoš, Podsadek – Ožvoldová & Frantová, 1997; Litmanovské Klippen – Ožvoldová *et al.*, 2000) indicated the presence of the following unitary radiolarian zones of the standard Baumgartner zonation: from U.A.Z. 9 – U.A.Z. 10 (Middle-Late Oxfordian) in the Podmajerz Radiolarite Member, to U.A.Z. 10 – U.A.Z. 11 (Late Oxfordian–Early Kimmeridgian) in the Buwałd Radiolarite Member. It should be remembered that no samples have been taken from the lowermost part of the Czajakowa Radiolarite Formation (cf. Ožvoldová & Frantová, 1997; Ožvoldová *et al.*, 2000), and the samples analysed by the present authors from the lowermost part of the radiolarite deposits from the Litmanovské Klippen and the Pieniński Stream appeared barren.

The succeeding nodular limestones ("upper nodular limestones") of the Czorsztyn Limestone Formation of the Czertezik Succession did not yield abundant ammonites with the exception of *Aspidoceras* sp. reported from Zázrivá-Plešivá area of western Slovakia (Haško, 1976). There is a little doubt, however, that the deposits belong to Kimmeridgian and Lower Tithonian. The *Saccocoma* microfacies recognized here is typical of the upper part of the Czorsztyn Limestone Formation in the Czorsztyn Succession well characterized by abundant ammonite fauna indicating this very stratigraphical interval (Myczyński & Wierzbowski, 1994; Wierzbowski, 1994).

CORRELATION OF JURASSIC DEPOSITS BETWEEN CZERTEZIK SUCCESSION AND OTHER SUCCESSIONS OF THE PIENINY KLIPPEN BASIN

Sequence of deposits of the lower part of the Czertezik Succession shows large similarity to other successions deposited on a southern slope of the Czorsztyn Ridge – the Czorsztyn Succession, and the Niedzica/Pruské Succession (Fig. 9). This similarity is expressed by common occurrence of marly deposits of the Krempachy Marl Formation, and overlying shales with spherosiderite nodules of the Skrzypny Shale Formation (Birkenmajer, 1977, and earlier papers cited therein). The latter yielded fairly rich Middle Aalenian (Murchisonae Zone), and lowermost Bajocian (Discites Zone) ammonite fauna in the Czorsztyn Succession (see Birkenmajer, 1963, pp. 31–35, and earlier palaeontological papers cited therein). The occurrence of younger ammonite zones of Lower Bajocian in the Skrzypny Shale Formation in the Czorsztyn Succession suggested by Birkenmajer (1963, 1977) is somewhat doubtful, as it is based mostly on specimens of "*Spaeroceras gervillei*" discussed by Siemiradzki (1923, pp. 7–8, pl. 1, fig. 18) of not well known level and locality (cf. Birkenmajer 1963, p 35). On the other hand, the boundary between the Skrzypny Shale Formation and overlying crinoidal limestones of the Smolegowa Limestone Formation is a distinct non-sequence horizon widely recognized in the Czorsztyn Succession and the Niedzica Succession. It is marked by common occurrence of reworked micritic limestone clasts, pyrite framboids, phosphatic nodules and large phosphatic oncoids, as well as by common occurrence of fossils (brachiopods, belemnites, ammonites) in the lowermost part of the crinoidal limestones (Krobicki, 2002). The ammonite fauna collected recently in the lowermost part of the Smolegowa Limestone

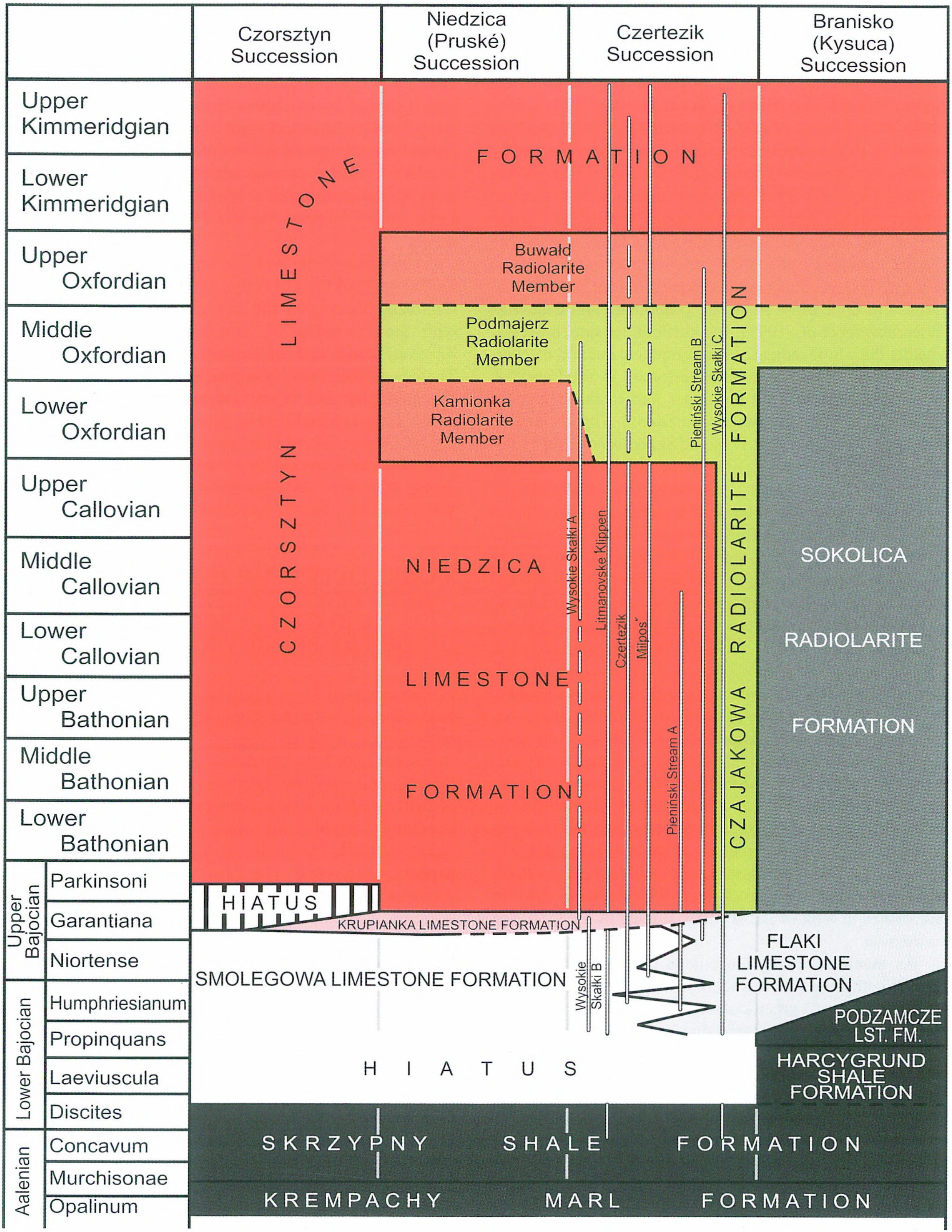

Fig. 9. Stratigraphical correlation between the lithostratigraphic units of the Middle and Upper Jurassic of the Czertezik Succession and these of the Czorsztyn, Niedzica/Pruské and Branisko/Kysuca successions of the Pieniny Klippen Belt; stratigraphical ranges of the sections studied are indicated

Formation in the Czorsztyn and Niedzica successions in Poland includes i.a. representatives of *Stephanoceras* (*Stephanoceras*, *Skirroceras*), and *Dorsetensia* (*Nannina*), indicative of the upper part of the Propinquans (Sauzei) Zone/lower part of the Humphriesianum Zone of the Lower Bajocian (Krobicki & Wierzbowski, 2004). Hence, it may be suggested that the largest gap in the Lower Bajocian part of the Czorsztyn – Niedzica/Pruské successions lies at the base of the crinoidal limestones, similarly as in the Czertezik Succession, covering at least marked parts of the Laeviuscula and Propinquans (Sauzei) zones. Earlier, Birkenmajer (1963, 1977) and Głuchowski *et al.* (1986) indicated a continuous sedimentary transition between the shales of the Skrzypny Shale Formation and the crinoidal limestones of the Smolegowa Limestone Formation in the Czerwona Klippe section of the Czorsztyn Succession in Poland. Unfortunately no actual exposure of the deposits in question exists at Czerwona Klippe, but the discussed interpretation is so different from presented herein, that more work is needed to resolve this apparent paradox.

The Branisko/Kysuca Succession and the Pieniny Succession represent partly different sequence of deposits than the successions discussed above. In the Branisko Succession, marly shales, marls and marly limestones rich in *Bositra* shells of the Harcygrund Shale Formation, completely unknown in the Czorsztyn to Czertezik successions, occur directly above marly deposits of the Krempachy Marl Formation, and shales of the Skrzypny Shale Formation (similarly developed as in the Czorsztyn to Czertezik successions). The deposits of the Krempachy Marl Formation and the Skrzypny Shale Formation of the Branisko Succession yielded several ammonite faunas (Myczyński, 1973; see also Horwitz, 1937) of Aalenian age strictly corresponding to these of the Czorsztyn to Czertezik successions. Younger ammonite fauna discovered in the Harcygrund Shale Formation of the Branisko Succession includes representatives of *Hyperlioceras*, *Reynesella*, *Oedania*, *Graphoceras*, *Sonninia* indicative of the Discites Zone and the Laeviuscula Zone of the Lower Bajocian, as well as of *Emileia*, *Otoites*, *Witchellia/Dorsetensia*, *Stephanoceras* indicative of a higher zones of Lower Bajocian – especially the Propinquans (Sauzei) Zone (Myczyński, 1973). Thus, it seems that the deposits of the Harcygrund Shale Formation fulfil mainly a stratigraphical gap occurring in the Czorsztyn-Niedzica-Czertezik successions between Skrzypny Shale Formation and crinoidal limestones (Fig. 9). Hence, the stratigraphical sequence of deposits in the Branisko Succession is more complete than that of the discussed Czorsztyn to Czertezik successions.

Higher in the Branisko Succession occur deposits called earlier "supra-Posidonia beds", corresponding actually to the Podzamcze Limestone Formation, and the Flaki Limestone Formation (Birkenmajer, 1977). The former consists of grey spotted limestones and marlstones with shale intercalations – they yielded ammonites *Oppelia*, *Oecotraustes*, *Dorsetensia*, *Sonninia patella* (Waagen), *Stephanoceras* (*Stephanoceras*, *Skirroceras*) indicative of the upper part of the Propinquans (Sauzei) Zone and the lowermost Humphriesianum Zone of the Lower Bajocian (Myczyński, 1973). The Flaki Limestone Formation in its type section in the Branisko Succession (Birkenmajer, 1977) consists of regularly bedded spotted spongiolites, arenaceous crinoid marlstones and filament limestones with chamositic concretions and phosphorite grains, micritic limestones and marlstones (Tyszka, 1995, 1999). The unit in its type section is developed, thus, in a variety of facies much more diversified than the grey crinoidal limestones traditionally attributed to the Flaki Limestone Formation in the Czertezik Succession. The ammonites *Stephanoceras* and *Oppelia* cf. *subradiata* (Sow.) described by Myczyński (1973) from the upper part of the Flaki Limestone Formation in its type locality are indicative of the Humphriesianum Zone of the Lower Bajocian. On the other hand, the Flaki Limestone Formation is not recognized in some sections of the Branisko Succession being possibly laterally replaced by the Podzamcze Limestone Formation which ranges up till the uppermost Lower Bajocian (cf. Birkenmajer & Myczyński, 2000).

The deposits representing the upper part of the Czertezik Succession include mostly the sequence consisting of nodular limestones of the Niedzica Limestone Formation, radiolarian cherts of the Czajakowa Radiolarite Formation and the nodular limestones of the Czorsztyn Limestone Formation. Such a sequence is very similar to that of the Niedzica Succession, and biostratigraphical interpretation of the deposits seems similar in both successions (see Wierzbowski *et al.*, 1999) (Fig. 9). Much more difficult is, however, correlation between discussed part of the Czertezik Succession and relevant deposits of the Branisko/Kysuca Succession.

The black manganese radiolarian cherts attributed to the Sokolica Radiolarite Formation directly overlie deposits of the Flaki Limestone Formation in the Branisko/Kysuca Succession. These radiolarian cherts yielded so far only the radiolarian microfauna in the Kysuca Succession in Sarišské Jastrabie section of eastern Slovakia (Ožvoldová & Frantová, 1997), indicating stratigraphical interval from uppermost Bajocian–Lower Bathonian (or even Callovian – unitary radiolarian zone U.A.Z. 5) to Middle/Upper Oxfordian (radiolarian zone U.A.Z. 9). Such a stratigraphical interpretation of the Sokolica Radiolarite Formation indicates that it is partly a time-equivalent of green radiolarian cherts of the Podmajerz Radiolarite Member of the Czajakowa Radiolarite Formation in the Czertezik Succession (see Birkenmajer, 1977). This is also consistent with finding of radiolarian microfauna indicative of Upper Bathonian – Callovian in green radiolarites of the Podmajerz Radiolarite Member in the Samášky section referred to the Pruské Succession in western Slovakia (Aubrecht & Ožvoldová, 1995). It seems, thus probable, that the green radiolarian cherts overlying grey crinoidal limestones with cherts (capped by thin bed of red crinoidal limestones) in the Czertezik Succession in section C in the Wysokie Skałki area (see Description of sections), may be treated as an age equivalent of the Sokolica Radiolarite Formation of the Branisko Succession (Fig. 9).

The red radiolarian cherts of the Buwałd Radiolarite Member of the Czajakowa Radiolarite Formation both in the Czertezik and Branisko successions yielded radiolarian microfauna (Ožvoldová & Frantová, 1997; Ožvoldová *et al.*, 2000) indicative of the unitary associations zones

(U.A.Z. 9 – U.A.Z. 10) corresponding to Middle/Upper Oxfordian to Lower Kimmeridgian; on the other hand, the Middle/Late Oxfordian age of red radiolarian cherts in the Branisko Succession may be confirmed by aptychi assemblages (Gąsiorowski, 1962; Durand Delga & Gąsiorowski, 1970).

CONCLUSIONS

The Czertezik Succession consists of several lithostratigraphic units of Middle and Upper Jurassic which formed in the Pieniny Klippen Basin (in area of both Poland and eastern Slovakia). Present study reveals only minor differences between the succession in question and the Niedzica Succession, suggesting the original position of the Czertezik Succession in the basin much closer to the Niedzica Succession (but linked also to the Branisko/Kysuca Succession), than to the Czorsztyn Succession.

Much of the Aalenian and the lowermost Bajocian deposits of the Czertezik Succession did not differ markedly from coeval deposits of other Klippen successions. It was not earlier than the Laeviuscula and Propinquans (Sauzei) Chrons of Early Bajocian when the deposits of particular successions became significantly different due to uplift of the Czorsztyn Ridge (see also Aubrecht *et al.*, 1997; Plašienka, 2003). The development of possibly highly condensed, and discontinuous deposits of the Czorsztyn – Niedzica/Pruské and Czertezik successions took place on the southern submerged slope of the Czorsztyn Ridge: these deposits have been successively reworked and occur as secondary lag conglomerate consisting of clasts of micritic limestones and phosphorite pebbles at the base of crinoidal limestones. An onset of crinoidal limestone sedimentation took place everywhere during latest Early Bajocian (turn of Propinquans and Humphriesianum chrons). That time already well developed facies zones on the southern slope of the Czorsztyn Ridge existed – the Czorsztyn Succession and the Niedzica/Pruské Succession with crinoidal grainstones of the Smolegowa Limestone Fm., and the Czertezik Succession with crinoidal grainstones as well as crinoidal-spiculitic grainstones with cherts of the Flaki Limestone Formation. The coeval deposits of the Branisko Succession represented a more diversified and more continuous sequence deposited during Early Bajocian in a deeper part of the basin. Here, except episodically redeposited more shallow-water organic remains (including crinoid remains), quartz and phosphate grains (and thus deposits partly similar in character to grey crinoidal limestones attributed to the Flaki Limestone Formation in the Czertezik Succession), more deeper water (and pelagic) deposits like grey spotted limestones, filament limestones and spongiolites were formed (Tyszka, 1995, 1999).

The deposition of ammonitico-rosso type deposits corresponding to the nodular limestones with filament microfacies (Wierzbowski *et al.*, 1999) begun abruptly above the crinoidal limestones on the southern slope of the Czorsztyn Ridge – from the Czorsztyn Succession through the Niedzica Succession to the Czertezik Succession (where thickness of the deposits in question is markedly reduced). It should be remembered that locally in the Czertezik Succession these deposits were totally missing, being possibly replaced by radiolarite sediments, similarly as in the Branisko/Kysuca Succession.

The younger deposits developed on the southern slope of the Czorsztyn Ridge during Oxfordian include ammonitico-rosso type deposits of the middle part of the Czorsztyn Limestone Formation in the Czorsztyn Succession (*Globuligerina* microfacies) and radiolarite units of the Niedzica Succession and the Czertezik Succession. These deposits indicate gradual deepening during Oxfordian – what was a regional phenomenon recognized widely in western part of the Tethys (see e.g. Wierzbowski *et al.*, 1999, and earlier papers cited therein). The development of the topmost part of the ammonitico-rosso deposits dominated by *Saccocoma* microfacies represented shallowing tendencies related to tilting of basemental blocks of the basin. Typical calcareous development of these deposits is recognized in the Czorsztyn-Niedzica-Czertezik successions, whereas their marly development is recognized in the Branisko/Kysuca Succession (see Birkenmajer, 1997).

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REFERENCES

Andrusov, D., 1926. Sigmoidal bends of the Klippen Belt between Orava and Kysuce. *Věstnik Statneho Geologickeho Ústavu ČSR*, 2: 234–345.

Andrusov, D., 1938. Etudes géologiques de la zone des klippes internes des Carpathes Occidentales. III partie: Tectonique. *Rozpravy Statneho Geologickeho Ústavu ČSR*, 9:1–135.

Aubrecht, R., Mišik, M. & Sýkora, M., 1997. Jurassic synryft sedimentation on the Czorsztyn Swell of the Pieniny Klippen Belt in Western Slovakia. In: Plašienka D. *et al.* (eds), *Alpine evolution of the Western Carpathians International Conference, Abstracts and Introductory articles to the excursion*, Geolgical Survey of the Slovak Republic, Bratislava, 53–64.

Aubrecht, R. & Oživoldová, L., 1994. Middle Jurassic–Lower Cretaceous development of the Pruské Unit in the western part of the Pieniny Klippen Basin. *Geologia Carpathica*, 45: 211–223.

Birkenmajer, K., 1958. *Przewodnik geologiczny po pienińskim pasie skałkowym*, część IV. Wydawnictwa Geologiczne, Warszawa, 1–55.

Birkenmajer, K., 1959. A new klippen series in the Pieniny Mts., Carpathians – the Czertezik Series. (In Polish, English summary) *Acta Geologica Polonica*, 9: 499–517.

Birkenmajer, K., 1963. Stratigraphy and palaeogeography of the Czorsztyn Series (Pieniny Klippen Belt, Carpathians in Poland). (In Polish, English summary). *Studia Geologica Polonica*, 9: 1–380.

Birkenmajer, K., 1970. Pre-Eocene fold structures in the Pieniny Klippen Belt (Carpathians) of Poland. (In Polish, English summary). *Studia Geologica Polonica*, 31: 1–77.

Birkenmajer, K., 1976. Jurassic: Pieniny Klippen Belt – areas of occurrence and stratigraphy, palaeogeography. In: Sokołowski, S., Cieśliński, S. & Czermiński, J. (eds.), *Geology of Poland, vol. I, Stratigraphy, part 2, Mesozoic, Wydawnictwa Geologiczne*, Warszawa: 421–443, 483–486.

Birkenmajer, K., 1977. Jurassic and Cretaceous lithostratigraphic units of the Pieniny Klippen Belt, Carpathians, Poland. *Studia Geologica Polonica*, 45: 1–158.

Birkenmajer, K., 1986. Stages and structural evolution of the Pieniny Klippen Basin, Carpathians. *Studia Geologica Polonica*, 88: 7–32.

Birkenmajer, K., 1988. Exotic Andrusov Ridge: its role in plate-tectonic evolution of the West Carpathians Foldbelt. *Studia Geologica Polonica*, 91: 7–37.

Birkenmajer, K., 2001. Pieniny Klippen Belt. Introduction, pp. 127–139. In: Paulo, A. & Krobicki, M. (eds), *Carpathian palaeogeography and geodynamics: a multidisciplinary approach, 12th Meeting of the Association of European Geological Societies, Field Trip Guide*. Państwowy Instytut Geologiczny, Kraków: 127–139.

Birkenmajer, K. & Myczyński, R., 2000. Bajocian age of the Podzamcze Limestone Formation at Stare Bystre, Pieniny Klippen Belt (Carpathians, Poland) based on its macrofauna. *Studia Geologica Polonica*, 117: 49–68.

Birkenmajer, K. & Znosko, J., 1955. Contribution to the stratigraphy of the Dogger and Malm in the Pieniny Klippen Belt, Central Carpathians. (In Polish, English summary). *Rocznik Polskiego Towarzystwa Geologicznego* (*Annales Societatis Geologorum Poloniae*), 23: 3–36.

Callomon, J. H. & Chandler, R.B., 1990. A review of the ammonite horizons of the Aalenian–Lower Bajocian stages in the Middle Jurassic of southern England. *Memorie Descrittive delle Carta Geologica d'Italia*, 40: 85–112.

Durand–Delga, M. & Gąsiorowski, M., 1970. Les niveaux à Aptychus dans les pays autour de la Méditerranée occidentale et dans les Carpathes. *Compte Rendouve Academy de Sciences Paris, série D*, 270: 767–770.

Gąsiorowski, M., 1962. Aptychi from the Dogger, Malm and Neocomian in the Western Carpathians. *Studia Geologica Polonica*, 10: 1–144.

Głuchowski, E., Krawczyk, A. J., Myszkowska, J. & Słomka, T., 1986. Lithofacies and fauna of Bajocian crinoid limestone near Dursztyn (Czorsztyn Succession, Pieniny Klippen Belt, Carpathians). (In Polish, English summary). *Studia Geologica Polonica*, 88: 143–155.

Golonka, J., Krobicki, M., Oszczypko, N., Ślączka, A. & Słomka, T., 2003. Geodynamic evolution and palaeogeography of the Polish Carpathians and adjacent areas during Neo-Cimmerian and preceding events (latest Triassic – earliest Cretaceous). In: McCann, T. & Saintot, A. (eds.) *Tracing tectonic deformation using the sedimentary record. Geological Society, London, Special Publications*, 208: 138–158.

Golonka, J., Rączkowski, W., 1984. *Objaśnienia do Szczegółowej Mapy Geologicznej Polski, Arkusz Piwniczna 1:50000. Wydawnictwa Geologiczne*, Warszawa: 1–85.

Haško, J., 1976. Czertezický vývin bradlového pásma v Zázrivej-Plešivej. *Geologicke Práce, Správy*, 85: 91–96.

Horwitz, L., 1937. Le faune et l'âge des couches à Posidonomyes (zone Piénine des Klippes, Karpates Polonaises), partie B (detailée). (In Polish, French summary). *Sprawozdania Państwowego Instytutu Geologicznego*, 9: 166–274.

Krobicki, M., 2002. Bajocian phosphatic event in the Pieniny Klippen Belt, Polish and Slovakian Carpathians. In: Martire L. (ed): *Abstracts and Program of 6th International Symposium on Jurassic Stratigraphy, Mondello, Sicily*, 103.

Krobicki, M., Wierzbowski, A., 2004. Stratigraphic position of the Bajocian crinoidal limestones and their palaeogeographic significance in evolution of the Pieniny Klippen Basin. (In Polish, English summary). *Tomy Jurajskie*, 2: 69–82

Książkiewicz, M., 1972. *Budowa Geologiczna Polski, T. IV, Tektonika, część 3, Karpaty. Wydawnictwa Geologiczne*, Warszawa: 1–228.

Mišik, M., 1997. The Slovak part of the Pieniny Klippen Belt after the pioneering works of D. Andrusov. *Geologica Carpathica*, 48: 209–220.

Mišik, M., Sýkora, M., Ožvoldová, L. & Aubrecht, R., 1994. Horná Lysá (Vršatec) – a new variety of the Kysuca Succession in the Pieniny Klippen Belt. *Mineralia Slovaca*, 26: 7–19.

Myczyński, R., 1973. Middle Jurassic stratigraphy of the Branisko Succession in the vicinity of Czorsztyn (Pieniny Klippen Belt, Carpathians). (In Polish, English summary). *Studia Geologica Polonica*, 42: 1–122.

Myczyński, R. & Wierzbowski, A., 1994. The ammonite succession in the Callovian, Oxfordian and Kimmeridgian of the Czorsztyn Limestone Formation at Halka Klippe, Pieniny Klippen Belt, Carpathians. *Bulletin of the Polish Academy of Sciences, Earth Sciences*, 42: 155–164.

Ožvoldová, L. & Frantová, L., 1997. Jurassic radiolarites from the eastern part of the Pieniny Klippen Belt (Western Carpathians). *Geologia Carpathica*, 48: 49–61.

Ožvoldová, L., Jablonský, J. & Frantová, L., 2000. Upper Jurassic radiolarites of the Czertezik Succession and comparison with the Kysuca Succession in the East-Slovak part of the Pieniny Klippen Belt (Western Carpathians, Slovakia). *Geologia Carpathica*, 51: 109–119.

Pavia, G., 1983. Ammoniti e biostratigrafia del Baiociano inferiore di Digne (Francia SE, Dip. Alpes-Haute-Provence, *Monografie Museo Regionale di Scienze Naturali Torino*, 2: 1–254.

Plašienka, D., 2003. Dynamics of Mesozoic pre-orogenic rifting in the Western Carpathians. *Mitteilungen der österreichischen geologischen Gesellschaft*, 94: 79–98.

Rakúš, M., 1990. Ammonites and stratigraphy of the Czorsztyn Limestones in Klippen Belt of Slovakia and Ukrainian Carpathians. (In Slovak, English summary). *Knihovnicka Zemneho Plynu a Nafty*, (Hodonin), 9b: 73–108.

Rioult, M., Contini, D., Elmi, S. & Gabilly, J., 1997. Bajocien. In: Cariou E. & Hantzpergue H. (coord.): *Biostratigraphie du Jurassique ouest-européen et méditeranéen. Bulletin des Centres de Recherches Elf Exploration-Production, Mémoire*, 17: 41–53.

Scheibner, E., 1964. Contribution to the knowledge of the Murchisonae Beds in the Klippen Belt of West Carpathians in Slovakia. *Geologicky Sbornik*, 15: 27–55.

Scheibner, E., 1968. The Klippen Belt of the Carpathians. In: Matejka E. (ed.), *Regional geology of Czechoslovakia, part II, The West Carpathians, Ústředni Ústav Geologický*, Praha: 304 – 371.

Schlögl, J., 2002. *Sedimentológia a biostratigrafia "ammonitico rosso" sedimentov čorštýnskeho súvrstvia čorštýnskej jednotky bradlového pásma (Západné Karpaty, Slovensko)*. Unpublished Ph.D. Thesis, Katedra Geológie a Paleontológie, Prirodovedecká Fakulta Univerzity Komenského, Bratislava.

Siemiradzki, J., 1923. Fauna utworów liasowych i jurajskich Tatr i Podhala. *Archiwum Towarzystwa Naukowego we Lwowie, III*, 3(8): 1–52.

Tyszka, J., 1995. *Mid-Jurassic palaeonvironment and benthic* *communities in the Klippen and Magura Basins, Pieniny Klippen Belt, Poland.* Upublished Ph.D. Thesis, Institute of Geological Sciences, Polish Academy of Sciences, Kraków: 1–192.

Tyszka, J., 1999. Foraminiferal biozonation of the Early and Middle Jurassic in the Pieniny Klippen Belt (Carpathians). *Bulletin of the Polish Academy of. Sciences, Earth Sciences*, 47: 27–46.

Tyszka, J. & Kamiński, M.A., 1995. Factors controlling the distribution of agglutinated foraminifera in Aalenian – Bajocian dysoxic facies (Pieniny Klippen Belt, Poland). In: Geroch M.A. *et al.* (eds), *Proceedings of the Fourth International Workshop on Agglutinated Foraminifera*, Grzybowski Foundation Special Publication, Kraków, 3: 271–291.

Wierzbowski, A., 1994. Late Middle Jurassic to earliest Cretaceous stratigraphy and microfacies of the Czorsztyn Succession in the Spisz area, Pieniny Klippen Belt, Poland. *Acta Geologica Polonica*, 44: 223–249.

Wierzbowski, A., Jaworska, M. & Krobicki, M., 1999. Jurassic (Upper Bajocian–lowest Oxfordian) ammonitico rosso facies in the Pieniny Klippen Belt, Carpathians, Poland: its fauna, age, microfacies and sedimentary environment. *Studia Geologica Polonica*, 115: 7–74.

Streszczenie

STRATYGRAFIA I PALEOGEOGRAFICZNA POZYCJA JURAJSKIEJ SUKCESJI CZERTEZICKIEJ, PIENIŃSKI PAS SKAŁKOWY (KARPATY ZACHODNIE) W POLSCE I WE WSCHODNIEJ SŁOWACJI

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Zbadane zostały szczegółowo najbardziej typowe profile sukcesji czertezickiej w pienińskim pasie skałkowym (Fig. 1) w Polsce (Pieniński Potok, Czertezik i Wysokie Skałki) oraz na Słowacji (Litmanovské Skalký, Milpoš). Badania te wykazały powszechną obecność, chociaż zredukowanego miąższościowo, "dolnego wapienia bulastego" (formacji wapienia niedzickiego) rozdzielającego wapienie krynoidowe (formacji wapienia ze Smolegowej/formacji wapienia z Flaków oraz występującej miejscami formacji wapienia z Krupianki) od formacji radiolarytów z Czajakowej (Fig. 2–4, 6, 7; por. także Birkenmajer, 1977). Jedynie w jednym z trzech przebadanych profilów w obrębie Wysokich Skałek (fIG. 4, profil C) brak jest formacji wapienia niedzickiego, a formacja radiolarytów z Czajakowej leży tu bezpośrednio na wapieniach krynoidowych formacji wapienia z Krupianki.

Dodatkowo, w obrębie wapieni krynoidowych – w niższej części formacji wapienia ze Smolegowej, znalezione zostały amonity diagnostyczne dla dolnego bajosu, a dokładniej dla najwyższej części poziomu Propinquans i dolnej części poziomu Humphriesianum (Fig. 5). Obserwacja ta łącznie z innymi obserwacjami, zarówno natury biostratygraficznej jak i sedymentologicznej (por. np. Scheibner, 1964; Krobicki, 2002), przeprowadzonymi w sukcesji czertezickiej przy dolnej granicy formacji wapienia ze Smolegowej/formacji wapienia z Flaków i podścielających utworów formacji łupków ze Skrzypnego, wskazują, że granica ta odpowiada dużej luce stratygraficznej obejmującej znaczną część dolnego bajosu (co najmniej znaczną część poziomów Laeviuscula i Propinquans) (Fig. 9). Luka ta jest nieobecna w sukcesji braniskiej, gdzie stwierdzono występowanie wskazanych poziomów amonitowych (Myczyński, 1973), a na czas jej istnienia przypada tam sedymentacja formacji łupków z Harcygrundu.

Przeprowadzone badania biostratygraficzne w obrębie formacji wapienia niedzickiego w sukcesji czertezickiej (profil Milpoš) wykazały obecność amonitów diagnostycznych dla najwyższego bajosu (poziomu Parkinsoni) oraz batonu (Fig. 8). Wskazuje to, że sedymentacja wapieni krynoidowych podścielających formację wapienia niedzickiego w sukcesji czertezickiej musiała zakończyć się, podobnie jak i w innych sukcesjach (por. Wierzbowski *et al.*, 1999), przed końcem bajosu.

Wskazane nowe dane zmieniają w znacznym stopniu dotychczasowy schemat korelacyjny, którego zmodyfikowana wersja przedstawiona została na figurze 9. Sukcesja czertezicka wykazuje szczególne pokrewieństwo do sukcesji niedzickiej i sukcesji braniskiej, a wyraźnie słabsze do sukcesji czorsztyńskiej. Jej pozycja paleogeograficzna w pienińskim basenie skałkowym znajdowała się zatem najprawdopodobniej pomiędzy sukcesją niedzicką a sukcesją braniską, a nie jak sądzono dotychczas pomiędzy sukcesją czorsztyńską, a sukcesją niedzicką (por. np. Birkenmajer, 1977).