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Stratigraphy and facies development of the upper Tithonian-lower Berriasian Niżniów Formation along the Dnister River (Western Ukraine)

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The deposits of the Niżniów Formation, exposed around Niżniów, mainly on the banks of Dnister River, accumulated in the most proximal, marginal position of the latest Jurassic-earliest Cretaceous epicontinental basin on the SW margin of the East European Platform. The Niżniów Formation directly onlaps a Palaeozoic substrate and consists of transgressive cliff-derived conglomerates, and sandstones and marls which pass laterally into shallow marine carbonates: mainly biomicrites, oncomicrites, and pelmicrites with an abundant benthic fauna dominated by nerineid gastropods. The thickness of the formation in the area studied ranges from 0 to more than 20 metres and was controlled by morphology of the pre-transgression substrate (mainly built of Devonian clastic rocks), synsedimentary fault tectonics and pre-mid-Albian erosion. The age of the Niżniów Formation can be determined, on the evidence of benthic foraminifers encountered in thin sections, as most probably late Tithonian-early Berriasian.

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Key words: Tithonian-Berriasian Ukraine, transgression, stratigraphy, facies development.

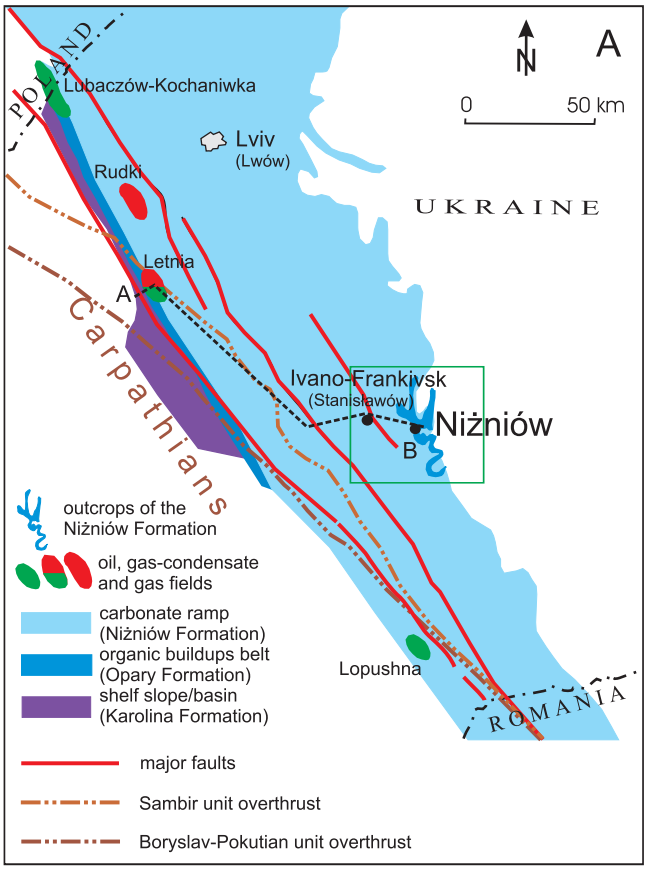
INTRODUCTION

The outcrops of Upper Jurassic deposits in the region of Niżniów[1] (Ukrainian: Nyzhniv) upon the Dnister River (Fig. 1) have not been studied in detail since the time of the classic monograph on molluscs by Alth (1881), although several Upper Jurassic formations, including the carbonate succession termed the Niżniów Formation (Russian: Nizhnievskaya svita, Ukrainian: Nyzhnivska svita), have been recognized since the 1950's in several boreholes in the Lviv Depression (Izotova and Popadyuk, 1996 and references cited therein) as potential hydrocarbon reservoir rocks . The exposures of the Niżniów region are the only ones of extra-Carpathian Upper Jurassic strata between the margins of the Holy Cross Mts. (Central Poland), the Crimea (*cf.* Popadyuk and Smirnov, 1996) and Dobrogea (*cf.* Gradinaru, 1984). Therefore, this comparative outcrop study should help better understand the facies development and stratigraphy of the Niżniów Formation in its subsurface development and should supplement the regional study of the Late Jurassic sedimentary basin of the Western Ukraine and adjoining SE Poland (Gutowski *et al*., this issue).

[1]The authors use Polish names of the localities according to these introduced to geological literature by Alth (1881).

GEOLOGICAL SETTING

The deposits studied accumulated in the most proximal, marginal position (Figs. 1 and 2) of the Late Jurassic-Early Cretaceous epicontinental sedimentary basin (Izotova and Popadyuk, 1996; Dulub *et al*., 2003; Gutowski *et al*., this issue) which developed on the SW margin of the East European Platform as the easternmost part of the epicontinental basin system of Western and Central Europe (Ziegler, 1990). The Niżniów Formation, extends widely further to the SE, S and NW of the Niżniów region throughout the Ukrainian Carpathian Foredeep (Fig. 2). It has been recognized in hundreds of exploration wells drilled in the second half of 20th century, mostly in 1950–1995. The exploration efforts have resulted in the discoveries of numerous fields, some of which produce hydrocarbons from the Upper Jurassic Niżniów and Opary Formations



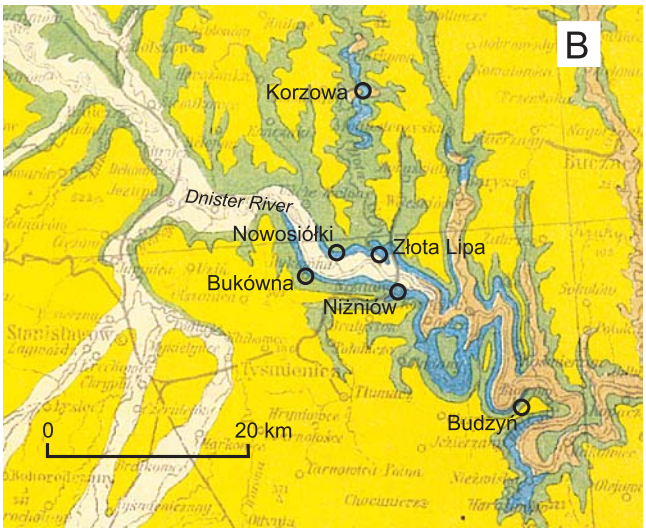


Fig. 1. Geological setting of the Niżniów region

A — palaeogeographic setting of the Niżniów area (rectangle indicates area enlarged in Fig. 1B): A–B — location of the geological cross-section (Fig. 2); **B** — location of the exposures studied against the *Geological Map of Poland* (edited by the Polish Geological Institute, 1926): blue — Niżniów Formation, beige — Quaternary, yellow — Miocene, green — Cretaceous, brown — Devonian

(for location of these fields see Fig. 1 and Fedyshyn, 1998). The bulk of the Niżniów Formation consists of bioclastic limestones formed in shallow marine conditions of open water circulation at/or just below wave base (Zhabina and Anikeeva, 2002 and references cited therein). It is commonly considered that the Niżniów Formation conformably onlaps anhydrites

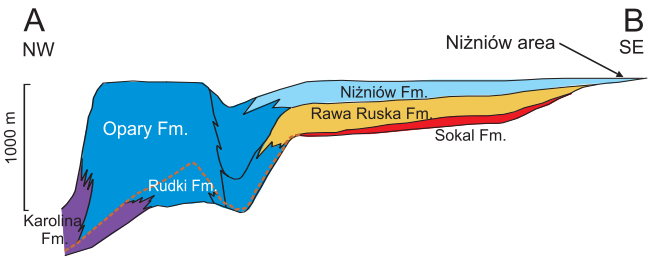


Fig. 2. Simplified geological cross-section through the Upper Jurassic formations of Western Ukraine (for location of the section see Fig. 1A)

and dolomites of the Kimmeridgian Rawa Ruska Formation (see cross-section A–B in Fig. 2). A significant change in lithology from bedded to bioconstructed (regarded as "reefal") limestone characterises the lateral contact between the Niżniów and the Opary Formations (Izotova and Popadyuk, 1996; Dulub *et al*., 2003). Both the Niżniów and the Opary Formations are strongly eroded and are overlain by Miocene strata in the most western part of the Ukrainian Carpathian Foredeep, whereas in the rest of the area discussed the Niżniów Formation is overlain by the Lower Cretaceous (Neocomian) Stawczany Formation (Utrobin, 1962; Dulub, 1972) or is unconformably overlain by Albian-Cenomanian siliciclastics deposits (Popadyuk and Bondarenko, 2001).

DESCRIPTION

Thirteen sections have been measured in six exposures (Fig. 1B) located in the vicinity of Niżniów. The samples have been collected bed by bed and then prepared for thin section analysis.

The locality of Korzowa (Fig. 3) is the most proximal exposure in which Alth (1881) described limestones and marls of Late Jurassic age. We have however not found Jurassic rocks in the abandoned large quarry in Korzowa in which Middle Devonian dolomites were mined for decades prior to 1992. Turonian marls and limestones directly overlie the unconformity developed in top of the Devonian strata at present state of the outcrop. It seems that the Upper Jurassic rocks formed residual lenses between the Cretaceous and Devonian strata which were originally preserved because of selective pre-mid-Albian erosion and were then removed in the course of quarrying. This history was deduced from the finding of Late Jurassic foraminifers in the layer resting directly above the sub-Turonian erosional unconformity (N. M. Zhabina, pers. comm.).

Conglomerates, including large (up to 1 metre in diameter) rocky blocks derived from the substrate, overlie the red Devonian sandstones, mudstones, and claystones in the locality of Budzyń (Fig. 4). The conglomerates pass successively upwards into yellowish sandstones, mudstones and marls. The total thickness of the formation exceeds 20 metres. It is overlain by Turonian marls and limestones. A similar sequence can be observed east of Niżniów, on the right bank of the Dnister River. The left bank of the river is more than 50 metres high and is composed exclusively of Devonian rocks. This suggests that the morphology of the Palaeozoic substrate, as well as the thickness of the Niżniów For-

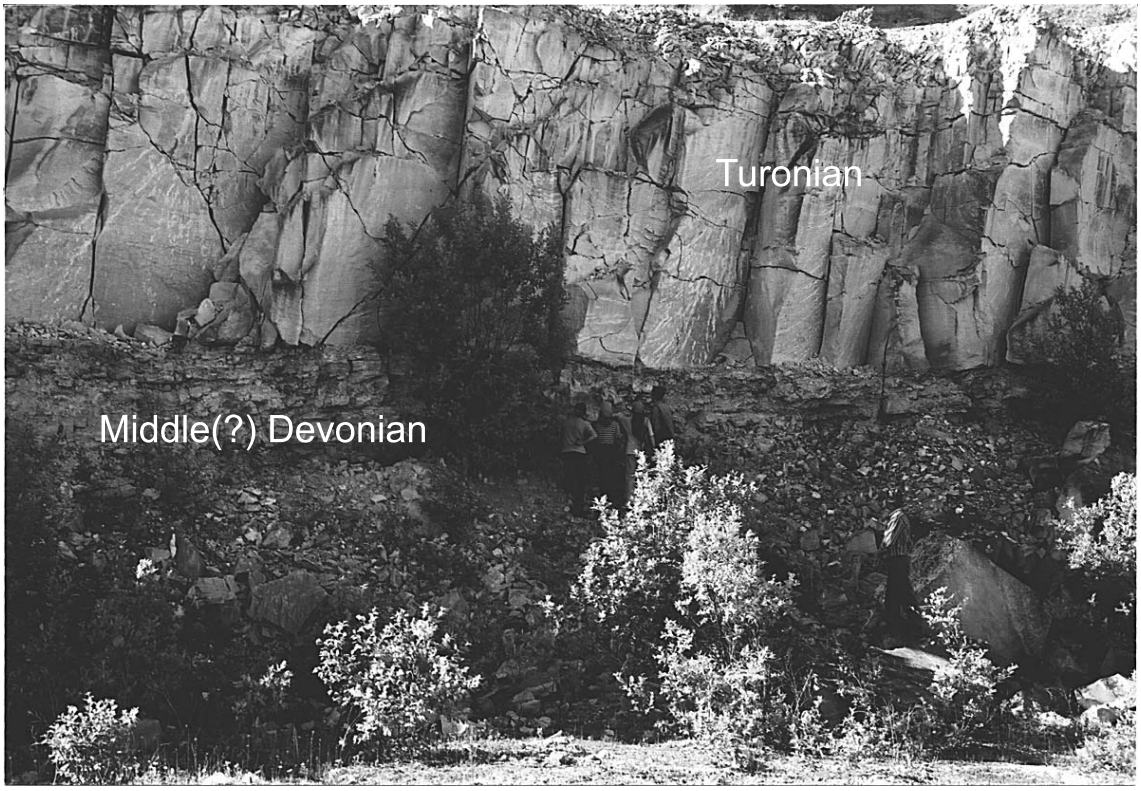


Fig. 3. Turonian siliciclastics unconformably overlying a Middle Devonian substrate at Korzowa

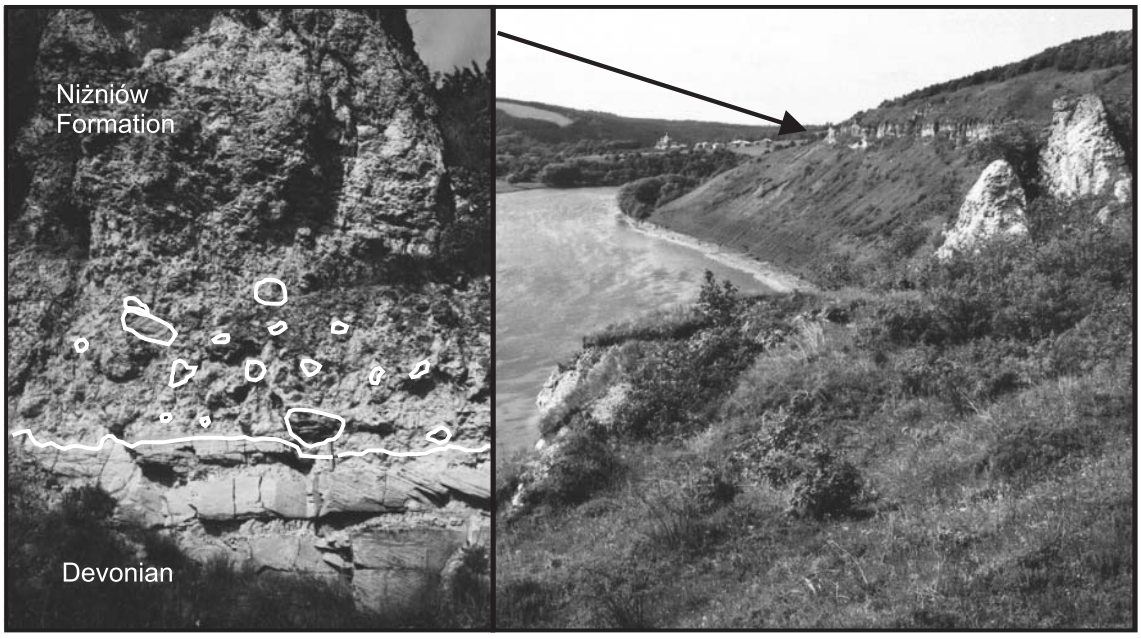


Fig. 4. Transgressive conglomerates of the Niżniów Formation overlying the abraded top of the Devonian substrate at Budzyń

mation, is highly variable, possibly at least partly due to fault tectonics during the Late Jurassic transgression.

The Złota Lipa exposure (Fig. 5) shows evidence of pre-mid-Albian erosion. The top of the "Niżniów Formation", comprising marls and micritic limestones, is overlain by green Albian sands in lows of sub-Albian surface and directly by Turonian limestones and marls on nearby highs.

The typical "Niżniów limestones"(*sensu* Alth, 1881) are exposed at Bukówna in several gorges cutting the high, right bank of the Dnister River (Fig. 6). This locality has yielded most of the macrofossils collected by A. Alth and his co-workers. Micritic limestones with bioclasts, oncoids, pellets and peloids (see Fig. 7) contain layers with abundant macrofauna (mainly nerineid gastropods) preserved as moulds. The lime-

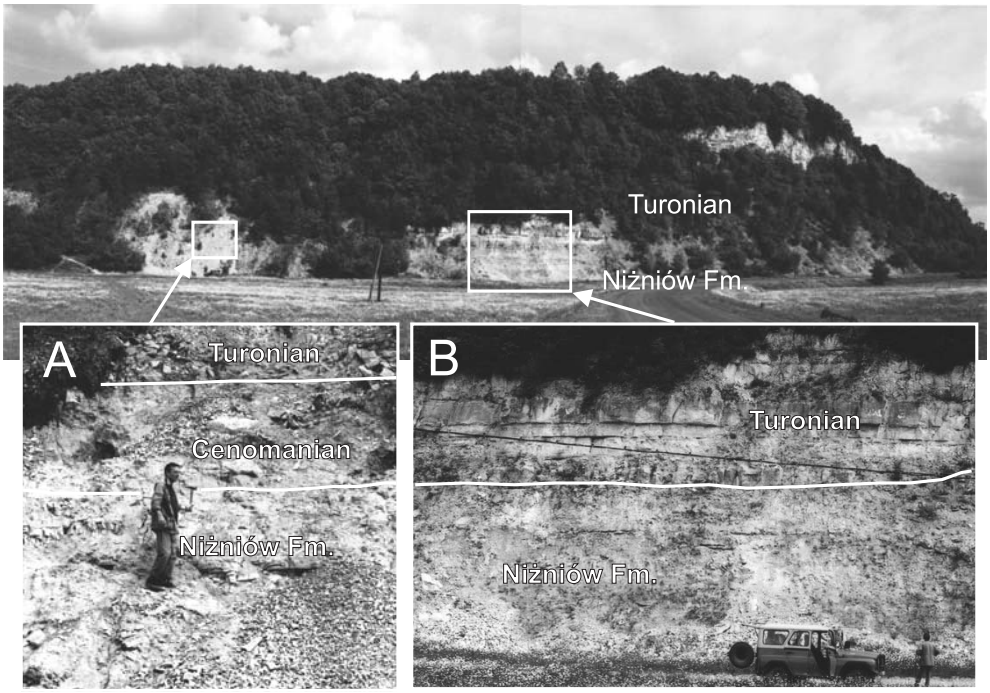


Fig. 5. Albian-Cenomanian glauconitic sandstones (A) and Turonian marls (B) overlying an abraded top of marly limestones of the Niżniów Formation at Złota Lipa

stones are in places intensively dolomitized and silicified. Locally, the rocks are very porous, probably due to selective late diagenetic dissolution. The pores (vugs) are often a few centimetres in diameter (Fig. 6) and may be empty or filled with sparite cement (Fig. 7D). The top of the Niżniów Formation forms the sub-Turonian abrasion surface. The visible part of the formation exceeds 17 metres in thickness down to river level.

The section at Nowosiółki is composed of alternations of micritic, oncolitic and also oolitic limestones. The latter are partly cross-bedded (Fig. 8).

FACIES DEVELOPMENT

The Niżniów Formation represents a maximum coastal onlap (see cross-section A–B in Fig. 2) of the Upper Jurassic/Lower Cretaceous succession on to the East European Platform. The fining upwards successions observed at Budzyń (Fig. 4) and Niżniów are interpreted as a sedimentary record of marine transgression (see Fig. 9). This transgressive sequence has been deposited along abraded rocky cliffs composed of Devonian clastic rocks. Denivelations in the palaeorelief of the Devonian

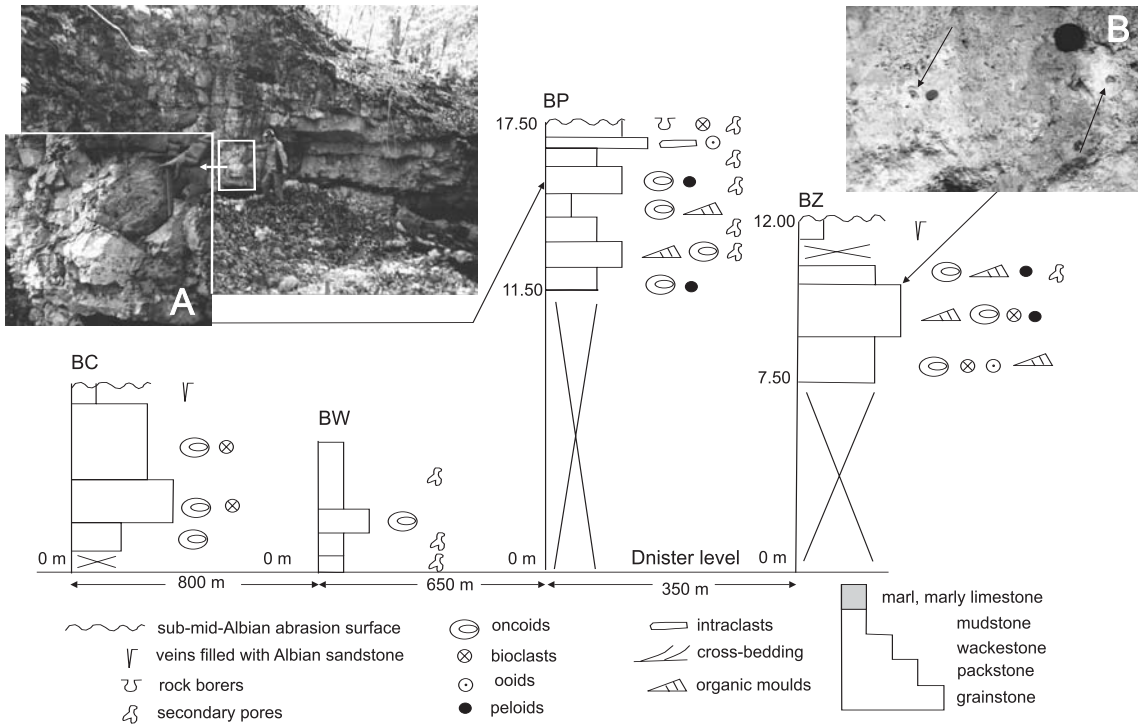


Fig. 6. Sedimentological logs of the Niżniów Formation at Bukówna

Measured sections (names according to Alth, 1881): BZ — Bukówna Zachód, BP — Bukówna Przewóz, BW — Bukówna Wschód, BC — Pidcerkownyj Perewal; A — system of secondary pores (vugs), B — nerineid moulds (arrowed)

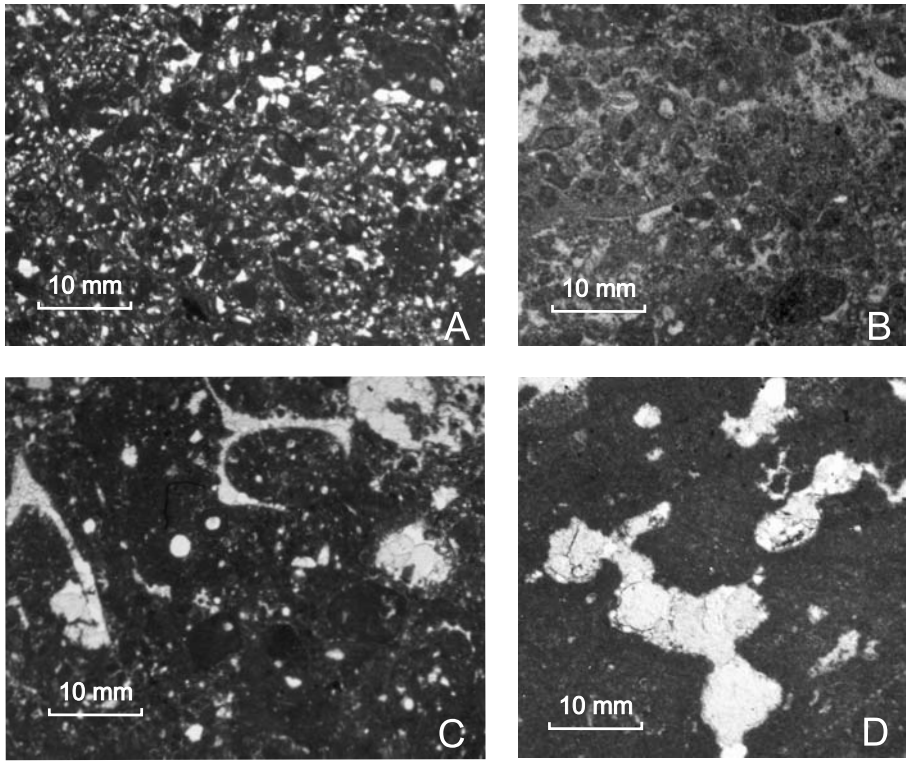


Fig. 7. Microfacies of the Niżniów limestone (all samples from Bukówna)

A — micrite with bioclasts, oncoids and peloids, **B** — bioclastic-oncoidal-peloidal micrite with secondary sparite infillings, **C** — oncoidal-peloidal micrite with gastropod shells, **D** — micrite with irregular secondary pores filled with sparite

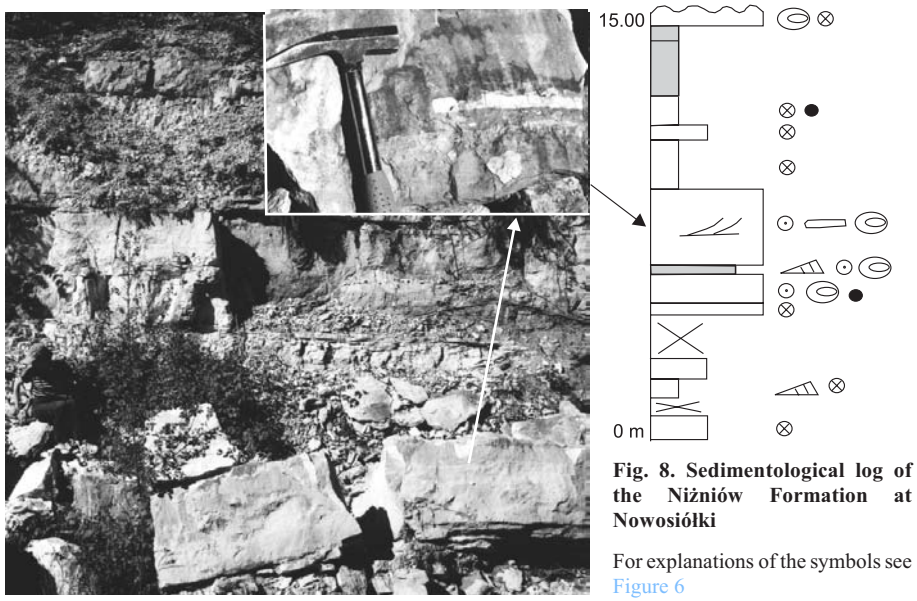


Fig. 8. Sedimentological log of the Niżniów Formation at Nowosiółki

For explanations of the symbols see Figure 6

substrate exceeded 50 metres, and were supposedly controlled by normal faults oriented NW–SE, as observed at Niżniów. This implicates tectonic control of the relative sea level rise and ensuing transgression (*cf.* Gutowski *et al.*, this issue).

The near-shore terrigenous sediments pass laterally, and probably also upwards in the sequence into carbonates at Bukówna, Nowosiółki and Złota Lipa (Fig. 9). The Bukówna succession (Fig. 6) was deposited in a quiet, normal marine environment. Oncoids, peloids and bioclasts dominate among the carbonate grains and only individual, micritized ooids appear. No high energy sedimentary structures have been observed. A benthic macrofauna is abundant at several levels. The shells are not destroyed and are probably preserved in life position. The sedimentary environment was situated most probably off-shore the oolitic barriers, below wave base or, alternatively, just behind the oolitic barriers in their hydrodynamic shadow.

Bioclasts identified in the Niżniów limestone were likely delivered from two sub-environments of the carbonate ramp: oolitic barrier and protected lagoon. Fecal pellets were supplied to the sediment by numerous Polymorphinidae, thin-walled ostracods and problematic organisms (?Decapoda) which lived in very shallow and calm, protected lagoons. There were abundant Miliolidae (*Quinqueloculina*, *Istriloculina*, *Decussoloculina*, *Moesiloculina*, *Scythiloculina*) and Valvulinidae (*Valvulina*, *Siphovalvulina*). Chlorophyta were delivered probably from "meadows" occurring in a more external part of the lagoon. Thick-walled foraminifera such as *Pseudocyclammina*, *Nautiloculina*, *Andersenolina* and *Neotrocholina* likely originated from thick mats of Cyanophyta and Codiacea and other algal-like organisms (*Thaumatoporella*, *Baccinella*) where they are usually trapped when alive. During storm events all microfossils were probably transported into adjacent depressions and accumulated in layers alternating with those of ooids derived from oolitic banks formed in a nearby high energy zone. The presence of these bioclasts and individual ooids suggest that oolitic barriers (banks) and protected lagoons probably existed near to the studied area although deposits typical of these environments have not been identified at Bukówna. Gently inclined cross-bedding has been observed in an oolitic

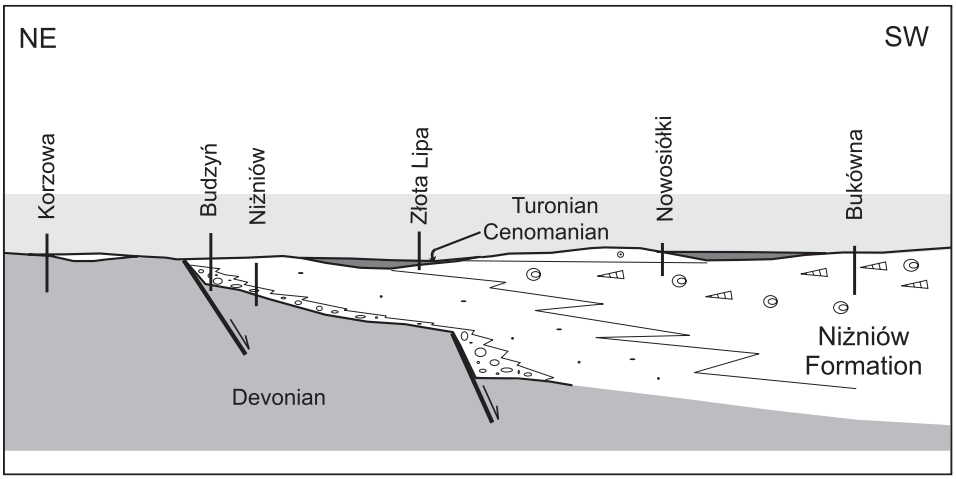


Fig. 9. Idealized reconstruction of facies development of the Niżniów Formation

The sections discussed in text are located against the facies pattern and not in their true geographic position; other explanations as on Figure 6

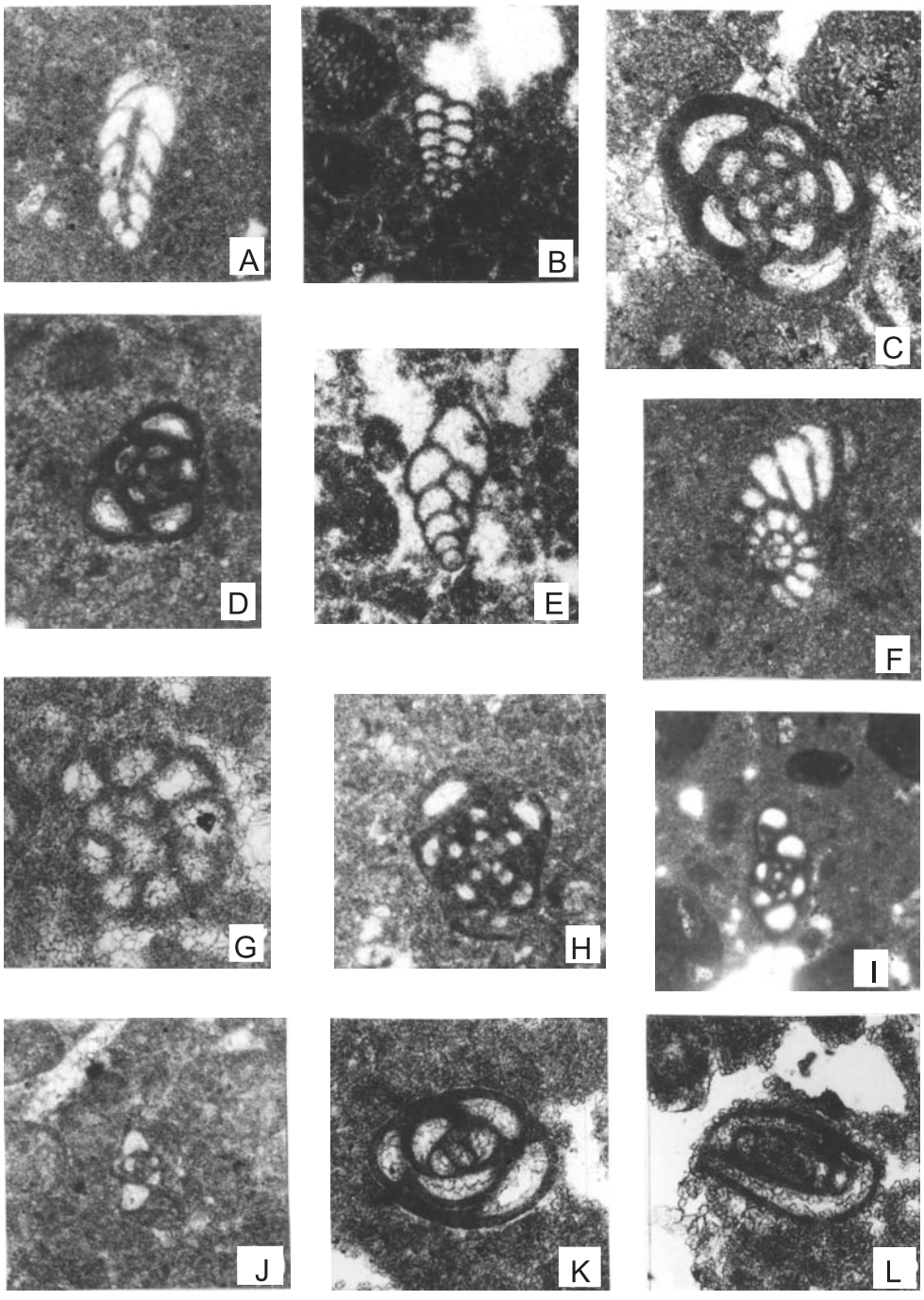


Fig. 10. Foraminifera of the Niżniów Formation (Bukówna locality; BW, BZ, BC, BP: profiles indicated on Fig. 6)

A — *Siphovalvulina variabilis* Septfontaine, longitudinal section, × 120, BW-2; **B** — *Pseudomorulaeplecta franconica* (Gümbel), longitudinal section, × 120, BZ-3a; **C** — *Quinqueloculina verbizhiensis* Dulub, lateral section, × 200, BZ-1; **D** — *Quinqueloculina podlubiensis* Terestschuk, lateral section, × 100, BC-4; **E** — *Belorussiella taurica* Gorbatchik, longitudinal section, × 200, no. 93 907; **F** — *Stomatoecha enisalensis* Gorbatchik, longitudinal section, × 100, BP-2; **G** — *Haplophragmoides joukowskyi* Charollais, Brönnimann et Zaninetti, eqatorial section, × 200, BP-J/2; **H** — *Scythiloculina confusa* Neagu, lateral section, × 120, BP-4; **I** — *Decussoloculina mirceai* Neagu, lateral section, × 120, BZ-3a; **J** — *Moesiloculina danubiana* Neagu, lateral section, Neagu, × 100, BP-J/2; **K** — *Istriloculina emiliae* Neagu, lateral section, × 120, BZ-3a; **L** — *Decussoloculina mirceai* Neagu, longitudinal section, × 120, BZ-3a

layer in the succession at Nowosiółki (Figs. 8 and 9). This succession was deposited in a more agitated shallow-water environment in which oolitic banks formed, as evidenced by ooids and intraclasts dominating in several layers.

The top of the Niżniów Formation was strongly eroded during the post-Berriasian emergence of the area and then abraded during the Albian transgression as shown by denivelations in the sub-Albian surface, observed even within an individual locality, e.g. at Złota Lipa (Figs. 5 and 9).

BIOSTRATIGRAPHIC ANALYSIS OF THIN SECTIONS

About 150 thin sections from all the localities shown on Figure 1 have been studied in the search for age-diagnostic microfossils. Most of the thin sections came from the Bukówna successions (BP, BW, BC and BZ in Fig. 6).

The fossil content of the thin sections studied is modest as a result of extensive dolomitization and probably also due to primary palaeoenvironmental conditions. Foraminifers, ostracods, calcareous algae, gastropods, polychaete worms and fecal pellets are the most common organic remains. Planktonic organisms such as calcareous dinocysts are extremely rare. Representatives of the Polymorphinidae, Miliolidae, Valvulinidae and Textulariidae dominate among foraminifers (see Fig. 10). The species identified appear frequently and are characteristic of areas of shallow-water carbonate sedimentation. Ostracods are represented by forms with very thin, unornamented carapaces. The calcareous algae belong to the Chlorophyta (*Pratumiella*, *Actinoporella*, *Clypeina*, *Salpingoporella*), Rhodophyta (*Marinella*), Cyanophyta (*Girvanella*). Rare fragments of the microproblematic *Thaumatoporella parvovesiculifera* Rainieri and *Baccinella irregularis* Radoičič were also identified. Gastropods are represented mainly by the genus *Nerinea* and polychaete worms by one species: *Terebella lapilloides* Münster. Fecal pellets are rather poorly preserved, making their specific identification difficult.

The age of the Niżniów limestone was designated for the first time by Alth (1881), based on the similarity of its mollusc assemblages to those known from Kimmeridgian-Portlandian successions of Western Europe. Foraminifers of the Niżniów limestone were described for the first time by Cushman and Głażewski (1949). Recent investigation has revealed the occurrence of 26 species of foraminifera of known age extent (see Fig. 11) on which the stratigraphic position of the Niżniów limestone may be assessed. The oldest assemblage is composed of species with their first appearance (FAD) in the Early-Middle Jurassic, although the most abundant species have their first appearance in the Tithonian. The youngest identified species have their first appearance (FAD) in the Berriasian. A characteristic assemblage of foraminifera (reported after Cushman and Głażewski, 1949) contains the following species: *Nautiloculina oolithica* Mohler, *Quinqueloculina verbizhiensis* Dulub, *Q. podlubiensis* Tereschuk, *Trocholina elongata* (Leupold), *T. alpina* (Leupold), *Charentia compressa* (Cushman et Głażewski). These authors described about 25 species of foraminifera (mostly new) from the Niżniów limestone of Bukówna. Unfortunately these identifications have not been revised and the taxonomic status of some species is unclear. Additionally, no foraminifera from the thin sections have yet been described, excluding direct correlation of the recent results.

The age of the Niżniów limestone may be determined by the co-occurrence of *Protopeneroplis striata* Weynschenk, known so far from deposits regarded as Liassic-Tithonian in the Mediterranean Tethys (Septfontaine, 1974) and *Moesiloculina danubiana* Neagu, known so far from deposits regarded as late Berriasian-early Aptian of S Dobrogea and

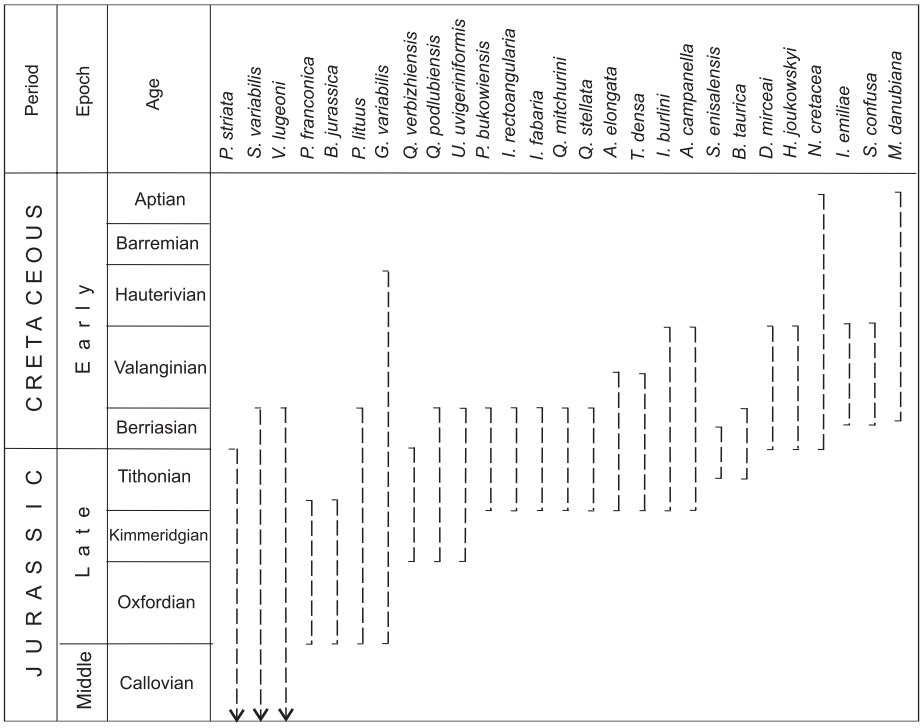


Fig. 11. Stratigraphic range of selected foraminifera of the Niżniów Formation (Bukówna locality)

France (Neagu, 1986). Both these forms occur together in the measured successions at Bukówna (Fig. 6) and, therefore, the co-occurrence most probably indicates a late(?) Tithonian-early Berriasian age. The pre-mid-Berriasian age of the discussed succession can be shown by rare specimens of *Calpionella elliptica* Cadish which have been reported from the upper part of the Stawczany Formation (Utrobin, 1962), which overlies the Niżniów Formation. It may suggest that the Niżniów Formation is older than the mid-Berriasian calpionellid Zone C (*cf*. Wierzbowski and Remane, 1992; Reháková and Michalik, 1997). The Niżniów Formation may be regarded as the stratigraphic equivalent of the Babczyn Formation of the SE Lublin Upland, Poland (Gutowski *et al*., this issue) whereas the Cieszanów Formation of the Lublin Upland (Niemczycka, 1976) corresponds to the Stawczany Formation. The Niżniów Formation can be also paralleled with the Štramberk type carbonates which developed widely in the more southern part of the Tethyan shelf, overthrusted at present by the Carpathian nappes (see Kutek, 1994; Hoffmann and Kołodziej, 2004; Gutowski *et al*., this issue).

CONCLUSIONS

1. Deposits of the Niżniów Formation, exposed in the region of Niżniów, mainly on the banks of the Dnister River, were deposited in the most proximal, marginal position (Fig. 2) of the latest Jurassic-earliest Cretaceous epicontinental basin of W Ukraine (Izotova and Popadyuk, 1996; Zhabina and Anikeeva, 2002; Gutowski *et al*., this issue). The formation represents a maximum coastal onlap (see cross-section A–B in Fig. 2) of the Upper Jurassic/Lower Cretaceous succession onto the East European Platform.

2. The Niżniów Formation is interpreted, in the area studied, as a transgressive succession and consists of conglomerates, sandstones and marls which pass laterally and also upwards in the sequence (Fig. 9) into carbonates, mainly biomicrites, oncomicrites, and pelmicrites with an abundant benthic fauna, dominated by nerineid gastropods (*cf*. Alth, 1881). The thickness of the formation ranges in the studied area from 0 to more than 20 metres and was controlled by the morphology of the pre-transgression substrate (mainly built of Devonian clastic rocks), synsedimentary fault tectonics and pre-mid-Albian erosion.

3. The age of the Niżniów Formation can be determined from analysis of benthic foraminifers in thin sections, as most probably late Tithonian-early Berriasian.

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