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The Ordovician rocks of Pobroszyn in the Łysogóry region of the Holy Cross Mountains, Poland

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In the village of Pobroszyn near Opatów, a faulted section of Ordovician deposits represented by upper Tremadoc clayey-silty lithofacies, upper Arenig carbonate-phosphorite lithofacies and Upper Ordovician claystones with limestone interbeds, were identified. The upper Tremadoc is dated on basis of acritarch. This is the first time that upper Tremadoc deposits have been documented in the Łysogóry region. The late Arenig transgressive deposits were probably preceded by emergence in the latest Tremadoc and early Arenig. The Ordovician rocks from Pobroszyn are intensely tectonised. Two groups of faults, oblique and longitudinal, are distinguished. The first one strikes from 120–140°, and dip to NE at 40–45°, and the second one that strikes 15–25° and dips 65–80° to E.

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Key words: Holy Cross Mountains, Łysogóry region, Ordovician, lithofacies, acritarchs, tectonics.

INTRODUCTION

In the Łysogóry region of the Holy Cross Mountains, Ordovician rocks have been mainly identified in boreholes, as solid exposures are scarce.

In 1998 the authors dug 3 pits at Pobroszyn, which exposed almost the entire Ordovician section (Figs. 1, 2). The contacts of the Ordovician deposits with Cambrian and Silurian rocks, and the lithologic units together with their contacts, were identified.

The sedimentological investigations described here were based on macroscopic observations and examinations of 25 thin sections, mostly of limestone and siltstone. The tectonic studies included macroscopic observations of tectonic mesostructures supported by strike and dip measurements of bedding and tectonic surfaces. Samples of clays and silts were sampled and analyzed for acritarchs. A palynoflora from the Cambrian-Tremadoc rocks was described and some of the acritarchs were identified.

HISTORY OF STUDIES AND GEOLOGICAL SETTING

The Ordovician deposits of Pobroszyn were originally described by Samsonowicz (1934). Tomczyk (1957), Czarnocki (1950), Tomczykowa (1968), Bednarczyk (1971, 1981), Kowalczewski *et al.* (1976) also commented on the Ordovician rocks from this section. Those studies were mainly focussed on the stratigraphy of the Pobroszyn section and on the geological structure of the Opatów district; neither sedimentological nor detailed palaeontological studies were carried out.

In the Łysogóry region of the Holy Cross Mountains, continuous sedimentation of dark *"Dictyonema"* clays was taking place from the Late Cambrian to the early Tremadoc (Tomczyk and Turnau-Morawska, 1967; Tomczykowa, 1968), though there is little palaeontological evidence for the presence of Tremadoc sediments, for it is uncertain that fragments of dendroid graptolites are of Tremadoc taxa. Previous studies showed a stratigraphical gap between the upper Tremadoc and upper Llanvirn deposits in the Jeleniów IG 2 borehole (Fig. 1). In the late Llanvirn, carbonates, known from boreholes

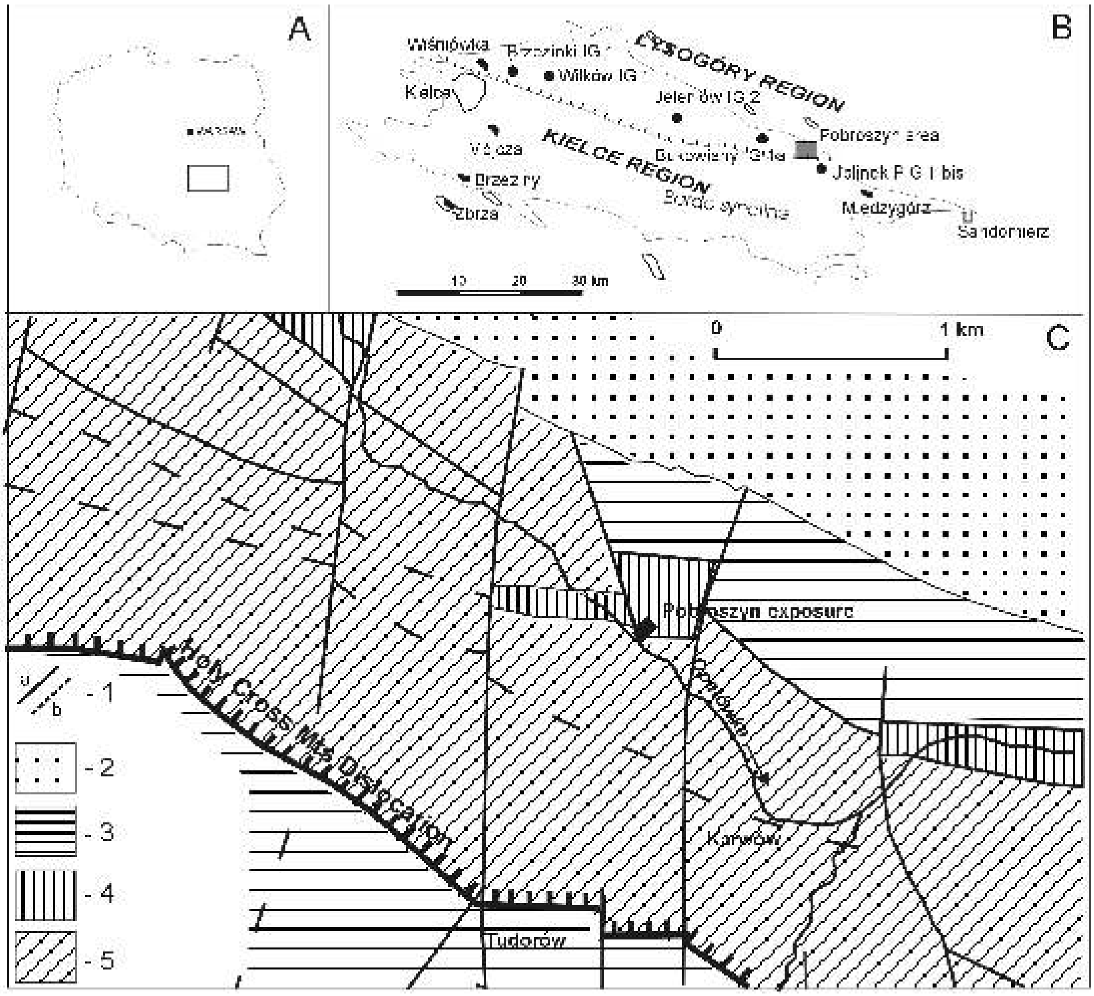


Fig. 1. Location map of the Pobroszyn section: **A** — Location of the Holy Cross Mountains in Poland; **B** — Palaeozoic block boundaries in the Holy Cross Mountains and location of the Pobroszyn section; **C** — Geological structure of the area of Pobroszyn (according to Kowalczewski *et al.*, 1976, modified)

1 — faults: a — confirmed, b — inferred; 2 — Permo-Mesozoic, 3 — Devonian, 4 — Ordovician and Silurian, 5 — Cambrian

Bukowiany IG 1a and Jeleniów IG 2, predominated (Tomczyk and Turnau-Morawska, 1967; Tomczykowa, 1968; Bednarczyk, 1971, 1981; Kowalczewski, 1972, 1994; Kowalczewski and Wróblewski, 1971, 1974). In the Caradoc, transgression of the *Nematograptus gracilis* Zone, dark grey claystones were deposited (Tomczyk and Turnau-Morawska, 1967; Tomczykowa, 1968; Deczkowski and Tomczyk, 1969). In the late Ashgill, a lowered sea level was marked by the deposition of limestones, sandstones and siltstones in many sections in the Łysogóry region (Czarnocki, 1950; Kielan, 1956, 1959; Tomczykowa, 1968; Deczkowski and Tomczyk, 1969).

LITHOFACIES AND DESCRIPTION OF THE POBROSZYN SECTION

Ordovician rocks crop out in the village of Pobroszyn, 4 km east of Opatów, in the Opatówka River valley (Fig. 1). These rocks are faulted against Cambrian rocks developed as variegated siltstones with reddish and brownish-grey thin- and medium-bedded quartzitic sandstones. The bottom surfaces of these sandstones contain many traces of the trilobite ichnogenera *Cruziana* and *Rusophycus* (Pl. I, Fig. 3). The top of the Ordovician succession is faulted against brown-grey Silurian shaley claystones. The exposed Ordovician section includes the following lithofacies:

Clayey-silty lithofacies. This is about 14.0 m thick (Fig. 2; packages A and C — Fig. 3; Pl. I, Fig. 1) encompassing dark grey claystones with thin-bedded siltstones and fine-grained sandstones cemented by silica (resembling quartzitic arenites). At the top these claystones are olive, becoming rusty-yellow and porous within a 30-cm zone close to the contact with overlying rocks developed in a carbonate-phosphorite lithofacies. This change of colour is connected with an increase in porosity and fissure spacing. In the upper portion of this section, an increase in silica-cemented siltstone and sandstone interbeds was noted. Some of these are lenticular resembling erosional channels. Within this facies, infaulted grey calcareous sandstones with phosphate brachiopod shells occur (Samsonowicz, 1934). The thickness of these sandstones is about 0.8 m (package B — Fig. 3; Pl. I, Fig. 2).

Carbonate-phosphorite lithofacies. Deposits of this lithofacies dated by conodonts on the upper Arenig (Dzik,

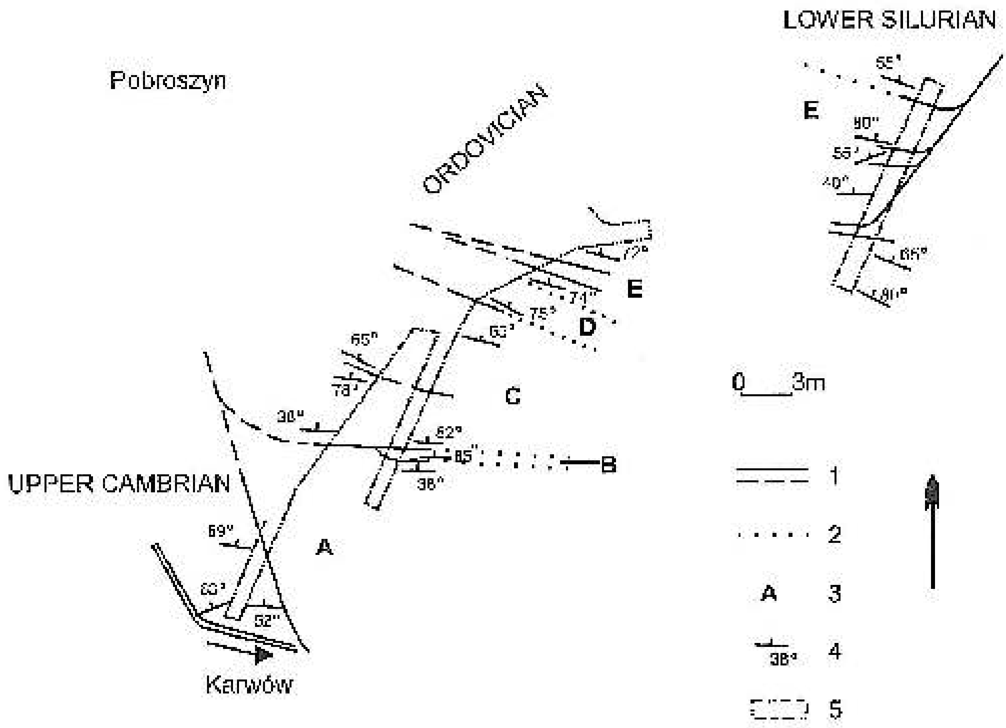


Fig. 2. Scheme of field works at Pobroszyn

1 — faults, 2 — boundaries of lithological successions, 3 — lithological complexes, 4 — strikes and dips, 5 — field data

1999) are about 3.6 m thick (package D — Fig. 3; Pl. I, Fig. 1) including:

— 20-cm bed of grey-green limestone with pebbles of 0.2–3 cm in diameter (Pl. II, Figs. 2, 3). The pebbles consist of black claystone, siltstone (cemented by silica), phosphorite, fine-grained sandstone (cemented by phosphate), quartz, and ferric (hematite) amorphous concentrations and grains. The pebbles are irregularly scattered in a groundmass; in some places form concretions. This bed includes erosional surfaces impregnated with ferric minerals. Most of the intergranular spaces and pebbles are encrusted with iron compounds.

— 20-cm bed of red limestones with low-angle cross-bedding, synsedimentary faults and small erosional channels (Pl. II, Fig. 3).

— 20-cm bed of carbonate-phosphorite rock showing a clotted-grainy structure composed of intraclasts up to 4 cm in diameter, crinoid detritus (Pl. II, Fig. 4) and phosphorite ooids. The intraclasts consist of limestones with pebbles and dark phosphorite rock.

— 3-m thick package of green-grey limestones and marly claystone with numerous spherical and discoidal phosphorite concretions (Pl. III, Fig. 2). The rounded concretions are about 0.5–4.0 cm in diameter, whereas the discoidal ones vary from 2 to 10 cm in diameter (Pl. III, Figs. 3, 4). These deposits contain dark grey and black phosphorite rock interbeds 5–15 cm thick, and show horizontal lamination (Pl. III, Fig. 1), as well as evidence of erosion and reworking marked by grey-brown small intraclasts reaching 0.5 cm in diameter.

At the bottom of the limestone bed with pebbles, calcite layers varying from 0.2 to 2.0 cm in thickness occur (Pl. III, Figs. 1, 2); on becoming thinner they assume lens-shaped forms. They consist two layers of calcite crystals. The thinner one is composed of small, isometric crystals about 0.1–0.3 mm in diameter, and the other consists of columnar crystals 0.5–1.0 mm long. Some of these layers are separated by 1-mm thick micrite and microsparite laminae. The calcite layers resemble microstalactite druse and crust (Thrailkill, 1976; Folk and Assereto, 1976; Esteban and Klappa, 1983; Vera *et al.*, 1988).

Within the pebbly limestone thin (0.2–1.0 cm thick), indistinctly laminated, brown-rusty overgrowths impregnated with iron occur (Pl. II, Figs. 1, 2). They show traces of mechanical disruption and erosion, dissolving and renewed precipitation. Small hollows are infilled with lithoclasts, phosphate-ferric ooids and pisoids, and other grains. These surfaces look like caliche (James, 1972; Read, 1974; Harrison, 1977; Harrison and Steinen, 1978; Esteban and Klappa, 1983; Peryt, 1984).

Grey claystone lithofacies. Deposits of this facies are about 15 m thick and strongly tectonically deformed (package E — Fig. 3), which makes any sedimentological analysis difficult. These rocks are dark grey with an olive and brown tint. At the bottom, a 1-m thick package of infaulted black claystones occur. They contain numerous siltstone interbeds reaching

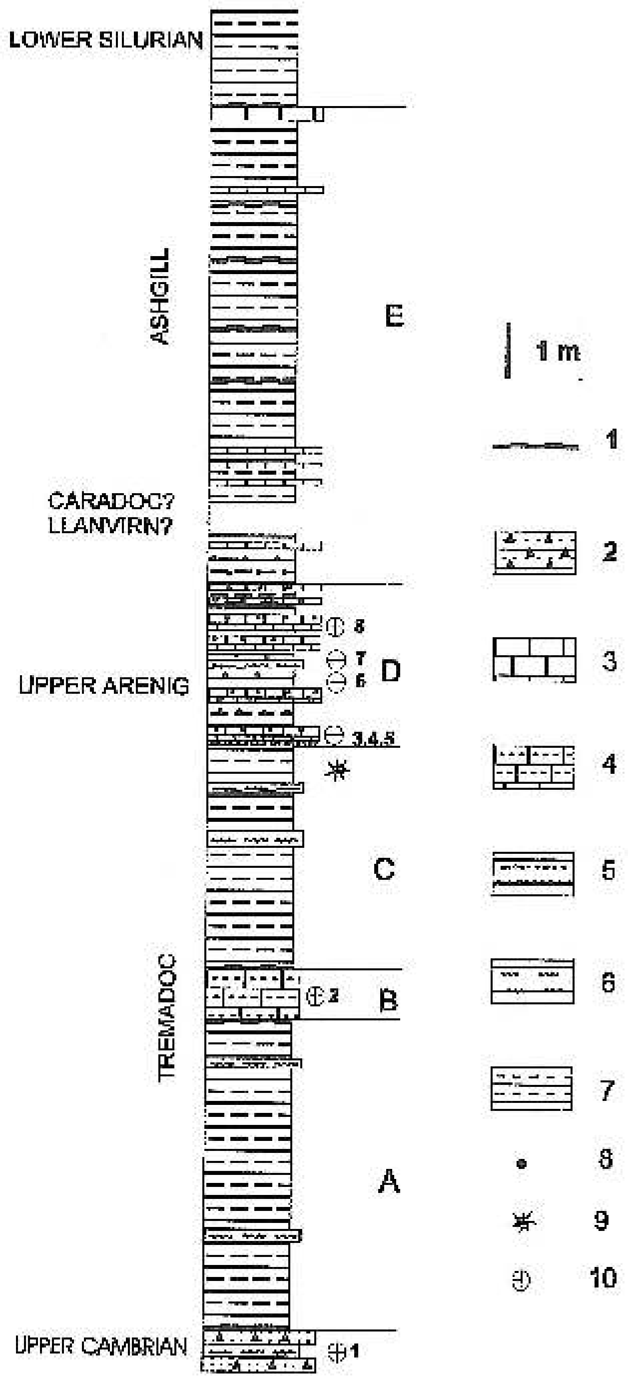


Fig. 3. Ordovician section studied at Pobroszyn

1 — tectonic contacts, 2 — quartzitic sandstones, 3 — limestones, 4 — calcareous sandstones, 5 — limestones with pebbles, 6 — siltstones, 7 — claystones, 8 — phosphorite concretions, 9 — locations of identifiable acritarchs, 10 — lithologic samples placed in the plates, A–E — lithofacies packages

2 cm in thickness; but their relationships are hard to determine due to tectonic modification. The deposits are gently horizontally laminated. In this portion of the section, scarce thin interbeds of lydite, phosphorite-ferric rock and sideritic limestone up to 5 cm thick occur. At the top a 10-cm grey limestone bed is present.

PALYNOLOGICAL STUDIES

In Pobroszyn section preliminary palynological (acritarch) analyses were carried on the clayey-silty lithofacies (packages A and C), as well as of the dark grey Ordovician (Figs. 2, 3) claystone (package E — Fig. 3).

Neither the Cambrian sediments nor the dark grey claystone lithofacies (E) contained any identifiable organic remains. Scarce carbonized detritus indicates that the lack of acritarchs in these rocks is due to thermal degradation.

In the clayey-silty lithofacies (packages A and C), a rich although damaged palynoflora was found. Most of the samples derived from complexes A and C contain poorly preserved specifically, unidentifiable acritarchs; forms of characteristic diacriodal symmetry (Diacromorphitae), those with a large polar opening (“galeate”), and radially symmetrical forms prevail here (*Polygonium*). Similar assemblages occur in uppermost Cambrian and Tremadoc sediments worldwide (Vanguestaine, 1974; Martin and Dean, 1981, 1988; Vanguestaine and Van Looy, 1983; Welsch, 1986; Di Mila *et al.*, 1989; Volkova, 1990; Martin, 1992).

Specimens identifiable to species level were found only in one sample from the upper portion of package C (Fig. 3; Pl. IV). The following species were documented: *Acanthodiacrodium* sp., ?*Caldariola* sp., ?*Cymatiosphaera* sp., *Cymatiogalea* sp., *Cymatiogalea polygonophora* Górka, *Dasydiacrodium* sp., *Ladogiella* sp., *Lophodiacrodium* sp., *Arbusculidium* sp., *Arbusculidium destombesii* Denuff, *Stelliferidium* cf. *modestum* (Górka), *Stelliferidium* sp., *Vulcanisphaera* sp. and *Peteinosphaeridium* sp. This assemblage differs from the uppermost Cambrian microflora, known from the Wilków IG 1 borehole and the Mąchocice (Szczepanik, unpublished). There are considerably fewer forms of diacrioidal symmetry *(Acanthodiacrodium, Dasydiacrodium)*, and far more acritarchs of the genera *Polygonium*, *Cymatiogalea*, *Stelliferidium* and *Multiplicisphaeridium*. The species *Cymatiogalea polygonophora* Górka, *Stelliferidium* cf. *modestum* (Górka), and the other acritarch genera *Caldariola* and *Peteinosphaeridium* may indicate upper Tremadoc or perhaps Tremadoc/Arenig boundary rocks. The taxonomic composition of this assemblage is similar to the late Tremadoc and Tremadoc/Arenig assemblage in the Bardo Syncline (Górka, 1969, 1990; Szczepanik, 1997*b*). It should be stressed here that acritarchs were found only in the higher (more northern) part of package C (Fig. 3). It cannot be excluded that the southern part, tectonically contacted with Cambrian rocks, may be older.

Colours of acritarchs from lithofacies A and C are generally black, in places dark brown, indicating palaeotemperatures above 100°C. A high degree of thermal alteration is typical for Lower Palaeozoic microflora of the Łysogóry region (Szczepanik, 1977*a*). The coeval rock successions from the Bardo Syncline and from the remaining areas of the Kielce region possess well-preserved acritarch assemblages showing no thermal alteration (Szczepanik, 1997*a, b*). Even at Ublinek, located only 5 km south from Pobroszyn, the microflora ascribed to the Cambrian/Tremadoc boundary shows a very low degree of thermal alteration.

STRATIGRAPHY

The presence of Tremadoc acritarchs in clayey-siltstone lithofacies of package C, and their position above Cambrian quartzitic rocks and below a carbonate-phosphorite Arenig succession (Dzik, 1999), indicates a chronostratigraphic position similar to that of the **Klonówka Shale Formation** (Orłowski, 1975).

The presence of lower Tremadoc claystones in sections Jeleniów IG 2 and Brzezinki IG 1 (Tomczyk and Turnau-Morawska, 1967; Tomczykowa, 1968) and late Tremadoc acritarchs in the Pobroszyn section may indicate continuous sedimentation in the Łysogóry region spanning the Cambrian to late Tremadoc interval. It cannot be excluded though that there were separate transgressions in the Late Cambrian and Tremadoc.

It should be noted that the acritarch species *Vulcanisphaera frequens* (Górka), *Cymatiogalea nebulosa* (Denuff) and *Peteinosphaeridium trifurcatum* (Eisenack), described by M. Moczydłowska in the Wiśniówka quarry (Moczydłowska in: Kowalczewski *et al.*, 1986), seem to indicate an younger age than the early Tremadoc. The species mentioned are also known from the upper Tremadoc **Zbilutka Siltstone and Chalcedonite Member** (Górka, 1969). They may hold the same stratigraphic position as microflora from an individual sample found at the top of package C at Pobroszyn. Both at Wiśniówka and Pobroszyn, a tectonic contact between the clayey-silty sediments and the Middle and Upper Cambrian quartzitic complexes was recorded. It cannot directly be confirmed that there is a continuous sedimentary sequence spanning Upper Cambrian to Tremadoc deposits, as is typical for the Klonówka Shale Formation (Orłowski, 1975). The brachiopods found within calcareous sandstones (package B — Fig. 3) also suggest the presence of upper Tremadoc deposits (Bednarczyk, pers. comm.).

The presence of lower Tremadoc rocks in the Łysogóry region of the Holy Cross Mountains is documented only by dendroid graptolites described as *Dictyonema* sp. by Tomczykowa (1968); their stratigraphic significance is questionable because this genus spans the Cambrian to the Carboniferous, and these specimens need further study. In the Brzezinki IG 1 borehole, below a depth (79.0 m) where a fragment of *Dictyonema* was found, graptolites of the genus *Bryograptus* (depth 87.2–88.9 m) occur, which may indicate at least an upper Tremadoc age for this succession (Czarnocki and Dembowska, 1950 in: Tomczykowa, 1968).

There is no certain evidence that sedimentation was continuous between the Cambrian and Tremadoc. The Tremadoc sediments (at Wiśniówka and Pobroszyn) may represent the upper portion of this stage, holding the same stratigraphic position as in the Kielce region. In the carbonate-phosphorite lithofacies of the Pobroszyn section, Dzik (1999) identified late Arenig (uppermost Volkhov and Kunda) conodonts. The deposits of this lithofacies show considerable similarity to upper Llanvirn carbonate rocks from the Jeleniów IG 2 and Bukowiany IG 1a boreholes (Tomczyk and Turnau-Morawska, 1967; Bednarczyk, 1971; Kowalczewski and Wróblewski, 1971, 1974; Kowalczewski *et al.*, 1976) where they overlie Tremadoc claystones. These rocks were assigned to the **Bukowiany Limestone Formation** (upper Llanvirn) (Bednarczyk, 1981).

The similarity of lithological sections at Pobroszyn and Bukowiany suggests that conodonts from contacts between Tremadoc claystones and carbonate deposits should be reexamined, to enables precise age determination of these sediments, particularly as closely located lithologically similar sections, have yielded different biostratigraphical ages. Eustatic changes of the sea level inferred in the Ordovician, and the common occurrence of carbonate-phosphorite lithofacies, point to two independent transgressive episodes which left very similar sediments.

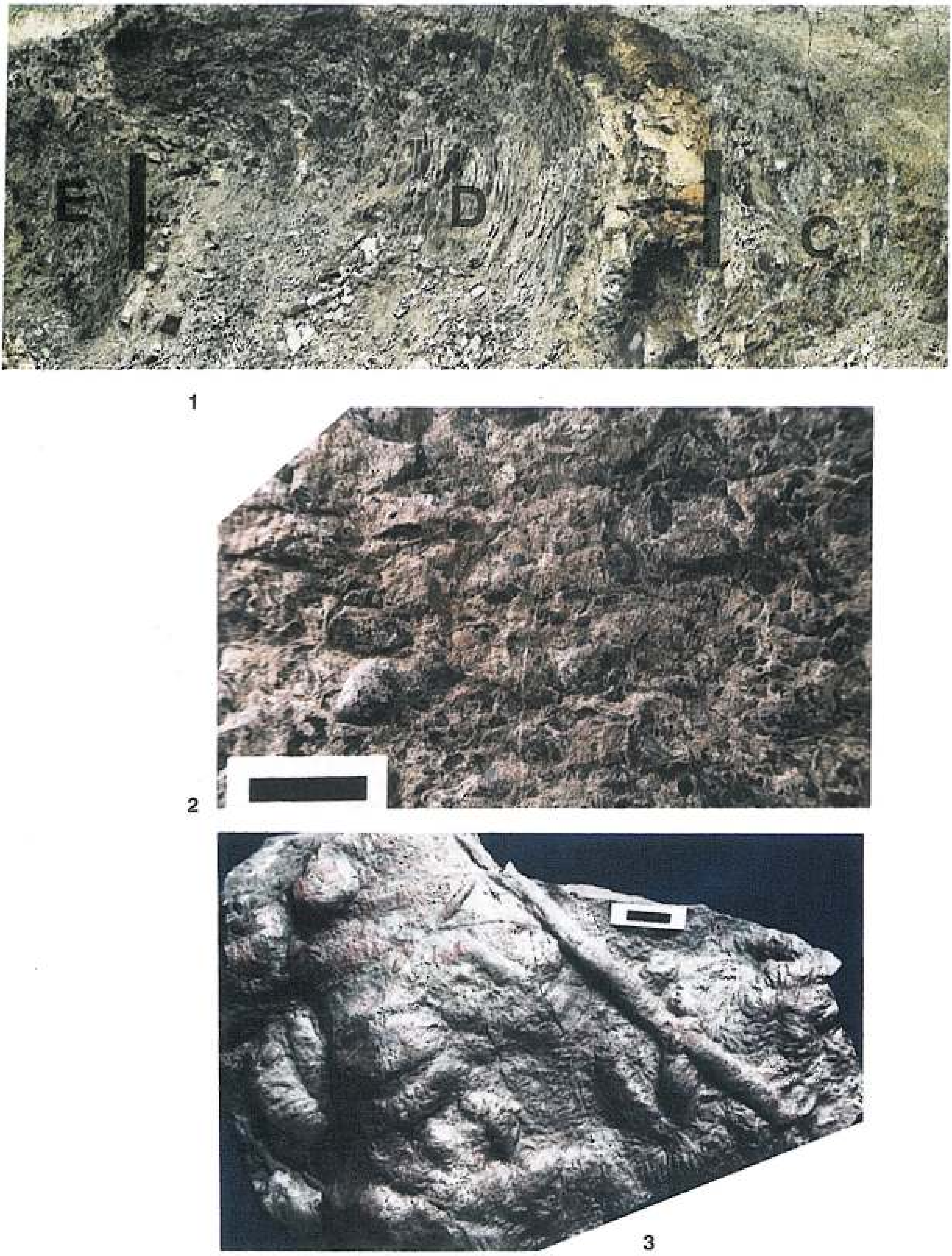
In the highest limestone interbed, placed at the top of the clayey succession (package E, Fig. 3) and probably assigned to the **Jeleniów Claystone Formation** (Caradoc) (Bednarczyk, 1981), Dzik (1999) identified conodonts spanning the latest Caradoc to Ashgill. The presence of lower Caradoc deposits in the Pobroszyn section was supported by the graptolite taxa: *Climacograptus* sp. and *Diplograptus* cf. *multidens* Elles et Wood (Samsonowicz, 1934; Tomczyk, 1957; Tomczykowa, 1968). The limestone interbeds observed at the top of this section are lithologically similar to carbonate deposits from the Wilków IG 1 borehole (Deczkowski and Tomczyk, 1969) ascribed to the **Wólka Siltstone Formation** (Ashgill) (Bednarczyk, 1981).

SEDIMENTARY ENVIRONMENTS

Sedimentological studies and reconstructions of sedimentary environments are hard to carry out because of tectonic deformation of the Tremadoc and Upper Ordovician deposits in this section, and so attention is focussed on the Arenig rocks and on their contact with the underlying Tremadoc rocks. At the Cambrian/early Tremadoc boundary of the Łysogóry region, sedimentation occurred below wave base, in a deep shelf setting (Tomczyk and Turnau-Morawska, 1967; Studencki, 1994). Lithological development of upper Tremadoc sediments at Pobroszyn suggests calm conditions that favoured the accumulation of clays. Individual thin layers and lenses of siltstones and fine-grained sandstones were probably linked to short and sudden storm episodes.

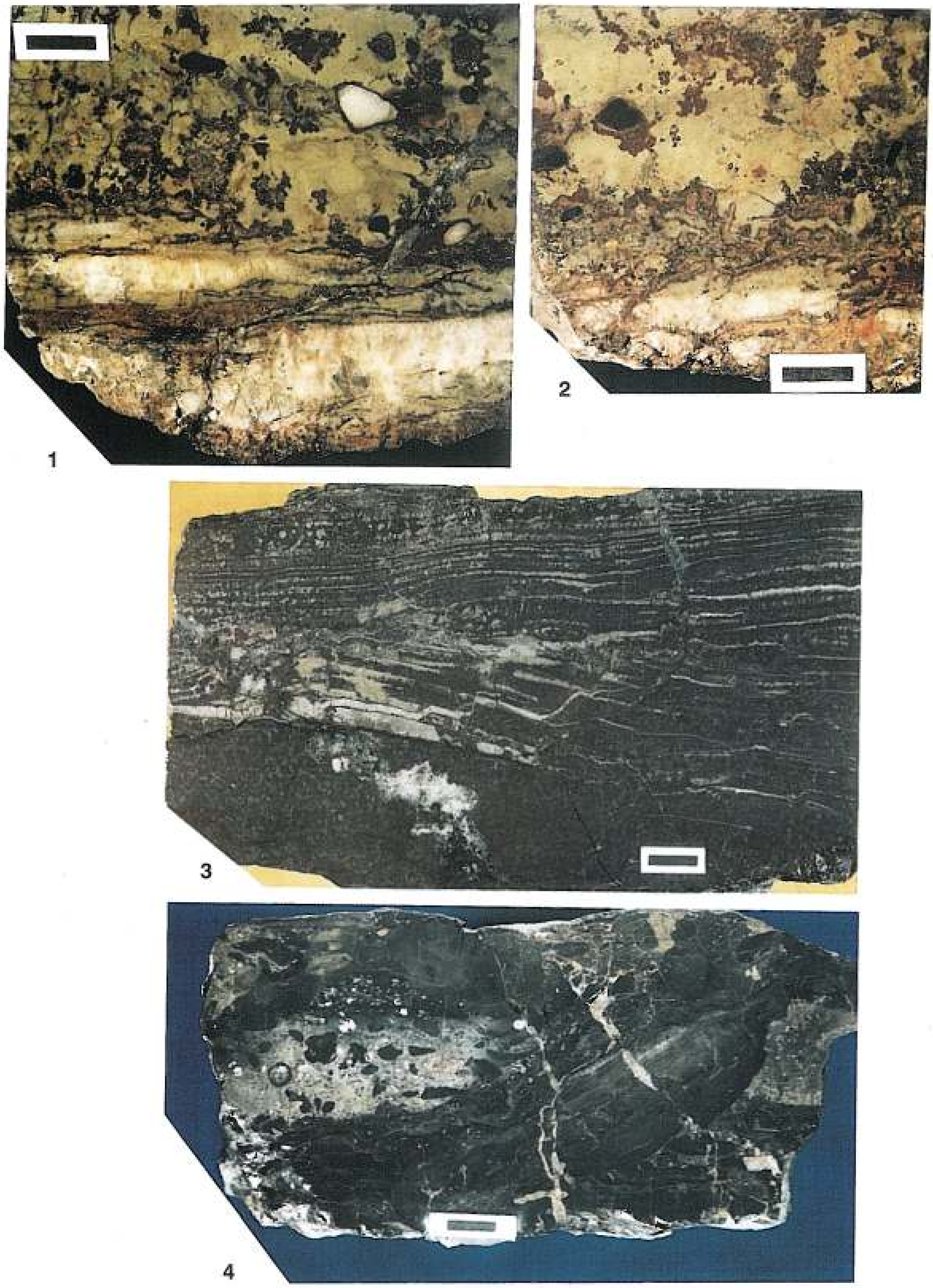
The Tremadoc and upper Arenig deposits of the section described reveal an erosional surface, probably related to the Ceratopyge (CRE) global regressive event (Erdtmann, 1986). Around Pobroszyn this indicates emergence and erosion at the late Tremadoc/early Arenig boundary. Weathering processes intensified leading to an increase of rock porosity and the oxidation of ferric minerals. The occurrence of microstalactite calcite overgrowths at the bottom of the pebbly limestones have an important significance in the analysis of the Ordovician basin

PLATE I



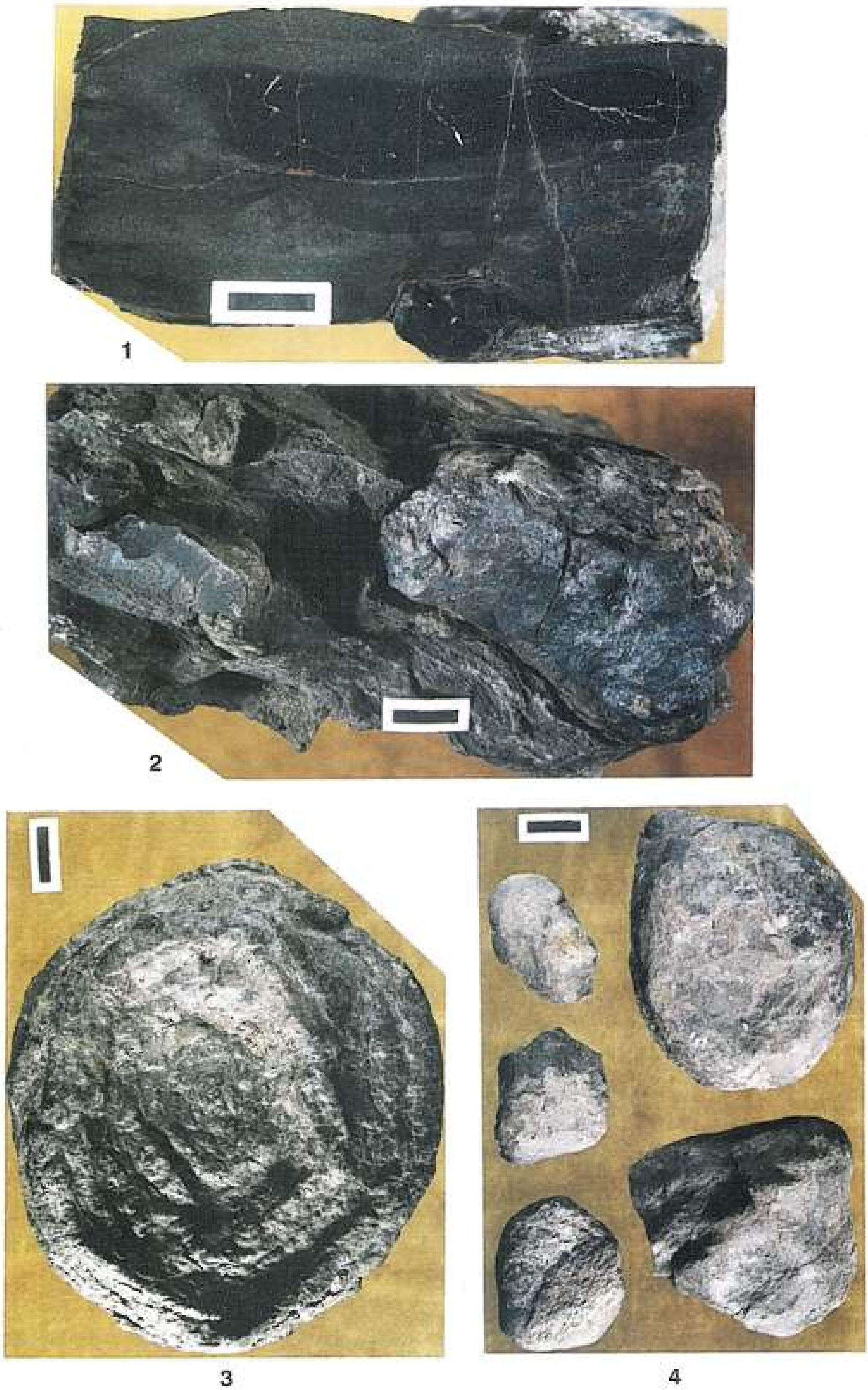
1. Exposed Ordovician section at Pobroszyn with marked packages: C — top of clayey-silty lithofacies, upper Tremadoc, D — carbonate-phosphorite lithofacies, upper Arenig, E — bottom of grey claystone lithofacies, Caradoc?. ***2.*** Top surface of calcareous sandstones with phosphate brachiopods, package B, upper Tremadoc, Fig. 3 — sample no. 2. ***3.*** Traces of trilobite species *Cruziana* and *Rusophycus* on bottom surfaces of sandstones, Cambrian, Fig. 3 — sample no. 1. Scale bar — 1 cm

PLATE II



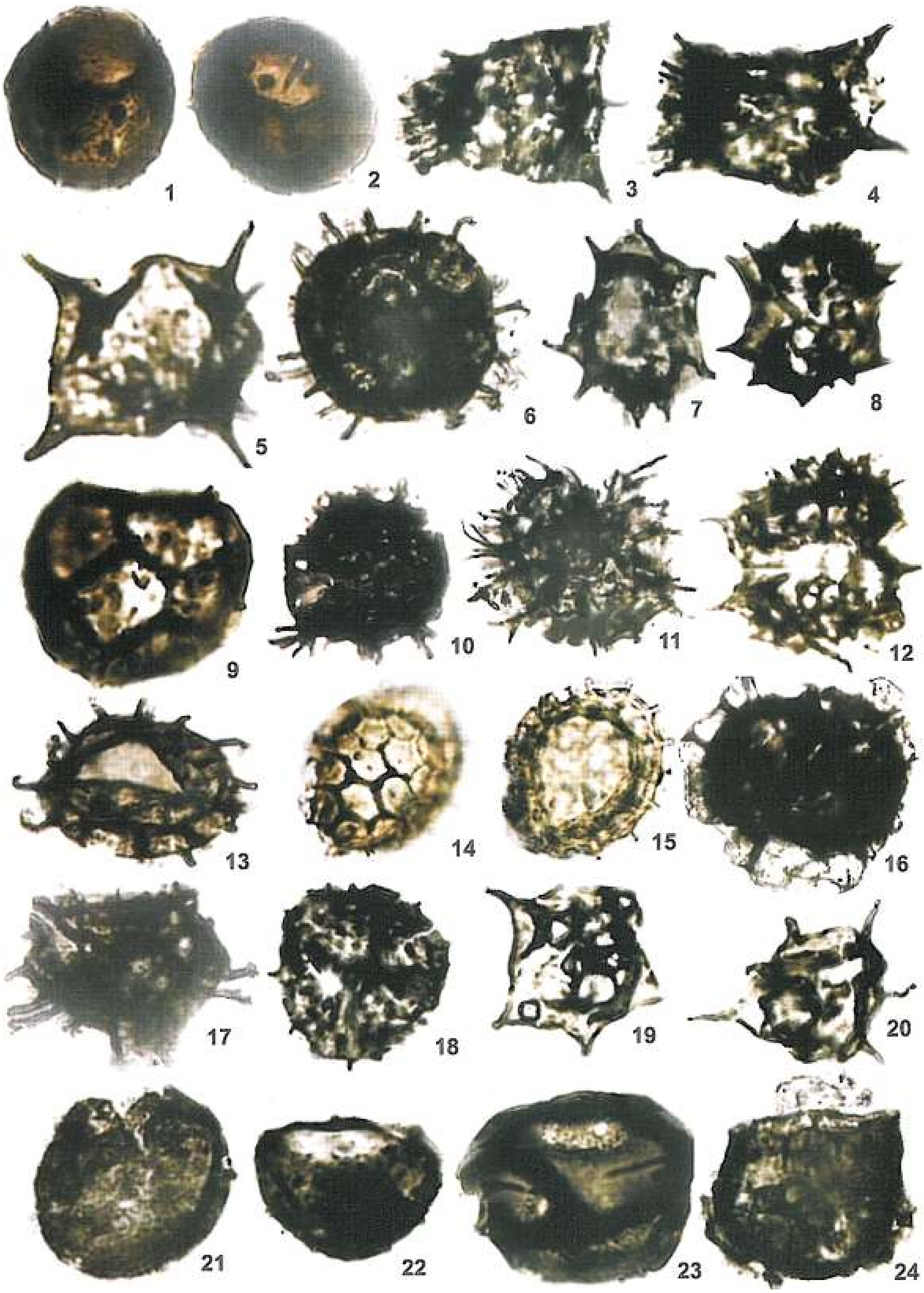
1, 2. Pebbly limestone; calcite layers and lenses below; thin discontinuous micritic overgrowths above; bottom of package D, upper Arenig, Fig. 3 — sample no. 3. ***3.*** Brown-red limestone bed with low angle cross-bedding and small synsedimentary faults; bottom of package D, 20 cm from package base, above pebbly limestone, upper Arenig, Fig. 3 — sample no. 4. ***4.*** Dark grey phosphorite rock with limestone intraclasts, pebbles and crinoids. Scale bar — 1 cm

PLATE III



1. Grey limestone, horizontally laminated, with a dark phosphorite rock interbed, package D, 2.0 m from package base, upper Arenig, Fig. 3 — sample no. 8. ***2***. Grey-green marly claystone with phosphorite concretion, package D, upper Arenig, Fig. 3 — sample no. 6. ***3, 4***. Phosphorite concretions; package D, upper Arenig, Fig. 3 — sample no. 7. Scale bar — 1 cm

PLATE IV



1, 2. *Stelliferidium* cf. *modestum* (Górka). ***3, 4***. *Arbusculidium destombesii* Denuff. ***5***. *Priscotheca* sp. ***6***. *Cymatiogalea* sp. ***7, 8, 12***. *Acanthodiacrodium* sp. ***9***. *Cymatiogalea* cf. *cristata* (Downie). ***10***. *Vulcanisphaera* cf. *nebulosa* Denuff. ***11***. *Vulcanisphaera* sp. ***13***. *Cymatiogalea* cf. *polygonophora* Górka. ***14, 15***. *Cymatiogalea polygonophora* Górka. ***16***. *Peteinosphaeridium* sp. ***17***. *Stelliferidium* sp. ***18***. ?*Coryphidium* sp. ***19***. *Stellechinatium* sp. ***20***. *Dasydiacrodium longicornutum* Górka. ***21, 22, 23***. *Caldariola* sp. ***24***. ?*Caldariola* sp. Different scale in the Łysogóry region. Both the present and ancient microstalactite druse and crusts occur in a supratidal zone or in the higher part of the intertidal zone (Purser, 1969; Purser and Loreau, 1973; Scholle and Kinsman, 1974; Peryt and Wagner, 1981; Shinn, 1983; Peryt, 1984). Thus, the lower part of this pebbly limestone was probably deposited within an eu- or even supralittoral (supratidal) zone, during marine transgression over a previously emergent area. The appearance of open marine conodonts (Dzik, 1999) in the overlying bed of the pebbly limestone might have resulted from open marine waters inflow with strong tides or currents (e.g. upwellings). Furthermore the caliche-like surface indicates a temporarily emergence associated with location in the intertidal zone. Storm waves or tides eroded lithoclasts from the underlying Cambrian and Tremadoc deposits. Strong turbulence continued during accumulation of sediments directly overlying the pebbly limestone, as evidenced by limestone intraclasts with pebbles, erosional channels and surfaces, as well as by a chaotic distribution of phosphorite ooids and crinoid detritus.

In the Łysogóry region the emergence that took place at the Tremadoc/Arenig boundary is correlated with a pre-Arenig regional sedimentary discontinuity in northeastern Poland (Modliński, 1973, 1982; Szymański, 1973, 1984; Znosko and Chlebowski, 1976).

The upper part of carbonate-phosphorite lithofacies shows a sea level rise and calm deposition of clays below a normal wave base. Periodic increases in environmental turbulence, erosion and redeposition of sediment took place. Individual limestones and carbonate-phosphorite beds reveal features of sediments accumulated by currents (Wilson, 1975; Flügel, 1982; Scholle *et al*., 1983; Aigner, 1984, 1985; Jones and Desrochers, 1992), and seem to be a record of attenuated distal storm currents.

The presence of claystones, limestones and phosphorite rocks generally formed in an sublittoral environment, above a thin layer of supra- and eulittoral sediments, indicates marine transgression in the late Arenig.

TECTONICS

In the section examined, the angle of dip varies across 30 m from 30 to 80°NNE, and is associated with faulting. The faults are grouped in two oblique and one longitudinal sets.

The oblique faults of the first set dip towards 120–140°, whereas the fault surfaces 40–50°NE, respectively. These faults are of strike-slip character with a small overthrust component towards the west. This array also includes the fault that separates Ordovician rocks on the eastern side from Cambrian rocks to the west, presumably closing the Pobroszyn element from the west. This is also evidenced by flexure in quartzite beds on the western side, in which strike changes from 73 to 97° at the fault drag. These beds were partly boudinaged and intensily fractured; shales from the eastern side of the fault change their colour from dark grey to brown-grey due to scattered haematite. This mineral forms spherical septaria up to 2 cm in diameter. Haematite occurs along 4 m of the fault, within a half-metre zone of altered shales.

The oblique faults of the second set have strikes of 15–25° and steep dips of 65–80°E. This set shows evidence of strike-slip motion. Alteration zones along these faults are only 10–15 cm thick bleached and shattered. One such oblique fault was seen to pass into a longitudinal overthrust.

The strikes of the oblique faults are in accordance with directions observed by Studencki (1985) in Jeleniów range of Holy Cross Mts., i.e. the first order set of faults is superior in relation to the second one. Transition from the oblique to longitudinal faults seems to be common phenomenon within the exposed rocks, relating to both sets of the oblique faults.

Proven longitudinal faults are strike-faults (95–110°) and are usually placed at sharp boundaries of mechanically different rocks, i.e. carbonate-ferric rocks and shales. Most of the boundaries in the successions examined are tectonic, and are accompanied by altered zones. They can be distinguished within shales as bleached and shattered zones up to 0.7 m thick. Within two limestone beds (complex E), which crop out in the pit examined, boudinage occurs as a result of overthrust movement.

CONCLUSIONS

In the village of Pobroszyn near Opatów, a faulted section of Ordovician rocks overlying Upper Cambrian quartzitic siltstones and sandstones occurs, dipping at 30 to 80° to the NNE.

The Ordovician at Pobroszyn includes dark grey clayey-silty lithofacies (packages A and C) 14.0 m thick, dated as Tremadoc by acritarchs. Near the middle part of these packages, infaulted grey sandy limestones with brachiopods (package B) occur. Higher in the section, a 3.6-m thick carbonate-phosphorite lithofacies assigned by conodonts to the upper Arenig (Volkhov) occurs (Dzik, 1999). The Upper Ordovician section is completed by a 15-m thick dark grey claystone lithofacies, in places with thin lydite, siltstone and grey limestone interbeds. In the highest limestone bed, conodonts documenting the Caradoc and Ashgill occur (Dzik, 1999).

At the late Tremadoc/early Arenig boundary, emergence took place. Marine transgression in the late Arenig is marked by littoral to supralittoral deposits overlain by sublittoral deposits.

The faulted Ordovician section at Pobroszyn includes Tremadoc clayey-siltstone lithofacies, Arenig carbonate-phosphorite lithofacies and Upper Ordovician dark grey claystone lithofacies. The uppermost Arenig sediments of the Łysogóry region, described by Dzik (1999), are a newly-discovered element of Ordovician sedimentation in the northern part of the Holy Cross Mountains. A thin deposit of littoral to supralittoral character formed after the basin had emerged or shallowed in the Pobroszyn area in the late Tremadoc and early Arenig. Overlying sublittoral sediments are an evidence of late Arenig marine transgression previously unknown in the Łysogóry region.

The faults form two oblique fault sets: the first strikes 120–140° and dips 40–55°NE and the other strikes 15–25° and dips 65–80°E, and there is also an oblique fault set (strike 95–110°) of overthrust character.

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