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Lower Famennian phytoplankton from the Holy Cross Mountains, Central Poland

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ABSTRACT

A rich phytoplankton assemblage and low diversity miospore microflora is described from the Lower Famennian deposits of the Kowala Quarry, Holy Cross Mountains, Central Poland. This assemblage is assigned to the Pw acritarcha zone, which is correlated with the late *triangularis–crepida* standard conodont zones based on appearance of the acritarch *Puteoscortum williereae*. Comparison of the present palynological results with well-documented data from Belgium clearly indicates differences in marine microflora composition in both regions. The important taxa *Visbysphaera* (?) *occultata*, *Ephelopalla media*, and *Palacanthus tripus* in Belgium are absent in the samples from the Holy Cross Mountains and by contrast, the phytoplankton frequent in Poland (*Lophosphaeridium*, *Dictyotidium* or *Cymatiosphaera*) are rare in Belgium. The taxonomical difference between the Holy Cross Mountains and Belgium palynoflora may probably reflect environmental differences: offshore and more proximal environmental conditions respectively. Three new species (*Leiofusa turnauae* sp. nov., *Lophosphaeridium irregularis* sp. nov. and *Veryhachium? kowalae* sp. nov.) have been formally instituted and two new taxa (*Centrasphaeridium* sp. A and *Centrasphaeridium* sp. B) are left in open nomenclature.

1. Introduction

An abundant, diverse, and well-preserved phytoplankton assemblage has been recorded from the Lower Famennian deposits (*triangularis–crepida* standard conodont zones) in the Kowala Quarry, Holy Cross Mountains (HCM), Central Poland (Fig. 1A). Phytoplankton from the Lower Famennian of southern and central Poland are poorly known and these new data enrich our knowledge about the microflora from the Holy Cross Mountains, following two critical global events: the Upper Kellwasser and Nehden (e.g. Walliser, 1996; House, 2002; Ning et al., 2008). This is particularly pertinent in light of problems highlighted by Jablonski (2005) concerning biotic crises and the factors controlling rate of recovery and evolutionary directions following environmentally stressful episodes in earth history. During the Famennian epoch, with the global collapse of mainly coral–stromatoporoid and other faunal groups (see Walliser, 1996), the pelagic fauna (conodonts and ammonoids) reached their peak of ecological success in development during their entire history (see Dzik, 2006). Meanwhile, the latest palynological research on the Frasnian–Famennian (F/F) boundary interval in the HCM has revealed that the microfloras did not change drastically during the F/F crisis (Filipiak, 2002). Similar conclusions were obtained from Belgium (Streel et al., 2000) and more recently from Germany (Hartkopf-Fröder et al., 2007). Moreover the Famennian is also the last epoch of the 'old type' phytoplankton (e.g. Riegel, 2008; Strother, 2008). From the beginning of the Carboniferous Period 'old phytoplankton' taxa are drastically reduced (e.g. Strother, 1996, 2008; Filipiak, 2005), creating a new era in phytoplankton development, referred to as the "phytoplankton blackout" by Riegel (2008). Therefore, the main aim of the present study is to document phytoplankton assemblages, from the interval just after the F/F crisis (e.g. Walliser, 1996; House, 2002) obtained from the HCM and compare the results with other well-documented sections.

Lower Famennian rocks are well exposed on the eastern wall of the active Kowala Quarry (Fig. 1B). This well-known quarry is located in the western region of the HCM and is situated in the eastern part of the Gałęzice–Kowala Syncline (Fig. 1A). The biostratigraphy and lithostratigraphy of this section have been described and discussed in detail by Szulczewski (1971, 1995), Racki et al. (2002), Racki and Baliński (1998) and Dzik (2006). Most of the previous palynological studies, especially in Kowala Quarry, have focused on the uppermost part of the Famennian. However, pioneering acritarch research from the Upper Famennian in the Łagów area was done by Górka (1974). Turnau (in Turnau and Racki, 1999) described older palynomorphs and palynofacies from the Givetian of the Bodzentyn Syncline (Fig. 1A). Other palynological investigations have been mainly from the Devonian/Carboniferous boundary interval, and were documented by Turnau (1985, 1990 — data from the Kowala IG1 borehole) and Filipiak (2004, 2005). The latter author provided microfloral data from the trench situated close to the northern border of the Kowala Quarry (Fig. 1B). Palynofacies studies from the F/F boundary of the Płucki and Kowala area were described by Filipiak (2002). Combined palynological and geochemical data was recently obtained from the uppermost

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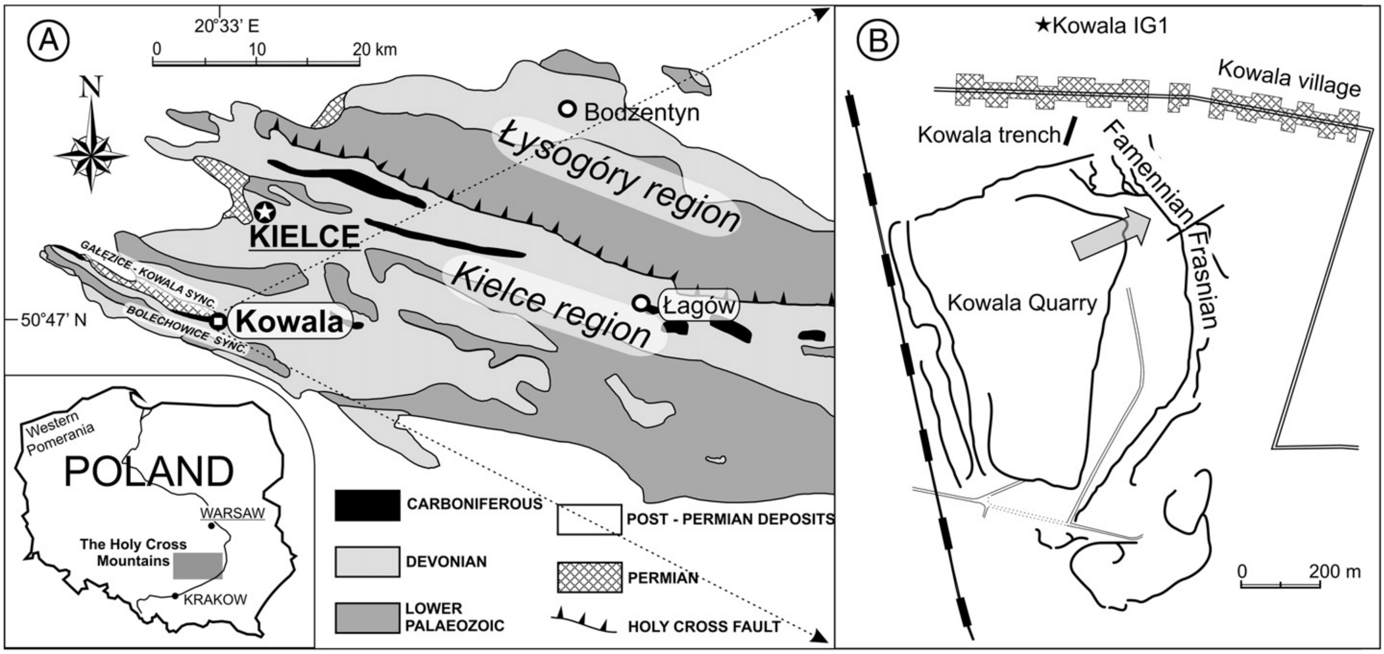

Fig. 1. Location of Kowala Quarry. A — simplified geological map of the Western Holy Cross Mountains; B — the Kowala Quarry and the location of the Kowala IG1 borehole and Kowala trench.

Famennian (Marynowski and Filipiak, 2007) and Early–Middle Frasnian (Filipiak in Marynowski et al., 2008).

In the present study the palynological characteristics of the Lower Famennian phytoplankton assemblage stratigraphically corresponding to the *triangularis–crepida* conodont zones, from the eastern Laurussian shelf region are presented. Palynostratigraphy based on acritarchs with environmental interpretation and comparisons with adjacent and more distant areas are also given.

2. Regional setting and the section investigated

In the Devonian the Kowala area was situated on the South Polish–Moravian carbonate shelf (see Racki et al., 2002). The part of the section investigated represents deep shelf, basinal facies, developed to the north of the central (reef) shoal. The quarry is located in the south-western part of the southern Kielce Region (Fig. 1A; the Chęciny–Zbrza Basin in palaeogeographical terms; cf. Szulczewski, 1971; Racki et al., 2002). Samples were taken from a nearly four-meter long monotonous section consisting of marls, rhythmically intercalated with limestones representing the lithological set H *sensu* Szulczewski (1971; see also Berkowski, 2002).

3. Palynological preparation

Standard laboratory procedures were used to remove mineral matter from palynological samples (Wood et al., 1996). Eight samples were taken in pairs, the one from the limestone and the other from the marl, in close proximity to each other (Fig. 2). Fuming (100%) HNO_3 acid was used to oxidise high organic carbon content — amorphous organic matter (AOM). All samples contained well-preserved palynomorphs, mainly phytoplankton, and rare miospore material. Samples from marls always contained much more organic material than those from limestones. For quantitative data up to 200 specimens of miospores, leiospheres and other phytoplankton components (acritarchs and prasinophyta) were counted. The preservation state of palynomorphs was very good. At least three slides were prepared from each residue. Cellosize was used as a dispersal agent to avoid organic clumping, but Peropoxy 154 was used as a mounting agent.

The palynological slides and residues are housed at the Faculty of Earth Sciences, University of Silesia in Sosnowiec. The new, important and/or most common acritarchs and prasinophytes are illustrated in Plates I–IV. The observation and documentation was completed using transmitted light microscope (Olympus BX51) and an environmental scanning electron microscope (ESEM) Philips XL30.

4. Lower Famennian phytoplankton assemblage

Phytoplankton are very well represented in all samples (Fig. 3). The organic residue is rich in AOM, and excluding the one sample from the middle part of the section (KcIII/13), is interpreted to represent a basinal facies deposited in an oxygen-restricted environment (e.g., Batten, 1996; Tyson, 1993). The dearth of structured terrestrially sourced organics (e.g. cuticle, woody tissue, miospores), and the presence of scolecodonts in all samples support this. The relative frequency of miospores ranges between 8 and 27% (see Table 1). But the most common are leiospheres. Their relative frequency ranges between 48 and 84%. Other phytoplankton components like acritarchs and prasinophyta excepting *Leiosphaeridia* are common as well, but with greater frequency differences, ranging between 4.5% in the KcIII/13 sample and 40.5% in the KcIII/18 sample (Table 1). Chitinozoans, on the other hand, were absent, except for the sample KcIII/2, where a single specimen was observed. Herkomorphitae (*Cymatiosphaera*, *Dictyotidium*, and *Muraticavea*) predominate in samples KcIII/1 and 2. In contrast, the remaining samples are dominated by small acanthomorphic forms, like *Gorgonisphaeridium* (short spines forms), *Lophosphaeridium*, *Micrhystridium*, *Unellium*, and *Veryhachium*. The bigger taxa (>50 µm), like *Exochoderma*, *Maranhites*, and *Stellinium* are rare. Thin-walled *Leiosphaeridia* and *Hemiruptia* are common in all the samples. The detailed succession of acritarcha and prasinophyta species in the section is shown in Fig. 3.

Some phytoplankton species, such as *Dictyotidium confragum*, *Exochoderma arca*, *E. triangulata*, *Maranhites britoi*, *Muraticavea munificus, Puteoscortum williereae*, and *Stellinium micropolygonale* were recognized for the first time from the Lower Famennian of the Polish part of eastern Laurussia. According to Turnau and Filipiak (2003), some of the species mentioned above, e.g. *E. arca*, *E. triangulata*, *S.*