

FLUCTUATION IN COMPOSITION OF GIVETIAN PHYTOPLANKTON ASSEMBLAGES FROM THE HOLY CROSS MOUNTAINS (POLAND)

ELŻBIETA TURNAU

Institute of Geological Sciences, Polish Academy of Sciences, Research Center in Cracow, Senacka 1, 31–002 Cracow, Poland;
e-mail: ndturnau@cyf-kr.edu.pl

ABSTRACT. Givetian samples have yielded well preserved prasinophytes, acritarchs, and coenobial algae. Four successive palynofacies are distinguished: (1) a spore dominated palynofacies lacking in acritarchs, (2) palynofacies with acritarchs, (3) palynofacies with abundant leiospheres, and (4) palynofacies dominated by thick-walled sphaeromorphs. The palynofacies changes are possibly related to eustatic sea level fluctuations, but changes in surface water circulation may have also been an important factor.

KEY WORDS: Devonian, Holy Cross Mts, Poland, acritarchs, prasinophytes, palynofacies

INTRODUCTION

Well preserved palynological material was recovered from the Givetian deposits exposed in the Łysogóry (northern) region of the Holy Cross Mts. The investigated sequences include the topmost part of the shaly-marly-limey Skały beds, the siliciclastic Świętomarz beds, and the lower part of the clayey-marly Nieczulice beds, from the Świętomarz-Śniadka and Skały-Włochy

sections (Fig. 1). The stratigraphy and age assignment of these strata are established on various fauna, and on miospores (see Malec & Turnau 1997, and Turnau & Racki in press). The phytoplankton discussed in this paper has been obtained from late Givetian deposits ranging from the Middle *varcus* to (at least) *hermanni-cristatus* zones.

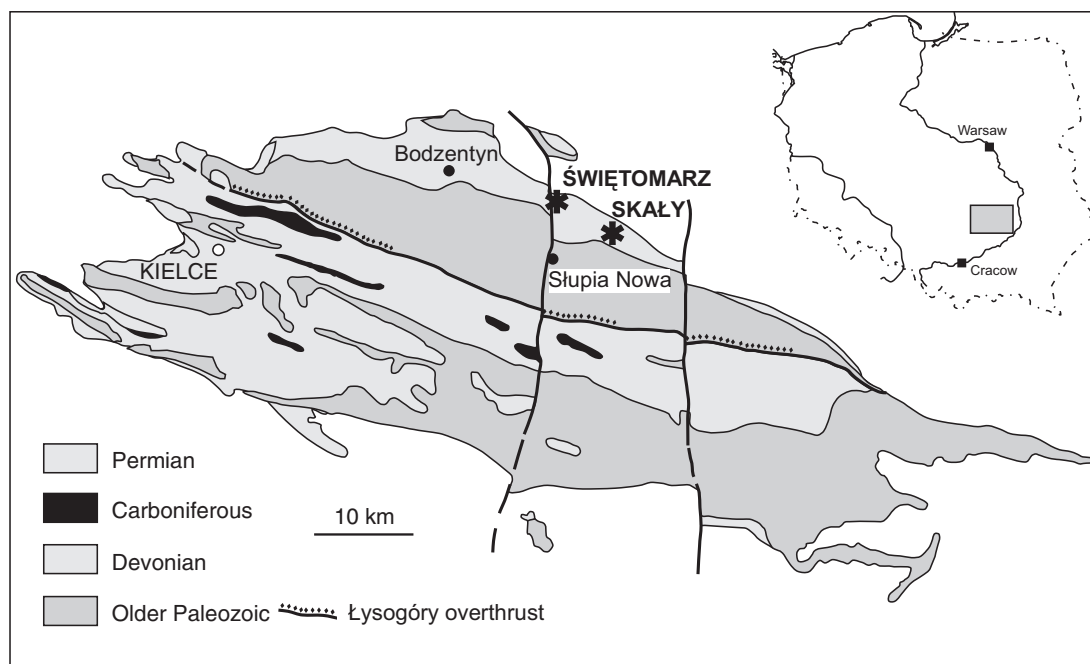


Fig. 1. Location of sections studied and simplified geological map of the Holy Cross Mountains; in upper right – position of study area within Poland

The strata under discussion are part of a ca 2 km thick siliciclastic to carbonate-argillaceous Devonian sequence of the Łysogóry intrashelf basin. The Świętomarz beds reflect a brief stage of siliciclastic sedimentation in the mostly carbonate shelf setting. These shallow marine deposits are interpreted as having formed due to regression (Malec & Turnau 1997) in accordance with the Euramerican eustatic pattern (final stage of pre-IIa regression; see Johnson *et al.* 1985). There are other suggestions as to the origin of these beds, such as conditions of activation of eastern land area as a source of fine terrigenous material, probably due to a tectonic event (Czarnecki 1950) or a climatic change (Kłossowski 1985).

The Nieczulice beds including fine-grained and dark deposits generally correspond to a deeper subtidal, chiefly pelagic sedimentary phase, probably associated with the sustained transgression (e.g. Kowalczewski & Malec 1990, Racki 1993, Malec & Turnau 1997) during the worldwide Taghanic inundation (IIa T-R cycle of Johnson *et al.* 1985).

MATERIAL AND METHODS

More than one-hundred samples were processed using standard palynological techniques. Forty samples contained well preserved organic residues which were filtered through 10 m screens. Two slides were prepared from each sample.

All slides were scanned for the presence of various kerogen types using normal transmitted light and reflected fluorescence light. Counts were made to determine the ratios of various palynomorph groups for selected samples. These ratios were determined by counting the first 250 identifiable palynomorphs.

PHYTOPLANKTON FLUCTUATIONS

COMMENT ON TAXONOMY

The important element of some of the palynofacies described here are thick-walled sphaeromorphs. They do not display any perceptible wall perforation diagnostic of the genus *Tasmanites*, and are morphologically close to *Hemiruptia* (see Ottone 1996).

The coenobial algae represent a new genus and species which has been described in detail in Wood & Turnau (in press). The species name is *Musivum gradzinskii*. The coenobia are square to slightly rectangular, single-layered, equant, planar colonies 29 to 93 µm in diameter, with maximum number of coenocytes = 256.

DESCRIPTION OF PALYNOFACIES STUDIED

Four palynofacies can be distinguished in our material. They differ one from the other in the presence/absence and proportions of palynomorph groups: spores, coenobial algae, leiospheres, thick-walled sphaero-

morphs, herkomorph and prismatomorph prasinophytes and acanthomorph acritarchs.

The palynofacies are named after the dominant palynomorph types. The proportions of different groups of palynomorphs and the succession of the palynofacies in the studied sequences are shown in Fig. 2. The palynofacies are as follows:

Spore palynofacies (S). It contains a high proportion of land plant spores (89–99%) the assemblages of which include specimens of various sizes. Phytoplankton is represented mostly by leiospheres. Acritarchs are absent, and algal coenobia may constitute up to 1 % of palynomorph assemblage.

Leiosphere/spore palynofacies (LS). It interfingers with, and follows the palynofacies S. Leiospheres and spores are the two main components constituting 30–64%, and 21–57% respectively of the palynomorph populations. The spore assemblages are not taxonomically diverse and dominated by small specimens. In some samples, algal coenobia are the dominant component constituting up to 45% of the palynomorph populations. Acritarchs are scarce to absent, and so are herkomorph/prismatomorph prasinophyte phycomata, except for the sample SS2/6. Thick-walled sphaeromorphs are minor to conspicuous constituent of palynomorph populations so that the distinction between the LS and H palynofacies is arbitrary (cf. Fig. 2).

Spore/acritarch palynofacies (SA). It is described from the Nieczulice beds from Świętomarz. These strata may be the lateral equivalent of a part of the Pokrzywianka beds (below the Nieczulice beds) of the section near Skąły, or a lowermost part of the Nieczulice beds from that section which yielded the palynofacies LS. The proportion of land plant spores in this palynofacies is high, and proportion of acanthomorph acritarchs is higher than in the other palynofacies though the acritarch assemblages are not taxonomically diverse. The assemblages of spores are less varied than in the palynofacies S, and large spore specimens are rare. Prasinophytes are represented by leiospheres which are not abundant. Coenobia were found in one sample.

Hemiruptia palynofacies (H). This palynofacies is dominated by prasinophytes of which thick-walled sphaeromorphs (mainly of *Hemiruptia* type) are most abundant. Acritarchs are almost absent (usually below 1%), and land plant spores are subordinate. Algal coenobia have not been observed.

INTERPRETATION

The composition of palynomorph assemblages is often used as a tool for determining palaeoenvironments and shoreline proximity. The criteria which are consid-

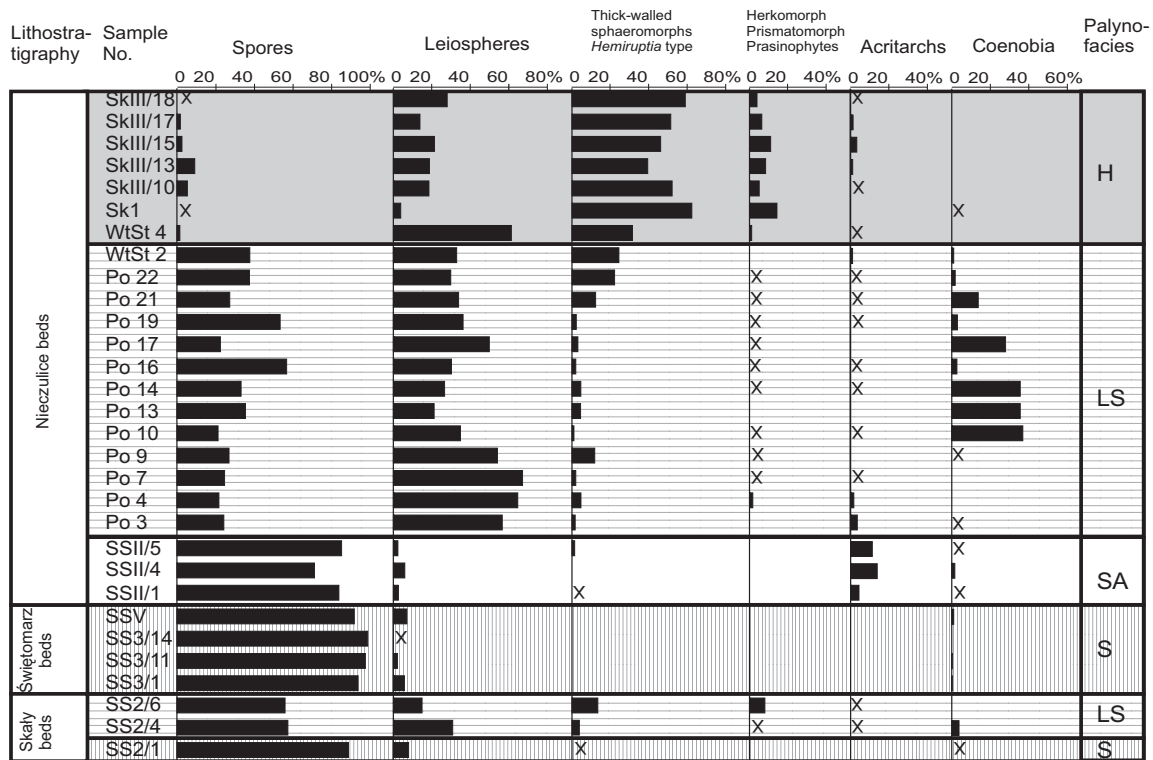


Fig. 2. Stratigraphical distribution and relative abundances of palynomorph groups from selected samples of the Świętomarz and Skąły-Włochy sequences. X = presence %. The percentages for samples do not add to 100 as some rare or undeterminable forms are omitted. Key to palynofacies names: S – spore, LS – leiosphere/spore, SA – spore/acritarch, H – *Hemiruptia* type

ered most important are the spore/acritarch, or spore/phytoplankton ratio (diminishing off-shore) and changing composition of phytoplankton assemblages (prevalence of morphotypes). This has been discussed comprehensively, among others, by Riegel (1974), Richardson (1984), Richardson and Rasul (1990), and reviewed by Tyson (1995) and Molyneux *et al.* (1996). The suggested model which emerges from studies of the Palaeozoic and Mesozoic phytoplankton and spore distribution is the following: (1) nearshore assemblages – high dominance (of simple, thin walled sphaeromorphs or short-spined, cosmopolitan acanthomorphs), and high content of spores and phytoclasts; (2) off-shore shelf assemblages – phytoplankton taxonomically diverse, less thin-walled sphaeromorphs, increase in longer-spined acritarchs, herkomorph prasinophytes and netromorph acritarchs often better represented, spores less abundant and sorted; (3) deep water assemblages – reduced diversity, dominance of thick-walled sphaeromorph taxa.

It should be noted that in the opinion of a number of palynologists, the presence of sphaeromorphs in deeper environments is caused by the spread of brackish waters (see discussion in Tyson 1995, p. 305). Occurrence of prasinophyte-rich assemblages is also thought to be related to high latitudes, reduced salinity waters of salinity stratified basins, and to periods following pulses of terrigenous input (Prauss & Riegel 1989), also to nutrient-

depleted (Tappan 1980, Tyson 1995) or nutrient rich environments related to anoxia (among others: Huysken *et al.* 1992, Stasiuk 1993). Thus, the factors controlling distribution of phytoplankton are very complex, and therefore the above ideal model should be applied with caution.

The most striking attribute of the palynofacies described here is the dominance of prasinophytes combined with low diversity or absence of acritarchs. Of various explanations mentioned above regarding occurrences of prasinophyte dominated assemblages the most plausible one in the present case is (recurrent ?) salinity stratification of the sea in the late Givetian Łysogóry basin. The distinct reduction of benthic fauna in the Nieczulice beds, and its lack at certain intervals may be considered as confirmation of this suggestion. The high proportion of leiospheres in the leiosphere/spore palynofacies can not be explained as indicative of a near-shore environment as the host deposits were formed in an intrashelf basin (see Introduction). Possibly, it is due to basinward surface water circulation. This is supported by the occurrence in this palynofacies of high proportion of land plant spores and the coenobial algae which are generally considered as fresh-water or brackish organisms.

The differences between the palynofacies may be interpreted in terms of sea-level falls and rises.

The direct cause of the very high content of land plant

spores in the palynofacies S must be the siliciclastic nature of the Świętomarz beds deposited in the regime of increased input of terrigenous material. This regime favoured an increased supply of land plant matter and inhibited the growth of phytoplankton. The deposition of the Świętomarz beds may be due to the eustatic sea-level fall (see Introduction). The latter cause is favoured here because the deposition of these beds in the conodont Middle *varcus* Subzone seems to coincide with the end of the pre-IIa regression of Johnson *et al.* (1985). Thus, this palynofacies is considered as the shallowest of the succession.

The appearance of acanthomorphs, and decrease of the spore/phytoplankton ratio in the palynofacies SA and LS may indicate a sea level rise. The shift from palynofacies S to SA or LS also in the Middle *varcus* Zone coincides with the facies shift thought to be equivalent of the Taghanic (IIa) eustatic rise.

The shift from palynofacies LS to palynofacies H, i.e. from the dominance of leiospheres to that of thick-walled tasmanitids (of *Hemiruptia* type), increase of relative abundance of herkomorph and prismatomorph prasinophytes, and considerable decrease of abundance of spores may reflect a sea-level rise. This shift does not coincide with any conspicuous lithological change. It occurs above the base of the conodont *hermanni-cristatus* Zone, then it follows shortly the initial deepening of the IIa2 T-R cycle (*sensu* Witzke *et al.* 1988).

To conclude, the described palynofacies shifts seem to coincide with the eustatic sea level changes, i.e. the end of the pre IIa regression, and base of the IIa transgression as defined by Johnson *et al.* (1985). But other causes than eustatic sea level fluctuations should be considered as well.

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