The very last phase of the Permian from the microfloral point of view

Eva PLANDEROVA

Geological Institute Dionys Stur, Mlynska dolina 1, CS-81704 Bratislava, CSFR

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Introduction

The uppermost Permian is a very interesting time from palaeofloristic point of view. In the region of the West Carpathians an essential change in composition of the microflora took place in the uppermost Permian or at the Permian/ Triassic boundary.
From the point of view of microfloristic Upper Permian zonation (GOCZAN & PLANDEROVA 1989) this involves the microfloral zone V (*Guttulapollenites - Crucisaccites* zone) and the microfloral zone VI (*Karpatisporites - Gnetaceaepollenites* zone) (fig.1).
A relatively well preserved microflora has been discovered in Upper Permian sediments throughout the West Carpathian region. Based on the determined associations, palynozones were distinguished and correlated (GOCZAN & PLANDEROVA 1989) with palynozones in Hungary. The correlation enabled the zonation of West Carpathian Upper Permian sediments with Permian sediments of the Danube region which were also dated by microfauna (GOCZAN et al. 1987).
The present work deals only with the microflora of the latest Permian. The development of this microflora differs from that of the Alpine region (KLAUS 1963) as well as that of the Transdanubian one (GOCZAN et al. 1986); it also differs from the correlation of the Upper Permian microflora in Europe.

The West Carpathian microflora of the uppermost Permian

It has the following main composition: The associations include bisaccate pollen of the class Coniferae. Species of the genus *Karpatisporites* are the dominant component here (up to 55%). This genus has very small bisaccate pollen whose dimension varies within a range of 15-25 μm (PLANDEROVA 1973). These were neither found in older, nor in younger sediments. The percentage of *Lueckisporites virkkiae* pollen grains decreased distinctly compared to microfloral zone IV. All species of bisaccate pollen grains are of smaller dimensions than in the underlying sediments e.g. *Klausipollenites*, *Jugasporites*, *Striatites*. All may be described to species which have been termed as "*minimus*" or "*minor*" (*Klausipollenites minimus*, *Striatites minor*, etc.).
A significant component of this association of small bisaccate pollen are species of the genera *Cycadopites* and *Gnetaceaepollenites*, which represent the phylogenetically younger component of the flora.
The uppermost Permian or Permian/ Triassic boundary is also indicated by the fact that Lower Triassic sediments with the faunal elements *Anodontophora fassaensis* and *Myophora costata* were found closely overlying Upper Permian grey shales.
In the Upper Permian of the West Carpathians, sedimentation largely took place in lacustrine environment. The lakes may have been surrounded by

mountains or other elevations, produced by volcanic activity, which were overgrown with a rich conifer vegetation (*Ullmannia*, *Pseudovoltzia*). At that time the area of the lakes or enclosed lagoons was reduced and therefore the microflora of *Karpatisporites* types was established only at several localities; this contrasts with the wide extension of the earlier Upper Permian microflora. This represents the last established terrestrial flora within the uppermost Permian. The droughts must have been so extreme that even the conifer species adapted to them could not survive the Permian. Such a very dry and warm climate could have altered the vegetation to a steppe like character; the result could have been an essential reduction in the number of conifer species found up to the *Karpatisporites* - *Gnetaceaesporites* zone.
In our country this uppermost Permian microfloristic zone was established in the Choc nappe Permian. A similar microflora (*Karpatisporites* - *Gnetaceae-sporites* zone) was mentioned from the uppermost Permian of the Arctic Canadian islands (written communication by STAPLIN) and designated as typical for the Permian/ Triassic boundary.
Our information on an essential change in the flora at the uppermost Permian corresponds to the results of palaeobotanists and palaeozoologists, who have reported a reduction of flora and fauna in various regions of the world and correlated it with the Hercynian folding. According ALASTER (1973) the changes in the flora preceeded those in the fauna. This period is marked by great hiatuses in sediments all over the world. The emersion of continents caused most of the characteristic benthos in the epicontinental areas to disappear; this was presumably accompanied by a drastic change in salinity.
A major warming of the climate, together with a world-wide regression, were the main factors in the sudden change of the fauna and flora. Red pelitic sediments were deposited in many regions, testifying to desert conditions. Microfloristic investigations have revealed that the microflora in the Upper Permian consisted mainly of conifer pollen grains, indicating a dry climate. In the investigated region, Permian sedimentation proceeded up to the Permian/ Triassic boundary, when a sudden disappearance of species which were abundant in the earlier Upper Permian (mainly in microfloral zone IV) is recorded.
In the latest Permian we recorded manifestations of a distinct, world-wide biological catastrophe. This is documented by a conspicuous change in the flora. In marine regions this change was obscured. KLAUS (1980) mentions an interesting fact about the Permian/ Triassic boundary: sulphur isotopes decreased at this boundary due to the influence of bacteria species of the genus *Desulfurvibrians* and *Clostridium nigrificans*, which reduced the content of sulphur in the anaerobic environment.

Comparison of different European regions

The attempt at correlating the Upper Permian microfloristic associations from the West Carpathian region is based on our knowledge about the Germanic development of the Permian, the "Zechstein" (LESCHIK 1956), the Bellerophon beds from the Karnic Alps (KLAUS 1963), the Mecsek area (BARABAS-STUHL 1981), the Transdanubian area (GOCZAN et al. 1986, GOCZAN et al. 1987) in Hungary and anhydrite beds in Ireland (VISSCHER 1971).
The microflora from the Zechstein in Germany (LESCHIK 1956) contains all elements of the Euro-American Upper Permian flora. It differs from the

presently investigated flora by the absence of the association of small bisaccate pollen grains of the genus *Karpatisporites* as well as by the prevalence of the genera *Lueckisporites* and *Klausipollenites*. It corresponds to the microfloral zone IV.
From the Karnic Alps, KLAUS (1963) mentioned a microflora from the Bellerophon beds. This microflora may be correlated with our microfloral zone IV. Species of the genera *Lueckisporites*, *Jugasporites*, and *Klausipollenites* are highly prevalent compared with other bisaccate species. KLAUS (1963) mentioned the dominant occurrence of these species in beds which he correlates with the Middle Zechstein. This correlation also agrees with the results of a comparison of Permian floras by VISSCHER (1971, 1980), who considers the microflora from the Bellerophon beds to be older and places it to the *Lueckisporites* A/C zone, i.e. equivalent to microfloral zone IV.

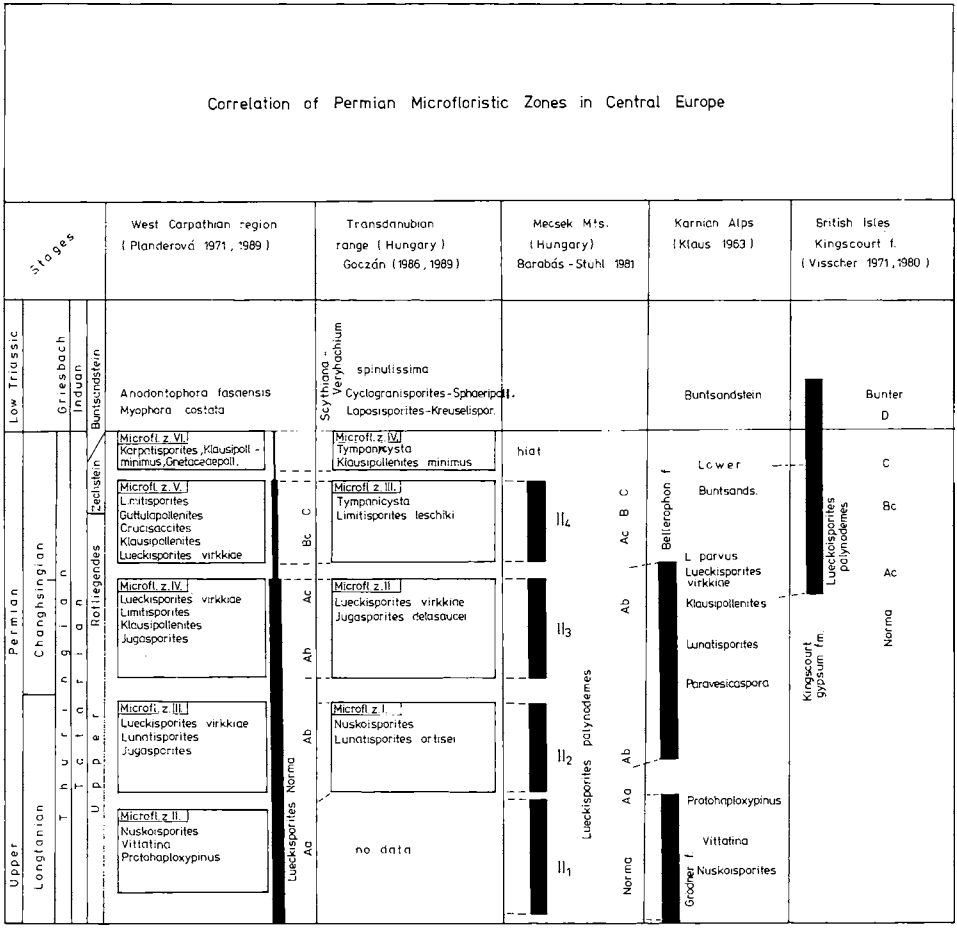

fig. 1: Correlation of Permian microfloristic zones in Central Europe

Palaeomagnetic investigations indicate that the Zechstein was much shorter than previously thought (only 5 m.y. MENNING et al. 1988). This is also supported by the fact that it only included one microfloristic zone.
The Upper Permian microflora from the Mecsek area (BARABAS - STUHL 1981) is divided into microfloristic zones II-1 to II-3. In the uppermost Permian there is a hiatus.
The microflora from the Transdanubian area (GOCZAN et al. 1986, GOCZAN et al. 1987) passes without interruption into the Lower Triassic. The uppermost Permian is represented by marine plankton of the genus *Tympanycysta* and pollen of the species *Klausipollenites minimus*. This area is characterized by marine sediments. The species *Klausipollenites minimus* allows us to correlate microfloral zone VI (*Karpatisporites - Gnetaceae-pollenites*) with the IVth zone of the Transdanubian area. As mentioned above, the presence of the sea could have had a moderating effect on the extreme droughts and hot climate; the floral change here was therefore not manifested as distinctly as in the Carpathian region.
A comparison of the uppermost Permian microflora of the Carpathian region with that of the Upper Permian from the British Isles (VISSCHER 1971, the Kingscourt - Gypsum Formation, Upper Mudstone member) shows that the latter contains a microflora with prevailingly multiteniate pollen and a higher percentage of pollen of the genera *Guttulapollenites* and *Stellapollenites*. This zone may be correlated with the microfloral zones V to VI from the West Carpathian region. The difference between both floras is, however, evident. In the Kingscourt - Gypsum Formation no small bisaccate pollen of the genus *Karpatisporites* have been found, and in our region species of the genus *Stellapollenites* (*Lueckisporites norma D*) are missing. The occurrence of the genera *Guttulapollenites* and *Klausipollenites* is the only common feature.
The fact that the uppermost Permian microflora is widespread throughout the Carpathian region is demonstrated by finds from several localities in two tectonic units - the Hronicum and Veporicum as well as from the Canadian Arctic islands - from the uppermost Permian.
An important research objective would be to search for manifestations of a biological catastrophe in uppermost Permian sediments, preferably in continental areas where these could have been most conspicuous.

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