COMPARISONS BETWEEN THE CRETACEOUS AND TERTIARY FLORAS OF CENTRAL AND SOUTHWEST EUROPE: A COMMENTARY

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ABSTRACT

The well documented floras from the Lower Cretaceous of Spain are useful for a comparison with similar floras from Portugal, Germany, France and England. The Upper Cretaceous floras in Spain are characterized by only a few plant remains, in contrast to the rich floras from Bohemia. The genus *Frenelopsis* occurred worldwide in the Cretaceous.

A mangrove vegetation with *Nipa* and *Acrostichum* as known from Spain spread along the Eocene shoreline from England-Belgium-France-Spain-Italy-Hungary to Ukraine. The flora from Sarreal near Tarragona is similar to that from Haring in Austria. Arcto-tertiary elements, whose frequency increased during the Oligocene in Bohemia and Germany, were developed less abundantly in Spain. A warm (subtropical) climatic oscillation during the Early Miocene has not been noted in Spain, but is well known in Central Europe. Leaves identified as *Castanea atavica* or *Quercus kubinii*, which are widespread in Central Europe in Middle-Upper Miocene strata are apparently not well represented in Spain. There are some similarities between the flora from Cerdanya (Rerolle, 1884) and Crespià (Roiron, 1983) in NE Spain and that of Willershauen in Germany. The names of modern plants should not be used for Pliocene leaves. It is not possible to regard the flora from Crespià to be of Pleistocene age for it contains a high percentage of typically Neogene species (e.g. *Zelkova zelkovaefolia*, *Acer integerrimum* and *Parrotia pristina*).

Keywords: Cretaceous, Tertiary, important plant assemblages, Spain, Central Europe.

INTRODUCTION

A brief stay at the Department of Palaeontology, Faculty of Geological Sciences, University of Madrid (Complutense), in 1991, allowed the present writer to put some thoughts down on the subject of Cretaceous and Tertiary floras in Spain.

It seems useful to point out some of the similarities and differences between the Cretaceous and Tertiary floras of Spain and those of Central Europe. Unfortunately, it has only been possible to observe the material deposited in Madrid at the Departamento de Paleontología, Facultad de Ciencias Geológicas, Universidad Complutense. The illustrations in some important papers were often not clear enough to serve for a precise comparison with Central Europe (e.g. Menéndez Amor, 1955).

CRETACEOUS

Rich fossil plant collections have been described since 1820 from the Cretaceous of Bohemia, mainly from the so-called Peruc Member of Cenomanian age.
These collections were studied mostly by Velenovský, Vinklár, Bayer, and Mařík in the second half of the nineteenth century and in the early part of the twentieth century. After the Second World War the Cenomanian leaves were studied by Hušťík, Kvaček and Knobloch. These are the richest Cenomanian megafossils in Europe. The Cretaceous floras in other parts of Europe are mainly of early Cretaceous age (Portugal, Spain, France, Germany, England) or of the late Cretaceous (Germany, Portugal, Austria). Only a few Cretaceous plant fossils have been recorded from Italy, Poland and Rumania.

The finds of plant megafossils (leaves) being quite limited, it is good that additional information has been obtained from palynology. Encouraging results have been obtained in this way from the surroundings of Burgos (Floquet & Lachkar, 1979) and in the Dordogne (Cohn, 1974). Especially the Cenomanian megaspores from these localities show interesting similarities with those from Bohemia.

Two questions are particularly important with regard to the Cretaceous floras, viz. the use of the generic name Sphenopteris, and the ecological characters of Frene-lopis, in relation to its distribution and species differentiation.

It is difficult to decide whether the formgenera Sphenopteris and Pecopteris should be used for Cretaceous floras. Their application has been mainly in the Carboniferous and Permian where these formgenera have been used for fernlike foliage without a known fructification. At least ten species of Sphenopteris have been recorded from Portugal (Teixeira, 1948). From Spain, Depape & Doubinger (1956, 1960) described Sphenopteris (Ruffordia) goepperti Dunker and Sphenopteris hispanica Depape & Doubinger. Some of the leaves described under Sphenopteris may be attributed to Oxychlopis. Likewise, some of the forms recorded as Pecopteris may be attributed to Gleichenites or Cladophlebis (e.g. Pecopteris dunkeri Schimper = Cladophlebis dunkeri (Schimper) Seward). From Bohemia several species have been referred to Sphenopteris, Pecopteris, Gleichenia, Gielchenites or Cladophlebis.

The genus Frene-lopis occurs worldwide in Cretaceous deposits of the northern hemisphere. In Czecho- slovakia there are indications that this genus was connected with a brackish marine environment (e.g. F. hoheneggeri which occurs in marine flysch deposits).

Nevizszyda obtusa has often been found together with Frene-lopis alata in Bohemia, and Eretophyllum ande- gavense (= Nevizszyda obtusa andegavense) occurs under similar conditions in the surroundings of Anjou where it is found together with marcasite (Pons, Boureau & Brouín, 1976; Hušťík, 1986). Similar environmental conditions were ascertained for Frene-lopis oligostomata Romariz emend. Alvin in the Cretaceous of Portugal (Pons & Brouín, 1978).

A summary appraisal of studies on the Cretaceous floras of western Europe and North Africa (e.g. Alvarez Ramis et al., 1981) suggests that most of these floras are characterised by only a few species. In Spain only the Lower Cretaceous floras can be used for a comparison with other countries. The Stramberg flora of the Lower Cretaceous in Moravia (Czechoslovakia) has only Zanites spp. and Cladophlebis albertsii (Dunker) Brongniart in common with the Spanish flora. The genera Brachyphyllum, Frene-lopis and Sphenopteris are represented by different species (for a full account of the Moravian flora, see Purkyňová, 1980).

**TERTIARY**

The Eocene floras of Spain show important components of a mangrove vegetation, such as Nipa burtini (Brongniart) Ettingshausen and Acrostichum tanzeanum (Visiani) Reid & Chandler (see Alvarez Ramis, 1982). Nipa is extensively represented along the Eocene shoreline from England through Belgium, France, Spain, Italy and Hungary to Russia (Tralau, 1964). The fern Acrostichum has a similar distribution (for more details see Barthel, 1976). Whilst the fruit of Nipa is unrecorded from Bohemia, the fern leaves of Acrostichum have been found in the locality of Kučín (Bůzek et al., 1990).

The flora from Sarreal near Tarragona, in Catalonia (Fernández Marrón, 1973), shows similarities with the Upper Eocene flora of Häröing in Austria (Ettingshausen, 1853). They share the presence of Dyandra (Comptonia) schrankii (Sternberg) Berry and Zizyphus ungeri Heer, as well as many of a large number of species with small leaves or leaflets, such as Dalbergia, Acacia, Cae- salpinia, Colutea, Podogonum, Cygius, etc., all similar to the Leguminosae. The presence of the so-called Calli- tris bronniarii Endlicher is also noted, whereas Fagus gautieri Laurent & Marty has probably been wrongly identified since Fagus is unlikely to be present in this kind of assemblage. Anyway, the morphological features of the plant identified as such are quite different to those of the northern Fagus.

The Oligocene floras from Spain are not as rich as those in Bohemia which have a larger number of species. The data are summarised in the work of Fernández Marrón (1971). It is noted that Arotetertiary elements, which prevail in the Oligocene floras of Bohemia, are few and far between in the Spanish Oligocene. Genera such as Cercidiphylum, Ulmus, Tilia, Betula, etc. are completely absent from the Spanish floras. Some of the leaves identified as Salix (a true Arotertiary element) may be related forms, but not very likely Salix itself. Some leaves with entire margins may well belong to a Palaearctic element of uncertain systematic affinity. Fan-shaped palm leaves mentioned as Sabal and Flabellaria from Sarreal and Ribesalbes in Catalonia show a resemblance to elements from older Tertiary floras (Eocene, lower Oligocene) in Central Europe (Häröing, Gieseltal, Monte Prornia, Staré Sedlo, Kučín). It seems that palaearctic elements are more prevalent in Spain than they are in the Oligocene floras of Bohemia.

The upper Eocene is the most important warm interval during the Miocene (Knobloch, 1989; Bůzek & Kvaček, 1990). The Egergebirgen Stage forms the basal part of the Miocene in the area of the Paratethys and corresponds in age to the Aquitanian of the Mediterranean area. This extremely warm (subtropical) climatic oscillation is characterised by the well known
mastixioidean flora (both fruits and seeds) from Wiesa (Mai, 1964) and Schwandorf (Gregor, 1978) in Germany. The same kind of flora is known from Arjuzanx in southwestern France, but its age has been disputed (Gregor, 1990). The mastixioidean flora probably corresponds in age with the leaf flora from Lipovany in Slovakia (Nemejc & Knobloch, 1973). These subtropical floras correspond to a wet environment and are quite different to the one found in the Znojmo locality of southern Moravia (Knobloch, 1969) which shows a prevalence of small leaves with entire margins or margins with small teeth. The latter are mainly sclerophyllous and correspond, most likely, to shrubs and trees growing under dry and hot climatic conditions. The Znojma flora seems ecologically and stratigraphically equivalent to the flora from Martorell (Catalunya) as described by Sanz de Siria Catalán (1981).

In the late Pontian (Messinian) the connection between the Atlantic Ocean and the Mediterranean was severed for a short time (c. 500,000 yrs). This create the so-called salinity crisis in the West Mediterranean (Rögl & Steininger, 1983), a concept that needs to be examined. The Messinian flora from Korfu, as described by Heimann, Jung & Braune (1975) and Heimann & Jung (1976), contains some plants which may be regarded as pre-Mediterranean elements. These are, for instance, Cupressus sempervirens Linné, Berberis sp., Palurus cf. spinaria Mill and Pistacia cf. sativa Miller. Besides, a number of plants are present that need a certain amount of humidity: Populus, Ulmus, Persea, Taxodium, Platanus, etc. This seems to confirm an observation made in the Badenian of northern Moravia (Knobloch, 1969) where a gypsophytic encastment mine yielded the leaves of Fagus, Acer, Carpinus, Platanus and Buxus. Neither these plants nor the Messinian flora reflect dry environmental conditions, and it appears that the theory of a circum-Mediterranean dry phase with sclerophyllous evergreens (Rögl & Steininger, 1983, p. 12) cannot be maintained on the palaeobotanical evidence. Also some floras found in gypsesiferous sediments in Italy, fail to reflect dry conditions in either the leaf form or the nature of the genera (Rörolle, 1984; Knobloch, unpublished information).

In the Upper Miocene and Pliocene floras the relation between the fossil and the modern leaves becomes important. Some genera, such as Populus, Fagus, Quercus, Acer and Fraxinus become prominent. With regard to Populus, there are similarities between the modern Populus alba and fossil leaves of Populus tremula; however, these are only similarities because the leaves are not identical. It is, therefore, clear that one cannot accept names like Populus alba Linné and P. tremula Linné for the leaves recorded by Rörolle (1984, p. 692, figs 9-12). Neither can one accept Populus tremula (piocenica) and P. canescens (Aiton) Smith (piocenica) for the leaves illustrated by Rörolle (1884, pl. IX, Figs. 8-9). It also seems unlikely that a flora with predominantly deciduous plants (Acer, Populus, Quercus, Betula, etc.) would contain as well Zelkova crenata Spach and the fossil Z. subeakati Rörolle, as Rörolle recorded from Cerdanya. All the fossil leaves of the genus Zelkova belong to extinct species which are comparable but not identical to modern forms of Zelkova. The same situation exists with regard to Acer, Populus, Betula and others.

Although there are a few differences with regard to taxonomy and the ecology of leaves recorded from Seu d’Urgell and Cerdanya, the percentage of leaves with an entire margin is quite similar in both localities (40% in Seu d’Urgell and 31% in Cerdanya - see Alvaraz Ramis, 1981, p. 562). To judge from the drawings and photographs of the Seu d’Urgell flora, this contains a higher proportion of smaller (and more poorly preserved) leaves than Cerdanya. Perhaps, a warm temperate climate is more likely than a subtropical one.

It seems that leaves recorded from Central Europe as Castanea atavica, Quercus kubinii, and other denticulate forms, which are ubiquitous and characteristic of the Upper Miocene floras in this area (Knobloch, 1986), appear but rarely in Spain, whilst being apparently absent in Spain.

The palaeobotanical literature from Spain (mainly summarised by Alvaraz Ramis & Fernández Marrón, 1983a) shows a generally poor preservation of leaf specimens. Therefore, the relevant detail is not always visible on the photographs.

It is noted that the South European floras of the Miocene (or Pliocene?) show a larger representation of Lauraceae than occurs in Central Europe. This is apparent from the Siurana flora (Girona province of Catalunya), as recorded by Sanz de Siria Catalán (1982), and also from Italy (Berger, 1958) where Daphnognie polymorpha (Al. Baum) Ettingshausen and Oreodaphne heeri Gaudin have been found. Only Sassafras ferreitanum Massallongo occurs in the Pliocene of the Rhône Valley (Depape, 1922) as well as in the German localities of Willershausen (Strauss, 1930) and Berga (Mai & Walther, 1988).

Most important for a comparison with the Pliocene floras of Central Europe is the rich assemblage from Papiol (Catalunya) which is characterised by a large variety of dicotyledons, 140 taxa having been recorded by Alvarezo Ramis & Fernández Marrón (1983b). A small collection from Papiol has been examined by the present writer during his stay at the Department of Palaeontology, Madrid University (Complutense). The genus Daphnognie was the prevailing element in this collection. This element of the Lauraceae is present in the flora from Cerdanya, but is lacking from the younger flora in Crespa. It also fails to occur in the Pliocene floras of Central Europe. It should be interesting to check on the various points of extinction of laurifolious elements in the different localities in Spain.

The flora from Cerdanya (Rörolle, 1884) is regarded as late Miocene (Pontian) by Alvaraz Ramis (1981), whereas that of Mont-Doré in France (Boulay, 1892) is assigned to the Pliocene, and that of Crespa to the Pliocene-Pleistocene (Rörolle, 1983). All these floras are somewhat similar to the Pliocene flora of Willershausen (Strauss, 1930; Knobloch, 1990a-c). They all show the presence of Miocene relict forms, such as Zelkova zelkovaefolia, Acer integerrimum, Parrotia pristina, and the husks of Carpinus ex gr. grandis and of Carpinus ex gr. kisseri var. orientalis. Whereas the palaeotropical genus Daphnognie is present at Cerdanya, it is absent from Willershausen, Mont-Doré and Crespa. Differences are
also apparent in the representatives of Acer and Quercus.

There is a reasonable similarity between the flora from Willershausen and that from Cresta in Catalunya, but some differences are apparent. Roiron (1983) described some leaves as Populus alba and P. tremula from the Cresta locality, but it is quite certain that these fossil leaves are not the same as the Recent ones. The same problem exists with Zelkova. Why use the name of a modern species, Zelkova crenata, when it is impossible to prove that the fossil leaves show all the characteristic features of the Recent species? At Cresta as well as in Willershausen, Carya minor, Acer integerrimum, and the same representatives of Tilia, Parrotia, Hedera and Sorbus are present. Platanus and Liquidambar are lacking in both localities. The very important oaks are different in the two localities, but the Betulaeae are the same. Fagus is lacking in Cresta.

Some of the common species of Cresta are the same as in Willershausen. Some of these are typical Miocene relicts, e.g. Zelkova zelkovaefolia, Carya minor, Acer integerrimum, Parrotia saviana and Tilia saviana. For this reason one cannot very well accept Roiron’s suggestion that the Cresta flora is partly of Pleistocene age. I assume that the flora from Willershausen belongs to the middle or upper Pliocene. If the Miocene relicts lasted into the Pleistocene, as is suggested by absolute age dating in the Massif de l’Escandorque near Lunas in Hérault, France (vide Roiron, 1983, p. 709), the age of the Willershausen flora would also come into question. All data will have to be taken into account for the definition of floral zones which do not necessarily conform to the standard zonation based on vertebrate palaeontology.

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