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Climatic changes in the area of Central Paratethys during the Tertiary (based on the macroflora)

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ABSTRACT: The plants have an important role in the determination of the climate of the Tertiary. In the present work we have observed the climatic changes in the area of Central Paratethys during the Tertiary. The Hungarian Tertiary flora and climate are compared with surrounding flora in the south and north of this country.

The plant fossil with respect to determining age and rock formation is expectional, but its ecological role on the mainland is quite unique, especially during the Tertiary.

In the following the floral changes and relationships of the neighbouring countries will be considered, on the basis of which conclusions will be drawn concerning the climatic fluctuations of the Tertiary.

Already at the beginning of the Tertiary there appear the two main types of flora, which cannot only be traced but are the determinants of the florae of later ages. One is the Arctotertiary flora which appears already in the Paleocene with deciduous, dendroid, dicotyledonous plants around the Arctic. The Liquidambar, Salix, Populus, Betula, Ulmus, Alnus, Carpinus, Fagus, Quercus, Juglans, Platanus, Acer genera indicate temperate climate. There are a few genera among them indicating a warmer climate, such as Cinnamomum, Magnolia. The flora has the same name as that of the Turgai flora of KRISTOFOVICS (1955), in the area of the Eastern Paratethys; they are the same. The deciduous flora indicates continental climate and seasonal rhythm. The date of the appearance of Arctotertiary elements is of decisive importance in the determination of paleoflorae. This will be discussed in detail in connection with the different ages.

The other important type of flora is the Paleotropical. This is the same as the Poltawa flora of KRISTOFOVICS (1955), the Tethys flora of REID and CHAND-

LER (1933) and CHANDLER's: Lower Tertiary Flora (1964). To this can be related the so-called Mastixioidea flora (KIRCHHEIMER 1938), which has become universally known through the palaeocarpological branch of paleobotanics. No Mastixioidea has been recovered from leaf-flora, or else the finds are uncertain. Its pollen badly fossilates, but its fruits can be found in large quantities. Earlier it was thought to be characteristic only of the Tertiary of West Europe, lately however it has been described in a great number of other places. On account of its extensive occurrence and that it to a definite biocenosis it is a good object for correlation-tests. Mastixioidea flora indicates laurophillous evergreen vegetation in a subtropical climate. In addition to the family Mastixiaceae; Symplocaceae, Magnoliaceae, Arctostaphyloides and Castanopsis are to be found in this flora. The flora flourished in the Eocene under tropical conditions. Then it stretched from West Europe to Kazahstan with roughly the same or similar species. In the Neogene it occurs as a relic; in the Miocene it has been described by several authors. Its Easternmost appearance in the Miocene known at the present is in the Southern part of Poland. In Hungary the palaeocarpological section of paleobotanics is a field where little research has been conducted so far, and therefore Mastixioidea flora has not been found either in Eocene or later.

Of the Eocene florae the most significant and nearest to us is the one in Geiseltal in the GDR, dating from the Middle Eocene (RÜFFLE 1967). The climate was warm and rainy, tropical or a warmer subtropical. This is indicated by the great number of palm remains. At the same time in the Eocene on the area of Germany Arctotertiary elements appeared already and they prevailed in the Lower Oligocene. But they are missing in the Eocene and Lower Oligocene in Czechoslovakia, they appear in the Middle Oligocene flora of Kuclin, where they are of no significance yet and become prevalent only during the Egerian (Upper Oligocene). This shows similarity and even identity with the time of the spread of the Arctotertiary flora in Hungary.

In this country in spite of the considerable carbon formations in the Eocene, there are no remains similar to the excellently conserved flora of Geiseltal. With the exception of the Lábatlan locality only sporadic finds can be mentioned. RÁSKY (1948) has described Nipa remains from Dudar, KOVÁCS (1958, 1959) described Magnolia and Dryophyllum from Lábatlan. On the basis of remains the above authors assume a subtropical climate. No research has been made in the Upper Eocene of this country, only RÁSKY describes a couple of plants in the Buda Marl, on the basis of which she supposes a relationship of the flora with that of South-East Asia today.

In the area of Czechoslovakia similar flora is described by KNOBLOCH (1967). A common feature of each is the Indo-Malaysian character. As regards the climate, it indicates subtropical conditions.

Oligocene is a much better examined age than Eocene, yet it is still less explored than Neogene. In Czechoslovakia the Lower Oligocene has been determined by Doliostrobus which extends to the Middle Oligocene. This genus is known from the Upper Crete and can be found right up to the Middle Miocene at different places with different species. In the area of the Czech Massive it first appears in the Lower Oligocene and is characteristic for the Lower and Middle Oligocene (BUZEK-HOLY-KVACEK 1968). This seems to be a level-marking genus, since it occurs in large quantities also in the area or at least in part of the area of Central Europe. On the one hand the remains men-

tioned by RÁSKY by the name of Araucaria hungarica and Sequoia sternbergii have proved to be Doliostrobus on the basis of examinations of BUZEK, HOLY, KVACEK, on the other hand Doliostrobus remains have been found lately in Tard Clay (HABLY 1979).(The remain described under the name Sequoia sternbergii from the Kiseged flora (near Eger, NOVÁK 1950), also belonging to a Tard Clay formation is probably also Doliostrobus.) Consequently the Doliostrobus level should be suitable for levelling longer distances. A wider expansion is shown by Libosedrites salicornioides from the Lower Oligocene in this country; this has been found both in Kiseged and in Óbuda, and even occurs everywhere in Tard Clay formations but is not present in the Egerian. (Note: JABLONSZKY (1914) describes Libocedrites fossil from Ipolytarnóc. This is a find of a much later age from Ottnangian. Its mass occurrence however can be dated from the Lower-Middle Oligocene). This is where it shows difference from the Bohemian expansion, where it is present in the Middle Oligocene and continues in the Egerian. Of the Czech Middle Oligocene florae the most significant one is that of Kuclin, there Paleotropical elements dominate mainly with laurophillous flora: Magnolia, Daphnogene, Laurophyllum, Diospyros, Sassafras, Sterculia, Nectandra, Terminalia. A great number of palms is to be found: Sabal major, Chamaerops kutschlinica, rendering a highly tropical character to the flora, indicating a still earlier age. There are a few Arctotertiary elements but their number is not significant. A characteristic feature is the presence of primieval types of Quercus, Q. drymeja and Q. kutsclinica.

From the Hungarian Lower Oligocene, from the Tard Clay, from the brickyard of Szépvölgy (Budapest) among others Pinus, Taxodium, Myrica, Salix, Pterocarya, several species of Quercus, Ulmus, Zelkova, Ficus, Persea, Laurus, Cinnamomum are mentioned by RÁSKY (1943). In addition to the above he lists also Sabal from Csillaghegy, Budapest. According to the genus-list the number of Arctotertiary elements is relatively high, but the Salix, Ulmus, Zelkova finds are uncertain as only one specimen of each has been found, and these of rather poor conservation. Although the long narrow Salix-type leaves are rather frequent, their poor conservation makes it impossible to prove that they are Salix; in some cases where the venation is visible a definite Lauraceae character can be observed.

The Kiseged flora (near Eger) also belongs to Tard Clay formation. At any rate the two florae (Kiseged and Budapest) shows great similarity. Apart from Doliostrobus and Libocedrites remains Taxodium, Sequoia, Pinus are to be found in both places. Of the dicotyledonous Magnolia, Cinnamomum, Sterculia, Ficus, Zizyphus are detectable in both florae. A new entry is Platanus neptuni (HABLY 1979) which figures under different names in the description of RÁSKY(1943) and ANDREÁNSZKY (1957,1959,1965,1966) as the species shows great variability. It was found in great quantities in Tard Clay formation when the Budapest Metro was being constructed (HABLY 1979),but it can be found in great quantities also in former collections unnamed or listed under a different name.The species was recognised and described by BUZEK, HOLY and KVACEK (1967) from Middle Oligocene of Bohemia (Kuclin). In Hungary as indicated by researchers so far, it can be dated from the Lower Oligocene. In Europe it is known from the Oligocene (KNOBLOCH 1973). Particular attention has been given to this species as it is of great significance both from climatological and from biostratigraphical aspects. Its stratigraphical value has already been mentioned. As to the climate we can draw conclusions from its eucological

requirements. It is of expressly xerophilous element, i. e. not aquatic, but of medium water requirement and is characteristic of the flora of hilly regions. This supports ANDREÁNSZKY's supposition about dry climatic conditions, which is proved also by the great number of Dryophyllum furcinerve. This species figures under different names in the papers of ANDREÁNSZKY, revised by RÜFFLE MÜLLER-STOLL and LITKE (1976). In Bulgaria it is mentioned by PALAMAREV from the Lower Oligocene as a characteristic species as Castanopsis furcinervis. (RÜFFLE-MÜLLER STOLL-LITKE 1976). The Dryophyllum furcinerve prevailing in the Bulgarian Middle Oligocene (PALAMAREV 1967) indicate xerophillous, mezoxerophillous flora. PETRESCU (MÉSZÁROS-PETRESCU 1967) has published a similar flora to Tard Clay from the Lower Oligocene of Mera (Romanian) with Zizyphus zizyphoides, Laurus and Castanopsis furcinervis=Dryophyllum furcinerve (RÜFFLE-MÜLLER-STOLL-LITKE 1976). The plants seem to indicate that in the Middle Oligocene the climate grew more and more arid proceding from the North to the South. In the Balkans there are no Arctotertiary elements at all in the Middle Oligocene whereas they are present in Bohemia and Hungary even though in lesser number than in other places.

A decisive change in the flora occurred in the northern part of the Central Europe in the Egerian (Upper Oligocene). It is in this age that the Arctotertiary flora begins to dominate both in the area of the Czech Massivum, and on the territory of Hungary. In the Balkans this takes place only later; here they appear in the Lower Miocene and become prevalent in the Sarmatian. (PANTIC 1967). In the Czech Egerian two levels have been set up by KNOBLOCH (KNOBLOCH et al. 1975) on the basis of the flora: one the holotype locality of which is Markvartice, in the Laurophyllum medimontanum-Platanus neptuni-Acer palaeosacharinum zone. In addition to the name giving species Comptonia acutiloba, Libocedrites salicornioides, Engelhardtia detecta, Ulmus fischeri are to be found. The other also Egerian zone is the Cystoseirites partschii-Cunninghamia miocenica-Platanus neptuni, whose holotype locality is Krumvir. It should be noted that in both Egerian flora zones Platanus neptuni is present. In Hungary it is known from the Egerian only of the Wind brickyard. Regarding Egerian florae in this country it can be stated that as in Bohemia, in Hungary a great change occurred the course of which the Paleotropical elements were supressed by the Arctotertiary flora in the Egerian. It would be untimely to set up zone-marking species for the Hungarian Egerian, but on the basis of the above findings it seems almost certain that they do not correspond to the Czech zone-marking species. The climate, however, would have been similar in the two areas and the difference in species components can be explained by other eucological and phytogeographical reasons. According to MAI (1967) it was in the Egerian that the Arctotertiary flora reached the stage of development when major connections were formed from Eastern Europe to Siberia. MAI defines 12 biostratigraphical zones on the basis of macroflorae especially of seed and fruit collections. In the first zone dating from Upper Oligocene, in addition to other plants, Libocedrites salicornioides, Comptonia are to be found similarly in the Czech Upper Oligocene. Also to be found are Taxodium, Sequoia which are also dominating in the Hungarian Egerian. At the time of transition from Upper Oligocene to Lower Miocene, still in the Egerian, a new flora, characterized by laurophillous elements takes over. On the basis of seeds and fruits MAI establishes Mastixioidea so the climatologi-

cal optimum of this zone is almost subtropical. According to MAI there existed a deciduous flora under an fluctuating warmer climate.

Further on it is difficult to make comparisons between flora in this country and in zones delineated in other areas as the majority of florae dealt with so far belongs to the Sarmatian stage and little is known about the antecedents. KNOBLOCH (KNOBLOCH et al. 1975) sets up two zones in the Eggenburgian stage the first of which he identifies with MAI's zone IV. MAI assumes warm and humid climate at the beginning of the Miocene. In zone IV. a mixture of Arctotertiary and laurophillous can be observed with the flora tending to become laurophillous at its optimum.

In the Ottnangien stage KNOBLOCH designates one single zone which is significant also in Hungary its paratype locality being Ipolytarnóc. This is the Engelhardtia detecta-Laurophyllum div. sp. - Calamus noszkyi zone. In the flora laurophillous leaves with entire margin dominate.

In the Karpatian stage KNOBLOCH distinguishes three further flora zones and demonstrates its similarity with MAI's zone on the basis of the presence of Mastixioidea flora, maintaining, however, that this is older. Zone VI. shows great similarity to the Eocene flora. According to KNOBLOCH this corresponds roughly to the Eggenburgian, and can be regarded as the flourishing of the Mastixioidea flora in Germany after the Eocene. In Bohemia this dates from a later age according to KNOBLOCH, from the Ottnangian/Karpatian. The flora of zone VI. suggests to MAI a definitely tropic climate with temperatures ranging from 20 to 23°C and a rainfall of between 1000-2000 mm.

In the Upper Karpatian and Lower Badenian florazone Mastixioidea disappears in the Czech regions and there is a higher proportion of Arctotertiary elements. In the other zone, also of Lower Badenian, only Arctotertiary elements are present and of Paleotropical ones only the representatives of the longlasting Lauraceae family are to be found. In the Middle Badenian three phytocenose are isolated, in one of them there is a preponderance of Arctotertiary elements. The rich Sarmathian flora of this country also contains predominantly Arctotertiary elements. In the Pannonian and Pontian are poor in species in the Czech regions, moreover the Hungarian Pliocene does not contain a large number of species compared to the abundance of the Miocene.

HORVÁTH (1963) describes Salix species from around Sé (Western-Hungary near Szombathely) from this he concludes the cool and rainy climate. There is a large amount of Glyptostrobus europaeus as well as two species: Pteris sp. and Osmunda parschlugiana in its herb layer. The Myrica species of the flora belong to Myrica gale-form. The flora of Upper Pliocene indicate the approaching of the ice-age. The gradual impoverishment is to be explained by the deterioration of the climate.

Summing up the climatic variations in the Tertiary it can be concluded that in the Upper Eocene and in the Lower Oligocene under a subtropical climate a thermophillous Paleotropical flora dominated, which probably survived until the Middle Oligocene. The borderline between the Lower and Middle Oligocene is rather difficult to draw. The Middle Oligocene is characterized by a rather more drier climate, getting drier South of Hungary. In the Egerian decisive changes occur in the northern part of the Central Paratethys. This is the time when the Arctotertiary elements become dominant. The deciduous flora indicate cooler climate and seasonal changes. The Eggenburgian shows a warming up in Germany and to a lesser extent in Bohemia. This cannot be

demonstrated in Hungary on account of the absence of flora. At the border of the Ottnangian/Karpatian the flourishing of the Mastixioidea flora indicates a warm climate again in Bohemia. This has not been demonstrated in this country. The Badenian is characterized by deciduous flora with a frequent presence of laurophillous. In the Sarmation no considerable change occurs in Czech territory but in the Balkans the Arctotertiary flora takes over in this age. The process takes place somewhat earlier with respect to Roumanian florae and proceeding towards the south a gradual time-lag can be observed. The Arctotertiary elements appear here already in the Egerian but they become dominating only in the Badenian. In Yugoslavia the appear in the Eggenburgian and become prevalent in the Sarmatian. After that the flora gradually becomes impoverished to the ice-age.

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