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EVOLUTION OF NEOGENE MEDITERRANEAN VEGETATION AND THE QUESTION OF A DRY UPPER MIOCENE PERIOD (SALINITY CRISIS)

by

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Not only in Northern European countries are known rich fossil floras (FRG, GDR, Poland, ČSSR etc) but also in the Mediterranean area, for example from Spain (Tarragona, Izarra, Barcelona, Siurana) and Portugal (Povoa de Santarem, Tagus) to France (Cerestë, Pont-de-Gail, Cessenon, Pichegu, Cerdagne), Italy (Senigallia, Gabbro, Castellina maritima, Florence, Stirone), Greece (Kumi, Aliveri, Vegora, Likudi, Prosilion) and Turkey (Çanakkale, Soma, Sahinali, Saray, Edirne) (see Fig. 1). Most of these are of leaf character, but also fructifications and pollen-grains occur in these floras, belonging to a period which reaches from the Oligocene through the Miocene to the Pliocene, including one part of the Pleistocene, too (see Documenta naturae 25, 1985; GREGOR, 1983).

Through the ages there are equivalent facies like open water-, reed-, swamp-, bottomland forest—and mixed mesophytic forest (see MAI, 1981).

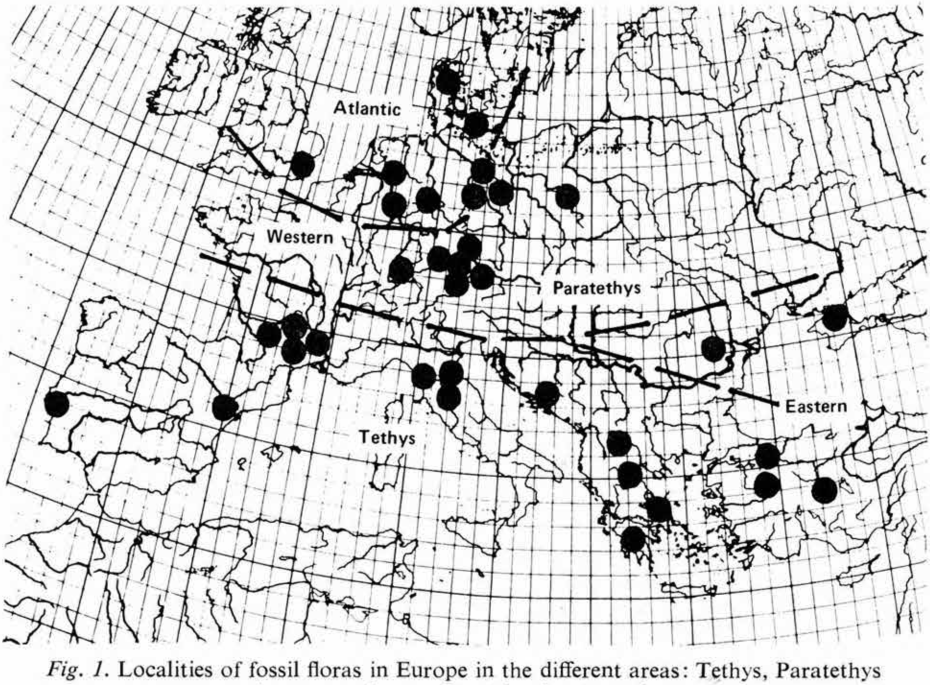

Fig. 1. Localities of fossil floras in Europe in the different areas: Tethys, Paratethys (eastern and western), Atlantic—Boreal

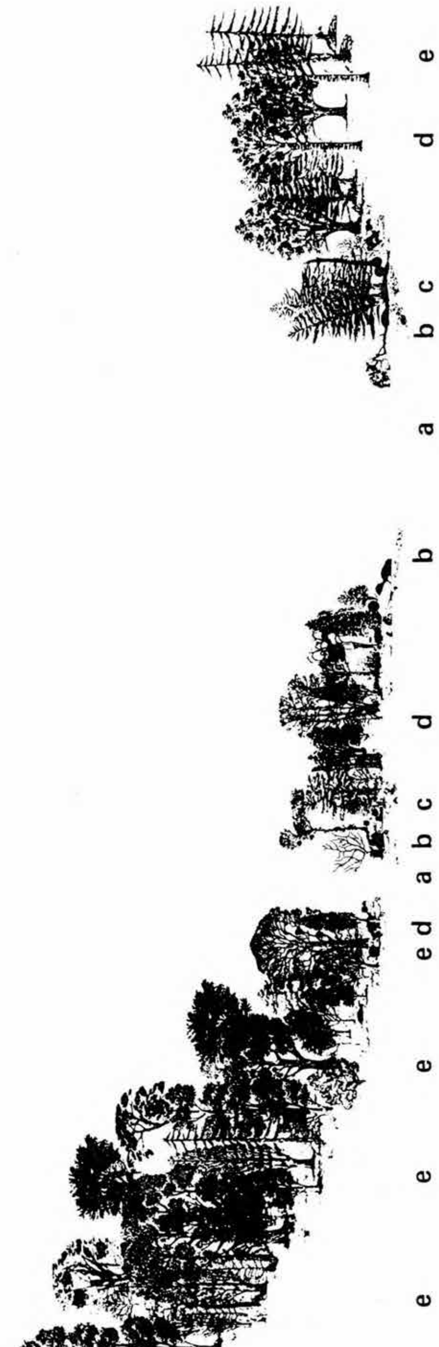

Fig. 2. Different facies-types of fossil floras, equivalent in Paratethys and Mediterranean floras

a = open water, b = reed, c = swamp, d = bottomland forest, e = mixed forests

Important plant elements for these types were for example (see Fig. 2):

a) open water: Nymphaeaceae, Brasenia, Stratiotes, Ceratostratiotes;

b) reed: Bolboschoenus, Scirpus, Schoenoplectus, Carex;

c) swamp: Glyptostrobus europaea, Taxodium dubium, Myrica, Spinophyllum;

d) bottomland forest: Populus, Salix, Gleditsia, Cinnamomum (vel Daphnogene), Alnus, Betula, Fraxinus;

e) mixed-mesophytic forest: Quercus, Laurus, Cinnamomum (vel Daphnogene) Sapidus, Acer, Ulmus, Fagus, Paliurus, Pinus, Carpinus, Cephalotaxus, Liquidambar, Mastixia.

If we have a look on the composition of the different facies in the run of the time we see a slow change from a highly evergreen to less exotic and more native vegetation, running to the Recent one in later Pleistocene times (Fig. 3).

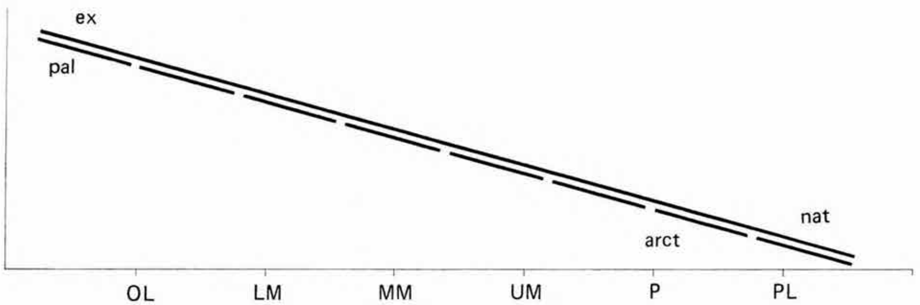

Fig. 3. Decline of exotic (ex) and palaeotropical (pal) elements in Paratethys floras (—) and Mediterranean ones (----) to native (nat) and arctotertiary (arct) composition (a model)

We have same shift from palaeotropical elements to arctotertiary elements for example in Germany (GREGOR, 1982), Poland etc. If we compare the elements of the Mediterranean and the Paratethys-floras we discover a high degree of similarity, not comparable to the Recent floras as these are connected with vegetation zones and different climate types. Some differences in the floral record may be mentioned here. In contrast to Paratethys-areas, the common Mastixias we know from there are nearly all missing in the Tethys area, including many subtropical elements like Symplocaceae, Theaceae, Magnoliaceae etc (see GREGOR, 1978; 1980) (Fig. 4).

All floras from the Paratethys area and the Tethys area indicate wet or humid subtropical (warm-temperate) climate of Cfa-type (Virginia-climate, sensu KÖPPEN, see Fig. 5). We only have to distinguish between the palaeotemperature curve over wide areas from an Eocene Af-Cfa-climate to a Plio—Pleistocene Cfa (Cw)-Cs-climate (see Fig. 5). The special climate-diagramms of certain smaller areas (sensu WALTHER, see Fig. 6) give an idea about local factors like humidity, wind, frost, desiccation etc.

To give an impression about the real concordance of fossil floras in the Paratethys and Tethys areas, some examples are brought here (as extracts only), see Documenta naturae 25, 1985; 29, 1986; GREGOR, 1978, 1980, 1982;

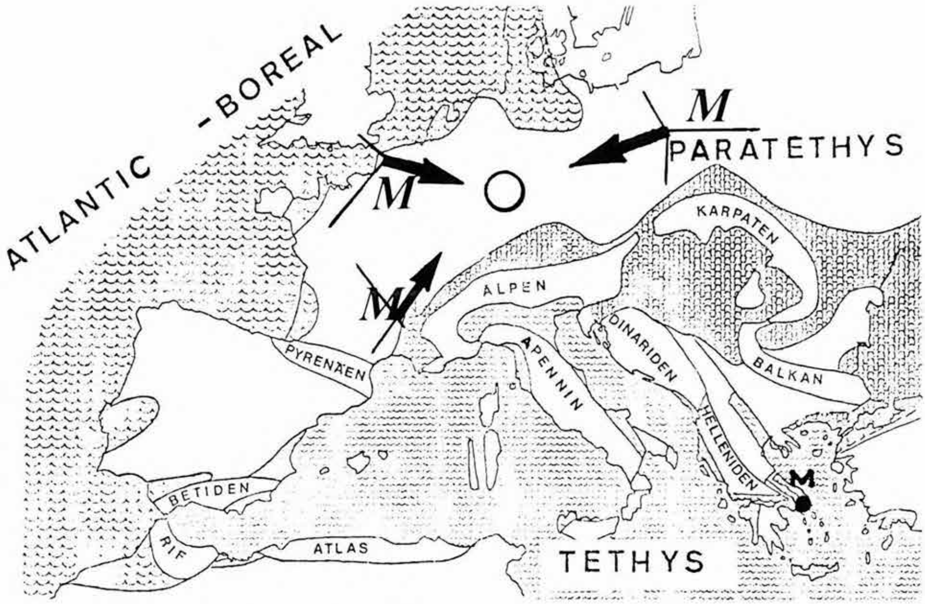

Fig. 4. Europe in the Lower Miocene with Mastixioidean floras (M) a possible centre of this typical flora and the only Greek locality yielding such types

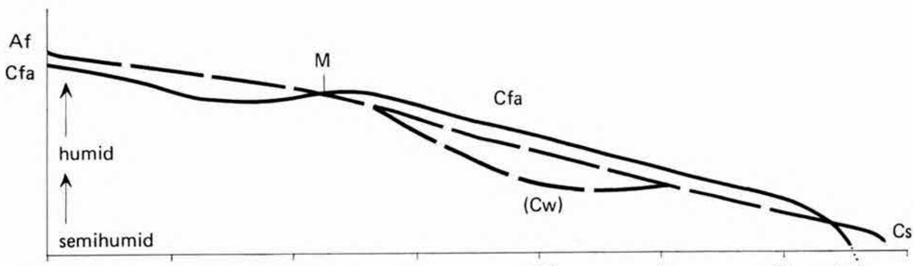

Fig. 5. Principal model of the decline of the palaeotemperature curve from Oligocene (OL) to Pleistocene (PL) in Paratethys-area (—, with Mastixioidean maximum M) and the Mediterraean (----, with elongated line in Pleistocene and missing Lower Miocene temperature maximum, lack of Mastixias)

Lower Miocene

Floral list from Arjuzanx (France) and Schwandorf (FRG):

Carya ventricosa
Liquidambar magniloculata
Magnolia sp.
Mastixia sp.
Myrica stoppii
Nyssa ornithobroma
Ocotea rhenana
Parabaena europaea
Retinomastixia oerteli
Sapindoidea globosa
Spinophyllum daemonorops
Symplocos div. sp.
Toddalia rhenana
Trigonobalanus sp.
Zanthoxylum sp.

Lower Miocene

Floral list from Aliveri (Greece), Langenau and Schwandorf (FRG):

Glyptostrobus europaea	Paliurus sibiricus
Myrica div. sp.	Sambucus pusilla
Rubus laticostatus	Sparganium camenzianum
Toddalia div. sp	Carex plicata
Zanthoxylum ailanthiforme	

Middle Miocene

Floral list from Soma (Turkey) and Oehningen (FRG):

Cinnamomum div. sp.	Populus latior
Myrica lignitum	Gleditsia sp.
Laurophyllum princeps	Glyptostrobus europaea
Quercus div. sp.	Magnolia ludwigii
Acer trilobatum	Tilia sp.
Salix varians	Cercis sp.

Upper Miocene

Floral list from Likudi and Vegora (Greece), Achldorf and Massenhausen (FRG):

Paliurus thurmanni	Platanus leucophylla
Pinus sp.	Zelkova zelkovaefolia
Alnus sp.	Fagus sp.
Carpinus grandis	Quercus div. sp.
Corylus sp.	Ostrya sp.
Populus sp.	Alnus ducalis
Ceratophyllum vösendorfense	Acer div. sp.
Sassafras sp.	

Plio—Pleistocene

Floral list of Stirone river and St. Barbara (Italy), Frankfurt and Willershausen (FRG):

Carya angulata	Platanus aceroides
Juglans bergomensis	Populus latior
Liquidambar europaea	Salix varians
Cephalotaxus sp.	Quercus div. sp.
Corylus avellana	Acer integrilobatum
Picea sp.	Carpinus grandis
Pinus sp.	Juglans acuminata

The question arises whether there was a "Messinian crisis", a desiccation of the Mediterranean sea—or not. Now as we have seen—all floras are of wet character and show no hint of any arid climate or a typical arid phase neither in the Messinian nor anywhere else. In contrast—the floras in gypsum or salt are of the same type as before or after the deposits of Messinian age (6 m.y. ago, see Fig. 4, 6).

To state this floral behaviour we will show here some typical Messinian floras (and from the time shortly before and afterwards) in their composition of elements.

The floral remains all show a humid (semihumid!) hinterland area with dense forests. As we have so many similar floras the question of a local "oasis"-type vege-

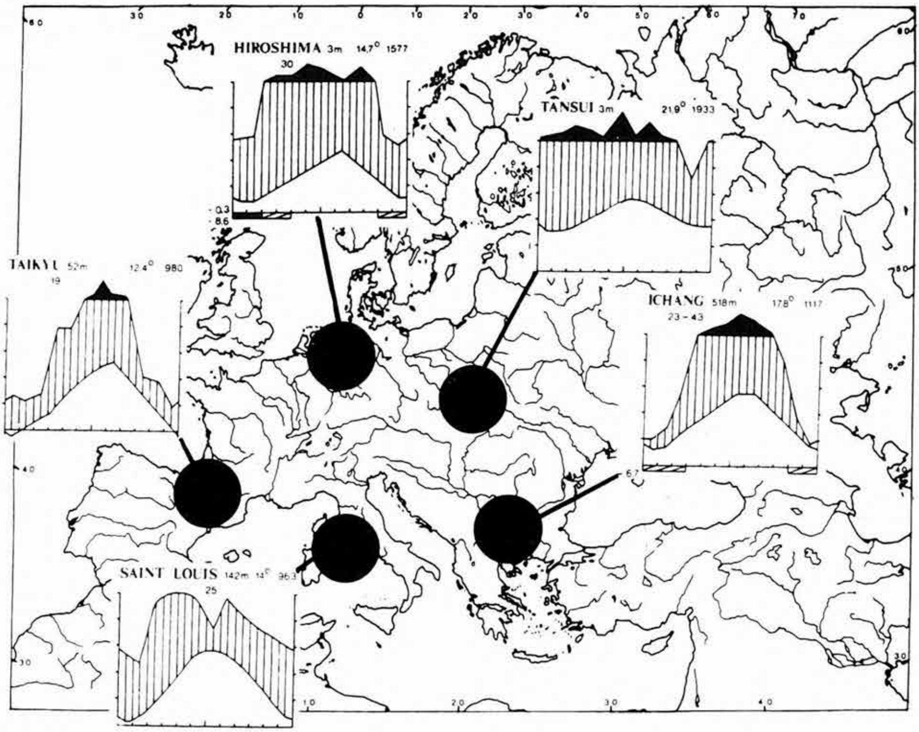

Fig. 6. Theoretical model for climate diagrams in Europe for Upper Miocene times (salinity crisis) to show the differences in a Cfa-climate. In the Mediterranean we have less rain per year and a certain "winterdry" season

Taxa	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Platanus	+	+		+	+	+	+	+
Populus	+	+	+	+	+	+	+	+
Acer	+	+		+	+	+	+	+
Quercus	+	+	+	+	+	+	+	+
Ostrya		+		+		+		+
Carpinus	+		+	+		+	+	+
Betula/Alnus			+	+	+	+		+
Zelkova	+			+	+	+	+	+
Pterocarya		+		+		+	+	+
Cinnamomum	+	+	+			+	+	+
Glyptostrobus			+	+		+		+
Taxodium						+	+	+
Ulmus		+		+			+	+
Leguminosae	+					+	+	+
Salix	+	+				+	+	+
Fagus	+		+	+		+		+

Fossil floras from *1* Chios: Nenita-Strata, *2* Korfu: Paghi-Strata, *3* N Evia, *4* NW Macedonia, *5* Strymon Basin, *6* Turkey, *7* Italy, *8* SW Germany.

tation is *not* given. The reason for the deposition of huge gypsum-horizons at that time is (as we think) not due to on arid climate but to semihumid conditions or a Cw--climate-type (see Fig. 5). This means that we have no desert climate with summer desiccation and partly winter draught (like in a Cs- or Bs-climate), but a drier (semihumid means for example 700—1000 mm rain/year instead of 1500—2000) one or a winter dry Cw-climate with one to three months less rainfall rather than desiccation (Fig. 6).

Accordingly the gypsum deposits in the Messinian time-span and other ones perhaps need another explanation, which is not our problem (but see SONNENFELD, 1984).

To prove the given information we bring here some additional data from faunal and other records at this time. In Pikermi for example 80% of the animals are of wetland or swamp-character, only 20% grazing animals in more open countries.

Also the huge gravel beds with well rounded pebbles from Pikermi gorge (Megalorhema) cannot be explained by less rainfall but by heavy seasonal rainfall (as in Cw or Cfa-climate); the flora (Doc. nat. 25. p. 3, 1985) is also of typical wetland facies. On the contrary many special question remain, including monsoon-climate, in which way the rain was distributed per year (one or two peaks e.g.) or the endurance of frost or snow or the question of local swamp or wetland areas in an relatively open country forest.

The following picture tries give a model of a mediterranean vegetation in Early Miocene, Late Miocene (Messinian) and Plio—Pleistocene times. The forest systems cover the existing areas at the mentioned times and are connected with those of the Paratethys (Fig. 7, climate and vegetation models).

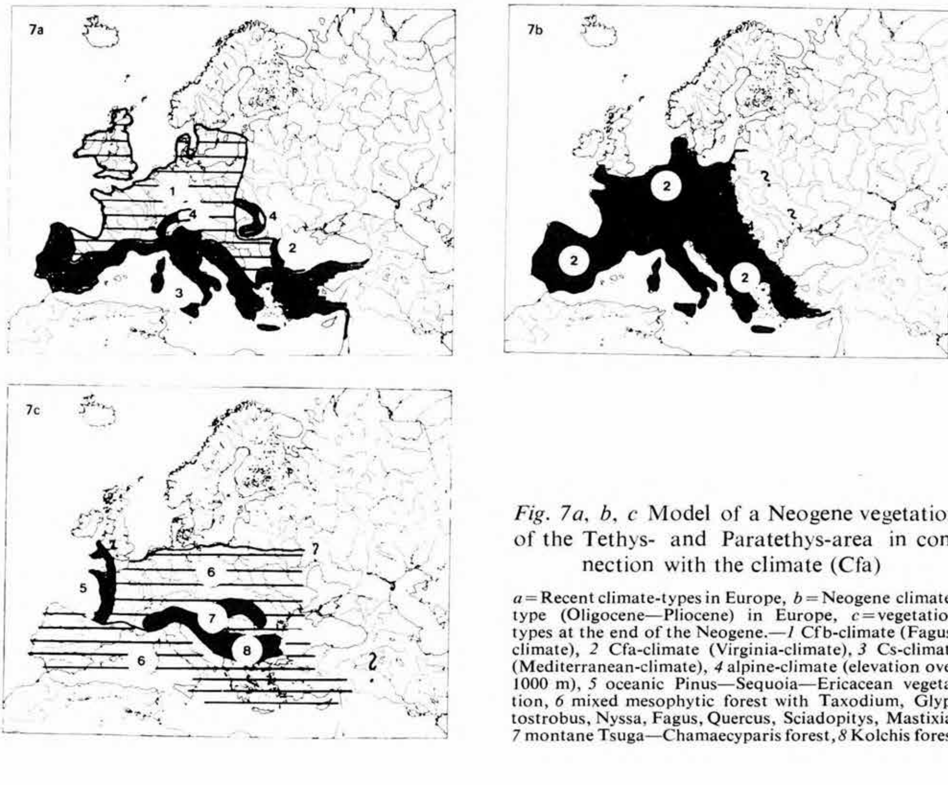

Fig. 7a, b, c Model of a Neogene vegetation of the Tethys- and Paratethys-area in connection with the climate (Cfa)

a = Recent climate-types in Europe, *b* = Neogene climate-type (Oligocene—Pliocene) in Europe, *c* = vegetation types at the end of the Neogene.—*1* Cfb-climate (Fagus-climate), *2* Cfa-climate (Virginia-climate), *3* Cs-climate (Mediterranean-climate), *4* alpine-climate (elevation over 1000 m), *5* oceanic Pinus—Sequoia—Ericacean vegetation, *6* mixed mesophytic forest with Taxodium, Glyptostrobus, Nyssa, Fagus, Quercus, Sciadopitys, Mastixia, *7* montane Tsuga—Chamaecyparis forest, *8* Kolchis forest

The next important question concerns the Plio—Pleistocene boundary, the Villafranchian. The flora from the Stirone river for example, of Calabrian age (Pleistocene!) is of *typically* Pliocene character (see Doc. nat. 25. p. 31) comparable with those of Frankfurt, Czorsztyn, Kroscienko. So the first cold phase had, as it seems, no effect in the Mediterranean, and we have to postulate a divergence of fossil floras in the run of the Pleistocene—between the Tethys and Paratethys floras. Here we have another topic—the question of the glacial and fluvial episodes and the floras of these times.

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