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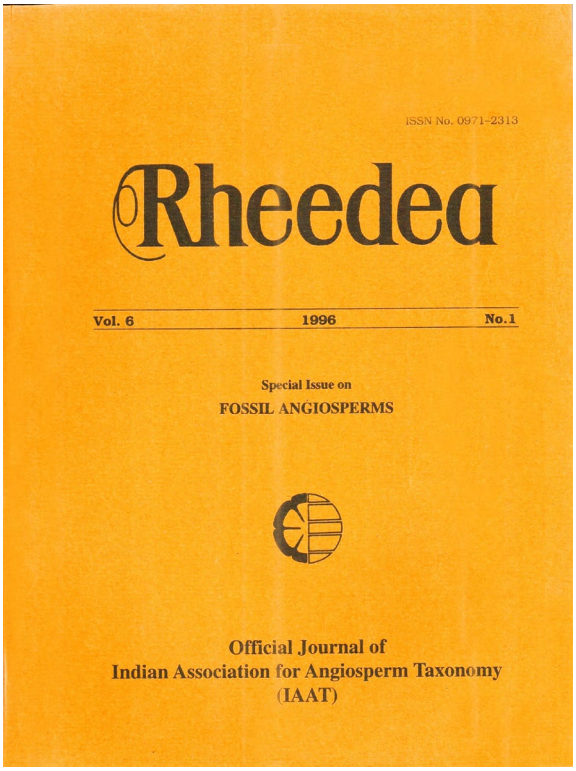

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Connections of Israeli Upper Cretaceous flora with coeval floras of adjacent regions

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Abstract

New study of Israeli Upper Cretaceous flora shows that it has some common features with the Upper Cretaceous floras of the northern shore of the Tethys and other common features with coeval floras of its southern shore. This flora can be considered as transitional between two types or as a "mixed" flora. The transitional character of the Israeli Negev flora shows that an important connection between the northern and southern shores of the Tethys existed during the Upper Cretaceous.

Previously, on the basis of miospores, the equatorial area (Northern Gondwana) has been thought to be more closely allied to those of Southern Gondwana (Notal area) than to more northern floras. Megaplant material shows that in the Upper Cretaceous the Middle East was connected more closely with Europe and Kazakhstan. We see its connections with both Laurasia and with Africa.

INTRODUCTION

The position of Israel near the boundary between the Eurasian and African continental plates (Condie, 1989, fig. 32) makes it a key region to solve problems concerning reltations of continental plates during geological history. If we look on the maps of global phytogeographical zonation in the Upper Cretaceous (Herngreen & Chlonova, 1981; Vakhrameev, 1985; Krassilov, 1985; Batten & Wenden, 1987) we see principal disagreements in boundaries only in the Mediterranean. On some maps it is put in the middle of the Mediterranean Sea, on others it crosses southern Europe or northern Africa. The position of Israel on all maps is unclear.

Also in the Triassic the exact position of the boundary between Eurasian and African plates is not clear : the position of some terrestrial blocks in southern Europe is still discussed (Brandner & Sperling, 1995). New Permian paleontological discoveries in the area from Oman to central Morocco (Broutin et al. , 1995) reveal a "mixed" Permian Gharif paleoflora containing Gondwanian, Cathaysian and Euramerican elements together.

If we look on the map of modern plant geographical regions represented in Flora Palaestina (Flora Palaestina, 1966, map 2) we see that four different plant geographical regions are gathered exactly in Israel : Mediterranean, Irano-Turanian, Saharo-Arabian and

Sudanian. Even more, on the more detailed map for the more restricted area showing plant geographical territories and districts of Palestine (*op. cit.*, map 1) we see the same four regions together. The question arises: how much does this picture depend on modern climate and how much does it depend on the geological history of our region? Let us analyse new data on the Upper Cretaceous plants of Israel.

MATERIALS

Upper Cretaceous plants were collected in the southern Negev, southern Israel more than thirty years ago by A.Danin and later by J.Lorch with his students (Lorch, 1965). Some new specimens were added to this collection in 1995 by the author. Material occurs from the Gerofit and Qetura valleys (Fig. 1). The collections are stored in the Institute of Life Sciences of the Hebrew University of Jerusalem [coll. "T" (Gerofit flora) and coll. "N" (Qetura flora), HUJ] (Dobruskina, 1996 a; Dobruskina, 1996 b-in press).

Upper Cretaceous plants were described earlier from southern Jordan (Fig.1) E and ESE from localities in the southern Negev (Bender & Madler, 1969) and from central Lebanon near the coast (Dilcher & Basson, 1990). There are also two Upper Cretaceous localities with fossil woods in Negev but they are not discussed in the present paper.

GEOGRAPHICAL AND STRATIGRAPHICAL POSITION OF THE MIDDLE EAST UPPER CRETACEOUS FLORAS

The Gerofit and Qetura floras of the Negev are noteworthy from a stratigraphic point of view because it occurs in well defined Turonian deposits with ammonites and bivalves. In the Negev Upper Cretaceous fossil plants were found in the upper Member of the Early Turonian Ora Shales Formation in two localities. The first one is on the bank of the Gerofit valley where it empties into the Arava valley (35°, 05E/29°, 56N; coordinates 1572/9337 according to the Israeli grid). The locality is situated near Quetra junction - the turn to the NW from the main Eilat- Dead Sea road (62 km from Eilat) to Shizzafon, Mizpe Ramon, Beersheva. The second one is in the Qetura valley 4.5 km north of the Gerofit locality (35°, 04E/30°, 12N; coordinates 1570/9380 according to the Israeli grid).

The geological age determinations were made in the sixties (Freund, 1962; Eckstein,1963; Freund & Raab, 1969) on the basis of the Lower Turonian amonites from the lower part of the Ora Shales. Recent investigations did not change this.

Explanation of Figure 1. Ciphers on the map: Israel: 1 - Gerofit, 2 - Qetura; Jordan: 3 - 50 km NNW from Mudawwara, 4 - 71.5 km ENE from Mudawwara, 5 - 76 km ENE from Mudawwara, 6 - 42 km WNW from Kilwa, 7 - 39 km WNW from Kilwa, 8 - 37.7 km WNW from Kilwa, 7 - 39 km WNW from Kilwa, 8 - 37.7 km WNW from Kilwa, 9 - 44.5 km NW from Kilwa, 10 - 45.5 km NW from Kilwa, 11 - 41 km from Kilwa; Lebanon: 12 - Nammaoura.

Connections of Israeli Upper Cretaceous Flora

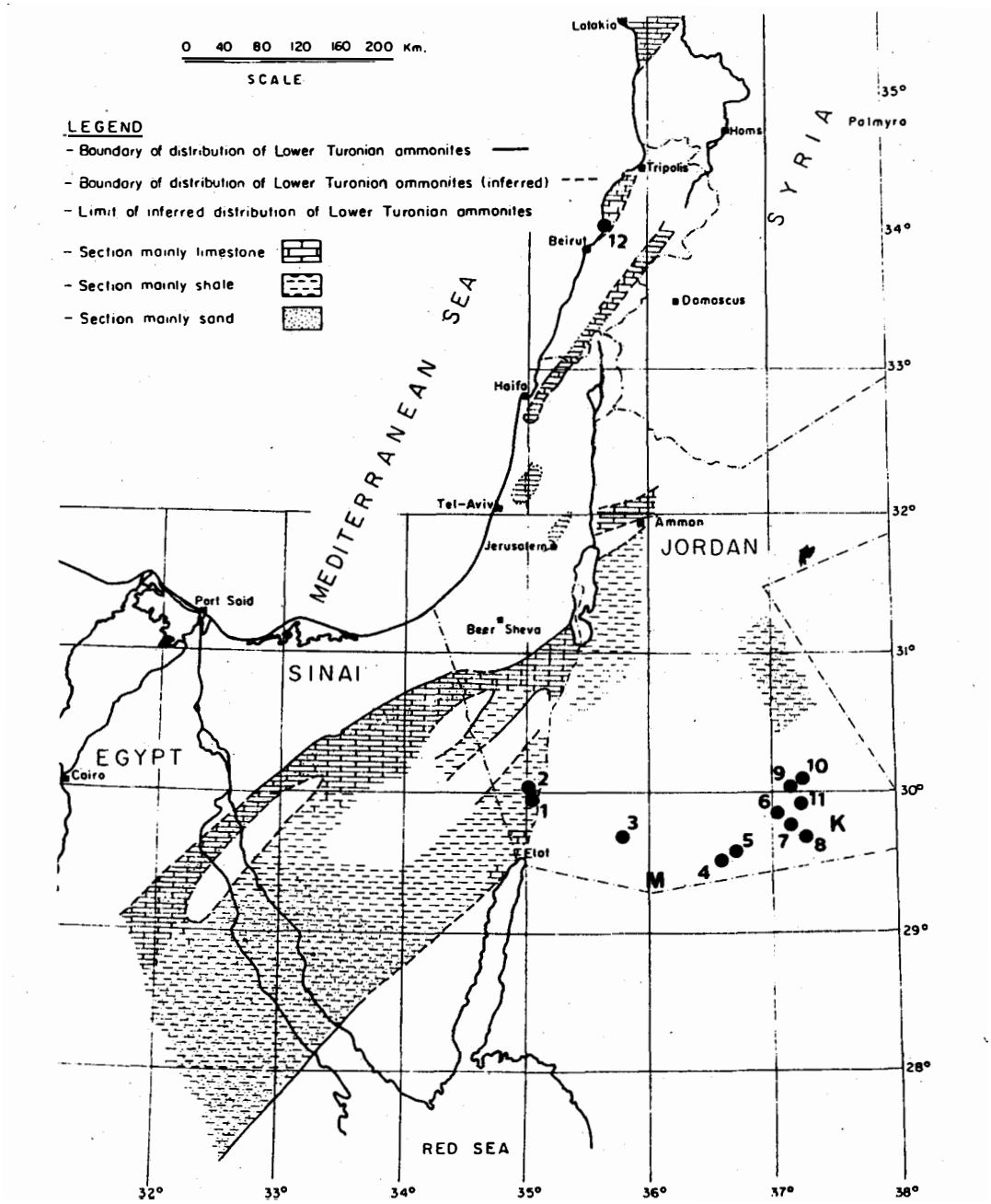

Fig. 1. Localities of the Upper Cretaceous plants in the Middle East (on the map of Lower Turonian basins in the Middle East made by Freund & Raab, 1969). M – Mudawwara, K – Kilwa.

The Ora Shales Formation and its correlatives are widely distributed in the Negev. According to Bartov *et al.* (1972), the Ora Shales Fm. consists of thick, soft shale beds with Calcareous intercalations and gypsum layers. The lower part of the overlying Gerofit Fm. is Late Turonian in age based upon the occurrence of marine fossils. The Ora Shales Fm. was deposited in shallow seas on a stable, slowly subsiding shelf which was a part of the large Arabo-Nubian platform. The Upper Member of the Ora Shales was deposited in shallower water than the previous members. A very shallow water environment is indicated by the presence of terrestrial plants and the temporary existence of hypersaline conditions leading to the deposition of gypsum. The southern Negev Basin was seperated from the open sea by some sort of barrier.

The Upper Cretaceous plant localities in southern Jordan are situated between Aqaba and Kilwa (Bender & Madler, 1969, fig.12). Madler showed the geographical position of 10 sites with angiosperms in this area (*op. cit.*, tab. 2), but nothing is described from the most eastern locality. Fossil plants occur in the continental sandstones of the Upper Cretaceous and according to Madler represent an early stage of the evolution of the angiosperms. The Cenomanian age of the plant-bearing beds was assigned by the authors because of the similarity of Jordanian flora and Cenomanian flora of Portugal described by Saporta and Teixeira.

In central Lebanon a locality called Nammoura is situated at the coast of Lebanon about 20 km NE of Beirut; fossil plants are preserved in Cenomanian dolomitic limestones (Dilcher & Basson,1990). Fossils of this locality are a mixture of fern and angiosperm remains with those of lizard and marine fish. Till now, only a new species of *Sapindopsis* is described.

COMPOSITION OF GEROFIT AND QETURA FLORAS FROM SOUTHERN ISRAEL

The flora is almost all angiospermous. The collection from Gerofit valley consists of more than 300 imprints of fossil leaves, twigs, stems and fructifications. There are also 75 similar imprints in the collection from Qetura valley.

In addition to angiosperms there are horsetails (several imprints of stems and a diaphragm), conifers of *Brachyphyllum* type (three small twigs), and may be ferns (several very small and badly preserved imprints). The majority of stems and roots probably also belong to angiosperms. If so, angiosperms constitute 95% of the whole flora. Among them are the following taxa (Dobruskina, 1996 b):

Family Nymphaeaceae Salisbury, 1805
Genus *Nymphaea* L., 1753
Nymphaea mesozoica Dobrusk.
Genus *Nelumbites* Berry, 1911
Nelumbites tenuinervis (Font.) Berry, 1911

Family Menispermaceae S. L. De Jussieu, 1789
Genus *Menispermites* Lesquereux, 1874
Menispermites ? sp.
Family Caprifoliaceae A. L. De Jussieu, 1789
Genus *Viburniphyllum*.
Viburniphyllum sp.
Family Platanaceae Dumortier, 1829
Genus *Platanus* L., 1753
Platanus ? sp.
Family Magnoliaceae A. L. Jussieu, 1789
Genus *Magnoliaephyllum* (Krasser) Seward, 1926
Mangnoliaephyllum palaeocretacicus (Sap.) Teixeira, 1950
Mangnoliaephyllum lusitanicum Teixeira, 1950
Incertae sedis (Araliaceae?)
Genus *Debeya* Miquel *emend.* Knobloch
Debeya grofitica Dobrusk.

There are also three specimens with fructifications. One of them was described by Krassilov (Krassilov & Dobruskina, in press) as a Proto-Cyperaceous plant *viz., Archaecypera lorchii* gen. *et.* sp. nov.

If we exclude from our calculations stems (11%) and roots (15%) of unknown affinity, the most common plant in the Gerofit collection are narrow-leaved trees *Magnoliaephyllum* (16%) and *Debeya* (12%). Less common are the water plants *Nymphaea* and *Nelumbites* (24%). Next in abundance are wide leaves of small trees or shrubs *Viburniphyllum* and lianas *Menispermites* (12% and 6% correspondingly). Platyphyllous leaves, possibly of Platanoids, constitute 4% of the imprints.

The composition of the Gerofit and Qetura plant assemblage indicates deposition of the plants in a big freshwater lake.

COMPOSITION OF JORDANIAN AND LEBANONIAN UPPER CRETACEOUS FLORA

Madler (Bender & Madler, 1969) described the following taxa from southern Jordan:

Gymnospermae

Nilssoniales

Nilssoniophyllum benderi Madler

Angiospermae

Monocotylendonae

Phyllotaenia teixeirae Madler

c. f. *Phragmites cretaceus* Lesqu.

Dicotyledonae

Ficophyllum jordanicum Madler

Trochodendroides sp.

Magnolaephyllum palaeocretacicus (Sap.) Teixeira

Magnolaephyllum lusitanicum Teix.

Perseophyllum grandifolium Madler

Sassafras acutilobum Lesqu.

Sassafras brachlobum Madler

Cinnamomophyllum broteri (Teix.) Madler

Cinnamomophyllum ellipticum Madler

Cinnamomophyllum jordanicum Madler

Oreodaphne beirensis Teix.

Laurophyllum sp.

?Hamamelidaceae

Leguminosites orientalis Madler

cf. *Cissites limae* Teix.

Cornus sp.

Sideroxylophyllum angustifolium Madler

Diospyros sp.

?Hernandaceae

Explanation of Ciphers on the map - Fig. 2. 1 - Gerofit and Qetura valleys, southern Israel; 2 - Portugal; 3 - Rona basin, France; 4 - Aachen, Westfalien, Germany; 5 - Peruch, Northern Czekhia; 6 - Southern Czekhia; 7 - Austria; 8 - Potylicy, Western Ukraine; 9 - Kanev, Ukraine; 10 - northern margins of the Donbass; 11 - Transilvania, Romania; 12 - Bulgaria; 13 - Aush, Daralagez, Azerbaydzhan; 14 - Bahariya; 15 - Kharga; 16 - Baris; 17 - Aswan and Wadi Abu Agag; 18 - Gebel Kamil; 19 - Kiseiba and Wadi Halfa; 20 - Dungul; 21 - Wadi Wahedia; 22 - Oasis Nukheila and El Atrun; 23 - Gebel Abyad; 24 - Dongola; 25 - Darfur; 26 - Wadi El Malik; 27 - Khartoum; 28 - 30 - southern Jordan; 31 - central Lebanon; 32 - Chushkakul, West Kazakhstan (Lower and Middle Albian); 33 - Emba river, West Kazakhstan (Upper Albian – Cenomanian).

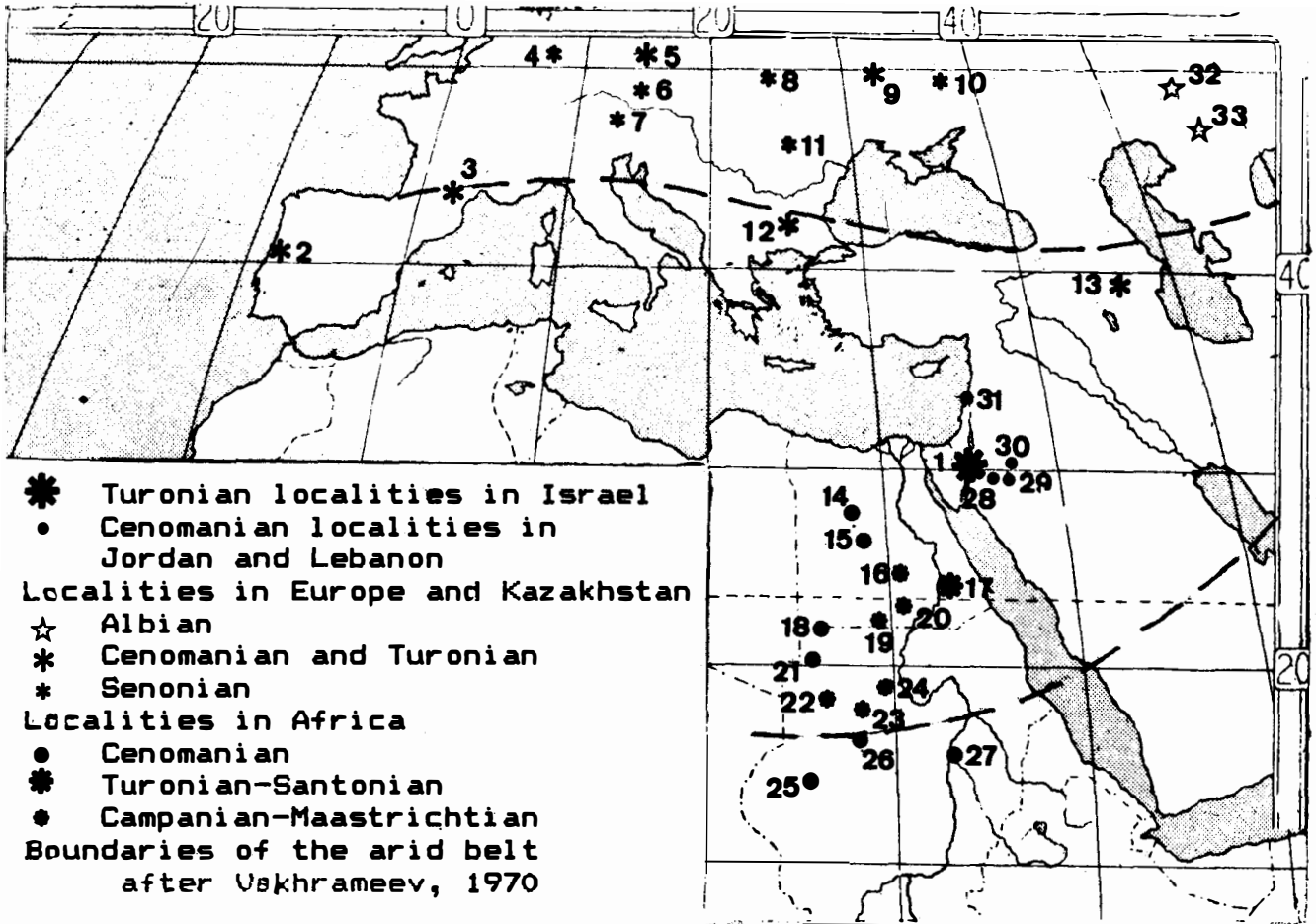

Fig. 2. Localities of the Upper Cretaceous plants in the Mediterranean and West Kazakhstan (localities in southern Europe and Kazakhstan after Vakhrameev, 1952, 1970, 1978; localities in Egypt and Sudan after Schrank, 1992 and Klizsch & Lejal-Nicol, 1984; Boundaries of the arid belt after Vakhrameev, 1970).

From central Lebanon, Dilcher (Dilcher & Basson, 1990) described only one species: *Sapindopsis anhouryi* and mentioned ferns and early angiosperm remains.

COMPARISON OF THE UPPER CRETACEOUS FLORA OF THE MIDDLE EAST WITH COEVAL FLORAS OF THE MEDITERRANEAN

Upper Cretaceous floras are known from southern Europe (Portugal, France, Italy, Chekhia, Austria, Romania, Bulgaria) (Fig.2), from Ukraine, Caucasus and western Kazakhstan and from northern Africa (Egypt and Sudan) (Hassan, 1973; Klitzsch & Lejal-Nicol, 1984; Lejal-Nicol, 1987; Lejal-Nicol & Dominik, 1990; Awad & Schrank, 1991; Schrank, 1992).

The Upper Cretaceous plant localities of Europe are situated to the north of latitude 40. The northern boundary of the arid belt in the map of Vakhrameev (1970) approximately coincides with the northern shore of the Tethys. Upper Cretaceous floras of the northern shore of the Tethys are tropical or subtropical. The most southern of them (Portugal and Transcaucasus) are xerophytic. Evergreen dicotyledonous plants are present everywhere; fern trees are known in Czechia, palms in Romania and Austria. Small Platanoid leaves appear in Czechia (Peruch) and the Transcaucasus (Aush), and platyphyllous plants appear to the north – in Graz and Aachen.

The common feature of Upper Cretaceous floras of southern Europe and Middle East is the presence of narrow-leaved angiosperms (Magnoliaceae and Araliaceae?) and different species of *Debeya/Dewalquea* (Fig. 3). In figures 4-6 you can see outlines of the new speices of *Debeya* from southern Israel: a general view of leaves and a mode of their attachment to rachis. Sometimes, when we find isolated leaves it is difficult to determine whether they belong to this genus or, for example, to narrow-leaved *Magnoliaephyllum* (Fig. 6 – T, U, V). Platanaceae are present in southern Europe in small numbers (they dominate in Kazakhstan). If Israeli leaves really belong to *Platanus*, it would be the next common feature in these floras. *Trochodendroides, Cissites, Leguminosites,* described from Jordan, connect Middle East floras with Europe, Kazakhstan and Siberia. Other angiosperms are different in Europe and the Middle East. The abundance of ferns and conifers distinguishes European floras from the Gerofit and Qetura flora, as well as from Jordanian one.

Madler saw a big similarity between Jordanian flora and the Cenomanian flora of Portugal (Teixeira, 1950). He described 19 species of angiosperms from the Jordanian. Among then he has found 11 common species in Jordanian and Portugese floras. They belong to the genera *Phyllotaenia, Trochodendroides, Magnoliaephyllum, Sassafras, Cissites, Cinnamomophyllum* and *Sideroxylophyllum*. Nearly all of them are widely distributed also in Kazakhstan and Siberia.

Explanation of Figure 3. A – narrow-leaved angiosperms; C – *Cinnamomophyllum*; Cs - Cissites; D - *Debeya*; L - *Laurophyllum*; Le - *Leguminosites*; Ma - *Magnoliaephyllum*; Me - *Menispermites*; N - *Nelumbites*; P - *Platanus*; S - *Sapindopsis*; Ss - *Sassafras*; T - *Trochodendroides*.

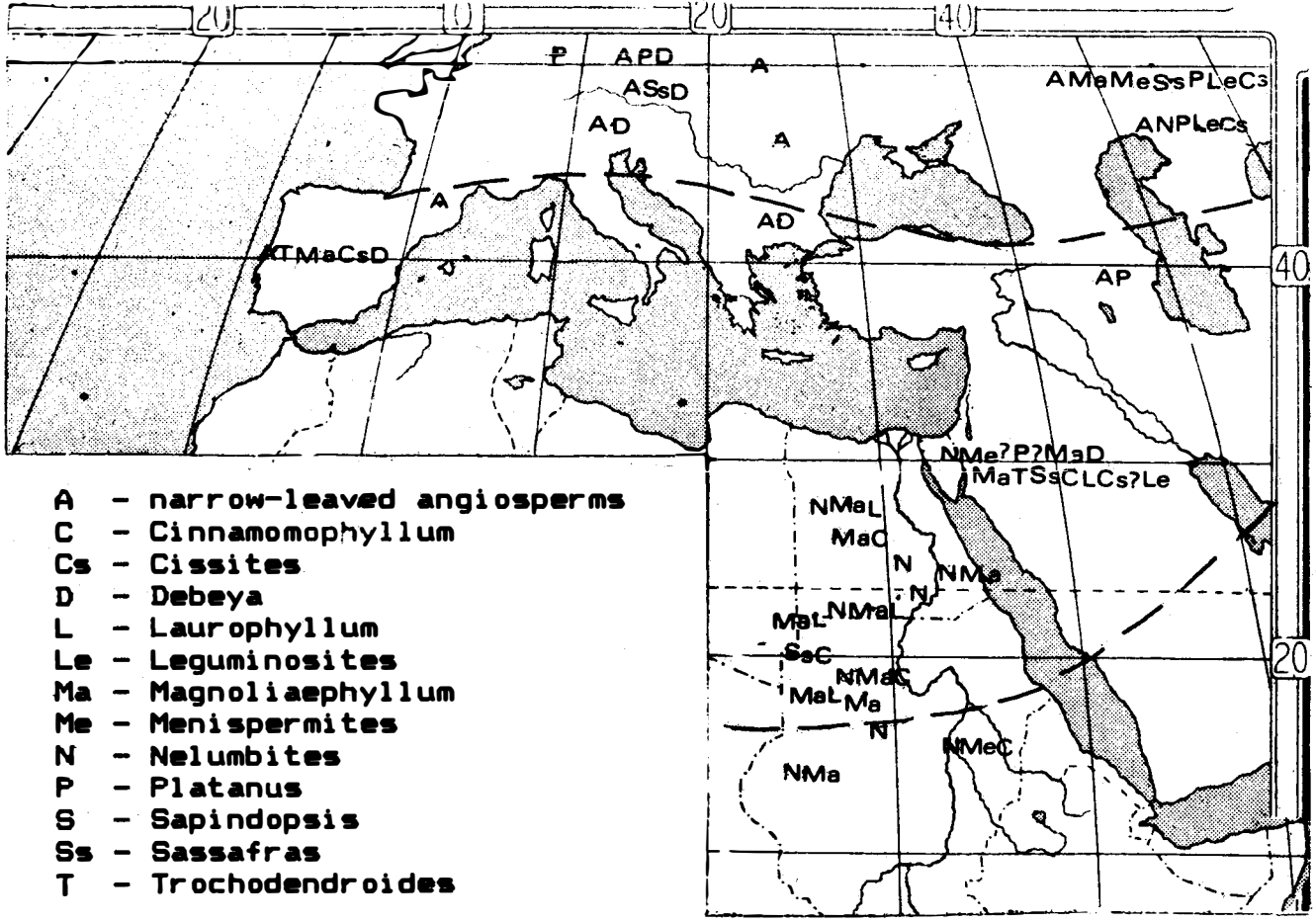

Fig. 3. Distribution of the Middle East plant genera in Europe, West Kazakhstan and Africa.

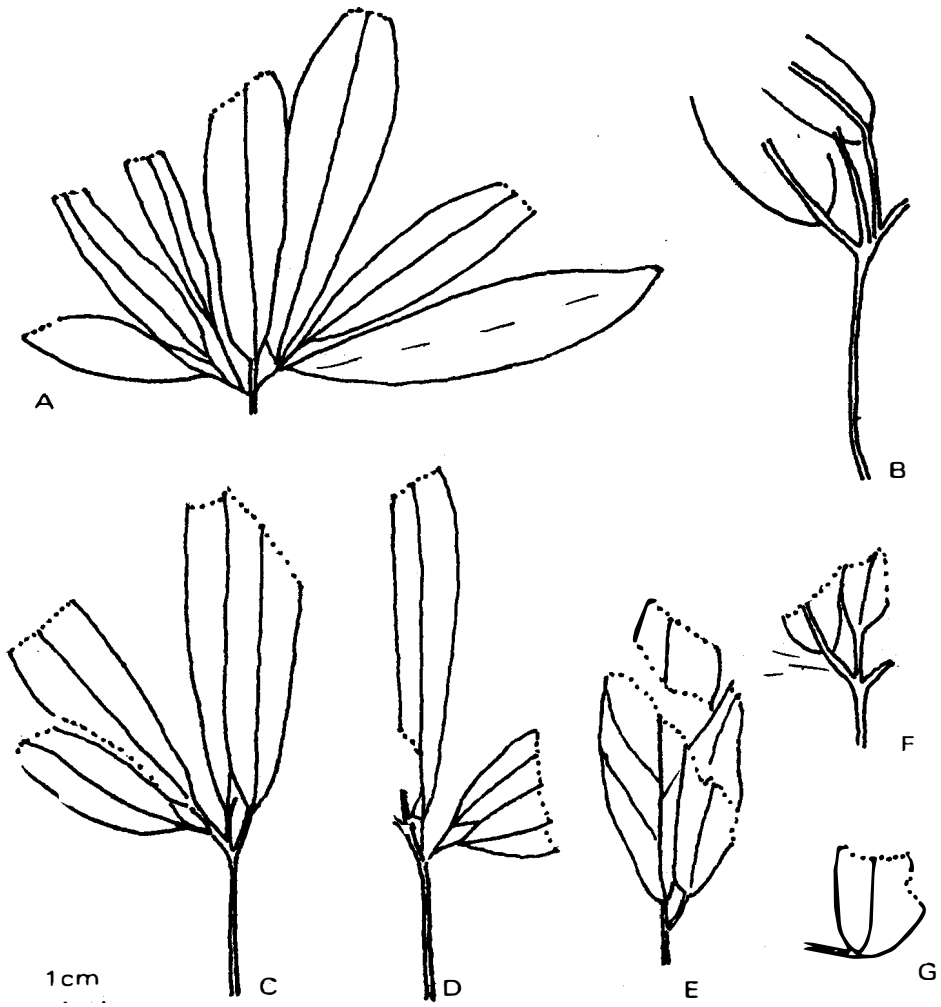

Fig. 4. *Debeya grofitica* Dobrusk., x 0.5: A – # T3–1; B– # T17; C – # T300; D – # T72–1; E – # T250 – 1, 2; F – # T142; G – # N58.

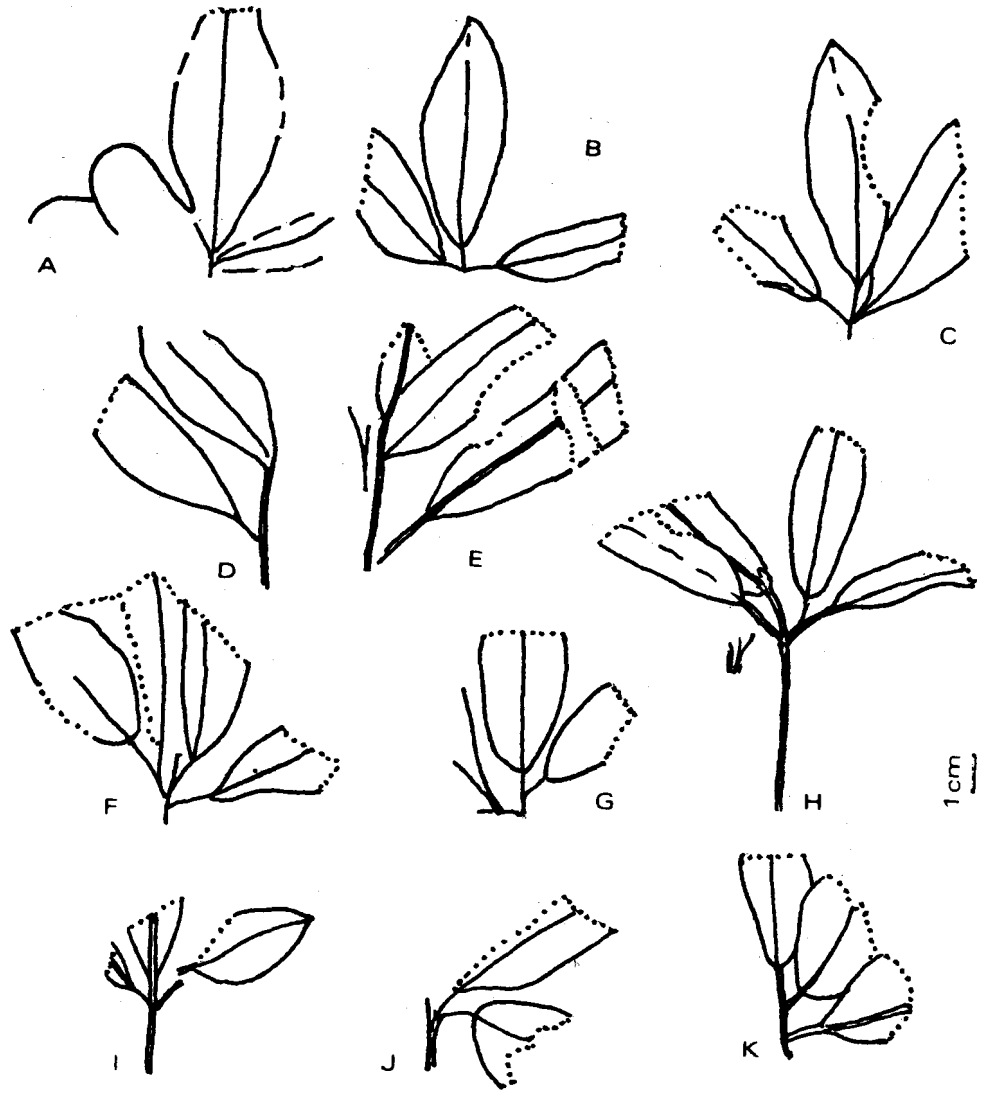

Fig. 5. *Debeya grofitica* Dobrusk., x 0.5: A – # T26–3; B– # T32; C – # N40; D – # T133A–1; E – # T133 – 1; F – # T296; G – # T105; H – # T87; I – # N60; J – # N9–1; K – # T81.

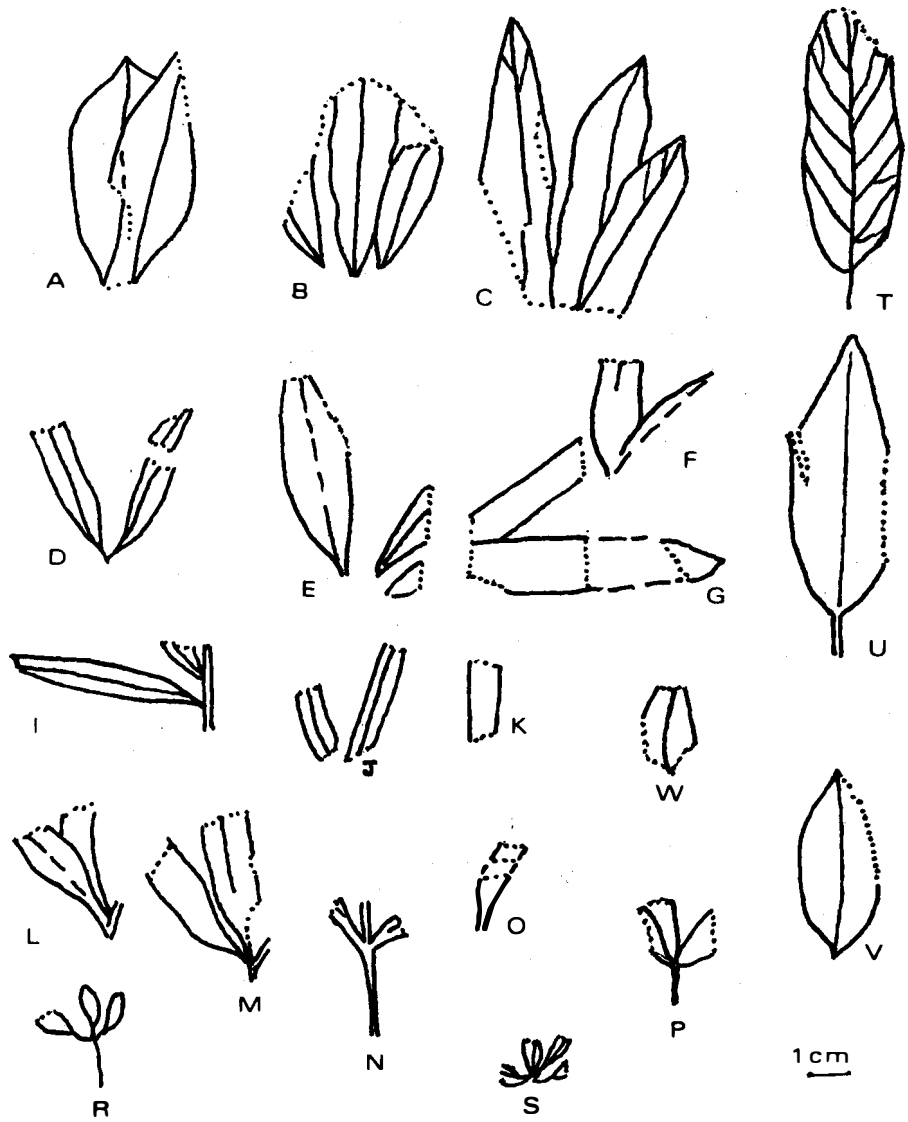

Fig. 6. *Debeya grofitica* Dobrusk., x 0.5: A – # T285–1; B– # T251; C – # T145–1; D – # N14; E – # N43–1; F – # N42–2; G – # N42–3; I – # N25; J – # N55; K – # N51; L – # T283; M – # N1; N – # T312–3; O – # N3–4; P – # N9–2; R – # T259–4; S – # T24–1; narrow-leaved *Magnoliaephyllum* or isolated leaves of *Debeya,* x0.5; T – Lorch, 1965; fig. 2; U – # T259–5; V – # M42–1; W – # N64–2.

Connections of Israeli Upper Cretaceous Flora

The localities of Upper Cretaceous floras of northern Africa are closer geographically to the Negev and Jordanian localities and are also inside the arid belt. Nevertheless, there is less similarity between these floras. The common feature is the very small quantity of ferns and conifers, excluding the abundance of fern *Weichselia* in the Cenomanian of Bahariya. The abundance of this fern may depend on nearness to the shoreline. The dominant forms among angiosperms in the two floras under consideration are different. Common forms are different species of *Magnoliaephyllum* (approximately half of African angiosperms) and *Nelumbites* (several imprints). Platyphyllous *Magnoliaephyllum* are abundant in Jordan as well as in northern Africa. The genus *Sapindopsis* reported from Lebanon is known also from the Cenomanian of northern Africa. *Debeya* and big leaves of Nymphaeaceae are not known in northern Africa.

Thus, *Debeya,* narrow-leaved *Magnoliaephyllum, Trochodendroides, Cissites* and *Platanus?* connect the Israeli and Jordanian floras with southern Europe. All of them except *Debeya* and *Nelumbites* connect it also with Kazakhstan. *Nelumbites,* platyphyllous *Magnoliaephyllum, Laurophyllum, Cinnamomophyllum, Sapindopsis* and small quantities of conifers connect it with northern Africa.

We can conclude that the Middle East Upper Cretaceous flora shows some common features with the Upper Cretaceous floras of the northern shore of the Tethys and other common features with coeval floras of its southern shore. This flora can be considered as transitional between two types or as a "mixed" flora.

The transitional character of the Israeli Negev flora shows that an important connection between the northern and southern shores of the Tethys existed during the Upper Cretaceous.

Shallow water ammonites show the same connections (Freund & Raab, 1969, text fig. 15). The two most important groups of ammonites, found in Israel, "Paravascoceratid ammonites", were dominant on the southern shelf of Tethys (Africa); "Vascoceratid ammonites" were dominant on the northern shelf of Tethys (Europe). Some other similar genera lead to Middle Asia.

PHYTOGEOGRAPHICAL ZONATION

Phytogeography in the Cretaceous resembles recent zonation more than Palaeozoic (Dobruskina, 1990). It was thought that the extreme isolation of phytochoria in the Palaeozoic ceased to exist in the very beginning of the Mesozoic (Dobruskina, 1982, 1994). New discoveries in the Middle East (Broutin *et al.*, 1995) permit moving it back to the Upper Permian. At this time the most important barriers, at least inside Eurasia, were broken and Siberian and European-Sinian paleofloristic areas appeared. These areas were already similar to those in the Cretaceous. This agrees with the idea that continents which were separated during the Palaeozoic united to form the single Pangea in the end of the Permian.

However, in the Cretaceous the continents were probably not yet in their present position. In contrast to their current situation, we do not see analogs of a nontropical Siberian area in the Southern Hemisphere (Vakhrameev, 1972). This may be because the southern continents were in a higher latitude during Cretaceous time than they are now.

In the Cretaceous, the main latitudinal boundary was the boundary between the Siberian and European–Sinian areas, while in the Palaeozoic and Lower Triassic, it was between the Gondwana and Laurasian kingdoms. In the Cretaceous we see greater similarity in floras of the Northern and Southern hemispheres. The huge exchange of plants between Laurasia and Gondwana began in the middle of the Triassic after the origin of many new plant groups.

In the middle of the Cretaceous, a longitudinal zonation can be seen against the background of normal latitudinal zonation (Zaklinskaya, 1970, 1978; Hallam, 1981). This is similar to the situation in the middle of the Triassic (Dobruskina, 1982, 1994) when a gerat change in the floral kingdom also took place: transition from the Paleophytic to the Mesophytic in the middle of the Triassic as well as the transition from Mesophytic to the Cenophytic in the middle of the Cretaceous.

On the maps of Vakhrameev (1970, 1978, 1985) and Meyen (1987) for the Upper Cretaceous, Israel is considered to be the part of equatorial area. According to the ideas of Krassilov (1985), *Debeya* shows subtropical conditions and its absence either a temperate or tropical climate. Following this idea the presence of *Debeya* permits referring the Negev area to the subtropical climatic zone together with the European area and in contrast to the north African area. North Africa is considered tropical.

Before intensive study of north African Upper Cretaceous floras began in eighties, all conclusions on phytogeography and climate could be done only on the basis of miospores. The equatorial area (Northern Gondwana) has been thought to be closer to those of Southern Gondwana (Notal area) than to more northern floras. Megaplant material shows that in the Upper Cretaceous the Middle East was connected more closely with Europe and Kazakhstan. We see its connections with Laurasia on one hand and with Africa on another.

Acknowledgements

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