| Πρακτικά | 6ου Συνεδρίου | | Μάϊος 1992 |
|---|---|---|---|
| Δελτ. Ελλ. Γεωλ. Εταιρ. | Τομ. XXVIII/3 | σελ. 151-170 | Αθήνα 1993 |
| Bull. Geol. Soc. Greece | Vol. | pag. | Athens |

# PALYNOLOGICAL AGE REVISION OF THE NEOGENE SOMA COAL BASIN

F.AKGUN

## ABSTRACT

The Neogene coal field in the surroundings of Soma ( Western Anatolia ) has been studied from stratigraphical viewpoint by several investigators. However, the rock unit classification and age assignment of Nebert have found a widespread acceptance. He distinguished two formations separated by an unconformity: the lower Soma and upper Deniş formations. Using the litostratigraphy and related designations of Nebert , it is recently recognized that $k_1$ and $k_2$ coal seams are Middle Miocene ( early Serravalian ) in age , on the bases of sporomorphs and fossil plants.

The present palynological study supports the above age assigment and , on the other hand , introduces a younger Middle Miocene ( middle Serravalian ) age for the stratigraphically higher $k_3$ coal seam ( or $P_1$ unit of Nebert ), which was dated Late Miocene or Pliocene in previous work .

Relevant coals were formed in peats of *Taxodium* and Cupressacae boggy forest and in the swamps of flood - plains covered by *Alnus , Carya, Platanus-Salix,* Juglandaceae and *Pterocarya* . The swamps were immediately surrounded by a mixed forest of *Quercus* and Castanea , and Conifer forest of *Pinus*, respectively , of low and high topographic setting. It seems that hot and moist climatic conditions prevailed during the accumulation of the three coal seams ( $k_1$ , $k_2$ and $k_3$ ).

---

D.E.Ü. Müh. Mim. Fak. Jeoloji Müh. Böl. 35100 İZMİR/TÜRKİYE

| Πρακτικά | 6ου Συνεδρίου | | Μάϊος 1992 |
|---|---|---|---|
| Δελτ. Ελλ. Γεωλ. Εταιρ. | Τομ. | σελ. | Αθήνα |
| | XXVIII/3 | 151-170 | 1993 |
| Bull. Geol. Soc. Greece | Vol. | pag. | Athens |

# PALYNOLOGICAL AGE REVISION OF THE NEOGENE SOMA COAL BASIN

**F.AKGUN**

ABSTRACT

The Neogene coal field in the surroundings of Soma ( Western Anatolia ) has been studied from stratigraphical viewpoint by several investigators. However, the rock unit classification and age assignment of Nebert have found a widespread acceptance. He distinguished two formations separated by an unconformity: the lower Soma and upper Deniş formations. Using the litostratigraphy and related designations of Nebert , it is recently recognized that $k_1$ and $k_2$ coal seams are Middle Miocene ( early Serravalian ) in age , on the bases of sporomorphs and fossil plants.

The present palynological study supports the above age assigment and , on the other hand , introduces a younger Middle Miocene ( middle Serravalian ) age for the stratigraphically higher $k_3$ coal seam ( or $P_1$ unit of Nebert ), which was dated Late Miocene or Pliocene in previous work .

Relevant coals were formed in peats of *Taxodium* and Cupressacae boggy forest and in the swamps of flood - plains covered by *Alnus , Carya, Platanus-Salix,* Juglandaceae and *Pterocarya* . The swamps were immediately surrounded by a mixed forest of *Quercus* and Castanea , and Conifer forest of *Pinus*, respectively , of low and hig. topographic setting. It seems that hot and moist climatic conditions prevailed during the accumulation of the three coal seams ( $k_1$ , $k_2$ and $k_3$ ).

---

D.E.Ü. Müh. Fak. Jeoloji Müh. Böl. 35100 İZMİR/TÜRKİYE

## INTRODUCTION

Several authors ( e.g. KLEINSORGE , 1940 and 1941 ; NEBERT, 1960 and 1978 ; BRINKMANN et al., 1970 ) studied , and suggested that coal seams occur in three stratigraphically different parts of the Neogene sequence . TAKAHASHI and JUX ( 1991 ) considered the Neogene of Soma to have consisted of Lower,Middle and Upper Miocene.

The rock unit classification and age assigment of Nebert ( 1978) have found a widespread acceptance . He distinguished two formations separated by an unconformity;the lower Soma formation consisting,in ascending order, of pebblestone ( $m_1$ ),marl ( $m_2$ ) and limestone ( $m_3$ ) units and the upper Deniş formation consisting of sandstone - claystone ( $p_1$ ), tuff-marl ( $p_2$ ), cherty limestone ( $p_3$ ) and tuff- agglomerate ( $p_4$ ) units . The coal seams occur in different parts of the Neogene sequence: the lower seam ( $k_1$ ) is at the base part of the marl unit ( $m_2$ ), the middle seam ( $k_2$ ) is in the upper part of the limestone unit ( $m_3$ ) and the upper seam ( $k_3$ ) is in the upper part of the sandstone -claystone unit ( $p_1$ ) (Figure 2).

The pollen assemblages of the Soma basin were believed to indicate Middle Miocene, Late Miocene and Early Pliocene ages ( BENDA in BRINKMANN et al., 1971; BENDA ,1971 ). On the other hand, palynological data from the lower and middle coal seams ( $k_1$ and $k_2$ ) ( AKGÜN et al., 1986 ) and the fossil plants obtained from the marl unit overlying the lower coal seam ( $k_1$ ) ( GEMİCİ et al., in press ) , indicate a Middle Miocene ( early Serravalian ) age .

The present study ( 1 ) introduced new palynological datas for the upper coal seam ( $k_3$ ) ,( 2 ) assigned a new age to $k_3$ ,( 3 )

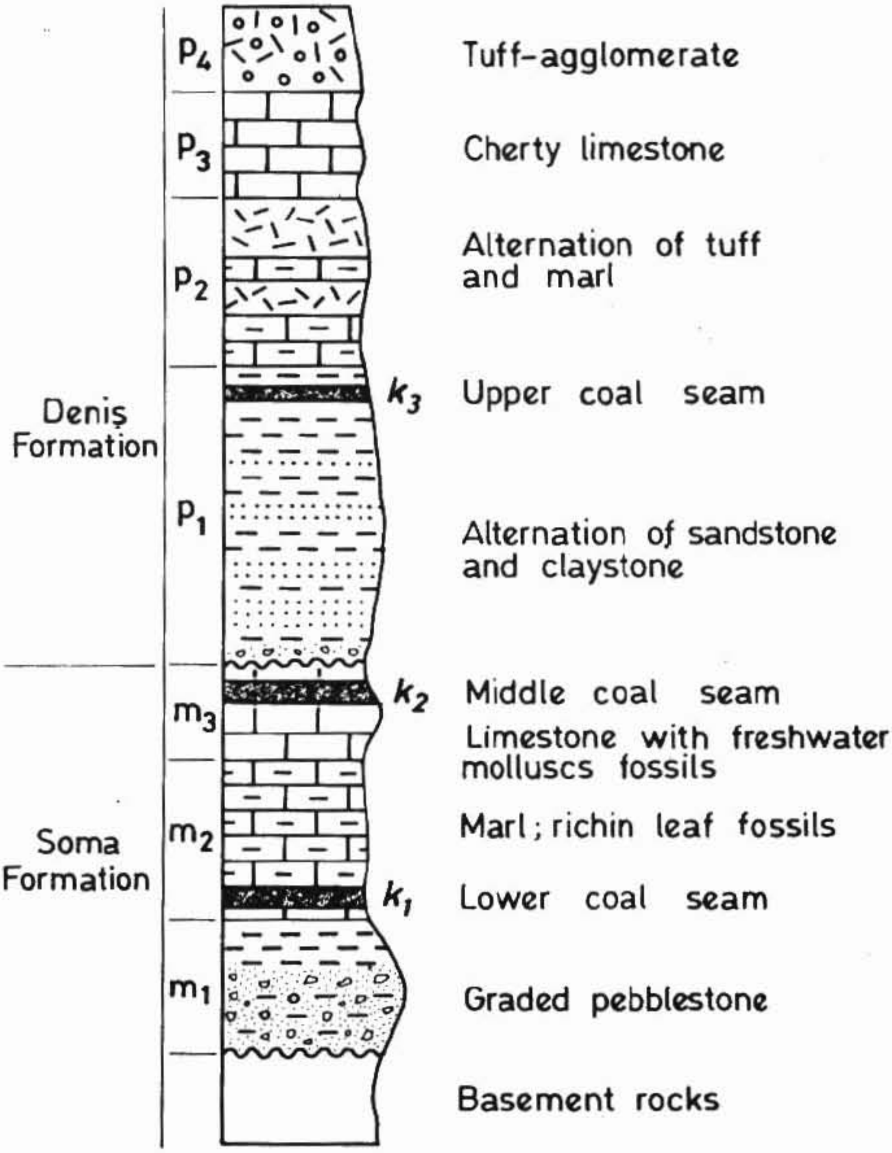



Figure 2.- Stratigraphic sections of Neogene sequence in Soma basin (modified from Nebert,1978).

reinvestigated the ages of $k_1$ and $k_2$, and ( 4 ) compared palynological results derived from three coal seams and reconstructed paleoclimate and paleoenvironment during the formation of coals .

## MATERIAL AND METHOD

41 samples from coal seams ( $k_1$, $k_2$, $k_3$ ) are examined palynologically . 32 samples represent $k_3$ . 26 of them were derived from five different drillings in the Işıklar and Eynez coal field and 6 of them are recovered from outcrops in the Eynez, Işıklar and Deniş I mining districts. 4 surface sample belong to $k_2$ from the Işıklar coal field .5 samples were collected from the outcrops of $k_1$ in the Deniş II mining district ( Figure 1 & 3 ) . Samples were processed using standart palynological techniques . This include the treatment of the samples with hydrochloric and hydrofluoric acid,Schulze's solution .

## COMPOSITION OF THE PALYNOMORPH ASSEMBLAGES

Only 25 samples out of the 41 appeared suitable for qualitative and quantitative pollen analysis. All other samples proved to be barren of microfossils or contained few pollen and spores for a statistically reliable study .

Spores and pollens of 47 taxa , consisting of 2 pteridophytic spores , 7 gymnosperm pollens and 39 angiosperm pollens were encountered in the samples (Appendix). Palynomorph diagrams for each of the coal seams depict relative frequency of taxa (Figure 4) .

The palynomorph assemblage of the upper coal seam ($k_3$) contains

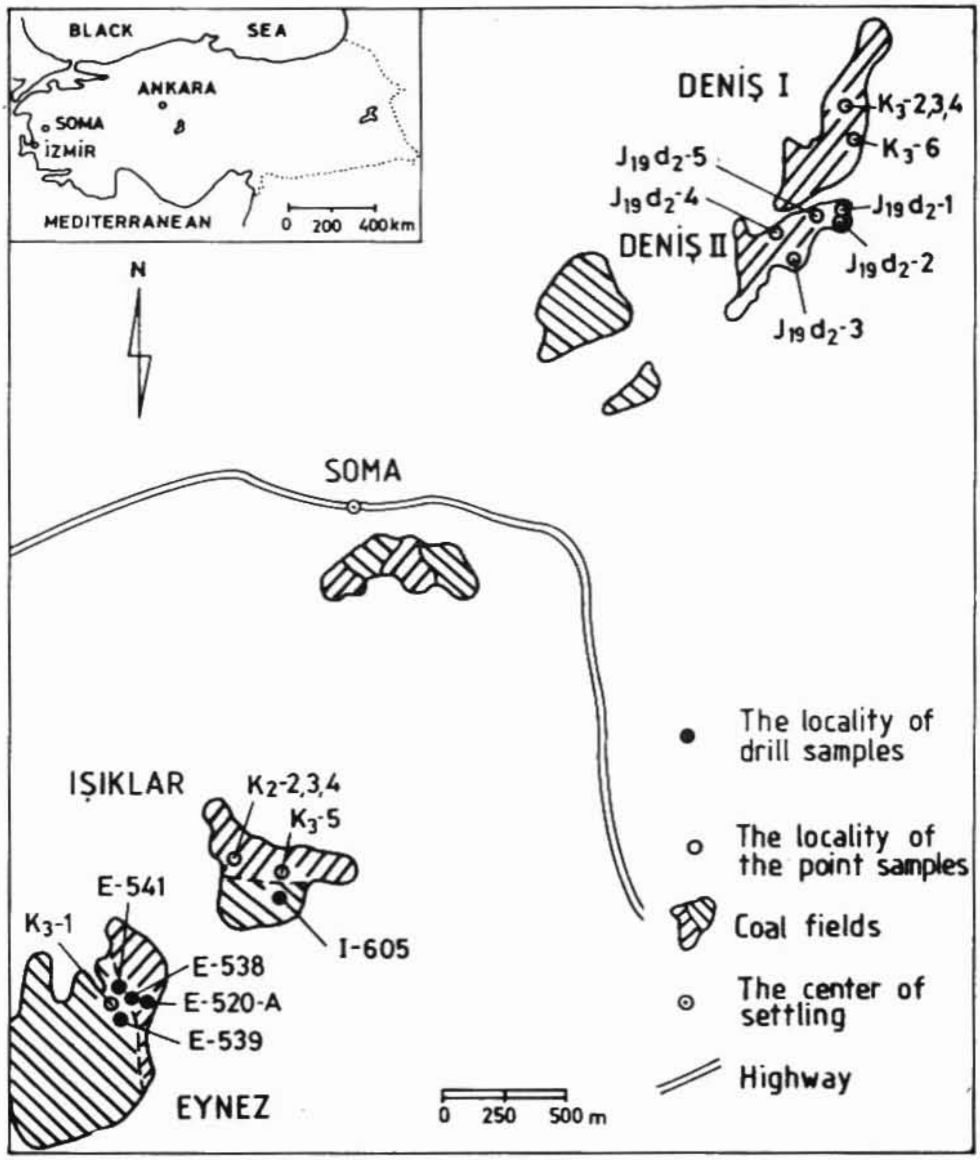



Figure 1.- Location map of the samples

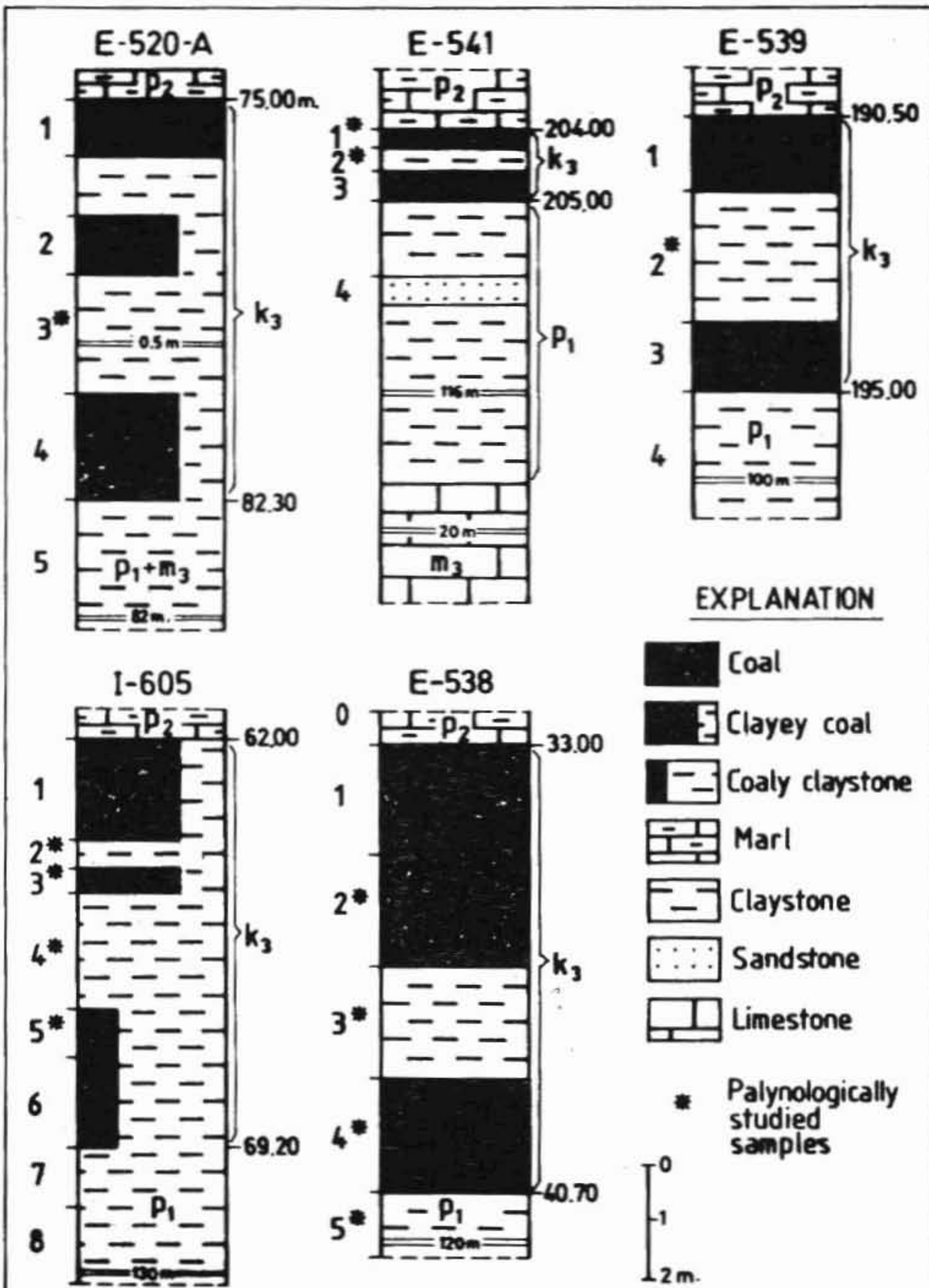



Figure 3.-Drill logs of the upper coal seam ($k_3$)

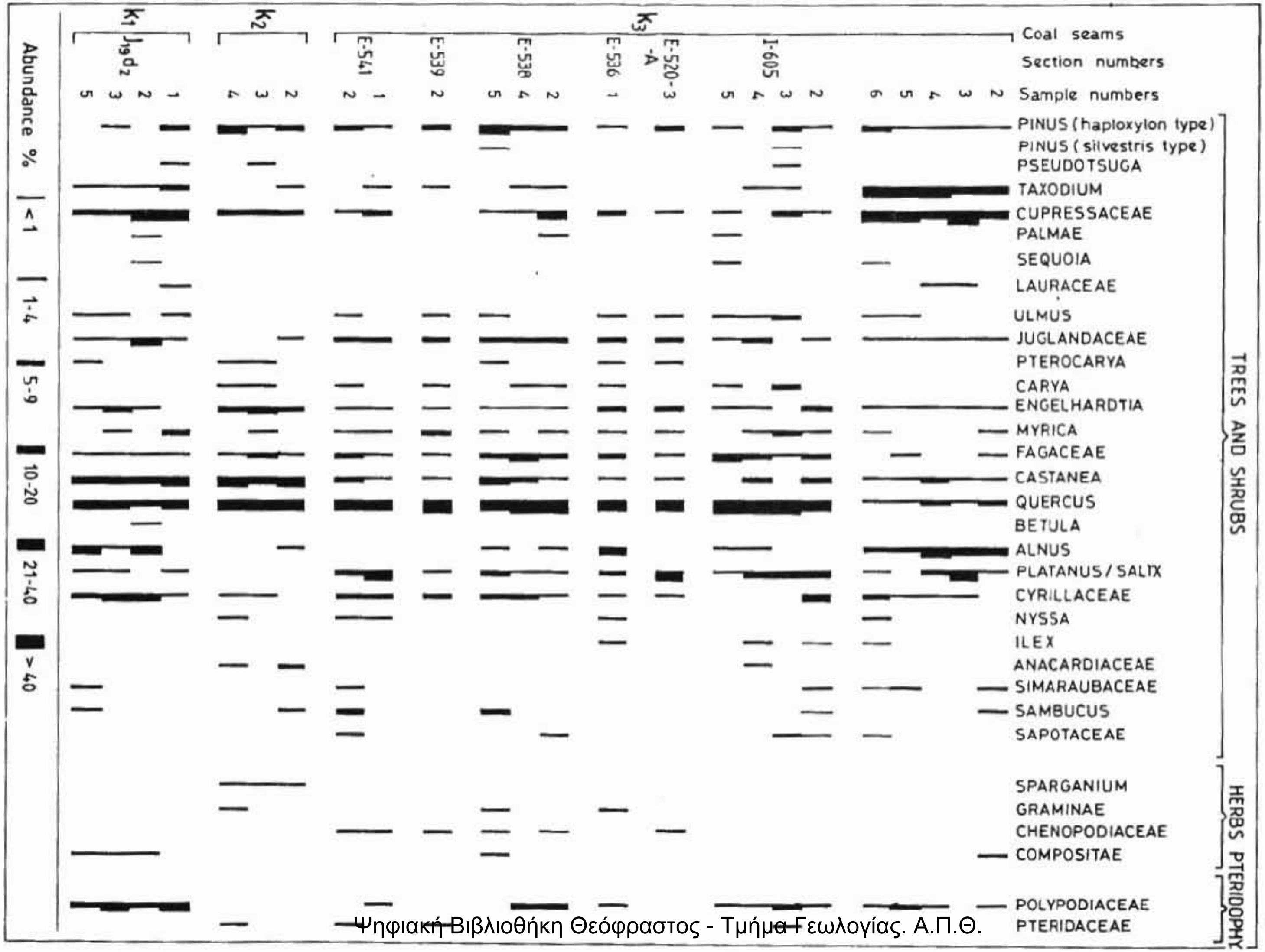



Figure 4.- Palynomorph diagrams of the three coal seams

distinctly high percentages ( from 15 % to over 50 % ) of *T . microhenrici* and *T. densus* ( *Quercus* ) . Representatives of *I.hiatus* ( *Taxodium* ),*I.dubius* (Cupressaceae),*P. verus* (*Alnus*) , *T . retiformis* ( *Platanus - Salix* ) are variously abundant . Especially , the percentage of *I.hiatus* ,*I. dubius* and *P. verus* shows a peak which is accompained by decrease in that of *T.microhenrici* and *T . densus* . Although *P. microalatus* (*Pinus haploxylon* type ) , *T . simpliformis* and *T . labraferus* ( Juglandaceae ), *T. coryphaeus* ( *Engelhardtia* ),*T . liblarensis* ( Castanea ) and *T . megaexactus* ( Cyrillaceae ) show low percentages, they are almost present in all samples . Relative frequencies of *P . undulosus* ( *Ulmus* ) ,*S. simplex* ( *Carya* ), *T. bituitus and T. rurensis* ( *Myrica* ) fluctuate in amount . The range is from absence to 1-6 % . All other taxa , such as *P.labdacus* (*Pinus silvestris* type),*M. gramineoides* ( Graminae ), *P . multiporatus* ( Chenopodiaceae ) and *Tricolporopollenites sp.* ( Compositae ) are extremely rare or absent.

The palynomorph compositions of the lower and middle coal seams ( $k_1$ and $k_2$ ) show a distinct similarity to each other (AKGÜN et al . , 1986 . In both palynomorph assemblages , *T. microhenrici* and *T. densus* are the most representative pollens. *L . haardti* ( Polypodiaceae ) occur in high amount in the lower coal seam with respect to in the middle coal seam . *P. microalatus* , *I. dubius* and *T. cingulum* are variously abundant. *I.hiatus, T.simpliformis and T. labraferus, T. corphaeus, T. liblarensis* and *T.megaexactus* occur almost uniformly in small amounts. Relative frequencies of *P.labdacus, I.magnus* (*Pseudotsuga*), *P.undulosus, P.stellatus* ( *Pterocarya* ), *S. simplex , T. bituitus ,T . rurensis , P . verus* and *T . retiformis* fluctuate in amount ,from absence to 1-4 % . *M . solaris* ( *Sparganium - Typha* ) and *Tricolporopollenites sp* . which are nonarboreal pollens, are represented , in the middle and lower coal seam , respectively . The abundance of these two taxa is rather low ( 1-2% ) . Other herbaceous pollens and spores are absent .

## AGE AND COMPARISION

The three palynomorph assemblages are compared and the results are given below;

- Nearly all of taxa are represented in the palynomorph compositions of the three coal seams .
- The three palynomorph assemblages are characterized by a high percentage of Quercoid forms . In some samples *Pinus* ( *haploxylon* type ), Cupressaseae and *Alnus* pollens are abundant.
- All of the Pinus pollens , which occur in these three palynomorph assemblages, are of *haploxylon* type *Pinus* forms. *Silvestris* type *Pinus* forms are sporodically represented.
- Representatives of Juglandaceae , *Engelhardtia* , *Myrica* and Cyrillaceae pollens occur in low percentages in the palynomorph assemblages .
- The percentages of Castanea pollens is generally low in the lower and middle seams and minimum in the upper seam.
- The rare taxa , such as Graminae , Chenopodiaceae and Compositae, show almost uniform distribution in all samples.

The above comparision reveals the similarity between the three palynomorph assemblages.

Previous works ( eg. BENDA et al., 1977 ; VAN DE WEERD , 1983 ) have shown that " Index species " suitable for determining the biostratigraphic position of a sample are extremely rare in the Turkish and Mediterranean Neogene . The relation between the percentages of pollen species and the overall change of the composition of the pollen diagrams may allow to drive conclusions regarding the biostratigraphic position of a sample or a set of sample .

All species , except for, *M . gramineoides , P . multiporatus* and *Tricolporopollenites sp.* and *P.labdacus* , show a remarkable distribution throughout the Turkish Neogene . However, the above first three pollen forms are in small amounts ( max. 2-3 %) in the Middle Miocene .The relative frequencies of these forms are about 10% in the Late Miocene and reach to high percentages ( min. 40 % ) in the Pliocene .

Two *Pinus* morphotypes have been used for the biostratigraphic subdivision .The *Pinus haploxylon* type is considered to be the older morphotype that lost its predominance in the associations of Turkish and Greek areas. *Pinus silvestris* type becomes more abundant near the Miocene -Pliocene boundry ( BENDA ,1971; VAN DE WEERD, 1983 ).According to BENDA (1971) the relation between the relative frequencies of *P. haploxylon* and *P . silvestris* types has a ratio such as 10/1 in the latest Middle Miocene and the earliest Late Miocene . The rate of change in these types' dominance seemes to be 2-3 / 1 in the Late Miocene and 1/3-5 in the Pliocene .

On the basis of the above considerations , the three palynomorph assemblages seem to be Middle Miocene in age . The palynomorph assemblages of the lower and middle coal seams ($k_1$ and $k_2$) show that these coal seams are early Serravalian in age ( AKGÜN et al.,1986). The palynomorph assemblage of the upper coal seam ( $k_3$ ) which is stratigraphically higher, is middle Serravalian in age .

On the basis of changes in quantitative compositions, BENDA ( 1971 ) established the sporomorph associations including from base to top Kurbalık , Kale , Eskihisar , Yeni Eskihisar , Kızılhisar and Akça sporomorph associations.The Soma palynomorph spectrum shows the characteristic features of those of the Eskihisar sporomorph association . Although the Eskihisar association was considered by BENDA & MEULENKAMP, 1990 to be latest Burdugalian to early -? middle Serravalian age . The palynological composition of the Soma basin does not imply an earlier age of latest Burdigalian .

Unfortunately , there is no radiometric dates on the Neogene deposits of the Soma basin to compare with the palynological dating of this study . TAKAHASHI & JUX (1991) have applied the radiometric age-supported standart Neogene units of SW Anatolia (i.e. Early Miocene Turgut, Middle Miocene Sekköy and Late Miocene Yatağan Members : BECKER-PLATEN, 1971 ) to the Neogene of the Soma basin . They proposed that units comprising the lower, middel and upper " coal beds " of the Soma basin represent , in the same order , the Turgut , Sekköy and Yatağan members.

The ostracod biostratigraphy of the Denizli - Muğla Neogene sequence in SW Anatolia ( GÖKÇEN , 1982 ) and mammalia faunas of Sarı Çay and Mesevle-Muğla ( MN6,Turgut member) and of Yeni Eskihisar-Muğla ( MN8 , Sekköy member) (STEININGER et al. ,1989) indicate that Turgut and Sekköy members correspond with the Middle Miocene time range ( BENDA et al., 1975 ). LUTTIG & STEFFENS ( 1976 ) regarded Middle Miocene for the commencement of continental deposition in W Anatolia .

In conclusion , it appears that the Soma formation and the lower part of the Deniş formation are of Middle Miocene age .

## PALEOECOLOGY

It seems to be difficult to reconstruct the paleoecological conditions solely on the basis of palynomorph data . However, the floristic composition may suggest that these coals were formed in swamps and/or flood plains, surrounded by topographic rises covered by forests.

The similarity between the pollen flora of the three coal seams may indicate recurring conditions of vegatation and hot-moist climate.The percentage of arboreal pollens is much higher than nonarboreal ones in all samples. The chief contributions to the percentage of arboreal pollens are *Quercus, Pinus,* Cupressaceae and *Alnus*.

The reed community consisting of *Typha* ( reed mace ) and Sparganium indicates the swamp environment . The existence of the *Quercus* ( oak tree ) and *Pinus* ( *pine* ) taxa in all samples imply a mixed forest covered the surrounding topographic highs . The percentage of Pinus pollen ( max. 15 % ) in the samples of three coal seams indicates a large distance between the topographic heights occupied by Conifer forest and the swamp. *Quercus* associations might have also existed in the plains . *Sequoia* ( Californian red wood ) probably took part in that mixed forest.

*Taxadium* ( decidious cypress ) , *Myrica* , *Nyssa* , Lauraceace ( sweet buy ), *Sambucus* (elder) and Cupressaceae taxa represent a boggy forest surrounding the swamp. Between the boggy forest and the mixed forest there must have been decidious forest of Fagaceae , Castanea ( chestnut ) , *Carya* ( big-bud hickory ) and Sapotaceae , *Alnus* ( older ) , *Betula* ( birch-tree ), *Ulmus* (elm tree ) , *Platanus* ( plane tree ), *Salix* (willow) , *Engelhardtia,* Juglandaceae , Cyrillaceae and Anacardiaceae , indicating flood plains . Besides , the dry ground of all kinds of forests nonarboreal taxa such as Chenopodiaceae, Compositae and Graminae might have been widespread.

ACKNOWLEDGEMENTS

I am thankfull to the TTK's engineers for their field assistance help during sample collection. I thank M . GÜRLE for their technical assistance

R E F E R E N C E S

AKGÜN, F., ALİŞAN, C. & AKYOL, E. (1986). Soma Neojen stratigrafisine palinolojik bir yaklaşım.Türkiye Jeol. Kurumu Bült., 29, 13-25.

BECKER-PLATEN, J.D. (1971). Stratigraphic division of the Neogene and oldest Pleistocene in Southwest Anatolia. Newsl. Stratigr., 1, 3, 19-22.

BENDA, L. (1971). Grundzuge einer pollenanalytischen Gliederung des turkischen Jungtertiars (Kanozoikum und Braunkohlen der Türkei. 4.). Beih. Geol. Jb. 113, 46p..

BENDA, L. & MEULENKAMP, J.E. (1990). Biostratigraphic correlation in the Eastern Mediterranean Neogene 9.sporomorph associations and event stratigraphy the Eastern Mediterranean. Newsl. Stratigr. 23, 1, 1-10.

BENDA, L., HEISSIG, K., & STEFFENS, P. (1975). Die Stellung der Vertebraten-Faunengruppen der Türkei innerhalb der choronostratigraphischen System von Tethys und Paratethys,in Sickenberg, O. (ed.), "Die Gliederung des höheren Jungtertiärs und Altquärtars in der Türkei nach Vertebraten und ihre Bedeutung für die internationale Neogene-Stratigraphie." Geol. Jb., B. 15, 110-116.

BENDA, L., MEULENKAMP, J.E., STEFFENS, P., SCHMIDT, R.R. & ZACHARIASSE W.J. (1977). Biostratigraphic correlation in the Eastern Mediterranean Neogene. 2. Correlation between sporomorph association and marine microfossils from the Oligocene-Lower Miocene of Turkey. Newsl. Stratigr., 6, 1-22.

BRINKMANN, R., FEIST, W., MARR, U., NICKEL, E., SCHLIMM, W. & WALTER, H.R. (1971). Geologie der Soma Dağları . M.T.A. Büll., no. 74, 7-23.

GÖKÇEN, N. (1982). The Ostracod biostratigraphy of the Denizli-Muğla Neogene sequence. Yerbilimleri Büll., 9, 111-131.

GEMİCİ, Y., AKYOL, E., SEÇMEN, Ö. & AKGÜN, F. (in prep.). Soma kömür havzası fosil mikro ve makro florası. M.T.A. Büll.

KLEINSORGE, H. (1940). Manisa Vilayetinde Soma civarında bulunan Linyiti muhtevi Tersiyerin jeolojik etüdlerine müteallik rapor. M.T.A. Rep. no. 1080 (unpublished).

KLEINSORGE, H. (1941 ) . Zur Geologie der Umgebung des Braunkohlenbeckens von Soma Vilayet Manisa, Türkei. M.T.A.Publ. A 5, 57 p..

KREMP,G. (1949). Pollen analytischen Untersuchung des miozanen Braunkohlenlagers von Konin an der Warthe. Palaeontogr. 90.

LUTTIG, G. & STEFFENS, P. (1976). The paleogeographie atlas of Türkey from the Oligocene to the Pleistocene. 64p., Bundesanstalt f. Geowissenschaften und Rohstoffle.

MEON-VILAIN, H. (1970). Palynologie des formations Miocenes Superieures et Pliocenes du bassin du Rhone (France). Docum. lab. Geol. Fac. Sci. Lyon, 38, 167 p.

NEBERT, K. (1960). Bericht uber die Ergebnisse der im Sektor "Eynez" (Neogengebiet von Soma) ausgefuhrten Bohrarbeiten. M.T.A. Rep. no. 3026 (unpublished).

NEBERT, K. (1978). Linyit içeren Soma Neojen bölgesi. M.T.A. Dergisi, 90, 20-68.

POTONIE, R. (1931). Pollenformen der miozanen Braunkohle. Ber. Ges. Naturf. Freunde, 24-28.

POTONIE, R. (1934). Zur Mikrobotanik des eozanen Humodils des Geiseltals. Arb. Inst. Palaobot. Petrog der Brennsteine, t. 4, 25-125.

POTONIE, R. & VENITZ, H. ( 1934 ) . Zur Mikrobotanik des miozanen Humodils der niederrheinischen Bucht. Arb. Inst. Palaobot. Petrogr. Brennsteine,Preuss Geol. L.-A. 5,54p..

POT., R. & GELL., J. (1933). Uber die Pteridophyten sporen einer eozanen Braunkohle aus Dorog, Ungarn.- Sitz. Ber. nat. Freunde.

STEININGER, F.F., BERNOR, R.L., & FAHLBUSCH, V. (1989). European Neogene marine/continental chronolgic correlations : European Neogene mammal chronolgy , 15-46, New York.

TAKAHASHI, K. & JUX, U. (1991). Miocene palynomorphs from lignites of the Soma Basin (West Anatolia, Turkey).Bull. Faculty Liberal Arts, Nagasaki Univ., (Naturel Science),32 (1), 7-165.

THOMSON, P. W. & PFLUG, H. ( 1953 ) . Pollen und Sporen des mitteleuropaishen Tertiars . Palaeontographica, Abt. B, 94, 138p.

VAN DE WEERD, A. (1983) . Palynology of Soma Upper Miocene and Pliocene formations in Greece. Geol.Jb., B 48, 3-68.

WOLFF, H. (1934). Mikrofossilien des Pliozanen Humodils der Grube Freigericht bei Dettinden a . M. - Arb. Inst. Palaobot. u Petrogr. Brennsteine , 5, 55-58.

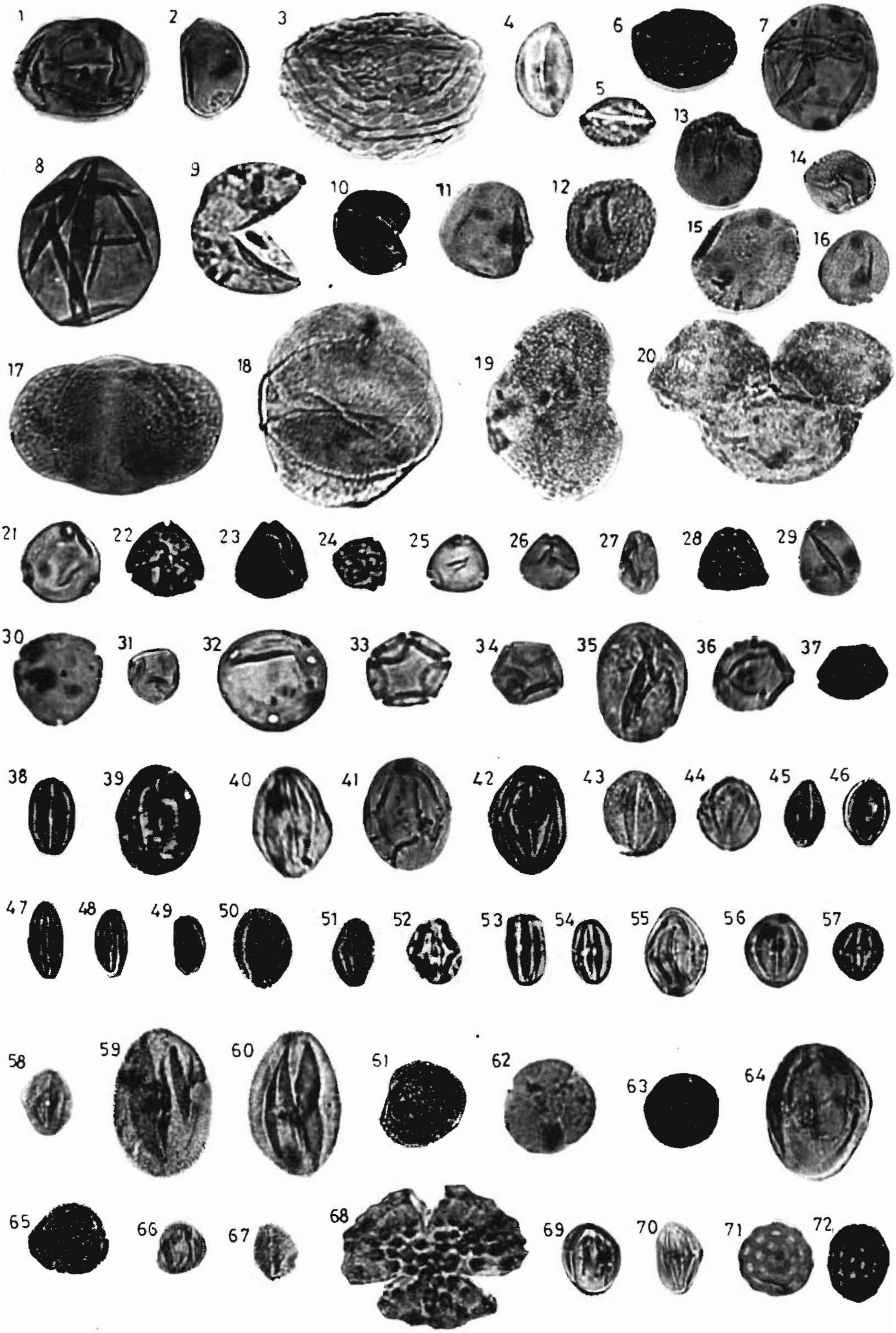
# PLATE I

All photomicrographs x 500

Fig.1,2- *Laevigatosporites haardti* (R.POT. et VEN.1934) TH. et PF. 1953
3- *Cingulatisporites macrospeciosus* (R.POT. et GEL. 1933) NAKOMAN, 1966
4- *Monocolpopolenites tranquillus* (R.POT.1934) TH. et PF. 1953
5- *Monocolpopollenites areolatus* (R.POT.1934) TH. et PF. 1953
6- *Monoporopollenites gramineoides* MEYER ,1956
7- *Inaperturopollenites dubius* (R.POT. et VEN.1934) TH.et PF. 1953
8- *Inaperturopollenites magnus* (R.POT.1931) TH. et PF. 1953
9,10- *Inaperturopollenites hiatus* (R.POT.1931) TH. et PF. 1953
11- *Inaperturopollenites polyformosus* (THIERG. 1938) TH. et PF. 1953
12-16- *Inaperturopollenites verrucosus* MEON-VILAIN,1970
17-19- *Pityosporiites microalatus* (R.POT.1931) TH. et PF. 1953
20- *Pityosporites labdacus* (R.POT.1931 *in* R.POT. 1934)TH. et PF. 1953
21,22- *Triatriopollenites rurensis* PF. et TH. *in* TH. et PF. 1953
23,24- *Triatriopollenites bitutitus* (R.POT.1931) TH. et PF. 1953
25,26- *Triatriopollenites coryphaeus* (R.POT.1931) TH. et PF. 1953
27- *Triatriopollenites plicatus* (R.POT.1934) TH. et PF. 1953
28- *Triporopollenites megagranifer* (R.POT.1951) TH. et PF. 1953
29,30- *Triporopollenites simpliformis* PF. et TH. *in* TH. et PF. 1953
31- *Triporopollenites labraferus* (R.POT.1934) TH. et PF. 1953
32- *Subtriporopollenites simplex* (R.POT.1931) TH. et PF. 1953
33,34- *Polyvestibulopollenites verus* (R.POT.1931) TH. et PF. 1953
35- *Polyporopollenites undulosus* (WOLFF. 1934) TH. et PF. 1953
36,37- *Polyporopollenites stellatus* (R.POT. et VEN. 1934) TH. et PF. 1953
38- *Tricolpopollenites parmularius* ssp. *cylindrior* (R.POT.1934) TH. et PF. 1953
39,40- *Tricolpopollenites henrici* (R.POT. 1931) TH. et PF. 1953
41,42- *Tricolpopollenites asper* PF. et TH. *in* TH. et PF. 1953
43,44- *Tricolpopollenites densus* PF. *in* TH. et PF. 1953
45,46- *Tricolpopollenites microhenrici* ssp. *intragranulatus* (R.POT.1931) TH. et PF. 1953
47-49- *Tricolpopollenites liblarensis* ssp. *liblarensis* (TH. in R.POT., TH. et THIERG. 1950) TH. et PF. 1953

50,51- *Tricolpopollenites retiformis* PF. et TH. *in* TH. et PF. 1953
52- *Tricolporopollenites pacatus* PF. *in* TH. et PF. 1953
53,54- *Tricolporopollenites cingulum* ssp. *fusus* (R.POT.1931) TH. et PF. 1953
55,56- *Tricolporopollenites pseudocingulum* (R.POT.1931) TH. et PF. 1953
57- *Tricolporopollenites megaexactus* (R.POT.1931) TH. et PF. 1953
58- *Tricolporopollenites steinensis* PF. *in* TH et PF. 1953
59,60- *Tricolporopollenites helmstedtensis* PF. *in* TH. et PF. 1953
61- *Tricolporopollenites satzveyensis* PF. *in* TH et PF. 1953
62,63- *Tricolporopollenites kruschi* (R.POT.1931) TH. et PF. 1953
64- *Tricolporopollenites porasper* PF. *in* TH. et PF. 1953
65,66- *Tricolporopollenites microreticulatus* PF. et TH. *in* TH. etPF. 1953
67- *Tricolporopollenites microiliacus* PF. et TH. *in* TH. et PF. 1953
68- *Tricolporopollenites* sp. (tubuliflorae type)
69- *Tetracolporopollenites microellipsus* (R.POT.1931) TH. et PF. 1953
70- *Tetracolporopollenites manifestus* (R.POT.1931) TH. et PF. 1953
71,72- *Periporopollenites multiporatus* PF. et TH. *in* TH. et PF. 1953

PLATE 1


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72

**Relative percentages of palynomorphs encountered in the samples.**

| THE COAL SEAMS | $K_3$ | | | | | $K_3$ | | | | $K_3$ | $K_3$ | $K_3$ | | | $K_3$ | $K_3$ | | $K_2$ | | | $K_1$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SECTION NUMBERS | | | | | | I - 605 | | | | E- 530 | E- 536 | E - 538 | | | E- 539 | E - 541 | | | | | | | | |
| SAMPLE NUMBERS | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 3 | 1 | 2 | 4 | 5 | 2 | 1 | 2 | 2 | 3 | 4 | 1 | 2 | 3 | 5 |
| SPORES | | | | | | | | | | | | | | | | | | | | | | | | |
| Polypodiaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Laevigatosporites haardti | 3.00 | 6.00 | 4.00 | 5.00 | 2.00 | 1.00 | 5.00 | 1.00 | 3.00 | | 2.00 | 7.00 | 5.00 | | | 3.00 | | | | 3.00 | 11.00 | 8.00 | 39.00 | 14.00 |
| Pteridaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Cingulatisporites macrospeciosus | | | | | | | + | | | | | | | | 1.00 | | 1.00 | | | 1.00 | | | | |
| GYMNOSPERM POLLEN | | | | | | | | | | | | | | | | | | | | | | | | |
| Pinus | | | | | | | | | | | | | | | | | | | | | | | | |
| Pityosporites microalatus(haploxylon type) | 3.00 | 4.00 | 3.00 | 4.00 | 9.00 | 1.00 | 6.00 | | 2.00 | 5.00 | 3.00 | 6.00 | 6.00 | 10.00 | 8.00 | 2.00 | 6.00 | 9.00 | 4.00 | 12.00 | 5.00 | | 2.00 | |
| P. labdacus (silvestris type) | | | | | | | + | | | | | | | + | | | | | | | | | | |
| Pseudotsuga | | | | | | | | | | | | | | | | | | | | | | | | |
| Inaperturopollenites magnus | | | | | | | 1.00 | | | | | | | | | | | | 2.00 | | 4.00 | | | |
| Taxodium | | | | | | | | | | | | | | | | | | | | | | | | |
| Inaperturopollenites hiatus | 16.00 | 13.00 | 23.00 | 34.00 | 24.00 | | 2.00 | 1.00 | | | | 2.00 | 3.00 | | | 1.00 | | 1.00 | | | 8.00 | 2.00 | 1.00 | 2.00 |
| Cupressaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Inaperturopollenites dubius | 40.00 | 43.00 | 16.00 | 33.00 | 32.00 | 4.00 | 5.00 | | 3.00 | 4.00 | 8.00 | 10.00 | 3.00 | 4.00 | | 7.00 | 2.00 | 8.00 | 9.00 | 4.00 | 29.00 | 24.00 | 5.00 | 8.00 |
| Sequoia | | | | | | | | | | | | | | | | | | | | | | | | |
| Inaperturopollenites polyformosus | | | | | + | | | | 1.00 | | | | | | | | | | | | | + | | |
| Lauraceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Inaperturopollenites verrucosus | | 3.00 | 2.00 | | | | | | | | | | | | | | | | | | 3.00 | | | |
| ANGIOSPERM POLLEN | | | | | | | | | | | | | | | | | | | | | | | | |
| Dicotyledonae | | | | | | | | | | | | | | | | | | | | | | | | |
| Myrica | | | | | | | | | | | | | | | | | | | | | | | | |
| Triatriopollenites rurensis | | | | + | | 2.00 | 4.00 | 4.00 | | 3.00 | 3.00 | 1.00 | | | 6.00 | 4.00 | 2.00 | | | | 4.00 | | 1.00 | |
| T. bituitus | 1.00 | | | | + | | 1.00 | | | | 1.00 | | | 2.00 | | | | | 1.00 | | 2.00 | | | |
| Engelhardtia | | | | | | | | | | | | | | | | | | | | | | | | |
| Triatriopollenites coryphaeus | 4.00 | 1.00 | 1.00 | 1.00 | 3.00 | 4.50 | | 2.00 | 4.00 | 7.00 | 5.00 | 3.00 | 3.00 | 2.00 | 4.00 | 1.00 | 2.00 | 9.00 | 15.00 | 8.00 | | 3.00 | 5.00 | 2.00 |
| Juglandaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Triatriopollenites plicatus | | | | | | 2.00 | | | | | 1.00 | | | | | | | 1.00 | | | | 2.00 | | |
| Triporopollenites simpliformis | 3.00 | 1.00 | | 1.00 | 3.00 | 0.50 | • | 4.00 | 1.00 | 2.00 | 3.00 | 6.00 | 5.00 | 7.00 | 2.00 | 5.00 | 3.00 | + | | | 1.00 | 5.00 | 3.00 | 2.00 |
| T. labraferus | 1.00 | 5.00 | 4.00 | | | 1.50 | | 1.00 | | 3.00 | 1.00 | 2.00 | 2.00 | 2.00 | 3.00 | 1.00 | 2.00 | + | | | 3.00 | 4.00 | 1.00 | |
| Betula | | | | | | | | | | | | | | | | | | | | | | | | |
| Triatriopollenites megagranifer | | | | | | | | | | | | | | | | | | | | | | + | | |
| Carya | | | | | | | | | | | | | | | | | | | | | | | | |
| Subtriporopollenites simplex | | 1.00 | | | | | 7.00 | | 2.00 | | 3.00 | 3.00 | 4.00 | | 4.00 | | 2.00 | | 1.00 | 3.00 | | | | |
| Alnus | | | | | | | | | | | | | | | | | | | | | | | | |
| Polyvestibulopollenites verus | 13.00 | 17.00 | 23.00 | 8.00 | 8.00 | | | 1.00 | 1.00 | | 17.00 | 2.00 | | 1.00 | | | | 3.00 | | | | 10.00 | 3.00 | 10.00 |
| Ulmus | | | | | | | | | | | | | | | | | | | | | | | | |
| Polyporopollenites undulosus | | | | 2.00 | 2.00 | | 5.00 | 1.00 | 3.00 | 4.00 | 1.00 | | | 2.00 | 2.00 | | 4.00 | | | | 1.00 | | 1.00 | 4.00 |
| Pterocarya | | | | | | | | | | | | | | | | | | | | | | | | |
| Polyporopollenites stellatus | | | | | | | | | | 1.00 | 3.00 | | | 2.00 | | | | | 2.00 | 1.00 | | | | 3.00 |
| Quercus | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolpopollenites henrici | | | | | | | 9.00 | 2.00 | 4.00 | | 1.00 | 3.00 | | • | | 1.00 | 1.00 | 3.00 | | 2.00 | | | | 1.00 |
| T. asper | | | | | | | 1.00 | | | | | | | | | | | | 1.00 | 2.00 | | | | |
| T. densus | 4.00 | 1.00 | 2.00 | 3.00 | 3.00 | 17.50 | 27.00 | 17.00 | 39.00 | 16.00 | 14.00 | 23.00 | 24.00 | 14.00 | 29.00 | 13.00 | 21.00 | 17.00 | 20.00 | 9.00 | 11.00 | 6.00 | 3.00 | 9.00 |
| T. microhenrici | 1.00 | 2.00 | 3.00 | + | 1.00 | 22.00 | 12.00 | 37.00 | 22.00 | 20.00 | 15.00 | 19.00 | 21.00 | 9.00 | 20.00 | 19.00 | 14.00 | 22.00 | 19.00 | 33.00 | 2.00 | 9.00 | 13.00 | 15.00 |
| Fagaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolpopollenites parmularius | | | | | | | | | | | 1.00 | | | | | | | | | | | | | |
| T. liblarensis | 2.00 | | | 1.00 | | 8.50 | 1.00 | 5.00 | 12.00 | 4.00 | 4.00 | 6.00 | 11.00 | 3.00 | 3.00 | 1.00 | 5.00 | 1.00 | 8.00 | 4.00 | 2.00 | 2.00 | 3.00 | 3.00 |
| Tricolporopollenites porasper | | | | | | | | | | | | | | | | | | | | 1.00 | | | | |
| Platanus, Salix | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolpopollenites retiformis | 2.00 | 1.00 | 1.00 | 3.00 | 1.00 | 11.50 | 13.00 | 13.00 | 3.00 | 25.00 | 9.00 | 2.00 | 3.00 | 6.00 | 3.00 | 27.00 | 9.00 | | | | 2.00 | | 4.00 | 3.00 |
| Castanea | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites cingulum | 2.00 | 1.00 | 9.00 | 2.00 | 4.00 | 9.00 | | 6.00 | | 2.00 | 1.00 | 1.00 | 5.00 | 16.00 | 4.00 | 4.00 | 7.00 | 17.00 | 9.00 | 20.00 | 15.00 | 7.00 | 9.00 | 9.00 |
| Cyrillaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites megaexactus | | 3.00 | 2.00 | 2.00 | 6.00 | 12.50 | | | | 4.00 | 1.00 | 1.00 | 5.00 | 7.00 | 9.00 | 5.00 | 6.00 | | 3.00 | 4.00 | 2.00 | 14.00 | 13.00 | 9.00 |
| Nyssa | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites kruschi | | | | | 2.00 | | | | | | 1.00 | | | | | 4.00 | 2.00 | | 1.00 | | | | | |
| Ilex | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites microiliacus | | | | | + | 0.50 | | 3.00 | | | 1.00 | | | | | | | | | | | | | |
| Anacardiaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites pseudocingulum | | | | | | | | 1.00 | | | | | | | | | | 5.00 | | 2.00 | | | | |
| Simaroubaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites pacatus | 1.00 | | | 1.00 | + | 1.00 | | | | | | | | | | | 2.00 | | | | | | | 1.00 |
| Sambucus | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites microreticulatus | 2.00 | | 2.00 | | | | | | | | | | | 3.00 | | | 5.00 | 3.00 | | | | | | 4.00 |
| Compositae | | | | | | | | | | | | | | | | | | | | | | | | |

# Appendix

| THE COAL SEAMS | $K_3$ | | | | | $K_3$ | | | | $K_3$ | $K_3$ | $K_3$ | | | $K_3$ | $K_3$ | | $K_2$ | | | $K_1$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SECTION NUMBERS | | | | | | I - 605 | | | | E- 520 | E- 536 | E - 538 | | | E- 539 | E - 541 | | | | | | | | |
| SAMPLE NUMBERS | 2 | 3 | 4 | 5 | 6 | 2 | 3 | 4 | 5 | 3 | 1 | 2 | 4 | 5 | 2 | 1 | 2 | 2 | 3 | 4 | 1 | 2 | 3 | 5 |
| Tricolporopollenites sp. | 1.00 | | | | | | | | | | | | | 1.00 | | | | | | | | 1.00 | 1.00 | 1.00 |
| Sapotaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Tetracolporopollenites microellipsus | | | | | | | | | | | | | | | | | | | | | | 1.00 | + | |
| T. manifestus | | | | | + | 0.50 | 1.00 | | | | | 1.00 | | | | | 1.00 | | | | | | | |
| Doubtful | | | | | | | | | | | | | | | | | | | | | | | | |
| Tricolporopollenites steinensis | | | | | | | | | | | | | | | | 1.00 | | | | | | 1.00 | | |
| T. helasteddensis | | | | | | | | | | | | | | | | | | | | | | + | | |
| T. satzvevensis | | | | | | | | | | | | | | 1.00 | | | | | | | | | | |
| Monocotyledonae | | | | | | | | | | | | | | | | | | | | | | | | |
| Graminae | | | | | | | | | | | | | | | | | | | | | | | | |
| Monoporopollenites gramineoides | | | | | | | | | | | 1.00 | | | 1.00 | | | | | | 2.00 | | | | |
| Sparganium/Typha | | | | | | | | | | | | | | | | | | | | | | | | |
| Monoporopollenites solaris | | | | | | | | | | | | | | | | | | 1.00 | 2.00 | 2.00 | | | | |
| Palmae | | | | | | | | | | | | | | | | | | | | | | | | |
| Monocolpopollenites tranquillus | | | | | | | | | 1.00 | | | | | | | | | | | | | | | |
| M. areolatus | | | | | | | | | | | | 1.00 | | | | | | | | | | | | |
| Chenopodiaceae | | | | | | | | | | | | | | | | | | | | | | | | |
| Periporopollenites multiporatus | | | | | | | | | | 1.00 | | 1.00 | | 3.00 | 2.00 | 1.00 | 3.00 | | | | | | | |
| Total | 99.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 101.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 106.00 | 100.00 | 100.00 | 100.00 |