

Palynological investigation of the Lower Tertiary Sardinia coal layers

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RIASSUNTO — Sono state studiate le associazioni palinologiche dei campioni provenienti da due carotaggi (n. 304 e 307) effettuati nel bacino lignifero del Sulcis; da campioni provenienti dalle ridotte serie in affioramento nella zona circostante il bacino stesso, e precisamente: Piolanas, Caput Aquas, Bacu Abis, e da qualche campione prelevato nelle crevasse delle miniere di Monteponi e San Giorgio.

La cattiva conservazione degli sporomorfi ha reso la classificazione alquanto difficile da effettuarsi ed essa, in qualche caso, è provvisoria. Le forme ritrovate sono numerose e per la maggior parte (Normapolles e Postnormapolles) sono morfologicamente atipiche. Nella composizione globale l'associazione è di tipo europeo anche se è stato osservato qualche genere (*Echitriporites*, *Scabratiporites* ed altri indeterminati) a tipica affinità nord africana e sudamericana.

Le essenze a maggior diffusione sono le palme (*M. tranquillus* e *Disulcites*), le *myricace* e le felci tropicali della famiglia delle *Schizaeaceae*, ma in particolare il genere *Lygodium* (*Leiotriletes adriennis*, *microadriennis* e *dorogensis*). Le essenze ad alto fusto non sono di molto rilievo nelle sezioni, ad eccezione delle *juglandace* e *sapotace* che fanno un'apparizione più consistente rispetto alle altre.

Un aspetto interessante è la presenza di alcune forme che sono caratteristiche dell'Eocene inferiore del bacino di Parigi (*Plicapollis* molto abbondanti e *Juglandaceae*), e di altre che determinano la *facies* a *Lygodium* caratteristica della parte inferiore dell'Eocene medio dell'Ungheria. Per la presenza di pollini del gruppo dei Normapolles: *Vacuopollis*, *Basopollis*, *Interpollis*, *Nudopollis*, *Minorpollis* e soprattutto *Plicapollis*, l'età viene data come Eocene inferiore.

Il punto che a nostro avviso è interessante per ulteriori indagini rimane l'atipicità morfologica dei pollini del Sulcis in vista della collocazione della Sardegna nelle province botaniche instauratesi in Europa sin dal Cretaceo superiore. C'è da domandarsi pertanto se questo fatto è solo un aspetto locale della microflora della Sardegna o se realmente, come avevano supposto Goczan ed. al. 1967) si sarebbe instaurata in contrapposizione alle province ad *Aquilapollenites* e a Normapolles dell'Europa rispettivamente orientale ed occidentale, una provincia mediterranea che fosse caratterizzata da atipici Normapolles.

SUMMARY — Some palynological investigations on the Sulcis (Sardinia) coal basin have been carried out. The material comes from two cores and from different outcrops in the surrounding area of the basin.

The examined material is not well preserved and some determinations are therefore only tentative.

The association is composed by several types of atypical Normapolles, Postnormapolles grains, pollen of palms and spores of tropical ferns. In the assemblage some similarities with the Lower Eocene of the Paris basin and with the Hungarian (Dorog basin) lower part of Middle Eocene have been observed. An interesting point is that the *Lygodium facies* is in association with «*tranquillus*» and *Calamus* type of palms, but not with *Cicatricosisporites*.

The age of the association is supposed to be Lower Eocene.

KEY WORDS — Palynology, Lower Tertiary, Sardinia.

INTRODUCTION

The aim of this investigation can be schematically summarized as follows: i) To compare the Sardinian association with that of other countries, particularly with those from France and Hungary on one hand, and with that from north Africa on the other in view of the geographical position of Sardinia during Eocene period. ii) To have a general picture of the Sardinia vegetation during Lower Tertiary. iii) To reconstruct the ecological aspect. iv) To establish the relative age of deposition which is pointed out from the general picture of the pollen and spores assem-

blage and, moreover, from the presence of the main stratigraphical forms. v) To carry out a comparative study regarding the general character of the assemblage, and to point out similarities and differences among this and other basins.

MATERIAL AND METHODS

The material coming from two cores (number 307 and 304) of the coal basin, situated in the south western part of Sardinia (see fig. 1), and from other samples taken in different places (outcrops)

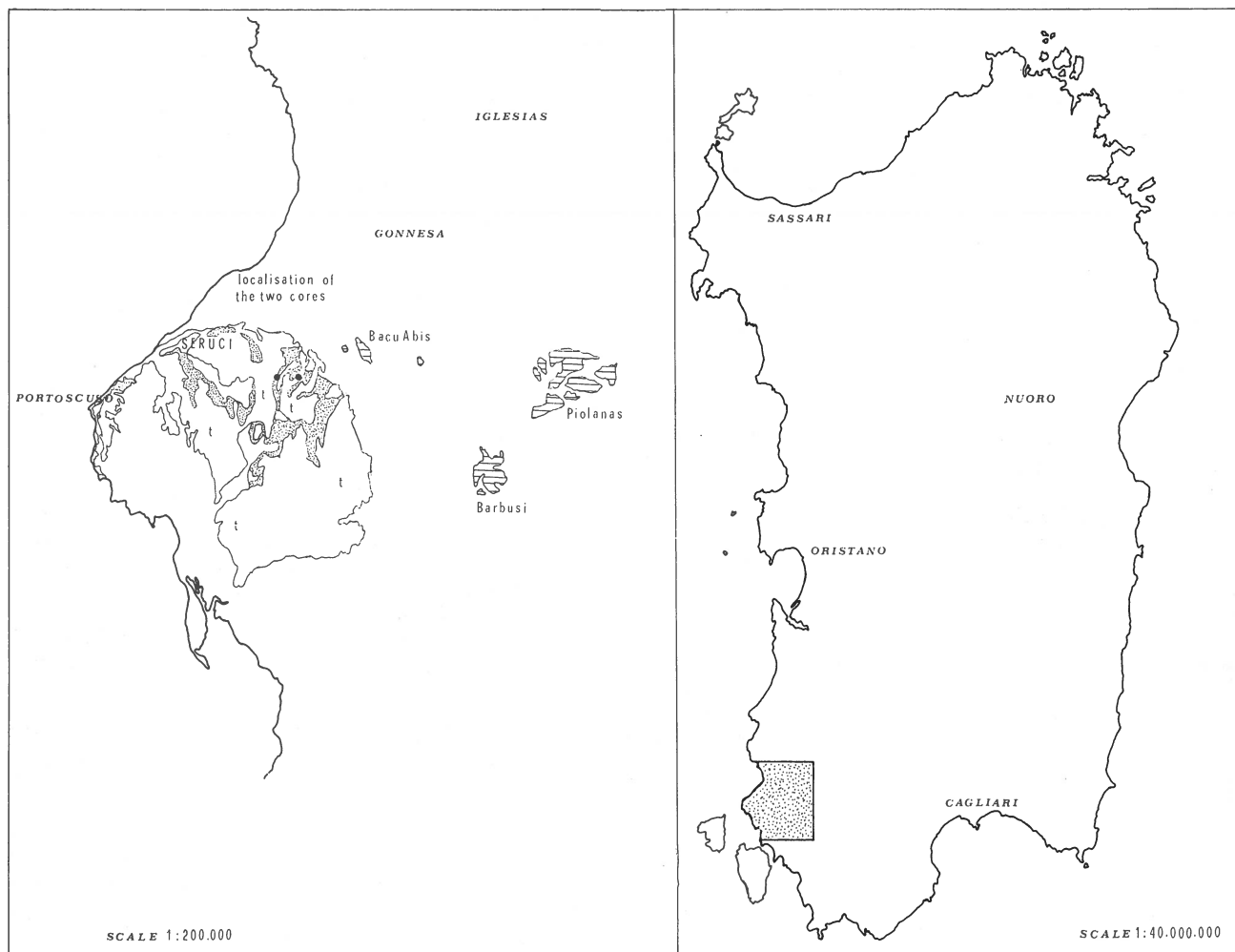


Fig. 1 - Geographical position of the studied localities.

around the basin itself (Piolanas, Bacu Abis, Caput Acquas) and in the crevasses of Monteponi and San Giorgio mines, have been examined.

The lignitiferous series is represented at the base by fossiliferous limestones with Miliols, Ostracods, Lamellibranchs and Gasteropods. In the cores it con-

PLATE I

- Fig. 1 - *Leiotriletes adriennis* (R. POT. & GELL. 1933) W. KR. 1959, subfsp. *pseudomaximus* (TH. & PF. 1953) W. KR. 1959 b. SCHIZAEACEAE, cf. *Lygodium*.
 Fig. 2 - *Leiotriletes microadriennis* W. KR. 1959 b. SCHIZAEACEAE, cf. *Lygodium*.
 Fig. 3 - *Leiotriletes triangulus* W. KR. 1959.
 Figs. 4, 5 - *Stereisporites* (*Stereisporites*) *minor* (RAATZ 1937) W. KR. 1959 b, subfsp. *minor*. SPHAGNACEAE, *Sphagnum*.
 Figs. 6, 7 - *Stereisporites* (*Tripunctisporis*) fsp.
 Fig. 8 - *Granulatisporites* fsp.
 Figs. 9, 10 - *Polypodiaceosporites bauxitus* KDS. & RÅK. J. 1965, PTERIDACEAE, *Pteris*.
 Figs. 11, 12 - *Segmentizonosporites triangulus* KDS. 1966.
 Fig. 13 - cf. *Verrucingulatisporites* fsp.
 Figs. 14, 15 - *Verrucatosporites tenellis* (W. KR. 1959 b) W. KR. 1962.
 Fig. 16 - *Microreticulatisporites* fsp.

All $\times 1000$



tinues for at least 80 m with repeating layers of limestone, coal shales and coal, while in outcrops for about 35 meters.

Samples have been treated with HF, HCl and Schulze's mixture; after cleaning, dehydration with alcohol and enrichment by heavy solutions, they have been mounted in Canadian balsam. Slides are deposited at the Institute of Geology of Cagliari University.

RESULTS

Unfortunately the examined material is not well preserved as a consequence of the pyritization of the lignite.

The amount of pollen and spores observed is not high, and determinations were often difficult therefore, they are in some case temporary. For classification, the artificial system proposed for fossil spores and pollen was followed; observations were made by light microscope as the bad preservation of the grains did not allow any investigation by modern methods like scanning or transmission electron microscope. This short paper is a report about the Sardinia Eocene palynology and it is our intention to continue these studies and to apply combined methods by light microscope and SEM and TEM as soon as well preserved and representative forms will be found.

The following is a list of the found sporomorphs.

LIST OF SPOROMORPHS

LEIOTRILETES (NAUM. 1937) R. POT. & KR. 1954.
L. *adriennisi* (R. POT. & GELL. 1933) W. KR. 1959 b, subfsp.

pseudomaximus (TH. & PF. 1953) W. KR. 1959 b. SCHIZAEACEAE, cf. *Lygodium*.
L. *adriennisi* (R. POT. & GELL. 1933) W. KR. 1959 b, subfsp. *pseudomaximus* (TH. & PF. 1953) W. KR. 1959 b, fvar. *triplan* KDS. 1961 a. SCHIZAEACEAE, cf. *Lygodium*.
L. *microadriennisi* W. KR. 1959 b. SCHIZAEACEAE, cf. *Lygodium*.
L. *microadriennisi* W. KR. 1959 b, fvar. *pseudodivisus* KDS. 1961 a. SCHIZAEACEAE, cf. *Lygodium*.
L. *microadriennisi* W. KR. 1959 b, fvar. *triplan* KDS. 1961 a. SCHIZAEACEAE, cf. *Lygodium*.
L. *microadriennisi* W. KR. 1959 b, fvar. *pseudotriplan* KDS. 1961 a. SCHIZAEACEAE, cf. *Lygodium*.
L. *dorogensis* (KDS. 1960) KDS. 1961 a, fvar. *triplan* KDS. 1961 a. SCHIZAEACEAE, cf. *Lygodium*.
L. *dorogensis* (KDS. 1960) KDS. 1961 a, fvar. *pseudotriplan* KDS. 1961 a. SCHIZAEACEAE, cf. *Lygodium*.
L. *triangulus* W. KR. 1959 a.
L. *triangulus* W. KR. 1959 a, n. fvar. *triplan*.
L. *seidewitzensis* W. KR. 1962 b.
L. *microlepidoidites* W. KR. 1962 b.
L. *microlepidoidites* W. KR. 1962 b, n. fvar. *triplan*.
L. *neddenioides* W. KR. 1962 b.
L. *ellipsoideus* KDS. 1961 a.
L. fsp.
cf. L. fsp. a.
cf. L. fsp. b.

STEREISPORITES TH. & PF. 1953.

a) subfgn. STEREISPORITES (STEREISPORITES).
St. (St.) *minor* (RAATZ 1937) W. KR. 1959 b, subfsp. *minor*. SPHAGNACEAE, *Sphagnum*.
St. (St.) *minor* (RAATZ 1937) W. KR. 1959 b, subfsp. *pliocoides* W. KR. 1963. SPHAGNACEAE, *Sphagnum*.
St. (St.) *cyclus*, subfsp. *microcyclus* W. KR. 1963. SPHAGNACEAE.
b) subfgn. STEREISPORITES (TRIPUNCTISPORIS) W. KR. 1966.
St. (Tr.) fsp. SPHAGNACEAE.

TOROISPORIS W. KR. 1959 b.

a) subfgn. TOROISPORIS (TOROISPORIS).

T. (T.) *pessinensis* W. KR. 1962 b. GLEICHENIACEAE.
T. (T.) *irregularis* W. KR. 1959 b. GLEICHENIACEAE.

PLATE II

- Fig. 1 - *Cupressacites* fsp.
Figs. 2, 3 - *Kopekipollenites* fsp.
Figs. 4, 5 - *Arecipites granulatus* (KDS. 1961) KDS. 1974. PALMAE.
Figs. 6, 7 - *Disulcites kalewensis* R. POT. 1960. PALMAE, *Calamus*.
Figs. 8, 10 - *Disulcites* fsp. PALMAE.
Figs. 11, 12 - *Plicapollis pseudoexcelsus* (W. KR. 1958) W. KR. 1961, subfsp. *pseudoexcelsus*. MYRICACEAE.
Figs. 13, 14 - *Plicapollis pseudoexcelsus* (W. KR. 1958) W. KR. 1961, subfsp. *turgidus*. MYRICACEAE.
Figs. 15, 16 - cf. *Nudopollis thiergarti* (R. POT. 1951) PF. 1953, subfsp. *minutus* PF. 1953.
Figs. 17, 18 - *Minorpollis* fsp.
Fig. 19 - *Interpollis microsupplingensis* W. KR. 1961.
Figs. 20, 21 - *Interpollis* fsp.
Figs. 22, 23 - *Triatriopollenites minimus* (GLADK. 1965) KDS. 1974. JUGLANDACEAE, *Engelhardtia*.
Figs. 24, 25 - *Plicatopollis lunatus* KDS. 1974. JUGLANDACEAE.

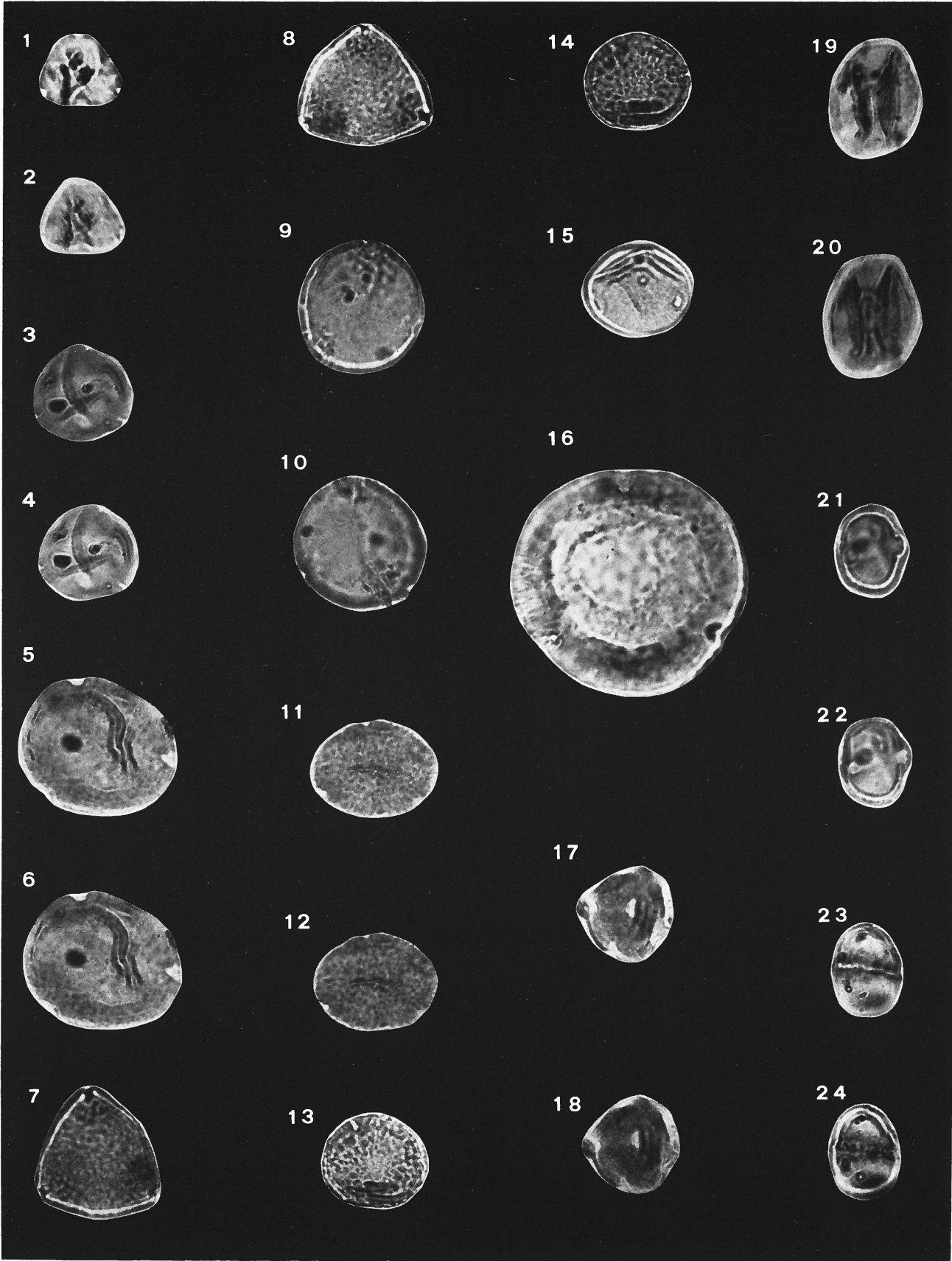
All × 1000



- SPONGIOSPORIS W. KR. 1959 b.
S. torrugulatus W. KR. 1959 b. ? *Lycopodium*.
 CONCAVISPORITES PF. 1953.
 subfgen. CONCAVISPORITES (CONCAVISPORITES).
C. (C.) acutus PF. in TH. & PF. 1953. GLEICHENIACEAE.
 TRILITES COOK. 1947 ex COUP. 1953.
 cf. *Tr. fsp.* SCHIZAEACEAE. ? LYCOPODIACEAE.
 GRANULATISPORITES (IBR. 1933) POT. & KR. 1954.
 Gr. fsp.
 LEPTOLEPIDITES COUP. 1953.
 L. fsp.
 cf. L. fsp.
 MICROFOVEOLATISPORIS W. KR. 1959 b.
 cf. M. fsp.
 CICATRICOSISPORITES R. POT. & GELL. 1933.
C. fsp. SCHIZAEACEAE, cf. *Anemia*.
 POLYPODIACEOISPORITES R. POT. 1956.
P. bauxitus KDS. & RÅK. J. 1965. PTERIDACEAE, *Pteris*.
P. rugulatearis KDS. & RÅK. J. 1965. PTERIDACEAE, *Pteris*.
P. fsp.
 SEGMENTIZONOSPORITES KDS. 1966.
S. triangulus KDS. 1966. PTERIDACEAE.
S. paleogenicus KDS. & RÅK. J. 1965. PTERIDACEAE.
S. zengövarkonyensis (E. NAGY 1969) n. comb. POLYPODIACEAE.
S. fsp.
 cf. *S. fsp.*
 VERRUCINGULATISPORITES KDS. 1961 a.
 cf. V. fsp.
 LAEVIGATOSPORITES IBR. 1933.
 cf. L. fsp.
 VERRUCATOSPORITES TH. & PF. 1953.
V. tenellis (W. KR. 1959 b) W. KR. 1962 b.
V. fsp.
 MICRORETICULATISPORITES (KNCX 1950) R. POT. & KR. 1954.
M. fsp.
 CUPRESSACITES BOLCH. 1956.
C. fsp.
 cf. *C. fsp.*
 RESTIONIIDITES ELSIK 1968.
R. hungaricus (KDS. 1965) ELSIK 1968. RESTIONACEAE.
 KOPEKIPOLLENITES KDS. 1974.
K. fsp.
 CYCADOPITES WODEH. 1933 ex WILSON & WEBSTER 1964 (sensu lato).
C. sp.
 MONOCOLPOPOLLENITES TH. & PF. 1953.
M. tranquillus (R. POT. 1934) TH. & PF. 1953, subfsp. *tran-*
quillus. PALMAE.
M. tranquillus (R. POT. 1934) TH. & PF. 1953, subfsp. *cras-*
siexinus KDS. 1968. PALMAE.
M. tranquillus (R. POT. 1934) TH. & PF. 1953, subfsp. *ma-*
gnus KDS. 1968. PALMAE.
 ARECIPITES WODEH. 1933.
A. wiesaensis W. KR. 1970. PALMAE.
A. granulatus (KDS. 1961 a) KDS. 1974. PALMAE.
A. fsp.
 DISULCITES ERDT. 1945 ex R. POT. 1960.
D. kalewensis R. POT. 1960. PALMAE, *Calamus*.
D. fsp. PALMAE.
 cf. *D. fsp.*
 PLICAPOLLIS PF. 1953.
P. pseudoexcelsus (W. KR. 1958) W. KR. 1961, subfsp. *pseudoexcelsus*. MYRICACEAE.
P. pseudoexcelsus (W. KR. 1958) W. KR. 1961, subfsp. *tur-*
gidus PF. 1953. MYRICACEAE.
P. pseudoexcelsus (W. KR. 1958) W. KR. 1961, subfsp. *semi-*
turgidus PF. 1953. MYRICACEAE.
P. pseudoexcelsus (W. KR. 1958) W. KR. 1961, subfsp. *minor*
 PF. 1953. MYRICACEAE.
 NUDOPOLLIS PF. 1953.
 cf. *N. thiergarti* (R. POT. 1951) PF. 1953, subfsp. *minutus*
 PF. in TH. & PF. 1953.
 BASOPOLLIS PF. 1953.
 cf. *B. fsp.*

PLATE III

- Figs. 1, 2 - *Platycaryapollenites* fsp. a. JUGLANDACEAE, *Platycarya*.
 Figs. 3, 4 - *Platycaryapollenites* fsp. b. JUGLANDACEAE, *Platycarya*.
 Figs. 5, 6 - *Triporopollenites megagranifer* (R. POT.) TH. & PF. 1953.
 Figs. 7, 8 - *Triporopollenites robustus* PF. 1953, subfsp. *minor* KDS. 1970. cf. BETULACEAE.
 Figs. 9, 10 - *Triporopollenites constans* TAK. 1961. CORYLACEAE.
 Figs. 11, 12 - cf. *Echitriporites* fsp.
 Figs. 13, 14 - *Subtriporopollenites urkutensis* KDS. 1974. JUGLANDACEAE or BETULACEAE.
 Fig. 15 - *Subtriporopollenites facilis* (BOTSCH. 1966) KDS. 1970. JUGLANDALES.
 Fig. 16 - *Subtriporopollenites subporatus* W. KR. 1961, subfsp. *magnus* W. KR. & VANH. 1967. JUGLANDALES.
 Figs. 17, 18 - *Cretaceisporites* fsp.
 Figs. 19, 20 - *Psilatricolporites parmularius* (R. POT.) KDS. 1975. ? EUCOMMIAACEAE.
 Figs. 21, 22 - *Tetracolporopollenites* cf. *halimbaense* KDS. 1961b. SAPOTACEAE.
 Figs. 23, 24 - *Polycolporopollenites* cf. *ellipticus* KDS. 1965b. POLYGALACEAE.
 All $\times 1000$



- MINORPOLLIS W. KR. 1959 a.
M. fsp.
- INTERPOLLIS W. KR. 1961.
I. *microsupplingensis* W. KR. 1961.
I. fsp.
- VACUOPOLLIS PF. 1953.
cf. V. fsp.
- OCULOPOLLIS PF. 1953.
cf. O. fsp.
- TRIATRIOPOLLENITES TH. & PF. 1953.
T. *intermedius* (GLADK. 1965) KDS. 1974. MYRICACEAE, *Myrica*.
T. *lubomirovae* (GLADK. 1965) KDS. 1974. MYRICACEAE, *Myrica*.
T. *minimus* (GLADK. 1965) KDS. 1974. JUGLANDACEAE, *Engelhardtia*.
cf. T. fsp.
- PLICATOPOLLIS W. KR. 1962 a.
P. *lunatus* KDS. 1974. JUGLANDACEAE.
P. cf. *minor* KDS. 1974. JUGLANDACEAE.
P. fsp.
- PLATYCARYAPOLLENITES E. NAGY 1969.
P. fsp. a. JUGLANDACEAE, *Platycarya*.
P. fsp. b. JUGLANDACEAE, *Platycarya*.
P. fsp. c. JUGLANDACEAE, *Platycarya*.
cf. P. fsp.
- TRIPOROPOLLENITES PF. & TH. 1953.
T. *robustus* PF. 1953, subfsp. *minor* KDS. 1970. Betulaceae.
T. *megagranifer* (R. POT.) TH. & PF. 1953. Betulaceae.
T. *constans* TAK. 1961. CORYLACEAE.
cf. T. *spackmanii* (TRAV. 1955) KDS. 1970.
T. cf. *pflugii* KDS. 1974.
T. fsp. a.
T. fsp. b.
T. fsp. c.
- ECHITRIPORITES VAN DER HAMMEN 1956.
cf. E. fsp.
- SCABRATISPORITES VAN DER HAMMEN 1956.
cf. S. fsp.
- SUBTRIPOROPOLLENITES PF. & TH. 1953.
S. *simpathicus* (BOTSCH. 1960) KDS. 1970. JUGLANDACEAE.
S. *urkutensis* KDS. 1974. JUGLANDACEAE.
S. *facilis* (BOTSCH. 1960) KDS. 1970. JUGLANDACEAE.
cf. S. *paleogenicus* KDS. 1970. JUGLANDACEAE.
S. *constans* PF. 1953, cf. subfsp. *constans* KDS. 1970. JUGLANDACEAE.
S. *subporatus* W. KR. 1961, subfsp. *magnus* W. KR. & VANH. 1967. JUGLANDACEAE.
- CARYAPOLLENITES R. POT. 1960 (ex RAATZ 1937) W. KR. 1961.
C. *triangulus* (PF. 1953) W. KR. 1961. JUGLANDACEAE, *Carya*.
- INTRATRIPOROPOLLENITES PF. & TH. 1953.
I. *schliebenensis* W. KR. 1961. TILIACEAE.
- BOMBACIDITES COUP. 1960.
cf. B. fsp. cf. BOMBACACEAE.
- CRETACEISPORITES HERNGREEN G. F. W. 1973.
C. fsp.
cf. C. fsp.
- CUPULIFEROIDAEPPOLLENITES POT., TH. & THIERG. 1950.
C. *liblarensis* (TH. in POT., TH. & THIERG. 1950) R. POT. 1960. FAGACEAE, *Leguminosae*.
C. *quisqualis* (R. POT. 1934) R. POT. 1960. FAGACEAE, *Leguminosae*.
- PSILATRICOLPITES (V. D. HAMMEN 1956) V. D. HAMMEN & WJM. 1964.
P. fsp.
- STRIATOPOLLIS W. KR. 1959 a.
S. fsp.
- TRICOLPITES (ERDT. 1947, COOK. I. 1947, ROSS 1949, COUP. 1953) R. POT. 1960.
T. fsp. a.
T. fsp. b.
T. fsp. c.
- RETITRICOLPITES VAN DER HAMMEN. 1956.
R. fsp.
- SERNAPOLLENITES STOVER 1966.
S. fsp.
- PSILATRICOLPORITES VAN DER HAMMEN 1956.
P. *parmularius* (R. POT.) +KDS. 1975. ? EUCOMMACEAE.
P. fsp. a.
P. fsp. b.
P. fsp. c.
- CUPULIFEROIPOLLENITES R. POT. 1951.
C. *pusillus* (R. POT. 1934) R. POT. 1960. FAGACEAE, *Castanea*.
C. *oviformis* (R. POT. 1931) R. POT. 1960. FAGACEAE, *Castanea*.
C. *kovácsae* (KDS. 1965 b) +KDS. 1975. FAGACEAE, *Pasania*.
- INTRAGRANULITRICOLPORITES +KDS. 1975.
I. cf. *wolffi* +KDS. 1975. RHAMNACEAE.
cf. I. fsp. a.
cf. I. fsp. b.
cf. I. fsp. c.
- INTRABACULITRICOLPORITES +KDS. 1975.
I. fsp.
- FOVEOTRICOLPORITES +KDS. 1975.
F. *gruas-cavagnettoae* +KDS. 1975.
- TETRACOLPOROPOLLENITES TH. & PF. 1953.
T. cf. *halimbaense* KDS. 1961 b. SAPOTACEAE.
T. *obscurus* PF. & TH. 1953. SAPOTACEAE.
T. *ellipus* KDS. 1965 c. SAPOTACEAE.
T. *foliiformis* PF. 1953. SAPOTACEAE.
T. cf. *occultus* PF. & TH. 1953.
T. fsp. a.
T. fsp. b.
T. fsp. c.
- POLYCOLPOROPOLLENITES KDS. 1965 b.
P. cf. *ellipticus* KDS. 1965 b. POLYGALACEAE.
- INCERTAE.
- OVOIDITES.
- O. *microligneolus* W. KR. 1959.
O. *longiligneolus* GR. CAV. 1967.

On the bases of the sporomorphs list the botanical affinities according to the Natural System are as follows:

Phylum : BRYOPHYTA
 Classis : *Musci*
 Subclassis : *Sphagnidae*
 Genus : *Sphagnum*

Phylum : PTERIDOPHYTA
 Classis : *Pteropsida*
 Subclassis : *Leptosporangiatæ*
 Ordo : *Filicales*
 Familia : *Schizæaceæ*
 Genus : cf. *Lygodium*
 » : cf. *Anemia*
 Familia : *Gleicheniaceæ*
 » : cf. *Cyatheaceæ*
 » : *Polypodiaceæ*
 » : *Pteridaceæ*
 Genus : *Pteris*
 Phylum : GYMNOSPERMATOPHYTA
 Classis : *Coniferopsida*
 Ordo : *Pinales*
 Familia : *Cupressaceæ*

Phylum : ANGIOSPERMATOPHYTA
 Classis : *Dicotyledones*
 Ordo : *Hamamelidales*
 Familia : *Eucommiaceæ*
 Ordo : *Anacardiales*
 Familia : *Polygalaceæ*
 Ordo : *Rhamnales*
 Familia : *Rhamnaceæ*
 Ordo : *Malvales*
 Familia : *Tiliaceæ*
 » : *Bombacaceæ*
 Ordo : *Ebenales*
 Familia : *Sapotaceæ*
 Ordo : *Fagales*
 Familia : *Betulaceæ*
 » : *Corylaceæ*
 » : *Fagaceæ*
 Genus : cf. *Castanea*
 » : cf. *Pasania*
 Ordo : *Juglandales*
 Familia : *Juglandaceæ*
 Genus : *Platycarya*
 » : cf. *Carya*
 Ordo : *Myricales*
 Familia : *Myricaceæ*
 Genus : *Myrica*

Classis : *Monocotyledones*
 Ordo : *Bromeliales*
 Familia : *Restionaceæ*
 Ordo : *Spadicifloræ*
 Familia : *Palmae*
 Genus : cf. *Gaussia*, *Microkentia*, *Martinezia*
 » : *Erythea*
 » : *Ptychosperma*
 » : *Calamus*

The pollen spores assemblage shows that:

The *Leiotriletes* spores are continuously represented in the series in relatively high quantity. Similar, from this point of view, is the behaviour of the « *tranquillus* » type of palms pollen grains. In the lower part of the cores the early types of *Myricaceæ* (*Plicapollis pseudoexcelsus pseudoexcelsus*, *Pl. pseudoexcelsus turgidus* and *semiturgidus*) are relatively abundant, while in the upper part they decrease sensibly.

In one layer of the upper part of both cores the *Calamus* type of palms pollen appears in a very high quantity and correspondingly there is a decrease of « *tranquillus* » type. All other forms have a sporadic occurrence and the distribution of the ancient forms is not restricted to the lower part of the series; for this reason the coal succession can not be subdivided in different stages.

DISCUSSION

The *Leiotriletes* group is very common in the examined samples as found in the Eocene of Europe, but the association of « *adriennoid* » forms (*Leiotriletes adriennis* and *microadriennis*) with « *tranquillus* » type is typically represented in Hungary in the lower part of the Middle Eocene. It must be pointed out however, that in a such kind of association spores of *Cicatricosisporites* formgenus have always been found, like in the Paris basin (*Kedves* 1967) and in the Hungary one (*Kedves* 1960, 1961 a); in our material, on the contrary, *Cicatricosisporites* is poorly represented, only one or two specimens were observed, and as atypical form.

For the age determination it is interesting the presence of *Stereisporites Tripunctisporis* fsp.; this subgenus is absent in the Hungarian Middle Eocene, and it is present, as a characteristic form, in the Paleocene (Tanetian II) of the Paris basin (*Kedves* 1967). Inside the spores group, several types of *Zonotriletes* have been found. These Pteridaceæ and Polypodiaceæ, although they have no stratigraphical meaning, are important in identifying the ecological aspects.

A great number of *Zonotriletes* is present in Hungarian Eocene. The absence of typical gymnosperms is curious, there are only some small specimens, probably belonging to *Cupressacites* formgenus, but not (at least in the examined material) pollen of *Pinus* or really *Cycadopites*. The presence of this last type has been noticed in the basin, but they are atypical form.

Some specimens similar to those observed by *Kedves* in the Paris basin (cf. *Disulcites* fsp. b, *Kedves* 1968), probably belonging to the *Calamus* type, which is very common in the upper part of the basin, have been found.

Pollen of Normapolles are problematic. This extinct group, referred to ancient *Amentiflorae* by *Kedves* and *Pardutz* (1970) after their studies by transmission electronmicroscope on some types of Normapolles, is of great importance for the stratigraphical recognition of the sediments starting from Upper Cretaceous till the Middle Eocene; in this short time they differentiated from each other in an excellent way, so that different associations for different stages are found.

Among all the Normapolles types present in our samples, only the *Plicapollis* is in the characteristic form; others, like *Vacuopollis*, *Basopollis*, *Interpollis*, *Minorpollis* and *Oculopollis* are not in the typical form for those genres, and furthermore a rebedding for the last of them can not be excluded. In conclusion there are no characteristic Lower Eocene forms belonging to the Normapolles group.

Regarding the association of *Plicatopollis* and *Platycaryapollenites* something interesting can be said. After the literature we know that in Hungarian layers *Plicatopollis* is in a high quantity and well differentiated in several types, while is not the same for *Platycaryapollenites*, poorly represented there. In other countries, as for instance in the western part of Europe, the *Platycarya* type is well represented and by the same time not the *Plicatopollis* type. In Sardinia *Platycaryapollenites* and *Plicatopollis* are both present in low proportion.

For the Postnormapolles group the presence of the following types was observed: *Triporopollenites*, *Subtriporopollenites* and *Caryapollenites*, but as it seems the general rule, they are not typical, although most of them are founding in the European Lower Eocene.

The presence of *Cretaceisporites* and *Echitripurites*, which up to now have only been observed in African and south American sediments, has to be explained.

Cupuliferoidaepollenites and *Cupuliferoipollenites* pollen are present in low amount, while in the European lower Tertiary they are very abundant. The presence of *Psilatricolporites parmularius* is important for the age determination since it appears in the Upper Paleocene and in the Lower Eocene. The sapotaceoid forms are in a relatively high quantity and many of them may be characteristic for the Lower Eocene. *Sernapollenites* is also present in Sardinian sediments.

In conclusion we would like to mention the position of Sardinia in the botanical ancient province according to different authors. *Zaklinskaya* (1963) considered the island as a part of the Mediterranean region which includes Spain, Portugal and a big part of north Africa. This region was called arid province. *Goczan et al.* (1967) included Sardinia with south Europe and a narrow zone of north Africa in the Mediterranean province, characterized by an atypical Normapolles association. In the present work an atypical association has been found, but we think that north Africa should not be included in this province because Normapolles have never been present.

CONCLUSIONS

On the base of the palynological data the following conclusions can be drawn:

The Sulcis region assemblage is palynologically similar to the European type in the composition of spores and pollen grains, but it differentiates for the presence of a few so called African forms.

The vegetation was that settled up in Europe during Lower Eocene; it was tropical, with several kinds of palms, other trees and shrubs. Palynological findings of grass plants are only restricted to one tropical form belonging to the *Restionaceae* family. The ecological aspect of course was in outline similar to the European one: the lower part of the section is mainly characterized by *Myricaceae* shrubs, palms and ferns, while the upper part by *Calamus* facies.

Referring to the age determination Lower Eocene is suggested but, unfortunately, further details can not be given because the restricted number of main stratigraphical forms. An interesting point is the presence of some forms which are characteristic of the Lower Eocene of the Paris basin (pollen of *Myricaceae* and *Juglandaceae*) and of some others, which, on the contrary, are characteristic of the lower part of Middle Eocene of the Hungarian region (spores of *Lygodium*, *Polypodiaceae* and palms pollen) and of the Lutetian of the Geiseltal coal in Germany. Non definite comparison can be made with the Lutetian of the Paris basin because it has not been fully investigated.

It remains to be cleared if the association of many palms, *Myricaceae*, ferns (excluding *Cicatricosisporites*) and other atypical Postnormapolles and extinct Normapolles, is only an aspect of a local vegetation belonging to the south and central Europe, or if it is really a slightly different composition, and therefore an investigation of Sardinia Early Tertiary seems to be very important.

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