FLORA TERTIARIA MEDITERRANEA

Die tertiären Floren des Mittelmeergebietes

Vegetationsgeschichte, Phytostratigraphie, Paläökologie, Paläoklimatologie, Paläogeographie

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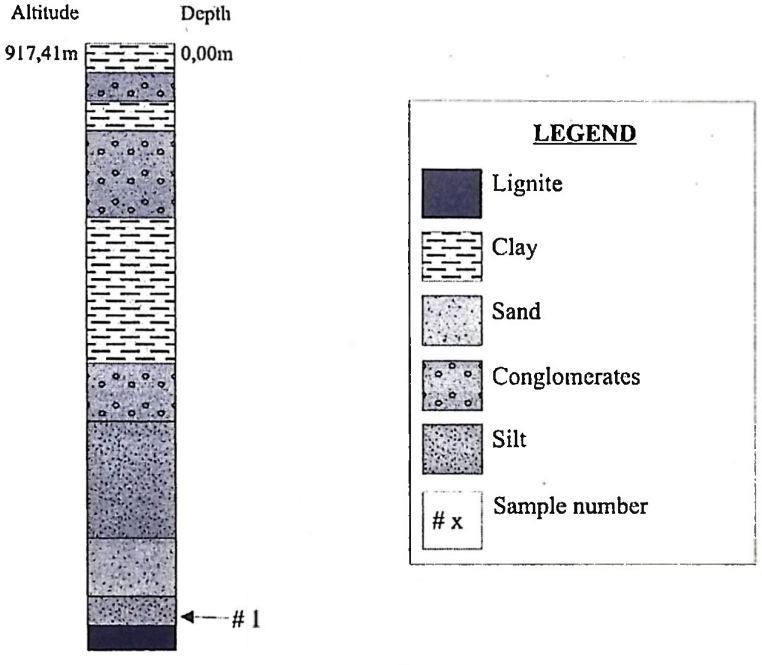

Sechster Band - Elfte Abteilung

München
Verlag Documenta naturae
2004

documenta naturae

Sonderband:

FLORA TERTIARIA MEDITERRANEA

Band VI - Abteilung 11

Jahrgang 2004

ISBN 3-86544-822-4
ISSN 1433-1705

Herausgeber: Dr. Hans-Joachim Gregor, Daxerstr. 21, D-82140 Olching

Vertrieb: Dipl.-Ing Herbert Goslowsky, Valerystr. 55, D-85716 Unterschleißheim

Der Sonderband aus dem Verlag Documenta naturae erscheint in zwangloser Folge mit Themen aus den Gebieten Geologie, Paläontologie, Paläophytologie, Botanik, Stratigraphie, Paläökologie, Taphonomie, Paläoklimatologie usw., nur das Mediterrangebiet betreffend

Der Sonderband ist Mitteilungsorgan der
Paläobotanisch-Biostratigraphischen Arbeitsgruppe (PBA)
im Heimatmuseum Günzburg und im Naturmuseum, Im Thäle 3, D-86152 Augsburg

Für die einzelnen Beiträge zeichnen der Autor bzw. die Autoren verantwortlich,
für die Gesamtgestaltung der Herausgeber.

Layout: Juliane Gregor und Hans-Joachim Gregor

Umschlagbild (E. Palamerev): Areale der rezenten und fossilen *Celtis*-Arten

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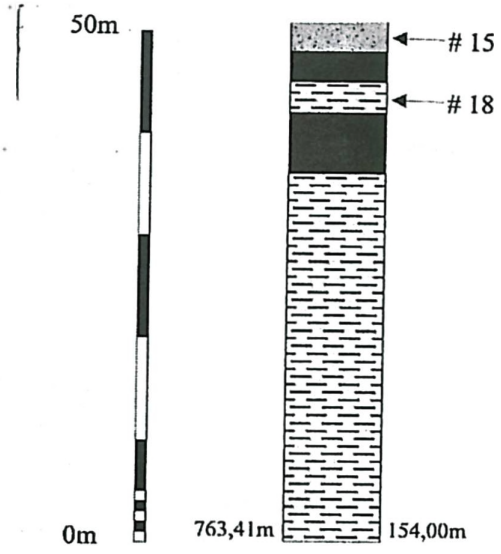
FLORA TERTIARIA MEDITERRANEA VI. 11

Two Papers on Greek Browncoals, from Klidi and Prosilio Lignite Deposits (Northern Greece) with reconstruction of the palaeoenvironment

P. ANTONIADIS, H.-J. GREGOR & E. MAVRIDOU



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FLORA TERTIARIA MEDITERRANEA V.11 p. 1-9 2 figs. 1 plate München 2004

Paleoenvironmental Interpretation of the Klidi Lignite Deposit (Northern Greece) based on Seeds and Fruits

P. ANTONIADIS [a)], H.-J. GREGOR [b)] & E. MAVRIDOU [a)]

ABSTRACT

Fossils of seeds and fruits coming from a representative borehole of Klidi lignite deposit in Ptolemais region (Peloponnesos) were studied in the present paper. The conclusions consider mainly the paleoenvironment of peat formation and the climate conditions as well as stratigraphy. Among paleobotanic residues most important is the presence of species *Glyptostrobus*. The existence of that species suggests certain paleoenvironments that coincide with what we already know for the whole area. All collected samples were classified according to the wetland they represent and the paleoclimate information they provide.

ZUSAMMENFASSUNG

Von Klidi, einer Braunkohlenlagerstätte in der Region Ptolemais (Peloponnes) werden Samen und Früchte mitgeteilt und palökologisch interpretiert. Die Überlegungen betreffen hauptsächlich die ehemalige Umwelt der Torfbildung, Klimabedingungen und Stratigraphie. *Glyptostrobus* ist einer der wichtigsten Überreste und dokumentiert die Sumpffazies der Region, wie schon bekannt. Die Florenliste wird palökologisch-paläoklimatisch charakterisiert und klassifiziert.

Keywords: Miocene, Pliocene, Lignite, Carpology, Faces.

Schusselwortes: Miozan, Pliozan, Lignit, Karpologie, Fazies.

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1. GEOGRAPHIC LOCATION AND GEOLOGIC FRAMEWORK

The lignite deposit of Klidi (figure 1), situated between Vevi and Amynteon, belongs to the lignite basin of Ptolemaida, which is part of a tectonic graben that begins from Furom (Bitola) and continues to the south through the cities of Florina-Amynteon-Ptolemais-Kozani and Servia in Greece. The basin is the most important of Neocene basins on Greece, because of the occurrence of numerous lignite deposits that are currently used for power generation. The average elevation of the basin is 600m; the basin is about 100km long and 20km wide and has a NNW – SSE orientation (PAVLIDIS, 1985).

The basin of Amynteon – Ptolemais consists of two sub-basins: those of Amynteon and Ptolemais, with the first being located north of the second one that also includes the deposit of Klidi.

The basin belongs to the Pelagonic geotectonic zone while its eastern boundary belongs to the Axios zone. Both basins form a plateau that is bordered to the north by the lakes of Chimaditida, Petron and Vegoritida and to the east by the Vermion mountain range. According to KOUKOUZAS et al. (1979) the lignite sub-basin of Amynteon is geologically similar to that of Ptolemais. Both consist of the same geologic units, the continuity of which has been disrupted by numerous tectonic movements that took place prior to and during Quaternary. The base and the margins of the Ptolemais – Amynteon Neocene-Quaternary basin consists of the pre Mesozoic and Mesozoic formations some of which have been metamorphosed.

The lignite deposit of Klidi is characterized by a thick sedimentary succession of Neocene age that is covered entirely by Quaternary deposits of fluvial and limnic origin. The geology of the region will only be mentioned briefly since the region has been an object of study for many scientists such as: KARAGEORGIOU E., (1950), PAPASTAMATIOU I., (1952), VETOULIS D., (1956), BRUNN J.H., (1956), ANASTOPOULOS I.X. & KOUKOUZAS C.N., (1972), PAVLIDIS S., (1985), KEFALAS S. & DIAMANTI – XIROPOULOU (1987), KAOURAS G., (1989), ANTONIADIS P., (1992) AND ANTONIADIS P. & LAMPROPOULOU E. (1995). More detailed information can be acquired from studies mentioned in the references of this paper since the objective of this study was to reconstruct the paleoenvironment during formation of the deposit of Klidi based on seeds and fruits coming from the interbedded strata, as well as from the poor argillaceous lignite beds.

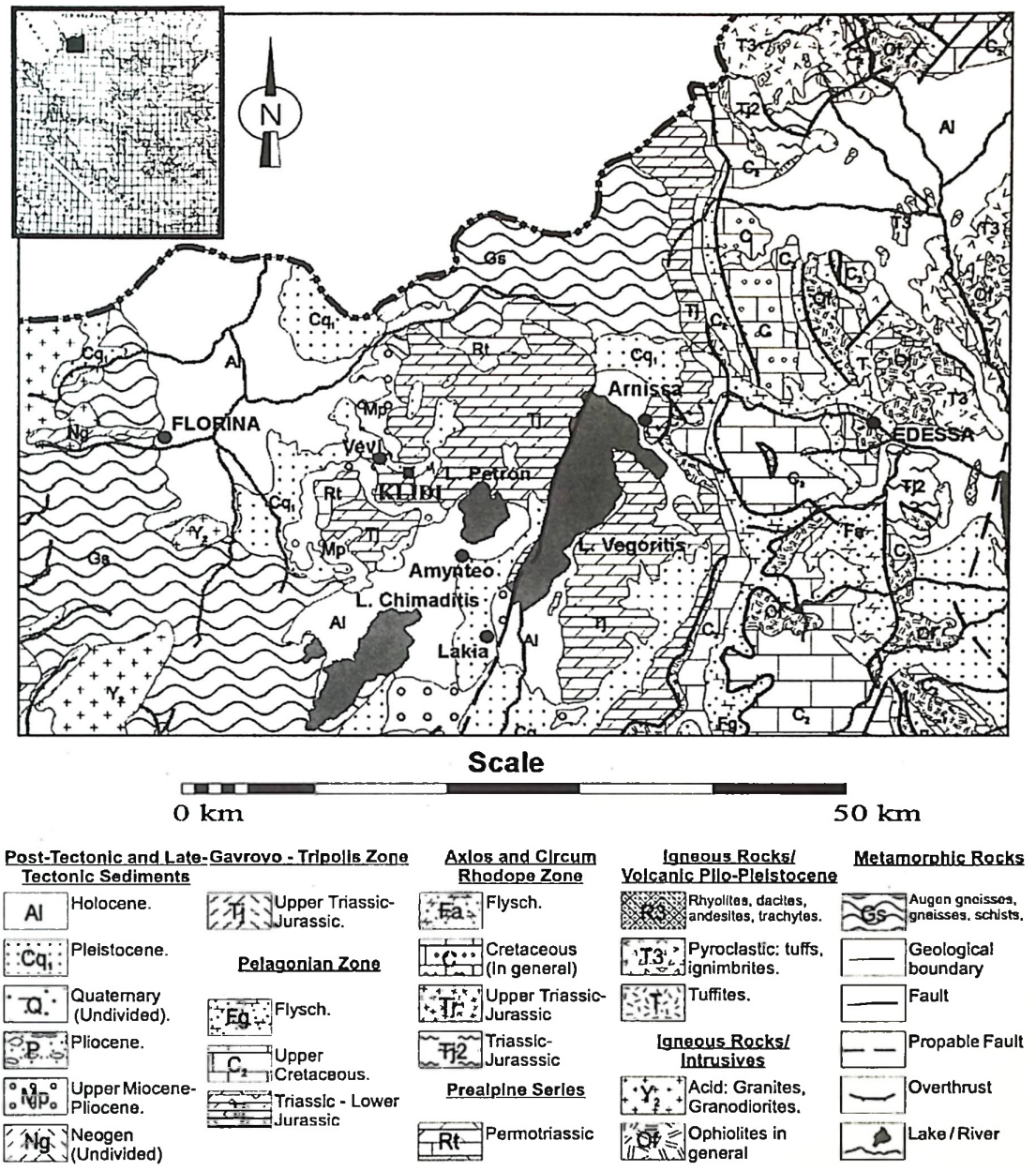

Figure 1. Geological map of Klidi area.

Post-Tectonic and Late-Tectonic sediments

Al: Alluvial deposits in valleys, plains and coastal deposits. **Cq1**: Lacustrine and continental deposits. **Q**: Marine and continental formations undivided. **P**: Lacustrine deposits: Conglomerates, sand, clays, marls, marly limestones and often lignite beds. **Mp**: Lacustrine and terrestrial deposits: conglomerates, sand, marls, clayey material, marly limestones and clays. Sometimes lignite beds. **Ng**: Lacustrine deposits: Conglomerates, sandstones, clays, marls, sometimes with lignite beds.

Gavrovo – Tripolis zone

Tj: Limestones mainly dolomitic (biosparudites, biomicrudites) often with "*Megalodon*"

Pelagonian zone

C2: Limestones (mainly biosparudites). **Tj**: Limestones (mainly biosparudites) and dolomites

Axios and Circum Podope zone

C : Limestones pelagic or neritic, calc-shists, locally jaspers and chlorite schists. **Tj**: Volcano-sedimentary series. **Tj2**: Schists, sandstones, marbles or quartzites, phyllites, diabases, limestones (Svoula series)Prealpine series

Rt : Limesones, greywackes, shists, volcanic rocks

STRATIGRAPHICAL COLUMN OF BORE KL-60

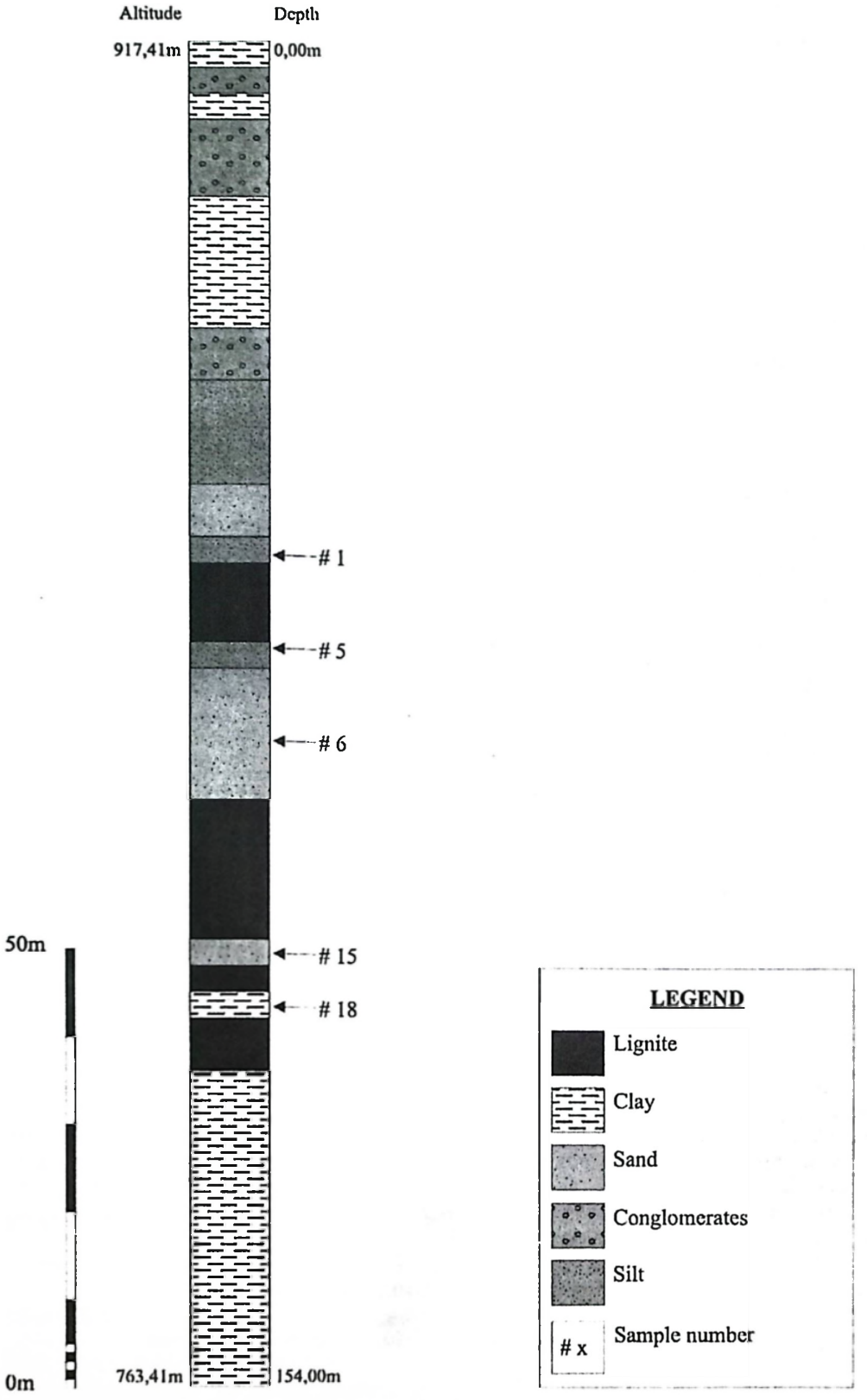

Fig. 2: Stratigraphical column of bore KL-60

2. PRE – TERTIARY

The underlying series of Neocene age (Paleogene does not exist, and even if it has existed it eroded afterwards) is rich in Mica, crystallic schist, ophiolites of Pre-Mesozoic age, as well as gray crystallic and mainly dolomitic limestones of Mesozoic age.

3. TERTIARY

For practical reasons, Neocene sediments and the Pleistocene overlying strata are divided in two series according to KOUKOUZAS et al., (1979). His division is used in the present paper. Only the upper series is of importance for the economic geology point of view and therefore this is divided in three individual layers (lower, middle (lignite), upper).

a. The overlying layers of Neocene sediments consist mainly of transition forms from clay to marl while at the same time, the portion of sand increases when moving upwards. These series are above the lignite beds and are of upper Pliocene, Pleistocene and Holocene age. Pleistocene strata are gray to sub green and the thickness also varies due to pre-Pleistocene tectonics. Series of Quaternary fluvial-Terrestrial deposits were later formed.

b. The middle layer (or lignite series) is of Pliocene age and consists of lignite beds and interbedded strata of sand silt, marls and argillaceous marls. More information can be obdained from the borehole KL-60 in figure 2. Analogous beds are also described from ANTONIADIS & RIEBER (1997) at the Lava–Servia deposit. According to Ioakim (1981), the middle layer is of Pliocene age while the upper part of the layer of terrestrial – limnic deposit was formed in the Upper Pliocene.

c. The underlying series contain the strata that underlie the deepest lignite beds (Pliocene). The age of this series is propably lower Pliocene to upper Miocene (see figure 2)

4. MEGAFLORA

Pr1: *Glyptostrobus europaeus* – seeds (pl. I, figs. 1,2), Conifer needle, aff. *Cornus* sp., *Myrica* cf. *ceriferiformoides, Typha* sp.

Pr5: leaf remain, fish teeth and vertebrae, *Bithynia*-opercula, *Glyptostrobus europaeus,* Mica-minerals, Umbelliferae gen. indet. (pl. I, figs. 6), *Decodon* sp., *Batrachium* sp.,

Pr6: *Cenococcum geophilum* – Perithecium, *Glyptostrobus europaeus* – scale, *Potamogeton* sp., *Phellodendron* sp. (pl. I, figs. 3, 4), Fusinite, *Carpinus* sp., aff. *Eoeuryale* sp.,

Pr15: Cyperaceae, *Cenococcum geophilum*, *Typha* sp., *Glyptostrobus europaeus*

Pr18 : Umbelliferae gen. indet., *Eoeuryale* sp., *Glyptostrobus europaeus* – twigs and seeds, Cyperaceae gen. indet., *Decodon* sp., *Batrachium aquatilis*, Kokons, *Typha* sp., *Potamogeton* sp., *Eoeuryale* sp. (pl. I, figs. 5).

The reconstruction of the environment is simple, as we nearly only have plants living in water or nearby and only two mesophytic elements – and these badly damaged.

Water facies: *Potamogeton, Eoeuryale, Batrachium,* Fish, Gastropods

Reed facies: Umbelliferae, *Typha, Cyperaceae*

Swamp facies: *Glyptostrobus europaeus, Myrica, Decodon,*

Riparian facies:

Forest: *Cornus, Phellodendron, Carpinus*

Funghi: *Cenococcum*

About the climate we hardly can say something, because we have only few plants for data: Eoeuryale surely needs warm summer temperature, Carpinus and Phellodendron are Mio-Pliocene elements of a cooler Cfa- and Cfb-climate, Glyptostrobus is a mesophytic Chinese element in a Cfa-climate. These poor data only allow to say it is a Neogene age and typical climate.

5. QUATERNARY

Towards the overlying Quaternary, the occurring sediments consist mainly of red loam and gray to sub green sandy clays and argillaceous sands as well as of carbonate pebbles. At the beginning of Quaternary (lower Pleistocene) intense tectonic activity took place resulting in the formation of grabens and horns. The same tectonic activity is obvious on the surface since erosion affected areas of high altitude and coarse-grained materials gathered in lower areas. Therefore, sediments of fluvial – terrestrial origin of various grading materials are unconformable to the Neocene strata below.

Special thanks : We would like to give special thanks to our colleagues V. Makris, Siskos D., Tsakiris N., Nikou A. and Kalaitzopoulos P., working for the Exploration Team of Public Power Corporation for their help during the sampling.

Prof. U. Thewalt from the Mineralogy Department of the University of Ulm was so nice to manage the necessary REM-fotos in a very short time.

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Plate I

The REM fotos were kindly made by Prof. Dr. U. Thewalt from the Mineralogy Department of the University of Ulm, Germany

Figs. 1-6 from Klidi, figs. 7,8 from Prosilio (see next article)

Fig. 1: Overview of REM-plate
Fig. 2: *Glyptostrobus europaeus* - seed
Fig. 3: *Phellodendron* sp. – broken seed
Fig. 4: *Phellodendron* sp. – surface of seed testa (fig. 3)
Fig. 5: *Eoeuryale* sp. - seed
Fig. 6: Umbelliferae gen. et spec. indet. - fruitlet
Fig. 7: wood remain
Fig. 8: cell structure of wood (fig. 7)

Plate I

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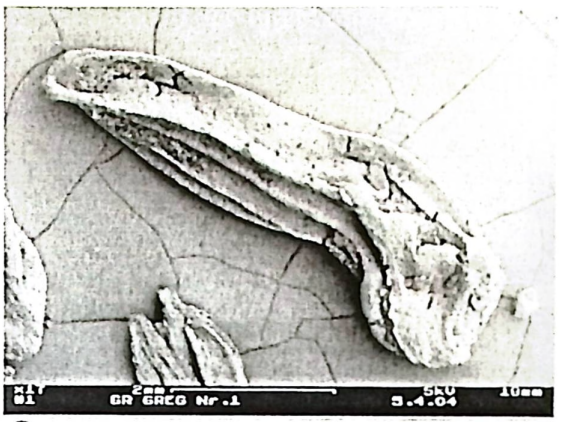

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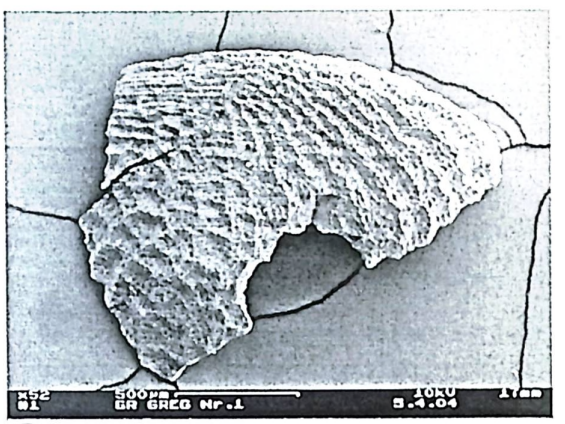

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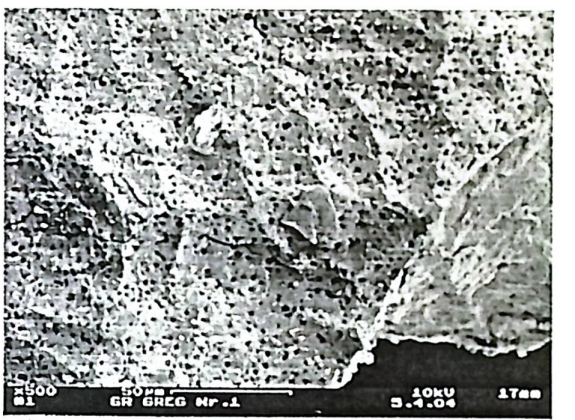

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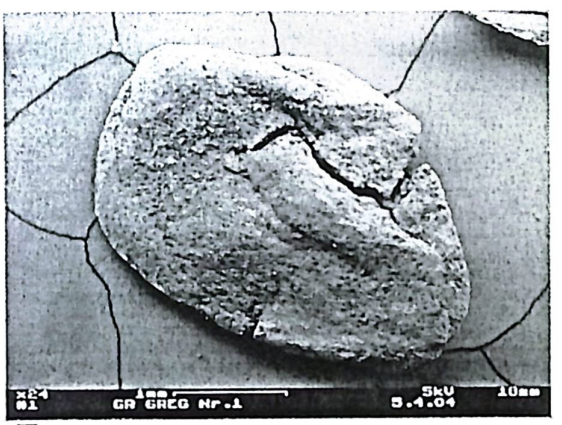

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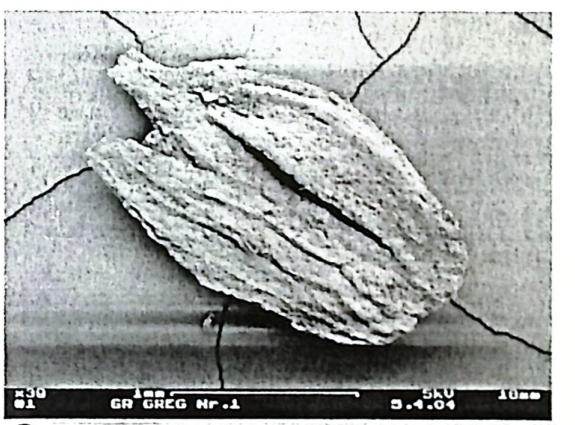

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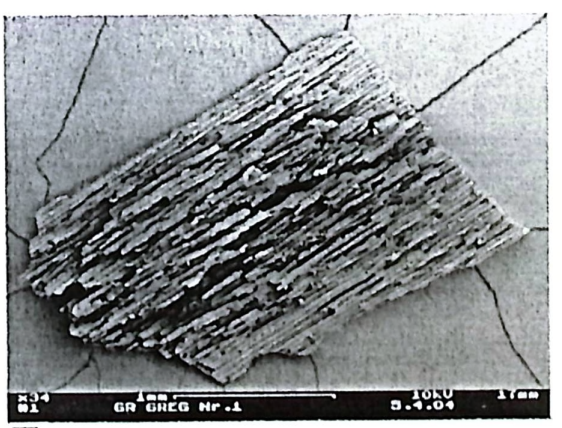

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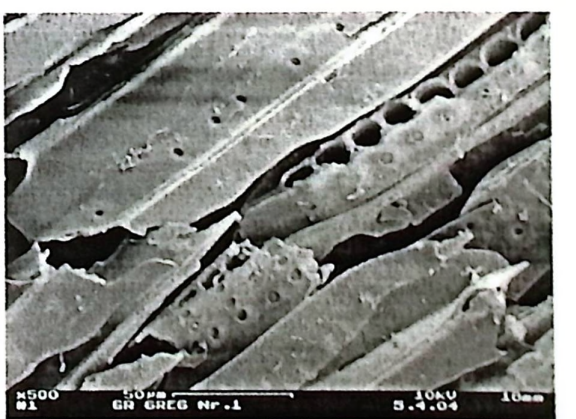

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FLORA TERTIARIA MEDITERRANEA V.11 p. 11-19 2 figs. 1 plate München 2004

The Seed- and fruitflora from the Prosilio Lignite Deposit (Northern Greece) and it's Paleoenvironmental Interpretation

P. ANTONIADIS [a], H. GREGOR [b] & E. MAVRIDOU [a]

ABSTRACT

In the present study a number of collected samples of seeds and fruits coming from several lignite layer of Prosilio field were examined. The fossils suggesting telmatic fields are represented by genus *Typha, Scirpus*, the species *Carex flagelata* and the class Cyperaceae. On the other hand, genus *Alisma* and *Stratiotes* as well as Characeae class suggest wet environments. Fossils providing information about the paleoclimate were not found.

ZUSAMMENFASSUNG

Es werden einige Diasporen aus den Ablagerungen von Prosilion beschrieben und der Versuch einer palökologischen Interpretation unternommen. Die Proben aus verschiedenen Braunkohleschichten ergeben mit ihrer Komposition von *Typha, Scirpus* und *Carex flagelata* sowie Cyperaceen ein telmatisches Ried. Auf der anderen Seite haben wir mit *Alisma* und *Stratiotes* sowie Characeen eine eindeutige Wasserfazies. Diese Fossilien erlauben keine paläoklimatische Interpretation

Keywords: Miocene, Pliocene, Lignite, Carpology, Faces.

Schusselwortes: Miozan, Pliozan, Lignit, Karpologie, Fazies.

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1 INTRODUCTION AND GEOLOGIC FRAMEWORK

The present paper is a study of the seeds and fruits fossils of the coal-bearing Prosilio basin, belongs to the Pelagonic geotectonic zone that trends NNW-SSE across mainland Greece. The studied area of Prosilio is a part of Ptolemais basin tract, which stretches from Furom (Bitola) till northern Greece.

Geologically, the basin consists mainly of pre Mesozoic formations of the Pelagonian nappe. More specifically, the crystalline base consists of pre Mesozoic gneiss and crystalline limestone, followed by upper Paleozoic to middle Triassic – lower Jurassic age. Tertiary and Quaternary sediments appear after the above formations (figure 1).

According to ANASTOPOULOS et al. (1973) Paleogene is reported as unknown in the area of study. During Paleogene, Pelagonic zone eroded during it's uplift. A period of movement followed, resulting in a system of fractures and syndeposition of large volumes of sediments. The tectonic graben of Ptolemais was formed as a result of the above structural events.

The sediments of the sub-basin that are traced in the area of study are mainly Neogene lignite formations and other sediments of Quaternary age. Neogene sediments are separated as follows:

a) The upper series, b) The lignite series (or middle) and c) The lower series.

The upper Neogene series include yellow-gray fine grained clastic sediments of alternating layers of sands, clays, sandy marls, loose conglomerates and mica as well as strata of green-gray clay and marl sediments that consist of sandy clays and silt argillaceous marls. The entire series is more than 100m thick. The lignite series of upper Miocene – late Pliocene age include two lignite beds having 20m total thickness. The interburden strata consists of clay and mainly marl formations of 5 to 10m thick and separates the lignite succession in an upper and lower lignite bed. Both beds have as characteristic the big number of alternations between lignite argillaceous lignite and thin strata of clay and marl (figure 2)

The lower Neogene series consist mainly of sands and sandstones alternating with clays and cones of breccia-conglomerate material that was carried by the streams from the margins of the basin and was set down in the basin with the form of alluvial fans (dilluvial formation). Alluvial formations include recent fluvial deposits and weathered layers of some of the previous mentioned rocks.

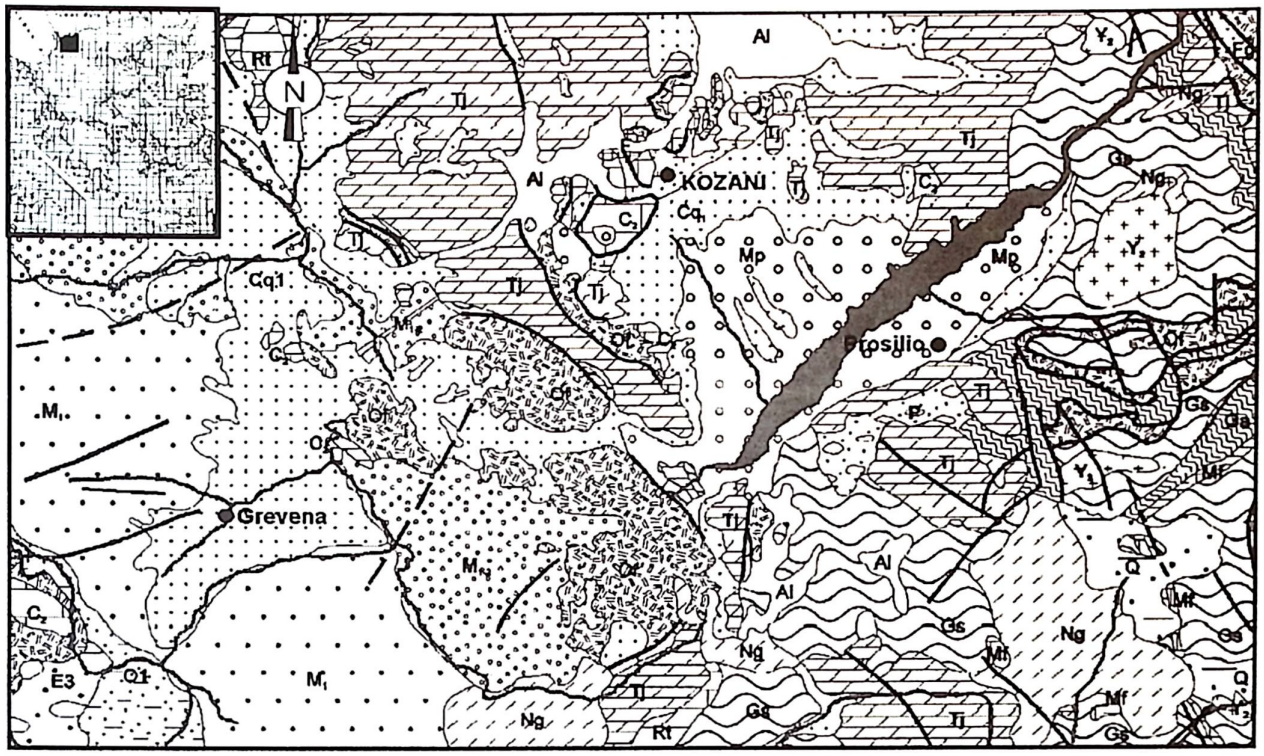

Figure 1: Geological map of Prosilio area.

Post-Tectonic and Late-Tectonic sediments

Al: Alluvial deposits in valleys, plains and coastal deposits. **Cq1**: Lacustrine and continental deposits. **Q**: Marine and continental formations undivided. **P**: Lacustrine deposits: Conglomerates, sand, clays, marls, marly limestones and often lignite beds. **Mp**: Lacustrine and terrestrial deposits: conglomerates, sand, marls, clayey material, marly limestones and clays. Sometimes lignite beds. $\mathbf{M_{1\text{-}2}}$: In the Mesohellenic Trench (Tsotylion series) molasses: conglomerates and sandstone. $\mathbf{M_1}$: In the Mesohellenic Trench (Pentalofon series) molasses: conglomerates, sandstones, red clay-sandy material. **Ng**: Lacustrine deposits: Conglomerates, sandstones, clays, marls, sometimes with lignite beds. **O1**: In the Mesohellenic Trench (Eptachorion series) molasses: conglomerates, sandstones. **E3**: In the Mesohellenic Trench (Crania series) molasses: conglomerates, marls, sandstones

Gavrovo – Tripolis zone

Tj: Limestones mainly dolomitic (biosparudites, biomicrudites) often with "*Megalodon*"

Pelagonian zone

C2: Limestones (mainly biosparudites). **F**: Flyschoids of the Upper Cretaceous transgression metamorphosed to phyllites and schists. **Tj**: Limestones (mainly biosparudites) and dolomites

Prealpine series

Rt : Limesones, greywackers, shists, volcanic rocks

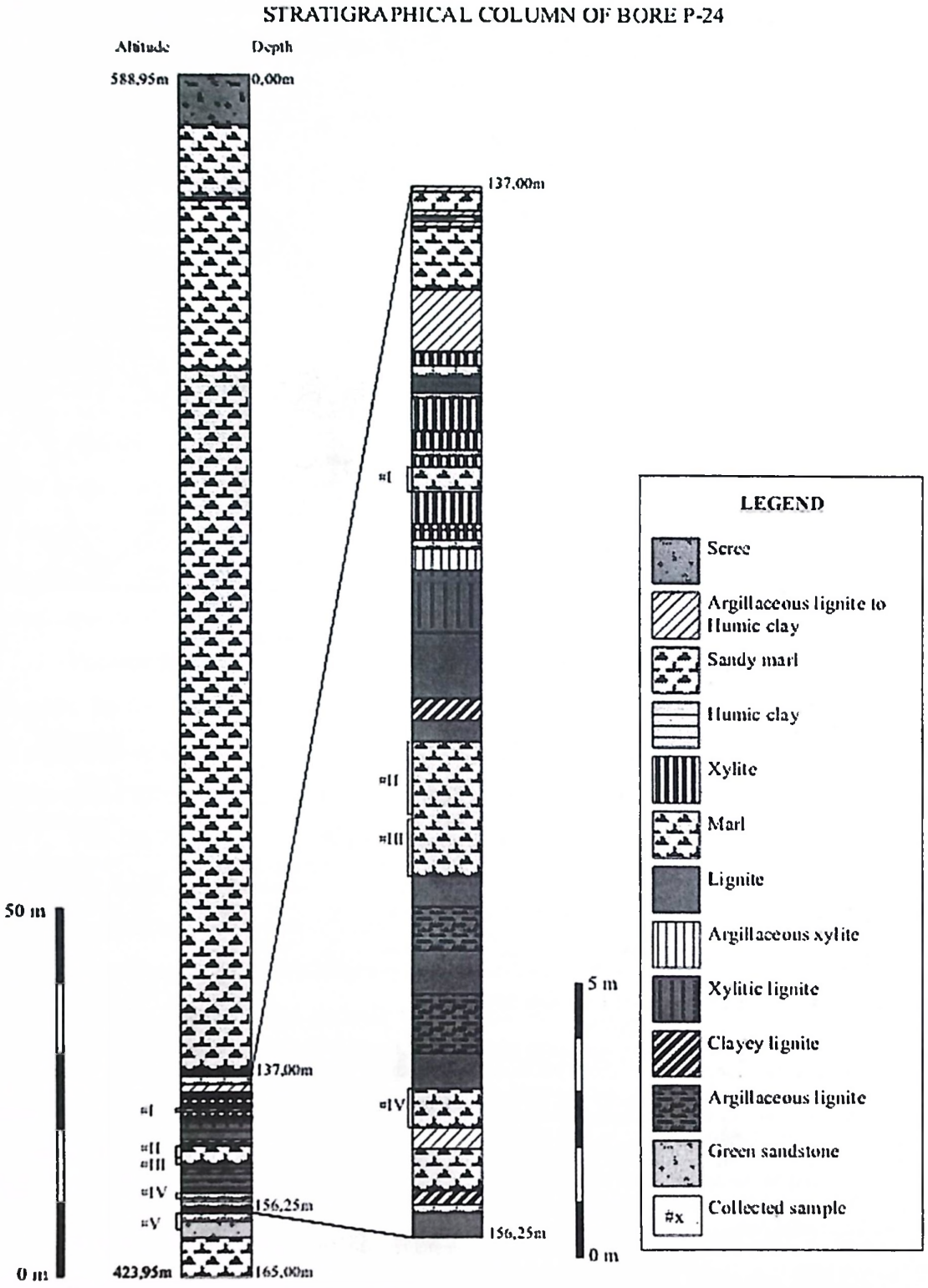

Figure 2: Stratigraphical column of bore P-24

A brief introduction to the geology of the referred region followed by information coming from the drillhole profile and legend is also part of the study (drillhole P24 in figure 2). More geological information can be acquired from:
ANASTOPOULOS, I. & BROSOULIS, I. (1973), KOUKOUZAS C. et al. (1979), IOAKIM, C. (1981), PAVLIDIS S. (1985), KOUKOUZAS C. et al. (1981), GREGOR, H.-J. & VELITZELOS, E. (1986), VELITZELOS, E. & GREGOR, H.J. (1996), ANTONIADIS P. (1992), ANTONIADIS, P. & GREGOR, H.-J. (1996), ANTONIADIS, P. & RIEBER, E. (1977), ANTONIADIS P. et al. (2003 A,B), MAVRIDOU E. et al. (2003).

2 THE MEGAFLORA

In the samples from the browncoal we often find Fish teeth, otracods, gastropods and other animal remains of unknown origin.

Samples:

Pr1 root remains

Pr2 indet.

Pr3 perithecia of funghi

Pr4 insect

Pr5 wood remains (pl. I, figs. 7, 8),

Pr6 Characeae

Pr7 Characeae, ostracod

Pr8 wood

Pr9 lignite, root

Pr10 *Batrachium aquatilis*

Pr11 aff. *Typha* sp.

Pr12 *Batrachium aquatilis*, many seeds

Pr13 clay

Pr14 *Scirpus* sp.

Pr15 seed indet.

Pr16 aff. *Typha* sp.,

Pr17 Cyperaceae

Pr18 indet.

Pr19 *Typha latissima*

Pr20 seed indet.

Pr21 Characeae

Pr22 *Potamogeton* sp. (many seeds, pl. II, fig. 1), *Carex flagellata*

Pr23 animal bones and seeds indet.

Pr24-intercalated clay: Pyrite fromboids, Kokons

Pr24 (142,0-142,6m): Characeae (pl. II, figs. 3, 4)

Pr24 (147,7-148,8m): indet. pant remains

Pr24 (153,6-154,2m): *Batrachium aquatilis* (pl. II, fig. 2), *Stratiotes* sp., aff. *Naumburgia* sp.,

Pr24 (156,3-159,0m) : *Batrachium aquatilis*, Characeae, *Alisma* sp., Fish teeth

Without number: crystals of aragonite, dissolved typical in stagnant water (pl. II, figs. 5-8) by algal dominance (FELDER et al. 2004)

The palaeoenvironment is typical water facies with *Potamogeton, Batrachium*, Characeae, *Alisma* and *Stratiotes*. The reed facies yields only *Typha, Scirpus, Carex flagellata* and *Cyperaceae.* The Naumburgia is a herb near the water, but is not very well determinable. About the climate we have no data, the age is perhaps Pliocene, having *Carex flagellata* in mind.

Special thanks : We would like to give special thanks to our colleagues V. Makris, Siskos D., Tsakiris N., Nikou A. and Kalaitzopoulos P., working for the Exploration Team of Public Power Corporation for their help during the sampling.

To Prof. U. Thewalt from the Mineralogy Department of the University of Ulm we are indebted because of managing REM-fotos in a very short time.

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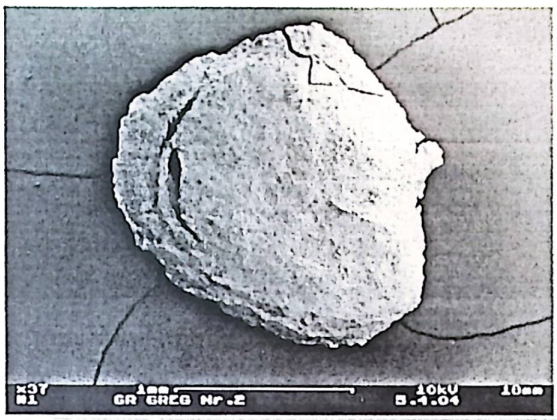
Plate II

The REM fotos were kindly made by Prof. Dr. U. Thewalt from the Mineralogy Department of the University of Ulm, Germany

Figs. 1-8 from Prosilio

Fig. 1: *Potamogeton* sp. - fruitlet
Fig. 2: *Batrachium aquatilis* - fruitlet
Fig. 3: Characeae gen. et spec. indet.
Fig. 4: Characeae gen. et spec. indet.
Fig. 5: crystal of aragonite, partly dissolved
Fig. 6: crystal of aragonite, partly dissolved
Fig. 7: crystal of aragonite, partly dissolved
Fig. 8: crystal of aragonite, partly dissolved

Plate II



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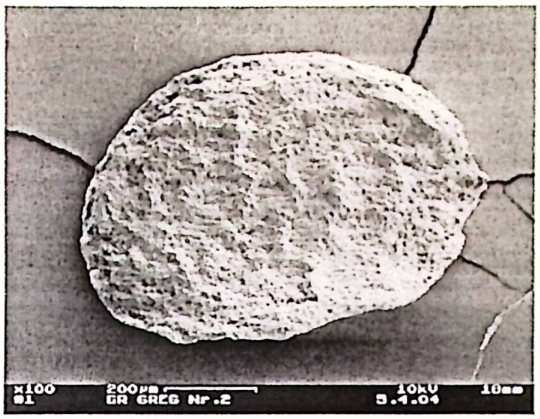

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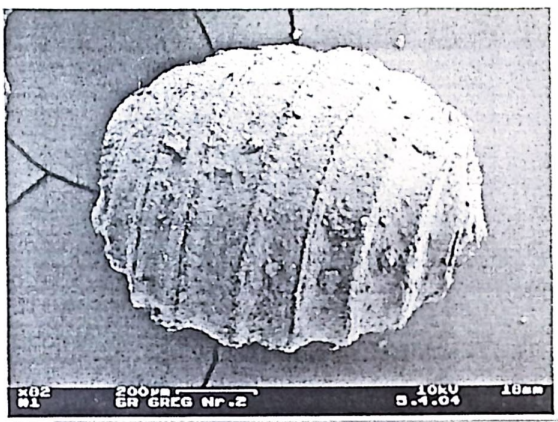

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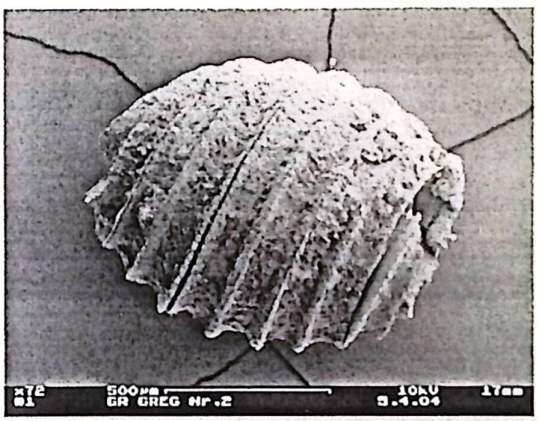

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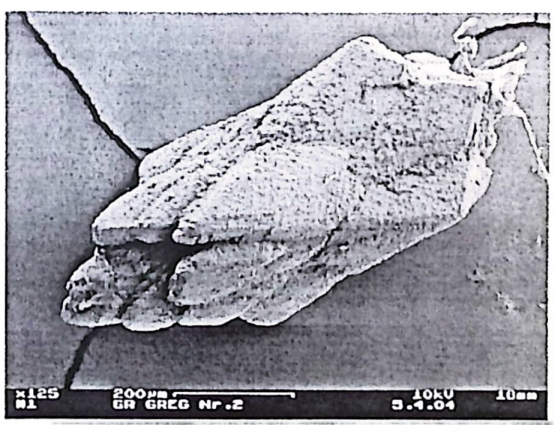

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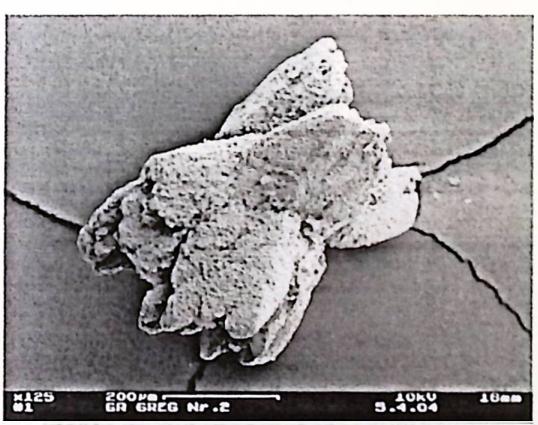

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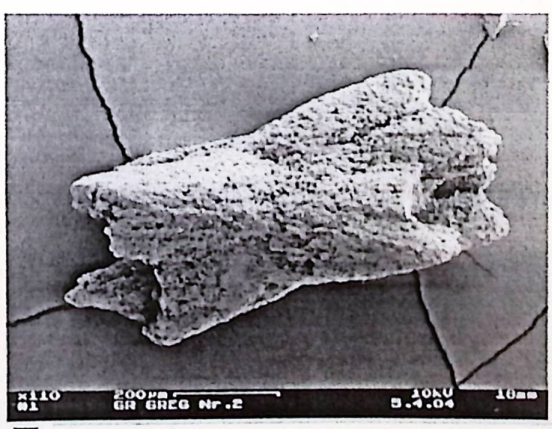

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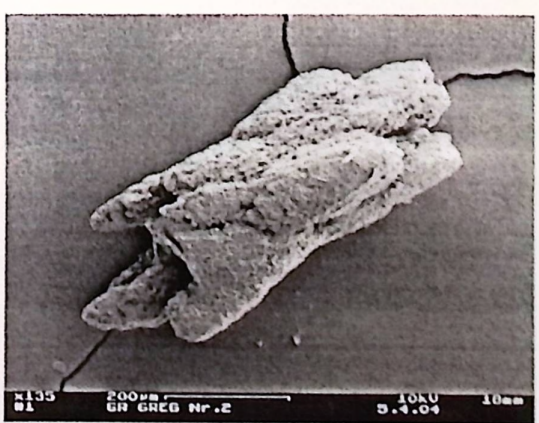

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ISBN 3-86544-822-4