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Coal Petrology and Palynology of the Early Miocene Lignite Seam from the Opencast Mine Oberdorf (N Voitsberg, Styria, Austria)

IRENEUSZ KOLCON & REINHARD F. SACHSENHOFER*)

6 Text-Figures and 2 Tables

Styria
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Contents

Kohlenpetrologie und Palynologie des untermiozänen Braunkohlentagebaues Oberdorf (N Voitsberg, Steiermark, Österreich)

Zusammenfassung

Petrologische und palynologische Daten wurden benutzt, um vertikale Faziesunterschiede im Oberdorfer Unter- und Oberflöz, sowie in kohligen Lagen in den Hangendschichten zu untersuchen. Sowohl das Unter- als auch das Oberflöz entstanden in einem relativ feuchten, nicht-marinen Niedermoor mit relativ hohem pH-Wert. Die Flöze werden durch nach oben zunehmende Baumdichten charakterisiert. Am häufigsten treten Pollen eines gemischten mesophytischen Waldes und eines feuchten Baummoores auf.

Abstract

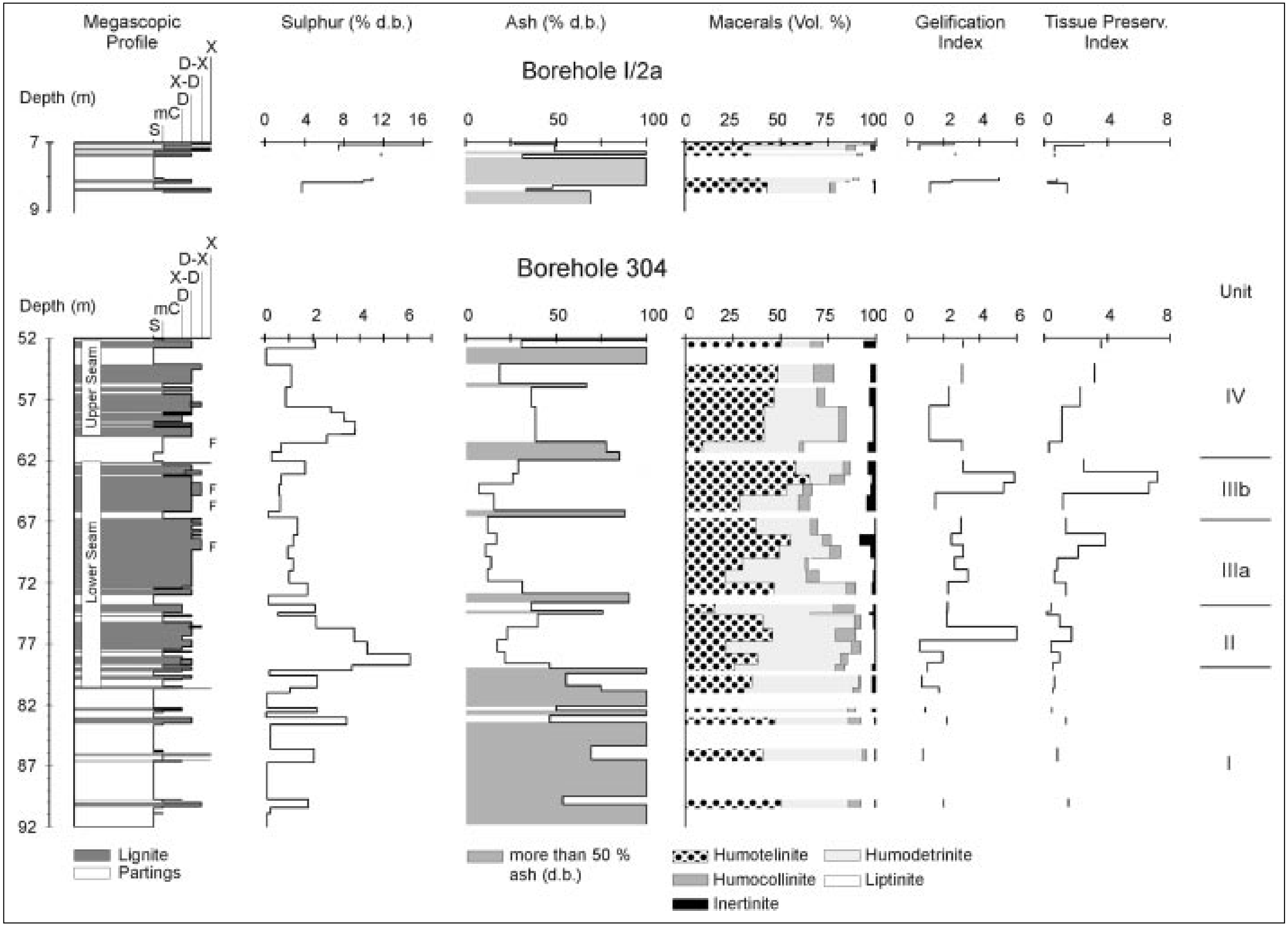
Petrological and palynological data have been used to study vertical facies variations within the lower and the upper Oberdorf seam and within coaly layers in the hanging wall sediments. The lower seam and the upper seam originated in a relatively wet, non-marine low-moor with relatively high pH-values. They are characterized by an upward increase in tree density. Pollen from a mixed mesophytic forest and a swamp forest are most abundant.

1. Introduction

Petrological and palynological investigations of several profiles of the main seam in the eastern subbasin of the Oberdorf trough were performed in order to characterize the depositional environment of the Early Miocene lignite. The results of borehole 304, drilled near the center of the basin, have been selected here as a case example. In this area the main parting separating the main seam into an upper and a lower seam is thin (Text-Fig. 1).

Thin coal layers without any economic significance occur about 50 to 60 m above the top of the main seam within fluvial hanging wall sediments (HAAS, this volume). Petrographic data from these coaly sediments are included in the present paper, because a fauna rich in micro-mammals was found at their base (DAXNER-HÖCK, this volume).

*) Authors' adress: Dr. IRENEUSZ KOLCON and Dr. REINHARD F. SACHSENHOFER: Institute of Geological Sciences, University of Leoben, Peter-Tunner-Straße 5, A-8700 Leoben, Austria.



Text-Fig. 1.
Megascopic profile, sulphur, ash, maceral group content, gelification index, tissue preservation index of hanging wall seam (Borehole I/2a) and of the main seam (Borehole 304).
X = xylitic coal; D-X = detrito-xylitic coal; X-D = xylo-detritic coal; D = detritic coal; mC = mineral-rich coal; S = clastic sediments.

Based on its moisture content of approx. 40 % (ash free; POHL, 1970) and on vitrinite reflectance values ranging from 0.25 to 0.32 % Rr (EBNER & SACHSENHOFER, 1991), the coal is a lignite (Weichbraunkohle according to the German classification).

2. Megascopic Seam Description and Ash Content

Megascopic seam sections and the vertical distribution of ash contents (dry basis = d.b.) of borehole 304 and of coaly layers within the hanging wall sediments (hanging wall seam) are shown in Text-Fig. 1. Megascopically recognizable bands of coal seams are called lithotypes. In the present paper we use the lithotype classification shown in Table 1.

Table 1.
Lithotype terminology used in the paper (modified after WOLF, 1988).

Lithotype	Description
Xylitic coal	bright to dark brown, well preserved fossil wood
Fusitic coal	satin lustre, friable
Detritic coal	dark brown to brownish-black, mostly banded, seldom homogeneous coal consisting of small (<<1cm), predominantly microscopic plant remains.
Detrito-Xylitic coal	xylitic coal with a considerable content in fine-detritic matrix
Xylo-Detritic coal	detritic coal with a considerable content in xylitic particles
Mineral-rich coal	contains more than 50% of clay and silt, either in intimate mixture with coal or in separate bands, each less than 5 mm thick

Main Seam

The workable part of the main seam lies between 54.15 and 79.24 m depth. Seam correlations show that the (main) parting at 61 m depth represents the boundary between lower and upper seam. The base of the seam contains several unworkable coaly (xylitic) layers (unit I). Partings at 73.5 and 66.5 m enable a subdivision of the lower seam into units II (ash-rich with numerous partings), IIIa and IIIb (both with relatively pure coal). The upper seam (unit IV) follows above the main parting.

The most abundant macrolithotype is xylo-detritic coal (50 %). Detrito-xylitic coal (15 %), detritic coal (8 %) and xylitic coal (<1 %) are less frequent. Fusitic coal is present in thin layers. Approximately one fourth of the workable part of the seam (27 %) consits of mineral-rich coal or fine-grained clastic sediments. The high ash content is a clear indication for a topogenous setting of the former peat.

Hanging Wall Seam

The coaly layers within the hanging wall sediments are 43 and 37 cm thick. They consist of intercalations of ash-rich xylo-detritic coal, thin xylitic layers and silty sediments. Gastropods occur within a 4 cm thick interval in xylo-detritic coal.

3. Sulphur Content and pH Conditions

Sulphur contents in coals are influenced by the acidity of the peat (S-reducing bacteria prefer pH values around 7) and by the sulphate content of waters within the peat (e.g. CASAGRANDE, 1987). Marine (brackish) peats, and fresh-water peats with marine roof rocks are generally sulphur rich. PETRASCHECK (1952) and TEICHMÜLLER & TEICHMÜLLER (1982) emphasized that fresh-water coals deposited in calcium-rich environments have similar composition as brackish-marine coals. Changes in the sulphur content can therefore be discussed in connection with pH conditions. The sulphur contents (wt.-%, dry basis = d.b.) have been plotted in Text-Fig. 1.

Main Seam

Sulphur contents of non-coal layers are generally low (0.05–0.25 %), whereas sulphur contents of lignites (ash contents <50 % d.b.) range from 0.6 to 6.5 %. Maximum values occur near the base of the lower and of the upper seam. This is attributed to a concentration of sulphate-rich water close to the less permeable base. A positive correlation between ash and sulphur contents is visible in the upper (low-ash) part of the lower seam, indicating that waters flowing into the peat not only deposited mineral matter but also raised the pH value by diluting humic acids formed in the peat. Carbonate-rich surface waters from the north (Graz Paleozoic) most likely further raised the pH value and are therefore responsible for the high sulphur content.

The observed slight increase in sulphur content close to the top of the main seam is typical for coal in a transgressive setting (flooding of the moor).

Hanging Wall Seam

The coaly layers are even more sulphur-rich than the main seam (7–16 % d.b. in samples <50 % ash d.b.) indicating neutral or even slightly basic pH-conditions. Obviously, the latter promoted the preservation of gastropods in lignite and of mammal bones found close to the base of the coaly layers, which would be decomposed in an acidic environment.

4. Micropetrography, Facies Indicators

The petrographic composition of coal depends on the ecology, the plant communities, and the rank. The petrographic composition therefore provides information on the moor facies. As plants react sensitively to changes in local conditions, petrographic investigations provide a precise tool for facies analysis (e.g. TEICHMÜLLER & TEICHMÜLLER, 1982).

During the last decade, a number of authors developed facies indicators based on maceral analysis. The most commonly used are those of DIESSEL (1986; see also KALKREUTH et al., 1991):

- ❍ Gelification Index (GI: proportion of gelified to non-gelified macerals), which represents a measure for the wetness of the peat.

$$GI = \frac{(\text{texto-ulminite + eu-ulminite + corpohuminite + densinite + macrinite})}{(\text{textinite + attrinite + fusinite + inertodetrinite})}$$

- ❍ Tissue Preservation Index (TPI: proportion of preserved to degraded plant tissues), which is a measure of tree density and/or for suitable conditions for tissue preservation; DEHMER, 1989, 1995).

$$TPI = \frac{(\text{textinite + texto-ulminite + eu-ulminite + corpohuminite + fusinite})}{(\text{attrinite + densinite + macrinite})}$$

The change in maceral group contents with depth is evident in Text-Fig. 1.

Main Seam

Huminite (62–95 vol.-% miner matter free = m.m.f.) is by far the most abundant maceral group. Liptinite (above all resinite, suberinite, sporinite, liptodetrinite) contributes 4–35 vol.-% to the composition of the lignite, while inertinite (fusinite, sclerotinite, inertodetrinite) contributes 0.4–8.0 vol.-%.

Table 2.
Taxa represented by palynomorphs in borehole 304.

Classis	Familia	Genus
Bryopsida		Bryophyta div. sp.
	Sphagnaceae	Sphagnum
Equisetopsida	Equisetaceae	Equisetum
Lycopsida	Lycopodiaceae	Lycopodium
Selaginellopsida	Selaginellaceae	Selaginella
Pteropsida	Cyathea-, Dicksonia-, Schizaeaceae	gen. indet.
	Gleicheniaceae	gen. indet.
	Osmundaceae	Osmunda
	Polypodiaceae	gen. indet.
	Pteropsida incertae sedis	
Gnetopsida	Ephedraceae	Ephedra
Pinopsida (=Coniferales)	Pinaceae	Abies Cathaya Picea Pinus
	Taxodiaceae, Cupressaceae	Taxodiaceae-Cupressaceae Taxodium, Glyptostrobus Sciadopitys
Magnoliopsida (=Dicotyledones)	Aceraceae	Acer
	Alangiaceae	Alangium
	Aquifoliaceae	Ilex
	Araliaceae	Aralia
	Asteraceae (Compositae)	Artemisia gen. indet.
	Betulaceae	Alnus Betula Carpinus
	Caprifoliaceae	Lonicera
	Chenopodiaceae	gen. indet.
	Ericacaeae	gen. indet.
	Fagaceae	Castanopsis Fagus Quercus Quercoideae Trigonobalanopsis
	Hamamelidaceae	gen. indet.
	Juglandaceae	Carya Engelhardtia Platycarya Pterocarya
	Loranthaceae	Arceuthobium
	Lythraceae	Decodon
	Mastixiaceae	gen. indet.
	Myricaceae	Myrica
	Nymphaeaceae	gen. indet.
	Nyssaceae	Nyssa
	Oleaceae	Fraxinus, Olea, Ligustrum
	Platanaceae	Platanus
	Rosaceae	gen. indet.
	Salicaceae	Salix
	Sapotaceae	gen. indet.
	Staphylleaceae	gen. indet.
	Sterculiaceae	Reevesia
	Styracaceae	gen. indet.
	Symplocaceae	gen. indet.
	Theligonaceae	Theligonum
	Tiliaceae	Tilia
	Ulmaceae	Celtis Ulmus Zelkova
	Umbelliferae	gen. indet.
	Vitaceae	Parthenocissus, Vitis
	Magnoliopsida incertae sedis	
Liliopsida (=Monocotyledones)	Arecaceae (Palmae)	gen. indet.
	Cyperaceae	gen. indet.
	Poaceae (Gramineae)	gen. indet.
	Liliaceae, Iridaceae	gen. indet.
	Sparganiaceae - Typhaceae	gen. indet.
	Liliopsida incertae sedis	

Tissue preservation (TPI) decreases slightly within the unworkable layers at the base of the seam (unit I) and generally increases upwards within the lower seam. Maximum TPI values occur in the middle parts of units II, IIIa and IIIb. In the upper seam (unit IV), TPI increases towards the top. With the exception of unit IIIa (68–76 m depth), which is characterized by constant GI values, the GI and TPI values correlate positively. This confirms that tissue preservation is controlled not only by tree density, but also by the wetness of the peat.

With the exception of a few samples from units I and II, GI values are >1. This indicates that the peat was relatively wet during its entire evolution.

According to DIESSEL (1986), the observed facies indicators suggest a moderate moist bushmoor (unit I), which changed periodically with wet forest swamp conditions (unit II). Wet forest swamp conditions with transitions to a fen environment occurred during formation of unit III. The indices of unit IV are characteristic for the transition from a bushmoor to a wet forest swamp.

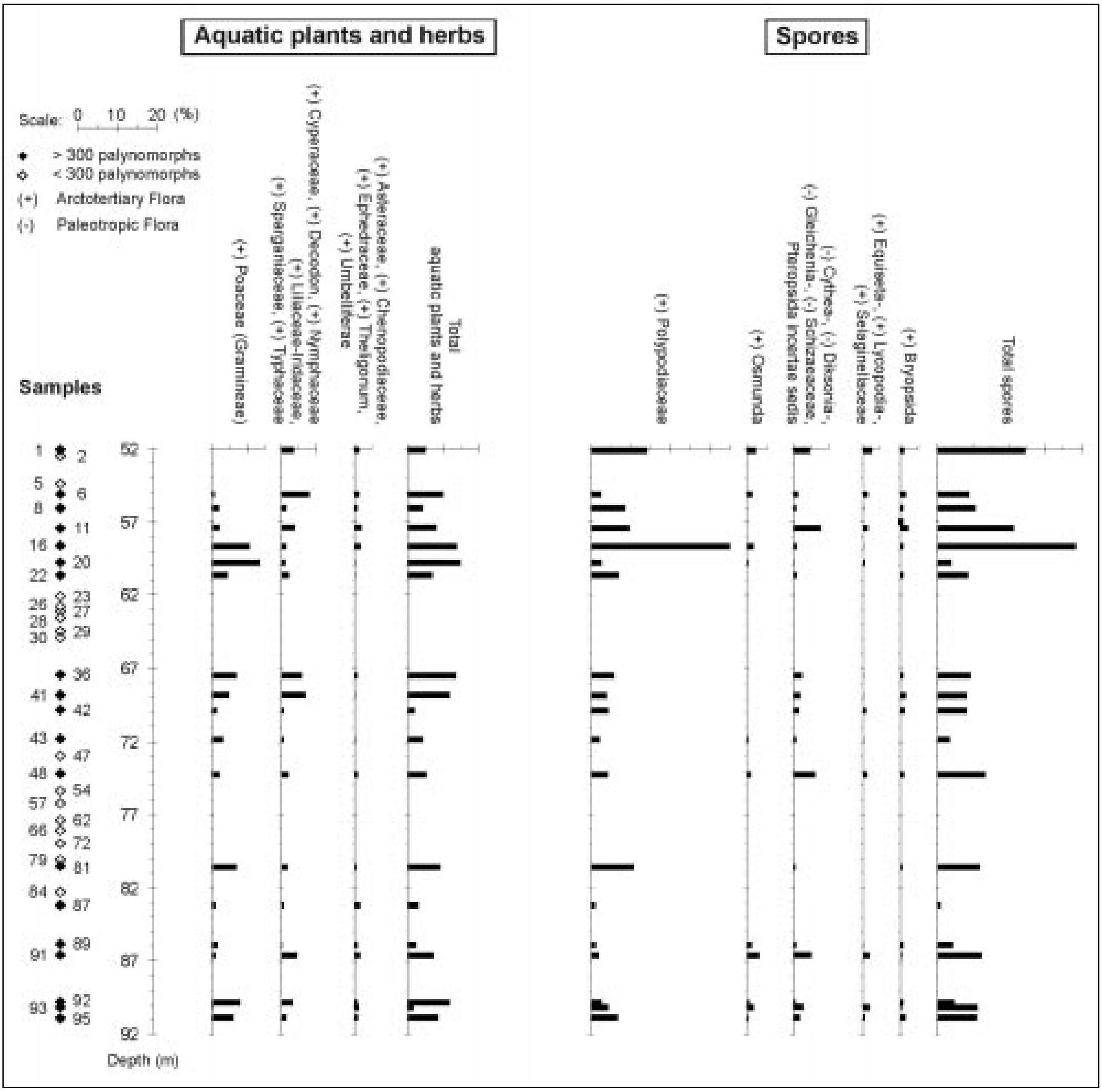
Hanging Wall Seam

Huminite contents range from 80 to 100 vol.-% m.m.f. Inertinite contents exceed 1 vol.-% only in a single sample. Facies indices are indicative for wet conditions with varying tree density.

5. Palynology

Palynology offers an independant data-set for facies reconstructions. Thus the integration of petrological and palynological information extends the knowledge of former coal-forming environments (e.g. SCOTT, 1991).

Thirty-five point samples (from lignites and partings) from borehole 304 were investigated palynologically. Only few palynomorphs are present in samples from units II and IIIb



Text-Fig. 2.
Content of pollen of aquatic plants and herbs and of spores (Bryopsida and Pteridophyta) in borehole 304.

whereas samples from units I, IIIa and IV contain more than 300 palynomorphs and therefore can be evaluated statistically. The taxa listed in Table 2 were determined and assigned to different plant communities (cf. MAI, 1995):

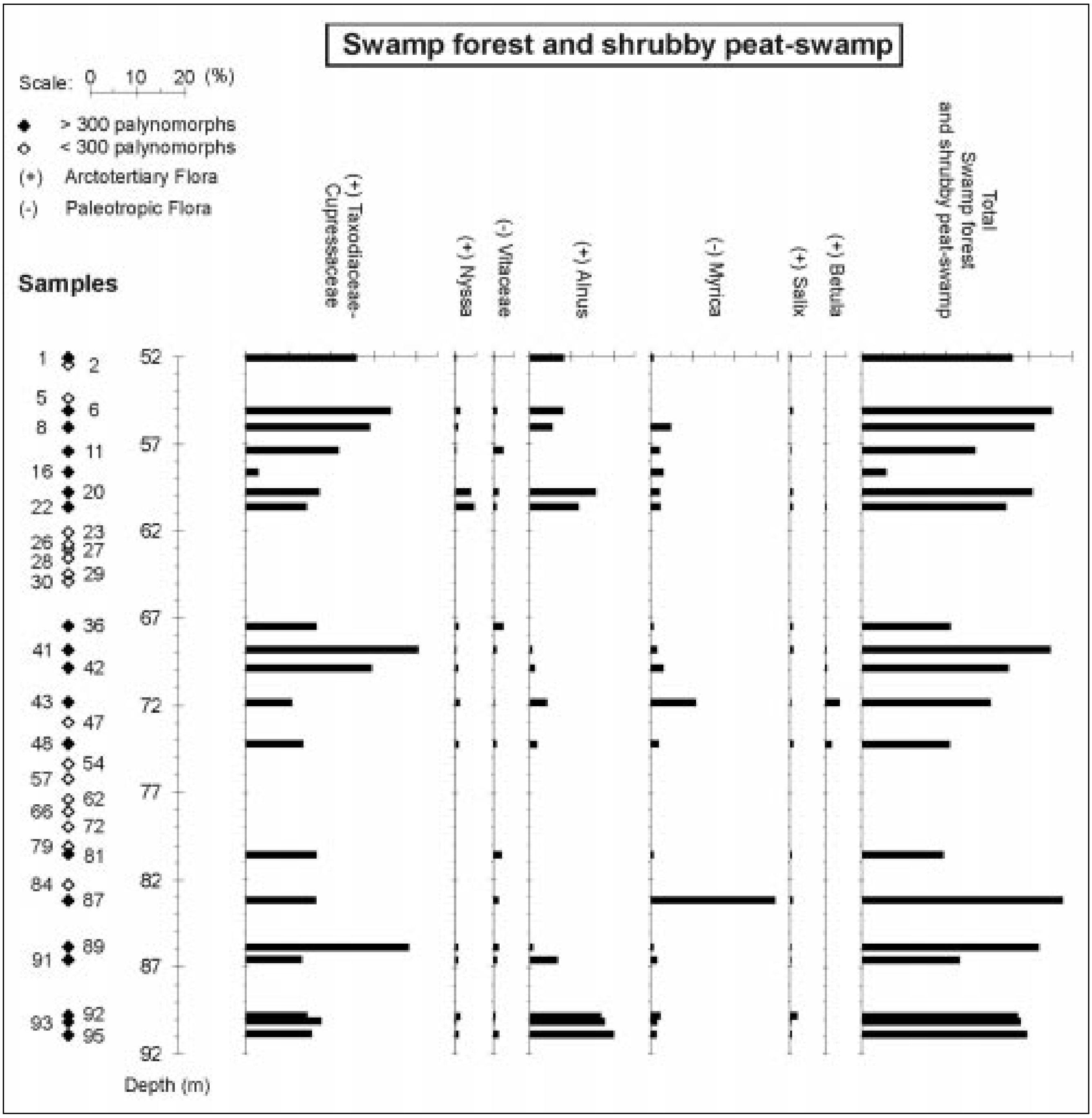
– Aquatic plants and herbs (Text-Fig. 2).
– Swamp forest and shrubby peat-swamp (Text-Fig. 3).
– Mixed mesophytic forest (Text-Fig. 4).
– Spores of Bryopsida and Pteridophyta are presented separately (Text-Fig. 2).

Most abundant are pollen from the mixed mesophytic forest and from the swamp forest. Other groups are generally rare, although Polypodiaceae spores occur in large numbers within some samples from the upper seam (unit IV). Pollen of *Alnus* and *Myrica*, characteristic for wet bush moors, occur in great numbers within some samples from unit I and unit IV.

Text-Figs. 2–4 show that there is little variation in relative frequencies of plant communities with depth. However, the percentage of Taxodiaceae-Cupressaceae (Text-Fig. 3) shows a clear upward increase within the upper seam, suggesting that the parallel increase in TPI (Text-Fig. 1) is mainly due to increasing tree density. The same is true for the high TPI value in unit IIIa.

The ratio between paleotropic and arctotertiary plants is close to one. Relatively high values occur between the upper part of unit I and unit III.

The statistical evaluation of the counts (cluster analysis) enabled the samples to be arranged into 4 groups (A–D). Text-Fig. 5 shows their average composition with regard to plants of different facies zones. Group A is represented only by one sample (rich in Polypodiaceae). Most samples belong to group B or D. These groups differ mainly in the ratio between mixed mesophytic forest and swamp forest



Text-Fig. 3.
Content of swamp forest and shrubby peat-swamp pollen in borehole 304.

plants. Group B shows a high ratio and represents drier conditions than group D. Group C is similar to group D, but includes a relatively high number of bush moor plants.

Text-Fig. 6 shows their succession in the seam profile. Accordingly, lignite formation began in a habitat dominated by mixed mesophytic forest. The large number of partings points to interruptions of moor growth due to flooding. Part of the sporomorphs may also be wind-transported from a nearby hinterland. Samples with group D and C assemblages occur in the upper part of unit I.

Unit IIIa starts and ends with group B associations and is characterized by high percentages in Taxodiaceae-Cupressaceae (group D) in its middle part. There is a close relation between sporomorph assemblage and TPI in this unit suggesting that high TPI values are due to high ratios between swamp forest plants and plants growing in a mixed mesophytic forest. On the other hand, the close relation between palynological and petrographic evidence indicates that the sporomorphs are autochthonous.

Unit IV is dominated by group D. Group C and A assemblages only occur in its lower part.

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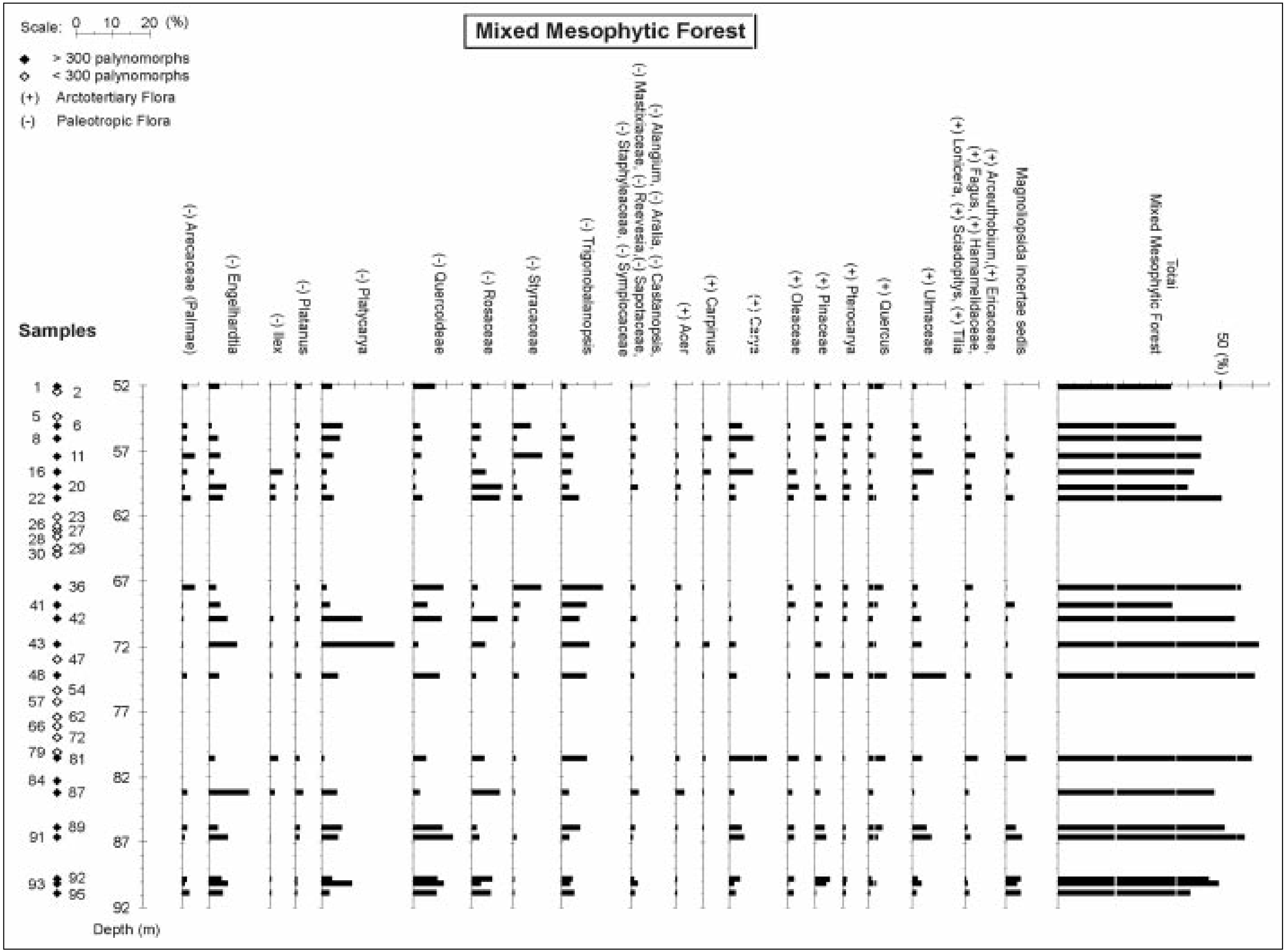

Text-Fig. 4.
Content of mesophytic forest pollen in borehole 304.

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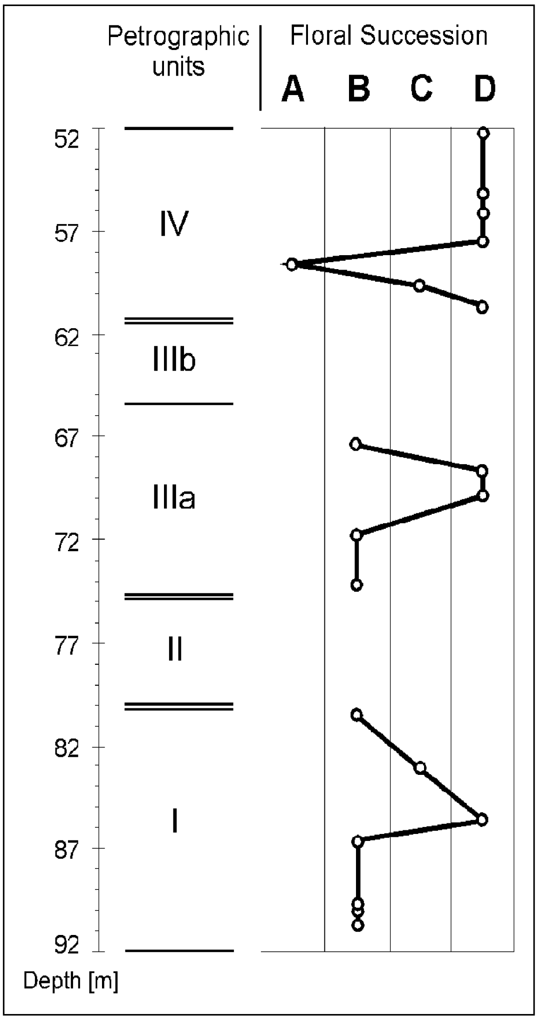
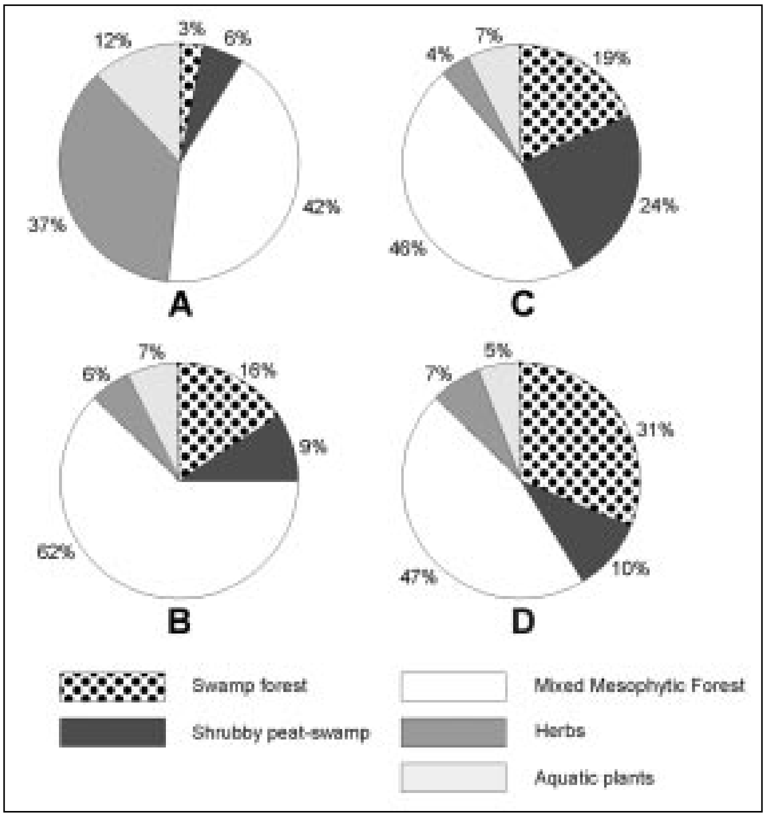


Text-Fig. 6
Coal-petrographic units and floral succession in borehole 304.



Text-Fig. 5.
Average composition of the plant communities in the various phases of moor development in borehole 304.

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