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Palynofacies studies of lake sediments with examples from the Saar-Nahe Basin (Permocarboniferous; SW-Germany)

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Abstract: A provisional palynological organic matter classification is applied for the palynofacies from lacustrine sediments of the uppermost Carboniferous and lowermost Permian of Southwest-Germany (Rotliegend). Sedimentary organic matter of mainly higher biological origin is determined microscopically. The definition of three fixed major- and variable subdivisions led to the creation of seven palynofacies types. These PF-Types are in addition graphically defined by a ternary diagram, a palynofacies-triangle. 30 lake horizons of different stratigraphic positions and their surrounding environments were studied and the results compared to each other. A preliminary model provides an overview on relations between PF-Types and corresponding environments. Differences in the palynofacies composition of the pelagial facies help to characterise the relative size of fossil lakes. The results from the sedimentary sequences of whole lake successions in comparison are partially blurred and have to be analysed separately. In these successions the complete development of one lake is documented by the palynofacies. The PF-analyses provide valuable data and lead to more accurate reconstructions of fossil lake environments, especially its inhabitants.

Kurzfassung: Eine vorläufige Klassifikation für palynologische organische Materie wird auf die Palynofazies lakustriner Sedimente des obersten Karbon und unteren Perm (Rotliegend) Südwestdeutschlands angewandt. Das sedimentäre organische Material mit weitgehend höherer biologischer Herkunft wurde mikroskopisch bestimmt. Die Definition dreier festgelegter Haupt- und variabler Unterabteilungen führte zur Bildung von sieben Palynofazies-Typen. Diese PF-Typen werden zusätzlich graphisch durch ein ternäres Diagramm, ein „Palynofazies-Dreieck", definiert. Dreißig Seehorizonte unterschiedlicher stratigraphischer Position und ihre umgebende Umwelt wurden untersucht und die Ergebnisse miteinander verglichen. Ein vorläufiges Modell bietet einen Überblick über Beziehungen zwischen PF-Typen und korrespondierendem Environment. Unterschiede in der Zusammensetzung der Palynofazies helfen die relative Seegröße zu bestimmen. Ergebnisse von den vollständigen sedimentären Abfolgen sind vergleichsweise partiell undeutlich und müssen getrennt analysiert werden. In diesen Abfolgen wird die komplette Entwicklung eines Sees durch seine Palynofazies dokumentiert. Die PF-Analyse liefert somit wertvolle Daten und führt zu genaueren Rekonstruktionen fossiler Lebensräume im See, speziell seiner Bewohner.

1. Introduction

The history of palynofacies analysis is generally based on the study of palynological remains. COMBAZ (1964) introduced the name „palynofacies" for the field of study, but his interpretation was controversely discussed (e.g. SIGAL 1965). As one result from these discussions, a lot of different proposals to establish a useful classification for organic matter can be found throughout the literature. Unfortunately most attempts lack a transferability to various facies types and environments or different geological systems. They are most often only functional for the material and the examples published in the respective studies.

At a workshop held in Amsterdam, June 1991, the need for an international classification of organic material in sediments was discussed (Lorente & Ran 1991). There, the subject was called Palynological Organic Matter (POM). A preliminary classification was proposed. This classification avoided interpretation and names that would be confusing. It tried to be strictly descriptive and freely adaptable to everyones use, despite the actual study area or field of study. Four major divisions were proposed: palynomorphs, structured debris, amorphous matter, and indeterminate matter. These were subdivided into further 2nd and 3rd order divisions. Other subdivisions can be individually added if needed. An international comittee will define and shall publish this classification in the hopefully nearby future. So, in no way I want to imply that the basic classification used here is solely my own development, but a test of its applicability.

The Saar-Nahe Basin is one of the largest Permocarboniferous basins in central Europe. During the Upper Carboniferous and the Lower Permian the basin settled along the Southern Hunsrück Fault (Henk 1993). It represents a large molasse trough (Schäfer 1986) with sediments of fluvio-lacustrine origin (Falke & Kneuper 1972, Stollhofen & Stanistreet 1994), which form a sedimentological unit. The sediments of the Lower Rotliegend were deposited in a wide, roughly structured depression (Schäfer & Rast 1976). Falke (1954) introduced the lithostratigraphic standard classification used since then with only slight alterations (Boy & Fichter 1982, Stapf 1990).

The microflora of the permocarboniferous sediments has not aquired the same interest during this century. This may be due to a relatively worse preservation of palynomorphs compared to other localities of the same age. Most studies were concentrated on the boundary between Carboniferous and Permian (Bhardwaj & Venkatachala 1958). The different workers often tried to enhance the stratigraphical correlations (Helby 1966, Reimann 1975, Engel 1986) or compared the deposits with other localities (Visscher et al. 1974, Hochuli 1985). More recent studies dealt with biometrical examinations and their environmental significance (Fechner 1991, 1993). A complete taxonomical revision of the palynoflora is in prepraration and has not been finished yet (Hartkopf-Fröder, pers. comm.).

A working group at the University of Mainz (Germany) tried to establish a new look on the palaeoecology of the lake sediments. Various new lake horizons were found during the last few years and are subsequently examined (Boy et al 1990, 1993, Boy 1994, Clausing 1989, 1990, Clausing et al. 1992). One working direction incorporated is that of micro-organofacies, a combination of methods from microfacies, palynofacies and coalpetrology studies (Clausing 1993a). For the optical studies on the palynofacies some new ideas have been developed during the project. They mainly resulted from the need to classify the abundant organic matter of the sediments and simplify it for the reconstruction of palaeoenvironmental models. For this purpose, a review of existing proposals had to be done to find an appropriate classification. The current paper provides an example for an adapted PF-classification used for lacustrine permocarboniferous sediments. This paper is an attempt to classify this material by optical means and test the applicability for first palaeoecological interpretations. Parts of this study have previously been established for a doctoral thesis and are now presented with additional data.

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2. The Palynofacies concept

The primary roots for studies on organic components of rocks of microscopical scale can be dated back to the last century. The three major working directions directly concerned are coal petrology, microfacies, and palynology. They all established a specialized terminology of their own, which is often difficult to combine or compare to each other, due to an often unfortunate choice of similar or well known terms for new organic remains. Although pollen and spores are commonly included, most of the studies deal with sediments of marine or brackish origin. The lacustrine environment has been less extensively studied in means of palynofacies.

As previously noted, the term "palynofacies" (COMBAZ 1964) itself was not generally approved by. A lot of other ideas for similar or identical studies were developed during the following years, with a terminology mostly depending on the type of observations done. The term most commonly used for the overall subject in english literature is "organic matter" (e.g. GEHMANN 1962, LORENTE 1990), sometimes replaced by "palynodebris" (BOULTER & RIDDICK 1986, FARR 1989, BOULTER 1994). French studies correspondingly often use "matière organique" for descriptions (ALPERN 1970, DURAND & ESPITALIE 1970). Kerogen is defined as organic matter that can not be solved in organic or inorganic fluids like acids or bases (while bitumen is solvable). As a result, most components of the palynofacies could geochemically be understood as kerogen (DURAND 1980, 1987, NOHR-HANSEN 1989). The organic components can generally be derived from autochthonous and allochthonous material. Their preservation ranges from particulate organic matter (= "POM") to dissolved organic matter (= "DOM", e.g. HART 1986). The first one is commonly studied by optical means (COMBAZ 1980, BATTEN 1980, 1983) and additionally, most substances can be chemically analysed (DURAND & ESPITALIE 1970, COMBAZ 1971). Attempts to gain further information from the assemblages led to various classifications for the different components of the palynofacies.

2.1. Classification problems

As a result from the studies mentioned before, a broad variety of classifications for organic matter in rocks exists and is steadily increasing in number (ALPERN 1970, ALPERN et al. 1972, BATTEN 1973, 1982a,b, HART 1986, etc.). A lot of new proposals are subsequently added without an internationally approved, meaningful standard terminology (compare TYSON 1995). Palynology, coal petrology, and geochemistry sometimes significantly oppose each other (e.g. ROBERT 1979) and the field of study generally seems to prevent a uniformous terminology. One general problem is to differentiate between description, determination, and interpretation. The first is the clearly understood scientific begin, the second is the taxonomic attempt and the third is imaginative. To select between these three ways for ones own classificational needs is often difficult or sometimes even impossible.

Tab. 1: Composition of the Palynological Organic Matter classification applied in the Saar-Nahe Basin, largely based on the preliminary "Amsterdam POM Classification".

1st Division (Major)	2nd Division	3rd Division
palynomorphs	pollen	monosaccate
		bisaccate
		type *Potonieisporites*
		type *Florinites*
	spores	monolete
		trilete
		sculptured
		type *Vittatina* (striate)
	indeterminate pollen/spores	
	"algae"	cyanobacteria
		Botryococcus
		prasinophytes
	acritarchs	
	fungal spores	
structured material	woody remains	
	plant epidermis/cuticle	
	plant tissue	
	fungal remains (sclerotia)	
	arthropod remains	
amorphous material	finely dispersed particles	yellowish-brown particles
		black particles
	homogenous particles	translucent
		yellowish-brown particles
		black particles
	heterogenous particles	yellowish-brown particles
		black-brown particles

The palaeontological approach tries to appoint the remains to fossil genera or species and is primarily based on biological features. An example for this is the study of HART (1986): phytoclasts (plant origin), zooclasts (animal origin), protistoclasts (protistal origin), scleratoclasts (fungal origin), and receptorclasts (dissolved remains) are distiguished, further components are possible (tab. 2). The components mentioned are neither complete nor good to use, because they strongly depend on interpretation. Description and determination are mixed up, so that this classification can not easily be transferred to other environments or geological times. By including preservation stages with a classification of its own, the difficulty to apply it is additionally enhanced.

The sedimentological terminology uses macerals and micro-lithotypes as applied in coal petrology to describe the material (STRUCKMEYER & FELTON 1990, HART 1994). ALPERN (1970) originally proposed seven groups of organic matter as "organolites": textites, gelites, detrites, bitumina, spherolites, sporites, and organites. Unfortunately, this kind of terminology is nearly identical to that of coal petrology and as such irritating or even superfluent.

The geochemical results are based on different analyses of mostly amorphous substances (e.g. oils and resins). These are connected to macerals or palynomorphs. From this a mixed classification with terms of both approaches mentioned results. This mainly provides a classification in which interpretation and observation are also mixed up (ALPERN 1970, 1980, DURAND 1980, 1987). It is often concentrated on the total organic matter, not solely on the kerogen or the figured organic matter.

The problem with finding a proper terminology was recently discussed by TYSON (1995). An attempt to find an appropriate description is the term "organic particles" as used e.g. by TRAVERSE (1994). To illustrate some of the difficulties which arise while the different classifications are used, some important ones were selected and are briefly discussed in the following chapter.

2.2. Palynofacies classifications

From todays point of view the original definition of palynofacies by COMBAZ (1964) with its division into three major categories was astonishingly advanced in comparison to younger ones. Three groups were suggested: microfossils (spores, pollen, acritarchs, etc.), plant remains (fragments of cuticles, etc.) and amorphous organic matter. The latter was described as dispersed or fluffy and could contain asphalt or resinite spheres; unfortunately, this included a first interpretation.

ROBERT (1979) used another line of approach: he compared the results of reflected and fluorescence light microscopy (coal petrology) to that of transmitted light (microfacies, sediment petrology). His classification includes terms from the three directions, in which not all possible components are included and are not directly comparable. This application seems to be restricted to certain special models.

BATTEN (1973, 1980, 1982a,b) re-used the palynofacies concept introduced by COMBAZ (1964). He constructed facies types which are significant for certain environments. These types contain groups of components with key character, like palynomorphs, planctic organisms, or palynodebris. The examples ("Purbeck Beds palynofacies", BATTEN 1982b) are clearly defined, but can only be transferred with great difficulties. A term as *Classipollis*-palynofacies could be more appropriate, but such facies types could only be applied for the time during that a special pollen existed. Characteristic groups of components were collected in further studies (BATTEN et al. 1984, GAUPP & BATTEN 1985). Their nomenclature is easy and appropriate, but specific components again limit the application to certain stratigraphic levels.

Tab. 2: Various components and similar terms of some selected classifications for sedimentary organic matter in opposition to each other (? = no strictly comparable components).

Alpern (1970)	Hart (1986)	Boulter & Riddick (1986)	Lorente (1990)
?bitumites	protistoclast	specks	algal/bacterial masses
détrites	phyto/protistoclast	comminuted debris	?
organites	protistoclast	dinoflagellates	?
sporites	phytoclast	jurassic palynomorphs	exines
		tertiary palynomorphs	exines
		bisaccates & spores	sporomorphic exines
?bitumites	protistoclast	amorphous matter	algal/bacterial masses
dérites	phytoclast	degraded bundles	degraded plant material
gélites		unstructured debris	resins & humic gels
sphérolites		?	resins & humic gels
détrites	phyto/protistoclast	degraded debris	?
textites	phytoclast	parenchyma	epidermal remains
		leaf cuticle	cuticular remains
		well-preserved wood	wood
		brown wood	wood
détrites		black debris	"charcoal"
sphérolites	scleratoclast	fungi	fungal remains
organites	protistoclast	algae	unicellular/colonial algae
	zooclast	?	animal exoskeleton remains

A similar classification was presented by Boulter & Riddick (1986). Botanical or petrographical influenced creation of new termini are avoided. This makes comparison to previously published terms easier (tab. 2). Representative types (second phase variables) are created from the palynodebris and applied statistically. The resulting component groups are again characteristic for certain environments, but are very complicated to use and difficult to transfer.

Lorente (1986, 1990) differentiated structured and unstructured components of aquatic and terrestrial origin for her organic matter classification (tab. 2). These components might contain fluorescing "palynomacerals". Again, the study concentrates on the gathering of different methods, and again the results are not widely transferable.

Tyson (1989) summarized organic material as kerogen and opposes his descriptions of particles to the probably equivalent macerals. The kerogen is divided into phytoclasts, amorphous and exinitic organic matter and the frequency plotted in a ternary diagram (palynofacies triangle). Major phytoclasts are figured in an additional ternary plot and provide distinct features for single localities. Eight groups of particles are introduced, referred to by abbreviations (Wu, Wd, I, C, Tp, E, AOM, F) and their frequency is analysed. Using these results, the respective sedimentary environment with its typical components is given. The conclusions drawn are very convincing for determinations in the marine environment.

Another important classification was introduced by van BERGEN et al. (1990). It is less interpretative than the ones mentioned before and easily adaptable. Three major groups of components are divided: palynomorphs, structured palynodebris, and unstructured palynodebris. This classification is probably one of the best published yet and has formed the basis for the original Amsterdam POM classification.

Recently a new collection of articles on sedimentation of organic particles was published and a lot of new studies were presented (TRAVERSE 1994). Of all contributing authors, only BOULTER (1994) added an enhanced approach to a standard terminology. He comments again, that a lot of general difficulties are based on the use of description versus determination versus interpretation and following misuse of terms. His primary 36 components (variables) are collected under the term "palynodebris". In this analysis, he excluded some components (foraminiferal linings, reworked spores, and fern sporangia) as being of little value for the marine palynofacies. He also neglected the value of algae and different plant material for interpreting marine palynofacies on the base of statistical analysis. All components are collected under the somewhat unfortunate term "palynodebris", because it could be misunderstood. One outside the field of study might imply that only allochthonous particles are of interest. A lot of autochthonous components, like algae or primary producers, will probably get lost by this selection. But these are important constituents of the facies for an environmental reconstruction, not only, but especially in lakes (CLAUSING 1993b).

The most recent overview on palynofacies s.l. was presented by TYSON (1995) in a first mononographic work on sedimentary organic matter. His classification scheme closely follows the proposal of Amsterdam, with the exception of a few renamed terms. He points out, that a classification used is generally correlated to the aim of the study. The various attempts to create a new terminology are relevant if they are comparable to each other, if not, they are totally superfluent.

3. The Palynofacies Components

For this study an optical approach was chosen with the focus on palaeontological and palaeoecological data. The three main divisions used for the interpretation of the palynofacies in the Saar-Nahe Basin are palynomorphs, structured, and amorphous material (tab. 1). The components were optically identified, if possible and defined by data accessible, if existing. This is extremely problematical in the Palaeozoic because most often only rough informations e.g. on plants and their corresponding environment are known, if at all. Habitats of plants are often simply divided into hygrophilous, mesophilous and xerophilous environments, depending on the amount of water accessible only (e.g BARTHEL 1982) and interpreted from actuo-studies and facies interpretation. The identification of components in general was always cross-checked by use of fluorescence microscopy (CLAUSING 1993a) to eliminate, for instance, contamination as much as possible.

3.1. Division 1: Palynomorphs

The group "palynomorphs" consists of small, often unicellular remains. This closely resembles the various pollen and spores mentioned by BOULTER (1994), but additionally includes algae, acritarchs, and fungal spores. Their current systematics in the Saar-Nahe Basin is based on few observations (chapter 1). Some new attempts led to the identification of some algae and possible acritarchs (Clausing 1993b). For ecological interpretations, morpho-types of pollen and spores can be used with some certainty (e.g. type *Potonieisporites*). In fact, as Traverse (1988) noted, relations between fossil palynomorphs and plant genera are widely unknown, so an interpretation of the ecological significance of palynomorphs remains difficult for a lot of taxa.

3.2. Division 2: Structured Material

All organic components, which are neither palynomorphs nor taxonomically identifiable animal remains and do posess cell structures or similar features, are described as "structured material". Here, these are possible wood remains, plant epidermis and cuticles, plant tissue, fungal remains, and arthropod or other animal fragments. This is nearly identical to the definition of components called "palynowafers" by Boulter (1994). Relations to complete organisms are relatively unknown. Some earlier attempts for a correlation to certain plants were made by Barthel (1962, 1976, 1982) and Kerp (1990) but have never been completed. A description and interpretation of isolated cuticles was tried by Busche (1966, 1968) and Busche et al. (1978).

3.3. Division 3: Amorphous Material

The remains which are collected as "amorphous material", see also Boulter 1994, are characterised by the lack of clearly visible features. The same components are also called unstructured material (Tyson 1995) to oppose it to the structured material. Finely dispersed material, homogenous material, and heterogenous material are the secondary divisions used here, which can be further seperated by their colour. A more detailed differentiation might be achievable by additional fluorescence analyses (Clausing 1992) or geochemical data. It is probably mainly derived from primary producers and/or higher plants, which are largely degraded.

3.4. The Palynofacies Types

In the Amsterdam meeting, the Palynological Organic Matter was originally divided into four divisions. During my studies I noticed that the "indeterminate matter" could almost always be included into one of the three major divisions (tab. 1). I found no need to use "indet. matter" as a sole major division at all and eliminated that term on this level. Additionally, there is probably no real use for the term "indet. matter" in palynofacies analyses for environmental studies. The results were much more transparent if the term "indet. matter" was included into the sub-divisions, on the same level as pollen or "algae". Most of the samples studied here, contained unidentifiable matter, but in all cases that could be assigned to amorphous material at least. Nevertheless, the term "indet. matter" could provide important clues for the following taphonomic analysis and study of the palaeoenvironment.

Three major divisions remain and provide the opportunity for the construction of a ternary diagram (fig. 1), as previously used for instance by Tyson (1989, 1993). This kind of model is widely known and has also been applied in a similar way for coal petrology studies (Struckmeyer & Felton 1990) and the classification of microlithotypes (Bustin et al. 1983, p. 62). In the study presented here, the "Palynofacies-Triangle" is based on qualitative and semi-quantitative analyses. The results can probably also be used quantitatively, but only with great caution (Clausing 1995). With such a diagram, palynofacies types can be clearly and unequivocally defined. A current problem I noted however is that components of the 2nd and 3rd division are difficult to figure in this triangle analysis (e.g. pollen, "algae"). They could partially be included into the diagrams as "dots", but are diffi-

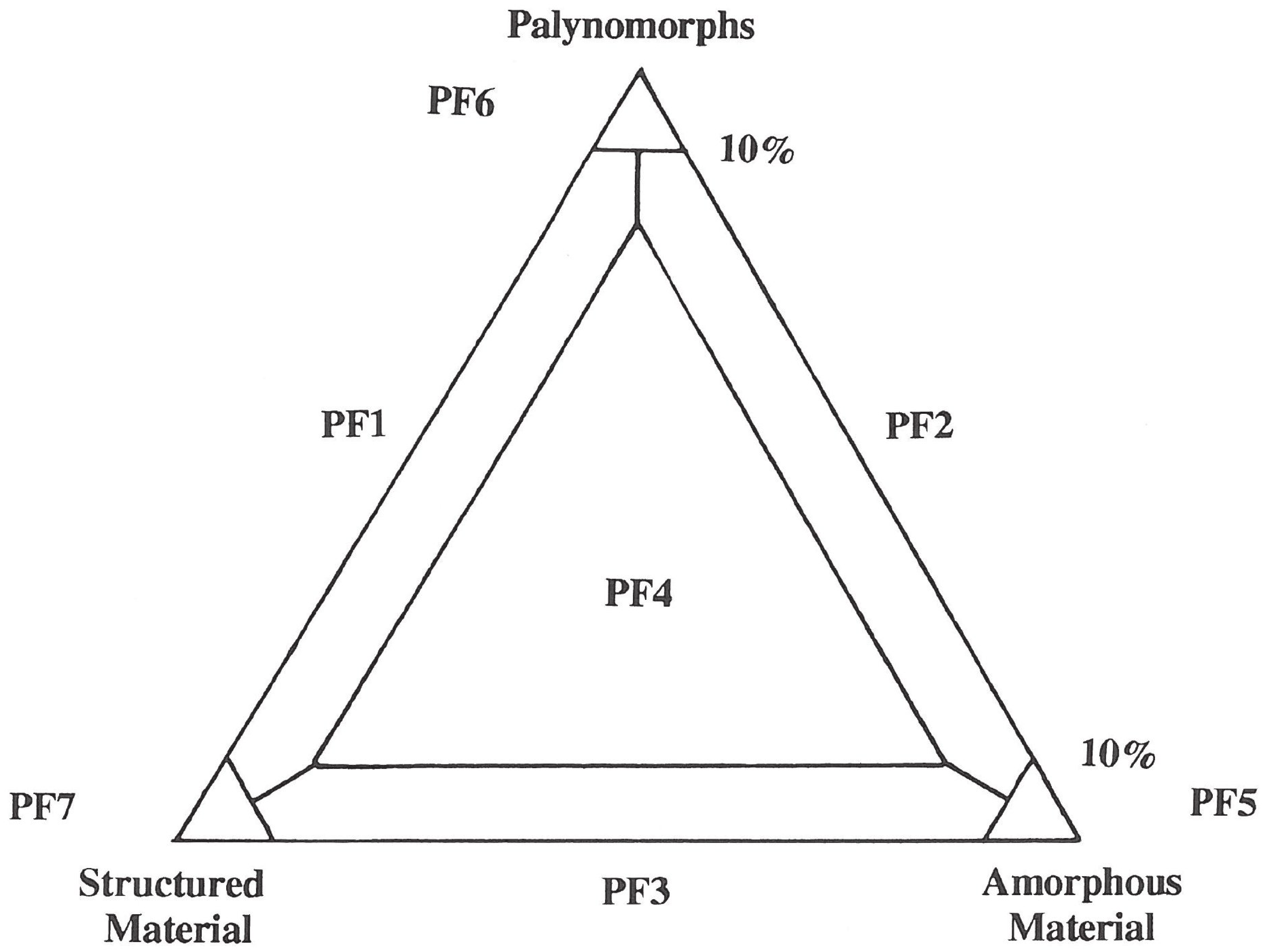

Fig. 1: Palynofacies-Triangle: Ternary diagram representing the three major divisions of the Palynological Organic Matter and the resulting definition of palynofacies types.

cult to interpret afterwards. Thus, the diagram is limited in its graphical possibilities and should be thought of as a first model for further development rather than a final construction.

Nevertheless, the application for palaeoecological interpretations on Permian lacustrine sediments seemed successful (chapter 4). The interpretation and following comparison with sedimentological features (Micro-Organofacies) helped in the characterization of sedimentary environments by the palynofacies types (PF-Types; fig. 3). They are useful tools for the analysis of terrestrial environments. When firmly defined once, a comparison of environmental settings of marine and continental sediments may be possible in the future, e.g. for stratigraphical applications.

As a result of the previously shown studies and discussions, the three major divisons mentioned are combined into several main PF-Types according to their possible occurrence in the sediments. The distribution of components from the three major divisions in percent is studied. This is defined here as follows: Major components are represented with > 10–100 %, minor components form 0–10 % of the total organic matter (obtained from prepared slides). These main PF-Types may also be divided for further needs. The primary criterion for this more detailed definition is the distribution of common components of the 2nd or 3rd order division (here: pollen, "algae").

Palynofacies subtypes are erected, based on the analyses of samples from the Saar-Nahe Basin and so far only valid for this environment. Their definition is a combination between the three major divisions and the dominant components of the facies (tab. 3). As in various facies interpretations, the simplification provides the required transferability of the general facies types to other possible cases of study. The PF-Types are defined as follows:

Type PF1: Palynomorphs and structured material
Definition of PF1: Palynomorphs and structured material form the major components of the PF-Type with 90–10 % and 10–90 %. Amorphous material exists as a minor component (0–10 %).
PF1a: Pollen and spores form the major components.
PF1b: Pollen forms the major component.

Type PF2: Palynomorphs and amorphous material
Definition of PF2: Palynomorphs and amorphous material are the major components with 90–10 % and 10–90 %; structured material is if present a minor component (0–10 %).
PF2a: Palynomorphs and amorphous material are the major components.
PF2b: Pollen are the major palynomorphs.
PF2c: Spores are the major palynomorphs.
PF2d: "Algae" are the major palynomorphs.

Type PF3: Structured material and amorphous material
Definition of PF3: Structured and amorphous material form the major components with 90–10 % and 10–90 %; Palynomorphs are minor components (0–10 %).
PF3a: "Woody" remains are the major component of the structured material.
PF3b: Epidermis/cuticles are the major components of the structured material.
PF3c: Plant tissue is the major component of the structured material.

Type PF4: Palynomorphs, structured material and amorphous material
Definition of PF4: All three divisions, palynomorphs, structured and amorphous material are present as major components (10–90 %).
PF4a: All main divisions provide major components.
PF4b: Pollen are the major palynomorphs.
PF4c: Spores are the major palynomorphs.

Type PF5: Amorphous material
Definition of PF5: Amorphous material is the major component of the organic matter (90–100 %). If existing, other material forms a minor component with less than 10%.
PF5a: Homogenous and heterogenous amorphous material are the major components.
PF5b: Particles and heterogenous amorphous material are the major components.
PF5c: Heterogenous amorphous material is the major component.

Type PF6: Palynomorphs
Definition of PF6: Palynomorphs are the major components of the organic matter (90–100 %). Other material if present, does only exist as a minor component with less than 10 %.
PF6a: Pollen are the dominant palynomorphs.

Type PF7: Structured material
Definition of PF7: Solely structured material (90–100 %).
This theoretically possible facies type has not been found in the Saar-Nahe Basin yet and may not be accomplished in nature.

Tab. 3: Correlation between the stratigraphic succession of lakes in the Saar-Nahe Basin and the major PF-Types represented in the sediments.

				complete sedimentary succession						profundal lacustrine facies						
Stage	Formation/Group	Abbrev.	lake horizon	PF1	PF2	PF3	PF4	PF5	PF6	PF1	PF2	PF3	PF4	PF5	PF6	0
Saxonium	Nahe	N 2														–
	Gorup	N 1														–
	Thallichtenberg F.	T	Lake Boos		✔		✔				✔		✔			
	Oberkirchen F.	Ob														–
		L-O 10	Lake Humberg			✔	✔	✔						✔		
	Odernheim	L-O 9	Lake Kappeln		✔						✔					
	Formation	L-O 8	Lake Ruthweiler		✔						✔					
			Lake Odernheim		✔		✔							✔		
A		L-O 7	Lake Erdesbach													–
u		L-O 6	Lake Jeckenbach		✔						✔					
t			Lake Niederkirchen		✔						✔					
u			Lake Raumbach					✔			✔			✔		
n	Jeckenbach	L-O 5														–
i	Formation	L-O 4	Lake Breitenheim					✔						✔		
u			lower and upper Lake Ulmet		✔						✔					
m		L-O 3	Lake Meisenheim				✔						✔			
			Lake Grumbach		✔						✔					
			Lake Schorrenwald		✔			✔						✔		
			Lake Bauwald (WI E1)		✔						✔			✔		
		L-O 2	Lake Medard								✔					
	Lauterecken		Lake Wiesweiler													–
	Formation	L-O 1	Lake Odenbach											✔		
			Lake Roßbach				✔			✔	✔					
	Quirnbach	Q	Lake Hohenöllen						✔		✔					
	Formation		Lake Immetshausen				✔				✔		✔			
	Wahnwegen F.	W	Lake Nerzweiler					✔						✔		
	Altenglan	A	Lake Hirschfeld													–
	Formation		Lake Reckweilerhof				✔						✔			
	Remigiusberg F.	R	Lake Theisberg-Stegen													–
			Lake Godelhausen					✔						✔		
Stefanium	Breitenbach	BR	Lake Altenkirchen					✔						✔		
C	Formation		Lake Habach					✔						✔		
			L. Oberweiler-Tiefenbach				✔				✔					

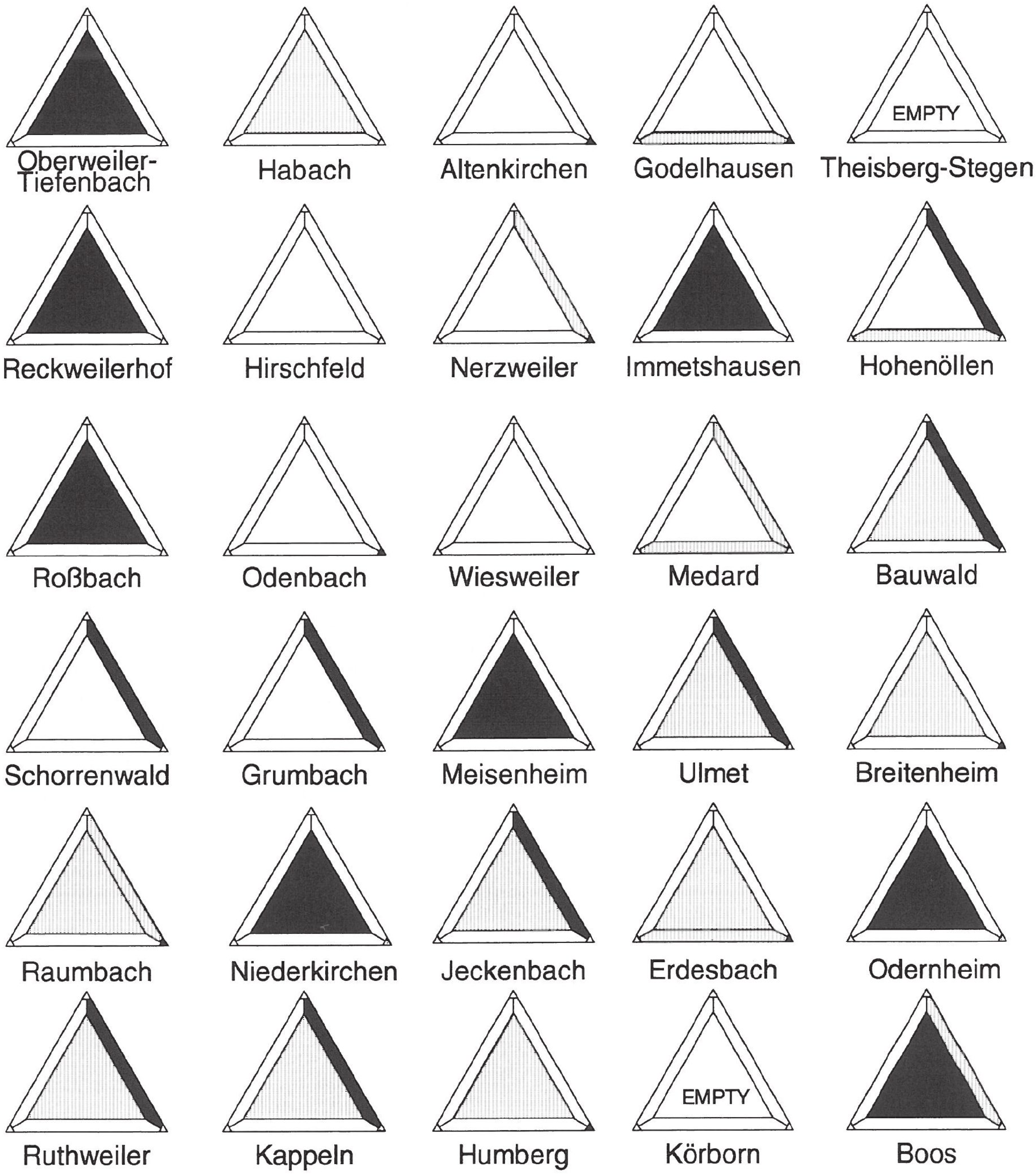

Fig. 2: Representation of the palynofacies in 30 different lake horizons of the Saar-Nahe Basin from analyses of the complete sedimentary successions. The areas of abundantly occuring PF-Types in the lake horizons are filled in black, less common PF-Types are dotted in this simplified diagrams.

4.2. Interpretation of the Palynofacies-Types

The bad preservation of the palynomorphs is interpreted as mainly degradation before sedimentation and diagenesis. The exposition of the palynomorphs before sedimentation led to a biologically and physically induced partial decomposition. This has been exemplarily shown by Fechner (1991, 1993) in palynological studies from Lakes Alsenz and Odernheim. The thermal heating of some sediments also resulted in postsedimentary changes or destruction of all organic remains (Theisberg-Stegen, Niederkirchen). The effects of diagenesis are not clearly identified yet. It is known that coalification is locally variable (JOSTEN 1956, TEICHMÜLLER et al. 1983) and one source of degradation. The Saar-Nahe Basin is characterised by its often bad fossilization of pollen and spores in comparison to other basins.

The components of the POM which were found, point to a correlation of PF-Types to the environment. Partially more or less fluent transitions between facies types exist, which was also recognized in the microfacies (CLAUSING 1990). Nevertheless a preliminary differentiation of lake types by palynofacies analysis is possible.

As depicted in figure 2, the significance of the PF-Analyses based on the frequency of PF-Types present leads to PF-Triangles for every single lake. All lakes are characterized by their typical POM-distribution, respectively by their PF-Types. Similar lakes provide similar or identical patterns of PF-distribution.

Besides that, a differentiation can be observed between the analysis of the whole lake succession and the strictly pelagial facies. Primarily, the lacustrine successions with the surrounding sediments were examined as a whole to provide a distributionary pattern. Additionally, the fossiliferous horizons themselves, which generally represent the pelagial facies of the lakes, were analysed separately to show their characteristic features.

An analysis of the palynofacies distribution in the complete sedimentary successions was done, where only the most abundant PF-Types present were listed (compare tab. 3). This led to a generalized model that combines the sedimentological interpretation of the whole sequence with the PF-Types:
PF1 did not occur. PF2 characterises flat, often carbonaceous lakes of medium to large lateral size. PF3 is only present in the sedimentary succession incorporating the large Lake Humberg. PF4 is typical for deep, medium to large lakes which are laterally widespread. PF5 occurs in deltatop-, oxbow-lakes and in the Humberg lake. PF6 was only found in Hohenöllen lake and is probably dominant in the facies of a rise. In all cases, the PF-Types characterise the environment in which the lake had developed. This can be compared to sedimentary sequences of other lakes.

A different pattern in the distribution of the PF-Types is achieved, when solely the pelagial sediments were examined (tab. 3):
The PF-Types 2 and 5 are the most abundant ones, PF-Type 4 is less often represented, PF-Type 1 is rare and the PF-Types 3 and 6 were not found at all. This means, that the main lake phases are most often characterised by the presence of amorphous matter or a combination between amourphous matter and palynomorphs. In the few samples where structured material occurs, it is clearly underrepresented. In this way, the PF-Types represent conditions of the environment which are special for the main lake phases.

A schematic distribution of PF-Types in the Saar-Nahe Basin in correlation to the assumed environment is given graphically (fig. 3). It is based on the sedimentary evidence and current results from various analyses (BOY et al. 1993) and will certainly become more detailed with additional studies.

The Type PF1 is dominated by palynomorphs and structured material. It is significant for an environment where primary producers are seldom present or cannot be sedimentated. In the possibly fluvial environment the currents were obviously too strong to allow sedimentation of planktic organisms or amorphous matter. The occurence in the Saar-Nahe Basin is rare.

Type PF2 with palynomorphs and amorphous material is widely distributed. It is typical for the pelagial of very large and medium lakes (Odernheim, Jeckenbach) and for lakes of the delta plain (Schorrenwald, Grumbach). Differences in the palynomorphs are caused by the variable marginal zone of lakes (discussion in CLAUSING et al. 1992).

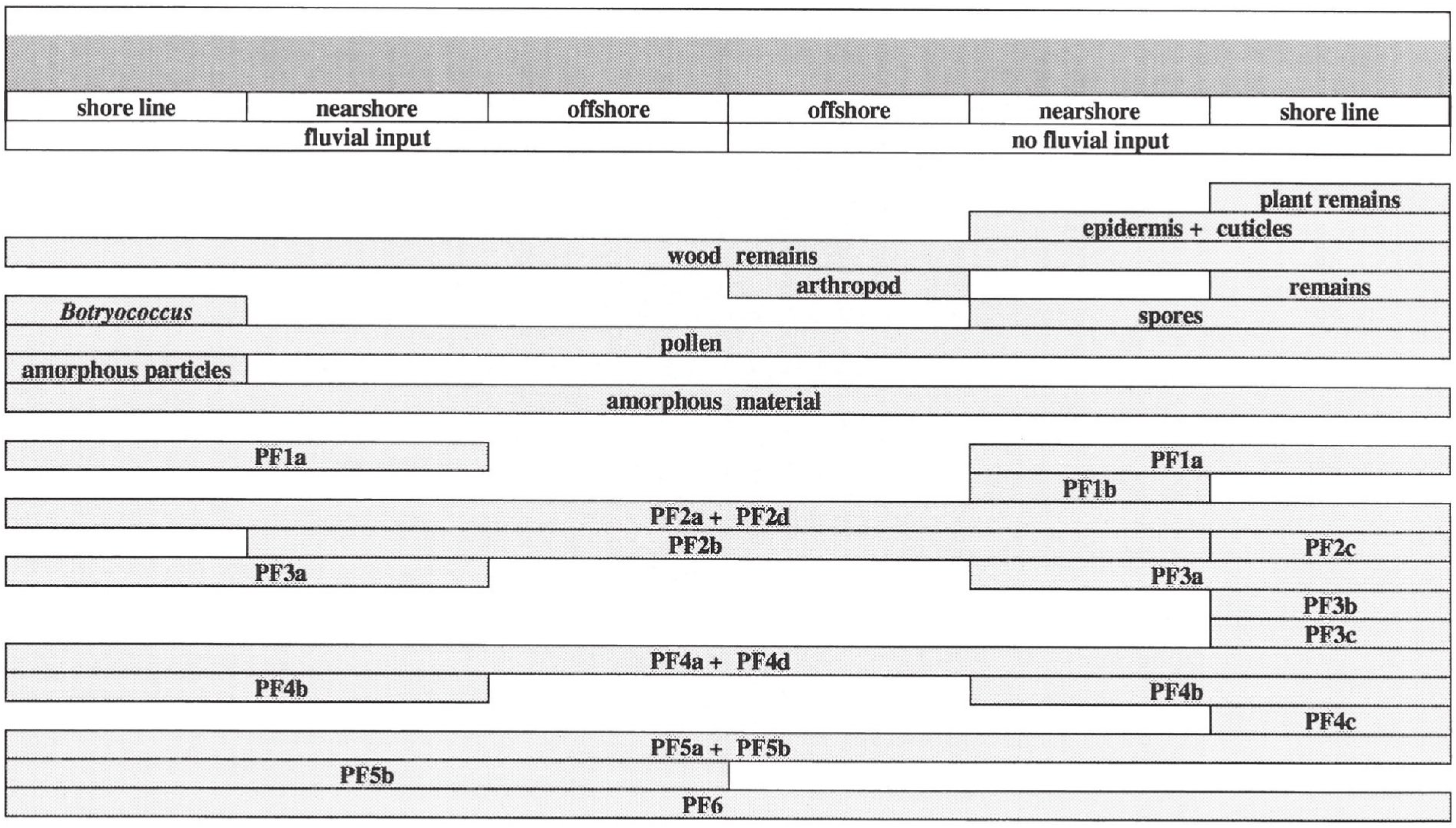

Fig. 3: Possible relations between the distribution of major Palynological Organic Matter divisions and the environment according to the analysis of 30 lake horizons in the Saar-Nahe Basin.

PF3 documents structured and amorphous material as major components. This special composition seems to be typical for the marginal area of very small lakes (Altenkirchen). It also occurs in the open pelagial areas of medium lakes (Medard, Odenbach).

In PF4, all the three major components are present. The environments characterized are medium to large lakes (Reckweilerhof, Meisenheim). They show an abundance of nutrients by allochthonous input and a highly diverse microfacies. This palynofacies is also typical for small lakes, which are rich in organic remains from the nearby shoreline (Habach, Altenkirchen).

Palynofacies Type PF5 with a majority of amorphous material is rarely documented. Only lakes with a very high organic content are representative environments. Most often they are extremely small (Habach, Altenkirchen) or show high internal subdivision of the lithofacies (Odenbach).

The current state of research does not reveal a very detailed view on the relations between the environment and the palynofacies yet. Further investigations will provide additional data on the palaeoenvironmental circumstances of the lakes studied, probably with a more quantitative aspect. Detailed observations will be collected in further monographic studies of single lake horizons. So far, the results presented are only proved valid for the sediments of the Saar-Nahe Basin.

5. General Conclusions

Some general conclusions are summarized in the following. Up to date, there is no completely satisfying classification internationally agreed upon (comp. Tyson 1995). The different working directions can most often be recognized by their terminology. Description, determination or interpretation of components are not, but are often used as if they were identical. Attempts on classifications are seldom transferable from one example to another or not at all. This means, that differences between geological ages are not or not sufficiently included. If interpretation follows determination after a description of components, then a lot of classificational problems could become obsolete. Preservation must be an additional feature for environmental interpretations, but should never be a major category of a classification.

An application of palynofacies analyses, as proposed in this article, proved to be a valuable addition to determine the development of fossil lake environments. Combined with microfacies and coal petrology studies, data for palaeoecological reconstructions are provided (Clausing 1993a, Clausing et al. 1993). The 30 lake horizons studied are from various stratigraphic positions from the Stefanium C to the Autunium. This allowed to incorporate the relative succession of lake types into the study and to compare their possible development through time. One result is, that palyno-stratigraphy is possible, but the distribution of pollen and spores is notably influenced by the original environment and preservation in general.

The formed palynofacies types are used to compare lake horizons throughout the Saar-Nahe Basin and may be also used to compare them to other areas. A biostratigraphical application of the palynofacies is impossible, because the analyses documented a direct correlation to environmental factors and preservation and not to time.

In contrast to the generalization by Pocock et al. (1987-1988), figured again by Boulter (1994, fig. 11.2), freshwater lakes are obviously much more complex in their palynofacies composition. The amorphous matter is an important feature for the interpretation of the lake palaeoenvironment, respectively their primary production, though difficult to decipher. Thus far this is one first attempt to deal with that problem and show some possibilities for environmental reconstructions incorporating PF-Analyses.

References

ALPERN, B. (1970): Classification pétrographique des constituants organiques fossiles des roches sédimentaires. – Rev. Inst. Francais du Petrole, **25** (11) , S. 1233–1267, 2 Abb., 6 Tab., 7 Taf., Paris.

– (1980): Pétrographie de kerogene. – In: DURAND, B. [ed.]: Kerogen. S. 339–383, 6 Abb., 3 Tab., 6 Taf., (Technip.) Paris.

ALPERN, B., DURAND, B., ESPITALIE, J. & TISSOT, B. (1972): Localisation et classification pétrographique des substances organiques sédimentaires fossiles. – Adv. in organic geochemistry, **1971**, S. 1–28, Oxford – Braunschweig.

BARTHEL, M. (1962): Zur Kenntnis inkohlter Blätter der Gattung *Cordaites* PRESL. – Hall. Jb. mitteldt. Erdgesch., **4**, S. 37–39, 4 Abb., 1 Tab., Taf. 7–9, Berlin.

– (mit Beiträgen von GÖTZERT, V. & URBAN, G.) (1976): Die Rotliegendflora Sachsens. – Abh. staatl. Mus. Mineral. Geol., **24**, 190 S., 19 Abb., 48 Taf., (T. Steinkopff) Dresden.

– (1982): Die Pflanzenwelt. – In: HAUBOLD, H. & BARTHEL, M. & KATZUNG, G. & SCHNEIDER, J. & WALTER, H. [eds.]: Die Lebewelt des Rotliegenden. Neue Brehm Bücherei, **154**, S. 63–131, Abb. 35–79, (Ziemsen) Wittenberg.

BATTEN, D. J. (1973): Use of palynologic assemblage-types in Wealden correlation. – Palaeontology, **16** (1), S. 1–40, London.

– (1980): Use of transmitted light microscopy of sedimentary organic matter for evaluation of hydrocarbon source potential. – Proc. IV. int. palynol. conf. Lucknov (**1976–77**), 2, S. 589–594, Lucknov.

– (1982a): Palynofacies, palaeoenvironments and petroleum. – J. Micropalaeont., **1**, S. 107–114, 1 Abb., 2 Taf., London.

– (1982b): Palynofacies and salinity in the Purbeck and Wealden of southern England. – In: BANNER, F. T. & LORD, A. R. [eds.]: Aspects of Micropalaeontology. S. 278–295, 3 Abb., 13 Taf., (Allen & Unwin) London.

– (1983): Identification of amorphous sedimentary organic matter by transmitted light microscopy. – In: BROOKS, J. [ed.]: Petroleum geochemistry and exploration of Europe. Spec. Publ. Geol. Soc. London, **12**, S. 275–287, 27 Abb., Oxford-London.

BATTEN, D. J. & CREBER, G. T. & ZHOU ZHIYAN (1984): Fossil plants and other organic debris in cretaceous sediments from deep sea drilling project LEG 80: their paleoenvironmental significance and source potential. – In: GRACIANSKY, P. C. de, et al. [eds.]: Initial reports of the DSDP. **80** (1), S. 629–641, 5 Abb., 1 Tab., 7 Taf., Washington.

BERGEN VAN, P. F. & JANSSEN, N. M. M., ALFERINK, M. & KERP,J. H. F. (1990): Recognition of organic matter types in standard palynological slides. – In: FERMONT, W. J. J. & WEEGINK, J. W. [eds.]: Proceedings Int. Symp. on organic petrology, Zeist – The Netherlands January 7–9, 1990. Meded. Rijks Geol. Dienst, **45**, S. 9–21, 3 Taf., Heerlen.

BHARDWAJ, D. C. & VENKATACHALA, B. S. (1958): Microfloristic evidence between the Carboniferous and the Permian systems in Pfalz (W.Germany). – The Palaeobotanist, **6** (1), S. 1–11, 5 Tab., 2 Taf., Lucknow.

BOULTER, M. C. (1994): An approach to a standard terminology for palynodebris. – In: TRAVERSE, A. [ed.]: Sedimentation of organic particles, S. 199–216, 12 Abb., 1 Tab., Cambridge.

BOULTER, M. C. & RIDDICK, A. (1986): Classification and analysis of palynodebris from the Palaeocene sediments of the Forties Field. – Sedimentology, **33** (6), S. 871–886, 24 Abb., 6 Tab., Oxford.

BOY, J. A. (1994): Seen der Rotliegend-Zeit – Ein Lebensraum vor rund 300 Millionen Jahren in der Pfalz. – In: KOENIGSWALD, W. v. & MEYER, W. [eds.]: Erdgeschichte im Rheinland – Fossilien und Gesteine aus 400 Millionen Jahren. Erdgeschichte mitteleuropäi-

scher Regionen, **1**, S. 107–116, 8 Abb., (Pfeil) München.
BOY, J. A. & CLAUSING, A. & SCHINDLER, T. & SCHMIDT, D. (1993): Durchführung und Auswertung geowissenschaftlicher Grabungen im lakustrinen Rotliegend des Saar-Nahe-Beckens (Permokarbon; SW-Deutschland). – Mainzer geowiss. Mitt., **22**, S. 211–226, 1 Abb., Mainz.
BOY, J. A. & FICHTER, J. (1982): Zur Stratigraphie des saarpfälzischen Rotliegenden (? Ober-Karbon – Unter-Perm; SW-Deutschland). – Z. deutsch. geol. Ges., **133**, S. 607–642, 7 Abb., Hannover.
BOY, J. A. & MECKERT, D. & SCHINDLER, T. (1990): Probleme der lithostratigraphischen Gliederung im unteren Rotliegend des Saar-Nahe-Beckens (?Ober-Karbon – Unter-Perm; SW-Deutschland). – Mainzer geowiss. Mitt., **19**, S. 99–118, 2 Abb., Mainz.
BUSCHE, R. (1966): Vorläufige Mitteilung über einige disperse Kutikulen aus den Kuseler Schichten. – Arg. Palaeobot., **1**, S. 159–164, 1 Abb., 1 Taf., Lehre.
– (1968): Als Laubmoosreste gedeutete Pflanzenfossilien aus den Lebacher Schichten (Autunien) von St. Wendel, Saar. – Arg. Palaeobot., **2**, S. 1–14, 1 Abb., 2 Taf., Münster.
BUSCHE, R. & HASS, H. & REMY, W. (1978): Möglichkeiten und Grenzen der Deutung von Ökologie und Klima mit Hilfe disperser Kutikulen aus dem Autun des Nahe-Raumes (Pfalz). – Arg. Palaeobot., **5**, S. 149–160, 1 Abb., 3 Tab., Münster.
BUSTIN, R. M. & CAMERON, A. R. & GRIEVE, D. A. & KALKREUTH, W. D. (1983): Coal petrology – Its principles, methods, and applications. – 2nd ed., Geol. Ass. Canada Short Course Notes, **3**, 230 S., 127 Abb., 40 Tab., 18 Taf., Ottawa.
CLAUSING, A. (1989): Verbreitung und lithologische Charakterisierung lakustriner Karbonathorizonte in den Lauterecken-Schichten des Saar-Nahe-Beckens (Rotliegend; SW-Deutschland). – Mainzer geowiss. Mitt., **18**, S. 125–156, 18 Abb., 2 Tab., Mainz.
– (1990): Mikrofazies lakustriner Karbonathorizonte des Saar-Nahe-Beckens (Unter-Perm, Rotliegend; SW-Deutschland). – Facies, **23**, S. 121–140, 14 Abb., 1 Tab., Taf. 16–18, Erlangen.
– (1992): Fluorescence microscopy of lake sediments from the Saar-Nahe Basin (Upper Carboniferous – Lower Permian; SW-Germany). Leica scientific and technical information, **10** (3), S. 72–79, 3 fig., 3 pl., Wetzlar. [Corrigenda: **10** (5), S. 188, June 1993].
– (1993a): Mikro-Organofazies lakustriner Horizonte im saarpfälzischen Rotliegend (Permokarbon; SW-Deutschland). – In: DABER, R. & RÜFFLE, L. & WENDT, P. B. [eds.]: Pflanzen der geologischen Vergangenheit, Festschrift Prof. Wilfried Krutzsch S. 61–72, 3 Abb., Berlin.
– (1993b): Eine Bestandsaufnahme der Süßwasser-Algenflora des mitteleuropäischen Permokarbon. – In: DABER, R. & RÜFFLE, L. & WENDT, P. B. [eds.]: Pflanzen der geologischen Vergangenheit, Festschrift Prof. Wilfried Krutzsch S. 73–83, 1 Abb., 1 Tab., Berlin.
– (1995): Some critical notes on qualitative versus quantitative analysis in terrestrial palaeoecology. – Berliner geowiss. Abh., **E 16**, S. 781–785, 1 Abb., 2 Tab., Berlin.
CLAUSING, A. & SCHMIDT, D. & SCHINDLER, T. (1992): Sedimentation und Paläoökologie unterpermischer Seen in Mitteleuropa. 1. Meisenheim-See (Rotliegend; Saar-Nahe-Becken). – Mainzer geowiss. Mitt., **21**, S. 159–198, 15 Abb., Mainz.
COMBAZ, A. (1964): Les palynofacies. – Revue de Micropal., **7**, S. 205–218, 1 Abb., 4 Taf., Paris.
– (1971): Thermal degradation of sporopollenin & genesis of hydrocarbons. – In: BROOKS, J. et al. [eds.]: Sporopollenin S. 621–653, 13 Abb., 11 Tab., (Academic Press) London, New York.
– (1980): Les kérogènes vus au microscope. – In: DURAND, B. [ed.]: Kerogen S. 55–111, 8 Abb., 10 Taf., (Technip) Paris.

DURAND, B. (1980): Sedimentary organic matter and Kerogen. Definition and quantitative importance of Kerogen. – In: DURAND, B. [ed.]: Kerogen S. 13–34, 3 Abb., 2 Tab., (Technip) Paris.

– (1987): Du kerogene au pétrole et au charbon: les voies et les mechanismes des transformations de matières organiques sédimentaires au cours de l'enfounissement. – Mem. Soc. geol. France, N. S., **151**, S. 77–95, 15 Abb., Paris.

DURAND, B. & ESPITALIE, J. (1970): Analyse géochemique de la matière organique extraite desroches sédimentaires: II. Extraction et analyse quantitative des hydrocarbures de la fraction C01 -C015 et de gaz permanents. – Rev. Inst. Français du Petrole, **25** (6), S. 741–751, 6 Abb., 2 Tab., Paris.

ENGEL, H. (1986): Palynologie stefanischer Flöze des Saarlandes und der Übergang vom Karbon zum Perm. – Cour. Forsch.-Inst. Senckenberg, **86**, S. 113–124, 5 Abb., Frankfurt/Main.

FALKE, H. (1954): Leithorizonte, Leitfolgen und Leitgruppen im pfälzischen Unterrotliegenden. – N. Jb. Geol. Paläont., Abh., **99**, S. 298–354, 2 Abb., 2 Tab., 1 Profil, Stuttgart.

FALKE, H. & KNEUPER, G. (1972): Das Karbon in limnischer Entwicklung. – 7. Congr. Int. Strat. Géol. Carbonifère Krefeld, C. R., **1**, S. 49–67, 20 Abb., Krefeld.

FARR, K. M. (1989): Palynomorph and palynodebris distributions in modern British and Irish estuarine sediments. – In: BATTEN, D. J. & KEEN, M. C. [eds.]: Northwest European micropalaeontology and palynology. Brit. Micropal. Soc. Ser., S. 265–285, 4 Abb., 1 Tab., 1 Taf., (Ellis Horwood) Chichester.

FECHNER, G. G. (1991): Palynologisch-biometrische Untersuchungen an Gymnospermendominierten Mikrofloren des Unterrotliegenden bei Alsenz (Saar-Nahe Becken, Deutschland). – Berliner geowiss. Abh., **A134**, S. 57–71, 2 Abb., 2 Taf., Berlin.

– (1993): Palynologische Untersuchungen in limnischen Ablagerungen des Unterrotliegenden bei Odernheim (Saar-Nahe-Becken, Deutschland). – Berliner Geowiss. Abh., **E9**, S. 57–71, 4 Abb., 3 Taf., Berlin.

GAUPP, R. & BATTEN, D. J. (1985): Maturation of organic matter in Cretacous strata of the Northern Calcareous Alps. – N. Jb. Geol. Paläont., Mh., **1985** (3), S. 157–175, 3 figs., 3 tabs., Stuttgart.

GEHMANN, H. M. jr (1962): Organic matter in limestones. – Geochim. Cosmochim. Acta, **26**, S. 885–897, 9 Abb., 1 Tab., Oxford-London.

HART, G. F. (1986): Origin and classification of organic matter in clastic systems. – Palynology, **10**, S. 1–23, 10 Abb., 3 Tab., Dallas/Texas.

HART, G. F. (1994): Maceral palynofacies of the Louisiana deltaic plain in terms of organic constituents and hydrocarbon potential. – In: TRAVERSE, A. [ed.]: Sedimentation of organic particles S. 141–176, 18 Abb., 13 Tab., (Univ. Press) Cambridge.

HELBY, R. (1966): Sporologische Untersuchungen an der Karbon/Perm-Grenze im Pfälzer Bergland. – Fortschr. Geol. Rheinld. Westf., **13** (1), S. 645–704, 6 Abb., 10 Taf., Krefeld.

HENK, A. (1993): Subsidenz und Tektonik des Saar-Nahe-Beckens (SW-Deutschland). – Geol. Rdsch., **82** (1), S. 3–19, 10 Abb., Berlin.

HOCHULI, P. A. (1985): Palynostratigraphische Gliederung und Korrelation des Permo-Karbon der Nordostschweiz. – Eclogae geol. Helv., **78** (3), S. 719–831, 14 Abb., 2 Tab., 12 Taf., Basel.

JOSTEN, K. H. (1956): Die Kohlen im Pfälzer Bergland. – Notizbl. hess. Landesamt Bodenforsch., **84**, S. 300–327, 10 Abb., 6 Tab., 3 Taf., Wiesbaden.

KERP, H. (1990): The study of fossil gymnosperms by means of cuticular analysis. – Palaios, **5**, S. 548–569, 5 Abb., Tulsa/Okla.

Lorente, M. A. (1986): Palynology and palynofacies of the Upper Tertiary in Venezuela. – Dissert. Botanicae, **99**, IX + 225 S., 43 Abb., 16 Tab., 27 Taf., 33 Diagr., (Cramer – Schweizerbart) Berlin – Stuttgart.

– (1990): Textural characteristics of organic matter in several subenvironments of Orinoco Upper delta. – Geol. en Mijnbouw, **69** (3), S. 263–278, 2 Abb., 2 Tab., Dordrecht.

Lorente, M. A. & Ran, E. T. H. [eds.] (1991): Open workshop on Organic Matter Classification, Amsterdam, June 27–28, 1991. – 73 S., (Hugo de Vries-Lab.) Amsterdam.

Nohr-Hansen, H. (1989): Visual and chemical kerogen analyses of Lower Kimmeridge Clay, Wetbury, England. – In: Batten, D. J. & Keen, M. C. [eds.]: Northwest European micropalaeontology and palynology. Brit. Micropal. Soc. Ser., S. 118–134, 8 Abb., 1 Taf., (Ellis Horwood) Chichester.

Pocock, S. A. J. & Vasanthy, G. & Venkatachala, B. S. (1987–1988): Introduction to the study of particulate organic materials and ecological perspectives. – J. Palynol., **23–24**, S. 167–188, Lucknow.

Reimann, K. K. (1975): Palynologisch-stratigraphische Untersuchungen an der Wende Karbon/Perm in der Saar-Nahe-Senke. – 7. Congr. int. stratigr. géol. Carbonifère Krefeld, C. R., **4**, S. 161–168, 6 Abb., Krefeld.

Robert, P. (1979): Classification des matières organiques en fluorescence. Application aux roches-mères pétrolières. – Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine, **3** (1), S. 223–263, 5 Abb., 2 Tab., 6 Taf., Pau.

Schäfer, A. (1986): Die Sedimente des Oberkarbons und Unterrotliegenden im Saar-Nahe-Becken. - Mainzer geowiss. Mitt., **15**, S. 239–365, 63 Abb., 1 Tab., 29 Prof., Mainz.

Schäfer, A. & Rast, U. (1976): Sedimentation im Rotliegenden des Saar-Nahe-Beckens. – Natur und Museum, **106** (11), S. 330–338, 6 Abb., Frankfurt/a. M.

Sigal, J. (1965): Palynofaciès: un néologisme illogique et superflu. – Rev. Micropal., **8** (1), S. 59–60, Paris.

Stapf, K. R. G. (1990): Einführung lithostratigraphischer Formationsnamen im Rotliegend des Saar-Nahe-Beckens (SW-Deutschland). – Mitt. Pollichia, **77**, S. 111–124, 2 Abb., Bad Dürkheim.

Stollhofen, H. & Stanistreet, I. G. (1994): Interaction between bimodal volcanism, fluvial sedimentation and basin development in the Permo-Carboniferous Saar-Nahe Basin (south-west Germany). – Basin Res., **6** (4), S. 245–267, 11 Abb., 1 Tab., Oxford.

Struckmeyer, H. I. M. & Felton, E. A. (1990): The use of organic facies for refining palaeoenvironmental interpretations: a case study from the Otway Basin, Australia. – Austral. J. Earth Sci., **37**, S. 351–364, 15 Abb., 3 Tab., Melbourne.

Teichmüller, M. & Teichmüller, R. & Lorenz, V. (1983): Inkohlung & Inkohlungsgradienten im Permokarbon der Saar-Nahe-Senke. – Z. deutsch. geol. Ges., **134**, S. 153–210, 13 Abb., 8 Tab., Hannover.

Traverse, A. [ed.] (1994): Sedimentation of organic particles. – 544 S., 255 Abb., 70 Tab., (Univ. Press) Cambridge.

Tyson, R. V. (1989): Late Jurassic palynofacies trends, Piper and Kimmeridge Clay Formations, UK onshore and Northern North Sea. – In: Batten, D. J. & Keen, M. C. [eds.]: Northwest European micropalaeontology and palynology. Brit. Micropal. Soc. Ser., S. 135–172, 15 Abb., 7 Tab., (Ellis Horwood) Chichester.

– (1993): Palynofacies analysis. – In: Jenkins, D. G. [ed.]: Applied Micropalaeontology S. 153–191, 5 Abb., 4 Tab., (Kluwer) Dordrecht.

– (1995): Sedimentary organic matter, organic facies and palynofacies. 615 S., 196 Abb., 50 Tab., 6 Taf., (Chapman & Hall) London.

VISSCHER, H. & HUDDLESTON SLATER-OFFERHAUS, M. G. & WONG, T. E. (1974): Palynological assemblages from "Saxonian" deposits of the Saar-Nahe Basin (Germany) and the Dome de Barrot (France) – an approach to chronostratigraphy. – Rev. Palaeobot. Palynol., **17**, S. 39–56, 3 Tab., 7 Taf., Amsterdam.

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