PALYNOFACIES RESPONSE TO DEPOSITION OF ORGANIC PARTICLES UNDER FLOW CONDITIONS

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Abstract. Palynofacies and its capability to disclose aspects of sedimentation of organic particles are undertaken. The study briefly approaches: (1) the necessary procedure of laboratory stage and microscopy to distinguish and separate distinctive categories of organic particles in terms of flow regime and standing water bodies plus some theoretical matters of deposition - hydrodynamics relationship and (2) an analysis of the main cases that were met with in fluvial systems with regards to particular sites where accumulation of organic fraction takes place. Sedimentation out of suspension inside adjacent pools and ponds occurring in the floodplain is also considered. The basic parameters which support this study are the *Kerogen Sedimentation Index* (KSI) and *Fragmentation Index* (FI) (Demetrescu, 1995). It is described a new mode of estimating the relative participation which different dimensional classes may have in a given micro-organic spectrum and it is proposed a new palynofacies parameter, the *Sifting Effect* (SE). Examples are given in which both modern and ancient sediments laid down in fluvial depositional systems of Romania are analysed with reference to certain sub-environments and specific sedimentary processes. Palynofacies types which define diverse fluvial habitats and products are illustrated and diagnoses to identify fluvial settings and deposits from specific values which the employed parameters may offer are presented.

Key words: Palynofacies. Fluvial processes. Sifting Effect (*new*). Modern/ancient deposits. Romania.

INTRODUCTION

Palynofacies research has advanced rapidly in the last decade. It has been extensively approached in the foregoing studies many of which having an outstanding importance (e.g. Combaz, 1964; Hughes and Moody-Stuart, 1967; Batten, 1972 and many others).

In this study we propose a different definition in respect with the subject approached: the microscopic reflection which exhibits the most peculiar attributes of any assemblage of organic particles collected from a sedimentary deposit, level, or structure. Inside any of these the respective assemblage may consist of distinctive micro-elements and may occupy a particular position as a consequence of three major controls: (1) the specificity of depositional system, (2) the typology of sedimentary particles other than of organic origin plus the way the sediments have been formed and (3) the particularities of organic input inside the accumulation site and the type of processes this fraction went through. The characteristic palynofacies of any micro-organic assemblage will disclose them all.

When looking into the microscopic eye-piece and see the sundry frameworks palyno-facies may display one can make out a suite of images and have at one end a picture suggesting subaerial exposure and oxidation and at the other end one reflecting a process of clogging or its sedimentary product which may be a lag deposit. Most of the remaining train of its various types fall somewhere between these two extremes. Consequently, reliance should never be placed solely on the appearance of a given palynofacies unless it bears a very distinctive feature and encompasses organic micro-elements typical of a certain depositional setting or indicating a specific sedimentary process.

Since the investigation of transport and deposition of organic particles under flow regime specifically basis on two palynofacies parameters: the Fragmentation Index (FI) and the Sifting Effect (SE), - the latter being introduced in this study as a new tool in palynofacies analysis - one have to follow previously a preliminary laboratory measuring of the organic residuum. The respective procedure gives us the proportion that this fraction bears to the sediment within which it is hosted, and is offered by the Kerogen Sedimentation Index (KSI).

In this study the term "kerogen" refers to the bulk of insoluble organic particles dispersed in sediments and analysed in terms of transmitted light techniques and related laboratory processing.

The mount of organic matter in sediments is a complex function governed by different factors out of which we shall resume to mention only the rate of clastics input that determines ultimately the degree of kerogen dilution or, in other words, the variance of kerogen participation versus a given volume of sediment.

An attempt to quantify this participation and establish a convenient parameter to characterize it as well as an application to unidirectional currents have already been made in some earlier studies

(Demetrescu, 1995, 1997). The then denomination has been Palyno-Sedimentation Index still "palyno" seemed rather restrictive and kerogen has been preferred instead for it includes a much larger category of organic assemblage types.

Classifications of organic fraction have been approached in many ways and for many purposes (Staplin, 1969; Burgess, 1974; Manskaya et al., 1976; Durand, 1980; Combaz, 1980; Brooks, 1981; Masran and Pocock, 1981; Parry et al., 1981; Tissot and Welte, 1984; Boulter and Riddick, 1986; Hart, 1986; Van Waveren and Visscher, 1994; Tyson, 1995), yet none responds adequately to our needs in terms of dimensional criterion that should be adopted in respect with the considered theme.

The fact that the quantity of kerogen varies with that of sediment which includes it hardly allowed us to set up a standard scale. It is this the main reason which has determined us to undertake further experiments and try to establish as reliable a set of values as possible. In this light, the former percentage scale (Demetrescu, 1995) has utterly been revised and its values have been re-evaluated. Notably, the problem of which should be the volume of analysed material has arisen some questions since it should cover the spectrum of organic-prone sediments built up in fluvial systems. Experiments have shown that a suitable quantity may be one large enough to yield organic material, if present, and easy to estimate as well. Such a quantity is that corresponding to a sediment column of 3 cm height if put in a Berzelius beaker of 1.5 l capacity; it equals 235 cm^3 (loose sediment saturated with water and then allowed to dry at some length to avoid significant change of the concentration of chemical reagents). It applies to clay, silty clay, silts and sandy clay (matrix supported). For in fluvial sedimentation clayey sands (grain supported sediments with reduced still variable clay content) may form thick deposits and analysis of such sediments may reveal significant aspects relative to the extent of kerogen dilution, they have also been taken into consideration

The degree of fragmentation which all organic particles are subjected to during transport, deposition and subsequent re-distribution, if any, in aqueous systems may have different meanings in different environments and may be the effect of either physical or biological causes. To analyse this effect and determine whatever factors have controlled it a convenient index has been established (ibid.) and successfully used to identify paleocurrents and their direction (Demetrescu, 1997). What we are concerned with here refers to its possible relationship with the Sifting Effect.

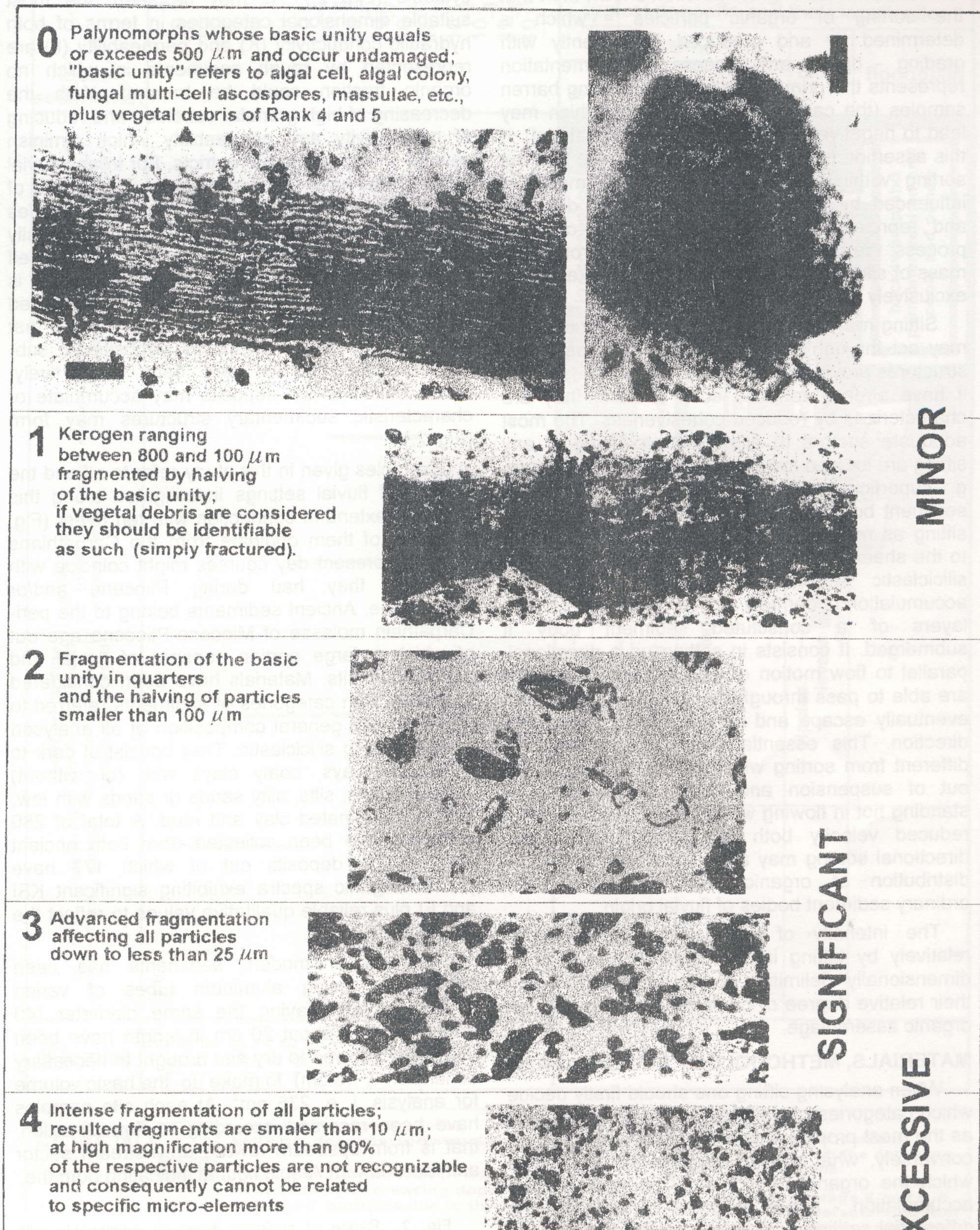
The intensity of fragmentation is a function of time residence during transport, the velocity of current and the physical properties plus variable resistance of any organic particle when in contact with clastics of higher hardness. For instance, if pellicular and planarly shaped they are more rapidly fragmented due to the action of sand grains; if smaller and denser they may show quite a different behaviour depending upon their outer wall morphology (whether ornamented or not), the degree of coating with clay and the way the contact with clastics produces.

Figure 1 illustrates some characteristic forms and their relationship with the intensity of fragmentation they might go through during transport and after settling in certain locations of a river channel or within certain deposits and structures originating in fluvial environment. As one can see the scale starts with "0", a situation very rarely met with in such a habitat. The non-fragmented state implies quiet waters where deposition produces out of suspension and the material is rapidly buried and covered with other sediments so that neither re-distribution nor bioturbation may take place. Such settings exclusively occur in the floodplain and are represented by backswamps and isolated pools and ponds or even plashy and puddly sites. Indices from 1 to 4 define the other stages of fragmentation corresponding to different intensities this process may be. Except the value 4, that was observed exclusively in beach sediments where the respective process reaches the highest intensity, the others usually characterize particles trapped in sundry depositional sites of both marine and continental environment. They are quite common in channel and bank deposits constituted under flow conditions, and also may reflect processes taking place in shallow standing water bodies.

Operating with these indices and experience have show that numerical values are not adequate since there is some difficulty in precisely estimating a particular stage of fragmentation. Consequently, three qualitative levels have been preferred instead the resulted correspondence being as follows: *minor*, (0, 1); *significant*, (2, 3); *excessive*, (4).

When discussing the state of organic residuum in palynological preparations relative to the possibility of extracting enough material and be able to avoid the producing of the so called "sterile" samples (Demetrescu, 1995), it has been pointed out that, irrespective to the depositional system, one of the most important factors which control the

Fig. 1 Degrees of fragmentation and the defining set of indices supporting the FI; scale bars: 150 µm; magnification order for FI = 0, 1, 4 x400; for FI = 2, 3 x63; specimens illustrated have been recovered from Upper Pliocene deposits of Motru-Jiu and Alunu Quarry (sites 3, 4) ⟶


0 Palynomorphs whose basic unity equals or exceeds 500 μm and occur undamaged; "basic unity" refers to algal cell, algal colony, fungal multi-cell ascospores, massulae, etc., plus vegetal debris of Rank 4 and 5
1 Kerogen ranging between 800 and 100 μm fragmented by halving of the basic unity; if vegetal debris are considered they should be identifiable as such (simply fractured).
2 Fragmentation of the basic unity in quarters and the halving of particles smaller than 100 μm
3 Advanced fragmentation affecting all particles down to less than 25 μm
4 Intense fragmentation of all particles; resulted fragments are smaler than 10 μm; at high magnification more than 90% of the respective particles are not recognizable and consequently cannot be related to specific micro-elements
MINOR
SIGNIFICANT
EXCESSIVE

kerogen distribution in sediments may be the mechanism of sorting. It has been shown then that the sorting of organic particles - which is determined by and produced concurrently with grading - during any process of sedimentation represents the primary cause in generating barren samples (the case of inverse grading which may lead to negative distribution of organic material). If this assertion is true then it is equally true that the sorting within loose, just settled, sediments is influenced by the current intensity and direction and represents the result of a more complex process: the sifting of organic particles through the mass of siliciclastic components which takes place exclusively under flow control.

Sifting may produce almost in all situations and may act through many sedimentary deposits and structures provided they are still unconsolidated or, if have already reached such a state, they are characterized by reduced cohesiveness. The most adequate sectors to allow the producing of any sifting are located toward the contact with water (e. g. superficial layers of the most submerged sediment bodies). In these terms one may define sifting as representing the process produced due to the shearing condition inside any body of loose siliciclastic sediment during its settling and accumulation under flow regime or through surficial layers of a constituted sediment body if submerged. It consists in setting up a directional, parallel to flow motion of smallest particles which are able to pass through the mass of clastics and eventually escape and be washed in the current direction. This essential characteristic makes it different from sorting which occurs during settling out of suspension and mostly takes place in standing not in flowing water bodies. Under flow of reduced velocity both sifting and subsequent, directional sorting may also occur and control the distribution of organic particles within many ordinary sediment bodies of fluvial origin.

The intensity of sifting may be assessed relatively by taking into consideration a suite of dimensionally delimited groups of particles and their relative degree of participation inside a given organic assemblage.

MATERIALS, METHODOLOGY AND DATABASE

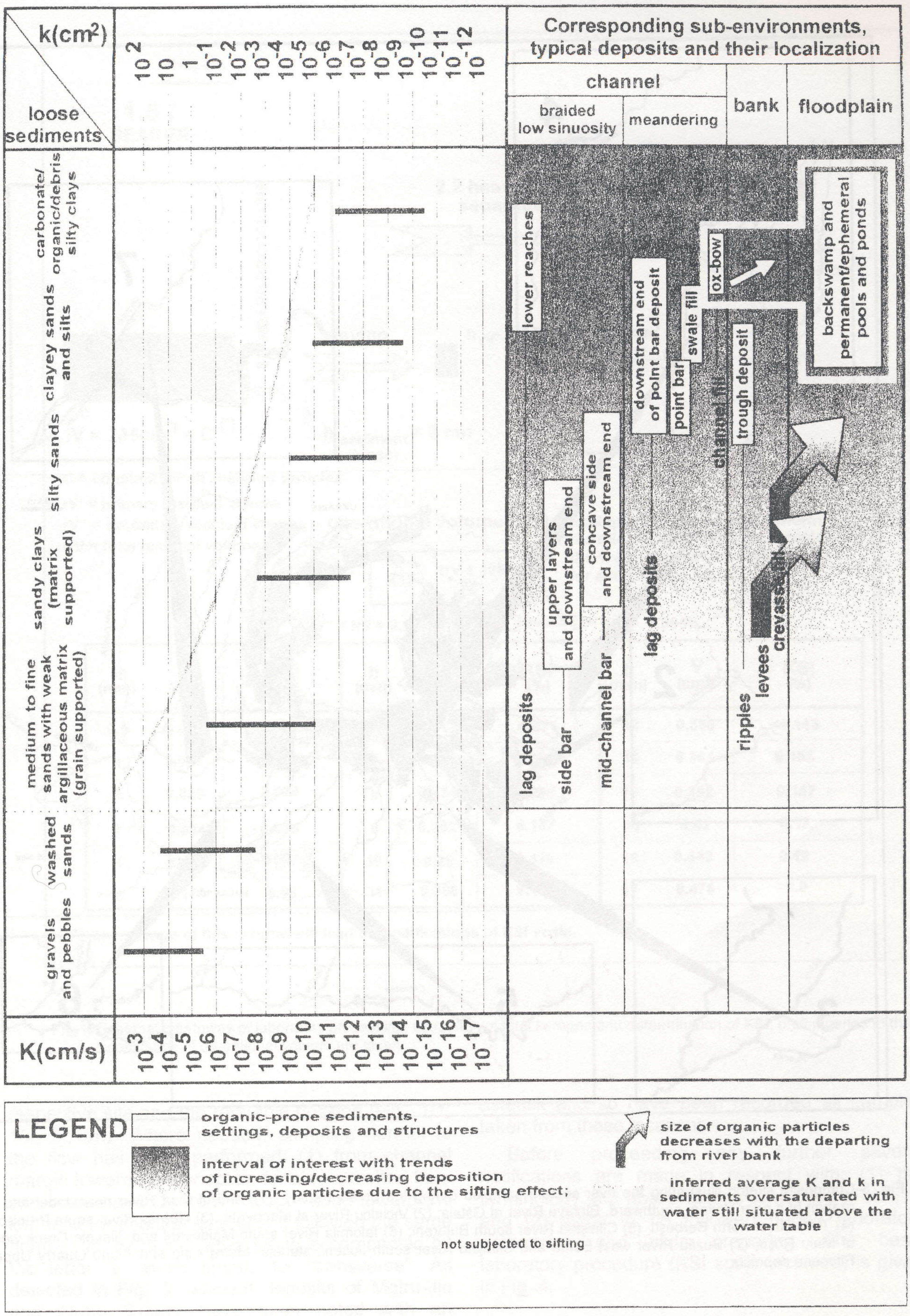
When analysing sifting one should firstly decide which categories of clastics have to be considered as the most propitious to allow its development or, conversely, what type of deposits are still left in which the organic fraction may be retained and accumulation - either chaotical or showing any differential settling under the effect of directionally induced sorting - may take place instead of washing away.

Davis (1969) and Freeze and Cherry (1979) offered us a set of values regarding the physical properties of different natural materials in aqueous systems (Fig. 2.). As may be seen, the most suitable dimensional categories in terms of both hydraulic conductivity (K) and permeability (k) are represented by rough sediments in which no organic fraction could be trapped. With the decreasing of high granular condition and reducing of conductivity and permeability which diminish several times, the range restricts. For in any fluvial system we have to deal with a large suit of sediments one have to eliminate all categories through which the organic particles are easily transported plus those where the flow itself slackens and becomes insignificant or it is completely impeded (e. g. highly compacted clays). Which leaves out four basic categories that largely occur in two distinctive depositional sub-environments: channel and bank respectively, inside which certain deposits may accumulate or characteristic sedimentary structures may form (Fig. 2.).

Examples given in this study refer to all and the sectors of fluvial settings investigated along this research extend in connection with ten rivers (Fig. 3.). Most of them originate from the Carpathians and their present day courses might coincide with directions they had during Pliocene and/or Pleistocene. Ancient sediments belong to the peri-Carpathian molasse of Miocene-Pliocene age out of which a large portion consists of fluvial and alluvial deposits. Materials have been considered in respect with categories of sediments referred to in Fig. 2., the general composition of all analysed samples being siliciclastic. They consist of dark to light grey clays, coaly clays with (or without) vegetal debris, silts, silty sands or sands with low, finely disseminated clay and mud. A total of 280 samples have been collected from both ancient and modern deposits out of which 177 have yielded organic spectra exhibiting significant KSI and FI plus reliable qualitative values to reflect the Sifting Effect.

Sampling of modern sediments has been carried out using aluminum tubes of varied dimensions still having the same diameter (40 mm). Cores of about 20 cm in length have been collected, allowed to dry and brought to necessary dimension (~18 cm) to make up the basic volume for analysis, i. e. 235 cm^3. At each site samples have been recorded according to flow direction, that is from upstream toward downstream sector and labelled with Arabic figures indicating both the

Fig. 2 Range of sediment types in relationship with hydraulic conductivity (K) and permeability (k) and sites of occurrence in fluvial systems; resulted deposits and/or structures are emphasized in terms of organic-prone sediments; (K and k based on data in: Davis and DeWiest, 1967; Davis, 1969; Freeze and Cherry, 1979) ⟶


k(cm2)
loose sediments
K(cm/s)
Corresponding sub-environments, typical deposits and their localization
channel
braided low sinuosity
meandering
bank
floodplain
gravels and pebbles
washed sands
medium to fine sands with weak argillaceous matrix (grain supported)
sandy clays (matrix supported)
silty sands
clayey sands and silts
carbonate/ organic/debris silty clays
lag deposits
lower reaches
side bar
upper layers and downstream end
mid-channel bar
concave side and downstream end
lag deposits
downstream end of point bar deposit
point bar
swale fill
ripples
levees
crevasse
channel fill
trough deposit
ox-bow
backswamp and permanent/ephemeral pools and ponds
LEGEND
organic-prone sediments, settings, deposits and structures
interval of interest with trends of increasing/decreasing deposition of organic particles due to the sifting effect;
not subjected to sifting
size of organic particles decreases with the departing from river bank
inferred average K and k in sediments oversaturated with water still situated above the water table

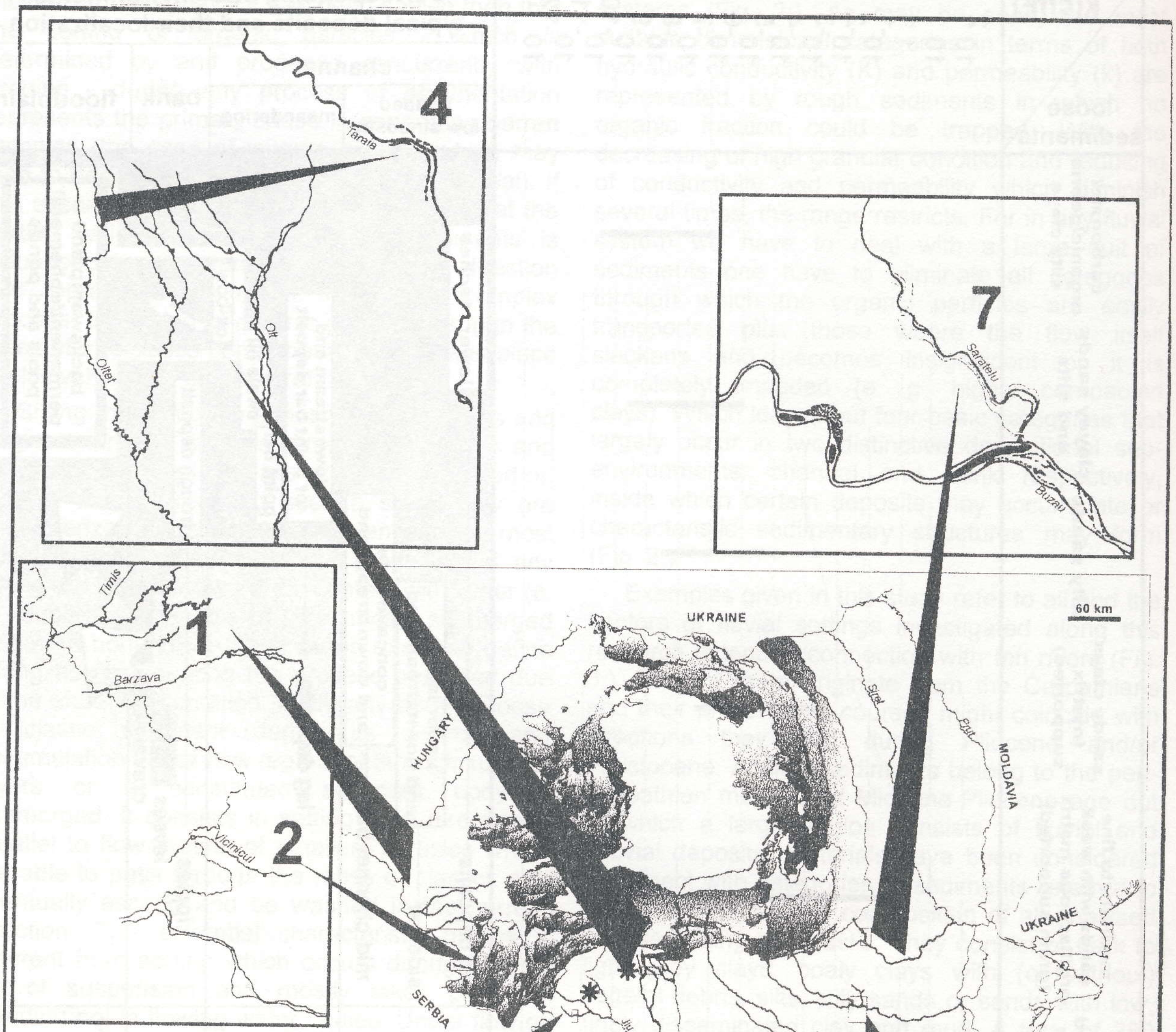
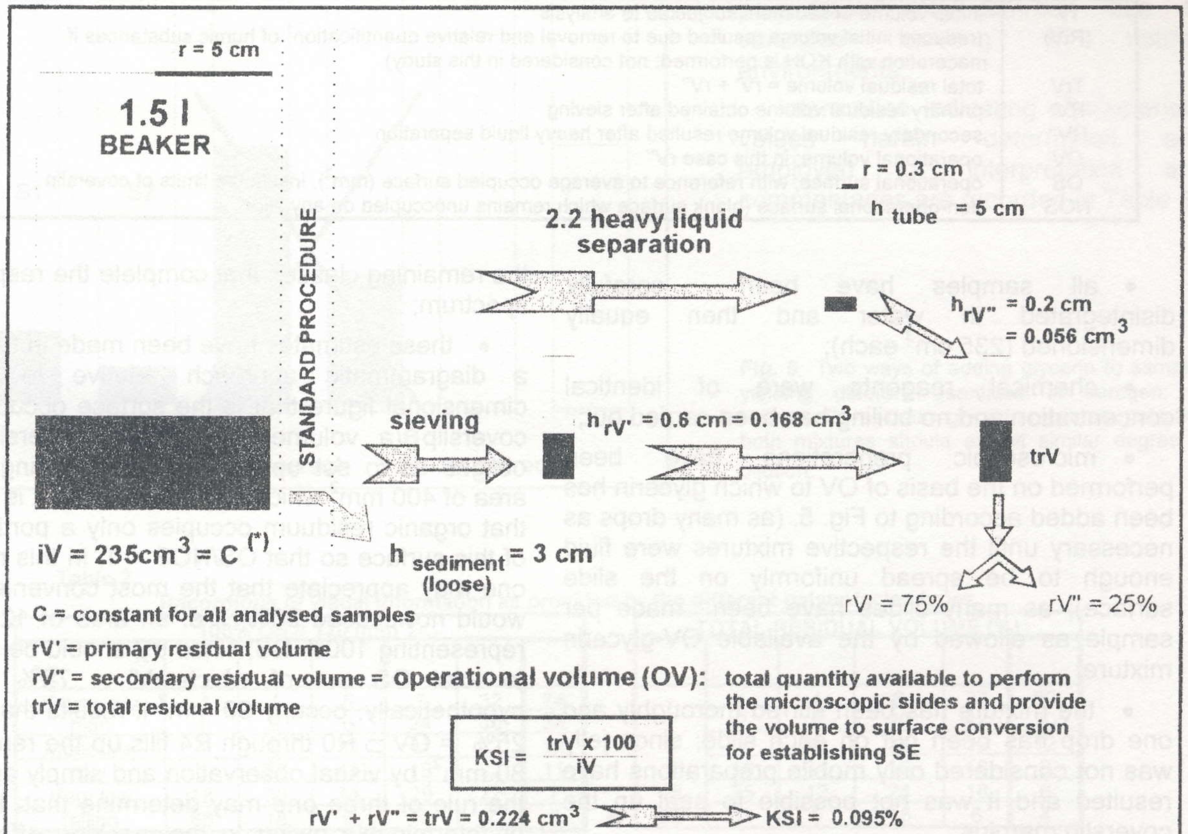


Fig. 3 Composite sketch illustrating the river sectors sampled during the present study; (1) Timişul Mort River near Jebel and a branch of it near Voiteg; southward, Bîrzava River at Gătaia; (2) Vicinicu River at Macovişte; (3) Huşniţa River south Prunişor; (4) Tîrîia River north Berbeşti; (5) Cilniştea River south Bujoreni; (6) Ialomiţa River south Moldoveni and Jilavele Creek west of Malu Roşu; (7) Buzău River west Berca and Sărăţelu River south Joseni; starlets: Motru - Jiu and Alunu Quarry Upper Pliocene deposits



h (mm)	V (cm³)	KSI (%)	h (mm)	V (cm³)	KSI (%)	h (mm)	V (cm³)	KSI (%)
0.5	0.014	<0.006	6	0.168	0.071	12	0.336	<0.143
1	0.028	<0.012	7	0.196	0.083	13	0.364	0.156
2	0.056	0.024	8	0.224	0.095	14	0.392	0.167
3	0.084	0.036	9	0.252	0.107	15	0.42	0.18
4	0.112	>0.047	10	0.28	0.119	16	0.448	0.19
5	0.140	0.06	11	0.308	0.131	17	0.476	>2.0

(*) any change of this volume will lead to modifications of KSI scale.

Fig. 4 Schematic pathway of laboratory processing, extraction of total kerogen and determination of KSI; preliminaries to the significance of operational volume are given

respective site and the referable position (e.g., 1/1, 1/2, ...,1//n). Where needed, sampling normal to the flow has been performed: (1) from channel margin toward the floodplain for side-attached bars and levees and (2) from the right bank toward the left bank for channel deposits. It followed the same numbering, each indicative being accompanied by the letter "t" which stands for "transverse". As depicted in Fig. 3., ancient deposits of Motru-Jiu and Alunu Quarry have been noted with an asterisk and so have been recorded all samples taken from these locations.

Before proceeding any further several notifications are made in respect with: (1) the terminology and abbreviations employed (Table 1) and (2) steps to be followed during laboratory processing and slide preparing. The basic laboratory procedure (KSI scale included) is given in Fig. 4.

Table 1

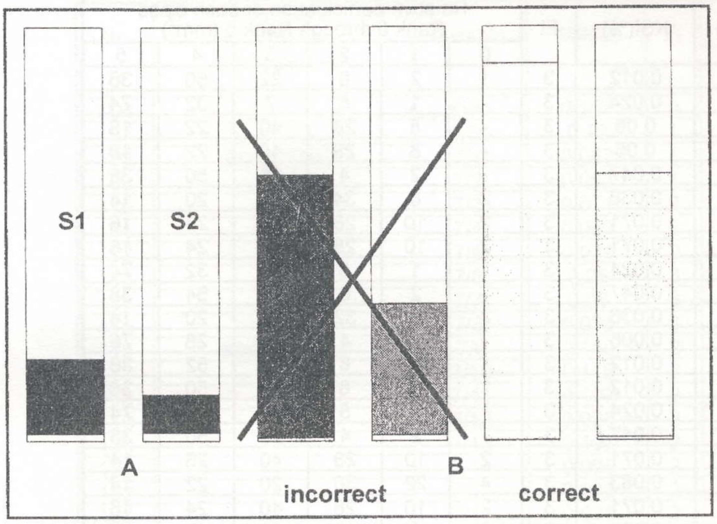
IV	initial volume of sediment subjected to analysis
(RiV)	(reduced initial volume resulted due to removal and relative quantification[1] of humic substances if maceration with KOH is performed; not considered in this study).
TrV	total residual volume = rV' + rV''
RV'	primary residual volume obtained after sieving
RV''	secondary residual volume resulted after heavy liquid separation
OV	operational volume; in this case rV''
OS	operational surface; with reference to average occupied surface (mm^2), inside the limits of coverslip
NOS	non-operational surface (blank surface which remains unoccupied on any slide

- all samples have been carefully disintegrated in water and then equally dimensioned (235 cm^3 each);
- chemical reagents were of identical concentration and no boiling has been carried out;
- microscopic preparations have been performed on the basis of OV to which glycerin has been added according to Fig. 5. (as many drops as necessary until the respective mixtures were fluid enough to be spread uniformly on the slide surface); as many slides have been made per sample as allowed by the available OV-glycerin mixture;
- the mixture has been stirred thoroughly and one drop has been put on each slide; since jelly was not considered only mobile preparations have resulted and it was not possible to seal up the coverslip margins.

Out of several properties we have to consider in such a study the particle size comes firstly and then the density and shape. Accordingly, the classification adopted here encompasses six dimensionally limited classes which cover the whole range of organic particles out of which a significant part commonly occur in terrigenous sediments of fluvial origin (Fig. 6). This way the dimensional intervals are comparable with those of Udden-Wentworth scale for clastics. The method is carried out in respect with this classification and the mode in which one may roughly delimitate these classes and qualitatively estimate how intense the sifting has been is based upon the following procedure:

- as seen in Figs. 4 and 6, trV of sample S offers an organic spectrum including all dimensional classes; the category which gives us the starting point in the evaluation of relative percentages of each is that of R5 represented by trV 75% (i. e., rV'); this leaves out trV 25% (i.e., rV'') to be taken into consideration as OV and out of which we have to estimate the participation of the remaining classes that complete the respective spectrum;
- these estimates have been made in terms of a diagrammatic approach relative to a bi-dimensional figure that is the surface occupied by coverslip (a volume to surface conversion); it obliges us to set up a grid corresponding to an area of 400 mm^2 which any coverslip is; it is known that organic residuum occupies only a portion out of this surface so that OS/NOS < 1; in this respect one may appreciate that the most convenient OS would not exceed 30%, i. e. an area of 120 mm^2 representing 100% OS; since trV should be related to total OS out of which rV' = 75% would, hypothetically, occupy 90 mm^2 it results that rV'' = 25% = OV $\supset$ R0 through R4 fills up the remaining 30 mm^2; by visual observation and simply applying the rule of three one may determine that: R0 = 0 (indeterminable owing to the masking effect that particles of higher Rank have on very small ones); R1 = 1 mm^2; R2 = 4 mm^2; R3 = 7 mm^2; R4 = 18 mm^2; one may further convert these surface units into percentages and obtain: R0 = 0% (excluded); R1 = 1%, R2 = 3%, R3 = 6%, R4 = 15%, which totals OV 25% (Fig. 7.);
- analysis of different samples are based upon three aleatorily chosen preparations (pilot slides); the same reasoning has been applied and the average participation of each class has been estimated as though R5 would have been considered; (the known volumetric percentage was converted to surface units and then it was used to establish the different surfaces occupied by the remaining classes; Fig. 8.); recordings have been made both in surface units and as percentages (Table 2) and further employed for graphic representations;
- the final diagram in which the relative participation of different assemblages in six different samples (including all categories from R0 through R5) defines six distinctive levels of intensity the sifting may be is illustrated in Fig.9.

[1] Establishing of Humic Cocncentration Scale (HCS) and possible estimation of CH_4 occurrence in deeper sediments (Demetrescu, in press).



Departures from these basic proportions are common due to variables existing in natural environments.

Information indicating characteristic values herein determined and employed for interpretation and commentaries are recorded in Table 3.

Fig. 5 Two ways of adding glycerin to samples yielding different quantities of kerogen; A: residua; B: residuum-glycerin mixtures; note that both mixtures should exhibit similar degree of dilution.

Table 2

Recordings of visual information as provided by the different palynofacies types

A

SE \ R	100% OS = 120 (mm²)					
Extremely	-*	1	5	7	32	74
high	1	2	6	24	50	36
Moderate	4	8	31	41	22	14
low	6	22	41	19	22	11
Very low	18	30	14	29	22	7
falling	66	18	6	18	7	5

B

TOTAL RESIDUAL VOLUME (%)					
-	1	4	6	27	62
1	2	5	20	42	30
3	7	26	34	18	12
5	18	34	16	18	9
15	25	12	24	18	6
55	15	5	15	6	4

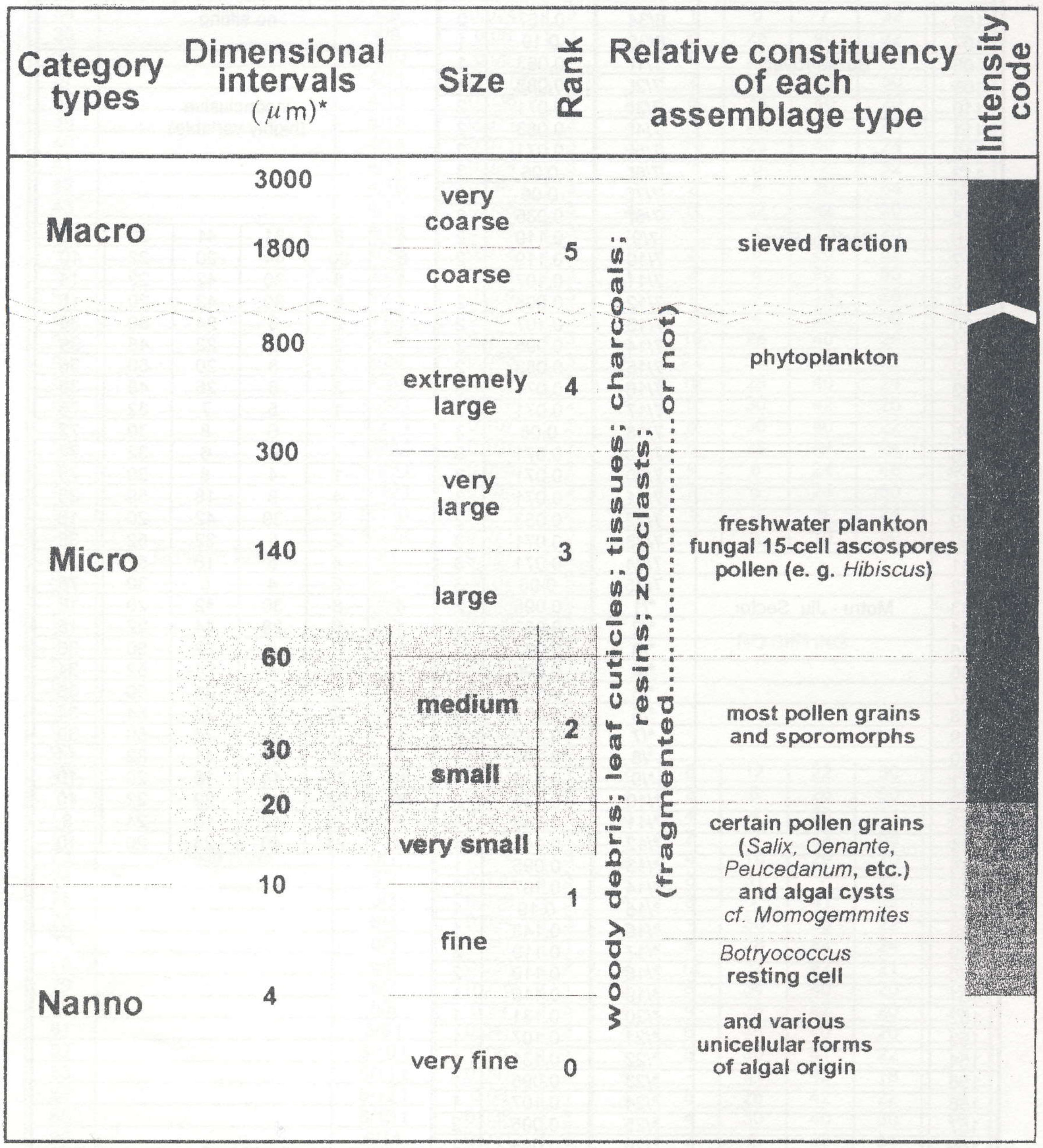
(*) not visible being masked by particles of higher Rank. A: values indicating areas each class occupies on any slide; B: their counterparts in relative percentages; vertical thickened columns in both A and B refer to R 5.

Table 3

Nr.	Location and/or river course	Sample	KSI(%)	FI	Relative participation of each class Rank 0 through Rank 5 (mm²)					
					0	1	2	3	4	5
1	Timisul Mort River	1/1	0.06	1	-	1	6	5	34	73
2		1/2	0.047	1	1	2	6	22	53	32
3		1/3	0.047	1	-	2	4	26	50	38
4		1/4	0.071	1	2	10	28	40	24	16
5		1/5	0.047	1	-	2	6	20	54	32
6		1/6	0.047	1	1	-	6	24	50	34
7		1/7	0.06	1	4	20	32	20	24	10
8		1/8	0.083	1	4	22	30	20	22	14
9	Bîrzava River	1/9	0.024	3	2	4	15	22	12	8
10		1/10	0.024	3	-	-	28	38	20	14
11		1/11	0.036	2	2	8	34	40	20	14
12		1/12	0.06	1	-	8	28	40	22	18
13	Macoviște, Vicinicu	2/1	0.071	3	1	5	7	32	32	44
14		2/2	0.071	3	-	5	7	32	30	46
15		2/3	0.107	3	-	1	5	7	32	74
16		2/4	0.119	3	1	2	6	24	50	36
17		2/5	0.083	3	4	22	30	20	22	14
18		2/6	0.071	3	-	5	7	30	32	44
19		2/7	0.095	3	1	2	6	24	50	30
20		2/8	0.119	2	1	2	6	24	50	32
21		2/9 t	0.071	2	inconclusive					
22		2/10 t	0.06	2						
23		2/11 t	0.047	2						
24	Hușnita River	3/1 t	0.012	2	1	2	8	22	50	36
25		3/2 t	0.006	3	-	-	7	32	40	36
26		3/3 t	0.047	3	1	5	7	30	30	46
27		3/4 t	0.06	3	1	5	8	30	30	44
28	Tîrîia River, between	4/1	0.024	3	-	1	5	7	32	74
29		4/2	0.024	3	-	1	5	7	32	74
30		4/4	0.047	3	-	2	6	20	54	38
31		4/5	0.012	3	1	2	8	20	52	36
32		4/6	0.006	3	-	-	4	8	30	76

Nr.	Location and/or river course	Sample	KSI(%)	FI	Relative participation of each class Rank 0 through Rank 5 (mm^2)					
					0	1	2	3	4	5
33		4/7	0.012	3	1	2	8	22	50	36
34		4/8	0.024	3	-	1	5	7	32	74
35		4/9	0.06	3	-	8	28	40	22	18
36		4/10	0.06	3	-	8	28	40	22	18
37		4/11	0.047	3	-	2	4	26	50	38
38		4/12	0.036	3	2	8	34	40	20	14
39		4/13	0.071	3	2	10	28	40	24	16
40		4/14	0.071	3	2	10	28	40	24	16
41		4/15	0.024	3	-	1	5	7	32	74
42		4/16	0.047	3	-	2	6	20	54	38
43		4/17	0.036	3	2	8	32	42	20	14
44		4/18	0.006	3	-	-	4	10	28	76
45		4/19	0.012	3	1	2	8	20	52	36
46		4/20	0.012	3	1	2	8	20	50	38
47		4/21	0.024	3	-	1	5	10	28	74
48		4/22	0.047	3	-	2	4	26	50	38
49		4/23	0.071	3	2	10	28	40	26	14
50		4/24	0.083	3	4	22	30	20	22	14
51		4/25	0.071	3	2	10	28	40	24	16
52		4/26 t	0.119	2	4	8	30	42	20	16
53		4/27 t	0.107	2	-	8	30	40	22	14
54		4/28 t	0.107	2	-	8	28	44	24	12
55		4/29 t	0.095	2	1	4	6	24	48	40
56		4/30 t	0.083	2	1	2	6	24	50	36
57		4/31 t	0.071	2	-	1	5	6	24	74
58		4/32 t	0.071	3	-	-	4	10	30	76
59	Cîlniştea River	5/1	0.167	0						
60		5/2	0.18	0						
61		5/3	0.155	0						
62		5/4	0.155	1						
63		5/5	0.167	0	NO SIFTING					
64		5/6	0.131	1						
65		5/7	0.107	1						
66		5/8	0.155	0						
67		5/9	0.119	1						
68		5/10	0.167	0						
69		5/11 t	0.047	1	2	8	12	22	50	28
70		5/12 t	0.071	1	2	2	6	26	50	36
71		5/13 t	0.071	1	2	4	4	28	54	32
72		5/14 t	0.06	1	-	2	2	22	58	38
73	Ialomiţa River	6/1	0.024	3	2	4	15	20	10	8
74		6/2	0.036	3	-	8	31	-	22	14
75		6/3	0.036	3	4	8	-	41	22	12
76		6/4	0.024	3	-	-	30	36	22	16
77		6/5	0.047	1	-	8	28	44	24	12
78		6/6	0.036	2	2	12	32	42	21	14
79		6/7	0.036	1	2	8	34	40	20	14
80		6/8	0.24	3	4	4	36	42	20	36
81		6/9 t	0.047	2	4	6	46	40	26	12
82		6/10 t	0.06	1	-	8	30	41	22	14
83		6/11 t	0.047	2	4	-	31	42	18	12
84		6/12 t	0.06	1	-	8	26	42	22	14
85		6/13 t	0.036	3	-	4	30	40	30	18
86		6/14	0.024	3	2	2	6	22	54	36
87		6/15	0.071	3	-	8	30	40	22	18
88		6/16	0.083	3	-	8	28	44	24	16
89		6/17	0.119	2	1	2	8	24	50	35
90		6/18 t	0.095	3	1	2	6	24	50	30
91		6/19 t	0.095	3	1	4	7	24	52	34
92		6/20 t	0.107	3	-	1	5	7	32	74
93		6/21 t	0.083	3	-	8	28	42	26	16
94		6/22 t	0.083	3	-	8	24	46	24	18
95		6/23 t	0.071	3	2	6	32	40	22	18
96		6/24	0.107	3	-	2	4	8	32	74
97		6/25	0.119	3	-	2	10	22	50	36
98		6/26	0.083	3	-	4	32	40	24	16
99		6/27	0.071	3	-	8	34	38	20	20
100		6/28	0.107	3	-	2	4	8	34	72
101		6/29	0.095	3	1	4	6	26	46	40
102		6/30	0.107	3	-	1	5	7	34	72
103		6/31	0.119	2	-	2	8	22	50	30
104		6/32	0/119	2	1	2	6	24	50	30
105	Jilavele Creek	6/33	0.167	0						

Nr.	Location and/or river course	Sample	KSI(%)	FI	Relative participation of each class Rank 0 through Rank 5 (mm²)					
					0	1	2	3	4	5
106		6/34	0.167	0	no sifting					
107		6/35	0.19	1						
108	Buzău River,	7/1t	0.083	1						
109		7/2t	0.083	1						
110		7/3t	0.071	2	inconclusive (highly variable)					
111		7/4t	0.083	2						
112		7/5t	0.071	2						
113		7/6t	0.06	3						
114		7/7t	0.06	3						
115		7/8t	0.036	3						
116	Sărățelu River	7/9	0.119	2	4	8	31	41	20	16
117		7/10	0.119	2	6	20	44	20	22	10
118		7/11	0.107	2	4	8	30	42	22	14
119		7/12	0.095	2	4	8	30	42	20	16
120		7/13	0.107	2	1	2	6	24	50	36
121		7/14	0.095	2	-	2	8	22	48	38
122		7/15	0.083	2	-	2	8	20	50	36
123		7/16	0.071	3	-	2	6	26	48	38
124		7/17	0.071	3	-	1	5	7	32	75
125		7/18	0.06	3	-	-	6	8	30	72
126		7/19	0.071	3	-	-	6	6	32	74
127		7/20	0.071	3	-	1	4	8	30	76
128		7/21	0.071	3	-	4	8	18	50	38
129		7/22	0.083	2	4	8	30	42	20	16
130		7/23	0.071	3	1	2	6	22	52	36
131		7/24	0.071	3	-	4	8	18	52	36
132		7/25	0.06	3	-	2	4	6	30	76
133	Motru - Jiu Sector	*/1	0.095	2	4	8	30	42	20	16
134		*/2	0.083	2	4	8	28	44	22	16
135		*/3	0.083	1	1	2	8	22	50	36
136		*/4	0.095	1	1	4	4	24	52	34
137		*/5	0.107	1	1	2	6	24	50	36
138		*/6	0.095	2	1	2	6	22	54	34
139		*/7	0.119	1	1	2	6	24	50	30
140		*/8	0.107	1	4	8	31	41	22	14
141		*/9	0.119	1	6	20	44	18	20	10
142		*/10	0.131	2	4	22	40	22	22	10
143		*/11	0.143	1	6	22	42	18	24	8
144		*/12	0.143	1	4	24	40	24	20	10
145		*/13	0.095	1						
146		*/14	0.167	0						
147		*/15	0.19	1						
148		*/16	0.143	1						
149		*/17	0.119	2						
150		*/18	0.119	2						
151		*/19	0.119	1						
152		*/20	0.131	1						
153		*/21	0.107	1						
154		*/22	0.131	1						
155		*/23	0.095	1						
156		*/24	0.107	1						
157		*/25	0.095	2						
158		*/26	0.095	2						
159		*/27	0.095	1	inconclusive					
160		*/28	0.095	1						
161		*/29	0.167	0						
162		*/30	0.155	0						
163		*/31	0.155	0						
164		*/32	0.155	0						
165		*/33	0.18	0						
166		*/34	0.18	0						
167		*/35	2.0	-						
168		*/36	2.0	-						
169		*/37	0.19	0						
170		*/38	0.167	0						
171		*/39	0.19	0						
172		*/40	0.095	1						
173		*/41	0.131	1						
174	Alunu Quarry	*/42 t	0.047	1	1	12	6	20	52	30
175		*/43 t	0.06	1	-	2	2	24	56	38
176		*/44 t	0.071	1	2	4	4	28	54	32
177		*/45 t	0.047	1	2	6	8	22	50	30



(*) millimetric subdivisions on a $\log_{10}$ scale

Fig. 6 Kerogen assemblage types in terms of dimensional criterion; shaded: the most susceptible of being either sub-represented or completely removed from spectra characterizing fluvial deposits.

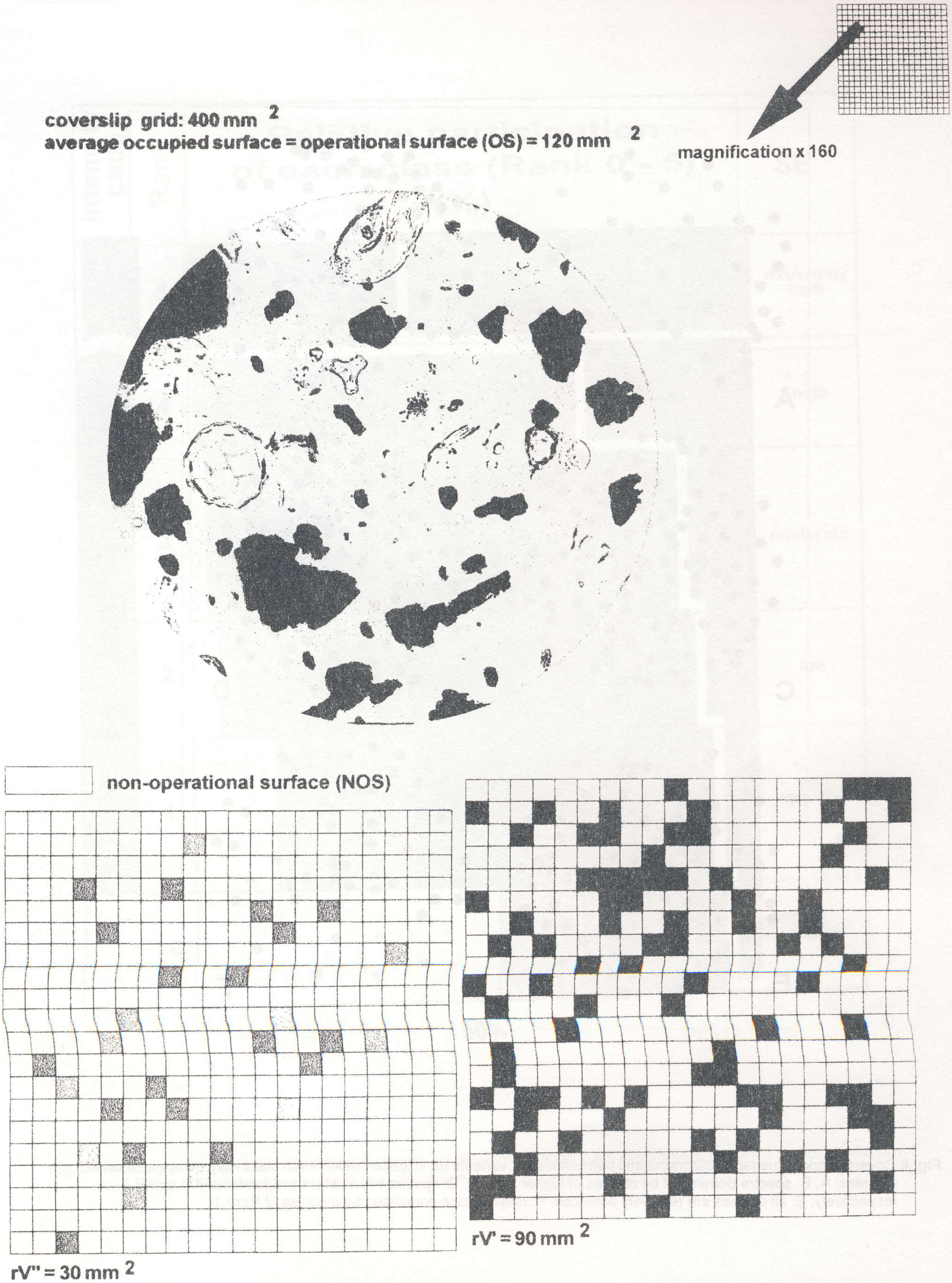


Fig. 7 Coverslip grid and the microscopic field of vision at magnification x160 covering less than 1 mm^2 (0.9375 mm^2); down: basic delimitation of R 0 through R 4 taken as a whole (left) and the hypothetically considered sub-fraction of R 5 (right) as against NOS.

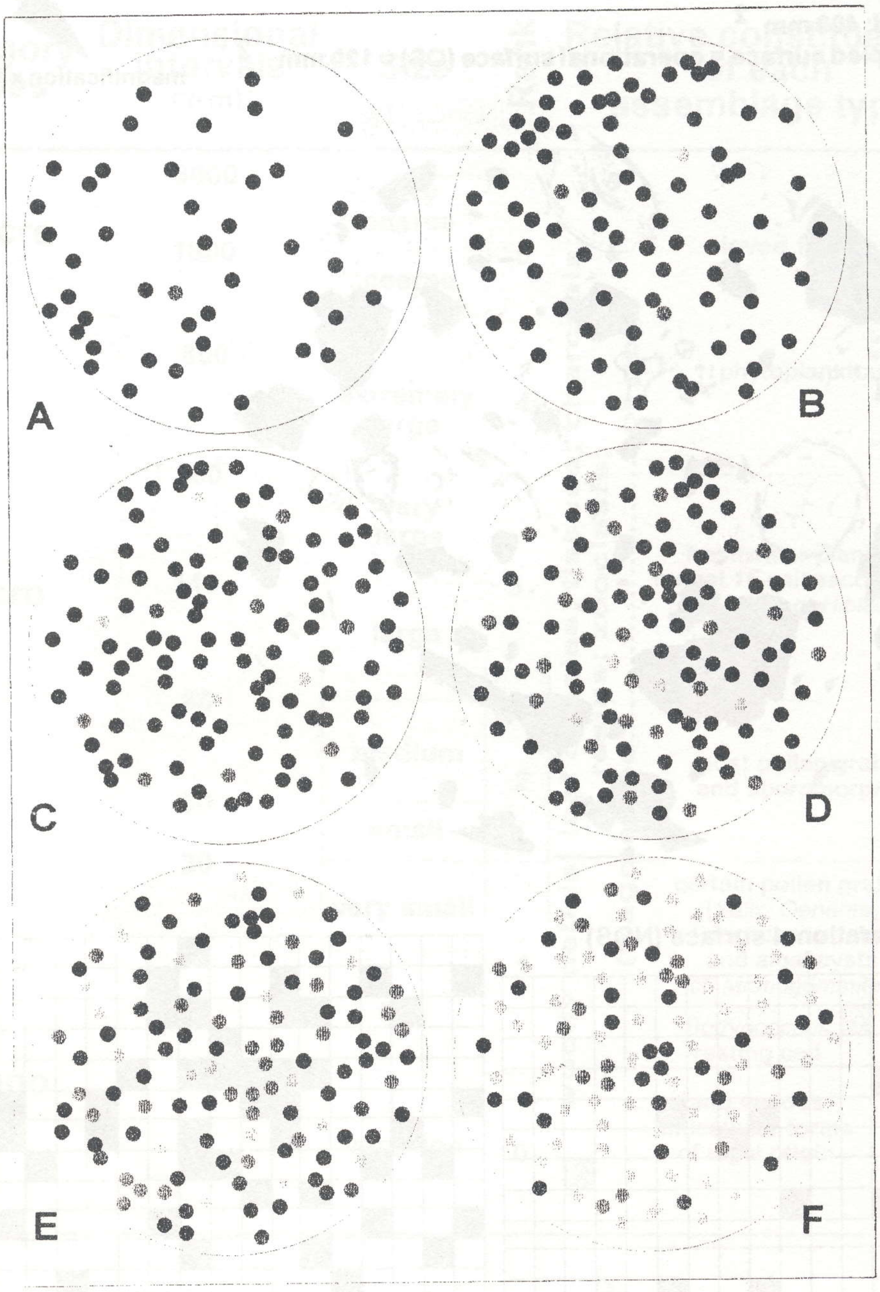


Fig. 8 Coverslip grids illustrating diagrammatic palynofacies of variable participation which each class may be in six different samples; A, B: spectra dominated by classes of higher rank; C, D: spectra within which predominate R 3 and R 2 respectively; E: all classes are relatively balanced; F: palynofacies dominated by particles of Rank 0.

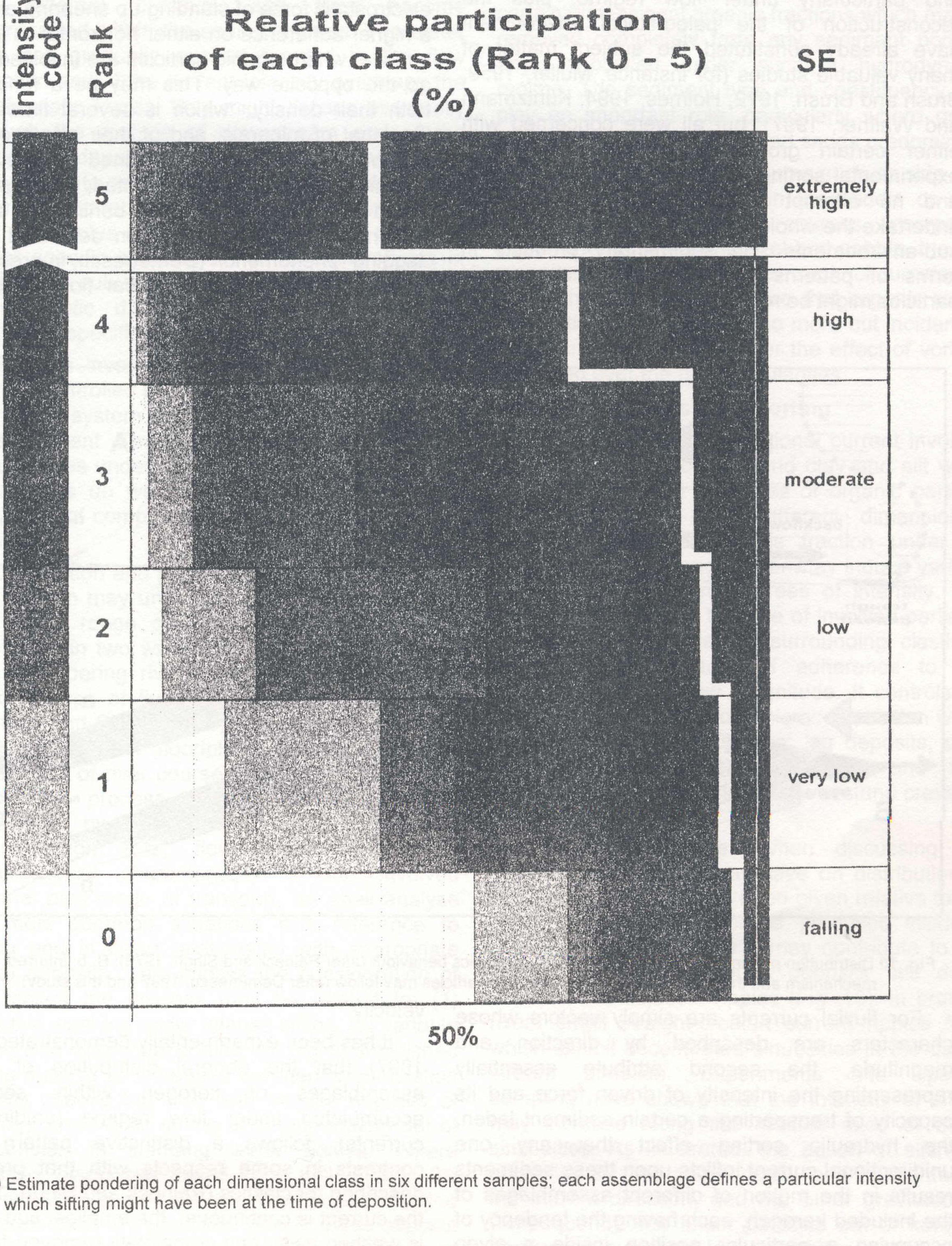


Fig. 9 Estimate pondering of each dimensional class in six different samples; each assemblage defines a particular intensity which sifting might have been at the time of deposition.

RESULTS

Aspects regarding the transport and dispersal and settling of sundry organic particles in water and particularly under flow regime, plus the reconstruction of the paleo-fluvial environment have already constituted the subject matter of many valuable studies (for instance, Muller, 1959; Brush and Brush, 1972; Holmes, 1994; Kuntzmann and Walther, 1997), but all were concerned with either certain groups of particles or specific experimental sorting and restricted fluvial sectors, and no attempt was made until present to undertake the whole fluvial system with its various sub-environments and sedimentary products in terms of patterns of deposition which organic particles might be related to.

For fluvial currents are simply vectors whose characters are described by direction and magnitude, the second attribute essentially representing the intensity of driven force and its capacity of transporting a certain sediment laden, the hydraulic sorting effect that any one unidirectional current inflicts upon these sediments results in the motion of different assemblages of the included kerogen, each having the tendency of occupying a particular position inside a given sediment body. The fact that this motion is, or may be, induced by the applied forces of shearing implies a first contrasting aspect in respect with the behaviour of either inorganic or organic particles, on the one hand, and patterns which shearing may have relative to the direction in which it acts, on the other hand.

Whereas in the case of siliciclastics the smaller the particle size is the greater may be the electrostatic force of standing up shearing and gain a higher adherence on either horizontal or inclined surface, when organic particles are involved things go the opposite way. This may be a function of both their density which is several times lower than that of minerals, and of their size too. On a horizontal or down-current inclined surface, if only organic particles are experimented, the larger ones would tend to stay and settle behind the smaller. This mode of setling has been described as the "lagging" phenomenon (Demetrescu, in press), and largely takes place under linear flow of reduced velocity.

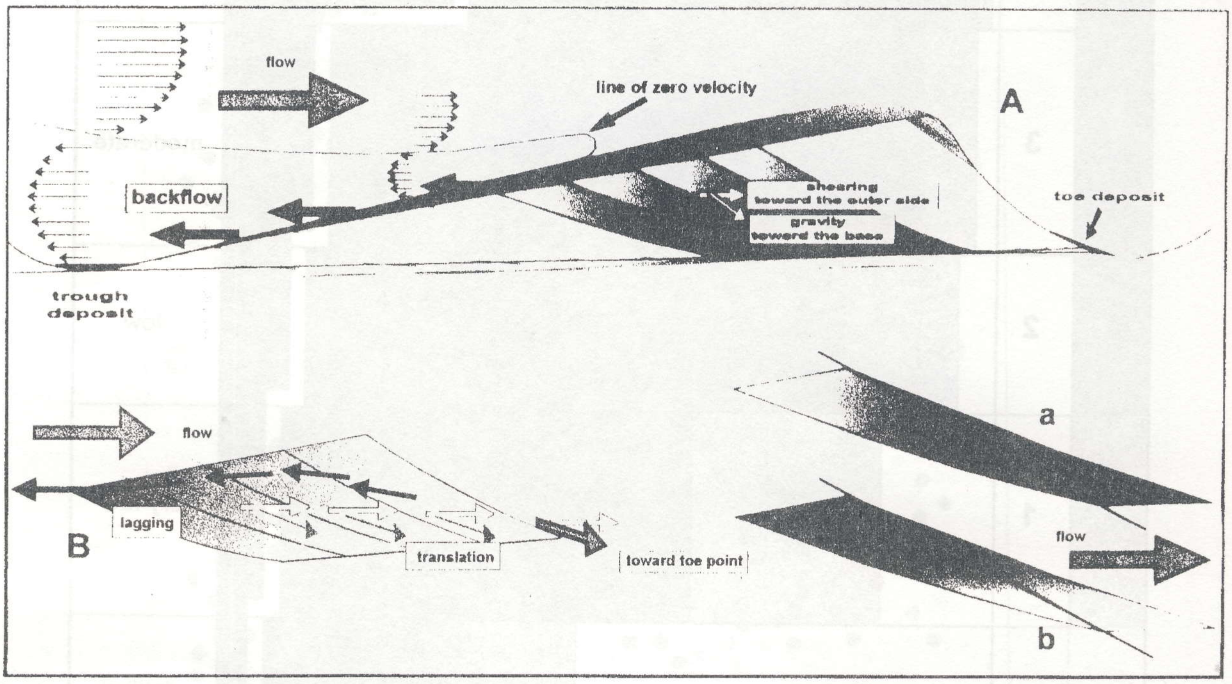


Fig. 10 Distribution patterns inside current ripple; A, a: clastics behaviour (after Reineck and Singh, 1973); B, b: inferred mechanism and trends of dispersal which organic particles may follow (after Demetrescu, 1997 and this study).

It has been experimentally demonstrated (idem, 1997) that the general distribution of various assemblages of kerogen within sediments accumulated under flow regime (unidirectional currents), follows a distinctive pattern which contrasts in some respects with that previously described for clastics (Reineck and Singh, 1973). If the current is continuous the smallest sub-fraction is washed away and completely removed from the resulted sediment body. This behaviour is illustrated in Fig. 10., in connection with distribution of organic particles within current ripples.

In the case of already formed sediments, such as longitudinal bars or point bar sequences sifting occurs through superficial layers. The minute particles firstly adhere to the outer surface under the external pressure and then become incorporated within the sediment mass. Thereafter they are gradually pushed forward in the flow direction and, if the current intensity oversteps the electrostatic forces, they might escape eventually through the surface of downstream end of the respective deposit. In view of this behaviour it is reasonable to assume that the process shows two clearly cut directions: sifting and relative sorting and sifting plus selective washing. Each produces under specific conditions, has different effects in different sub-environments and leads to characteristic distributions of organic particles relative to specific sedimentary deposits.

For this investigation is devoted especially to current-controlled sedimentation we shall approach the fluvial system as a depositing rather than an erosive agent. The scope is to see how kerogen accumulates under the given conditions and which possibilities do we have to predict the eventual existence of comparable accumulations in ancient sediments.

Distribution and patterns of accumulation which this fraction may undergo in fluvial systems cover an infinite range of possibilities which may be discussed in two ways: either referring to braided and meandering rivers, or considering the three major groups of fluvial products as presented in Reineck and Singh (1973), i. e. channel deposits, bank deposits and floodplain deposits, regardless of the type of river course they are connected to.. Since the process of kerogen deposition is controlled by many factors such as the sedimentation rate, flow conditions or the morphological characteristics of the involved channel plus mode of transport, we shall analyse the most common situations with reference to sifting and in close relationship with appropriate fluvial deposits. This implies the consideration of four cases the process may be related to: (1) selective washing under intense sifting, (2) variable sifting with directional sorting, (3) highly diminished sifting leading to increased kerogen accumulation (mostly chaotic but also with various degrees of sorting), and (4) no sifting at all but settling out of suspension in standing water bodies. Where possible, diagnoses based upon KSI, FI and SE and referable to different sediment bodies resulted ion each case are provided. Beside these aspects attention is drawn upon some particular cases of sifting possibly occurring through sediments situated above and/or below the groundwater table.

1. Intense sifting conditions

High flow velocity and turbulence in straight channels and the upper reaches of many braided streams have high negative influence on settling of certain dimensional organic fractions which may be removed completely from any sediment body (if any), deposited under such a hydrodynamic regime. The sediment type and constituency also play an important role, particularly where gravel and pebbles and large-grained sands predominate.

When sedimentary structures such as side- and mid-channel bars, formed in the middle or even lower reaches of braided courses, incorporate significant quantities of gravel and pebble, the flow magnitude increases. Under such circumstances the sifting becomes so active that organic matter can settle and accumulate no more but incidentally inside small holes and under the effect of vortices produced over the bed irregularities.

2. Sifting and directional sorting

The motion of any directional current involving the transport of fine sand and clay and silt which incorporate various quantities of organic particles and debris may bring different dimensionally delimited categories of this fraction under the shearing condition and further may induce variable sifting having different degrees of intensity. This variation depends on the size of involved particles, the physical properties of surrounding clastics - including their capacity of adherence to one another - and the flow magnitude. It controls the most ordinary forms of organic accumulation within fluvial sedimentary structures: lag deposits, side- and longitudinal bars, point bars and their superimposed swales, natural levees and crevasse splay deposits.

Channel bedforms. When discussing the consequences sifting may have on distribution of kerogen an example has been given relative to the mode in which the process produces inside a ripple structure and how it may contribute to the forming of toe and trough deposits laid down between two adjacent ripples (Fig. 10). In braided rivers small straight-crested current ripples form which exhibit accentuated sinuosities in the down-stream direction. Experiments and specific sampling have shown that the intensity of sifting may increase along the median axes of these sinuosities. As illustrated, the action of sifting is controlled by two components: one horizontal, in the current direction, and the other gravitational. Consequently, the finest particles out of kerogen fraction are subjected to a translation motion along and toward the base of the ripple while a significant portion of the same fraction representing the largest particles are caught - under the influence of backflow and subsequently induced sifting - above the stoss lamina and within it. Whereas the fines partly settle in front of ripple in the form of toe deposit and partly are washed away, the large ones tend to preferentially participate to the constitution of trough deposit (Demetrescu, 1997). Unfortunately no such delimitation could be made in terms of palynofacies due to the gradual transition from one to the other and we have to rely on a common spectrum which characterizes them both (Fig. 11).

Diagnosis: KSI between 0.024 and 0.06; FI >1...<3; SE moderate.

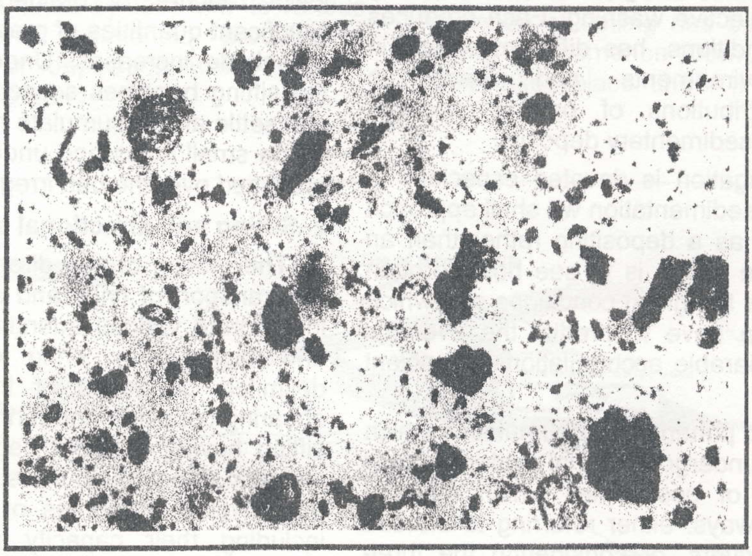


Fig. 11 Organic spectrum recovered from sediments accumulated between two adjacent ripples x160, Ialomita River; (it may also characterize the distal ends of crevasse splays and the rear sectors of swales cupping the point bars)

Lag deposits and mud plugs as parts of abandoned channel. A significant type of organic accumulation is that caught in the lower reaches of any stream provided the respective channel, or a branch of it, has been abandoned. Palynofacies describing lag deposits usually displays a concentration of vegetal microfragments including tissues and leaf debris (cuticles), woody fragments, insects skeleton remains, etc., but may also reflect intense clogging (Fig. 12).

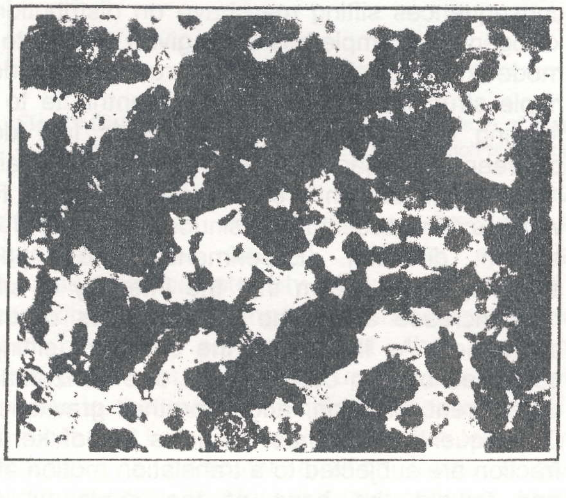


Fig. 12 Material collected from lag deposit x160; base of an abandoned channel deposit; transverse outcrop in Alunu Quarry.

In terms of sediment laden, the fraction which interests us has an extremely large dimensional range out of which the most particles - roughly appreciated at 150 μm though specimens up to several millimeters are not uncommon - are transportable as bed load and laid down as lag deposit. Producing of such an accumulation is due to sifting and its particular intensity which decreases rapidly while the clogging and infilling take place. This may lead to the forming of chaotically distributed accretions of organic matter which nestle here and there among clay boulders and gravel deposited before the channel has been abandoned. In some cases such accumulations may constitute linear deposits which thicken significantly in the down-current direction and may exhibit both directional and upward sorting. This effect is rather evident in mud plugs and also noticeable in the case of point bar units which display in their base and the lowest down-current sector of the point bar curvature important accumulation of organic debris with increased sporomorphs content (Fig. 13).

Diagnosis: KSI between >0.047and 0.095; FI <1...>1; SE moderate to extremely high.

Channel sedimentary forms. The most common sedimentary deposits laid down in fluvial systems may be divided in two major groups:

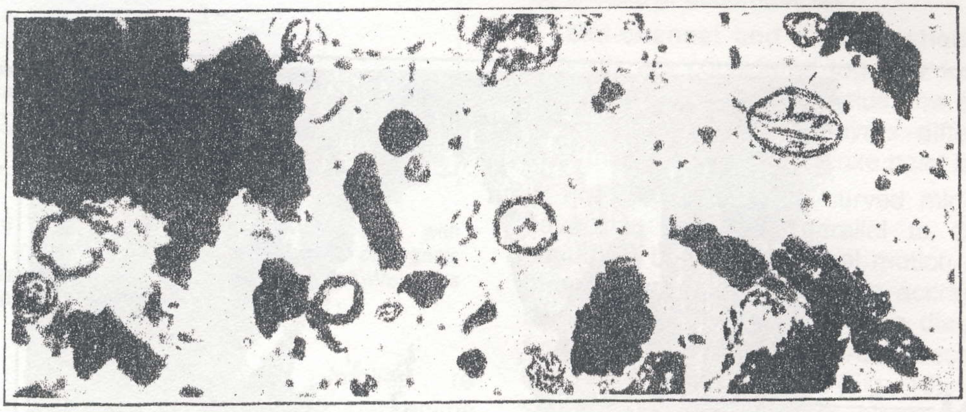


Fig. 13 Spectrum characterizing lag deposit of point bar sequence (lower sector) x160; a branch of Timisul Mort River between Jebel and Voiteg. (abandoned channel).

those formed by bed accretion and those formed by lateral sedimentation. The former may develop either along the main channel axis (longitudinal or curved mid-channel), or as elongate deposits attached to one of the two river banks (side bars). Both characterize predominantly the braided (anastomosing or not) streams. The latter are typical of meandering rivers still may occur rather frequently in braided channels with various degrees of sinuosity. Notably, side-attached bars may also form along the base of gentle convex side of longitudinal bars while point bars may form on the convex side of curved mid-channel bars (Fig. 14). Whichever the case such structures represent secondary deposits. Since kerogen follows a distinctive mode of accumulation in point bars, the process will be approached in connection with the state of diminished sifting conditions. It is noted that side-attached bars are the result of a combined process of bed accretion and lateral discharge in which the latter prevails. One of the cases presented in this study (the Vicinicu River, Site 2) offers us all these types of fluvial sedimentation (Fig. 15).

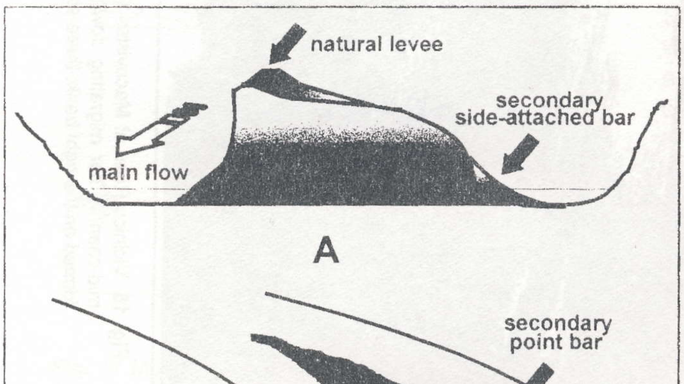


Fig. 14 Secondary deposits: A: cross - section to illustrate a side-attached bar formed along the convex side of a longitudinal mid-channel bar; B: point bar subsequently formed on the convex side of a curved mid-channel bar.

Generally speaking, braided courses are less important for accumulation of organic matter for three reasons: firstly, the flow is still high, even in anastomosing channels and in many instances erosion of fine particles prevails upon deposition; secondly, sediments building up mid-channel and side bars usually consist of coarse fraction and only the upper levels may include fine-grained material laid down at high flow; thirdly, the existence of intense and quite rapid shifting which represents an ordinary process in any braided river and leads to unpredictable changing of channel pattern. It is this process which determines a continuous change in the mode of distribution of organic particles. In this light, a particular pattern recognized at a given time and in connection with a given position of certain channel deposits may and usually do conflict with patterns which the distribution would have at a different time when the sediments would occupy a different position and would be subjected to a hydrodynamic control whose vectors would act from a different direction. The main effect on the organic fraction stands in its almost permanent re-distribution from one side of the river channel to the other. The shortest time interval elapsed between two moments of visible shifting recognized while this study was in progress has extended to twelve days.

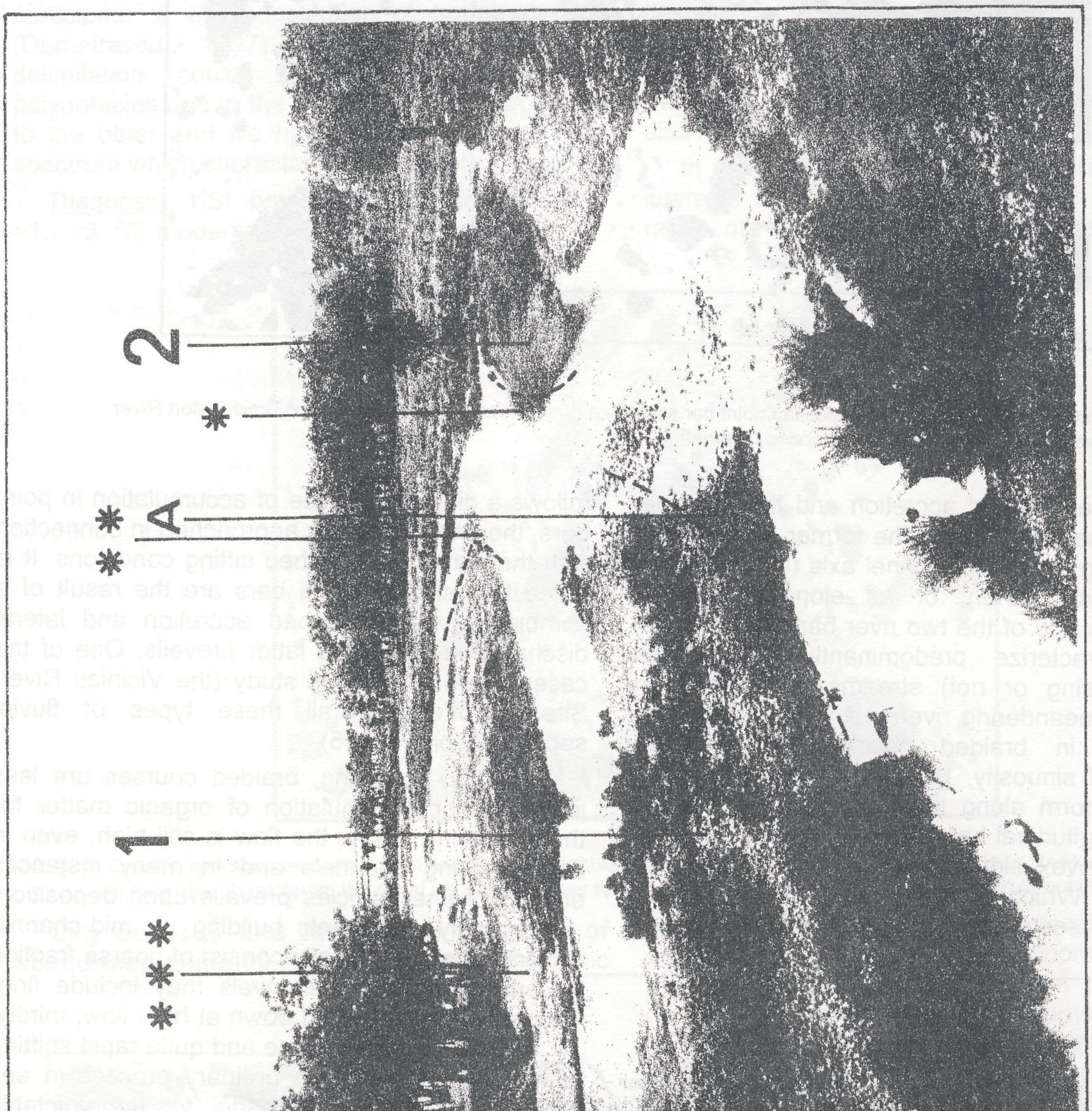


Fig. 15 Vicinicu River at Macoviste: 1: longitudinal midchannel bar with A subsequent bar and B levee; 2: curved mid-channel bar migrating downcurrent; starlet: lateral sedimentation (point bar?); two starlets: point bar(?) formed on the right bank; three starlets: sector submerged at high stage.

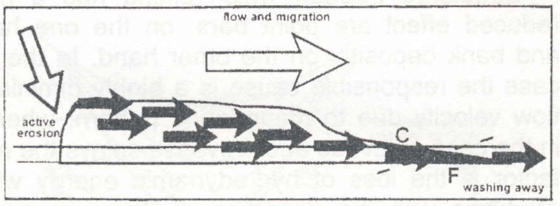


Fig. 16 Distribution patterns in connection with longitudinal mid-channel bars; typical settling of organic matter in front of a bar following the Leopold and Wolman's model; C: coarse; F: fine; black arrows: sifting.

Since re-distribution firstly implies re-suspension and this produces under flow regime, the more intense the flow velocity is the higher the process of washing away any particulate organic matter incorporated within the affected sediment mass. Whatever remains after re-distribution and the constitution of new sedimentary forms will fall once again under the influence of sifting with its two distinctive effects: washing away and subsequent differential sorting.

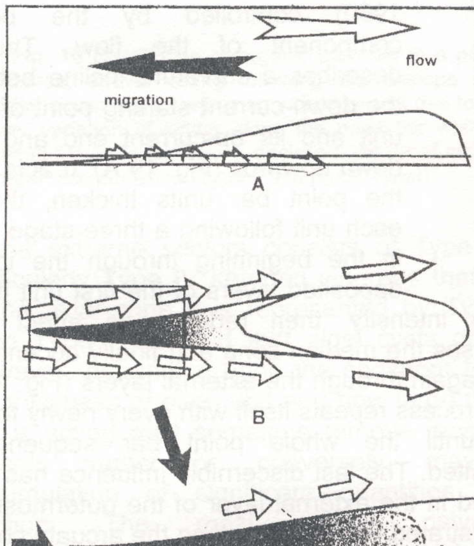


Fig. 17 Mode of accumulation of the same fraction in the up-stream end of a contrasting mid-channel bar migrating up-current (the Sărățelu River); A: lateral view (compare with Fig. 17); B: distribution of coarse and fine particles in the up-stream sector; C: enclosed zone of B to emphasize the accumulation of coarse fraction

Regardless of the negative aspects above discussed there still are sectors of all these fluvial structures which may host aleatoryly various quantities of organic fraction due to local conditions of accumulation.

Mid-channel and side-attached bars. These deposits are considered together for the mode of settling and accumulation plus how the sifting acts through their sediment layers differ significantly from those which characterize point bars.

For longitudinal and curved mid-channel bars have the long axis parallel to flow sifting is controlled by the directional motion and produces through the outermost layers accreted along the bar margins where it follows a diagonal transect from the upper part of up-stream sector to the base of the down-current end (Fig. 16). As observed, segregation (if any) takes place under gradually diminishing sifting the result standing in selective sorting with finer particles in front of larger ones that concentrate behind and slightly above. However, the highest quantity out of the small fraction may be lost in cases when the clay fraction, that usually increases the adherence, is sub-represented.

Examples of such bars are common in many rivers still quite a different situation was met with in the case of Saratelu River, Site 7. (Fig. 17). It has a narrow, slightly sinuous channel, with relatively coarse bed material. The bar is 8 m long and 1.5 m in width. At low stage it rises about half a meter above the water surface. Flow velocity is rather reduced and the sediment (mainly clayey sand) preferentially settles on the up-stream slope. This sector dips and flattens in the up-stream direction at very gentle angle which favours the laying down and accumulation of new material which forms a particular type of internal structure. Sifting induces a divergent motion of fine particles which are pushed forward through the layers accreted on either of the sides of the bar and concentrate the coarser faction of organic matter in a flatter and curling deposit (shaded). In marked contrast with the bars above discussed, it presents a much steeper down-stream margin which consists of coarse material, even with gravel in the two lower third, and large-grained sand mixed up with clay boulders on the top. Intermittent erosion of these sediments toward the base of the bar induces partial collapse of this sector in the way it happens with the down-current sectors of bars which follow the Leopold and Wolman's model. Hence, the confirmation of what Rust (1972) has shown. The Vicinicu River here has a channel that may host both types of bars: a longitudinal bar which accretes finer sediments in the up-stream sector and a curved bar where the finer material accumulates in front of the down-stream end. For both types of bars have been produced in the same channel we may conclude that in certain instances not only the sediment type is responsible for bar typology and behaviour but also the flow particularities which may play an important role in their forming process.

In the case of side-attached bars either of primary or secondary degree, the unique sector where organic particles might be recovered from is located toward the up-stream and the outermost margin. Sifting is very intense and produces exclusively through superficial layers over-

Fig. 18 Palynofacies characteristic of side-attached bars and natural levees x63; Tîrlia River

saturated with water. It removes almost all organic particles of small dimensions what remains to be found consisting of large and very large debris (Fig. 18).

Particularly in braided rivers with rich coarse sandy fraction it reaches extremely high values indicating that no fine material could be trapped in such sediments.

Diagnosis: KSI 0.071 to 0.119; FI <3...>3; SE high to extremely high.

3. Decreasing sifting intensity

The third case we are confronted with refers to diminution of the sifting conditions and its effect on the settling and accumulation of kerogen. Under reduced flow velocity the sifting also diminishes favouring an increased deposition of organic material. Since most organic particles - particularly palynomorphs such as pollen and spores and algal cysts which, in terms of hydrocarbons-prone deposits constitute the kerogen Type II - range dimensionally up to 100 μm, it is obvious why this aspect has an outstanding importance in the studying of the consequences of sifting.

Structures through which sifting has a more reduced effect are point bars, on the one hand, and bank deposits, on the other hand. In the first case the responsible cause is a highly diminished flow velocity due to meandering pattern, whereas in the case of levees and crevasse splays the main factor is the loss of hydrodynamic energy which produces with the departing of the river margin after any bank overspill has taken place.

Point bars. Flow in meanders has been extensively studied from hydrodynamical and sedimentological viewpoints (Bagnold, 1960; Leopold and Wolman, 1957, 1960; Leopold et al., 1964) yet not much is known about the particular mode of settling and accumulation which organic fraction follows in meandering rivers and their most important sedimentary deposits formed by lateral sedimentation: point bars.

In meandering streams sifting is confined to an upslope, diagonally directed motion (Leopold and Wolman, 1960) controlled by the bottom component of the flow. Thus it describes a curvature incline between the down-current starting point of each unit and its up-current end and from down upwards (Fig. 19 A). It acts while the point bar units thicken, through each unit following a three-stage pass: in the beginning through the initially deposited layers of the first unit it is of higher intensity, then reduces its effect while traverses the median zone and finally accentuates once again through the external layers (Fig. 19 B). The process repeats itself with every newly formed unit until the whole point bar sequence is deposited. The last discernible influence has been sensed in the external layer of the outermost unit. As illustrated (Fig. 19 C), along the arcuate contour of each unit sifting also has three degrees of intensity: accentuated enough through the up-current end, decreasing still variable - due to sediment type and unit thickness - in the apical sector and highly intensified toward and through the down-current sector. Accumulation of organic fraction conforms to these conditions, the variation of sifting intensity leading to either pervasively distributed particles or to selective sorting in which case segregation takes place both in the flow direction with fine particles predominantly toward the down-stream sector and from base upward (positive distribution, particularly in rivers carrying fine material).

It results from this that, in terms of kerogen types, the organic fraction which is usually trapped

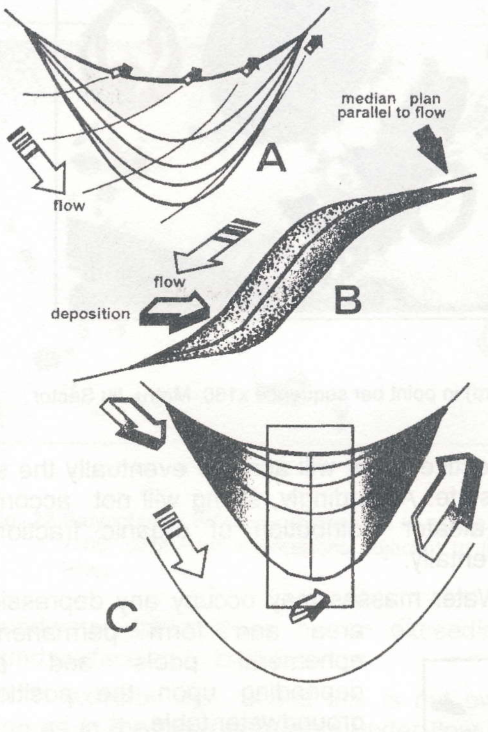


Fig. 19 Distribution of organic particles in a point bar sequence; above: sifting following the upslope motion; middle: accumulation within an individual unit due to sifting; down: variation of sifting along the point bar while each sediment layer is laid down; enclosed: sector of increasing kerogen accumulation (Type II and partly TypeI)

in the extreme sectors consists of Type III and particularly Type IV kerogen whereas that caught in the axial zone it is represented by Type II or even Type I provided that algal cysts do occur. However, depending upon the sediment type and the thickness of each unit and how large the point bar is sifting may sometime remove most of the organic matter or, conversely, may allow accumulation of significant quantities of this fraction. The most typical palynofacies characterizing point bar sequences exhibits more often a selective sorting with positive distribution of organic fraction (Fig. 20).

Diagnosis: KSI 0.095 to 0.155; FI 1 to 2; SE low to high.

Sifting through natural levees, crevasse splay deposits and point bar swales. Levees may form on either of the two river banks but are preferentially deposited on the concave side and present two important sectors: one steeper margin which may rise rather abruptly above the topographic relief of the respective bank and the other gradually sloping into the floodplain. When intense flood produces the convex bank and possibly associated point bars may also be overflown with sediments which grade into the point bar units.

Sedimentologically they signify rapid discharge which implies high sedimentation rate. They are the result of high flow and flood and, in time, the already deposited sediments may be subjected to intermittent subaerial exposure.

What it is important from our standpoint here depends on how the flow behaves immediate after the initial flood discharge and this behaviour may follow two trends: (1) to slacken rapidly in which case the bulk of kerogen may accumulate for intense sifting which controls the washing away mechanism under continuous flow will decrease, or (2) to last for a longer period of time so that the sifting will act consequently and the organic fraction will be spread over more extended an area and lose any interest in respect with significant accumulation. Nevertheless this, continued flood deposition may result in thick layers of mud (merely clay and specifically particulate organic matter), which will evolve toward backswamp deposits and eventually give born to coal-generating peat.

We shall resume to analyse the first trend. During flood near the channel settle resins, charcoals, very large tissues, i. e. organic micro-elements of Rank 5 (Fig. 21), whereas away from the channel margin will be deposited finer particles. If subsequent standing water remains in slight depressionary sectors of the floodplain then most of this fraction would be deposited out from suspension (see paragraph about deposition in the absence of sifting). If, on the contrary, desiccation intervenes the mud would be exposed to subaerial oxidation which affects drastically any organic matter and precludes preservation The organic content is reduced and includes micro-elements of open habitat (Fig. 22).

When intense overspilling is conjugated with coarser sediment laden then breaches through the initially deposited layers may form. Even though they may fill with material coarser than that of the sediment which constitute the respective levee a significant quantity of fine sediments may also participate in the infilling process and give born to crevasse fill deposits. Due to the sifting which associates with and follows the overflow, or even a gentle overspilling, the finest fraction fills the floodplain ends of these crevasses and spread between them producing crevasse splay layers. Kerogen always accumulates in greater quantity in these more departed sectors.

When flood at high flow affects the convex side too the point bar attached to, if any, it is overflown and various amounts of sediment laden speeds across its surface with variable velocity so that both coarse and fine particles are laid down. The

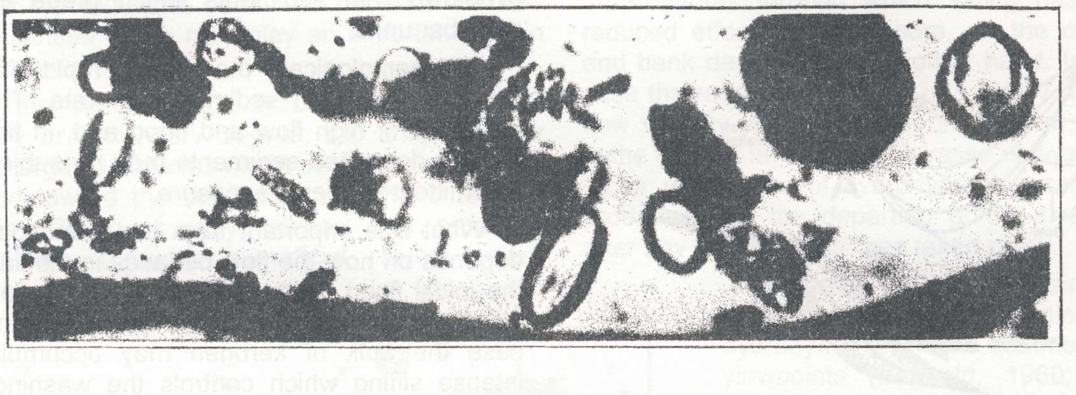


Fig. 20 Palynofacies reflecting positive palyno-sorting (fining upward) in point bar sequence x160. Motru-Jiu Sector

granular condition of the transported sediments favours the forming of slightly higher ridges of coarse inorganic detritus and elongate depressions filled with finer material such as clay and silt rich in organic fraction.

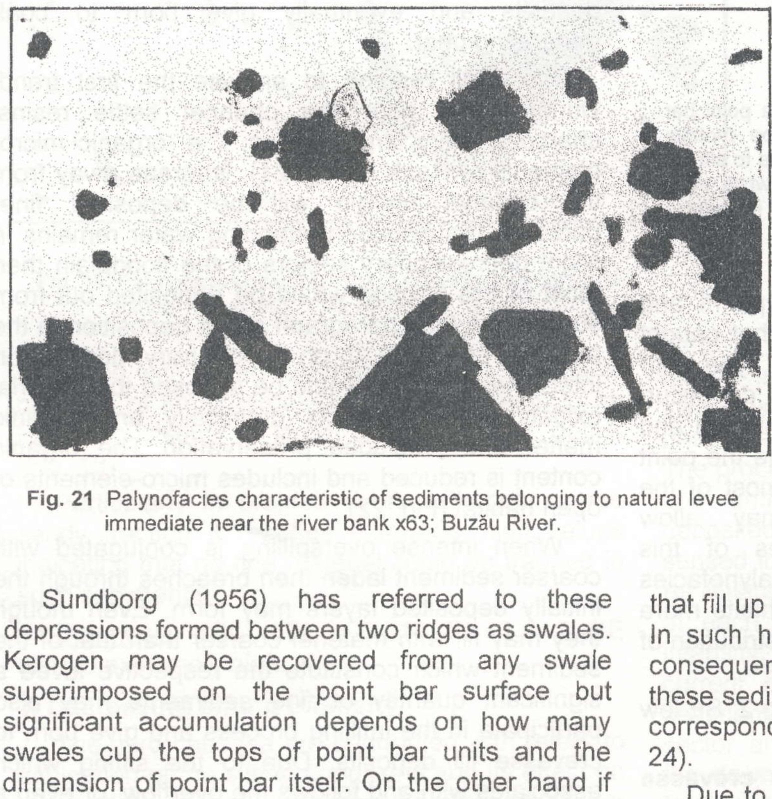


Fig. 21 Palynofacies characteristic of sediments belonging to natural levee immediate near the river bank x63; Buzău River.

Sundborg (1956) has referred to these depressions formed between two ridges as swales. Kerogen may be recovered from any swale superimposed on the point bar surface but significant accumulation depends on how many swales cup the tops of point bar units and the dimension of point bar itself. On the other hand if desiccation occurs the organic matter will be affected and will become more scarce (Fig. 23).

Diagnosis: KSI between 0.06 and 0.083; FI 2-3; SE highly variable.

Absence of flow conditions

Any flow generated by bank overspill during flood will cease to exist at a given momentum provided the distance from the river channel will become as large as necessary so that the respective water will achieve eventually the stand-still state. Accordingly, sifting will not accompany the aleator distribution of organic fraction but incidentally.

Water masses may occupy any depressionary area and form permanent or ephemeral pools and ponds depending upon the position of groundwater table.

Settling in such habitats produces exclusively out of suspension although it may be disturbed occasionally by new suspended river sediments washed in during floods. Locally derived floodplain material might also contribute to the infilling of these accumulation sites if significant rainfall would take place.

The most important accumulation areas in which kerogen is best preserved develop as backswamps and lakes which originate in cut-off meanders, namely chute or neck cut-off lakes that fill up with clay and abundant organic material. In such habitats sifting intervenes no more and consequently many organic spectra trapped within these sediments exhibit positive palyno-distribution corresponding to fining upward sequences (Fig. 24).

Due to gradual reducing of sediment discharge following each flood, KSI may give exaggerated values and consequently may induce erroneous conclusions with regard to the extent of organic matter (the absence of dilution phenomenon which, conversely, characterizes sequences formed at high sedimentation rate). For all that high organic matter productivity is common in these sub-environments and the good preservation state represents the consequence of high

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Fig. 22 Palynofacies reflecting desiccation in alluvial plains x160; catchment depressions adjacent to Ialomiţa River.

groundwater table close by or exceeding the ground surface as in backswamps.

If FI exhibits high values this is not owing to sifting as in the case of settling under flow regime but the existence of bioactivity taking place in surficial bottom layers. This might be extremely intense particularly in very shallow depressions and may drastically break down the most organic particles (Demetrescu, in press).

Diagnosis: KSI between 0.095 and 0.167 but may exceed 2.0 in the case of clogging; FI 0...1 (or higher if bioactivity will occur); SE low to falling (or indeterminable).

Fig. 23 Palynofacies of swales subjected to desiccation x160; Bîrzava River at Gătaia.

In the light of what has been discussed up to this point we can distinguish, in terms of the diagnoses herein presented, six clearly cut domains belonging to fluvial systems which the different accumulation sectors might be assigned to (Fig. 25.). As illustrated, each field occupies a well defined zone inside any ternary plot as a function of the particular KSI-FI-SE combination which characterizes it; alternatively, they superpose with one another as a consequence of interfacing depositional sub-environments and interrelated sedimentary processes.

PARTICULAR CASES OF SIFTING

There are situations when sifting may incidentally occur and we shall mention two cases: (1) sifting through sediments built up above the water table and usually exposed to subaerial conditions and (2) sifting through buried sediments subjected to groundwater influence. Both involve modern and Quaternary and Neogene sediments, on the one hand, and exclusively particles of Rank 0 and Rank 1 classes, on the other hand.

The first case refers to geomorphological changes that affect the sediment geometry, mostly taking place owing to high rainfall and landslide. It usually produces through fissures in sediments of low cohesiveness and may induce motion of minute particles over short distances.

The second case has a higher importance and implies the consideration of groundwater flow which is responsible for the occurrence of this mechanism.

Fundamentals of groundwater motion including aquifer system with its physical and geochemical characteristics plus the dynamics of groundwater flow have been treated exhaustively in many previous texts (Hubbert, 1940; Swartzendruber, 1962; Freeze and Witherspoon, 1968; Payne, 1970, 1975; Schwartz, 1977; Champ et al., 1979; Freeze and Cherry, 1979), and nowise makes the subject of this study. It is solely reminded that the implications of its significance in the distribution of organic particles cannot be neglected since it interfaces with both the depositional setting which it influences and the external conditions which control, in turn, its general framework and properties by way of downward percolating rainwater through sediments of reduce cohesiveness and fissures.

Groundwater flow specifically through grain-supported sediments of low cohesiveness tends to

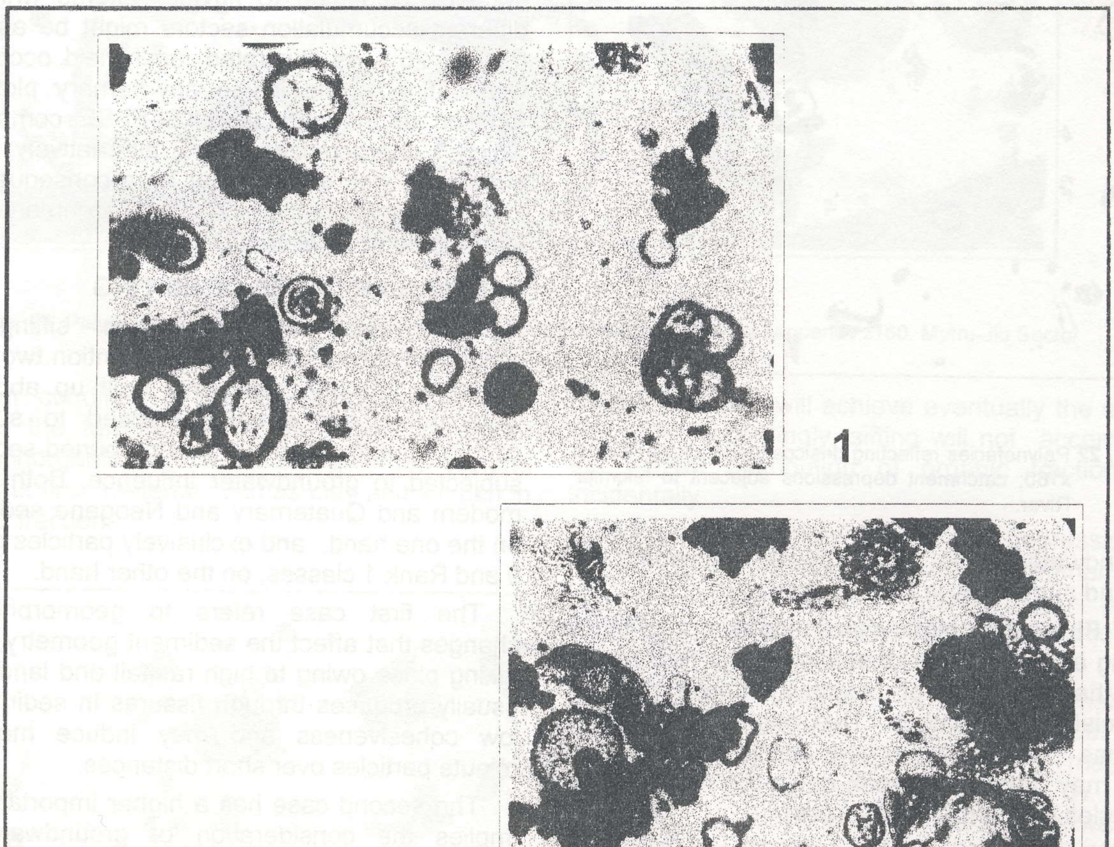

Fig. 24 Palynofacies of floodplain sub-environments x160; 1: backswamp (open water eye) with emergent taxa, Motru – Jiu sector; 2: cut-off meander loop at Jilavele Creek; 3: large and deeper pool adjacent to river course, Cîlniştea River; arrow: *Nymphoides*.

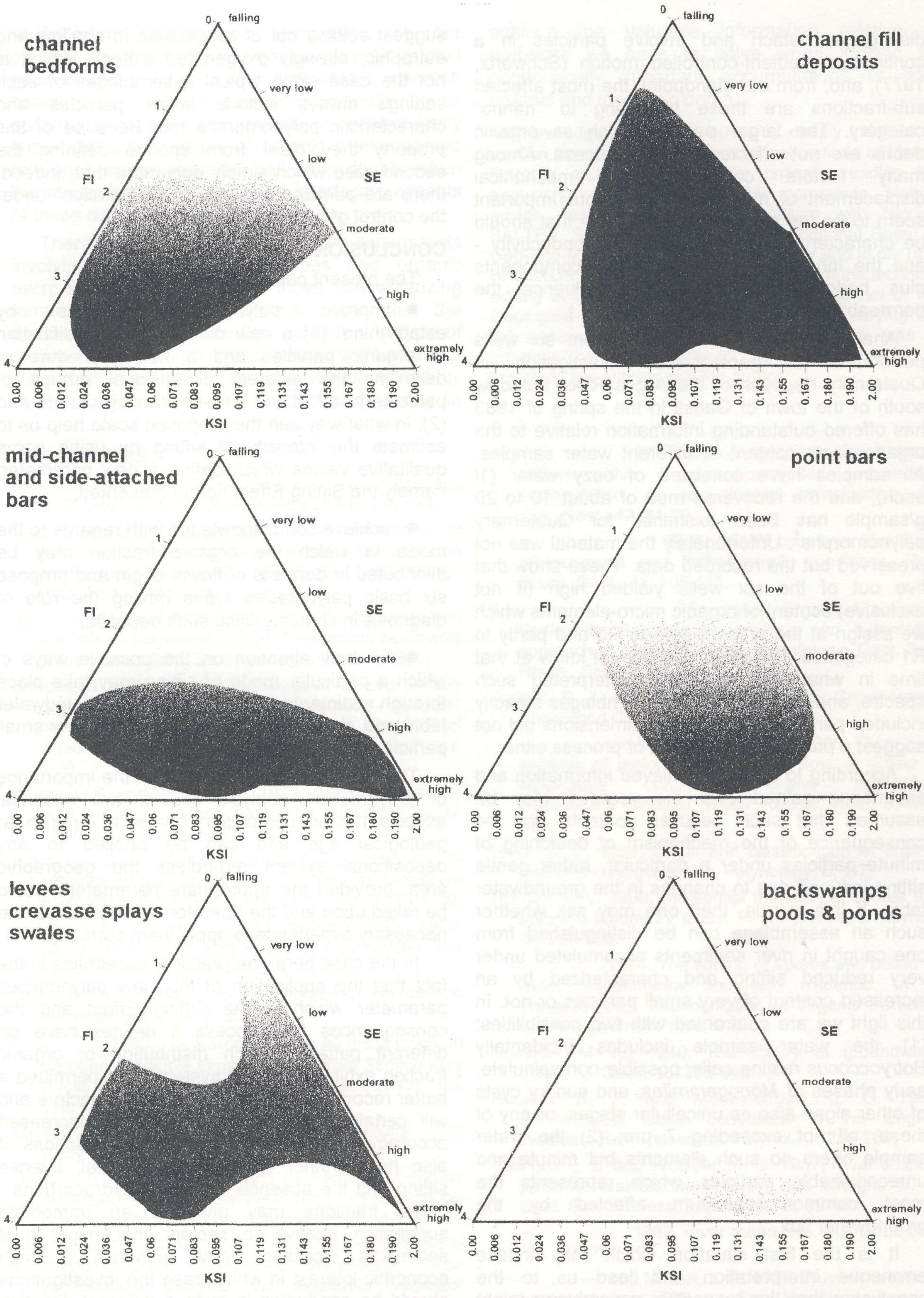

Fig. 25 Ternary plots showing the distribution of organic fraction inside different fluvial settings; the diagnoses which these diagrams are based upon should be considered with caution and the primary data should be corroborated with information regarding the nature and typology of the involved kerogen assemblage types.

disengage, detach and involve particles in a continuous gradient-controlled motion (Schwartz, 1977), and, from our standpoint, the most affected sub-fractions are those belonging to "nanno" category. The larger particles such as organic debris are not affected by this process. Among many factors controlling the mechanical displacement of minute particles more important seem to be the sediment mass itself - that should be characterized by high hydraulic conductivity - and the inhomogeneity of sediment components plus bedding morphology that influence the permeability of any aquifer system (ibid.).

Analysis of material collected from six wells performed for geotechnical investigation in Quaternary deposits of the Arges River meadow south of the town of Gaesti in the spring of 1983 has offered outstanding information relative to the organo-clasts content of different water samples. All samples have consisted of oozy water (1l each), and the recovered mud of about 10 to 20 g/sample has been examined for Quaternary palynomorphs[1]. Unfortunately the material was not preserved but the recorded data. These show that five out of the six wells yielded high (if not exclusive) content of organic micro-elements which we assign at the present time to R0 and partly to R1 categories. However, one did not know at that time in what way should be interpreted such spectra, and the fact that all assemblages steadily included particles of very small dimensions did not suggest a particular distribution or process either.

According to the new achieved information and experience gained over the years it may be assumed that such peculiar contents are the consequence of the mechanism of detaching of minute particles under a particular, rather gentle sifting induced due to changes in the groundwater table. If this is true, then one may ask whether such an assemblage can be distinguished from one caught in river sediments accumulated under very reduced sifting and characterized by an increased content of very small particles or not. In this light we are confronted with two possibilities: (1) the water sample includes incidentally *Botryoccocus* resting cells, possible non-spinulate, early phases of *Monogemmites,* and sundry cysts of other algae also as unicellular stages, or any of these, all not exceeding 7 µm; (2) the water sample offers no such elements but minute and unrecognizable particles which represents the most common spectrum affected by the groungwater flux.

It is the first situation which may induce erroneous interpretation and lead us to the conclusion that the respective assemblage might suggest settling out of suspension in shallow and eutrophic, strongly oxygenated waters. Which is not the case since typical assemblages of such settings always include larger particles and characteristic palynomorphs too. Because of this property they differ from spectra defining the second case which simply document that, indeed, there are particles involved in this "motion" under the control of groundwater flux.

CONCLUSIONS

The present paper has managed to:

- improve palynofacies analysis by establishing: (1) a new dimensional classification of organic particles and a new procedure of delimiting the different dimensional groups of particles to avoid the time-consuming counts and (2), in what way can the proposed scale help us to estimate the intensity of sifting by using some qualitative values which define a new parameter, namely the Sifting Effect herein presented;

- achieve some knowledge with regards to the mode in which the organic fraction may be distributed in deposits of fluvial origin and propose six basic palynofacies types having the role of diagnosis in characterizing such deposits;

- to draw attention on the possible ways in which a particular mode of sifting may take place through sediments situated below the groundwater table and change the initial position of very small particles.

The study has documented that the importance of palynofacies analysis lies in two essential aspects. It is not compulsory related to a particular geological age and can be applied to any depositional system regardless the geographic area, provided the appropriate parameters would be relied upon and the operator would possess the necessary experience to apply them correctly.

In the case here, the practical aspect lies in the fact that the application of this new palynofacies parameter which is the Sifting Effect and the consequences the process it defines have on different patterns which distribution of organic fraction exhibits in fluvial systems has permitted a better recognition of the organic-prone sectors and will certainly help us to predict with increased accuracy the possible fossil fuel accumulations. It also has another outstanding potential: intense sifting and the absence of coal or hydrocarbons - prone fractions may give us an immediate suggestion relative to sectors that might host sediments including heavy minerals of high economic interest in which case the investigations should be conducted in quite a different direction and by different methods.

[1] Analyses carried out at the Laboratory of Palynology, Faculty of geology and Geophysics, University of bucharest.

Although palynofacies represents, in our opinion, the best way to link up palynology and sedimentology and any modern research concerned with paleoenvironmental reconstructions and occurrence of economically important accumulation of organic matter should rely on it, some scientists still have doubts when the matter comes down to the interfacing aspects of these disciplines.

There is, however, hope that other experiments involving various sediment types and organic micro-elements other than those characterizing temperate regions as in this case, plus the consideration of variable flow velocity and type of motion (unidirectional or oscillatory), will become a subject of interest for both and will be tested by further studies, this representing the only way to achieve the valuable information relative to problems we have to solve when looking for economically important accumulations of both organic and inorganic origin.

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