

# PROBLEMS IN DIATOM ANALYSIS OF DEPOSITS: ALLOCHTONOUS VALVES AND FRAGMENTATION<sup>1</sup>

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## ABSTRACT

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A review of the various sources of allochthonous diatom valves in deposits is given. The importance of these problems in palaeoecological research is discussed and some simple methods for their approach in quantitative analysis are introduced.

## INTRODUCTION

Selective dissolution, fragmentation and influx of allochthonous valves are serious problems encountered in quantitative diatom-analysis of sediment cores for palaeoecological purposes, the effects of these phenomena being such that they have to be taken into account for each interpretation of obtained data. The process and consequences of selective dissolution have already been treated extensively (BRADBURY, 1973; JOHNSON, 1974; JØRGENSEN, 1955; KAMATANI, 1969; KAMATANI & RILEY, 1979; LEWIN, 1961; ROUND, 1964; SCHRADER, 1971). Influx of allochthonous valves and fragmentation, however, have been somewhat neglected until now.

## ALLOCHTONOUS VALVES

Due to their small dimensions and their particular shape, living diatoms and their valves are easily transported by moving water and air. For this reason, valves not belonging to the autochthonous flora are frequently found in deposits. It is obvious that it is of the greatest importance to differentiate between these allochthonous valves and those belonging to the original assemblage, for only the latter can give precise information on the local palaeoenvironment.

## Sources

Important transport of diatoms and their remnants can occur lateral as well as vertical. Lateral transport by marine currents may involve enormous distances (BURCKLE, 1978). Transport in water courses and run-off (HENDEY, 1974) result in an important seaward flux of fresh-water taxa, while marine and brackish taxa are carried far up into estuaries by tidal currents (BROCKMANN, 1940; GESSNER & SIMONSEN, 1967; SIMONSEN, 1969). In some cases, the allochthonous population can even exceed the autochthonous one quantitatively as well as qualitatively (SIMONSEN, 1969), which may easily lead to erroneous conclusions.

Allochthonous valves in lake deposits can be brought in from outside of the sedimentary basin, but also from different places in the lake itself. Solifluction (EVANS, 1970) and seasonal water movements (MERILAINEN, 1969) can lead to the deposition of littoral forms in the more profound parts of a lake, thus destroying the expected horizontal distribution of the valves in the bottom sediments. Aerophilous forms may be used to indicate the washing in of material (WALKER, 1978). Some caution should, however, be made in applying this assumption, since most aerophilous taxa may thrive in purely aquatic conditions as well.

Lateral transport by moving air (VAN OVEREEM, 1937; GEISSLER & GERLOFF, 1966; KALBE, 1973) can also be of some importance. SAAR (1967) investigated the transportation of living diatoms and valves by a strong seabreeze, and concluded that living diatoms (mainly fragile planctonic species) were blown on land in spray-droplets, while valves of strongly silicified benthonic forms were taken up from the beach sand and transported over many metres. Animals, for instance

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foraging birds (SIMONSEN, 1957), and human activities (ships, etc.) are also possibilities for lateral transport.

Vertical transport of valves in deposits is still badly known. Possible causes are reworking and infiltration. Both upward and downward movements occur. Probably, infiltration-effects can be quite important in coarse sediments involving small valves. Percolating rain- and melting water as well as fluctuations of the ground water level may displace valves. Fresh-water deposits may become contaminated with marine diatoms during a flooding with seawater as a result of infiltration and wave action. Vertical displacement may also result from bioturbation.

### Detection

It is often difficult to recognise the allochthonous component of a fossil assemblage, although it may form an important part of it. SIMONSEN (1969) suggested that benthonic forms should be used in order to find out the autochthonous component, since planctonic taxa are subjected to transport more frequently. Rare taxa, present in large numbers may also be regarded as autochthonous (BROCKMANN, 1940). A further discrimination may be based on ecological data. Sometimes the presence of rheophilous forms can be linked with lateral transport phenomena. A high degree of fragmentation does not necessarily coincide with transport over a long distance and should thus not be considered a very useful criterium. Recognition of vertical transport is often only possible when other (lithostratigraphic or paleontological) evidence is present as in the example given in Fig. 1.

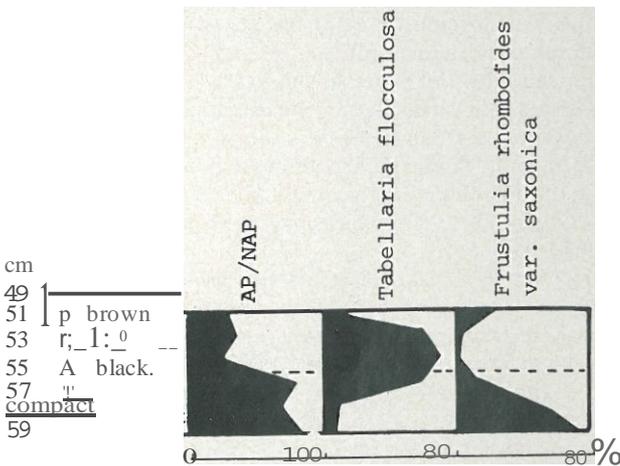


Fig. 1 Part of a section, taken in a bog at I-penrooi (Belgian Campine) showing a hiatus between 55 and 53 cm. (Beyens, 1980). An abrupt change in the vegetation (Arboreal/Non-Arboreal pollen) is observed at the same level, while the corresponding change in the diatom flora is situated beneath this boundary. This indicates that there has been a vertical migration of the *T. flocculosa* valves, which affected the composition of the assemblage at 55 cm in such a way that the percentage of *Frustulia*, which is in fact the most important autochthonous species at this level, is reduced to an insignificant value.

### Quantifying the allochthonous component

Knowledge of the amount in which allochthonous valves are present in analysed samples can give valuable indications on the physical and hydrographical environment during deposition and can simplify the interpretation of the data obtained. We can try to quantify the allochthonous component in such a way that subsequent samples can be compared mutually.

The following method uses salinity dependence and benthonic life style to differentiate allochthonous valves from autochthonous ones. It should, however, be mentioned that other ecological requirements (pH, trophic conditions, . . .) can be used in the same way. The salinity group in the classification of VAN OER WERFF & HULS (1957-1974) with the largest percentage of benthonic forms, the 'optimal group', is calculated for each sample. The percentage of this group is added to those of the two 'neighbour groups', giving a good estimation of the autochthonous group. Next, the percentages of the allochthonous groups on the fresh-water side and on the marine side of the autochthonous group are calculated and expressed as ratios (F- and M-values) of this group. An exemplary calculation follows:

optimal group	brackish	30%	
neighbour groups:	brackish-fresh	15%	
	brackish-marine	10%	
<hr/>			
	L	55%	autochthonous component
fresh-water allochthonous group:	fresh-brackish	5%	
	fresh	1%	
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	L	6%	F-value: 0,11
marine allochthonous group:	marine-brackish	20%	
	marine	19%	
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	L	39%	M-value: 0,71

Graphic figuration of these values, as in Fig. 2, gives a clear picture of the changes in the influx of allochthonous valves.

### FRAGMENTATION

One of the most annoying disturbances, when counting a diatom slide, is the presence of broken valves. It is only in some more recent papers (e.g. CLARYSSE, 1974; PALS, ET AL., 1980; VOORRIPS & JANSMA, 1974) that this evil has been faced, and taken into account when interpreting the data.

### Causes

Fragmentation by abrasion can result from various types of transport. This transport does not necessarily occur over considerable geographic distances. As a result of repeated resuspension by wave- or tidal action, a valve may be transported over a very long distance and still not be embedded far from its

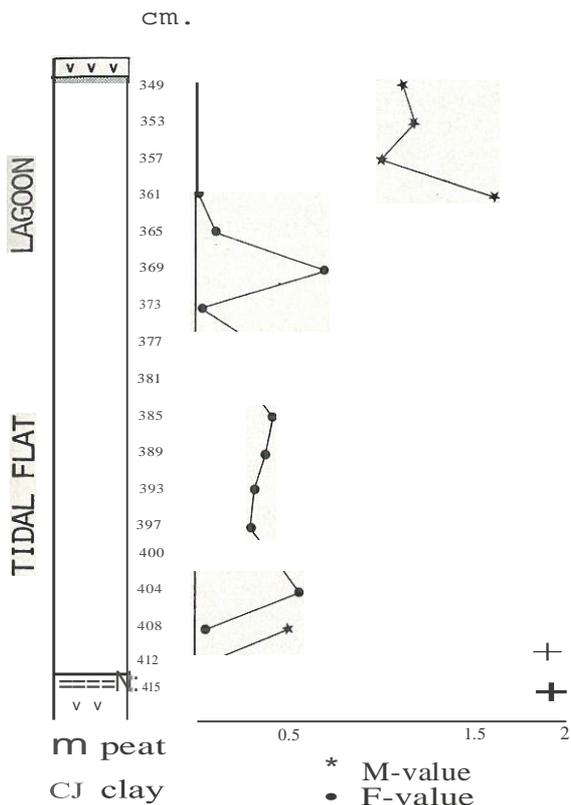


Fig. 2  
M- and F-values for an Atlantic-Subboreal Calais deposit *Erom Slijpe* (western Belgian coastal plain) (Denys, 1981). Arrows mark the onset of transgressive sea level changes. Samples at the 415, 408-373, 369 and 365 cm levels represent high salinity environments (brackish-marine to marine). Samples at the 373 and 361-349 cm levels were deposited in a brackish environment, the sample at 412 cm in fresh-brackish water. The high M-values for the lagoon stage indicate that this lagoon was connected with the open sea.

original place. Sometimes, strong fragmentation can be correlated with the existence of a nearby coastline (BERGLUND, 1971) or with a very shallow environment (DENYS, 1981). Fragmentation can only be used to indicate long-distance transport when clearly allochthonous valves are involved. Even in such a case there is no certain relation between transport and fragmentation, as indicated by the observation in a Subatlantic bog section that there was no correlation between the appearance of allochthonous *Meridon* valves, suggesting temporary floodings, and the number of fragments. Corrosion of valves is strongly enhanced by exposure to the air, especially in coarse sediments (BROCKMANN, 1940). Not only abrasion by wind, but also vegetation, percolating water, heating and strong temperature fluctuations will add to this effect. When other evidence exists, bad preservation of valves can be related with a period of exposure of the deposit to the air (PALS ET AL. 1980; DENYS, 1981). Storm surge deposits are also characterised by strong fragmentation (BROCKMANN, 1940). Fragmentation may also result from sediment compaction, predation (SCHRADER, 1979) or sample pretreatment. In general, large valves will break more easily than small ones.

*Including fragments in the total sum*

When a considerable number of the valves has been broken, one may ask whether these fragments should be included in the quantitative analysis, and if so in what way? CLARYSSE (1974) found that the number of fragments was proportional to the number of complete valves. Obviously, in such a case the counting of fragments will be of little or no use when working with relative percentages of taxa. In many other samples, however, certain species are almost solely found as fragments, making it appropriate to make an estimation of the original number of valves from which these fragments originated.

This may be done for each taxon present as follows:

- count the number of apical fragments and divide it by the number of apices of a complete valve
- count only those fragments which include at least half of the central part of the original valve
- when dealing with fragments of round valves, count those valves which include more than half of the central part as whole valves, those that include about half of the central part as 1/2 valves and so on . . .

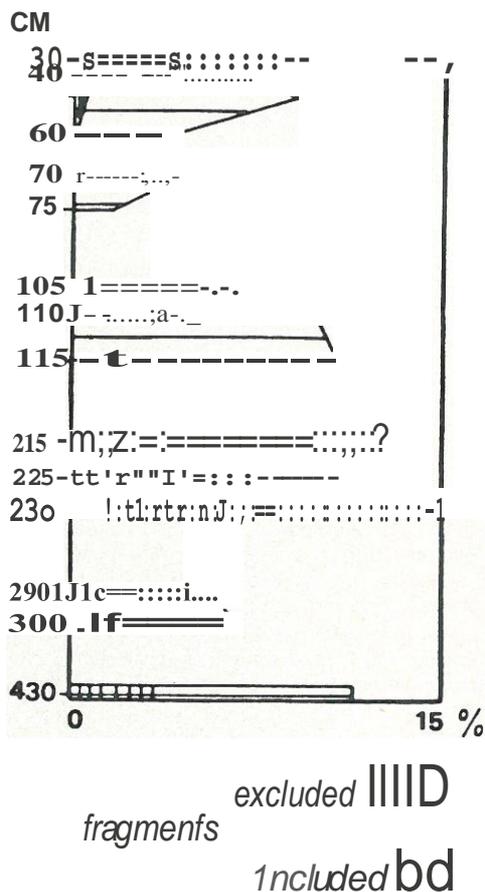


Fig. 3  
Differences in the evolution of the relative frequencies of *Pinnularia viridis* in a Holocene bog section from Wortel (Belgian Campine) when the fragments are excluded and included ('Mean-number' method) in the total sum.

– calculate the 'mean number' of complete valves (for valves with a more strongly developed apical axis) by means of the formula:

$$N = \frac{na + n}{2}$$

with n: the number of fragments

a = 1/L, being the mean length of the fragments,

L being the mean length of the complete valves.

Since a is species and sample specific, the last method can be very time-consuming. In addition, following difficulties may arise:

- if not enough complete valves are present to calculate a meaningful value of L, a similar value must be derived from literature data or if possible from a known length/width ratio
- larger valves break more rapidly than small ones so L will be underestimated
- fragments cannot always be identified.

Fig. 3 illustrates the difference in the quantitative importance of *Pinnularia viridis* in a holocene bog section, between inclusion and exclusion of fragments in the sum by means of the 'mean number' method.

Although the inclusion of fragments in the sum is time consuming and always loaded with errors, its advantages may be worthwhile for any palaeoecological interpretation of diatom data.

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