APPLICATION OF SIMPLE ARITHMETIC RATIOS TO STUDY OF DSDP BLACK SEA CORES

ALFRED TRAVERSE

Department of Geosciences, The Pennsylvania State University, U.S.A.

ABSTRACT

Steppe/forest (" SFI ") and marine influence (" MI ") curves have been used in study of DSDP Black Sea cores to demonstrate the occurrence of palaeoclimatic and palaeosedimentological events in the Black Sea basin. " SFI " is calculated as a modified ratio of certain herb and shrub pollen to tree pollen, " MI " as a modified ratio of dinoflagellates and acritarchs to pollen. One peculiar dinoflagellate type (" dinoflagellates 19-20 ") turns out to be a fresh-water dinoflagellate, and its counts must therefore be excluded from " corrected MI ". Cyclical deposition of thin Seekreide layers in the Black Sea is often related to high dinoflagellate 19-20 counts and usually to high " SFI " (indicating dry-cold climate), but not in any consistent way to corrected " MI ".

DSDP Leg 42B (*Glomar Challenger*) cored sediments at three sites in the Black Sea, representing about 11×10^6 years of sedimentation. Site 381 reached a bit deeper into the Miocene, but Site 380 represents the most nearly complete sequence of sedimentation in the Black Sea basin of the three sites cored (cf. Hsü, in press).

The gross problems for which palaeopalynological solutions were sought were (i) age-dating of the sediments, (ii) indications as to environment of deposition, and (iii) palaeoclimate in the Black Sea basin during Neogene time.

Pollen/spore data did permit the speculation while on board that both Site 380 and 381 reached Miocene sediments (cf. Traverse, in press). This was based primarily on the abundance of *Engelhardia* pollen, associated with palm pollen and various early Neogene tricolporate forms. More exact dating based on pollen/spores is tricky because it depends largely not on extinctions but on relative abundances in correlation with those of other places, mostly rather remote from the Black Sea. Some indications of Neogene chronology were apparent, however, from these relative abundances — for example, the onset of cold climate in the late Pliocene or early Pleistocene.

It was apparent, however, from palynological studies on board the *Glomar Challenger* that the analyses of samples fluctuated so much that methods must be sought to present the data in a more clearcut way than is customary in most late Neogene palynological studies. In particular, a method of graphic presentation was sought that would express the degree to which the palynoflora was dominated by steppe elements (primarily chenopods & *Artemisia* spp.), as opposed to forest elements (tree pollen of various genera). This was achieved by calculation of a Steppe-Forest Index (" SFI "):

$$\frac{\textit{Artemisia} + \text{Chenopodiaceae} + \text{Amaranthaceae}}{\text{(the above)} + \textit{Pinus} + \textit{Cedrus} + \textit{Picea-Abies} + \textit{Quercus} + \textit{Alnus} + \text{Ulmaceae (and other tree genera)}} \times 100$$

The idea resulted partly from careful study on board the *Glomar Challenger* of curves presented in van der Hammen *et al.* (1971). High " SFI " ratios indicate cool-dry climatic conditions in the Black Sea drainage, low ratios imply comparatively warm-moist conditions.

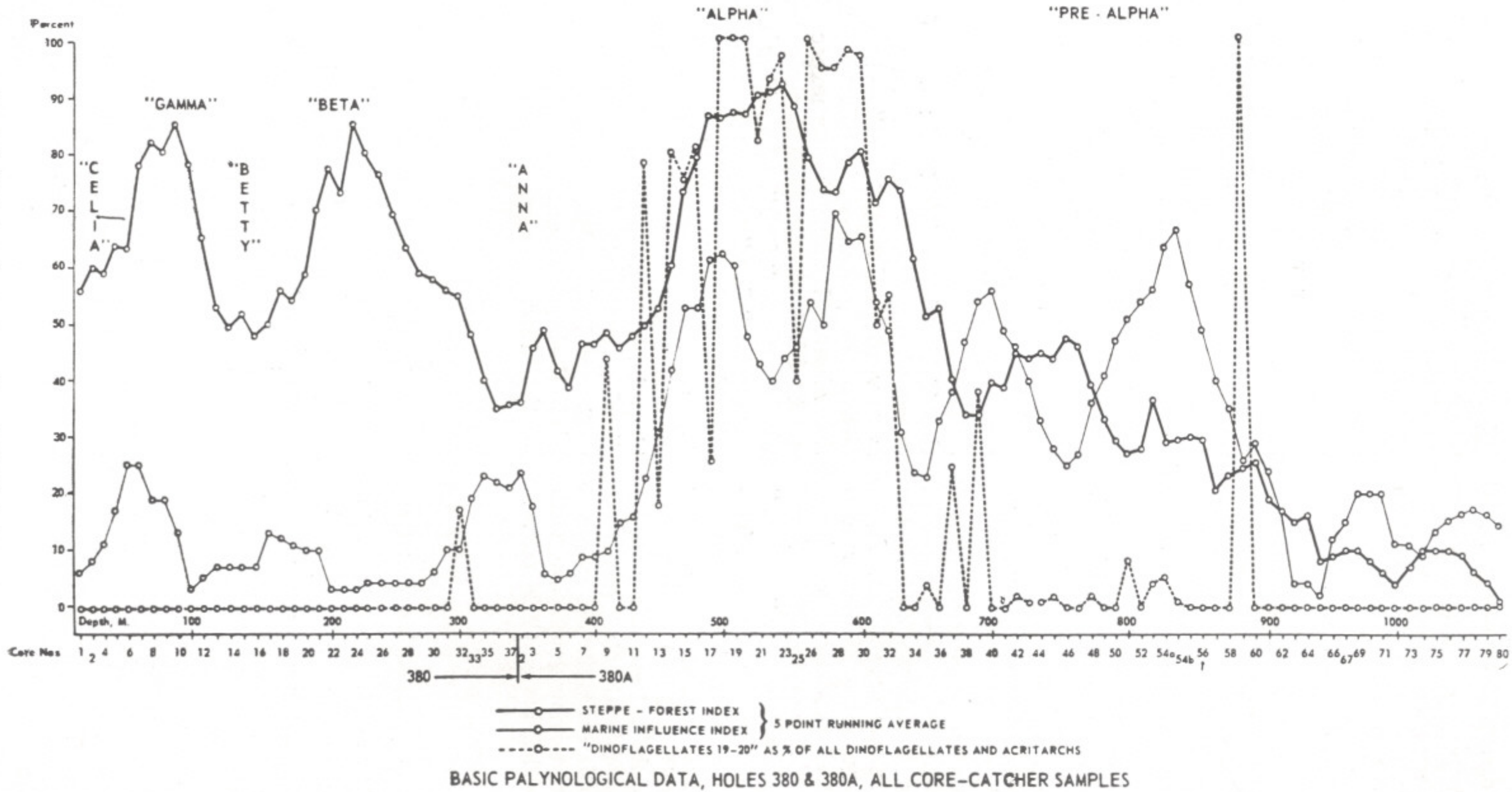
Later it became desirable to find some way of showing the degree to which the Black Sea palynofloras were dominated by palynomorphs indicating marine or partially marine conditions, and a Marine Influence Index (" MI ") was used:

$$\frac{\text{Dinoflagellates} + \text{Acritarchs}}{\text{(the above)} + \text{total pollen}} \times 100$$

High " MI " would imply in general more saline water than low " MI ". The data agreed with other lines of evidence in indicating that the Black Sea during much of the Neogene was a fresh-water lake. Previous models based on study of piston-cores of late glacial and post glacial sediment had indicated a close relationship between climate and marine transgression — more marine water in warmer times (cf. Traverse, 1974). The Leg 42B studies showed that more marine conditions did in fact occur with some of the colder parts of the Pleistocene. However, it has recently been pointed out to me by K. J. Hsü, that one of the most abundant dinoflagellates in the Black Sea sediments, " dinoflagellates 19 and 20 ", in fact is associated with fresh-water diatoms and ostracods and must be an essentially fresh-water dinoflagellate. This suggests that the " MI "

TABLE 1 — PALYNOLOGICAL INDICES FOR PRESUMED SEEKREIDE SEDIMENTOLOGICAL CYCLES, DSDP LEG 42B, BLACK SEA

SITE No.	CORE, SECTION & INTERVAL (in cm)	TRAVERSE SLIDE No.	" SFI " (%)	" MI " (%) (corrected- see text)	" DINOFLAGELLATES 19 + 20 ", % OF TOTAL DINOFLAGELLATES + ACRITARCHS	SEDIMENTOLOGICAL COMMENTS
379A	29 : 5 : 97-98	1-2-3	73	36	10	light
379A	29 : 5 : 101-103	1	32	5	5	dark
379A	29 : 5 : 2-3	1	19	8	7	diatom black mud
379A	50 : 5 : 147-148	2	48	5	94	light
379A	50 : 5 : 149-150	1	36	6	70	dark
379A	58 : 4 : 37-39	1	17	6	93	light
379A	58 : 4 : 41-42	1	22	15	68	dark
379A	58 : 4 : 68-69	1	72	6	93	light
379A	58 : 4 : 70-71	2	14	8	83	dark
379A	60 : 2 : 10-12	1	55	4	95	light
379A	60 : 2 : 6-9	1	9	21	35	dark
379A	60 : 2 : 15-17	3	83	3	97	light
379A	60 : 2 : 13-14	3	35	19	38	dark (pyrite)
379A	67 : 2 : 130-131	1	93	25	66	light
379A	67 : 2 : 134-135	1	18	50	5	dark
380A	12 : 4 : 41-42	1-2	83	19	29	light
380A	12 : 4 : 43-44	1-2-3	1	5	6	dark
		(this sample essentially barren)				
380A	14 : 3 : 52-53	1-2	67	27	65	light
380A	14 : 3 : 53-54	1-2-3	67	35	50	dark
380A	49 : 5 : 118-119	2	85	90	1	light
380A	49 : 5 : 119-120	1	10	58	1	dark
380A	53 : 2 : 117-118	1	63	42	2	light
380A	53 : 2 : 122-123	1	60	52	1	dark
380A	60 : 3 : 87-89	1	19	18	0	light
380A	62 : 2 : 95-97	1	35	2	0	dark
380A	65 : 2 : 126-127	2	12	3	0	light laminated
380A	66 : 1 : 27-28	1	29	3	0	black & white laminated
380A	69 : 4 : 130-132	1	10	12	0	dark mud
380A	71 : 2 : 143-145	1	3	7	0	black
381	38 : 1 : 134-136	1	0	38	40	no data
381	38 : 1 : 141-143	1	47	0	99+	no data



TEXT-FIG. 1 — " SFI " and " MI " palynological plots (see text) for DSDP Leg 42B Site 380 (holes 380 & 380A). Relationship of glacial intervals " Alpha ", " Beta " and " Gamma ", interglacials " Anna " and " Betty ", and post-glacial " Celia " to these palynological indicators of steppe and marine conditions is displayed.

Note — " Marine Influence Index " (" MI ") is uncorrected — see text for explanation.

should better be corrected for this fact, as follows:

$$\frac{\text{Dinoflagellates (excluding 19-20)} + \text{Acritarchs}}{\textit{All}\ \text{Dinoflagellates} + \text{Acritarchs} + \text{total pollen}} \times 100$$

This is the " corrected MI " presented in Table 1.

At first " SFI " and " MI " were plotted as calculated for each sample. The fluctuation between samples was so great that major events of the later Neogene which really were present in the data were obscured. When the numbers were plotted as a running average of three or five samples (as first suggested to me on shipboard by A. Erickson & K. J. Hsü) however, the gross trends were obvious. For example, the onset of cold climate and major glaciations (by " SFI ") can be seen.

Text-fig. 1 shows the combined " SFI " and " MI " (uncorrected) curves for Site 380-380A, mostly based on core-catcher samples (cf. Traverse, in press). The figure also displays the abundance of the remarkable dinoflagellates 19 and 20, bag-like forms that in many samples completely dominate the flora, representing fantastic " blooms " of this organism, at first thought (cf. Traverse, in press) to be a brackish water form (largely because of the comparative rarity of fresh-water dinoflagellates), now known to be almost certainly of fresh-water origin. Some of the (uncorrected) " MI " peaks are caused by dinoflagellates 19-20. These peaks can be detected at once by comparison with the associated dinoflagellates 19-20 curve.

Table 1 shows an example of another application of " SFI ", corrected " MI ", and associated data. K. J. Hsü has suggested that the apparently cyclical deposition of light and dark layers of sediment in parts of the Black Sea cores is related in some sensitive way to environment of deposition. Light layers are relatively high in $CaCO_3$, and these chalky layers are thought by Hsü to be analogs of Swiss lake " Seekreide ". The light layers of " cycles " selected by Dr Hsü are often very high in dinoflagellates 19-20. The circumstances encouraging $CaCO_3$ deposition also apparently encouraged growth of dinoflagellates 19-20. This Table also shows that " SFI " is generally (but not always) higher in the light layers of these " cycles ". " SFI " as a measure of cold-dry climate on shore might be expected to be independent of short-range differences in depositional environment in the water, but this Table shows (cf. 379A: core 67, for example) that samples only 3 cm apart can have vastly different " SFI " — bespeaking either very great climatic differences within a few hundred years, or an unexpected element of influence of local depositional environment on " SFI ". In either case, it shows that " SFI " can best indicate *general* climatic trends over hundreds of metres of core when plotted on the basis of a running average of data in the manner displayed in Text-fig. 1. " MI ", corrected by removal of dinoflagellates 19-20, is not closely connected to Seekreide deposition on the one hand or of the darker terrigenously derived sediment on the other.

REFERENCES

HSÜ, K. J. (in press). 15. Stratigraphy of the lacustrine sedimentation in the Black Sea. *Initial Reports of the Deep Sea Drilling Project*, **42B**.

TRAVERSE, A. (1974). Palynologic investigation of two Black Sea cores. *Amer. Assoc. Petrol. Geol. Mem.*, **20**: 381-388.

TRAVERSE, A. (in press). Palynological analysis of DSDP Leg 42B (1975) cores from the Black Sea. *Initial Reports of the Deep Sea Drilling Project*, **42B**.

VAN DER HAMMEN, T., WIJMSTRA, T. A. & ZAGWIJN, W. H. (1971). 15. The floral record of the late Cenozoic of Europe, in: Turekian, K. K., (Ed.): *The Late Cenozoic Glacial ages*. Yale Univ. Press: 391-424.