circulation at the beginning of the Miocene. The discrepancy in sedimentation rate profile of site 18 shows the same pattern in greater detail. An east-west fertility gradient may also play a role. Unfortunately, the crucial interval allowing investigation of the east-west differential was drilled, not cored.

Non-deposition and erosion, especially well documented for the Miocene record, are the more pronounced the greater the depth of deposition. This is expected if dissolution and the active flow of bottom water increase with depth and if these agents are responsible for the nonconformities observed. The eastern site 17 and the western site 14 show similar patterns, suggesting that non-deposition at 3,750 m depth started a little after 20 m.y. ago in both basins, unless, by chance, backward erosion proceeded to isochronous levels at these sites. Intense solution at depths below 4,000 m in both basins appears a likely agent for preventing accumulation of calcareous sediments during most of the Miocene. An east-west solution differential again seems to be present: the hiatus at 17 may be less complete than that of 14. Unfortunately, the interval was not bracketed by coring. In the western basin, and at greater depths (sites 19, 20), non-deposition started earlier, unless considerable backward erosion took place. Since nonconformities are bounded by slowly accumulating facies, however, deposition probably ceased gradually. Non-deposition and intermittent erosion at 4,000 m depth in the western trough consequently started 25 m.y. ago.

The trend of increased dissolution during Middle Miocene, terminated by enhanced calcareous sedimentation during the Pliocene, agrees with the trend in the North Atlantic (sites 10, 12, *JOIDES* 2 (ref. 1), and site 140, Scientific Staff, Leg 14 (ref. 2); see also Hay[3,4]). Ocean-wide trends within the Atlantic are expected, if bottom water circulation (influx of AABW, west of North Atlantic Deep Water production) and exchange with the Mediterranean (possible closing and reopening of straits of Gibraltar[19]) and the Pacific (closure of Panama isthmus) are responsible for the changes in carbonate patterns through time. Local tectonic uplift and subsidence would not provide this agreement over a large area.

Major redeposition of ridge chalk downward may have played a part in forming *Buarudosphaera* chalks at site 14, since sedimentation rates here are unusually high.

The lack of control for pre-Oligocene patterns and the possible complexity of the pre-Oligocene bathymetry of site 20 (which is much too shallow for its age) make interpretation of this part of the record rather hazardous. Among other factors, the relative importance of mechanical erosion and non-deposition and of chemical dissolution in Gazelle and Orondelle Formations must be clarified before low sedimentation rates within these units can be explained. (Being west of the Rio Grande Rise, the local tectonic history of sites 19 and 22 may be even more complicated. For the purpose of establishing general patterns, I have disregarded them.) The one available site from the North Atlantic that is instructive for a comparison of pre-Oligocene carbonate history is site 10 of *JOIDES*, Leg 2. At this site, sediments apparently were laid down near the CCD throughout Early and Middle Eocene. According to age-depth constancy, the site moved down-flank during this time by some 250 m. The CCD may have moved downward by the same distance.

It appears that the present distribution of carbonate facies is largely a result of seafloor spreading, changes in dissolution cycles, and local tectonism and redeposition processes. The hypothesis of age-depth constancy is well founded in present day observation and allows mapping of the major features of the carbonate record, at least for the post-Eocene in the Atlantic Ocean. (E. L. Winterer used the age-depth data of Luyendyk *et al.*, as well as other variables, to account for the distribution of sediment thicknesses in the equatorial Pacific: annual meeting of Geol. Soc. America, Washington, DC, November 1971.) Once bathymetrically controlled ancient solution levels have been reconstructed for the ridge flanks at various geological times, it will be possible to use these levels to follow the history of oceanic circulation as well as to elucidate tectonic movements in more complicated regions.

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[1] *JOIDES, Initial Reports of the Deep Sea Drilling Project*, 1-7 (US Government Printing Office, Washington DC, 1969–1971).
[2] Hsü, K. J., and Andrews, J. E., in *JOIDES*, 3 (1970).
[3] Hay, W. W., in *JOIDES*, 4, 669 (1970).
[4] Hay, W. W., *Science*, **172**, 1197 (1971).
[5] Sverdrup, M. U., Johnson, M. W., and Fleming, R. H., *The Oceans*, 1004, Fig. 259 (Prentice-Hall, 1942).
[6] Lisitzin, A. P., in *The Micropalaeontology of Oceans* (edit. by Funnel, B. M., and Riedel, W. R.), 206 (Cambridge University Press, 1971).
[7] Berger, W. H., *Deep-Sea Res.*, **15**, 31 (1968).
[8] Berger, W. H., *Marine Geol.*, **8**, 111 (1970).
[9] Berger, W. H., *Geol. Soc. Amer. Bull.*, **81**, 1385 (1970).
[10] Berger, W. H., *Marine Geol.*, **11**, 325 (1971).
[11] Olausson, E., in *The Micropalaeontology of Oceans* (edit. by Funnell, B. M., and Riedel, W. R.), 375 (Cambridge University Press, 1971).
[12] Sclater, J. G., Anderson, R. N., and Bell, M. L., *J. Geophys. Res.*, **76**, 7888 (1971).
[13] Menard, H. W., *Earth Planet. Sci. Lett.*, **6**, 275 (1969).
[14] Sclater, J. G., and Francheteau, J., *Geophys. J. Roy. Astron. Soc.*, **20**, 509 (1970).
[15] Maxwell, A. E., Von Herzen, R. P., Hsü, K. J., Andrews, J. E., Saito, T., Percival, S. F., Milow, E. D., and Boyce, R. E., *Science*, **168**, 1047 (1970).
[16] Berggren, W. A., *J. Foram. Res.* (in the press).
[17] Pimm, A. C., in *JOIDES*, 3, 495 (1970).
[18] *Geotimes*, **16** (2), 14 (1971).
[19] *Geotimes*, **15** (10), 12 (1970).
[20] *Geotimes*, **15**, Nos. 2, 4, 7, and 9 (1970).
[21] *Geotimes*, **16**, Nos. 2, 6, and 9 (1971).

Chlorinated Hydrocarbon Residues in Airborne Fallout

IN an analysis of the input and output of chlorinated hydrocarbon residues in a freshwater ecosystem in south Sweden, the amount entering the study area by means of precipitation and by airborne particles was estimated.

The fallout was trapped on a 200 μm nylon net (30 × 30 cm) which, in a standardized procedure, had been impregnated with a thin film of silicone oil (SE 30). The chlorinated hydrocarbons are collected and retained in the oil. Small particles, organic as well as inorganic, also become firmly attached to the net.

The impregnated nets were exposed in open places for 2–3 months. After collection, the nets were washed in Soxhlet extractors with n-hexane for 2 × 24 h. The hexane solution was evaporated to a suitable volume, cleaned by treatment with concentrated sulphuric acid and dried with anhydrous sodium sulphate and silica gel. An aliquot of the extract was injected on a gas chromatograph with electron capture detectors, and the relative retention times were estimated and compared with retention times of known substances. As a reference for polychlorinated biphenyls (PCB), a commercial product ('Clophen A 50') was used.

The samples were run on three different columns with SF 96 (4%), QF 1 (8%) and SF 96/QF 1 (3 : 1) as the stationary phases on 'GasChrom P' (100/120 mesh). The temperatures of the injection block, column and detector were 225°, 175° and 190° C, respectively.

The identity of the more important peaks in the chromatograms was confirmed by chemical methods. *p,p'*-DDT was hydrolysed to *p,p'*-DDE by boiling with alkali solutions, and

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this product was estimated by gas chromatography. *p,p'*-DDE, which interfered with some of the PCB peaks, was decomposed by oxidation with chromic acid. The chemical procedures did not affect the polychlorinated biphenyls[1].

The relative frequency of wind directions in the area of the fallout stations during the year (average values from 1961–1965) shows that the most frequent direction is W to SW (Fig. 1). This means that the study area is subjected to airborne material originating from industries along the Swedish west coast and in the Copenhagen area, as well as from heavily industrialized districts in West Germany. Stations A, D, E, F and G are situated in agricultural districts, station C in the city of Lund and station B in the city of Malmö, close to a disposal plant for municipal refuse.

The average monthly levels in ng/m² of ΣDDT (*p,p'*-DDT+*p,p'*-DDE) and PCB trapped in the fallout devices during 3 months (January, February and March 1971) show significant differences in the regional distribution of chlorinated hydrocarbon residues in the airborne fallout (Fig. 1). High levels of PCB were recorded in the western part of the region; for ΣDDT, no such distinct distributional pattern was found. In some of the samples analysed, unidentified electron-absorbing substances were also found; these are being subjected to mass-spectrometric investigations.

The differences between stations A and B are small, in spite of their different locations. Station A, situated on the seashore in an agricultural district, shows higher levels of PCB than station B, located just outside a big disposal plant for municipal refuse. At this plant, daily incineration of garbage is usual and it might be expected that waste products containing PCB would be burnt with the varied refuse. Being highly resistant to heat, polychlorinated biphenyls escape to the atmosphere and contaminate the environment. Since the wind direction is most frequently W to SW, station A is subjected chiefly to airborne products originating from across the Sound (Öresund), while station B (located east of the disposal plant) is also exposed to fallout from the plant.

A local source is presumably responsible for the relatively high amount of PCB recorded at station D, although the origin of this deposit is still unknown.

Stations C, E, F and G showed small to moderate levels of PCB, as was the case with station H, located in a forest district in south-central Sweden (Table 1). The amount of PCB and ΣDDT collected at station E from August 1969 to December

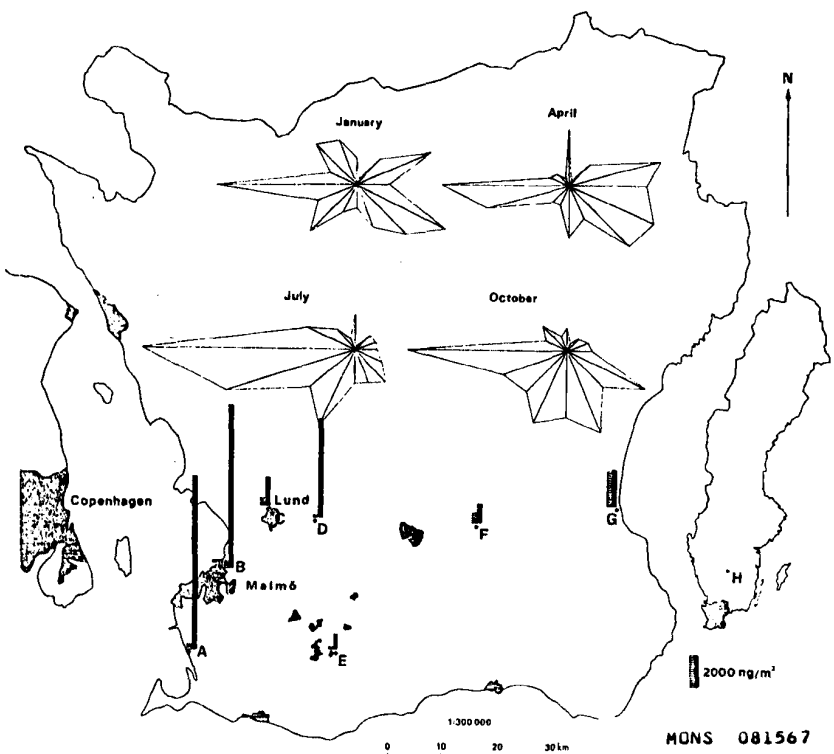


Fig. 1 Average monthly levels of PCB and ΣDDT in airborne fallout collected in south Sweden (ng m⁻² month⁻¹). Relative frequency of wind directions is indicated in the upper part of the figure.

1970 was fairly constant, but there was a significant increase in PCB collected during the period February to April 1970. Compared with the rest of the year, this period was characterized by a high mean precipitation (78 mm/month) which probably influenced the amount of airborne particles deposited.

Table 1 Average Monthly Levels of ΣDDT and PCB in Airborne Fallout collected in South Sweden (ng m^{-2} $month^{-1}$). The Symbols for the Collection Sites refer to Fig. 1. ΣDDT = *p,p'*-DDT + *p,p'*-DDE

Collecting site	Period of collection	ΣDDT	PCB
A	January–March 1971	330	10,510
B	January–March 1971	415	9,860
C	January–March 1971	460	1,740
D	January–March 1971	170	5,980
E	August–October 1969	1,200	910
	February–April 1970	1,350	4,460
	May–July 1970	1,300	1,590
	August–October 1970	690	550
	November–December 1970	230	1,800
	January–March 1971	200	850
F	January–March 1971	1,650	1,900
G	January–March 1971	2,075	2,190
H	January–March 1971	100	620

The regional distribution of ΣDDT was more uniform than that of PCB. In the study area, DDT has been used in moderate quantities mainly for spraying various crops. Since 1970, the use of DDT in gardening and agriculture has been prohibited in Sweden and only a restricted amount is being used in forestry. In spite of these restrictions, DDT was found in airborne material collected at various stations. It is not clear whether the DDT originated within the region or had been transported from places far away.

It has been shown that nearly half the amount of DDT applied to the surface of the soil in field conditions may volatilize, thus making a slow, long term contribution to the atmosphere[2]. Direct drift has been found to occur from spraying operations, especially when using aerial application[3].

The origin and general routes of transport of PCB compounds to the environment are, however, not fully understood. They are not spread around on the land as pesticides, but are used chiefly in industry as heat transfer media, lubricants and for insulation. They are also used in paints, varnishes, waxes and synthetic resins to improve chemical resistance, adhesiveness and flexibility[4,5]. Vapours and effluents from industrial processes using PCB compounds may contribute to their dispersal as may discarded manufactured products. Holden[6] has shown that crude sewage sludge can constitute a source of entry to the environment.

In a study of chlorinated hydrocarbon residues in rainwater, Abbott[7] demonstrated that the higher levels of DDT found in London rainwater, compared with that from a rural area, could be attributed to London air having a higher content of particulate matter, for which DDT has affinity. There is no estimate of the distribution of particulate matter in the air of the study area, but it is assumed that the atmosphere in the more populated and industrialized parts (for example, the region along the Sound) is more polluted than elsewhere. Because PCB also has strong affinity for particulate matter, the same mechanism of dispersal in the atmosphere may operate for both substances, thus influencing the regional distribution of PCB.

The evidence presented here indicates a general occurrence of PCB compounds in airborne fallout. It is suggested that transport by air or airborne particles is one of the main routes in the dispersal of PCB. In southern Sweden, there is regional variation in PCB levels. Correlated with the prevailing winds it is suggested that part of the PCB compounds originated not within the study area but further afield.

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1 Westöö, G., and Norén, K., *Acta Chem. Scand.*, 24, 1639 (1970).
2 Lloyd-Jones, C. P., *Nature*, 229, 65 (1971).
3 Frost, K. R., and Ware, G. W., *Agricultural Engineering*, 51, 460 (1970).
4 *Monsanto Company Tech. Bull.*, No. PL-306, 50 (1960).
5 *Encyclopedia of Chemical Technology*, 5, 289 (1964).
6 Holden, A. V., *Nature*, 228, 1220 (1970).
7 Abbott, D. C., Harrison, R. B., Tatton, J. O'G., and Thomson, J., *Nature*, 208, 1317 (1965).

Plasma Pyrolysis of Coal

When coal is heated rapidly to temperatures above 1,250° C, the emitted volatiles are cracked to yield lower hydrocarbons which, if conditions are favourable, will consist mainly of acetylene. Such conditions involve reaction times of only a few milliseconds coupled with very rapid quenching rates.

A variety of energy sources has been used to achieve rapid heating rates[1-7]. Although the temperatures and residence times to which the coal has been subjected in these various investigations differ widely, there is a similarity in the nature of the products obtained. The products consist principally of soot and gas; in most cases little or no tar is formed. At the temperatures used acetylene formation is thermodynamically favoured and significant quantities can be detected in the gas.

Work on the high temperature pyrolysis of coal started at Sheffield in 1962. James[8], and later Deyasi[9], pyrolysed coal

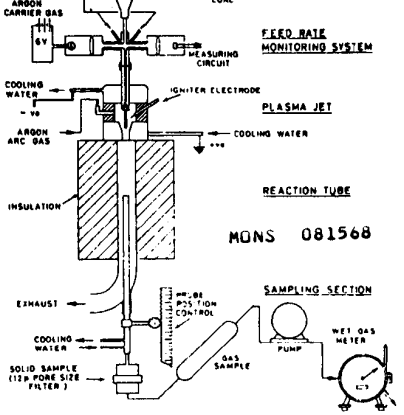


Fig. 1 Schematic diagram of plasma jet apparatus.