Hydraulics Research
Wallingford

VERTICAL PROFILES OF HEAVY METALS AND ORGANIC CARBON IN SEDIMENTS OF EASTERN LIVERPOOL BAY

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ABSTRACT

Depth profiles of metal and organic carbon concentrations are given for a set of seventeen sediment cores recovered from the approaches to the Mersey Estuary in 1983. The primary objective is to provide data on the thickness of the bed layer penetrated by man-made metals adsorbed on the fine-grained fraction of the sediment. The information is required to help in setting up a numerical model of Liverpool Bay and the Mersey Estuary with which Hydraulics Research are examining the movement and deposition of sewage sludge particulates. Seaward of the Mersey Bar, mixing depths of 0.1m were typical in water depths in excess of 15m. Nearer the Mersey, cores taken in the vicinity of discontinued and existing grounds for dredged spoil showed metal enrichment to at least 0.7m. Whether this depth can be taken as the thickness of bed layer that is regularly disturbed or whether it represents the net deposition from past disposal of dredgings is not known. Suggestions are made for future work.

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FIGURES

1. INTRODUCTION

Hydraulics Research (HR) have reported (Ref.1) on the feasibility of modelling mathematically the transport and physical dispersal of heavy metals in Liverpool Bay and the Mersey Estuary. The reproduction of water and fine sediment movements by a model together with the transfer of metals between the water and sediment phase by adsorption and desorption should make possible the prediction of the effects of changes in heavy metal input consequent on various strategies for sewage treatment on Merseyside. In addition to outlining the conceptual framework for the model a number of areas were identified by the desk study for which new data needs to be collected, either to improve the quality of various inputs to the model or to guide the modelling of processes that control quasi-steady concentrations of heavy metals in the Bay sediments. Prominent in the latter category is the requirement to be informed on the depth of seabed through which man-made heavy metal contaminants penetrate. Information is sparse on the depth of disturbance brought about by the processes of scour and accretion or turned over by the benthic organisms.

It was decided therefore to take a number of undisturbed sediment cores in the eastern part of Liverpool Bay in order to examine the upper sedimentary strata for heavy metals and organic matter. Locations were chosen to sample muddy sediments in the path of the Mersey outflow or on the line of suspected sludge migration, as well as at current or discontinued spoil grounds for dredgings from the Mersey and its docks (Fig. 1).

2. CORE RECOVERY

The vessel "Branding" was chartered from the Carmet Tug Company, Birkenhead and 17 cores were recovered on 9 February 1983. In order to obtain sufficient bed penetration HR in this instance employed its one metre long 50mm diameter vibro-corer instead of the 125mm diameter version used on its regular bed monitoring surveys (Ref.2). The latter is limited to a sample depth of 0.3m or less. The longer corer recovered core lengths that varied from 0.5 to 0.9m dependent on bed composition. Its structural design and smaller barrel bore have the disadvantage that physical disturbance of the bed surface is more likely, and could lead to preferential loss of low density organic material and any organic-associated metals from the uppermost stratum than has been customary with the 125mm diameter vibro-corer.

The cores were extruded from their PVC liner using compressed air on-board shortly after recovery and split into strata as follows: top 25mm; the next 75mm; and at 100mm intervals thereafter. The core division was carried out with a stainless steel spatula on a polystyrene tray to guard against contamination and returned to the laboratory in polythene bags.

3. LABORATORY TREATMENT AND ANALYSIS

HR's normal practice of determining the heavy metal and organic carbon content of only the mud fraction ($< 63\ \mu m$) was again adopted for the core strata. The mud fraction was first separated by washing each sample through a stainless steel sieve with tap water, air-dried, crushed and placed in a vacuum desiccator for 24 hours. Heavy metal and organic carbon determinations were normally made on subsamples but where the quantity of mud was insufficient for both, the organic carbon analysis was omitted.

Analytical procedures were the same as employed on previous HR work in Liverpool Bay sediments. With the exception of mercury, heavy metals were determined by atomic absorption spectrophotometry after dissolution in nitric/perchloric acid, evaporation to dryness and redissolving in hydrochloric acid. Mercury was measured separately by the cold-vapour atomic absorption method. All heavy metal analyses were carried out by a commercial analytical laboratory and concentrations have been adjusted in accordance with a number of standards that were incorporated with the sample batches (Ref.3, page 3). The metal extraction procedure is a vigorous one and, with the exception of chromium, results in values that correspond to essentially the total metal content of the mud fraction. The chromium values are perhaps only 60 per cent of total chromium content but are comparable with earlier reported results (Ref.3).

Organic matter was determined by wet oxidation of the carbonate-free dried mud fraction with the gravimetric estimation of the evolved carbon dioxide. Again as on previous surveys the organic carbon is reported as organic matter by the simple expedient of multiplying by a factor of 2.5 to convert carbon to the equivalent of dried organic residues.

4. RESULTS

The full analytical results are given in Table 1. Figures 2 to 5 depict distributions of mud, organic matter and heavy metals with depth, arranged approximately to their relative locations in the Bay. Figure 3B illustrates the vertical distribution of the organic content of the sediment as given by the product of organic matter concentration and the proportion of mud and takes no account of any organic material that may be present in the non-mud fraction of the sediment.

4.1 Mud distribution

The bed to the north of Newcome Knoll features the most muddy sediments found on the survey with consistently high values of 50 to 90 per cent mud. Elsewhere only occasional strata exceed 25 per cent mud. Frequently marked variations in mud content are found over the core depth and confirm the sand/mud layering that has been evident on earlier surveys. The thickness of individual mud and sand layers is often less than the stratum interval of 100mm and therefore the presentation does not always do justice to the finer structure of the sedimentary layering.

In contrast the core recovered from the depression to the north of Newcome Knoll shows a uniformly muddy black sediment to at least 0.7m depth. Since its inclusion in 1981/82 in the regular bed monitoring pattern this low lying area has exhibited consistently high percentages of finer sediment. In the past it has received immense quantities of dredged spoil, taking much of the river and dock dredgings of the Mersey Docks and Harbour Board, the Manchester Ship Canal, Wallasey Corporation and others. For more than sixty years the buoy marking the deposit site was located either on the axis of the presentday Newcome Knoll or to the north of that bank. Between 1897 and 1927 51 million m^3 of spoil were dumped at a position on the line of the existing bank but slightly towards the estuary from the bank's eastern extremity. In 1927 the buoy was transferred 2.8 km to the northwest closer to the position held by the highest point of today's Newcome Knoll and a further 28 million m^3 were dumped up to the outbreak of war in 1939. After the war the deposit buoy was moved to a new site about 2 km north of Newcome Knoll which took another 18 million m^3 of spoil until use of the area was discontinued in 1960.

Thus during this century that part of Liverpool Bay within a few kilometres of Newcome Knoll has received nearly 100 million m^3 of dredged spoil, much of it derived from the docks and Inner Mersey and therefore tending to be fine-grained and contaminated by metals. Comparison of charted depths indicates that although the greater part of the spoil has been re-distributed over the Burbo Bank and probably back into the Inner Mersey accretion of 1 to 3m occurred in the vicinity of Newcome Knoll between 1912 and 1955 (Ref.4). It seems highly probable that the pool of fluid mud reported along the northern flank of Newcome Knoll (Refs.5 and 6) and also the muddy sediments more recently found on HR's bed monitoring survey and closely mapped by Lancashire and Western Sea Fisheries Joint Committee in 1983 (Ref.7) represent the finer residues of past disposal of dredgings in this locality. Retention of only 2 to 3 per cent of the dredging is the equivalent to the total dry solids input arising from sludge disposal this century.

4.2 Organic matter in the mud fraction

The organic carbon content of the fines is generally higher in the cores taken nearer the Mersey. Those taken on lines P, Q and R (Fig.1) not only display less organics but the majority show a decrease with depth. Such a decrease would be expected if the bed is subject to only shallow or occasional disturbance so that the underlying organic matter is slowly decomposing and is not replenished by mixing. The more uniform depth distributions that characterise many of the cores taken nearer the Mersey on line T are indicative of beds that are frequently re-worked probably by a combination of tidal and wave action.

It has been noted frequently from previous monitoring surveys that higher organic concentrations are recorded in the fine fraction if the surface sediments are deficient in fines (< 1 per cent mud). The sub-surface sediments on the other hand, at least for the locations sampled on the present survey, do not repeat this characteristic. A possible explanation is that the organic carbon in the surface sandy layers represents freshly settled organic particulates whereas those trapped in the underlying layers have clearly been deposited for some time and conditions in the sands have favoured their decomposition.

4.3 Heavy metals in the mud fraction

It is possible to distinguish between heavy metal profiles indicating only shallow bed disturbance as exemplified by cores taken on the P, Q and R lines; and the evidence of greater mixing depths or deposit thicknesses nearer the Mersey.

4.3.1 Lines P, Q and R

The tendency for cores from the zone midway between the sludge disposal ground and the Mersey (ie. lines P, Q and R) to show diminuition of organic material with depth is paralleled by a more striking reduction in the concentrations of several of the heavy metals at lower levels in the bed. The step from high to low concentrations of certain metals is often abrupt.

For instance the vertical distributions of mercury, copper, zinc and lead display a distinct boundary at a level that varies from core to core: 25mm for location R10; 100mm, R9: 100 to 200mm, P10, P12 and R11; 200mm, P9; 400 to 500mm, R12. Higher chromium concentrations are also sometimes associated with the surface layer whereas nickel displays a uniform distribution with depth. Metal concentrations in the bed beneath the contaminated surface layers are probably representative of background values for fine sediments in Liverpool Bay.

The following mean base-line values are derived from 35 strata taken beneath the zone of obvious contamination and constitute our best estimate for unpolluted sediments in the area.

	Mercury	Copper	Zinc	Lead	Nickel	Chromium
			µg/g			
Liverpool Bay	0.09 (0.05)	19 (8)	98 (30)	51 (33)	36 (6)	25 (6)
Clyde Estuary (Ref.8)		25	177	67	53	43
Solway Firth (Ref.8)		13	88	53		39
MAFF Surveys (Ref.9)	0.04-0.13	5-18	30-115	10-90	30-45	17-50

(figures in brackets refer to standard deviation of values on the present survey).

Values for marine or estuarine muds from other British sources thought to be free of anthropogenic inputs are also included above. Rather surprisingly the concentrations in the undisturbed sediment of the cores of the present study are well within the range of tabulated values, bearing in mind possible variations in laboratory practice and differing source rocks. It seems likely that the metal values are representative of the fines from boulder clay sources of the eastern Irish Sea. However, the metal values of the 35 strata that are accepted as the "unpolluted sediment" group do not disclose any distinctive typing in the proportions of the individual metals. Only one metal pair shows a positive correlation between their concentrations in the basal undisturbed strata; that between mercury and lead being statistically significant ($P = <0.001$).

Another common characteristic of the undisturbed strata is that they are relatively low in organic matter, having only 2 to 3 per cent compared with the 4 to 7 per cent that is typical of the surface values obtained on the regular monitoring surveys. In this instance the differences between the upper and lower strata cannot necessarily be taken as a change in the organic loading on the Bay. A natural reduction in the amount of organic matter at the undisturbed lower levels would be expected as a consequence of degradation since the sediment was deposited.

Apart from nickel the concentrations in the surface layers of the other five metals are many times higher than the base-line values. The contribution made by apparently anthropogenic sources accounts for approximate enrichment factors as listed below:

	Mean	Maximum
Mercury	X15	X35
Copper	X9	X65*, X28
Zinc	X4	X10
Lead	X6	X20
Chromium	X1.3	X3

* = single exceptionally high concentration.

4.3.2. North of the Mersey outflow (T12 to 15, U15)

It is difficult to decide whether the anthropogenic loading on the P,Q and R lines is primarily due to the contribution of Mersey-carried inputs from the east or whether it is in response to the migration and settlement of sludge particulates from the west. However, it seems reasonable to assume that the sediment of the geographical grouping which is the subject of this section is influenced primarily by Mersey derived inputs. The loading arises either directly from the Mersey outflow or from dredged spoil dumped about 8 km north and northwest of the outflow.

The five cores included in this group all show high values compared with background for mercury, copper, zinc, lead and chromium throughout the length of each core which ranged from 0.5 to 0.8m. The metal contamination persisted to the full depth of sampling irrespective of whether the core was moderately uniform in its mud content (T12, T13, T14) or included distinct sand and mud layers (T15, U15). However, in the case of the latter the meagre fines of the sandy sediments (less than 1 per cent mud) yielded copper and zinc concentrations in excess of the concentrations in the fines of the more muddy strata. The differences were even more pronounced for lead and chromium: concentrations in the fines of the predominantly sandy deposits being an order of magnitude higher.

The metal concentrations taken as the mean of the 39 strata of this group yield the following enrichment factors:

	Mean	Maximum
Mercury	X32	X64
Copper	X5	X13
Zinc	X5	X7
Lead	X22	X181
Chromium	X2	X5

Comparison with the enrichment factors given earlier for the group nearer the sludge disposal ground shows that this region lying to the north of the Mersey outfall has higher enrichment of mercury and much higher enrichment of lead. On the other hand it is perhaps less enriched in copper.

Attention has already been drawn to the remarkably high levels of some metals in the fines of the predominantly sandy strata. However, examination of metal pairs fails to reveal any correlation in these strata (n = 9) between the concentration of one metal and that of another. In contrast, the greater number of more muddy strata (n = 30) from this area do suggest positive correlations ($P = <0.001$) between mercury and zinc, mercury and copper, and copper and zinc.

4.3.3 South of the Mersey Outflow (U10, YY3 and 4)

Two of the three cores taken to the south of the Mersey outflow were from the very muddy deposits to the north of Newcome Knoll in the area historically associated with dredging spoil from the inner estuary and dock systems of the Mersey. Both show penetration of most metals over the full 0.7m depth of the core.

The third core (U10) was recovered from north of the mud area and revealed predominantly sands generally high in metals overlying more mud-rich sediments at 0.4m depth. The low organic content and background concentrations for most metals in the deeper more muddy sediment suggests that the basement below 0.4 to 0.5m is rarely disturbed.

The metal concentrations taken as the mean of the 22 strata of this group yield similar enrichment factors to those reported for the cores to the north of the Mersey. Lead is the only exception: there being no values to match the abnormally high lead concentrations recorded to the north.

	Mean	Maximum
Mercury	X36	X60
Copper	X4	X10
Zinc	X5	X7
Lead	X4	X13
Chromium	X1.8	X6

In this geographical grouping, mercury with zinc and copper with lead are the only correlated metal pairs ($P = <0.001$).

5. CONCLUSIONS AND RECOMMENDATIONS

1. The sediments of Liverpool Bay in the approaches to the Mersey display considerable surface enrichment by five of the six metals studied, namely mercury, lead, copper, zinc and chromium.

2. Although it is perhaps dangerous to generalise on a relatively limited number of cores there appears to be distinct regional differences in the depth to which the enrichment penetrates.

   Cores taken seaward of the Mersey Bar, west of 3° 20' west, show the metal contamination of the fine-grained sediment confined to 0.5m thickness and in several cases only the top 0.1m or less. These cores were recovered from localities of at least 15m water depth below chart datum and the metal profiles indicate that at these depths bed mobility is retricted to the surface 0.5m or less.

   Nearer the Mersey the present study focussed principally on the dumping grounds for dredgings off Jordans Spit to the north of the Mersey outflow and on the now abandoned (since 1960) deposit ground for dredgings to the north of Newcome Knoll. In both areas core lengths (0.7m) were insufficient to reach the base of the enriched layer. Water depths at all the sampling locations of this set were less than 10m below chart datum. The shallower water depths clearly provide a greater probability for wave disturbance of bed sediments in these areas. However, an alternative explanation for the greater depth of metal enrichment should not be discounted. In the course of this century these two areas and particularly the one to the south of the Mersey have received vast quantities of fine-grained dredging spoil. It seems likely that the greater depth shown by the metal profiles owe more to net deposition over a long time scale from metal-contaminated dredgings than to bed mixing by wave and current forces or bioturbation.

3. Unusually high levels of lead enrichment have been recorded in the fines of sand strata in the vicinity of the more northern of the two dredging spoil grounds to the north of the Mersey. Use of the ground was discontinued in 1982.

4. There is a need for a more extensive exploration of the depth of metal enrichment, both by sampling at more locations including the sludge disposal ground, and by recovering longer cores in the east of the study area to map the full extent of metal penetration. It would be highly instructive to subject any lower enriched strata of the longer cores to radioactive dating with the objective of establishing whether these deeper bed layers are now stationary and their metal enrichment due to past net deposition from dredgings.

5. The desire to attribute the metal enrichment of a given area of the Bay to a specific input or to quantify the relative contributions made by different sources faces formidable difficulties. All the metals that have been the subject of analysis are present in the natural input and in the three major man-made sources as represented by the Mersey outflow, the dredgings and the sewage sludge. We are normally compelled to take proximity to a major source as a crude indicator for attributing responsibility. This leaves large areas of the Bay that exhibit enrichment but where it is not possible to quantify the relative significance of the various inputs. If one individual area is found to have a characteristic metal recipe as given by the relative proportions of each metal, then to a first approximation the source having that same recipe is the principal contributor. The first step on the approach to type-cast geographical areas with respect to man-made metal contaminants is to subtract the natural metal input from the data and then determine the correlations existing between the concentrations of man-made metals. The present study has yielded values that can be treated with reasonable confidence as natural background concentrations. However, any correlations found to exist between the concentrations of metal pairs of anthropogenic origin have been haphazard and have not furthered our attempts to link more conclusively the metals found in one area to a particular source.

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TABLE 1 - DEPTH PROFILES OF MUD, ORGANICS AND METALS

Site	Level mm	Mud %	Organics %	Mercury µg/g	Copper µg/g	Zinc µg/g	Lead µg/g	Nickel µg/g	Chromium µg/g
P9	0- 25	0.55	na	0.63	249	436	542	37	82
	25-100	0.30	na	1.73	198	816	943	38	41
	100-200	3.49	3.94	1.73	187	302	266	44	28
	200-300	13.01	2.27	0.11	18	95	107	44	18
	300-400	5.55	2.56	0.17	19	82	98	44	21
	400-500	0.25	2.27	0.07	13	79	31	46	21
	500-600	2.56	2.74	0.12	22	89	169	43	21
	600-700	22.65	2.27	0.11	20	83	69	52	22
	700-830	39.61	2.18	0.06	17	77	50	55	33
P10	0- 25	1.84	1.98	0.72	91	170	200	39	24
	25-100	0.45	3.10	0.24	286	201	146	37	21
	100-200	14.93	2.97	0.41	52	114	63	37	22
	200-300	15.40	1.78	0.07	32	77	31	34	22
	300-400	22.68	1.70	0.01	25	73	25	36	21
	400-500	16.15	1.86	0.04	36	74	24	38	20
	500-550	14.59	1.64	0.04	36	83	25	36	19
P11	0-25	2.14	3.66	0.67	1288	445	212	45	24
	25-100	1.54	2.97	0.34	542	462	180	44	26
	100-200	12.48	2.93	0.24	71	133	65	45	18
	200-300	0.95	2.85	1.47	179	230	129	45	17
	300-400	1.63	2.85	0.22	116	219	90	42	15
	400-500	0.56	1.86	0.02	212	250	160	34	20
	500-600	2.15	2.83	0.20	188	229	108	50	16
	600-700	6.73	2.49	0.11	31	110	101	45	18
	700-800	15.17	2.79	0.07	26	102	83	46	24
	800-900	0.77	3.28	0.99	93	265	370	49	23
P12	0-25	2.40	4.07	0.71	106	214	261	41	18
	25-100	2.32	3.89	1.46	74	231	158	48	44
	100-200	4.71	2.59	0.86	51	174	156	44	26
	200-300	9.20	2.35	0.09	25	112	52	42	17
	300-400	10.43	2.29	0.14	18	88	40	42	18
	400-500	7.42	2.10	0.09	23	94	64	42	18
	500-600	7.81	2.28	0.12	31	94	61	43	18
Q11	0-25	31.82	3.94	2.78	66	344	135	42	31
	25-100	11.14	3.47	2.17	62	573	136	42	28
	100-200	12.53	3.17	0.83	32	237	87	41	21
	200-300	16.51	2.23	0.25	17	191	51	41	23
	300-400	21.21	2.44	0.13	13	362	38	39	21
	400-500	16.33	2.55	0.05	11	131	33	39	18
	500-600	22.41	2.38	0.04	11	138	31	39	18
	600-700	23.30	1.99	0.03	14	171	29	38	17

TABLE 1 (continued)

Site	Level mm	Mud %	Organics %	Mercury µg/g	Copper µg/g	Zinc µg/g	Lead µg/g	Nickel µg/g	Chromium µg/g
R9	0-25	2.29	4.20	2.35	79	363	185	40	26
	25-100	5.67	3.60	0.90	45	204	108	40	22
	100-200	24.71	2.17	0.09	14	75	31	36	23
	200-300	28.32	2.00	0.06	14	68	44	34	22
	300-400	32.90	2.03	0.03	10	85	21	37	23
	400-500	26.73	1.64	0.05	13	80	28	40	21
	500-600	25.32	0.99	0.03	12	81	31	40	29
R10	0-25	3.95	3.88	1.93	108	331	165	43	22
	25-100	13.42	1.98	0.20	17	84	34	36	24
	100-200	25.57	1.59	0.10	16	65	26	32	28
	200-300	28.67	2.06	0.04	10	55	17	38	29
	300-400	20.24	1.85	0.16	15	65	27	33	34
	400-500	18.82	1.75	0.01	12	63	27	36	30
	500-600	25.98	1.71	0.01	9	34	11	19	79
	600-700	29.35	1.66	0.04	15	59	26	30	29
R11	0-25	0.82	na	1.83	263	739	635	51	31
	25-100	12.80	4.34	1.53	73	318	343	41	24
	100-200	17.32	2.83	0.46	33	144	128	34	24
	200-300	29.83	2.02	0.14	19	79	77	32	25
	300-400	44.24	1.42	0.10	15	64	57	31	23
	400-500	51.97	1.31	0.07	14	53	57	34	32
	500-550	43.15	1.52	0.05	13	52	52	39	43
R12	0-25	6.55	4.93	1.40	115	173	263	52	16
	25-100	6.94	5.93	0.66	99	194	649	61	26
	100-200	6.35	4.30	2.65	203	684	969	63	36
	200-300	1.01	3.86	0.96	122	195	717	39	26
	300-400	0.45	3.76	0.23	104	202	862	41	35
	400-500	1.90	3.33	0.12	45	114	435	42	21
	500-600	35.30	4.18	0.04	14	74	44	41	25
	500-700	43.21	3.94	0.34	15	71	42	39	26
T12	0-25	25.45	4.93	2.93	91	453	234	39	41
	25-100	19.52	5.63	2.48	116	470	343	43	49
	100-200	27.25	4.30	2.00	66	319	156	52	57
	200-300	42.32	3.86	1.33	56	249	110	35	30
	300-400	46.64	3.76	1.70	49	277	128	37	35
	400-500	59.10	3.33	1.60	46	231	102	37	38
	500-600	68.52	4.18	1.75	56	264	121	39	38
	600-700	50.80	3.94	1.29	54	249	115	40	37
	700-800	63.32	4.09	1.37	46	220	109	41	26

TABLE 1 (continued)

Site	Level mm	Mud %	Organics %	Mercury µg/g	Copper µg/g	Zinc µg/g	Lead µg/g	Nickel µg/g	Chromium µg/g
T13	0-25	10.53	4.86	2.63	101	380	1114	40	45
	25-100	12.29	5.90	3.58	86	430	289	43	34
	100-200	12.35	6.10	3.43	96	479	300	43	36
	200-300	7.85	5.97	2.76	94	470	355	45	33
	300-400	7.65	5.94	2.03	76	332	329	43	30
	400-450	4.72	5.03	1.44	103	353	581	44	33
T15	0-25	16.74	4.89	2.29	66	368	203	39	33
	25-100	0.21	na	1.71	134	334	1356	41	46
	100-200	0.18	na	2.12	218	496	2141	65	53
	200-300	0.39	5.10	2.58	233	453	1182	49	70
	300-400	3.43	4.97	2.60	86	416	409	42	32
	400-500	3.43	5.35	4.93	166	505	374	45	42
	500-600	1.82	5.89	2.57	99	414	581	42	57
	600-700	5.52	5.13	2.26	90	427	377	42	61
U10	0-25	1.96	2.02	0.82	65	191	112	24	34
	25-100	0.79	4.97	2.20	115	413	286	33	61
	100-200	1.30	5.57	2.88	149	453	249	38	36
	200-300	1.93	5.96	3.45	135	445	481	38	35
	300-400	0.87	4.85	1.49	187	436	635	43	46
	400-500	5.31	2.38	0.38	31	112	88	32	65
	500-600	13.74	2.12	0.11	15	67	31	38	40
	600-700	10.94	2.14	0.11	20	74	85	36	54
	700-800	25.42	1.92	0.11	16	71	19	38	23
U15	0-25	0.41	na	1.46	251	453	7607	46	135
	25-100	0.42	6.54	2.24	183	479	9244	42	97
	100-200	0.72	4.78	2.14	207	539	4718	46	84
	200-300	0.71	3.32	2.33	160	410	1348	41	65
	300-400	0.84	3.26	3.61	126	410	2725	45	125
	400-500	3.80	2.03	0.59	45	158	414	49	30
	500-600	25.93	2.61	0.93	38	141	133	52	25
	600-700	2.01	5.24	3.17	106	436	654	46	56
	700-800		na	3.46	280	556	3948	49	83
YY3	0-25	56.82	4.24	2.72	50	547	139	38	27
	25-100	84.13	4.34	2.76	54	410	123	37	26
	100-200	64.74	5.44	3.51	74	522	165	42	35
	200-300	34.31	5.02	3.48	69	436	158	40	38
	300-400	41.83	6.33	4.31	106	547	216	45	37
	400-500	22.92	3.84	1.73	42	333	93	42	25
	500-600	3.44	2.05	0.46	20	190	255	30	138
	600-700	4.81	2.39	0.14	30	410	236	33	101

TABLE 1 (continued)

Site	Level mm	Mud %	Organics %	Mercury µg/g	Copper µg/g	Zinc µg/g	Lead µg/g	Nickel µg/g	Chromium µg/g
YY4	0-25	64.10	4.97	3.35	65	470	168	40	30
	25-100	66.00	5.65	4.25	76	522	171	42	33
	100-200	91.42	5.62	4.60	78	462	169	42	33
	200-300	80.81	6.00	4.25	83	607	207	45	33
	300-400	66.28	6.55	3.87	85	522	191	44	30
	400-500	88.48	5.19	3.24	72	410	165	39	22
	500-600	72.61	4.95	2.82	73	428	170	40	22
	600-700	76.41	6.02	4.24	111	487	175	44	27
T14	0-25	8.60	5.21	3.49	93	445	215	42	39
SG	25-100	9.01	4.39	2.98	68	428	156	41	31
	100-200	6.06	5.70	3.20	77	410	173	44	36
	200-300	9.36	5.30	3.25	80	428	179	49	29
	300-400	16.57	5.14	3.27	76	425	169	41	25
	400-500	19.88	5.95	2.97	96	479	204	42	28
	500-600	20.15	5.17	3.31	83	402	178	44	28

na = not available, insufficient sample
SG = Spoil ground for dredgings

Figures

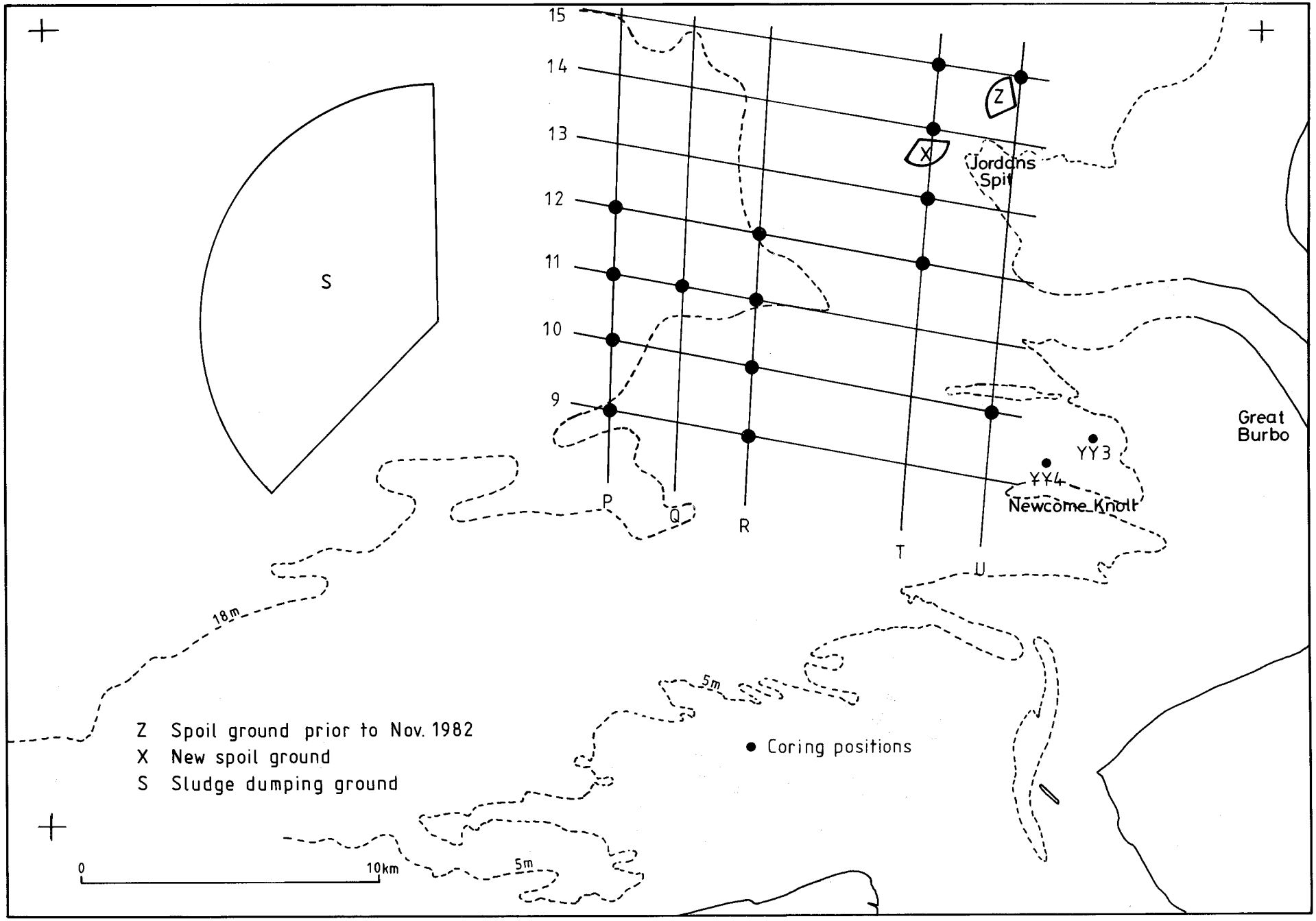
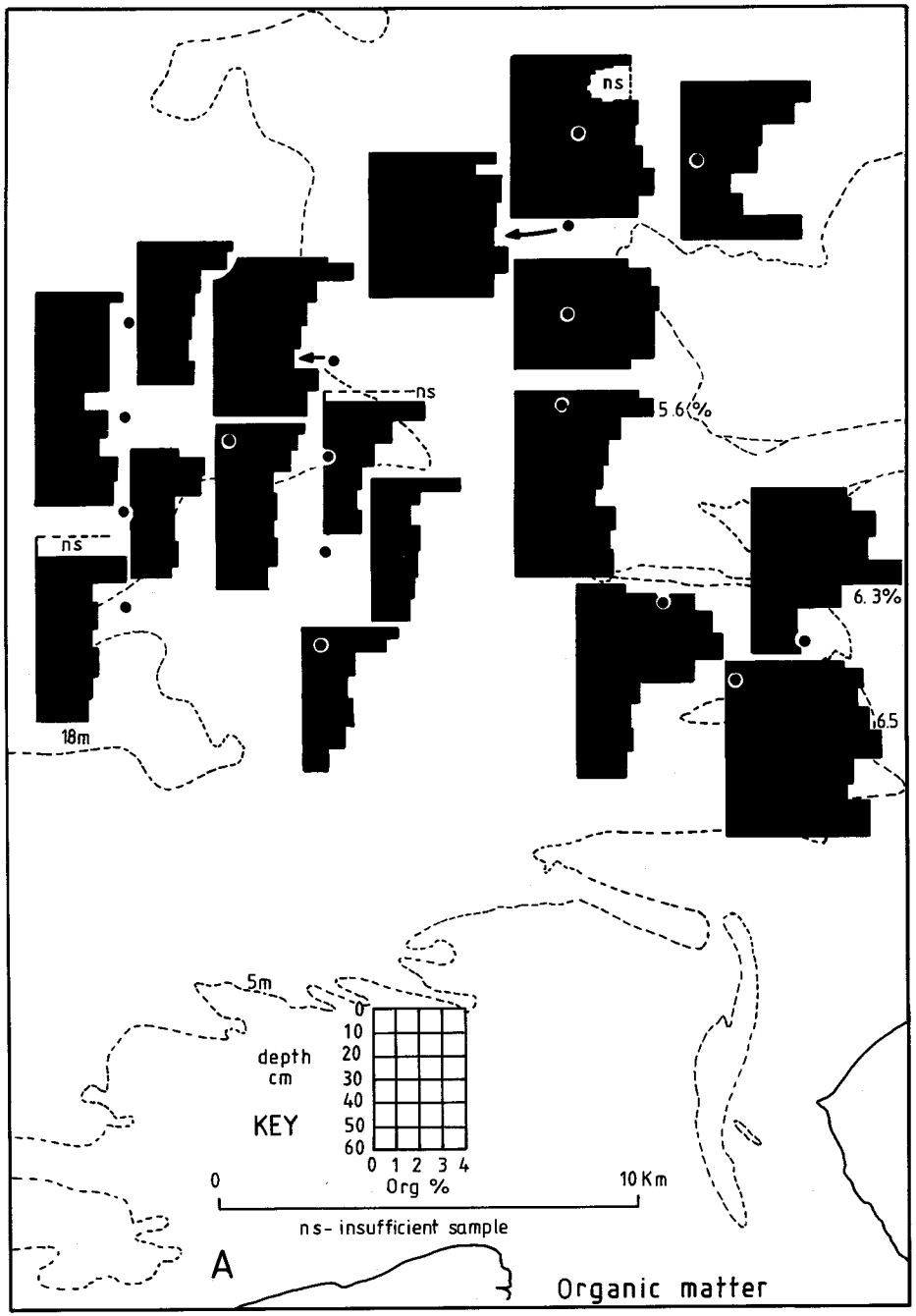


Fig 1 Coring positions

Fig.2 Depth profiles of mud content

Fig 3A&B Depth profiles of organic matter content



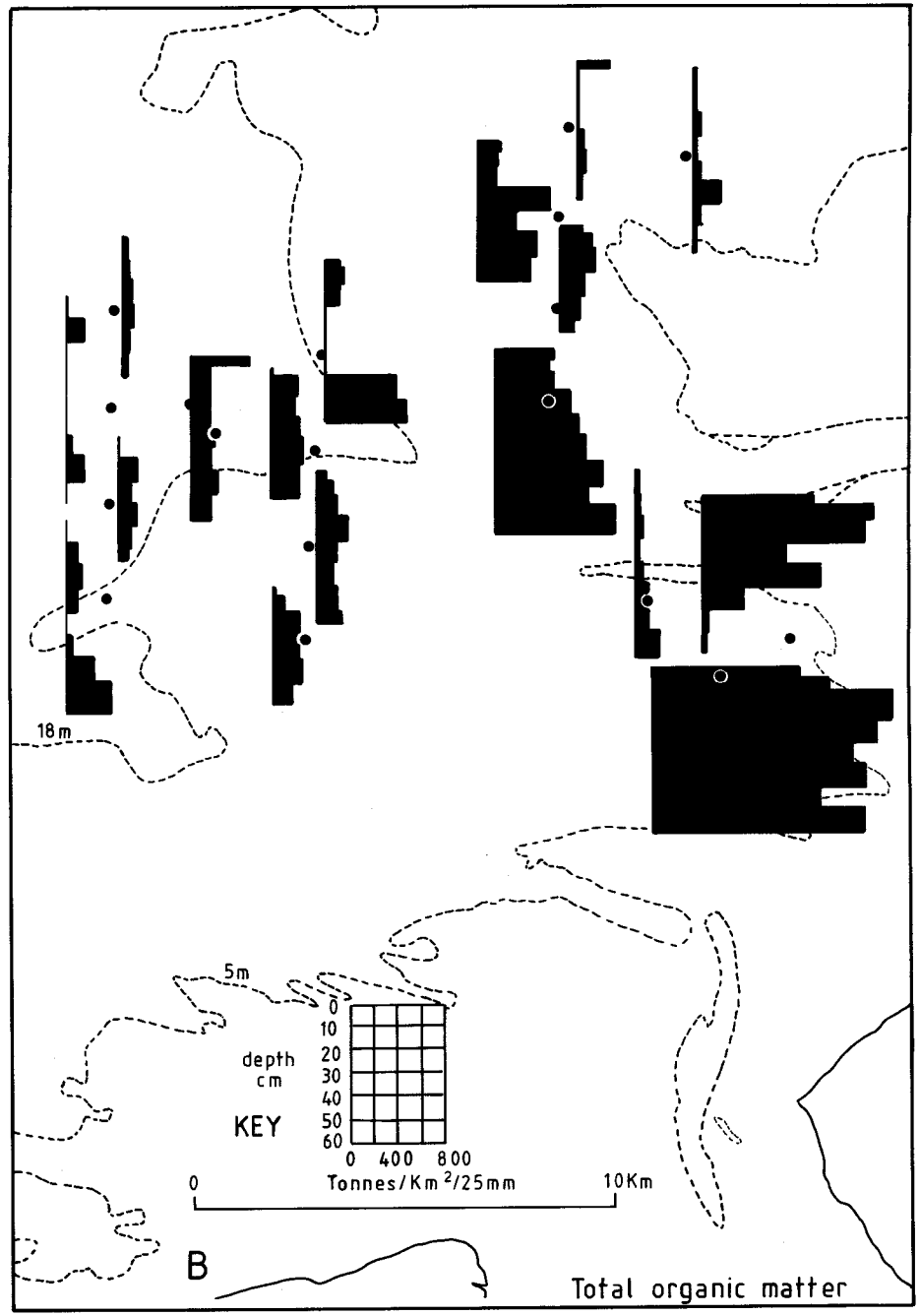
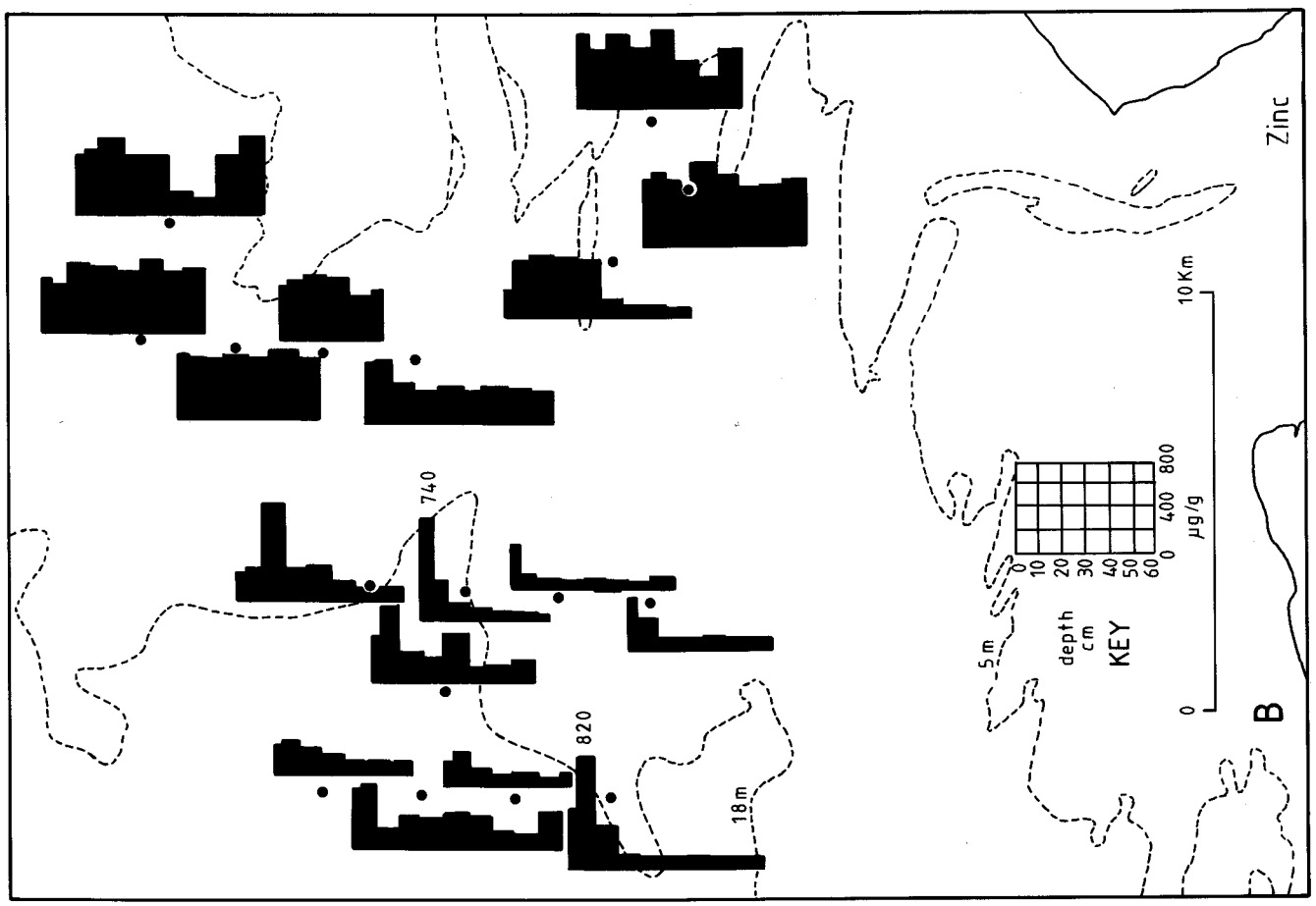


Fig. 4A & B Depth profiles of mercury and lead contents



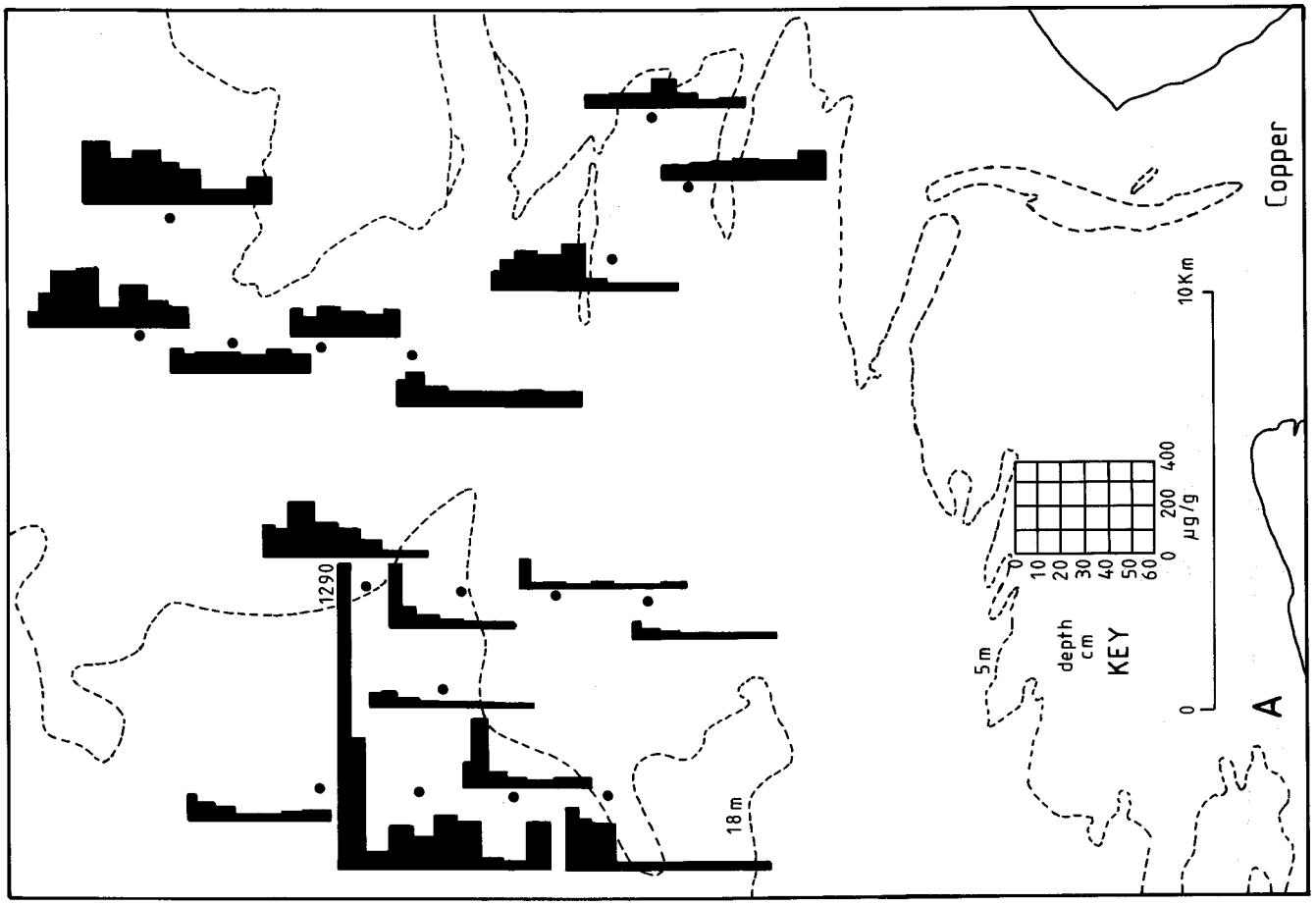
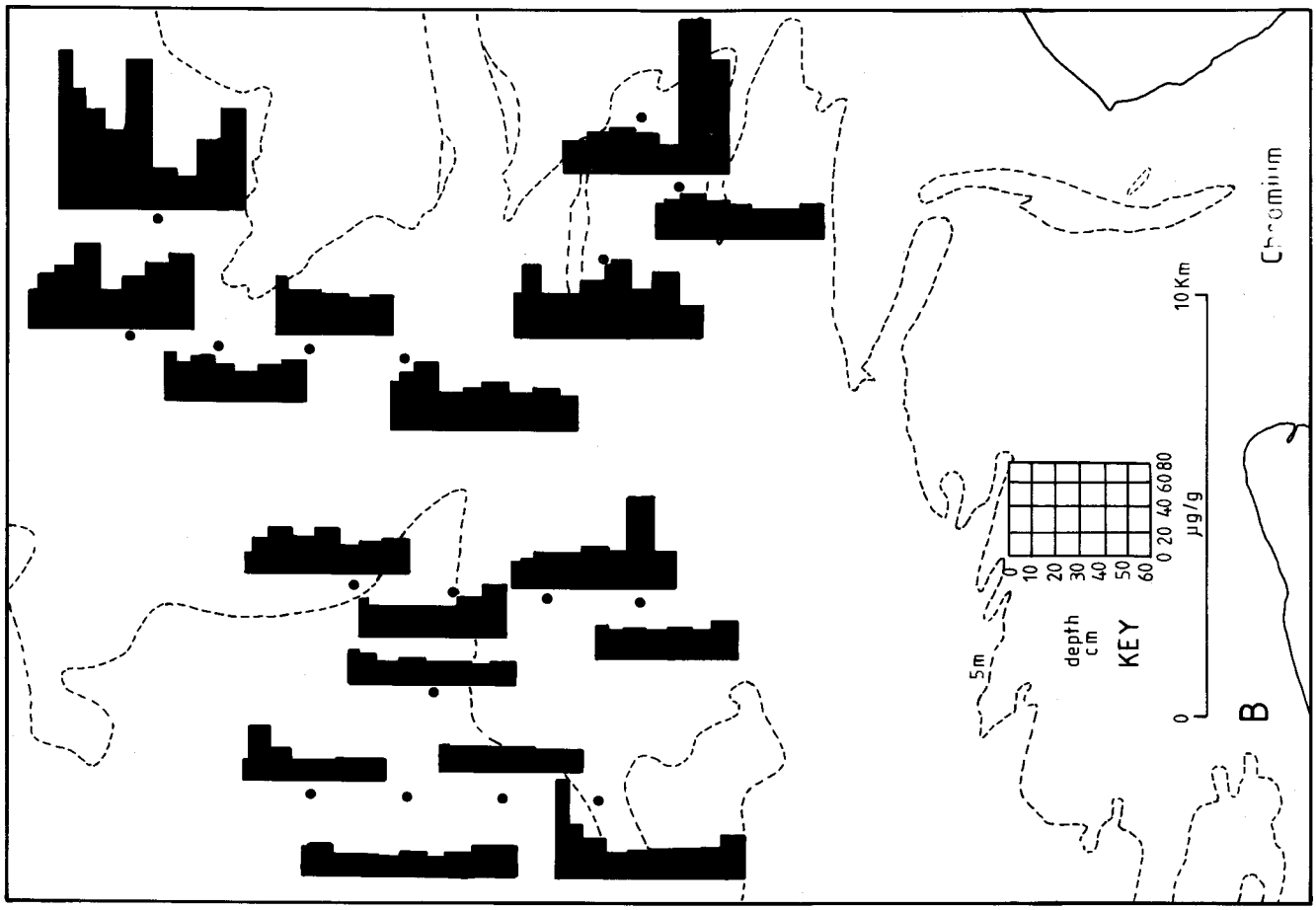


Fig. 5A & B Depth profiles of copper and zinc contents



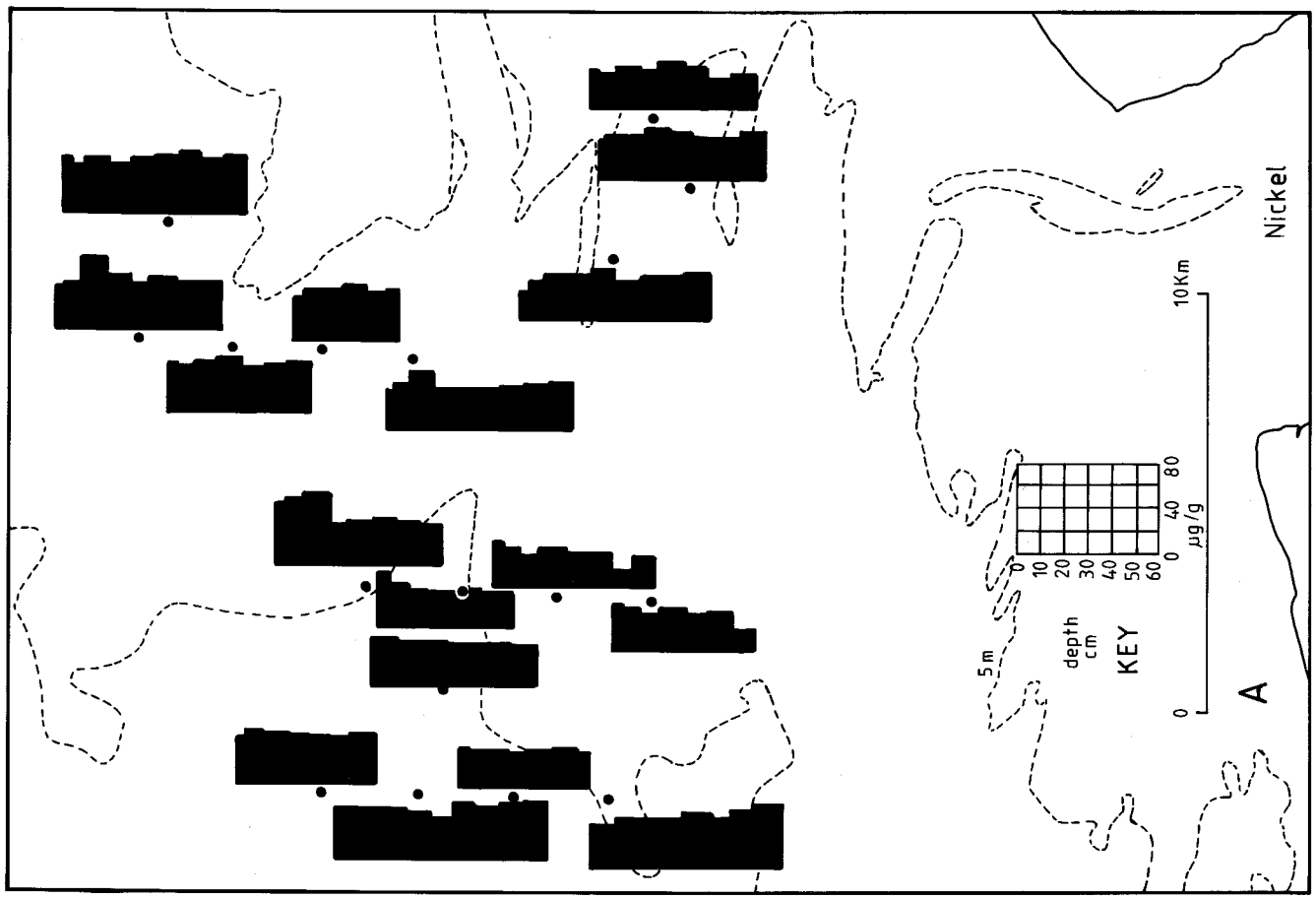


Fig. 6A & B Depth profiles of nickel and chromium contents