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No. 1268

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Chemical Studies of the Recent Sediments of Babine Lake British Columbia

by
John G. Stockner and Howard D. Smith

Pacific Environment Institute, West Vancouver, B.C.

February 1974

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INTRODUCTION

The Babine watershed was probably little affected by human activity prior to about 1940 when extensive logging began. In the past 10 years such activity has increased greatly as a result of major expansions in timber harvesting, establishment of two major mines extracting copper and zinc, two salmon enhancement projects and growth of a new community of 1,500 people. General public use of the watershed has increased accordingly.

In view of these developments and their likely effect on water quality and fish production, the multi-disciplinary Babine Watershed Change Program (1973) was initiated in 1971-1972 by the Department of the Environment to assess effects of environmental change on Babine salmon and trout production. The program includes paleolimnological studies to see if any changes in lake trophic state, or areal differences in historic plankton production are evident in the kind and distribution of diatom microfossils and chemical composition of bottom sediments.

This manuscript reports on selected chemical parameters of recent sediments. The distribution and abundance of microfossils will be reported separately.

It is hoped that this information will complement results of comprehensive studies now in progress by the Inland Waters Branch of the Water Management Service.

Babine Lake and environs is described in a general way in the extensive literature on its sockeye salmon production (e.g., McDonald 1969; Narver 1970; Smith 1973). In essence it is long (160 km), narrow (average about 3.5 km), and deep (to about 230 m). It drains from the central interior plateau northward through the Babine and Skeena rivers. The drainage and sampling locations referred to here are shown in Fig. 1.

METHODS

Field

Ten short cores (average length 40 cm) were obtained with a Phleger corer from deep-water regions of Babine Lake in August, 1972 (Fig. 2). Cores were extruded within a few hours of retrieval, and sectioned at 0.5 cm intervals to 5 cm; at 1 cm intervals from there to 10 cm; and at 5 cm intervals from there to the bottom of the core. Subsamples were all removed from the centres of the cores -- in aqueous upper layers by successively extruding and dipping, and in consolidated materials by scooping with a spatula. Each was placed in a small polythene bag, labelled and stored in the dark at 5 C until processed in the laboratory.

Laboratory

Moisture: Water content was estimated by drying wet sediment in pre-weighted porcelain crucibles at 90 C for 24 hr.

Loss on ignition (LOI): After drying samples were burned in a muffle furnace at 550 C for 4 hr and reweighed to determine percentages of volatile organics driven off and of inorganic residues (ash) remaining.

Carbon: Percentage organic carbon was determined from dry sediments using the Walkley-Black method as initially described in Methods of Soil Analysis, A.S.A. (1965).

Total phosphorous: Phosphorous was measured according to methods described by Strickland and Parsons (1968). Standards were not digested as previous tests indicated there would be little or no effect.

Copper and zinc: These were measured in a Jarrell-Ash atomic absorption spectrophotometer after HNO_3 digestion. This is similar to the method initially described by Jeffrey (1970).

Values for total phosphorous, organic carbon, zinc and copper are expressed on a per unit weight of dry sediment basis.

RESULTS AND DISCUSSION

A general description of the surface sediment characteristics from each core location is given in Table 1. In most locations 2-3 cm of unconsolidated aqueous materials lay on top of consolidated sediments which held their shape when extruded. All cores were of good quality, i.e., there was little or no smearing or running together of any but (possibly) surface layers.

Sediments were generally dark brown and excepting upper layers of core B5 possessed no discernible odour. All cores had some random horizontal banding which may reflect concentrations of organic matter which oxidized rapidly after extrusion. There was some suggestion of annual layering in cores B7 and B8. The latter yielded 20 dark, evenly spaced horizontal bands between 20 and 24 cm. If these are annual deposits then 2 mm/yr is a first approximation to the sediment rate in that southerly portion of the lake in the corresponding period of its sediment history. This is not unrealistic for a moderately productive lake of this size (Stockner 1972) and suggests the entire core spanned a time interval commencing 200-300 yr ago.

Considerable variation occurred in moisture and LOI among and within cores, and in addition, sediment composition in cores from north and south halves of the lake differed somewhat (see appendix). Highest values for both moisture and LOI occurred in the most recent sediments. They usually averaged 90-95% H_2O, and 10-15% LOI. Deeper, unconsolidated sediments averaged less moisture (65-70%), and lower LOI (6-7%). There were a few exceptions to this general pattern, most notably in core B10 taken in Port Arthur Harbour (see appendix figure labelled B10). At 17 cm in this core there was an abrupt change from typical lake sediments to rust-gray coloured clays believed to be of glacial origin. The change was also reflected in moisture and LOI values. Possibly there has been slumpage of post-glacial clays to account for the anomalous condition in this small bay.

Table 2 shows that average concentrations of all measured constituents of bottom sediments except zinc were highest in the north region of the lake (samples B1-B5, north of Fulton River). This contrasts with apparently higher biological production in waters of the southern regions (Johnson 1965; Narver 1967).

Sample values for organic carbon, total phosphorous, copper and zinc are tabulated in the appendix tables and plotted against depths in sediments in Fig. 3. Average values appear somewhat lower than might be expected on the basis of literature values for large lakes elsewhere (cf. Shapiro, Edmondson and Allison). Highest values of phosphorous, carbon and copper occurred in surface sediments (Table 3). Total phosphorous and organic carbon in the top 5 cm averaged 130-150% of concentrations in deeper strata. Possibly the lake has become more productive in recent times. Particularly high copper concentrations in surface layers at station B5 a few hundred metres east of Granisle may reflect waste leakage through rock-filled dykes during an early stage of mine development.

It is hoped that these results will be a useful supplement to those from detailed sedimentation and geochemical studies now in progress by the Water Management Service. Doubtless some of the questions raised here will be answered by the comprehensive studies.

ACKNOWLEDGMENTS

We wish to acknowledge excellent technical support from individuals at the Pacific Environment Institute and Pacific Biological Station. In particular we wish to extend sincere thanks to John Davidson and staff of the Environmental Quality Laboratory of the Northern Operations Branch for chemical analyses, F. P. Jordan and I. Miki for moisture and LOI determinations and J. Martell for assistance in coring and field measurements.

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Table 1. Core locations, water depths and general sediment characteristics.

Core no.	Location	Water depth (m)	Core length (cm)	Length of unconsolidated materials (cm)	General characteristics
B1	North Arm, Norlakes, mid-lake	42	50	1.5	dark brown; soft; banding evident.
B2	Morrison Arm, mid-lake	28	43	4.5	dark green-brown; soft; no banding top 5-6 cm.
B3	Main lake, 1 km S. of Old Fort, mid-lake	120	37	3.0	dark brown; soft; distinct banding.
B4	Rabbit Is., mid-lake	110	35	3.0	dark brown; soft; some banding.
B5	Hagan Arm, 300 m from McDonald Is.	55	42	2.5	top 1 cm white; detectable odour; no banding top 6 cm.
B6	Fulton R., 1 km N.E. of mouth	90	34	3.0	brown; gritty; sand, bark and other particulates.
B7	Twin Cr., mid-lake	110	44	2.0	dark brown; soft; thin bands less distinct than elsewhere.
B8	Bolings Pt., mid-lake	180	41	2.0	dark brown changing to gray at 2 cm; banding as in B7.
B9	Pinkut Cr., 1 km N. of mouth	120	33	2.0	brown, gritty; bark, grass and other particulates. No banding top 15 cm.
B10	Port Arthur mid-harbour	28	44	2.0	dark brown top 11 cm; gritty and more clay 11-20 cm; dense clay 20-44 cm.

Table 2. Amounts of total phosphorous, organic carbon, zinc and copper in north and south region sediments.

Core no.	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
		North region		
B1	1.78	2.40	65	122
B2	2.84	6.25	68	156
B3	2.51	4.28	60	109
B4	2.89	3.79	50	155
B5	2.35	4.71	86	152
$\bar{x}$	2.47	4.29	66	139
		South region		
B6	2.23	3.42	no sample	no sample
B7	2.62	3.25	43	173
B8	2.28	2.79	27	145
B9	2.48	2.45	31	106
$\bar{x}$	2.40	2.98	34	141
		All regions		
$\bar{x}$	2.43	3.63	50	140

Table 3. Average amounts of total phosphorous and organic carbon in surface (0-4.5 cm) and deeper (5.0-bottom) sediments.

Core no.	Total P (mg/g)				Organic C (%)			
	n	0-4.5	n	5.0-bottom	n	0-4.5	n	5.0-bottom
B1	10	2.43	16	1.38	10	2.71	16	2.22
B2	10	3.40	12	2.46	10	7.51	12	5.61
B3	10	2.76	10	2.28	10	5.01	10	3.63
B4	9	2.90	11	2.88	6	4.12	11	3.61
B5	10	2.67	12	2.10	10	5.04	12	4.44
B6	10	2.39	12	2.10	9	3.60	12	2.99
B7	10	3.30	13	2.10	9	3.83	13	2.84
B8	10	3.01	13	1.66	9	3.51	13	2.23
B9	10	3.02	11	1.98	10	2.82	11	2.33
B10	10	4.64	13	1.27	10	4.61	13	2.23
	$\bar{x}$	3.05		2.02		4.28		3.21

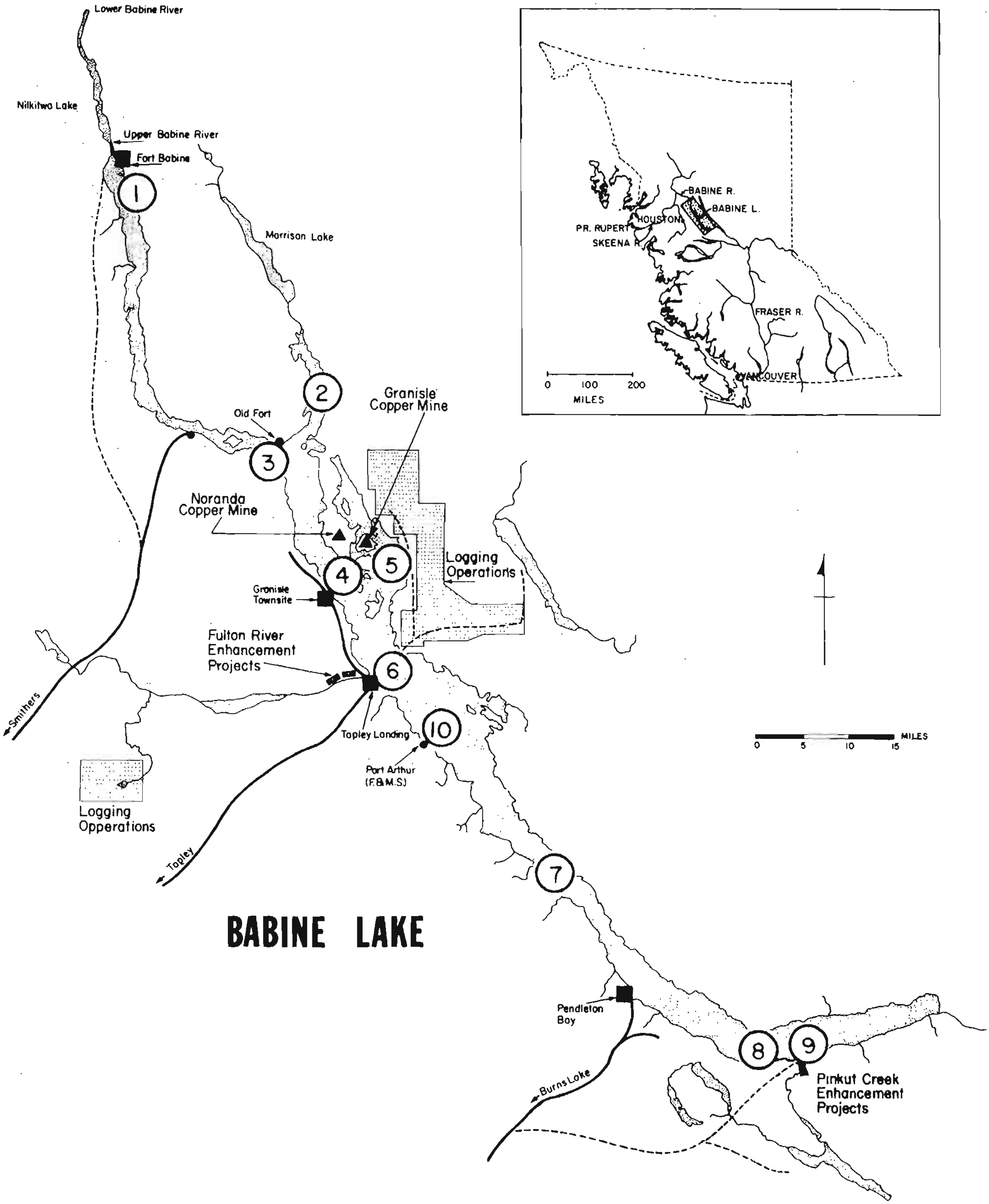


Fig. 1. Babine Lake showing locations of major activities and 1972 core sites.

Fig. 2. Lifting a core from a southend station.

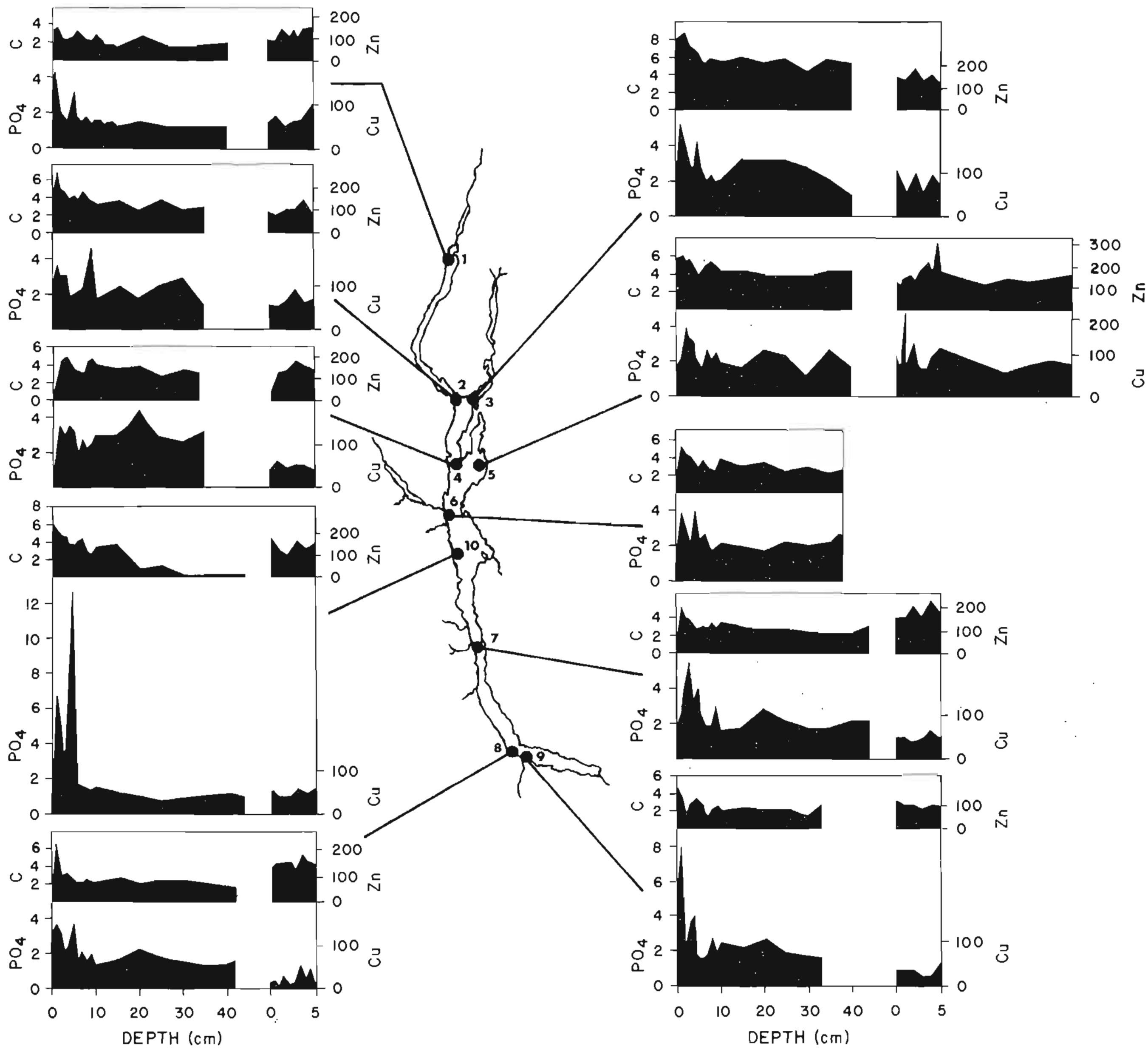
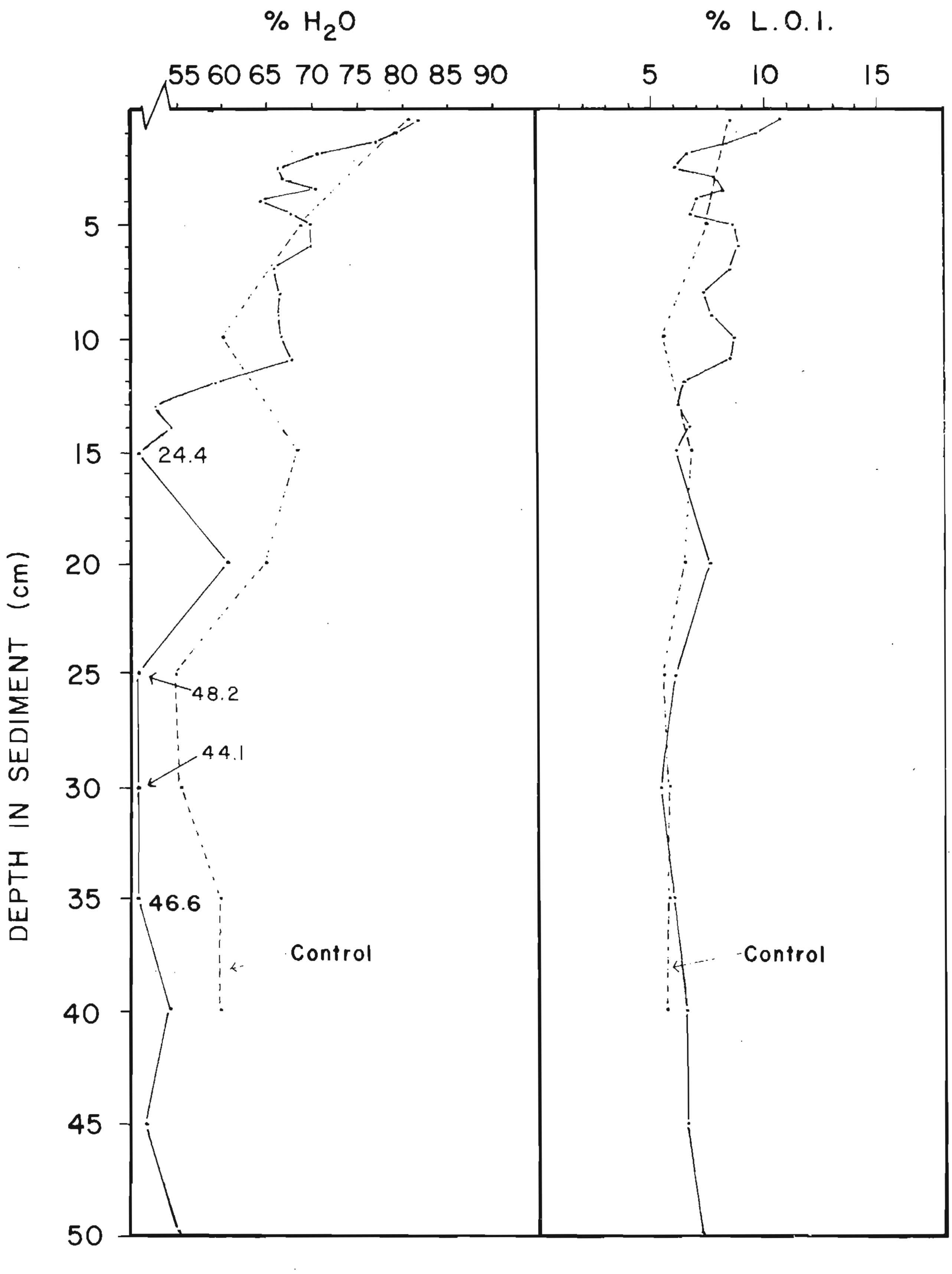


Fig. 3. Distribution of selected elements with depth in sediments.

APPENDIX TABLES

Core no. B1 Description: Norlakes

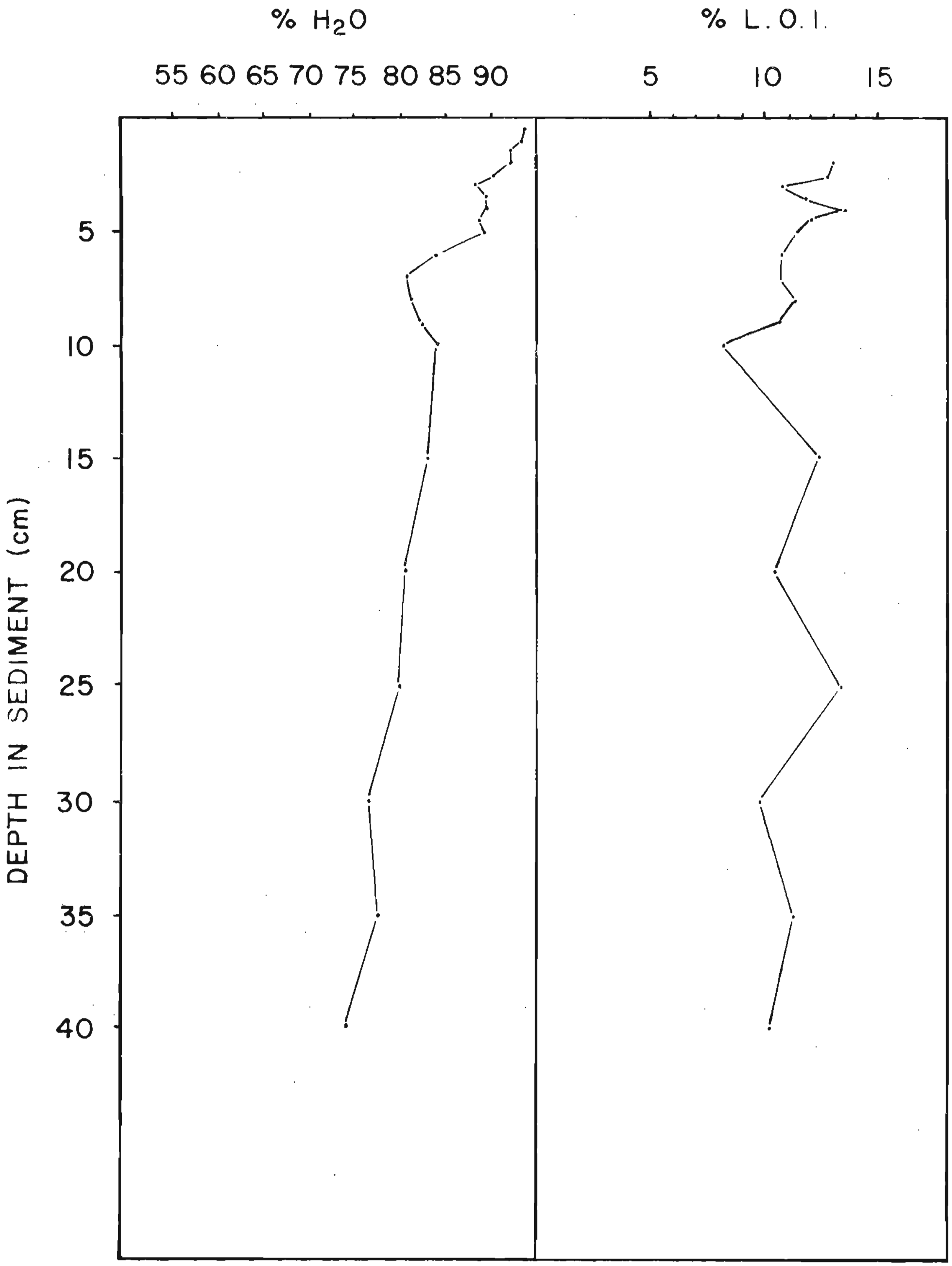
Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	4.20	3.54	60	100
2	0.5-1.0	4.25	3.76	70	90
3	1.0-1.5	3.05	3.02	70	150
4	1.5-2.0	2.00	2.60	55	90
5	2.0-2.5	1.55	2.34	55	100
6	2.5-3.0	1.50	2.29	60	140
7	3.0-3.5	1.60	2.33	55	110
8	3.5-4.0	1.40	2.47	65	150
9	4.0-4.5	1.45	2.14	70	150
10	4.5-5.0	3.25	2.57	90	140
11	5.0-6.0	1.60	3.32		
12	6.0-7.0	1.45	2.79		
13	7.0-8.0	1.60	2.39		
14	8.0-9.0	1.35	2.27		
15	9.0-10.0	1.50	2.81		
16	10.0-11.0	1.50	2.39		
17	11.0-12.0	1.30	1.93		
18	12.0-13.0	1.40	1.83		
19	13.0-14.0	1.40	1.88		
20	14.0-15.0	1.35	1.67		
21	20.0-21.0	1.40	2.55		
22	25.0-26.0	1.20	1.86		
23	30.0-31.0	1.20	1.57		
24	40.0-41.0	1.20	2.04		
25	45.0-46.0	1.30	1.98		
26	49.0-50.0	1.30	2.18		
	Mean	1.78	2.40	65	122


% H2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40
45
50
24.4
48.2
44.1
46.6
Control
Control

Core no. B2 Description: Morrison

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	3.65	*N.E.S.	105	150
2	0.5-1.0	5.20	8.64	43	140
3	1.0-1.5	3.30	N.E.S.	74	165
4	1.5-2.0	3.85	8.82	100	195
5	2.0-2.5	2.60	N.E.S.	65	165
6	2.5-3.0	2.80	N.E.S.	43	130
7	3.0-3.5	3.55	6.69	83	175
8	3.5-4.0	2.75	7.12	99	165
9	4.0-4.5	2.10	7.23	70	155
10	4.5-5.0	4.20	6.58	68	125
11	5.0	2.70	6.88		
12	6.0	2.65	5.81		
13	7.0	2.05	5.23		
14	8.0	2.45	5.73		
15	9.0	1.95	5.66		
16	10.0	2.15	5.71		
17	15.0	3.15	5.92		
18	20.0	3.15	5.44		
19	25.0	3.15	5.67		
20	30.0	2.65	4.43		
21	35.0	2.15	5.51		
22	40.0	1.35	5.38		
	Mean	2.84	6.25	75	156

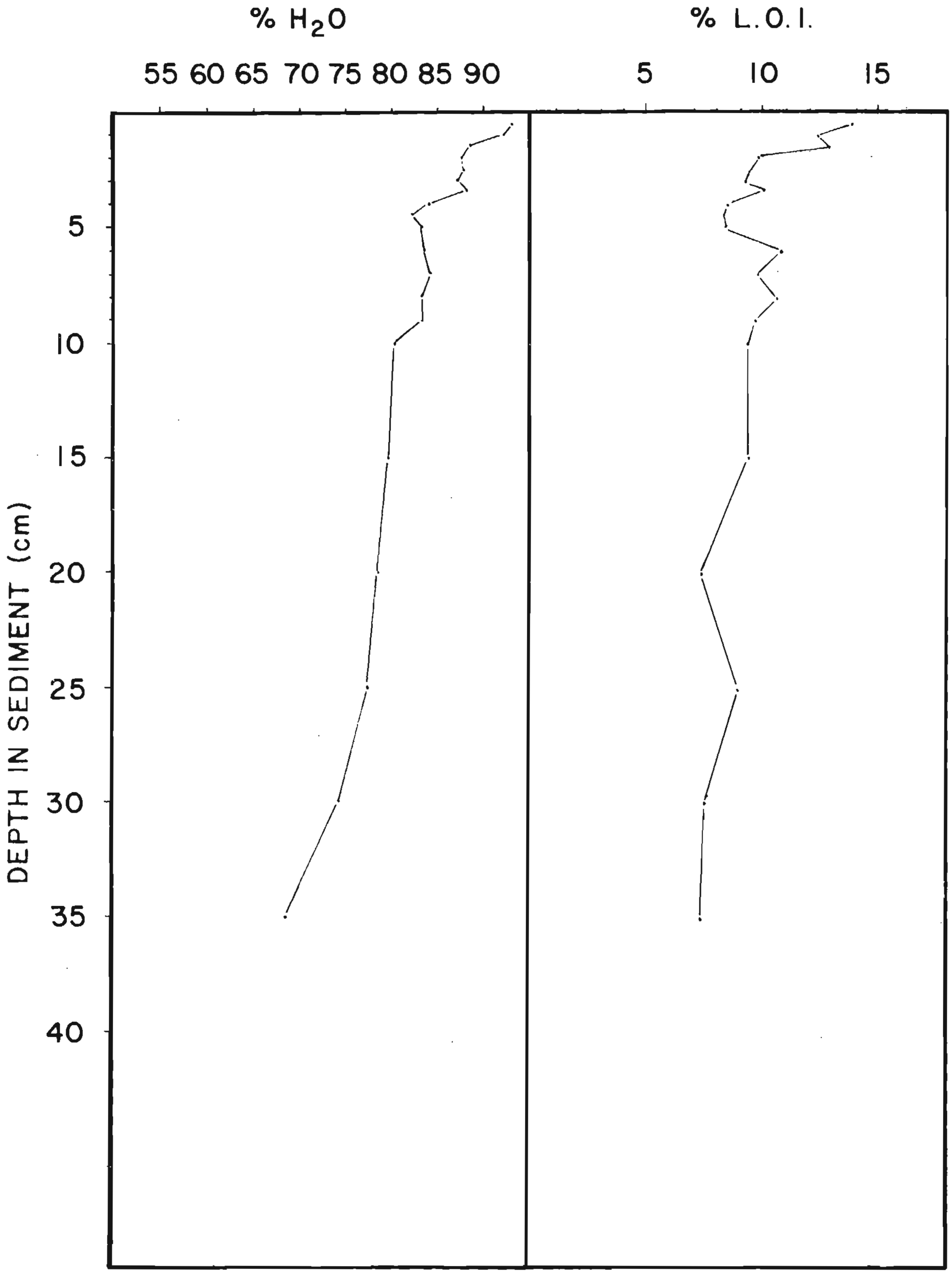
*N.E.S. = not enough sample.


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5
10
15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B3 Description: Old Fort

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	1.95	*N.E.S.	55	100
2	0.5-1.0	3.65	6.85	50	90
3	1.0-1.5	2.55	6.19	45	140
4	1.5-2.0	3.15	4.91	68	100
5	2.0-2.5	4.50	5.29	30	90
6	2.5-3.0	3.10	4.68	85	110
7	3.0-3.5	3.20	4.19	65	100
8	3.5-4.0	1.75	3.97	60	150
9	4.0-4.5	1.90	4.81	80	120
10	4.5-5.0	1.80	4.18	65	90
11	4.5-5.0	1.90	4.51		
12	6	2.10	3.88		
13	7	2.45	4.66		
14	9	4.60	3.85		
15	10	1.70	3.47		
16	15	2.40	3.77		
17	20	1.85	2.76		
18	25	1.50	3.66		
19	30	3.05	2.80		
20	35	1.20	2.91		
	Mean	2.51	4.28	60	109

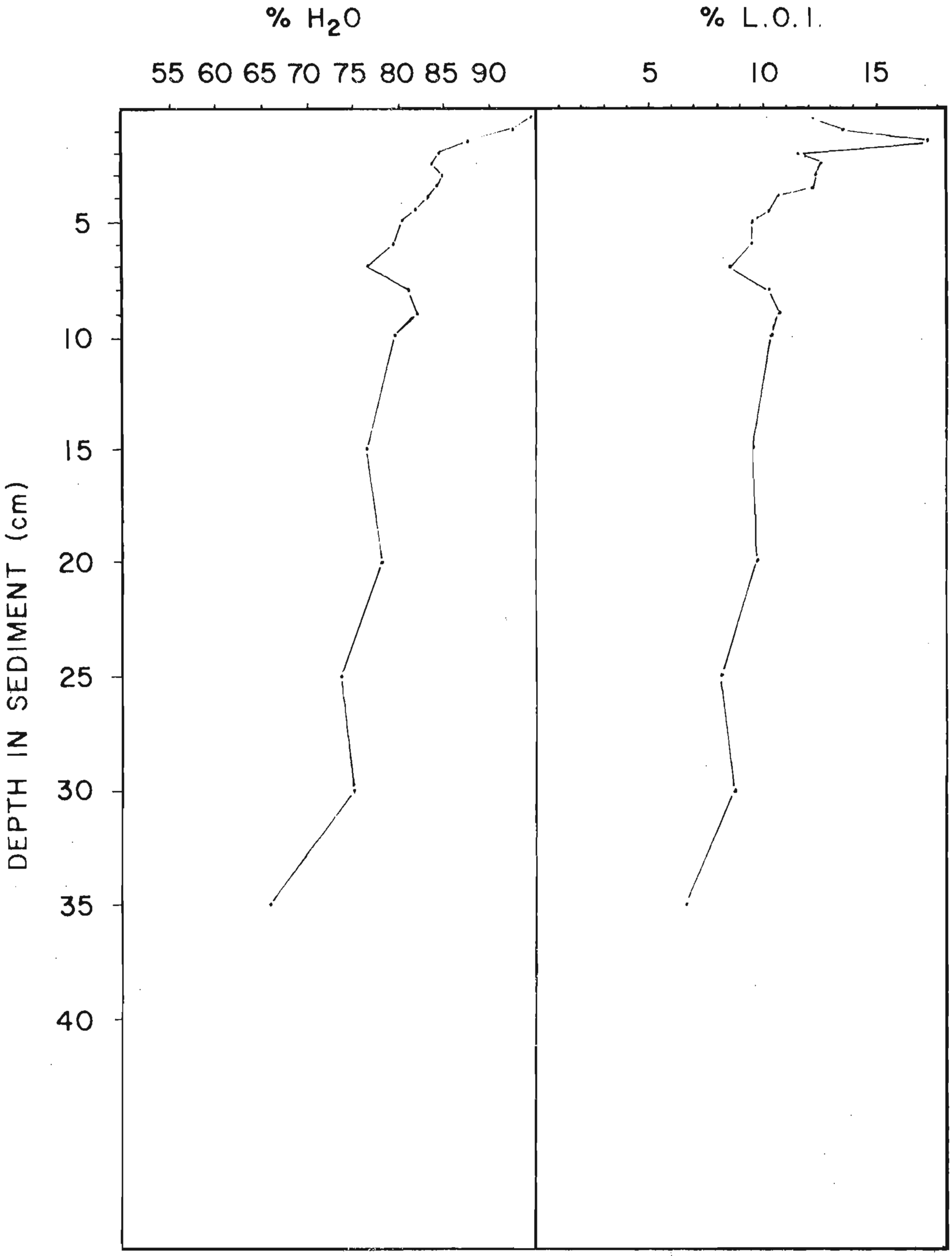
*N.E.S. = not enough sample.


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B4 Description: Rabbit I.

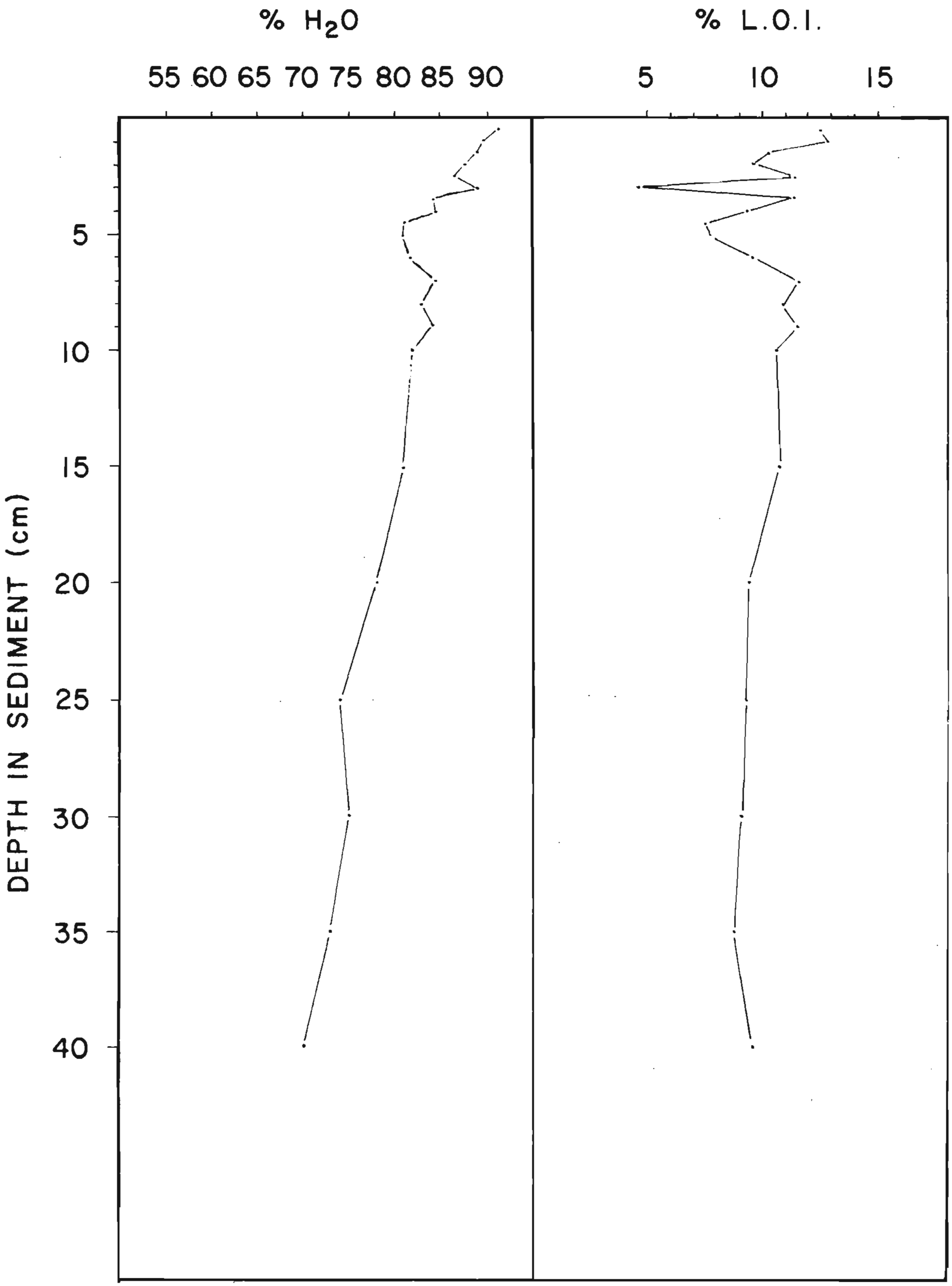
Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	N.E.S.	*N.E.S.	-	-
2	0.5-1.0	2.00	N.E.S.	65	130
3	1.0-1.5	5.00	N.E.S.	58	130
4	1.5-2.0	3.40	4.32	43	140
5	2.0-2.5	2.25	N.E.S.	58	165
6	2.5-3.0	3.05	4.72	50	180
7	3.0-3.5	2.30	4.33	50	165
8	3.5-4.0	3.45	4.45	50	165
9	4.0-4.5	2.55	3.50	43	165
10	4.5-5.0	2.10	3.42	35	155
11	5.0	3.25	3.56		
12	6.0	1.75	3.26		
13	7.0	2.70	3.08		
14	8.0	2.20	4.33		
15	9.0	2.50	4.41		
16	10.0	2.95	4.01		
17	15.0	3.05	3.59		
18	20.0	4.45	3.94		
19	25.0	2.95	2.94		
20	30.0	2.60	3.52		
21	35.0	3.30	3.03		
	Mean	2.89	3.79	50	155

*N.E.S. = not enough sample.


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B5 Description: Hagan

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (ug/g)
1	0.0-0.5	1.60	5.86	90	120
2	0.5-1.0	2.10	5.98	60	100
3	1.0-1.5	4.10	5.29	230	110
4	1.5-2.0	3.85	5.34	70	150
5	2.0-2.5	2.15	5.36	70	165
6	2.5-3.0	3.30	5.51	80	165
7	3.0-3.5	1.95	4.84	120	140
8	3.5-4.0	3.20	4.47	120	120
9	4.0-4.5	2.40	3.78	65	115
10	4.5-5.0	2.00	3.99	65	110
11	5	2.55	3.86	60	160
12	6	1.50	4.39	65	190
13	7	2.70	5.05	60	210
14	8	2.00	5.20	80	149
15	9	2.45	4.95	90	290
16	10	1.95	4.55	110	175
17	15	1.60	4.45	90	155
18	20	2.60	3.95	70	120
19	25	2.40	3.97	58	155
20	30	1.25	3.91	70	135
21	35	2.65	4.57	85	155
22	40	1.50	4.37	80	165
	Mean	2.35	4.71	86	152

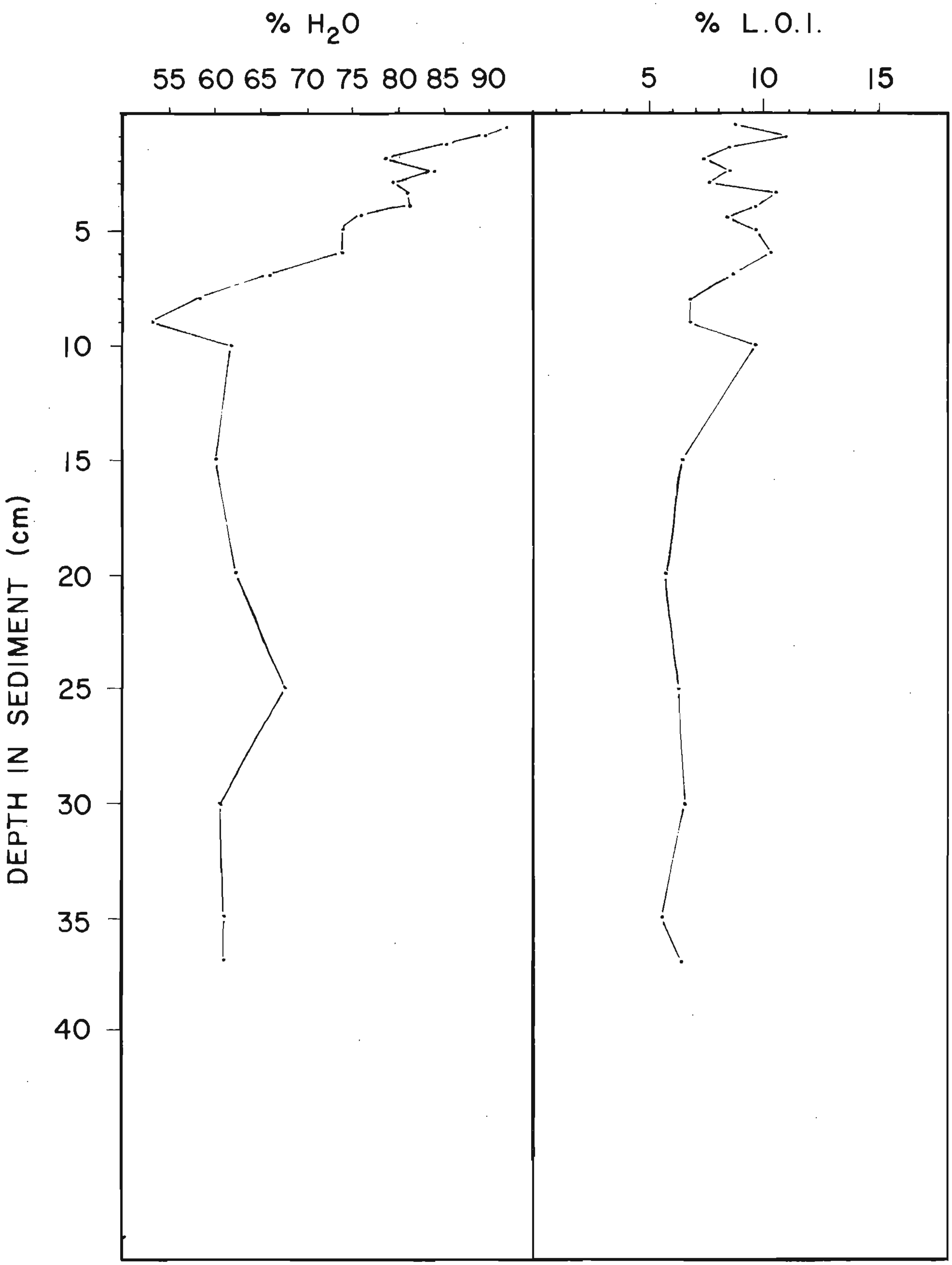

% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B6 Description: Fulton

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu µg/g)	Zn (µg/g)
1	0.0-0.5	1.75	*N.E.S.	**N/A	N/A
2	0.5-1.0	3.80	5.39		
3	1.0-1.5	3.10	4.46		
4	1.5-2.0	3.15	4.25		
5	2.0-2.5	2.50	4.07		
6	2.5-3.0	1.95	3.95		
7	3.0-3.5	1.95	3.99		
8	3.5-4.0	2.15	3.63		
9	4.0-4.5	1.70	3.33		
10	4.5-5.0	1.80	2.94		
11	5.0	2.40	3.19		
12	6.0	2.55	3.65		
13	7.0	2.15	2.92		
14	8.0	1.65	2.75		
15	9.0	1.85	2.64		
16	10.0	2.15	3.84		
17	15.0	1.80	2.96		
18	20.0	1.65	3.45		
19	25.0	2.20	2.48		
20	30.0	1.95	3.04		
21	35.0	2.20	2.33		
22	37.0	2.70	2.58		
	Mean	2.23	3.42		

*N.E.S. = not enough sample.

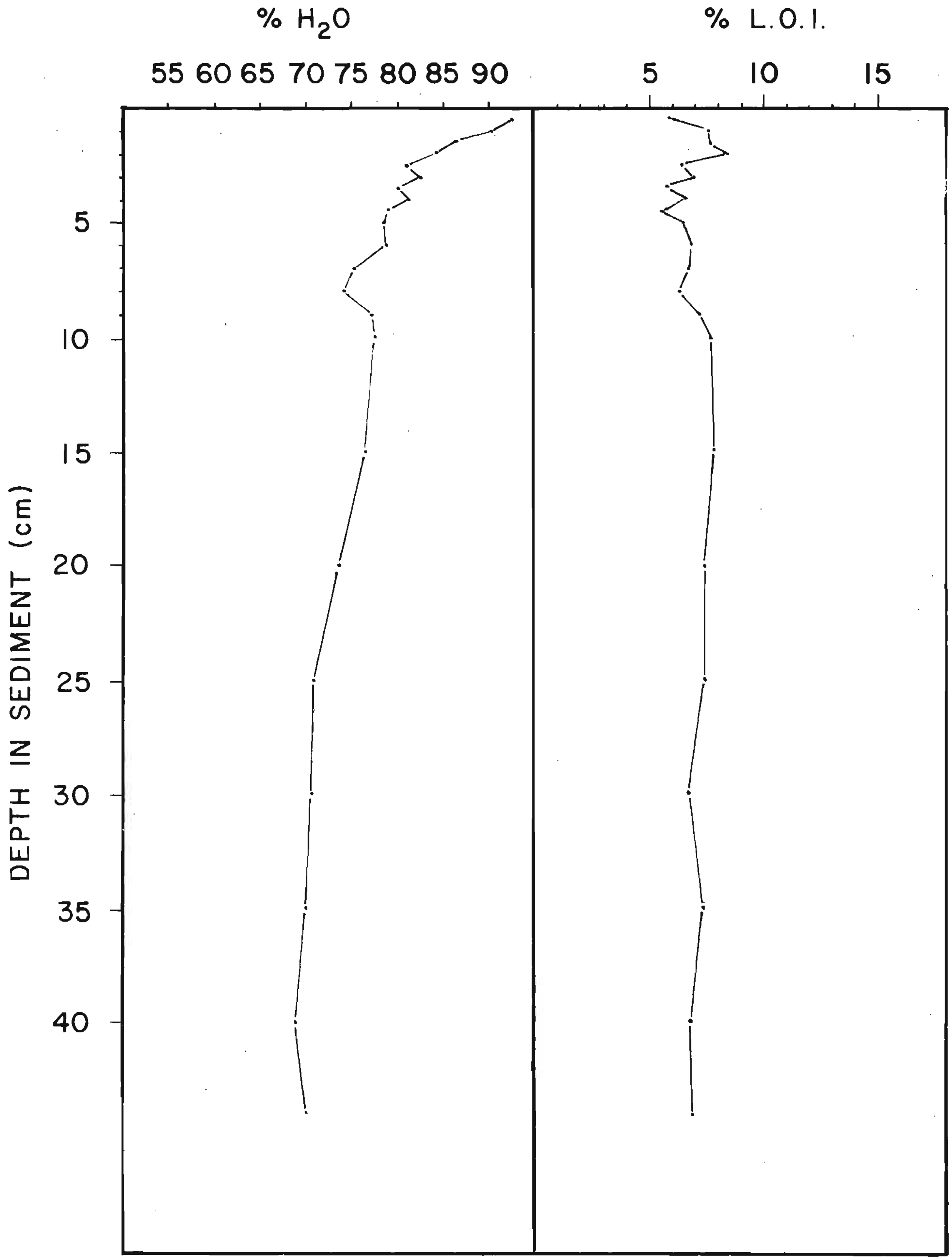
**Not available.


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B7 Description: Twin Cr.

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	1.85	*N.E.S.	45	160
2	0.5-1.0	2.55	5.29	45	160
3	1.0-1.5	5.50	5.07	40	165
4	1.5-2.0	3.90	4.03	30	225
5	2.0-2.5	2.35	3.64	45	160
6	2.5-3.0	5.40	3.88	40	155
7	3.0-3.5	2.25	3.52	25	110
8	3.5-4.0	3.00	3.27	60	240
9	4.0-4.5	2.25	3.04	50	175
10	4.5-5.0	3.90	2.71	50	175
11	5.0	2.10	2.97		
12	6.0	2.55	2.91		
13	7.0	1.80	2.79		
14	8.0	1.80	3.37		
15	9.0	2.95	2.89		
16	10.0	1.60	3.44		
17	15.0	1.75	2.86		
18	20.0	2.90	2.82		
19	25.0	2.15	2.84		
20	30.0	1.60	2.43		
21	35.0	1.75	2.37		
22	40.0	2.15	2.20		
23	44.0	2.15	3.07		
	Mean	2.62	3.25	43	173

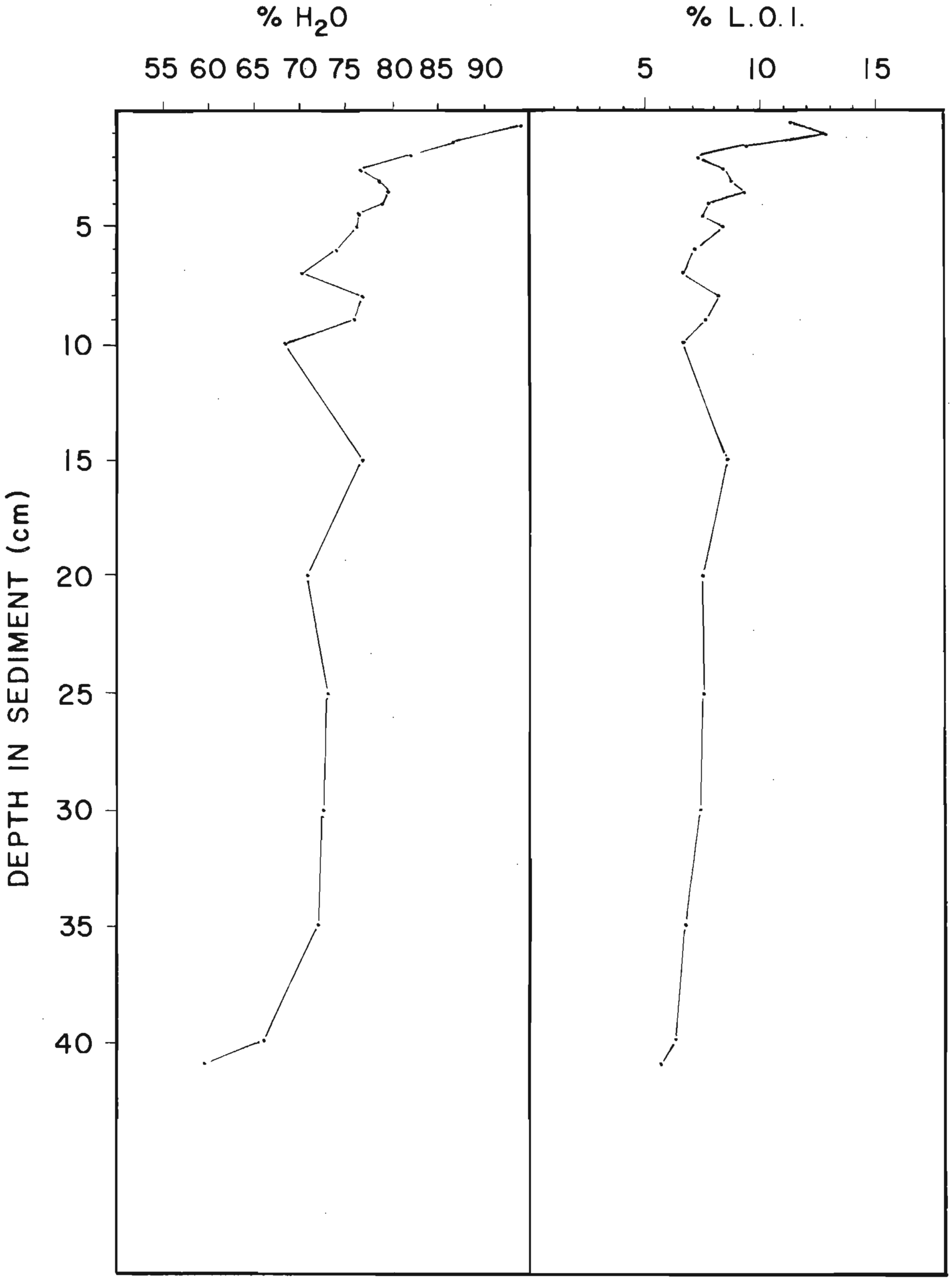
*N.E.S. = not enough sample.


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B8 Description: Bolings

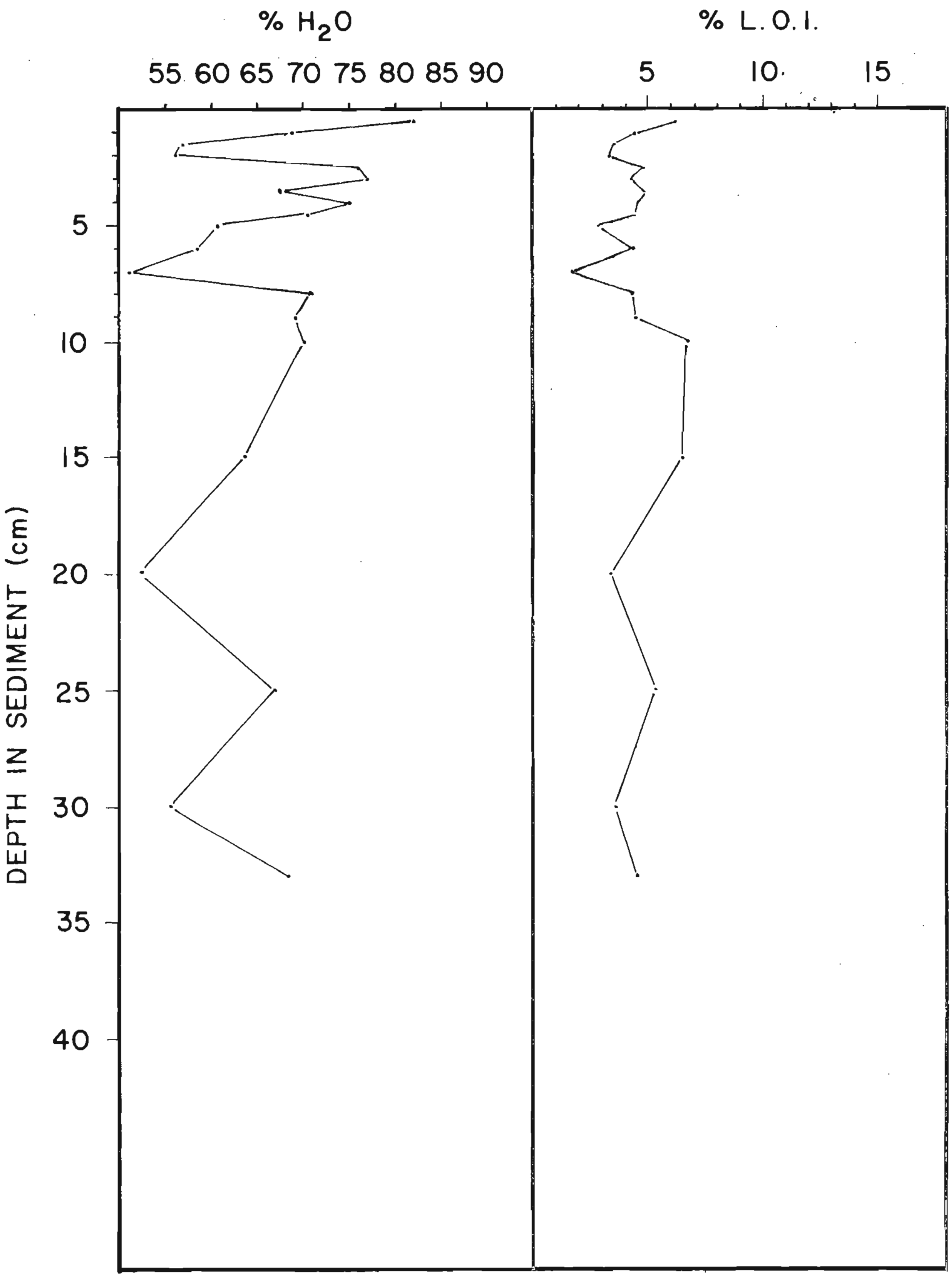
Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	1.90	*N.E.S.	18	120
2	0.5-1.0	3.60	6.43	18	130
2-2	0.5-1.0	2.90	5.53	-	-
3	1.0-1.5	3.95	4.19	35	140
4	1.5-2.0	3.45	2.80	18	140
5	2.0-2.5	3.00	2.67	18	140
6	2.5-3.0	2.10	3.00	25	120
7	3.0-3.5	3.95	2.71	50	170
8	3.5-4.0	2.30	2.81	25	155
9	4.0-4.5	2.25	2.50	43	150
10	4.5-5.0	3.70	2.45	18	185
11	5.0	1.70	2.68		
12	6.0	1.45	2.13		
13	7.0	2.05	2.12		
14	8.0	1.60	2.54		
15	9.0	1.95	2.10		
16	10.0	1.40	2.16		
17	15.0	1.65	2.74		
18	20.0	2.20	2.25		
19	25.0	1.75	2.45		
20	30.0	1.50	2.41		
21	35.0	1.35	2.07		
22	40.0	1.45	1.73		
23	41.0-42.0	1.55	1.61		
	Mean	2.28	2.79	27	145

*N.E.S. = not enough sample.


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5
10
15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

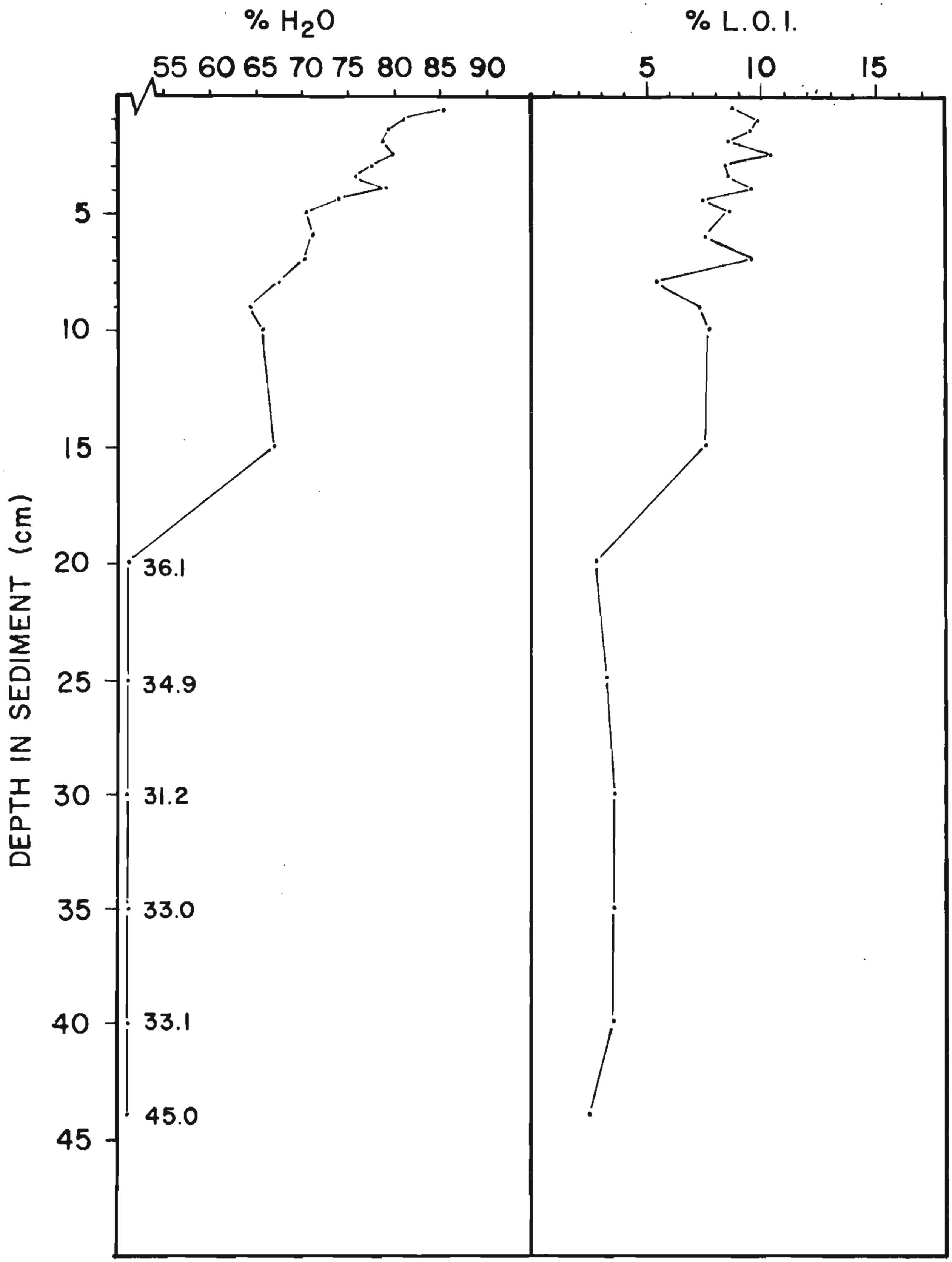
Core no. B9 Description: Pinkut

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (µg/g)	Zn (µg/g)
1	0.0-0.5	2.00	5.19	35	120
2	0.5-1.0	7.80	3.67	35	125
3	1.0-1.5	1.95	2.53	25	100
4	1.5-2.0	2.00	1.64	35	115
5	2.0-2.5	1.80	2.00	25	110
6	2.5-3.0	3.65	2.59	25	90
7	3.0-3.5	3.45	2.68	25	90
8	3.5-4.0	3.80	3.18	25	100
9	4.0-4.5	2.10	2.14	35	105
10	4.5-5.0	1.65	2.61	43	105
11	5.0	2.00	1.81		
12	6.0	1.55	2.40		
13	7.0	1.70	1.48		
14	8.0	2.65	2.12		
15	9.0	1.75	2.39		
16	10.0	2.45	2.09		
17	15.0	2.15	2.44		
18	20.0	2.65	2.02		
19	25.0	1.85	2.35		
20	30.0	1.55	1.56		
21	33.0	1.50	2.66		
	Mean	2.48	2.45	31	106


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5 10 15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40

Core no. B10 Description: Port Arthur

Sample	Depth (cm)	Total P (mg/g)	Organic C (%)	Cu (μg/g)	Zn (μg/g)
1	0.0-0.5	3.25	6.20	50	180
2	0.5-1.0	6.60	5.46	25	110
3	1.0-1.5	6.70	5.03	25	120
4	1.5-2.0	5.00	4.78	35	100
5	2.0-2.5	2.25	4.77	50	180
6	2.5-3.0	1.95	5.10	58	165
7	3.0-3.5	3.20	3.42	43	130
8	3.5-4.0	2.85	3.94	43	120
9	4.0-4.5	12.60	3.79	58	200
10	4.5-5.0	2.00	3.61	50	155
11	5	1.95	3.73		
12	6	1.60	3.97		
13	7	1.55	4.10		
14	8	1.45	2.63		
15	9	1.30	2.52		
16	10	1.45	3.18		
17	15	1.25	3.63		
18	20	1.05	1.02		
19	25	0.85	1.12		
20	30	0.95	0.76		
21	35	1.00	0.82		
22	40	1.15	0.71		
23	44	0.90	0.78		
	Mean	2.73	3.26	44	146


% H_2O
55 60 65 70 75 80 85 90
% L.O.I.
5
10
15
DEPTH IN SEDIMENT (cm)
5
10
15
20
25
30
35
40
45
36.1
34.9
31.2
33.0
33.1
45.0