TRACE ELEMENTS IN THREE SOIL MONOSEQUENCES AND IRON-MANGANESE CONCRETIONS FROM WESTLAND AND CANTERBURY, NEW ZEALAND.

PART TWO

APPENDICES 1, 2 and 3

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TABLE 1.5 Characteristics of the Chronosequence Soils[a]

Name and Abbreviation		Landform	Age (yr)	Altitude (metres a.s.l.)	Vegetation at site	Soil Classification
Hokitika	Ho	River flood-plain	1,000	190	Red beech, grasses, buttercup	Recent soil from alluvium
Hari Hari	Ha	River flood-plain	1,000	189	Red beech, grasses, buttercup	Recent soil from alluvium
Ikamatua	Io	Post-glacial degradational terrace	16,000	198	Red and silver beech, pepper tree	Lowland yellow-brown earth
Ikamatua (wetter)	Iw	Post-glacial degradational terrace	16,000	197	Manuka scrub, grasses	Lowland yellow-brown earth
Ahaura	Ah	Low glacial outwash terrace	18,000	210	Red and silver beech, grasses	Lowland yellow-brown earth
Kumara	Ku	Intermediate glacial out-wash terrace	>70,000	250	Manuka scrub, mosses, grasses	Lowland podzol; hydrous (gleyed podzol)
Okarito	Ok	High glacial outwash terrace	>130,000	390	Manuka scrub, bracken fern, umbrella fern, grasses	Lowland podzol; hydrous (strongly gleyed podzol)

[a] See reference 20

TABLE 2.1 CHRONOSEQUENCE

Soil pH, Horizon Depths, Weight Loss on Ignition, and Size Fractionation Data

Soil and Horizon		pH(H_2O)	Depth of Horizon(cm)	Weight Loss on Ignition (%)	Size Fractionation (% of Ignition Weight)		
					Sand	Silt	Clay
Ho	Au1	4.2	8	4.8	80	9	11
	Au2	4.5	12	3.5	81	9	10
	C	5.3	48	0.6	93	1	6
Ha	Ag	4.9	7	7.4	70	17	13
	ACg	5.1	9	4.2	75	15	10
	Cr	5.1	25	1.8	83	9	8
	Cs	-	1	-	-	-	-
	D	5.5	27	0.7	93	3	4
Io	OA	4.5	3	29.8	64	10	26
	A	4.7	6	16.6	63	18	19
	Bs1	5.0	16	9.5	68	12	20
	Bs2	5.3	15	4.8	80	8	12
	C1	5.1	6	2.5	80	10	10
	C2	5.2	25	1.6	89	6	5
Iw	OA	4.2	7	28.9	70	8	22
	A	4.6	6	20.4	66	9	25
	Ar	4.9	7	9.1	67	10	23
	Br1	5.2	6	5.7	64	14	22
	Br2	5.4	7	5.5	68	14	18
	Cr1	5.4	7	3.5	80	10	10
	Cr2	5.3	35	1.9	89	5	6
Ah	A	4.6	8	16.7	63	11	26
	AB	4.7	10	17.1	50	14	36
	Bs1	4.9	14	11.8	53	20	27
	Bs2	5.0	13	6.9	59	19	22
	Bs3	5.1	12	5.0	62	19	19
	C1	5.1	11	3.3	72	14	14
	C2	5.2	-	3.2	75	13	12
Ku	A	4.4	12	33.8	51	35	14
	Er	4.5	14	11.1	53	39	8
	Br1	4.7	15	3.9	47	34	19
	Br2	4.6	12	3.9	47	34	19
	Br3	4.7	8	5.0	50	30	20
	Cr	4.7	7	2.5	64	24	12
Ok	A	4.1	9	9.8	54	36	10
	Ag	4.3	9	4.7	55	36	9
	Br1	4.4	12	2.1	52	37	11
	Br2	4.5	8	1.4	57	33	10
	Br3	4.6	12	1.1	60	26	14
	Bs	-	1	2.1	61	22	17
	C	4.8	18	1.9	68	20	12

TABLE 2.2 BIOSEQUENCE

Soil pH, Horizon Depths, Weight Loss on Ignition, and Size Fractionation Data

Soil and Horizon		pH(H_2O)	Depth of Horizon(cm)	Weight Loss on Ignition (%)	Size Fractionation (% on Ignition Weight)		
					Sand	Silt	Clay
Ah	A	4.6	8	16.7	63	11	26
	AB	4.7	10	17.1	50	14	36
	Bs1	4.9	14	11.8	53	20	27
	Bs2	5.2	13	6.9	59	19	22
	Bs3	5.1	12	5.0	62	19	19
	C1	5.1	11	3.3	72	14	14
	C2	5.0	-	3.2	75	13	12
Pod Ah	O	3.6	9	50.0	53	24	23
	E	3.8	12	15.0	61	17	22
	Bs	4.7	22	11.8	62	18	30
	C	5.0	-	7.8	61	13	26

TABLE 2.3 TOPOSEQUENCE

Soil pH, Horizon Depths, Weight Loss on Ignition, and Size Fractionation Data

Soil and Horizon		pH(H_2O)	Depth of Horizon(cm)	% Clay	Loss on Ignition(%)	
					Clay	Whole Soil
L.F.S.	Ar	3.6	6	35	19.2	11.5
	Er	4.1	10	33	12.9	6.1
	Brs	4.2	4	51	23.9	15.3
	Bhrs	4.5	6	46	33.1	22.6
	Br	4.8	8	30	22.3	9.2
	Cr	4.9	13	4	28.9	6.8
CREST	E	3.7	5	20	15.6	5.0
	EB	4.1	4	26	19.0	7.0
	Bhs	4.5	8	39	20.7	10.2
	2Bs	5.1	7	37	18.9	9.0
	2Bw	5.2	13	27	16.8	6.8

TABLE 2.4 CHRONOSEQUENCE

Weights of the Size Fractions, Inorganic and Organic Fractions, and Soil Bulk Densities

Soil and Horizon		>2mm	<2mm	TOTAL	Inorganic	Organic	Bulk Density
		kg ha^{-1} x 10^4					g cm^{-3}
Ho	Au1	0	61	61	58	2.9	0.76
	Au2	0	133	133	128	4.7	1.11
	C	678	370	1048	368	2.2	2.18
TOTALS	TO: 0.38m (actual)	254	332	586	578	8.4	
	0.68m (act)	678	564	1242	1232	9.8	
	0.38m (estimate)	0	475	475	466	9.3	
	0.68m (est)	0	947	947	936	12.1	
Ha	Ag	0	62	62	57	4.6	0.89
	Acg	0	95	95	91	4.0	1.06
	Cr	0	283	283	278	5.1	1.13
	D	381	208	589	206	1.5	2.18
TOTALS	TO: 0.38m	0	406	406	393	13.1	
	0.68m (act)	381	648	1029	1013	15.2	
	0.68m (est)	0	863	863	845	16.7	
Io	A	0	33	33	27	5.5	0.55
	Bs1	0	130	130	118	12.4	0.81
	Bs2	0	170	170	162	8.2	1.13
	C1	0	79	79	77	2.0	1.32
	C2	289	238	527	234	3.8	2.11
TOTALS	TO: 0.38m	0	346	346	320	26.4	
	0.68m (act)	289	650	939	907	31.9	
	0.68m (est)	0	816	816	781	34.6	
Iw	A	0	46	46	37	9.4	0.77
	Ar	0	63	63	57	5.7	0.90
	Br1	0	64	64	60	3.6	1.07
	Br2	0	80	80	76	4.4	1.14
	Cr1	0	105	105	101	3.7	1.50
	Cr2	0	462	462	453	8.8	1.32
TOTALS	TO: 0.38m	0	424	424	396	28.1	
	0.68m (act)	0	820	820	784	35.6	
	0.68m (est)	0	820	820	784	35.6	

TABLE 2.4 (continued)

Soil and Horizon		>2mm	<2mm	TOTAL	Inorg-anic	Org-anic	Bulk Density
		kg ha^{-1} x 10^4					g cm^{-3}
Ah	A	0	40	40	33	6.7	0.50
	AB	0	64	64	53	10.9	0.64
	Bs1	0	99	99	87	11.7	0.71
	Bs2	0	124	124	115	8.6	0.95
	Bs3	0	164	164	156	8.2	1.37
	C1	0	152	152	147	5.0	1.38
TOTALS	TO: 0.38m	0	260	260	226	33.3	
	0.68m (act)	0	643	643	591	51.1	
	0.68m (est)	0	643	643	591	51.1	
Ku	A	0	35	35	23	11.8	0.29
	Er	0	70	70	62	7.8	0.50
	Br1	0	209	209	201	8.2	1.39
	Br2	0	142	142	137	5.5	1.18
	Br3	0	111	111	105	5.6	1.39
	Cr	0	99	99	96	2.5	1.41
TOTALS	TO: 0.38m	0	272	272	246	26.2	
	0.68m (act)	0	666	666	624	41.4	
	0.68m (est)	0	666	666	624	41.4	
Ok	A	0	73	73	66	7.2	0.81
	Ag	0	124	124	118	5.8	1.38
	Br1	0	185	185	181	3.9	1.54
	Br2	0	143	143	141	2.0	1.79
	Br3	0	206	206	204	2.3	1.72
	C	0	268	268	263	5.1	1.49
TOTALS	TO: 0.38m	0	525	525	506	18.9	
	0.68m (act)	0	999	999	973	26.3	
	0.68m (est)	0	999	999	973	26.3	

TABLE 2.5 CHRONOSEQUENCE

Total Amount of Sand, Silt and Clay

Soil and Horizon		Sand	Silt	Clay	Sand	Silt	Clay
		kg ha^{-1} x 10^4			kg ha^{-1} x 10^3 per cm of horizon		
Ho	Au1	47	5.2	6.4	58	6.6	8.7
	Au2	104	11.5	12.8	86	9.6	10.7
	C	342	3.7	22.1	71	0.8	4.6
TOTAL TO 0.38m		279	18.1	27.5			
% of TOTAL		85	6	9			
TOTAL TO 0.68m		493	20.4	41.3			
% of TOTAL		89	4	7			
Ha	Ag	40	9.7	7.4	57	13.8	10.6
	ACg	68	13.7	9.1	76	15.2	10.1
	Cr	231	25.0	22.2	92	10.0	8.9
	D	192	6.2	8.2	71	2.3	3.1
TOTAL TO 0.38m		311	45.4	36.0			
% of TOTAL		79	12	9			
TOTAL to 0.48m		531	54.6	46.9			
% of TOTAL		84	9	7			
Io	A	17	5.0	5.2	29	8.3	8.7
	Bs1	80	14.2	23.6	50	8.9	14.8
	Bs2	129	12.9	19.3	86	8.6	12.9
	C1	62	7.7	7.7	103	12.8	12.8
	C2	208	14.0	11.7	83	5.6	4.7
TOTAL TO 0.38m		236	33.4	49.4			
% of TOTAL		74	10	16			
TOTAL TO 0.68m		496	68.0	67.5			
% of TOTAL		79	11	10			
Iw	A	24	3.3	9.3	41	5.6	15.4
	Ar	38	5.7	13.1	55	8.1	18.7
	Br1	38	8.4	13.2	64	14.0	22.0
	Br2	52	10.6	13.7	74	15.2	19.5
	Cr1	81	10.1	10.1	115	14.4	14.4
	Cr2	403	22.7	27.2	115	6.5	7.8
TOTAL TO 0.38m		268	40.0	61.7			
% of TOTAL		72	11	17			
TOTAL TO 0.68m		636	60.8	86.6			
% of TOTAL		81	8	11			
Ah	A	21	3.6	8.6	26	4.5	10.7
	AB	27	7.4	19.1	27	7.4	19.1
	Bs1	47	17.6	23.8	33	12.6	17.0
	Bs2	67	21.7	25.1	52	16.7	19.3
	Bs3	97	29.6	29.6	81	24.7	24.7
	C1	106	20.6	20.6	96	18.7	18.7
	C2	-	-	-	-	-	-
TOTAL TO 0.38m		126	38.6	63.1			
% of TOTAL		55	17	28			
TOTAL TO 0.68m		365	100.5	126.8			
% of TOTAL		62	17	21			

TABLE 2.5 (continued)

Soil and Horizon		Sand	Silt	Clay	Sand	Silt	Clay
		kg ha^{-1} x 10^4			kg ha^{-1} x 10^3 per cm of horizon		
Ku	A	12	8.1	3.2	10	6.7	2.7
	Er	33	24.2	5.0	23	17.3	3.5
	Br1	94	68.3	38.2	63	45.6	25.5
	Br2	64	46.2	25.8	53	38.5	21.5
	Br3	53	31.5	21.0	66	39.4	26.3
	Cr	62	23.3	11.6	89	33.3	16.6
TOTAL TO 0.38m		120	86.9	38.8			
% of TOTAL		49	35	16			
TOTAL TO 0.68m		318	201.6	104.8			
% of TOTAL		51	32	17			
Ok	A	36	23.8	6.6	40	26.4	7.3
	Ag	65	42.5	10.6	72	47.2	11.8
	Br1	94	67.0	19.9	78	55.8	16.6
	Br2	80	46.5	14.1	100	58.2	17.6
	Br3	122	53.0	28.6	102	44.2	23.8
	C	178	52.4	31.4	99	29.1	17.5
TOTAL TO 0.38m		275	179.8	51.2			
% of TOTAL		54	36	10			
TOTAL TO 0.68m		575	285.2	111.2			
% of TOTAL		59	29	12			

TABLE 4.1 CHRONOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Sand Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	µg g^{-1}			%	µg g^{-1}			
Ho	Au1	0.23	35	18	296	2.04	10	19	11	33
	Au2	0.28	44	24	323	1.97	9	13	18	33
	C	0.24	45	24	288	2.05	8	12	6	41
Ha	Ag	0.30	36	24	350	2.18	10	10	13	49
	ACg	0.28	35	21	312	2.09	9	11	20	51
	Cr	0.32	35	25	408	2.05	9	9	7	48
	D	0.20	26	27	277	2.12	8	13	16	46
Io	OA	0.17	17	12	270	1.26	8	5	7	15
	A	0.19	13	10	277	1.32	6	6	9	12
	Bs1	0.16	17	13	223	1.17	7	6	8	21
	Bs2	0.25	30	19	376	1.73	9	8	11	34
	C1	0.22	30	18	358	1.80	9	13	20	38
	C2	0.26	35	24	408	2.17	10	19	13	55
Iw	OA	0.15	12	12	187	0.43	5	4	0	13
	A	0.24	17	13	252	0.89	5	5	11	15
	Ar	0.23	22	13	280	1.09	5	5	12	22
	Br1	0.22	22	16	268	1.54	6	4	4	27
	Br2	0.23	22	16	246	1.67	5	6	11	29
	Cr1	0.26	30	21	281	2.14	10	13	17	50
	Cr2	0.31	48	28	427	2.99	11	19	8	86
Ah	A	0.20	13	15	338	1.39	5	7	7	35
	AB	0.27	13	13	426	1.30	6	8	22	19
	Bs1	0.24	13	12	366	1.26	7	8	16	25
	Bs2	0.18	13	13	271	1.21	7	18	13	26
	Bs3	0.18	22	16	286	1.55	8	10	22	34
	C1	0.24	30	19	371	2.08	8	10	17	48
	C2	0.27	39	24	417	2.20	10	10	17	52

TABLE 4.1 (continued)

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	μg g^{-1}			%	μg g^{-1}			
Ku	A	0.31	5	4	273	0.29	3	3	3	0
	Er	0.25	4	0	149	0.24	3	4	1	0
	Br1	0.24	4	0	193	0.24	2	3	0	0
	Br2	0.24	4	4	181	0.24	2	3	4	0
	Br3	0.22	5	6	204	0.26	0	3	2	0
	Cr	0.17	9	6	148	0.26	0	5	2	0
Ok	A	0.12	3	0	68	0.08	0	3	0	0
	Ag	0.16	3	0	79	0.10	0	9	7	0
	Br1	0.17	4	0	78	0.10	0	3	6	0
	Br2	0.15	3	0	86	0.09	0	3	0	0
	Br3	0.13	3	0	99	0.11	0	0	0	0
	Bs	0.12	7	0	74	0.27	0	0	0	0
	C	0.17	4	0	135	0.19	0	17	0	0

TABLE 4.2 CHRONOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Silt Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
Ho	Au1	0.51	90	67	439	3.44	12	24	32	115
	Au2	0.51	93	75	486	3.96	14	24	29	108
	C	0.55	97	84	511	4.50	16	33	57	146
Ha	Ag	0.48	76	56	436	2.92	12	21	22	93
	ACg	0.48	76	63	435	3.42	13	21	17	103
	Cr	0.46	95	76	441	3.84	17	25	36	115
	D	0.53	110	83	424	4.18	18	30	40	116
Io	OA	0.48	51	31	381	2.02	15	45	125	59
	A	0.52	40	34	339	1.87	8	10	15	37
	Bs1	0.47	41	31	325	1.87	8	21	30	40
	Bs2	0.51	78	53	480	3.22	13	32	24	101
	C1	0.50	84	63	495	3.33	14	24	20	107
	C2	0.47	103	73	551	4.07	17	32	36	140
Iw	OA	0.57	30	35	253	1.17	9	26	53	44
	A	0.47	20	32	281	1.25	8	22	38	45
	Ar	0.45	52	32	328	1.75	9	20	15	45
	Br1	0.46	40	31	363	2.22	9	18	16	45
	Br2	0.47	50	38	368	2.66	9	12	16	55
	Cr1	0.49	85	66	466	4.00	16	25	28	103
	Cr2	0.53	98	75	520	4.49	17	32	32	154
Ah	A	0.40	35	25	415	1.99	7	33	41	124
	AB	0.37	18	22	427	1.32	8	13	14	35
	Bs1	0.38	27	23	296	1.30	8	21	23	41
	Bs2	0.38	36	28	398	1.95	10	16	25	54
	Bs3	0.37	58	37	483	2.56	10	15	17	63
	C1	0.40	66	42	534	3.11	12	18	29	93
	C2	0.43	84	54	592	3.83	16	22	29	128

TABLE 4.2 (continued)

Soil and horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	µg g^{-1}			%	µg g^{-1}			
Ku	A	0.25	5	4	163	0.26	2	9	13	7
	Er	0.68	71	31	142	0.43	7	30	41	18
	Br1	0.34	9	9	124	0.24	0	3	10	8
	Br2	0.33	9	12	139	0.29	0	10	29	9
	Br3	0.36	8	15	137	0.30	5	8	13	11
	Cr	0.37	10	19	158	0.42	0	4	4	12
Ok	A	0.30	3	3	98	0.16	0	15	34	10
	Ag	0.36	4	6	111	0.17	0	9	27	11
	Br1	0.40	6	9	113	0.19	0	4	7	7
	Br2	0.41	5	9	134	0.24	0	10	13	9
	Br3	0.45	6	15	137	0.28	4	7	10	10
	Bs	0.46	9	13	156	0.58	5	9	7	11
	C	0.52	9	15	296	0.48	5	10	13	12

TABLE 4.3 CHRONOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Clay Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	C	Ni	Cu	Zn
		%	μg g^{-1}			%	μg g^{-1}			
Ho	Au1	0.67	97	85	610	5.57	16	45	47	64
	Au2	0.63	84	83	744	6.05	24	46	67	55
	C	0.14	23	41	136	2.09	8	17	30	46
Ha	Ag	0.65	37	91	486	4.70	27	59	84	74
	ACg	0.59	67	84	461	4.42	25	45	61	72
	Cr	0.63	107	93	403	5.08	21	43	73	63
	D	0.62	104	101	374	6.19	23	50	111	64
Io	OA	0.51	41	47	271	2.54	20	33	55	83
	A	0.60	62	42	306	3.66	19	24	27	152
	Bs1	0.63	108	73	291	4.34	17	24	49	300
	Bs2	0.65	136	98	1848	6.70	42	47	57	302
	C1	0.69	154	104	1349	6.66	36	52	56	366
	C2	0.73	123	90	1403	7.19	40	50	62	237
Iw	OA	0.69	34	52	197	1.66	16	29	52	52
	A	0.71	42	67	153	1.99	13	36	44	86
	Ar	0.68	85	84	284	4.03	18	23	33	112
	Br1	0.61	98	89	317	5.41	21	39	39	164
	Br2	0.72	145	109	375	6.35	22	42	32	244
	Cr1	0.56	102	101	408	7.43	22	41	44	223
	Cr2	0.63	107	99	524	5.98	23	57	58	261
Ah	A	0.71	41	46	347	2.93	16	27	56	89
	AB	0.77	115	61	241	5.74	15	22	30	73
	Bs1	0.83	133	76	273	6.86	17	22	23	108
	Bs2	1.00	165	97	453	8.79	24	37	66	293
	Bs3	0.73	172	94	423	7.87	21	33	66	151
	C1	0.81	156	98	600	7.72	23	32	43	289
	C2	0.94	165	98	702	8.40	24	35	48	382

TABLE 4.3 (continued)

Soil and horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	µg g^{-1}			%	µg g^{-1}			
Ku	A	1.25	110	45	157	0.77	10	29	46	47
	Er	1.05	103	50	80	0.70	13	21	50	191
	Br1	1.49	180	74	138	1.10	7	13	20	49
	Br2	1.51	195	79	139	1.09	8	9	15	36
	Br3	1.59	191	71	134	1.10	10	20	26	58
	Cr	1.19	166	81	128	1.13	11	16	28	58
Ok	A	0.74	14	20	141	0.36	0	13	16	42
	Ag	1.26	24	20	259	0.44	4	13	19	18
	Br1	2.26	258	77	124	0.91	11	16	35	48
	Br2	2.71	299	81	159	1.00	12	12	15	62
	Br3	1.88	224	60	115	0.85	11	20	20	57
	Bs	1.85	313	80	122	7.42	12	12	15	46
	C	2.25	264	77	184	1.58	11	16	11	130

TABLE 4.4 CHRONOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Whole Soil

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	μg g^{-1}			%	μg g^{-1}			
Ho	Au1	0.30	47	30	343	2.55	11	22	17	44
	Au2	0.34	52	34	380	2.56	11	17	24	42
	C	0.24	44	26	281	2.08	8	13	8	42
Ha	Ag	0.38	43	38	382	2.63	13	18	24	60
	ACg	0.34	44	34	345	2.52	11	16	24	61
	Cr	0.36	46	35	411	2.45	11	13	15	55
	D	0.23	32	32	285	2.34	9	15	21	49
Io	OA	0.29	27	23	281	1.67	12	16	31	37
	A	0.33	27	20	294	1.86	9	11	14	43
	Bs1	0.29	38	27	249	1.89	9	11	19	79
	Bs2	0.32	47	32	561	2.45	13	15	18	72
	C1	0.30	48	32	471	2.44	12	18	24	78
	C2	0.30	44	31	466	2.54	13	21	17	69
Iw	OA	0.30	18	23	194	0.76	8	11	16	24
	A	0.38	24	28	230	1.20	7	14	22	35
	Ar	0.36	39	31	286	1.83	8	11	17	45
	Br1	0.34	41	34	292	2.49	10	14	13	60
	Br2	0.35	48	36	286	2.65	9	13	15	71
	Cr1	0.31	43	34	312	2.86	12	17	21	73
	Cr2	0.34	54	35	437	3.24	11	22	12	100
Ah	A	0.35	23	24	349	1.86	8	15	23	59
	AB	0.46	50	32	360	2.90	10	14	24	41
	Bs1	0.43	48	31	327	2.78	10	14	19	51
	Bs2	0.40	51	34	335	3.02	11	22	27	90
	Bs3	0.32	57	35	349	2.94	11	15	29	62
	C1	0.34	53	35	426	3.01	11	14	22	88
	C2	0.37	60	37	474	3.16	12	15	22	101

TABLE 4.4 (continued)

Soil and horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%		μg g^{-1}		%		μg g^{-1}		
Ku	A	0.42	20	10	218	0.35	4	9	13	9
	Er	0.48	38	16	141	0.35	5	16	21	22
	Br1	0.51	39	17	159	0.40	2	5	7	12
	Br2	0.51	42	21	159	0.42	2	7	15	10
	Br3	0.54	43	22	170	0.44	4	8	10	15
	Cr	0.34	28	18	148	0.40	1	6	6	10
Ok	A	0.25	4	3	86	0.14	0	8	14	8
	Ag	0.33	5	4	107	0.16	0.4	9	15	6
	Br1	0.49	33	12	96	0.22	1.2	5	10	8
	Br2	0.49	33	11	109	0.24	1.2	6	6	11
	Br3	0.45	35	12	111	0.25	4	5	5	11
	Bs	0.49	60	17	101	1.56	3	4	4	11
	C	0.49	36	12	173	0.41	5	16	4	18

TABLE 4.5 BIOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Sand Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
Ah	A	0.20	13	15	338	1.39	5	7	7	35
	AB	0.27	13	13	426	1.30	6	8	22	19
	Bs1	0.24	13	12	366	1.26	7	8	16	25
	Bs2	0.18	13	13	271	1.21	7	18	13	26
	Bs3	0.18	22	16	286	1.55	8	10	22	34
	C1	0.24	30	19	371	2.08	8	10	17	48
	C2	0.27	39	24	417	2.20	10	10	17	52
Pod Ah	O	0.26	10	8	321	0.85	4	8	11	11
	E	0.22	10	10	370	0.81	4	4	4	9
	Bs	0.23	17	12	307	1.21	5	12	14	19
	C	0.27	26	19	347	1.72	7	10	17	32

TABLE 4.6 BIOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Silt Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
Ah	A	0.40	35	25	415	1.99	7	33	41	124
	AB	0.37	18	22	427	1.32	8	13	14	35
	Bs1	0.38	27	23	296	1.30	8	21	23	41
	Bs2	0.38	36	28	398	1.95	10	16	25	54
	Bs3	0.38	58	37	483	2.56	10	15	17	63
	C1	0.40	66	42	534	3.11	12	18	29	93
	C2	0.43	84	54	592	3.83	16	22	29	128
Pod Ah	O	0.26	14	10	154	0.44	6	30	22	27
	E	0.31	11	11	299	0.76	6	12	33	12
	Bs	0.34	22	24	340	1.31	7	10	14	22
	C	0.34	36	25	395	1.73	7	10	11	39

TABLE 4.7 BIOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Clay Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
Ah	A	0.71	41	46	347	2.93	16	27	56	89
	AB	0.77	115	61	241	5.74	15	22	30	73
	Bs1	0.83	133	76	273	6.86	17	22	23	108
	Bs2	1.00	165	97	453	8.79	24	37	66	293
	Bs3	0.73	172	94	423	7.87	21	33	66	151
	C1	0.81	156	98	600	7.72	23	32	43	289
	C2	0.94	165	98	702	8.40	24	35	48	382
Pod Ah	O	0.94	43	27	174	1.15	14	27	55	82
	E	1.27	42	47	180	1.12	11	15	37	39
	Bs	0.85	128	80	276	5.90	11	20	18	150
	C	0.81	106	77	393	6.12	17	35	46	159

TABLE 4.8 BIOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Whole Soil

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
Ah	A	0.35	23	24	349	1.86	8	15	23	59
	AB	0.46	50	32	360	2.90	10	14	24	41
	Bs1	0.43	48	31	327	2.78	10	14	19	51
	Bs2	0.40	51	34	335	3.02	11	22	27	90
	Bs3	0.32	57	35	349	2.94	11	15	29	62
	C1	0.34	53	35	426	3.01	11	14	22	88
	C2	0.37	61	37	474	3.16	12	15	22	101
Pod Ah	O	0.42	19	13	247	0.82	7	18	24	31
	E	0.47	17	18	316	0.87	6	8	16	16
	Bs	0.46	53	36	334	2.76	6	15	17	61
	C	0.42	48	35	365	2.87	10	17	24	66

TABLE 4.9 TOPOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Clay Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
L.F.S.	Ar	0.71	64	40	83	0.78	9	14	25	30
	Er	1.12	211	81	116	1.78	11	8	11	105
	Brs	1.27	214	91	118	1.78	12	14	16	67
	Bhrs	0.87	130	66	105	1.51	14	20	16	70
	Br	1.34	190	105	149	2.26	17	17	18	140
	Cr	1.38	150	124	246	3.47	19	33	49	267
Crest	E	0.98	83	38	96	1.48	11	13	24	25
	EB	1.00	246	86	115	6.85	9	5	37	43
	Bhs	0.75	157	83	88	5.76	9	9	21	61
	2Bs	0.89	198	100	107	6.77	16	15	24	178
	2Bw	0.94	203	102	169	7.15	17	18	40	224

TABLE 4.10 TOPOSEQUENCE

Concentration of the Elements Ti,V,Cr,Mn, Fe,Co,Ni,Cu and Zn in the Whole Soil

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		%	$\mu g\ g^{-1}$			%	$\mu g\ g^{-1}$			
L.F.S.	Ar	0.32	29	18	53	0.40	6	11	14	17
	Er	0.36	32	26	59	0.51	8	5	2	30
	Brs	0.57	65	44	78	0.94	8	5	5	46
	Bhrs	0.48	68	33	81	0.87	9	12	12	41
	Br	0.40	39	35	95	1.00	10	7	1	44
	Cr	0.30	43	29	228	1.82	10	11	1	60
Crest	E	0.22	17	7	35	0.30	5	8	8	14
	EB	0.31	163	21	51	1.67	6	0	3	8
	Bhs	0.41	68	36	69	3.03	7	0	4	34
	2Bs	0.39	52	44	95	2.78	8	11	10	58
	2Bw	0.35	39	34	151	2.66	12	10	6	54

TABLE 4.11 CHRONOSEQUENCE

Weight of the Elements Ti,V,Cr,Mn,Fe,Co, Ni,Cu and Zn in the Clay Fraction

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		kg ha^{-1}								
		$x10^{3}$	$x10^{1}$	$x10^{1}$	$x10^{2}$	$x10^{4}$	$x10^{1}$	$x10^{1}$	$x10^{1}$	$x10^{1}$
Ho	Au1	0.43	0.62	0.54	0.39	0.36	0.10	0.29	0.30	0.41
	Au2	0.81	1.1	1.1	0.95	0.77	0.31	0.59	0.86	0.70
	C	0.31	0.51	0.91	0.30	0.46	0.18	0.38	0.66	1.0
Ha	Ag	0.48	0.27	0.67	0.36	0.35	0.20	0.44	0.62	0.55
	ACg	0.54	0.61	0.76	0.42	0.40	0.23	0.41	0.56	0.66
	Cr	1.40	2.4	2.1	0.89	1.13	0.47	0.95	1.6	1.4
	D	0.51	0.85	0.83	0.31	0.51	0.19	0.41	0.91	0.52
Io	A	0.31	0.32	0.22	0.16	0.19	0.10	0.12	0.14	0.79
	Bs1	1.49	2.5	1.7	0.69	1.02	0.40	0.57	1.2	7.1
	Bs2	1.25	2.6	1.9	3.57	1.29	0.81	0.91	1.1	5.8
	C1	0.53	1.2	0.8	1.04	0.51	0.28	0.40	0.43	2.8
	C2	0.85	1.4	1.1	1.64	0.84	0.47	0.59	0.73	2.8
Iw	A	0.66	0.39	0.62	0.14	0.19	0.12	0.33	0.41	0.80
	Ar	0.89	1.1	1.1	0.37	0.53	0.24	0.30	0.43	1.5
	Br1	0.81	1.3	1.2	0.42	0.71	0.28	0.51	0.51	2.2
	Br2	0.99	2.0	1.5	0.51	0.87	0.30	0.58	0.44	3.3
	Cr1	0.57	1.0	1.0	0.41	0.75	0.22	0.41	0.44	2.3
	Cr2	1.71	2.9	2.7	1.43	1.63	0.63	1.6	1.6	7.1
Ah	A	0.61	0.35	0.40	0.30	0.25	0.14	0.23	0.48	0.77
	AB	1.5	2.2	1.2	0.46	1.10	0.29	0.42	0.57	1.4
	Bs1	2.0	3.2	1.8	0.65	1.63	0.40	0.52	0.55	2.6
	Bs2	2.5	4.1	2.4	1.14	2.21	0.60	0.93	1.7	7.4
	Bs3	2.2	5.1	2.8	1.25	2.33	0.62	1.0	2.0	4.5
	C1	1.7	3.2	2.0	1.24	1.59	0.47	0.66	0.89	6.0
	C2	-	-	-	-	-	-	-	-	-

TABLE 4.11 (continued)

Soil and Horizon		Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		kg ha^{-1}								
		$x10^{3}$	$x10^{1}$	$x10^{1}$	$x10^{2}$	$x10^{4}$	$x10^{1}$	$x10^{1}$	$x10^{1}$	$x10^{1}$
Ku	A	0.40	0.35	0.14	0.05	0.25	0.03	0.09	0.15	0.15
	Er	0.53	0.52	0.25	0.04	0.04	0.07	0.11	0.25	0.96
	Br1	5.7	6.9	2.8	0.53	0.42	0.27	0.50	0.76	1.9
	Br2	3.9	5.0	2.0	0.36	0.28	0.21	0.23	0.39	0.93
	Br3	3.3	4.0	1.5	0.28	0.23	0.21	0.42	0.55	1.2
	Cr	1.4	1.9	0.94	0.15	0.13	0.13	0.19	0.32	0.67
Ok	A	0.49	0.09	0.13	0.09	0.02	0	0.09	0.11	0.28
	Ag	1.3	0.25	0.21	0.27	0.05	0.04	0.14	0.20	0.19
	Br1	4.5	5.1	1.5	0.25	0.18	0.22	0.32	0.70	0.96
	Br2	3.8	4.2	1.1	0.22	0.14	0.17	0.17	0.21	0.87
	Br3	5.4	6.4	1.7	0.33	0.24	0.31	0.57	0.57	1.6
	C	7.1	8.3	2.4	0.58	0.50	0.35	0.50	0.35	4.1

TABLE 4.12 CHRONOSEQUENCE

Weight of the Elements Si,Ti,V,Cr,Mn,Fe, Co,Ni,Cu and Zn in Whole Soil

Soil and Horizon		Si	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		kg ha^{-1}									
		$x10^5$	$x10^3$	$x10^1$	$x10^1$	$x10^2$	$x10^4$	$x10^1$	$x10^1$	$x10^1$	$x10^1$
Ho	Au1	1.93	1.7	2.7	1.7	1.99	1.48	0.64	1.3	0.99	2.6
	Au2	4.17	4.4	6.7	4.4	4.86	3.28	1.4	2.2	3.1	5.4
	C	12.0	8.8	16.2	9.6	10.3	7.65	2.9	4.8	2.9	15.5
Ha	Ag	1.90	2.2	2.5	2.2	2.18	1.50	0.74	1.0	1.4	3.4
	ACg	2.97	3.1	4.0	3.1	3.14	2.29	1.0	1.4	2.2	5.6
	Cr	9.06	10.0	12.9	9.7	11.4	6.81	3.1	3.7	4.1	15.3
	D	6.72	4.7	6.6	6.6	5.87	4.82	1.9	3.1	4.3	10.1
Io	A	0.95	0.89	0.73	0.54	0.79	0.50	0.24	0.30	0.38	1.16
	Bs1	4.07	3.4	4.5	3.2	2.94	2.23	1.1	1.3	2.2	9.3
	Bs2	5.41	5.2	7.6	5.2	9.09	3.97	2.1	2.4	2.9	11.7
	C1	2.59	2.3	3.7	2.5	3.63	1.85	0.92	1.4	1.8	6.0
	C2	7.75	7.0	10.2	7.3	10.9	5.9	3.0	4.9	4.0	16.1
Iw	A	1.38	1.4	0.89	1.0	0.85	0.44	0.26	0.52	0.81	1.3
	Ar	2.01	2.1	2.2	1.8	1.63	1.04	0.46	0.63	0.97	2.6
	Br1	1.96	2.0	2.5	2.0	1.75	1.49	0.60	0.84	0.78	3.6
	Br2	2.44	2.7	3.6	2.7	2.17	2.01	0.68	0.99	1.1	5.4
	Cr1	3.46	3.1	4.3	3.4	3.15	2.89	1.2	1.7	2.1	7.4
	Cr2	15.0	15.4	24.5	15.9	19.8	14.7	5.0	10.0	5.4	45.3
Ah	A	1.16	1.2	0.76	0.79	1.15	0.61	0.26	0.50	0.76	1.9
	AB	1.88	2.4	2.7	1.7	1.91	1.54	0.53	0.74	1.3	2.2
	Bs1	2.98	3.7	4.2	2.7	2.84	2.42	0.87	1.2	1.7	4.4
	Bs2	3.98	4.6	5.9	3.9	3.85	3.47	1.3	2.5	3.1	10.4
	Bs3	5.1	5.0	8.9	5.5	5.44	4.59	1.7	2.3	4.5	9.7
	C1	4.78	5.0	7.8	5.1	6.26	4.42	1.6	2.1	3.2	12.9
	C2	-	-	-	-	-	-	-	-	-	-

TABLE 4.12 (continued)

Soil and horizon		Si	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
		kg ha^{-1}									
		$x10^5$	$x10^3$	$x10^1$	$x10^1$	$x10^2$	$x10^4$	$x10^1$	$x10^1$	$x10^1$	$x10^1$
Ku	A	0.99	0.97	0.46	0.23	0.50	0.08	0.09	0.21	0.30	0.21
	Er	2.62	3.0	2.4	0.99	0.87	0.22	0.31	0.99	1.3	1.4
	Br1	8.2	10.3	7.8	3.4	3.20	0.80	0.40	1.0	1.4	2.4
	Br2	5.7	7.0	5.8	2.9	2.18	0.58	0.27	0.96	2.1	1.4
	Br3	4.4	5.7	4.5	2.3	1.79	0.46	0.42	0.84	1.1	1.6
	Cr		3.3	2.7	1.7	1.42	0.38	0.10	0.58	0.58	0.96
Ok	A	2.97	1.7	0.26	0.20	0.57	0.09	0	0.53	0.92	0.53
	Ag	5.32	3.9	0.59	0.47	1.26	0.19	0.05	1.1	1.8	0.71
	Br1	8.00	8.9	6.0	2.2	1.74	0.40	0.22	0.91	1.8	1.4
	Br2	6.2	6.9	4.7	1.6	1.54	0.34	0.17	0.85	0.85	1.6
	Br3	8.89	9.2	7.1	2.4	2.26	0.51	0.82	1.0	1.0	2.2
	C	11.1	12.9	9.5	3.2	4.55	1.08	1.3	4.2	1.1	4.7

[a] An estimated weight of inorganic material was used for the C horizon since it contained stones in the top 38 cm. Instead of an actual weight of <2mm material of 368×10^4 kg ha^{-1}, the estimated weight of inorganic material used was $(368 \pm 143) = 511 \times 10^4$ kg ha^{-1}.

TABLE 4.13 CHRONOSEQUENCE

Weight of Elements in Whole Soil to a Depth of 0.38m

Soil	Si[a]	Ti[c]	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
	kg ha^{-1}									
	x10^5	x10^3	x10^1	x10^1	x10^2	x10^4	x10^1	x10^1	x10^1	x10^1
Ho[b]	15.3	12.8	21.8	13.4	14.7	10.6	4.4	7.2	6.3	19.8
Ha	-	14.1	17.9	13.8	15.4	9.78	4.5	5.7	7.2	22.5
Io	10.9	9.9	13.4	9.4	13.4	7.01	3.6	4.2	5.8	23.2
Iw	13.4	13.5	17.0	13.2	12.4	9.97	3.9	6.1	6.6	26.8
Ah	7.86	9.4	10.4	7.0	7.7	6.2	2.3	3.6	5.2	13.3
Ku	10.2	12.2	9.1	3.9	3.9	0.94	0.72	2.0	2.7	3.5
Ok	22.5	21.4	11.6	4.5	5.1	1.02	0.44	3.4	5.4	4.2

a Weight of Si calculated using Si concentrations determined by Campbell[20].

b An estimated weight of 281 x 10^4 kg ha^{-1} of inorganic material was used for calculations involving the Ho C horizon down to a profile depth of 38 cm. The stones above 38 cm, in the C horizon can be replaced by 143 x 10^4 kg ha^{-1} < 2mm soil, and the 18 cm of the C horizon above a depth of 38 cm contain ($^{18}/_{48}$) x 368 = 138 x 10^4 kg ha^{-1} of <2mm soil.

c Si:Ti ratios; Ho(120), Ha(-), Io(110), Iw(99), Ah(84), Ku(84), Ok(105).

TABLE 4.14 CHRONOSEQUENCE

Weight of Elements in the Clay Fraction to a Depth of 0.38m

Soil	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
	kg ha^{-1}								
	x10^3	x10^1	x10^1	x10^2	x10^4	x10^1	x10^1	x10^1	x10^1
Ho[a]	1.5	2.1	2.3	1.57	1.48	0.54	1.2	1.7	1.9
Ha	2.3	3.0	3.3	1.56	1.74	0.84	1.7	2.6	2.4
Io	3.1	5.6	4.0	4.59	2.58	1.4	1.7	2.5	14.2
Iw	4.2	6.2	5.8	2.05	3.28	1.2	2.4	2.5	11.1
Ah	5.3	7.6	4.5	1.94	4.00	1.1	1.6	2.4	8.2
Ku	5.5	6.4	2.6	0.51	0.63	0.32	0.60	1.0	2.6
Ok	10.1	9.6	2.9	0.83	0.39	0.43	0.72	1.2	2.3

a The mass of inorganic material in the Ho C horizon above 38 cm was taken as 281 x 10^4 kg ha^{-1}, and therefore the inorganic mass of clay in the C horizon above 38 cm is 16.9 x 10^4 kg ha^{-1}.

TABLE 4.15 CHRONOSEQUENCE

'Corrected' Values for Weights of Trace Elements to 0.38m

(A) Assumed: 1) Si constant Ah to Ok
2) Ti constant Ho(c) to Ah

Soil	Si	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
	kg ha^{-1}									
	$x10^5$	$x10^3$	$x10^1$	$x10^1$	$x10^2$	$x10^4$	$x10^1$	$x10^1$	$x10^1$	$x10^1$
Ho(c)	19.4	14.3	26.2	15.5	16.7	12.4	4.8	7.7	4.8	25.0
Ho	17.1	14.3	24.4	15.0	16.4	11.8	4.9	8.0	7.0	22.1
Ha	-	14.3	18.2	14.0	15.6	9.92	4.6	5.8	7.3	22.8
Io	15.7	14.3	19.4	13.6	19.4	10.1	5.2	6.1	8.4	33.5
Iw	14.2	14.3	18.0	14.0	13.1	10.6	4.1	6.5	7.0	28.4
Ah	12.0	14.3	15.8	10.6	11.7	9.4	3.5	5.5	7.9	20.2
Ku	12.0	14.4	10.7	4.6	4.6	1.11	0.85	2.4	3.2	4.1
Ok	12.0	11.4	6.2	2.4	2.7	0.54	0.23	1.8	2.9	2.2
(B) Assumed: 1) Constant annual loss of 0.026 kg Ti ha^{-1}										
Ho(c)	19.4	14.3	26.2	15.5	16.7	12.4	4.8	7.7	4.8	25.0
Ho	17.1	14.3	24.4	15.0	16.4	11.8	4.9	8.0	7.0	22.1
Ha	-	14.3	18.2	14.0	15.6	9.92	4.6	5.8	7.3	22.8
Io	15.3	13.9	18.9	13.2	18.9	9.82	5.1	5.9	8.2	32.6
Iw	13.8	13.9	17.5	13.6	12.7	10.3	4.0	6.3	6.8	27.6
Ah	11.6	13.8	15.2	10.2	11.3	9.1	3.4	5.3	7.6	19.5
Ku	10.5	12.6	9.4	4.0	4.0	0.97	0.74	2.1	2.8	3.6
Ok	8.4	8.0	4.4	1.7	1.9	0.38	0.16	1.3	2.0	1.5
(C) Loss of elements as a percentage of the amount in Ho C horizon (Calculated from data in Table 4.15(B)).										
Ho	12	0	7	3	2	5	0	0	0	12
Ha	-	0	31	10	7	20	4	25	0	9
Io	21	3	28	15	0	21	0	23	0	0
Iw	29	3	33	12	24	17	17	18	0	0
Ah	40	4	42	34	32	27	29	31	0	22
Ku	46	5	64	74	76	92	85	73	42	86
Ok	57	44	83	89	89	97	97	83	58	94

TABLE 4.16 CHRONOSEQUENCE

Concentrations of Mn,Fe,Cu,Zn,Al and Si that are Extractable With Ammonium Oxalate

Soil and horizon		Mn	Fe	Cu	Zn	Al	Si
		μg g^{-1}					
Ho	Au1	200	3770	3	16	1560	520
	Au2	180	3690	3	10	1620	470
	C	59	1100	1	19	460	180
Ha	Ag	125	4880	5	31	1720	530
	ACg	89	5250	6	30	1520	410
	Cr	17	3630	5	30	1240	380
	D	8	2690	3	6	730	190
Io	OA	-	11940	4	39	7320	550
	A	286	12910	3	31	5290	690
	Bs1	254	12690	1	18	5600	950
	Bs2	327	7390	1	25	4790	1610
	C1	241	6060	1	22	5650	1470
	C2	141	2780	1	31	4410	1270
Iw	OA	30	7060	4	23	5320	0
	A	6	9040	2	12	4710	50
	Ar	8	8990	6	45	5750	1120
	Br1	8	7900	7	25	5880	1130
	Br2	8	8240	7	14	6070	1560
	C1	7	4560	6	15	4540	1570
	C2	6	1430	5	17	4180	1130
Ah	A	126	15460	3	22	5320	1570
	AB	35	20100	1	7	5970	710
	Bs1	35	18230	3	39	7820	2080
	Bs2	29	16140	2	18	7540	3280
	Bs3	21	11610	1	17	6410	3050
	C1	32	7120	1	10	6330	3180
	C2	25	4970	1	12	6190	3270

TABLE 4.16 (continued)

Soil and horizon		Mn	Fe	Cu	Zn	Al	Si
		$\mu g\ g^{-1}$					
Ku	A	9	3180	8	8	2180	140
	Er	4	1080	0	22	1720	0
	Br1	3	140	0	13	1170	0
	Br2	0	290	0	7	1790	0
	Br3	0	120	2	6	2280	0
	Cr	0	170	4	10	2690	210
Ok	A	6	150	0	18	30	0
	Ag	2	90	6	8	140	0
	Br1	0	60	0	5	800	0
	Br2	0	0	3	7	1090	0
	Br3	0	60	0	12	1360	0
	Bs	8	8730	0	8	3660	420
	C	0	870	0	13	5830	2130

TABLE 4.17 BIOSEQUENCE

Ammonium Oxalate Extractable Mn,Fe,Cu,Zn Al and Si Expressed as a Concentration ($\mu g\ g^{-1}$) and as a Percentage of the Total Amount of the Element in the soil (in parentheses)

Soil and Horizon		Mn	Fe	Cu	Zn	Al	Si
		$\mu g\ g^{-1}$					
Ah	A	126(36)	15460(83)	3	22	5320(7.5)	1570(0.44)
	AB	35(10)	20100(69)	1	7	5970(8.5)	710(0.20)
	Bs1	35(11)	18230(66)	3	39	7820(9.7)	2080(0.61)
	Bs2	29(9)	16140(53)	2	18	7540(9.3)	3280(0.95)
	Bs3	21(6)	11610(39)	1	17	6410(7.8)	3050(0.93)
	C1	32(8)	7120(24)	1	10	6330(8.1)	3180(0.98)
	C2	25(5)	4970(16)	1	12	6190(8.5)	3270(1.01)
Pod Ah	O	40(16)	6820(83)	4	24	5340	300
	E	6(2)	3860(44)	2	9	2580(4.6)	30(0.01)
	Bs	19(6)	18300(66)	0	38	9360(10.9)	3250(0.96)
	C	27(7)	12330(43)	4	16	8700(11.4)	4380(1.4)

TABLE 4.18 TOPOSEQUENCE

Ammonium Oxalate Extractable Mn,Fe,Cu,Zn, Al and Si Expressed as a Concentration ($\mu g\ g^{-1}$) and as a Percentage of the Total Amount of the Element in the Soil (in parentheses)

Soil and horizon		Mn	Fe	Cu	Zn	Al	Si
		$\mu g\ g^{-1}$					
L.F.S.	Ar	4	680(17)	0	10	2410(5)	0
	Er	2	550(11)	1	18	4140(7)	0
	Brs	2	450(5)	0	11	8570(12)	790(0.2)
	Bhrs	2	300(3)	1	10	9900(9)	2360(0.8)
	Br	0	300(3)	1	18	7930(8)	1970(0.6)
	Cr	2	570(3)	1	10	7090(8)	2160(0.7)
Crest	E	2	650(22)	0	13	1310(6)	0
	EB	6	6390(38)	1	21	4800(12)	210(0.1)
	Bhs	3	10810(36)	1	26	6910(11)	3150(0.9)
	2Bs	2	8440(30)	2	29	9470(10)	6760(2.1)
	2Bw	2	6000(23)	2	22	7360(8)	3960(1.2)

TABLE 4.19 CHRONOSEQUENCE

Weights of Ammonium Oxalate Extractable Al,Si,Fe,Mn,Cu and Zn Calculated Using Data from Tables 2.4 and 4.16

Soil and Horizon			Al	Si	Fe	Mn	Cu	Zn
			kg ha^{-1} x 10^3			kg ha^{-1} x 10^1		
Ho	Au1		0.90	0.30	2.19	11.6	0.17	0.93
	Au2		2.07	0.60	4.72	23.0	0.38	1.28
	C		1.69	0.66	4.05	21.7	0.37	6.99
TOTAL	TO:	0.38m	3.60	1.15	8.43	42.7	0.69	4.8
		0.68m	4.66	1.56	11.0	56.3	0.92	9.2
Ha	Ag		0.98	0.30	2.78	7.13	0.29	1.77
	ACg		1.38	0.37	4.78	8.10	0.55	2.73
	Cr		3.45	1.06	10.1	4.73	1.39	8.34
	D		1.50	0.39	5.54	1.65	0.62	1.24
TOTAL	TO:	0.38m	5.40	1.60	16.4	19.4	2.06	11.8
		0.68m	7.31	2.12	23.2	21.6	2.85	14.1
Io	A		1.43	0.19	3.49	7.72	0.08	0.84
	Bs1		6.61	1.12	15.0	30.0	0.12	2.12
	Bs2		7.76	2.61	12.0	53.0	0.16	4.05
	C1		4.35	1.13	4.67	18.6	0.08	1.69
	C2		10.3	2.97	6.51	33.0	0.23	7.25
TOTAL	TO:	0.38m	16.5	4.11	31.3	93.8	0.37	7.29
		0.68m	30.5	8.02	41.7	142.3	0.67	16.0
Iw	A		1.74	0.01	3.34	0.22	0.07	0.44
	Ar		3.28	0.64	5.12	0.46	0.34	2.57
	Br1		3.53	0.68	4.74	0.48	0.42	1.5
	Br2		4.61	1.19	6.26	0.61	0.53	1.06
	Cr1		4.59	1.59	4.61	0.71	0.61	1.51
	Cr2		18.9	5.12	6.48	2.72	2.27	7.70
TOTAL	TO:	0.38m	20.4	4.84	25.0	2.87	2.29	8.18
		0.68m	36.7	9.23	30.6	5.20	4.24	14.8

TABLE 4.19 (continued)

Soil and horizon		Al	Si	Fe	Mn	Cu	Zn
		kg ha^{-1} x 10^3			kg ha^{-1} x 10^1		
Ah	A	1.76	0.52	5.10	4.16	0.10	0.73
	AB	3.16	0.38	10.7	1.86	0.05	0.37
	Bs1	6.80	1.81	15.9	3.05	0.26	3.4
	Bs2	8.67	3.77	18.6	3.34	0.23	2.1
	Bs3	10.0	4.76	18.1	3.28	0.16	2.7
	C1	9.31	4.67	10.5	4.70	0.15	1.5
TOTAL	TO: 0.38m	15.7	4.45	40.3	10.6	0.52	5.45
	0.68m	39.7	15.9	78.9	20.4	0.95	10.8
Ku	A	0.50	0.03	0.10	0.21	0.18	0.18
	Er	1.07	0	0.67	0.25	0	1.4
	Br1	2.35	0	0.28	0.60	0	2.6
	Br2	2.45	0	0.40	0	0	0.96
	Br3	2.39	0	0.13	0	0.21	0.63
	Cr	2.58	0.20	0.16	0	0.38	0.96
TOTAL	TO: 0.38m	3.45	0.03	0.99	1.06	0.18	3.66
	0.68m	11.3	0.23	1.74	1.06	0.77	6.73
Ok	A	0.02	0	0.10	0.40	0	1.1
	Ag	0.26	0	0.16	0.24	1.1	1.5
	Br1	1.45	0	0.11	0	0	0.91
	Br2	1.54	0	0	0	0.42	0.99
	Br3	2.77	0	0.12	0	0	2.4
	C	15.3	5.60	2.29	0	0	3.4
TOTAL	TO: 0.38m	3.27	0	0.37	0.64	1.52	4.50
	0.68m	21.3	5.60	2.78	0.64	1.52	10.3

TABLE 4.20 CHRONOSEQUENCE

Percentage of the Total Amount of Elements Extracted by Ammonium Oxalate

Soil and Horizon		Percentage of Total Extracted					
		Mn	Fe	Cu	Zn	Al	Si
Ho	Au1	58	15	18	36	2	0.16
	Au2	47	14	13	24	2	0.14
	C	21	5	13	45	1	0.06
Ha	Ag	33	19	21	52	-	-
	ACg	26	21	25	49	-	-
	Cr	4	15	33	55	-	-
	D	3	11	14	12	-	-
Io	OA	-	71	13	105	9	0.16
	A	97	69	21	72	7	0.20
	Bs1	102	67	5	23	7	0.28
	Bs2	58	30	6	35	6	0.48
	C1	51	25	5	28	7	0.44
	C2	30	11	6	45	6	0.38
Iw	OA	15	93	25	96	8	0
	A	3	75	9	34	7	0
	Ar	3	49	35	100	7	0.30
	Br1	3	32	54	42	8	0.35
	Br2	3	31	47	20	7	0.49
	C1	2	16	29	21	6	0.46
	C2	1	4	42	17	6	0.34
Ah	A	36	83	13	37	8	0.44
	AB	10	69	4	17	9	0.20
	Bs1	11	66	16	76	10	0.61
	Bs2	9	53	7	20	9	0.95
	Bs3	6	39	3	29	8	0.93
	C1	8	24	5	11	8	0.98
	C2	5	16	5	12	8	1.01

TABLE 4.20 (continued)

Soil and Horizon		Percentage of Total Extracted					
		Mn	Fe	Cu	Zn	Al	Si
Ku	A	4	91	62	89	7	0.33
	Er	3	31	0	100	5	0
	Br1	2	4	0	-	3	0
	Br2	0	7	0	70	4	0
	Br3	0	3	20	40	6	0
	Cr	0	4	67	100	6	0.50
Ok	A	7	11	0	-	0.42	0
	Ag	2	6	40	-	1	0
	Br1	0	3	0	63	4	0
	Br2	0	0	50	64	6	0
	Br3	0	2	0	-	5	0
	Bs	8	56	0	73	-	-
	C	0	21	0	72	18	0.5

TABLE 4.21 CHRONOSEQUENCE

Percentage of the Amount of Elements to 0.38m, that is Extractable by Ammonium Oxalate or Sodium Pyrophosphate, Calculated using Tables 4.13, 4.19 and 4.25

Soil	Percentage of Elements that is Extractable									
	Al		Si		Mn		Fe		Zn	
	Oxal	Pyro	Oxal	Pyro	Oxal	Pyro	Oxal	Pyro	Oxal	Pyro
Ho	1.1	0.42	0.08	0	29	15	8	3.2	24	2.2
Ha	-	-	-	-	13	9.4	17	6.9	52	4.9
Io	6.6	8.0	0.38	0.07	70	17	45	32	31	6.0
Iw	6.8	6.1	0.36	0.17	2	0.5	25	15	31	5.6
Ah	9.0	14.4	0.57	0.51	14	11	65	51	41	12
Ku	3.5	2.7	0	0.02	3	2.1	11	11	105	22
Ok	4.3	4.2	0	0	1	1.1	4	0	105	0

TABLE 4.22 CHRONOSEQUENCE

Concentrations of Mn,Fe,Zn,Al and Si that are Extractable with Sodium Pyrophosphate

Soil and Horizon		Mn	Fe	Zn	Al	Si
		μg g^{-1}				
Ho	Au1	120	1760	3	720	0
	Au2	107	1760	2	750	0
	C	14	50	0	50	0
Ha	Ag	101	3030	2	2230	620
	ACg	66	2170	11	820	560
	Cr	11	1260	0	600	590
	D	1	650	0	160	550
Io	OA	-	10720	18	8030	1080
	A	153	11470	5	8470	480
	Bs1	98	10970	6	9450	440
	Bs2	41	3940	3	3950	70
	C1	14	2400	4	2620	70
	C2	12	750	2	1550	70
Iw	OA	27	7460	16	5910	1000
	A	4	6480	0	5060	840
	Ar	3	6450	18	8260	810
	Br1	3	6800	4	9170	1500
	Br2	2	6150	3	7830	730
	C1	0	3210	0	3590	620
	C2	0	570	0	1660	610
Ah	A	155	13100	31	10040	1610
	AB	24	19150	3	11800	1720
	Bs1	16	15840	4	13480	2320
	Bs2	6	6150	2	7020	970
	Bs3	4	2770	0	4750	820
	C1	0	1960	2	3180	760
	C2	0	2180	0	3460	620

TABLE 4.22 (continued)

Soil and Horizon		Mn	Fe	Zn	Al	Si
		$\mu g\ g^{-1}$				
Ku	A	16	3250	10	2020	220
	Er	7	500	3	1350	200
	Br1	0	0	1	800	10
	Br2	0	0	11	1410	10
	Br3	0	0	2	2040	60
	Cr	0	0	2	2750	510
Ok	A	7	0	0	40	10
	Ag	1	0	0	160	0
	Br1	0	0	0	710	0
	Br2	0	0	0	1210	0
	Br3	0	0	0	1170	10
	Bs	0	6410	11	3620	520
	C	0	390	0	3240	0

TABLE 4.23 BIOSEQUENCE

Sodium Pyrophosphate Extractable Mn,Fe,Al, and Si Expressed as a Concentration ($\mu g\ g^{-1}$) and as a Percentage of the Total Amount of Elements in the Soil (in parentheses)

Soil and Horizon		Mn	Fe	Al	Si
		$\mu g\ g^{-1}$			
Ah	A	155(44)	13100(70)	10040(14)	1610(0.46)
	AB	24(7)	19150(66)	11800(17)	1720(0.48)
	Bs1	16(5)	15840(57)	13480(17)	2320(0.68)
	Bs2	6(2)	6150(20)	7020(9)	970(0.28)
	Bs3	4(1)	2770(9)	4750(6)	820(0.25)
	C1	0	1960(7)	3180(4)	760(0.23)
	C2	0	2180(7)	3460(4.7)	620(0.19)
Pod Ah	O	62(25)	5640(69)	5820	1630
	E	8(3)	3820(43)	2500(5)	970(0.26)
	Bs	9(3)	13960(50)	14390(17)	2340(0.69)
	C	3(1)	4630(16)	5810(8)	730(0.22)

TABLE 4.24 TOPOSEQUENCE

Sodium Pyrophosphate Extractable Mn,Fe,Al and Si Expressed as a Concentration ($\mu g\ g^{-1}$) and as a Percentage of the Total Amount of Elements in the Soil (in parentheses)

Soil and Horizon		Mn	Fe	Al	Si
		$\mu g\ g^{-1}$			
L.F.S.	Ar	0	280(7)	2160(5)	760(0.2)
	Er	7	80(2)	3450(6)	0
	Brs	0	300(3)	11570(16)	1880(0.6)
	Bhrs	0	380(4)	13550(12)	5620(1.8)
	Br	0	170(2)	8980(10)	1980(0.6)
	Cr	0	30	6760(8)	1460(0.5)
Crest	E	0	550(18)	690(3)	670(0.2)
	EB	0	8200(49)	4620(11)	790(0.2)
	Bhs	4	8250(27)	8500(13)	1630(0.5)
	2Bs	0	810(3)	4660(5)	710(0.2)
	2Bw	5	460(2)	3170(4)	600(0.2)

TABLE 4.25 CHRONOSEQUENCE

Weights of Sodium Pyrophosphate Extractable Al,Si,Mn and Fe, Calculated Using Data from Tables 2.4 and 4.22

Soil and Horizon		Al	Si	Fe	Mn	Zn
		kg ha^{-1} x 10^3			kg ha^{-1} x 10^1	
Ho	Au1	0.42	0	1.02	5.96	0.17
	Au2	0.96	0	2.25	13.7	0.26
	C	0.18	0	0.18	5.15	0
TOTAL TO:	0.38m	1.45	0	3.34	22.6	0.43
	0.68m	1.56	0	3.45	25.8	0.43
Ha	Ag	1.27	0.35	1.73	5.76	0.11
	ACg	0.75	0.51	1.97	6.01	1.0
	Cr	1.67	1.64	3.50	3.06	0
	D	0.33	1.13	1.34	0.21	0
TOTAL TO:	0.38m	3.49	2.30	6.78	14.5	1.11
	0.68m	4.02	3.63	8.54	15.04	1.11
Io	A	2.29	0.13	3.10	4.13	0.14
	Bs1	11.2	0.52	12.9	11.6	0.71
	Bs2	6.40	0.11	6.38	6.64	0.49
	C1	2.02	0.05	1.85	1.08	0.31
	C2	3.63	0.16	1.76	2.81	0.47
TOTAL TO:	0.38m	20.2	0.76	22.7	22.5	1.39
	0.68m	25.5	0.97	26.0	26.3	2.12
Iw	A	1.87	0.31	2.40	0.15	0
	Ar	4.71	0.46	3.68	0.17	1.03
	Br1	5.50	0.90	4.08	0.18	0.24
	Br2	5.95	0.55	4.67	0.15	0.23
	C1	3.63	0.63	3.24	0	0
	C2	7.52	2.76	2.58	0	0
TOTAL TO:	0.38m	18.5	2.31	15.3	0.65	1.50
	0.68m	29.2	5.61	20.7	0.65	1.50

TABLE 4.25 (continued)

Soil and Horizon		Al	Si	Fe	Mn	Zn
		kg ha^{-1} x 10^3			kg ha^{-1} x 10^1	
Ah	A	3.31	0.53	4.32	5.12	1.02
	AB	6.25	0.91	10.1	1.27	0.16
	Bs1	11.7	2.02	13.8	1.39	0.35
	Bs2	8.07	1.12	7.07	0.69	0.23
	Bs3	7.41	1.28	4.32	0.62	0
	C1	4.67	1.12	2.88	0	0.29
TOTAL TO:	0.38m	25.0	3.98	31.5	8.10	1.64
	0.68m	41.4	6.98	42.5	9.09	2.05
Ku	A	0.46	0.05	0.75	0.37	0.23
	Er	0.84	0.12	0.31	0.43	0.19
	Br1	1.61	0.02	0	0	0.20
	Br2	1.93	0.01	0	0	1.51
	Br3	2.14	0.06	0	0	0.21
	Cr	2.64	0.49	0	0	0.19
TOTAL TO	0.38m	2.59	0.19	1.06	0.80	0.76
	0.68m	9.62	0.75	1.06	0.80	2.76
Ok	A	0.03	0.01	0	0.46	0
	Ag	0.19	0	0	0.12	0
	Br1	1.29	0	0	0	0
	Br2	1.71	0	0	0	0
	Br3	2.39	0.02	0	0	0
	C	8.52	0	1.03	0	0
TOTAL TO:	0.38m	3.22	0.01	0	0.58	0
	0.68m	14.1	0.03	1.03	0.58	0

TABLE 4.26 CHRONOSEQUENCE

Percentage of the Total Amount of Elements Extracted by Sodium Pyrophosphate

Soil and Horizon		Percentage of Total Elements Extracted				
		Mn	Fe	Zn	Al	Si
Ho	Au1	35	7	7	1	0
	Au2	28	7	5	1	0
	C	5	0	0	0	0
Ha	Ag	26	12	3	-	-
	ACg	19	9	18	-	-
	Cr	3	5	0	-	-
	D	0	3	0	-	-
Io	OA	-	64	49	10	0.31
	A	52	62	10	11	0.14
	Bs1	39	58	7	12	0.13
	Bs2	7	16	4	5	0
	C1	3	10	5	3	0
	C2	3	3	3	2	0
Iw	OA	14	98	67	9	0.27
	A	2	54	0	7	0.23
	Ar	1	35	40	10	0.23
	Bs1	1	27	7	12	0.46
	Bs2	1	23	4	10	0.22
	C1	0	11	0	5	0.18
	C2	0	2	0	2	0.18
Ah	A	44	70	53	14	0.46
	AB	7	66	7	17	0.48
	Bs1	5	57	8	17	0.68
	Bs2	2	20	2	9	0.28
	Bs3	1	9	0	6	0.25
	C1	0	7	2	4	0.23
	C2	0	7	0	5	0.19

TABLE 4.26 (continued)

Soil and Horizon		Percentage of Total Elements Extracted				
		Mn	Fe	Zn	Al	Si
Ku	A	8	93	111	7	0.1
	Er	5	14	14	4	0.1
	Br1	0	0	8	2	0
	Br2	0	0	111	3	0
	Br3	0	0	13	6	0
	Cr	0	0	20	7	0.1
Ok	A	8	0	0	1	0
	Ag	1	0	0	1	0
	Br1	0	0	0	4	0
	Br2	0	0	0	7	0
	Br3	0	0	0	5	0
	Bs	0	41	100	-	-
	C	0	10	0	10	0

TABLE 4.27 CHRONOSEQUENCE

Linear Correlation Coefficients

	CEC	pH	% Clay	LOI	TOT Al	TOT Si	TOT Ti	TOT V	TOT Cr	TOT Mn	TOT Fe	TOT Co	TOT Ni	TOT Cu	TOT Zn
CEC															
pH	-.395														
% Clay	.549	-.010													
LOI	.703	-.312	.508												
TOT Al	.216	.590	.332	.089											
TOT Si	-.123	-.642	-.184	.013	-.973										
TOT Ti	-.068	-.269	.339	.126	-.439	.555									
TOT V	-.274	.613	.232	-.243	.677	-.657	.101								
TOT Cr	.058	.637	.340	-.022	.937	-.925	-.267	.840							
TOT Mn	-.017	.652	.077	-.011	.853	-.881	-.450	.614	.853						
TOT Fe	.040	.600	.303	.021	.924	-.934	-.439	.706	.932	.880					
TOT Co	.163	.598	.229	.127	.917	-.908	-.414	.652	.896	.901	.912				
TOT Ni	.208	.303	.084	.159	.716	-.709	-.397	.418	.682	.710	.736	.834			
TOT Cu	.451	.093	.337	.439	.526	-.476	-.195	.284	.549	.452	.538	.628	.675		
TOT Zn	-.028	.641	.124	-.045	.859	-.875	-.480	.621	.862	.864	.900	.893	.712	.550	
Clay Ti	-.326	-.331	-.145	-.276	-.717	.749	.705	-.201	-.596	-.623	-.667	-.660	-.587	-.564	-.607
Clay V	-.485	.124	-.064	-.448	-.272	.303	.600	.331	-.095	-.199	-.236	-.239	-.342	-.427	-.187
Clay Cr	-.407	.558	-.060	-.475	.482	-.480	.043	.778	.637	.559	.492	.473	.304	.063	.542
Clay Mn	-.197	.523	-.264	-.220	.527	-.569	-.456	.336	.521	.833	.542	.643	.519	.222	.608
Clay Fe	-.162	.631	.175	-.125	.839	-.849	-.375	.736	.893	.880	.946	.863	.695	.476	.902
Clay Co	-.105	.647	-.073	-,106	.696	-.705	-.364	.516	.701	.882	.685	.808	.619	.392	.742
Clay Ni	-.007	.416	-.131	.019	.711	-.718	-.464	.468	.693	.855	.703	.817	.759	.485	.736
Clay Cu	.120	.384	-.006	.168	.674	-.674	-.394	.431	.689	.697	.649	.744	.710	.725	.712
Clay Zn	-.145	.502	-.211	-.107	.379	-.371	-.343	.196	.310	.519	.283	.482	.347	.223	.516
Pyro Al	.451	.218	.829	.481	.546	-.437	.018	.238	.472	.323	.524	.473	.302	.412	.412
Pyro Si	.545	.174	.370	.420	.475	-.390	-.342	-.033	.269	.269	.292	.430	.194	.321	.377
Pyro Mn	.884	-.197	.346	.547	.351	-.283	-.245	-.150	.182	.137	.168	.367	.359	.490	.147
Pyro Fe	.552	.082	.825	.606	.518	-.412	-.008	.161	.422	.316	.504	.453	.311	.429	.350
Oxal Al	.222	.526	.562	.263	.708	-.639	-.108	.498	.692	.622	.713	.745	.571	.522	.702
Oxal Si	-.205	.604	.190	-.109	.607	-.617	-.201	.578	.667	.659	.731	.666	.549	.392	.780
Oxal Mn	.693	.086	.381	.441	.564	-.504	-.362	.090	.412	.467	.433	.593	.464	.477	.367
Oxal Fe	.357	.326	.493	.419	.674	-.576	-.248	.235	.548	.471	.602	.610	.488	.541	.628
Oxal Zn	.337	-.012	.025	.625	.098	-.070	-.178	-.265	-.065	.123	.048	.201	.251	.199	.053

TABLE 4.27 (continued)

Correlation coefficients at the 5%, 1% and 0.1% levels of significance are 0.318, 0.434 and 0.541 respectively

Coefficients calculated using the concentrations of the elements in each horizon.

	Clay Ti	Clay V	Clay Cr	Clay Mn	Clay Fe	Clay Co	Clay Ni	Clay Cu	Clay Zn	Pyro Al	Pyro Si	Pyro Mn	Pyro Fe	Oxal Al	Oxal Si	Oxal Mn	Oxal Fe	Oxal Zn
Clay V	.812																	
Clay Cr	.891	.608																
Clay Mn	-.380	-.065	.549															
Clay Fe	-.510	-.037	.669	.649														
Clay Co	-.388	.028	.654	.912	.773													
Clay Ni	-.523	-.177	.533	.837	.755	.876												
Clay Cu	-.556	-.259	.403	.581	.660	.718	.834											
Clay Zn	-.272	.005	.388	.695	.372	.717	.559	.432										
Pyro Al	-.337	-.181	.017	-.022	.402	.213	.082	.172	.263									
Pyro Si	-.419	-.318	-.079	.172	.195	.332	.207	.241	.511	.608								
Pyro Mn	-.356	-.427	-.242	-.002	-.002	.131	.224	.297	.028	.357	.639							
Pyro Fe	-.410	-.332	-.133	-.027	.335	.164	.106	.172	.069	.953	.598	.421						
Oxal Al	-.344	.019	-.426	.314	.711	.569	.430	.433	.361	.782	.517	.309	.648					
Oxal Si	-.259	.127	-.578	.394	.820	.541	.462	.465	.240	.404	.090	-.080	.237	.799				
Oxal Mn	-.520	-.411	-.025	.376	.281	.463	.468	.395	.387	.471	.751	.800	.576	.435	.004			
Oxal Fe	-.474	-.275	.137	.181	.551	.394	.373	.502	.232	.753	.587	.405	.663	.755	.592	.354		
Oxal Zn	-.224	-.300	-.262	.118	.009	.171	.193	.141	.157	.265	.370	.370	.304	.236	.015	.282	.454	

TABLE 6.11 WATERTON CONCRETION

Analytical Data Obtained from Electron Microprobe Analysis

Large concretion from the Brs1 horizon of profile 3

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
					(%)					
High Mn areas										
	0.23	0.08	0.02	0.01	53.5	1.47	0.02	n.d.[a]	0.02	0.44
	0.94	1.11	0.02	0.01	51.9	1.71	0.21	0.10	0.02	0.31
	0.86	0.15	0.01	0.01	52.3	2.56	0.17	0.07	0.03	0.21
	0.72	0.31	0.02	0.02	49.9	3.85	0.14	0.07	0.02	0.24
	0.46	0.12	0.01	n.d.	53.1	0.84	0.02	0.07	0.01	0.46
	1.08	1.03	0.01	0.01	52.4	0.96	0.04	0.07	0.01	0.50
	0.32	1.13	0.01	0.02	49.6	4.32	0.10	0.05	0.18	0.31
	2.38	2.88	0.12	0.01	43.9	6.53	0.05	0.03	0.02	0.26
	0.35	0.12	0.01	0.01	51.3	1.75	0.04	0.06	0.02	0.49
	6.76	0.41	0.01	0.01	51.4	1.83	0.09	0.06	0.02	0.36
	0.52	0.12	0.02	0.01	51.3	0.82	0.05	0.07	0.01	0.34
	0.86	0.66	0.04	n.d.	47.7	4.04	0.12	0.06	0.01	0.17
	0.93	1.11	0.03	0.01	45.9	1.25	0.07	0.05	0.01	0.42
	0.52	0.17	0.01	0.02	48.1	1.77	0.03	0.07	0.02	0.37
	0.17	0.08	0.03	0.02	51.8	0.81	0.02	0.08	0.03	0.44
$\bar{x} \pm \sigma_{n-1}$	1.14±1.64	0.63±0.75	0.02±0.03	0.01±0.01	50.3±2.8	2.30±1.66	0.08±0.06	0.06±0.02	0.03±0.04	0.35±0.10

TABLE 6.11 (continued)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
						(%)				
High Fe areas										
	2.98	11.8	0.10	0.02	2.43	38.1	0.03	0.02	n.d.	0.04
	2.93	3.46	0.15	0.07	0.42	46.7	0.04	0.02	0.03	0.06
	2.47	7.00	0.35	0.05	0.40	42.1	0.04	0.02	0.01	0.06
	3.03	8.96	0.17	0.07	0.14	41.4	0.03	0.02	0.01	0.01
	2.57	9.93	0.17	0.03	1.35	37.5	0.03	0.01	0.02	0.04
	1.86	8.67	0.14	0.04	5.87	42.0	0.04	0.02	0.02	0.02
	1.36	4.27	0.05	0.04	8.68	38.9	0.03	0.02	0.03	0.06
	1.90	6.27	0.11	0.04	3.06	41.6	0.03	0.02	0.02	0.04
	2.75	6.50	0.06	0.02	11.0	35.1	0.04	0.02	n.d.	0.04
	7.49	16.5	0.24	0.05	2.15	33.6	0.03	n.d.	0.01	0.05
	0.09	6.56	0.02	0.05	3.15	47.2	0.04	0.01	0.02	0.05
	2.44	5.74	0.18	0.03	3.34	36.1	0.02	n.d.	n.d.	0.01
	1.32	4.92	n.d.	0.02	6.13	39.3	0.03	n.d.	0.01	0.04
	3.60	15.7	0.14	0.02	0.15	36.4	0.02	n.d.	n.d.	0.01
	1.04	4.36	0.09	0.03	5.39	39.4	0.05	n.d.	n.d.	0.02
	2.36	9.11	0.07	0.04	2.82	44.8	0.03	n.d.	n.d.	0.04
	5.24	18.1	0.27	0.06	1.99	40.8	0.02	n.d.	0.01	0.02
$\bar{x} \pm \sigma_{n-1}$	2.67±1.68	8.69±4.46	0.13±0.09	0.04±0.02	3.43±3.07	40.1±3.86	0.03±0.01	0.01±0.01	0.01±0.01	0.04±0.02

TABLE 6.11 (continued)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
					(%)					
Low Mn and Fe areas										
	5.28	9.93	0.60	0.02	20.7	15.0	0.09	n.d.	n.d.	0.60
	1.66	3.73	0.12	0.02	20.8	7.46	n.d.	n.d.	n.d.	0.07
	5.54	13.7	0.16	0.02	21.7	1.26	0.04	n.d.	n.d.	0.09
	4.99	10.6	0.26	0.02	6.55	23.4	0.03	n.d.	n.d.	0.01
	4.65	11.9	0.57	0.02	4.11	21.1	0.02	n.d.	n.d.	n.d.
	4.35	8.87	0.30	0.02	0.14	23.8	0.01	n.d.	n.d.	n.d.
	5.38	10.9	0.25	0.01	10.2	8.05	0.03	n.d.	n.d.	0.03
	9.38	19.3	0.31	0.02	16.7	9.92	0.03	n.d.	n.d.	0.03
	9.10	25.8	0.32	0.01	1.12	12.4	n.d.	n.d.	n.d.	n.d.
$\bar{x} \pm \sigma_{n-1}$	5.59±2.37	12.75±6.40	0.32±0.16	0.02±0.00	6.47±6.21	9.02±4.72	0.01±0.01	0	0	0.09±0.19

[a] n.d. = not detected

CORRELATION COEFFICIENTS - LARGE SAMPLE 3-Brsl

* significant (1% level)
** highly significant (0.1% level)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
Al										
Si	0.824**									
Ti	0.660**	0.709**								
V	0.108	0.294	0.277							
Mn	-0.473**	-0.695**	-0.658**	-0.646**						
Fe	0.441*	0.788**	0.694**	0.748**	-0.791**					
Co	-0.264	-0.432*	-0.413*	-0.274	0.561**	-0.340				
Ni	-0.530**	-0.704**	-0.587**	-0.403*	0.714**	-0.927**	0.618**			
Cu	-0.321	-0.329	-0.299	0.017	0.210	-0.033	0.299	0.315		
Zn	-0.389*	-0.617**	-0.602**	-0.507**	0.796**	-0.863**	0.345	0.669**	0.242	

Underlined correlation coefficients correspond to linear correlation coefficients obtained after logarithms of both parameters were taken.

TABLE 6.12 WATERTON CONCRETION

Analytical Data Obtained From Electron Microprobe Analysis

Small concretion from the Brs1 horizon of profile 3

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
					(%)					
High Mn areas										
	6.79	23.4	0.51	0.01	25.7	5.88	0.15	0.03	n.d.[a]	0.10
	4.99	16.6	8.38	0.09	15.4	1.99	0.05	0.04	0.03	0.15
	4.31	26.4	0.24	n.d.	18.5	2.30	0.06	n.d.	0.01	0.08
	6.57	16.3	0.25	n.d.	16.0	12.8	0.06	0.02	1.12	0.10
	4.66	21.8	0.13	n.d.	18.3	2.42	0.02	n.d.	0.04	0.09
	6.26	11.8	0.20	0.01	33.2	3.98	0.13	0.01	0.01	0.22
	4.41	10.0	0.17	0.01	35.0	6.68	0.14	0.01	0.01	0.09
	7.67	16.4	0.29	n.d.	24.6	6.02	0.12	0.03	0.02	0.14
	7.78	15.9	0.21	0.01	26.9	3.00	0.07	0.02	0.02	0.14
$\bar{x} \pm \sigma_{n-1}$	5.39±2.16	16.2±6.8	1.04±2.58	0.01±0.03	23.7±7.2	5.00±3.42	0.09±0.05	0.02±0.01	0.02±0.01	0.12±0.05
High Fe areas										
	2.98	33.2	0.10	n.d.	1.12	20.2	0.01	n.d.	n.d.	n.d.
	5.49	21.8	8.13	0.06	4.43	18.4	0.05	0.02	0.03	0.06
	7.67	20.4	0.31	n.d.	7.85	16.0	0.06	0.01	0.01	0.05
	12.5	22.6	1.66	0.03	0.64	19.1	0.01	n.d.	0.02	0.02
	0.70	2.91	0.16	n.d.	11.7	24.1	0.03	n.d.	n.d.	n.d.
	0.47	3.32	0.02	0.01	22.2	31.7	0.14	0.01	0.01	0.07

TABLE 6.12 (continued)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
					(%)					
	6.40	16.8	0.18	0.01	0.60	33.2	0.06	0.01	n.d.	0.05
	4.49	12.9	0.46	0.02	1.66	24.8	0.02	n.d.	0.01	0.02
	4.39	11.7	0.23	0.02	0.48	36.1	0.04	0.01	0.02	0.05
	0.08	1.29	32.0	0.22	0.81	35.2	0.09	0.05	0.06	0.10
$\bar{x} \pm \sigma_{n-1}$	4.52±3.82	14.7±10.3	1.25±2.63	0.04±0.07	3.25±4.00	25.9±7.6	0.05±0.04	0.01±0.02	0.02±0.02	0.04±0.03
Low Mn and Fe areas										
	12.3	33.2	n.d.	n.d.	n.d.	0.19	n.d.	n.d.	n.d.	n.d.
	1.76	45.4	0.07	n.d.	0.44	5.58	n.d.	n.d.	n.d.	n.d.
	6.99	21.2	0.24	0.01	12.2	5.28	0.05	0.01	0.01	0.03
	8.10	2.97	5.33	0.09	6.98	1.31	0.02	0.02	0.02	0.02
	4.38	17.1	5.40	0.03	6.44	10.1	0.07	0.02	0.03	0.03
	3.65	18.9	14.1	0.16	1.99	8.47	0.02	0.03	0.02	0.02
	8.70	23.6	0.24	n.d.	8.92	1.88	0.01	n.d.	0.91	0.03
	10.7	15.8	0.13	0.03	3.05	1.55	0.03	0.01	0.03	0.12
	8.29	28.1	0.50	0.01	8.29	7.10	0.05	n.d.	n.d.	0.02
	3.65	21.5	0.24	0.02	14.2	9.47	0.06	n.d.	0.02	0.03
	0.87	15.8	20.7	0.14	0.17	1.44	0.01	0.03	0.02	0.02
$\bar{x} \pm \sigma_{n-1}$	6.30±3.46	24.4±8.6	4.27±6.96	0.05±0.06	5.70±4.95	4.76±3.65	0.03±0.02	0.01±0.01	0.02±0.01	0.03±0.03

[a] n.d. = not detected

TABLE 6.12 (continued)

CORRELATION COEFFICIENTS - SMALL SAMPLE 3-Brsl

* significant (1% level)
** highly significant (0.1% level)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
Al										
Si	0.349									
Ti	-0.426*	-0.307								
V	-0.348	-0.283	0.955**							
Mn	-0.017	-0.287	-0.332	-0.344						
Fe	-0.393	-0.490*	0.168	0.126	-0.326					
Co	-0.157	-0.493*	-0.049	-0.094	0.769	0.117				
Ni	-0.228	-0.379	0.732**	0.735**	0.079	0.027	0.357			
Cu	0.154	-0.010	-0.082	-0.130	0.044	-0.091	-0.102	-0.008		
Zn	0.094	-0.400	0.006	0.002	0.689**	-0.188	0.640**	0.426*	0.053	

TABLE 6.13 WATERTON CONCRETION

Analytical Data Obtained from Electron Microprobe Analysis

Concretion from the Brs2 horizon of profile 3

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
					(%)					
High Mn areas										
	4.43	17.0	5.42	0.03	15.0	5.54	0.01	0.01	0.02	0.14
	2.05	13.4	0.17	0.02	23.0	10.2	0.07	0.01	0.01	0.10
	4.35	7.90	0.23	0.02	30.7	8.15	0.13	0.05	0.03	0.17
	1.57	2.26	0.07	0.02	53.3	2.59	0.04	0.15	0.06	0.45
	2.38	4.23	0.07	0.03	43.8	7.85	0.12	0.08	0.05	0.23
	4.85	3.96	0.06	0.02	50.5	2.36	0.04	0.14	0.05	0.34
	3.52	5.72	0.11	0.01	42.7	3.20	0.06	0.10	0.05	0.27
	2.63	4.97	0.08	0.02	42.0	1.71	n.d.[a]	0.12	0.04	0.39
	3.61	13.4	12.1	0.23	14.4	1.87	n.d.	0.03	0.03	0.18
	4.33	9.82	0.36	0.02	31.5	3.29	0.07	0.04	0.02	0.32
$\bar{x} \pm \sigma_{n-1}$	3.37±1.14	8.27±4.94	1.87±3.96	0.02±0.01	34.5±14.0	4.68±3.05	0.05±0.05	0.07±0.05	0.04±0.02	0.26±0.11
High Fe areas										
	4.24	8.09	n.d.	0.03	6.34	22.3	0.05	0.01	0.01	0.02
	5.09	11.4	0.22	0.03	7.63	31.2	0.06	0.02	0.03	0.07
	2.48	8.80	0.14	0.03	10.9	21.6	0.09	0.02	0.02	0.05
	5.24	10.4	0.37	0.04	11.2	26.4	0.07	0.02	0.03	0.08
	7.21	19.1	0.20	0.03	7.55	20.2	0.07	0.03	0.03	0.06

TABLE 6.13 (continued)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
					(%)					
	4.44	7.61	0.13	0.03	2.71	20.9	0.09	0.06	0.05	0.12
	5.55	12.8	0.26	0.04	3.58	36.7	0.09	0.03	0.03	0.08
	1.77	3.26	0.64	0.02	5.71	22.9	0.02	0.01	n.d.	0.07
	0.80	2.50	0.10	0.03	2.86	41.9	0.09	0.01	n.d.	0.06
	3.90	8.53	0.31	n.d.	6.18	18.0	0.03	0.02	n.d.	0.06
	1.28	3.99	4.37	0.04	5.96	18.6	n.d.	n.d.	0.03	0.04
$\bar{x} \pm \sigma_{n-1}$	3.82±2.01	8.77±4.76	0.61±1.26	0.03±0.01	6.42±2.85	25.5±7.8	0.06±0.03	0.02±0.02	0.02±0.02	0.06±0.03
Low Mn and Fe areas										
	12.1	31.4	0.14	0.01	1.52	11.4	0.01	0.01	0.01	n.d.
	4.82	21.3	0.14	0.01	7.12	11.2	0.02	0.02	0.01	0.01
	7.71	15.9	0.16	0.02	0.21	13.2	n.d.	n.d.	0.02	0.05
	3.55	26.1	14.0	0.16	1.60	4.49	n.d.	n.d.	0.03	0.03
	6.82	17.7	8.69	0.08	5.76	13.5	n.d.	n.d.	0.03	0.05
	4.93	10.7	1.62	0.03	10.1	8.79	0.07	0.03	0.01	0.05
	3.55	9.57	0.41	0.02	7.36	12.9	0.03	0.01	0.01	0.02
$\bar{x} \pm \sigma_{n-1}$	6.21±3.03	18.95±7.94	3.59±5.54	0.05±0.06	4.81±3.72	10.8±3.2	0.02±0.03	0.01±0.01	0.02±0.01	0.03±0.02

[a] n.d. = not detected

TABLE 6.13 (continued)

CORRELATION COEFFICIENTS Concretion 3-Brs2

* significant (1% level)
** highly significant (0.1% level)

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
Al										
Si	0.735**									
Ti	-0.029	0.396								
V	-0.064	0.274	0.890**							
Mn	-0.327	-0.491*	-0.231	-0.179						
Fe	-0.026	-0.122	-0.295	-0.194	-0.603**					
Co	-0.185	-0.369	-0.509*	-0.322	0.219	0.330				
Ni	-0.225	-0.494*	-0.293	-0.192	0.888**	-0.458*	0.181			
Cu	-0.084	-0.259	0.061	0.125	0.646**	-0.371	0.153	0.750**		
Zn	-0.314	-0.496*	-0.145	-0.069	0.919**	-0.554**	0.093	0.897**	0.678*	

TABLE 6.18 OKARITO IRON-PAN

Analytical Data obtained from Electron Microprobe Analysis

Sample 1 - iron-pan									
Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
				(%)					
High Fe areas									
6.12	1.95	0.08	n.d.[a]	n.d.	37.3	0.03	n.d.	n.d.	n.d.
6.90	7.66	0.46	n.d.	n.d.	25.9	n.d.	n.d.	n.d.	n.d.
3.42	5.37	n.d.	n.d.	n.d.	34.5	n.d.	n.d.	n.d.	n.d.
High Ti areas									
0.75	23.6	26.8	0.17	n.d.	0.49	n.d.	n.d.	n.d.	n.d.
3.38	21.6	29.5	0.14	n.d.	1.53	n.d.	n.d.	n.d.	n.d.
High Ti and Fe areas									
0.13	0.19	28.1	0.12	2.18	24.9	0.05	0.01	0.01	0.08
n.d.	0.02	26.2	0.10	2.30	22.9	0.02	0.02	0.02	0.08
n.d.	0.08	24.6	0.09	2.28	25.4	n.d.	0.01	0.01	0.06
n.d.	0.06	24.8	0.12	2.16	24.5	0.02	1.16	n.d.	0.05
0.33	1.39	39.4	0.17	2.80	23.4	0.02	n.d.	0.02	0.03
0.13	0.50	32.6	0.12	2.61	28.3	0.02	n.d.	0.02	0.05
0.03	0.37	32.2	1.33	2.43	25.7	0.04	n.d.	0.02	0.05
0.13	0.09	37.5	0.15	2.98	18.8	0.01	n.d.	0.01	n.d.
0.29	1.55	30.8	0.14	3.61	24.2	n.d.	n.d.	n.d.	n.d.
0.05	0.38	32.5	0.12	2.13	24.4	n.d.	n.d.	n.d.	n.d.

TABLE 6.18 (continued)

Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
				(%)					
0.71	2.40	29.2	0.17	2.06	18.3	n.d.	n.d.	n.d.	n.d.
1.81	7.53	30.6	0.13	3.24	18.5	n.d.	n.d.	n.d.	0.22
0.43	1.92	31.3	0.11	0.16	18.7	n.d.	n.d.	n.d.	n.d.
0.15	0.09	26.0	0.10	1.20	14.8	n.d.	n.d.	n.d.	n.d.
Low Ti and Fe areas									
2.98	30.4	0.70	n.d.	n.d.	0.85	n.d.	n.d.	n.d.	n.d.
15.9	19.9	1.35	n.d.	n.d.	9.29	n.d.	n.d.	n.d.	n.d.
4.19	27.1	0.37	n.d.	n.d.	13.1	n.d.	n.d.	n.d.	n.d.
9.56	31.8	0.39	n.d.	n.d.	6.24	n.d.	n.d.	n.d.	n.d.

[a] n.d. = not detected

CORRELATION COEFFICIENTS — Fe pan - sample 1

	Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
Al										
Si	0.570*									
Ti	-0.746**	-0.583*								
V	-0.302	-0.256	0.390							
Mn	-0.609**	-0.688**	0.754**	0.325						
Fe	-0.257	-0.796**	0.088	0.126	0.396					
Co	-0.214	-0.392	0.179	0.056	0.276	0.466				
Ni	-0.143	-0.162	0.058	-0.020	0.131	0.119	0.182			
Cu	-0.383	-0.432	0.476	0.481*	0.539*	0.332	0.546*	-0.122		
Zn	-0.256	-0.261	0.320	0.157	0.535*	0.189	0.280	0.106	0.299	

* significant (1% level)
** highly significant (0.1% level)

TABLE 6.19 OKARITO IRON-PAN

Analytical Data obtained from Electron Microprobe Analysis

Sample 2 - iron-pan

Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
				(%)					
High Fe areas									
4.83	20.0	0.081	0.05	0.01	16.5	n.d.[a]	n.d.	0.02	0.01
4.55	12.7	0.11	0.01	0.07	24.3	0.04	n.d.	0.02	0.05
3.61	17.9	0.15	0.01	n.d.	12.1	0.02	n.d.	0.01	0.02
10.2	9.31	0.10	0.01	0.02	17.4	0.02	n.d.	n.d.	n.d.
6.96	7.10	0.11	n.d.	n.d.	20.6	n.d.	n.d.	n.d.	n.d.
3.01	7.69	0.43	n.d.	n.d.	21.8	n.d.	n.d.	n.d.	n.d.
6.80	17.8	0.02	n.d.	n.d.	25.6	n.d.	n.d.	n.d.	n.d.
High Ti areas									
1.04	22.4	18.8	n.d.	0.36	4.63	n.d.	n.d.	n.d.	n.d.
1.16	9.11	16.1	0.05	0.54	9.06	n.d.	n.d.	n.d.	n.d.
High Fe and Ti									
0.13	0.02	31.9	0.12	2.09	20.0	0.07	0.03	0.04	0.07
0.15	0.11	40.6	0.23	1.66	21.5	0.04	0.04	0.04	0.03
1.23	9.94	27.9	0.13	1.62	15.5	0.08	0.02	0.02	0.03
n.d.	n.d.	29.5	0.13	2.44	26.6	0.03	0.03	0.05	0.08
0.18	0.57	31.2	0.14	2.08	20.8	0.07	0.02	0.05	0.08
0.08	0.03	30.8	0.12	2.22	20.6	0.05	0.03	0.05	0.08

TABLE 6.19 (continued)

Al	Si	Ti	V	Mn	Fe	Co	Ni	Cu	Zn
				(%)					
n.d.	0.04	27.0	0.08	2.28	24.4	0.02	n.d.	0.01	0.03
0.21	0.08	30.9	n.d.	1.74	19.2	0.01	n.d.	0.01	0.02
1.88	3.14	23.3	0.11	1.49	15.3	0.04	0.04	0.06	0.09
2.94	7.62	19.6	0.11	0.44	15.6	0.04	0.04	0.06	0.09
0.02	0.11	27.1	0.12	1.88	16.9	0.03	0.03	0.06	0.07
0.01	0.10	26.3	0.13	1.71	18.3	0.04	0.04	0.07	0.07
1.02	1.55	32.6	0.12	0.30	20.9	0.04	0.03	0.03	0.06
0.56	1.31	29.7	0.11	3.16	15.1	0.02	0.03	0.03	0.05
0.08	0.18	21.6	0.19	1.11	20.4	0.03	0.02	0.05	0.06
Low Fe and Ti areas									
9.95	12.4	1.24	n.d.	n.d.	5.58	n.d.	n.d.	n.d.	n.d.
7.72	15.1	0.08	0.01	n.d.	5.80	n.d.	n.d.	0.02	n.d.
8.40	24.8	0.19	0.01	n.d.	5.65	n.d.	n.d.	n.d.	n.d.
0.02	47.2	n.d.	n.d.	n.d.	0.03	n.d.	n.d.	n.d.	n.d.
1.94	24.7	0.27	0.02	0.01	6.02	0.01	0.01	n.d.	0.02
4.72	32.3	0.38	n.d.	0.02	5.14	0.02	0.02	0.02	0.02
5.52	9.84	12.7	0.09	0.01	4.93	0.01	0.01	0.03	0.03

[a] n.d. = not detected

TABLE 6.19 (continued)

CORRELATION COEFFICIENTS Sample 2 - iron-pan

* significant (1% level)
** highly significant (0.1% level)

Al	Al									
Si	0.302	Si								
Ti	-0.774**	-0.668**	Ti							
V	-0.616**	-0.593**	0.791**	V						
Mn	-0.705**	-0.634**	0.857**	0.664**	Mn					
Fe	-0.188	-0.713**	0.341	0.384	0.392	Fe				
Co	-0.430*	-0.499*	0.599**	0.672**	0.544**	0.429*	Co			
Ni	-0.433*	-0.511**	0.607**	0.667**	0.525**	0.328	0.687**	Ni		
Cu	-0.413*	-0.585**	0.558**	0.690**	0.523**	0.400	0.662**	0.883**	Cu	
Zn	-0.509**	-0.606**	0.618**	0.692**	0.602*	0.471*	0.750**	0.835**	0.914**	Zn

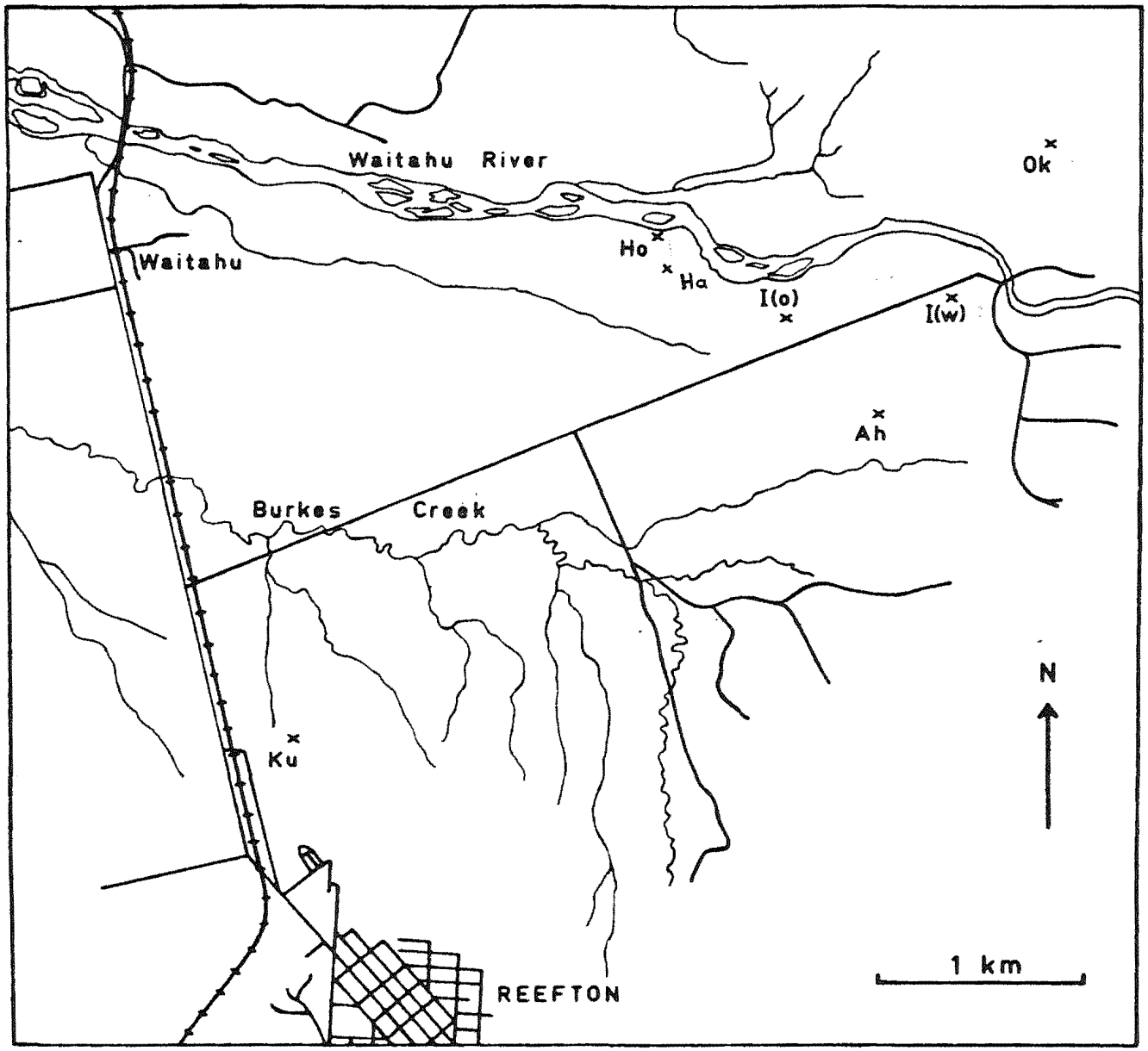

Figure 1.2. Map of area showing location of the Chronosequence sampling sites.

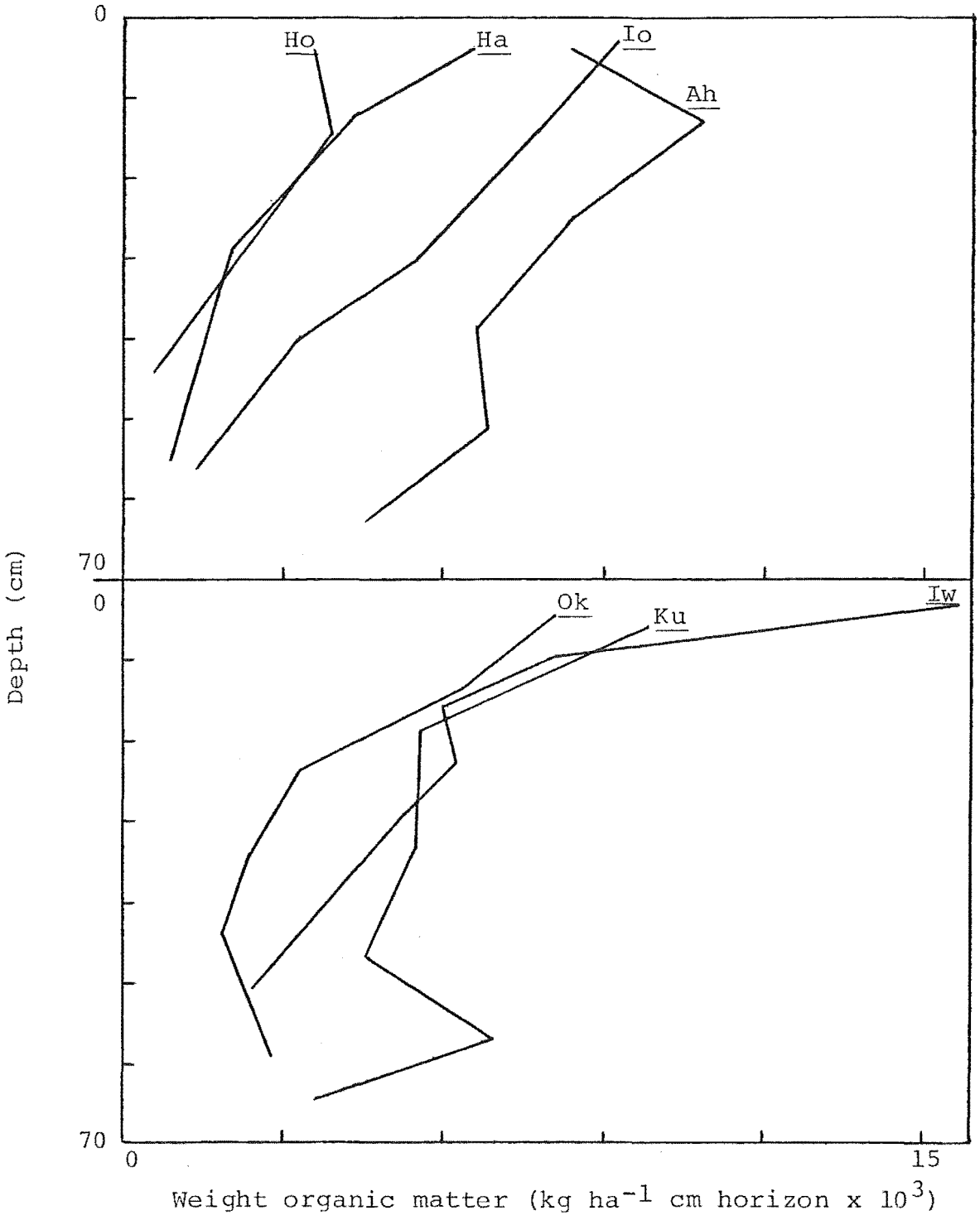

Figure 2.2. Variation in soil organic matter with depth - chronosequence

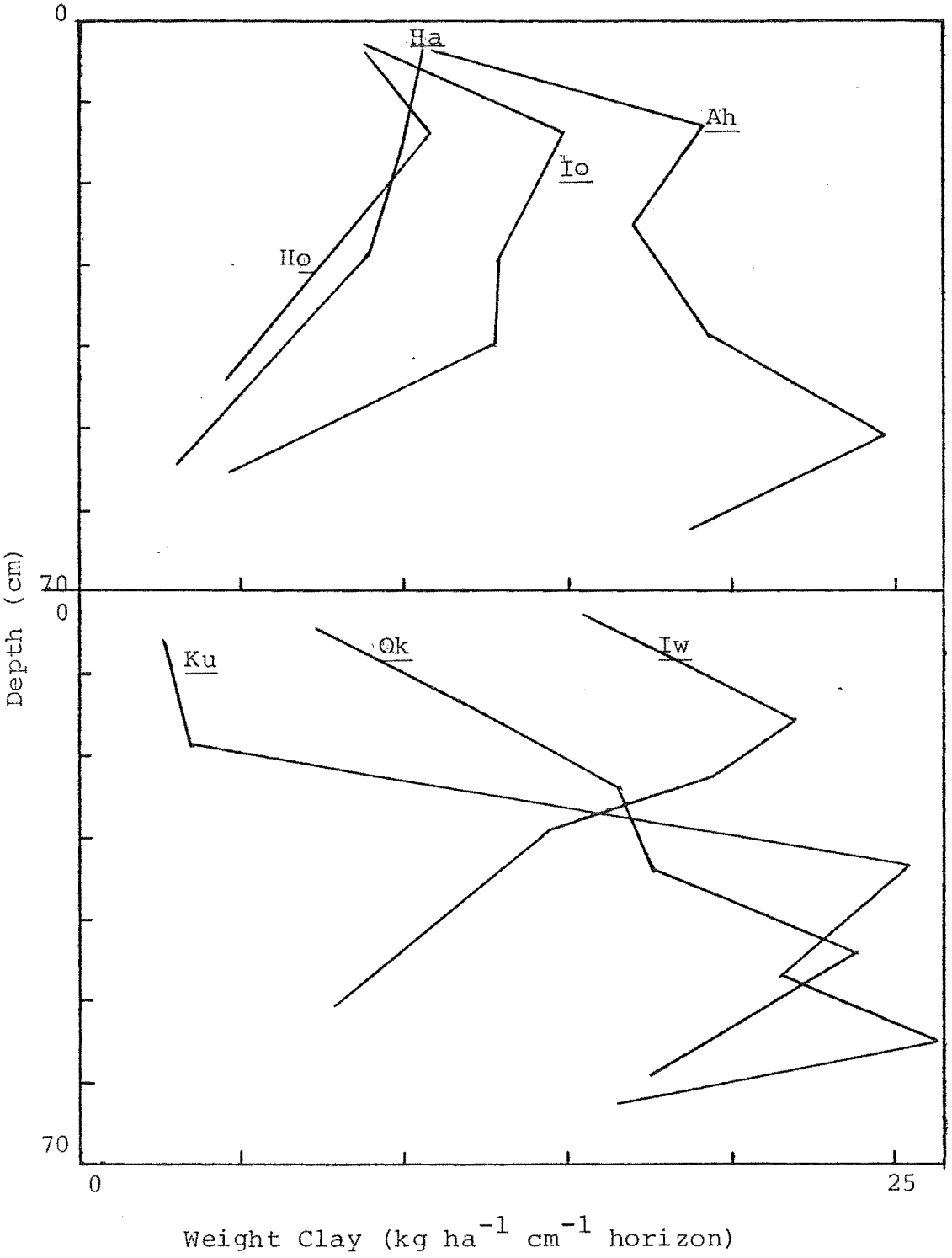

Figure 2.3. Variation in the amount of clay with depth - chronosequence

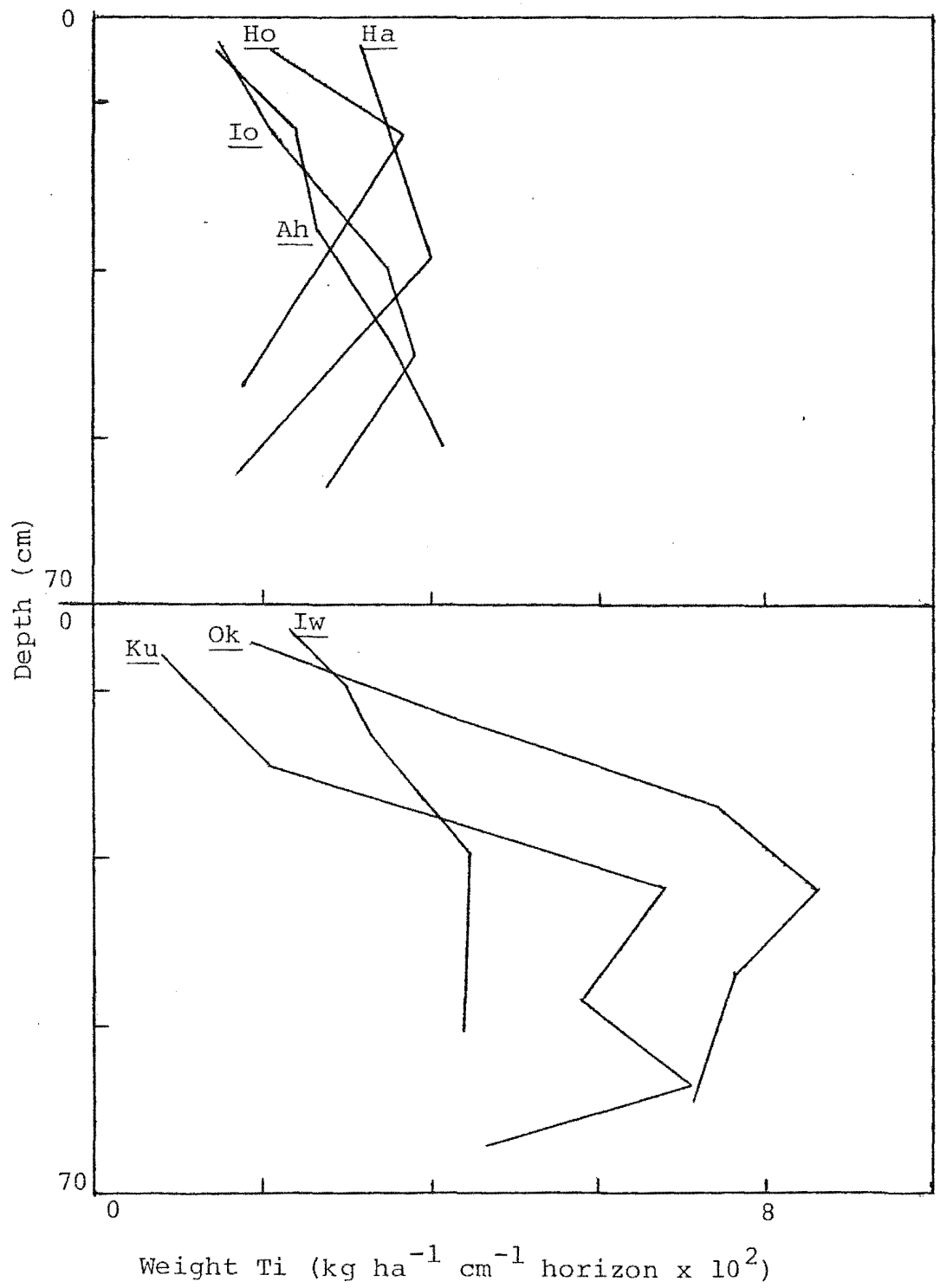

Figure 4.1. Variation in the weight of Ti in the Whole soil, per cm of horizon, with depth.

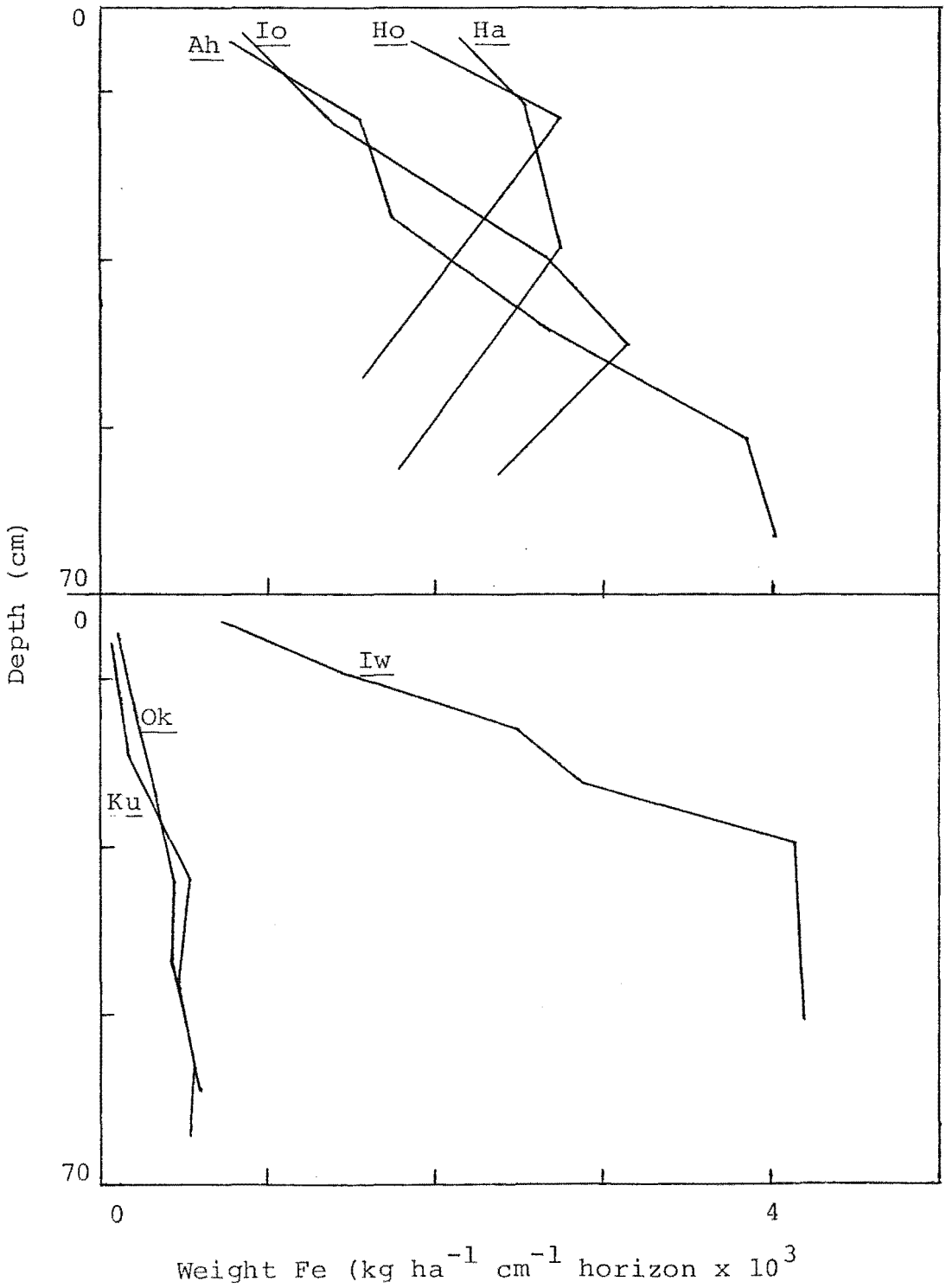

Figure 4.2. Variation in the weight of Fe in the whole soil per cm of horizon, with depth.

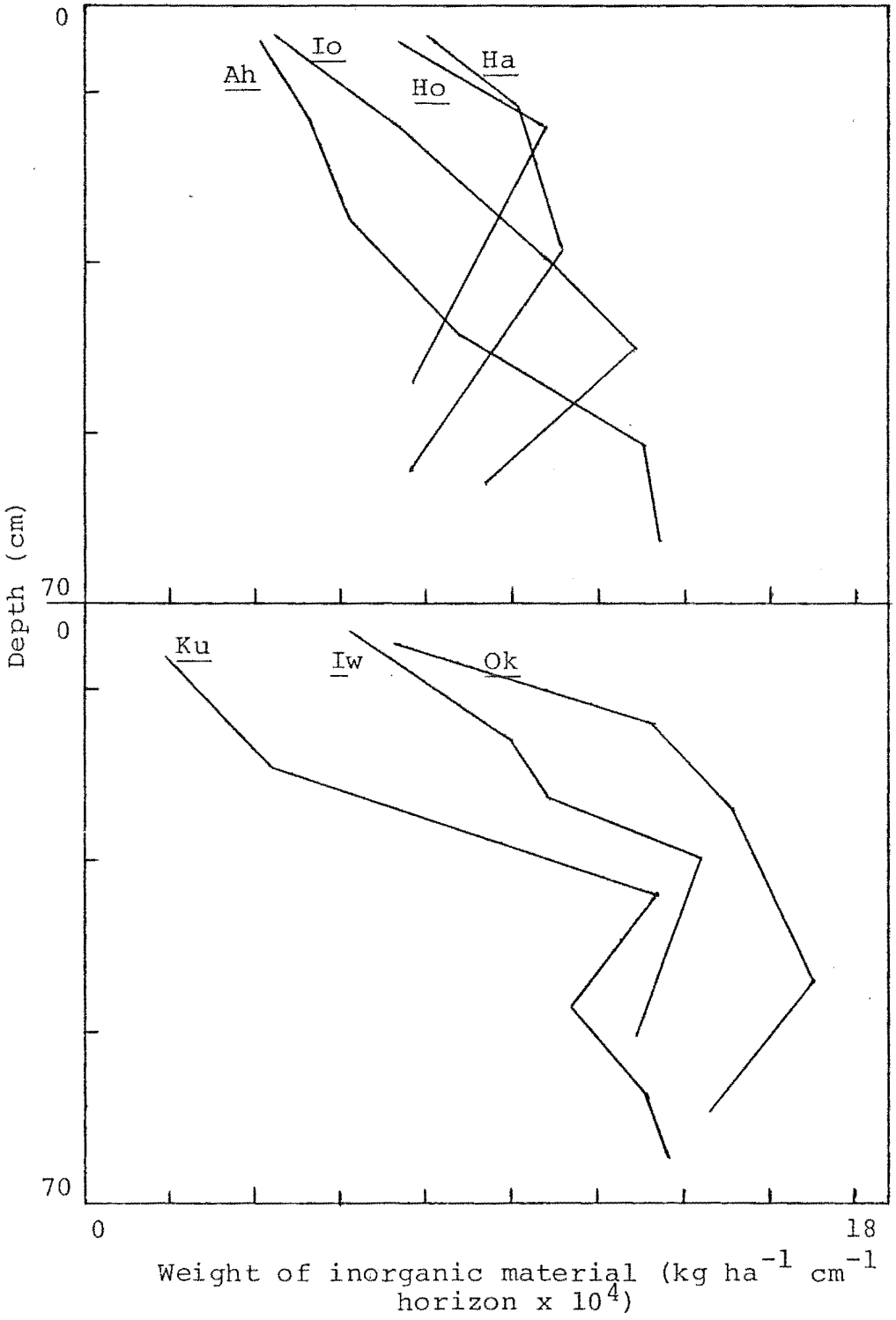

Figure 4.3. Variation in the weight of inorganic material with depth.

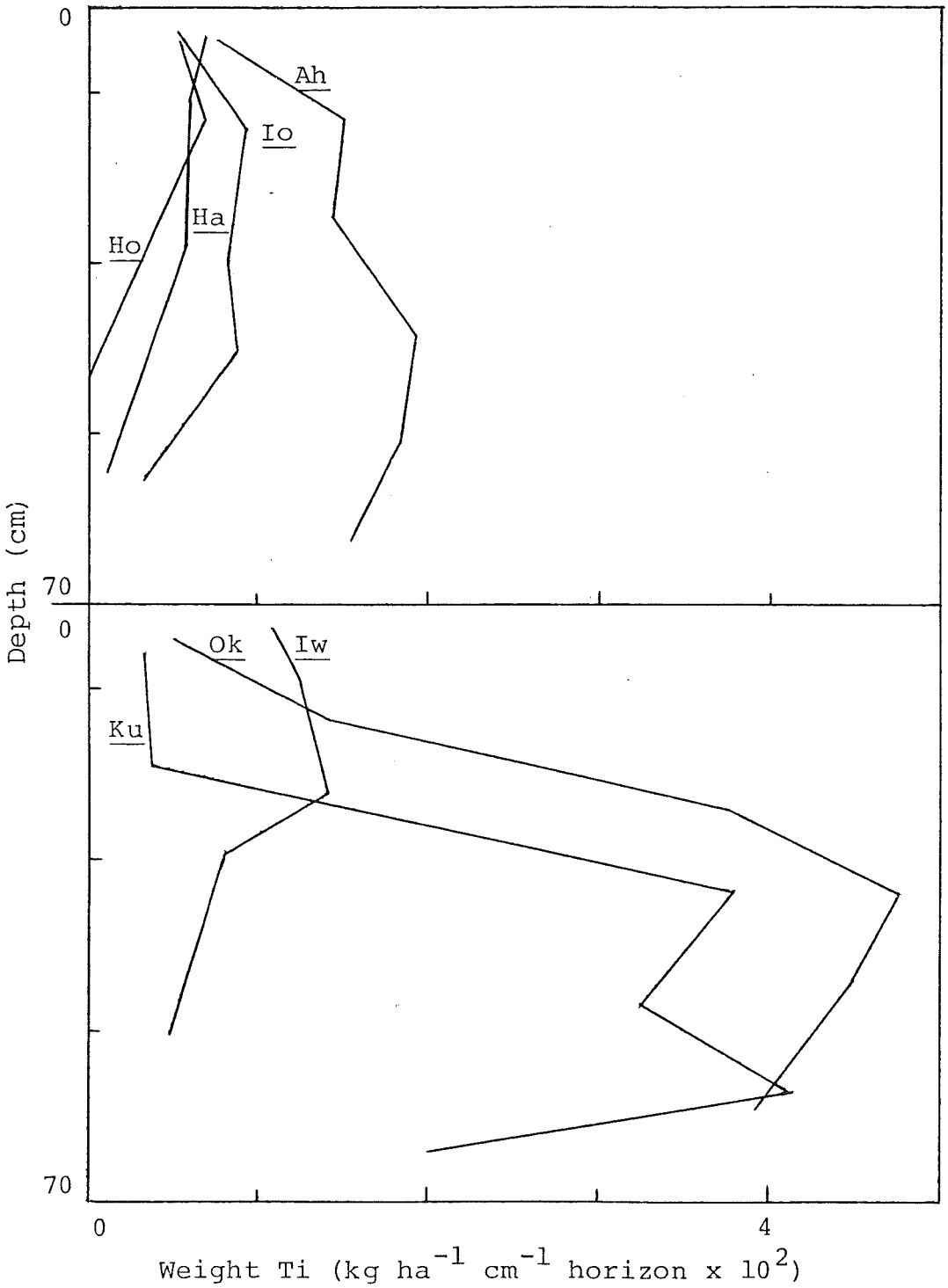

Figure 4.4. Variation in the weight of Ti in the clay fraction, per cm of horizon, with depth.

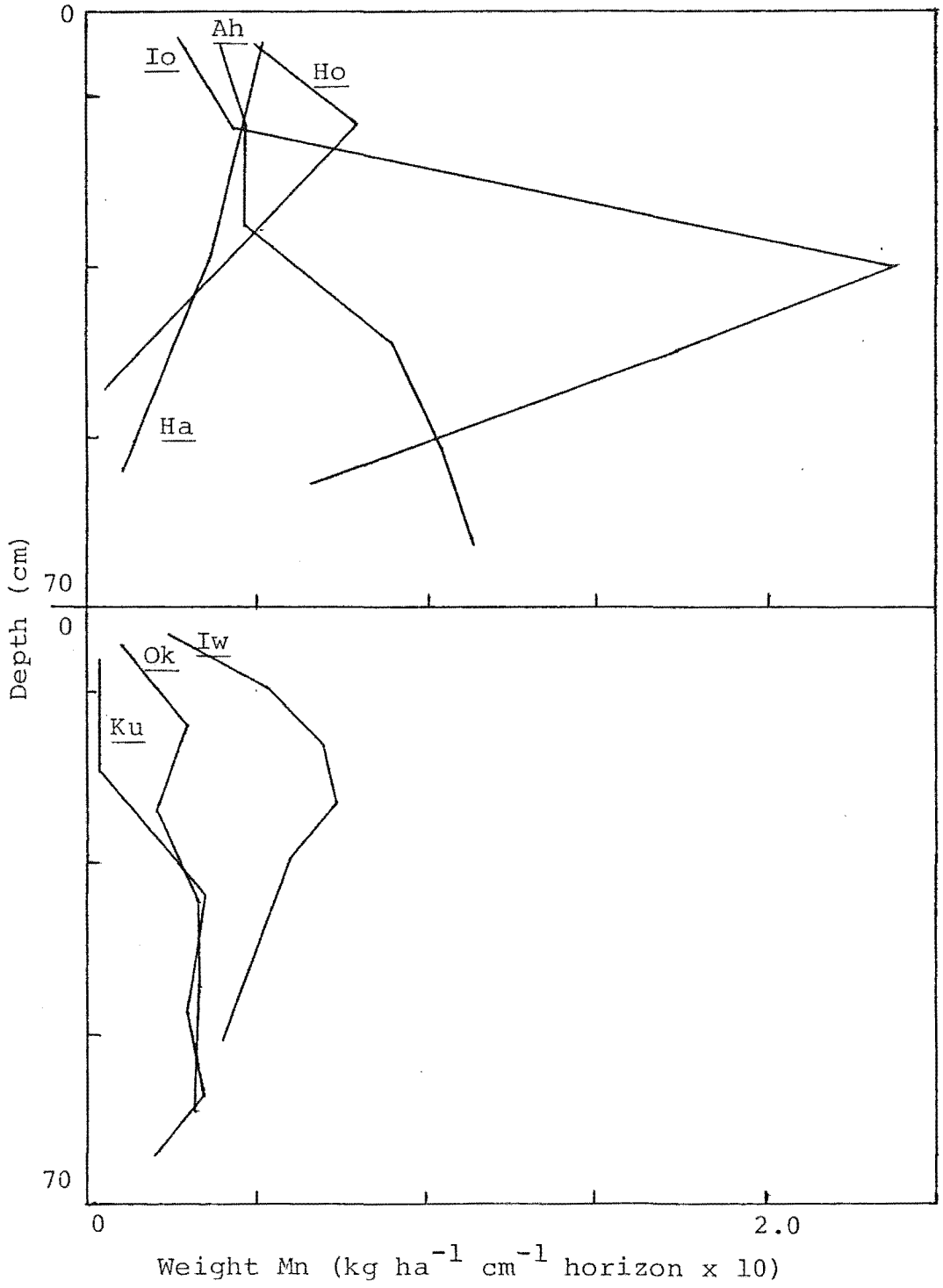

Figure 4.5. Variation in the weight of Mn in the clay fraction, per cm of horizon, with depth.

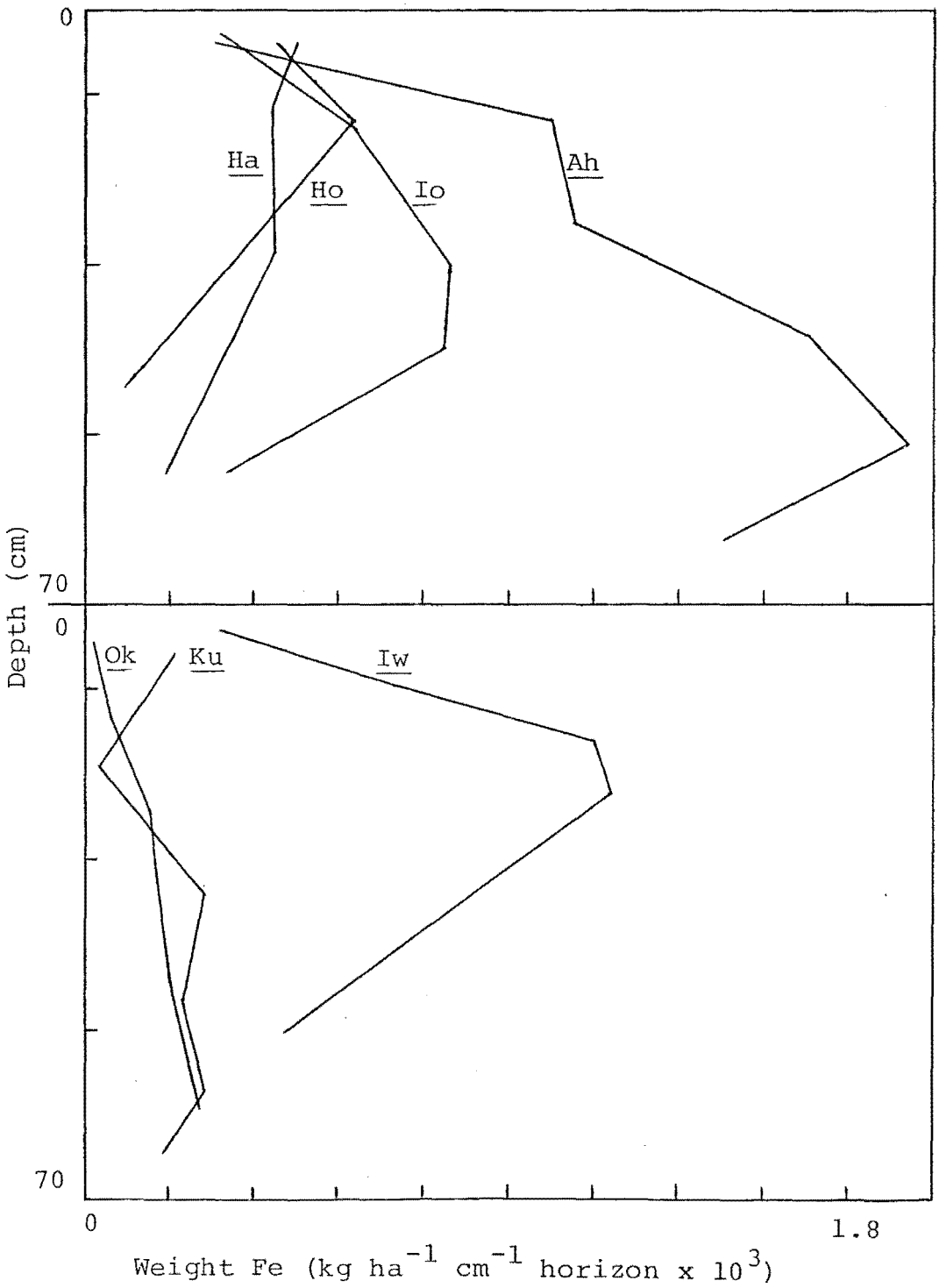

Figure 4.6. Variation in the weight of Fe in the clay fraction, per cm of horizon, with depth.

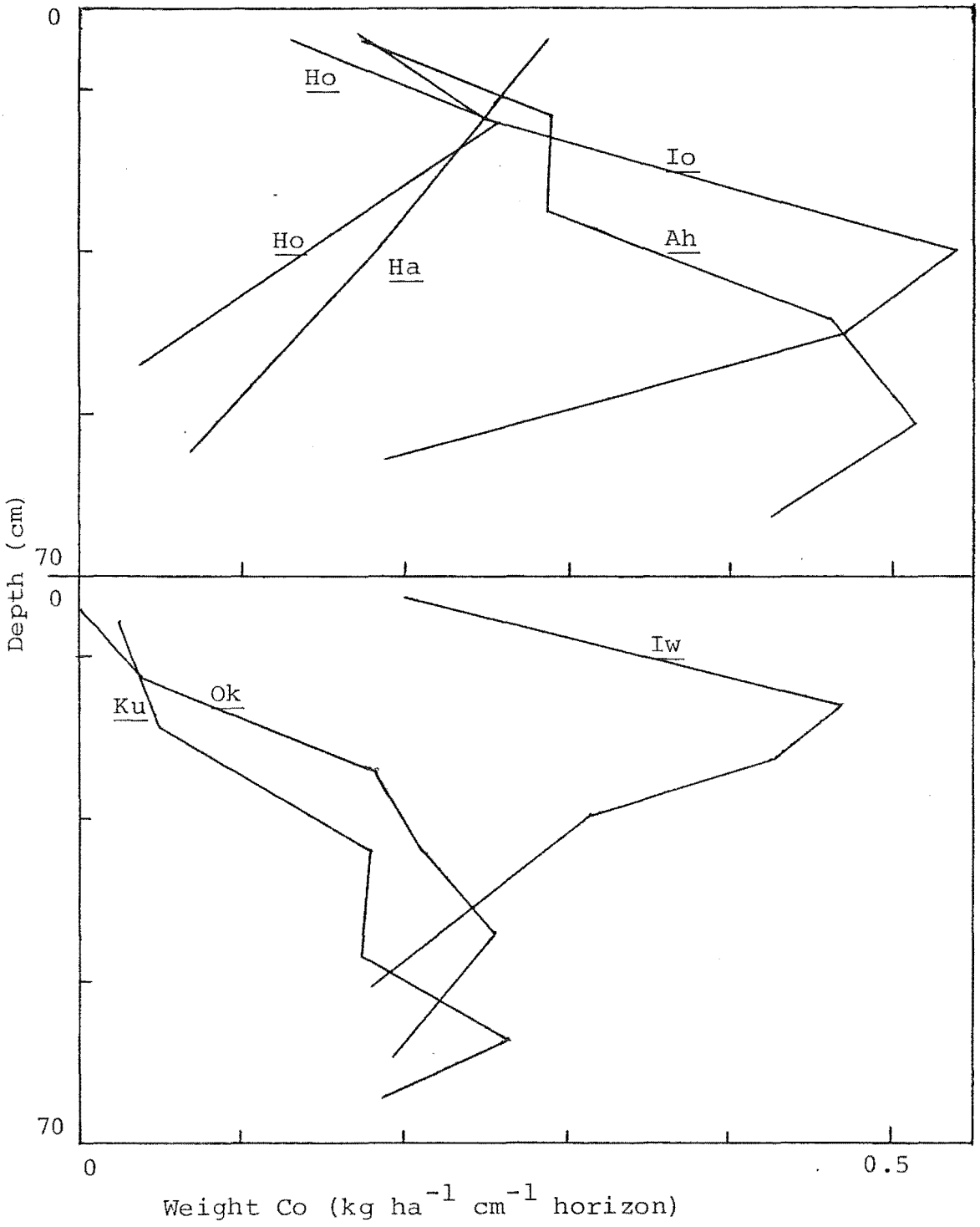

Figure 4.7. Variation in the weight of Co in the clay fraction, per cm of horizon, with depth.

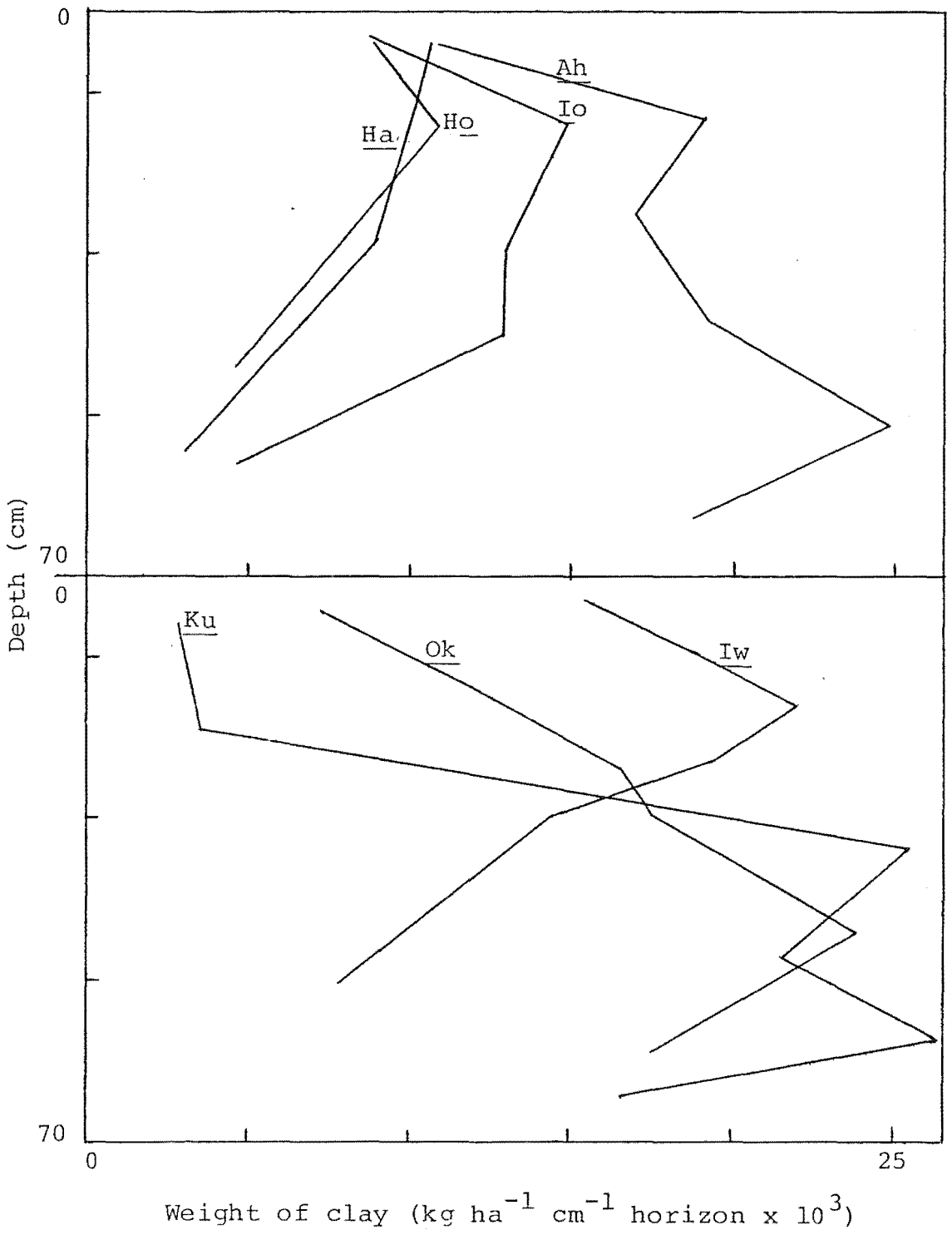

Figure 4.8. Variation in the weight of clay, per cm of horizon, with depth.

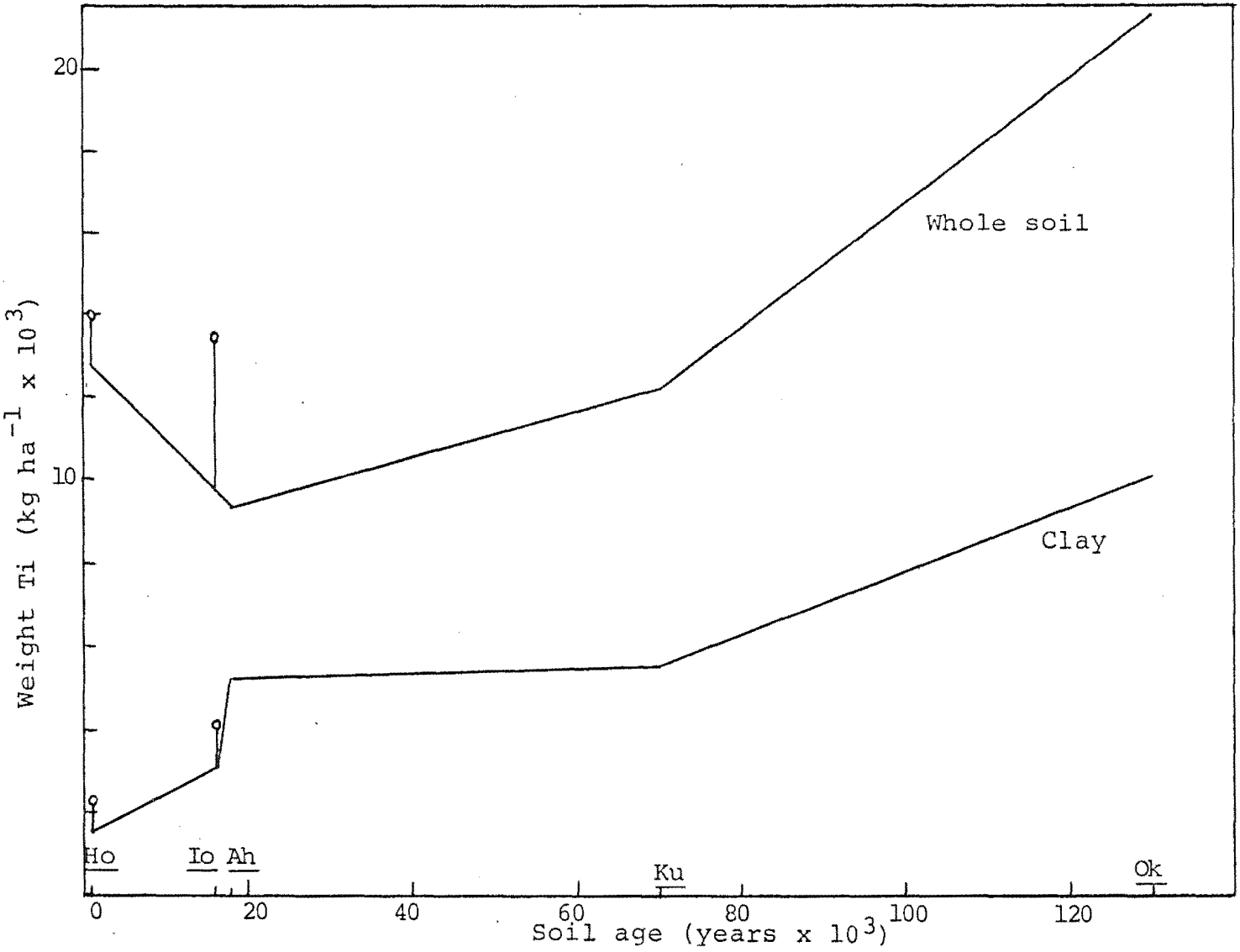

Figure 4.9. Variation in the weight of Ti, to 0.38m, with soil age.

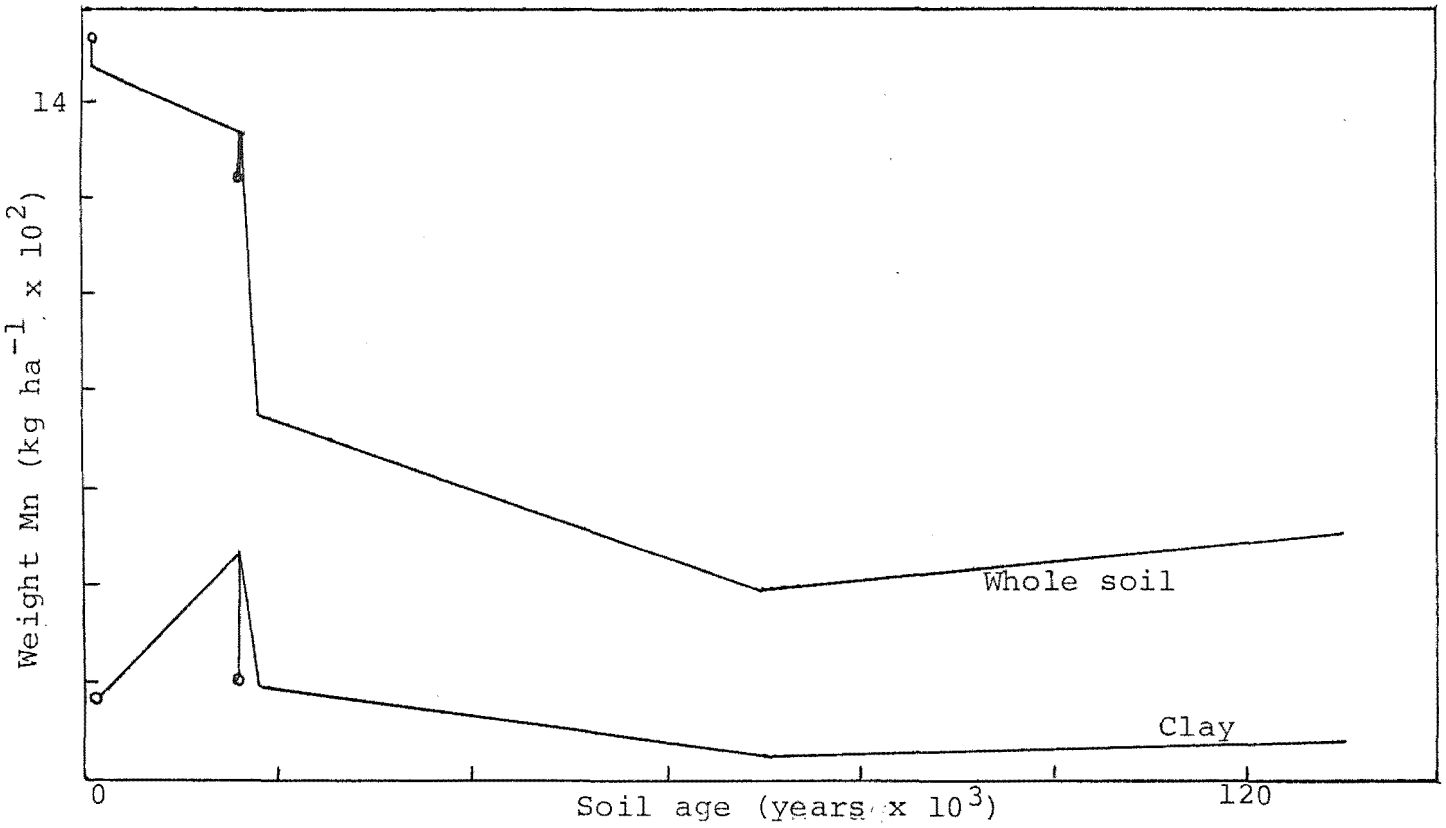

Figure 4.10. Variation in the weight of Mn, to 0.38m, with soil age.

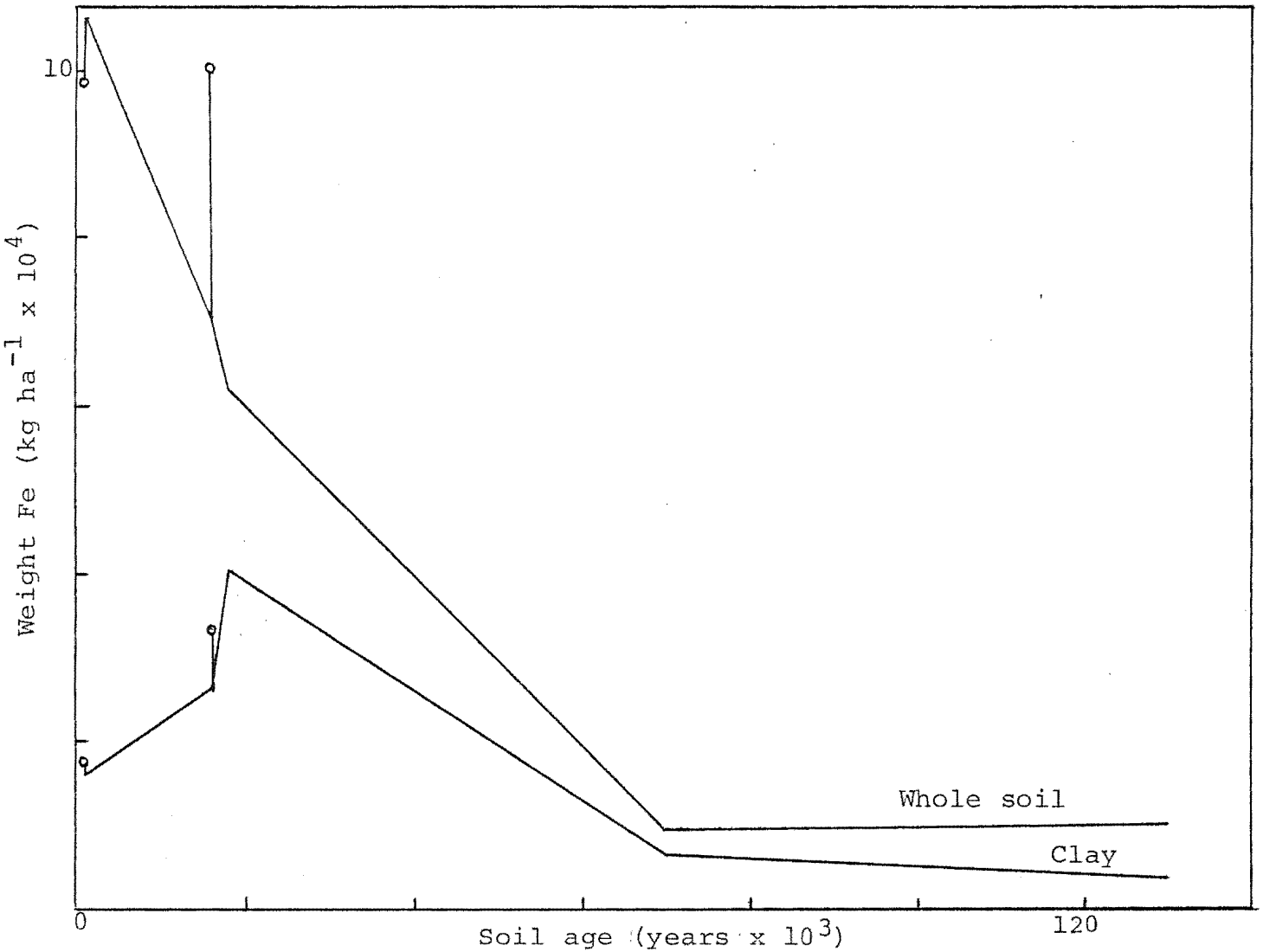

Figure 4.11. Variation in the weight of Fe, to 0.38m, with soil age.

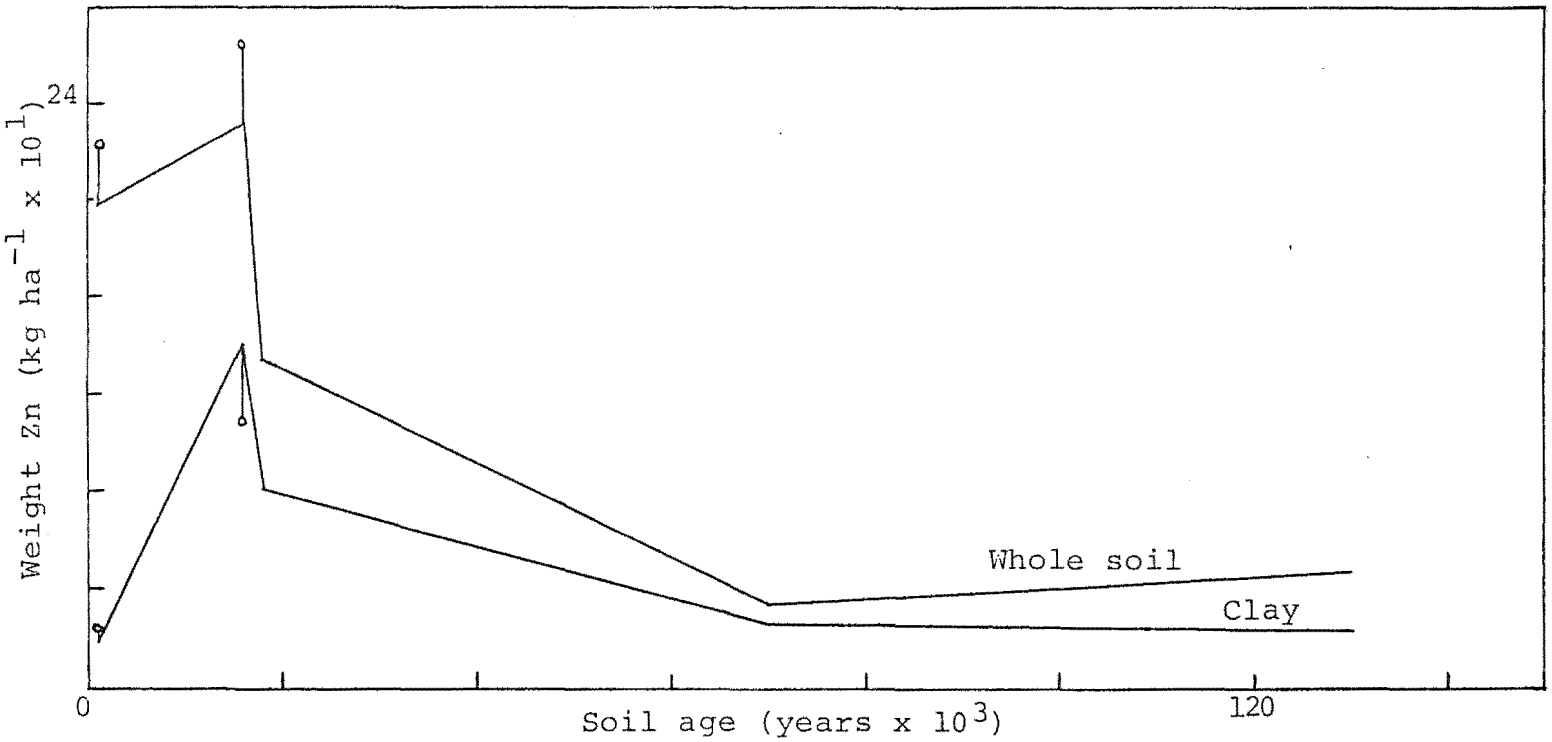

Figure 4.12. Variation in the weight of Zn, to 0.38m, with soil age.

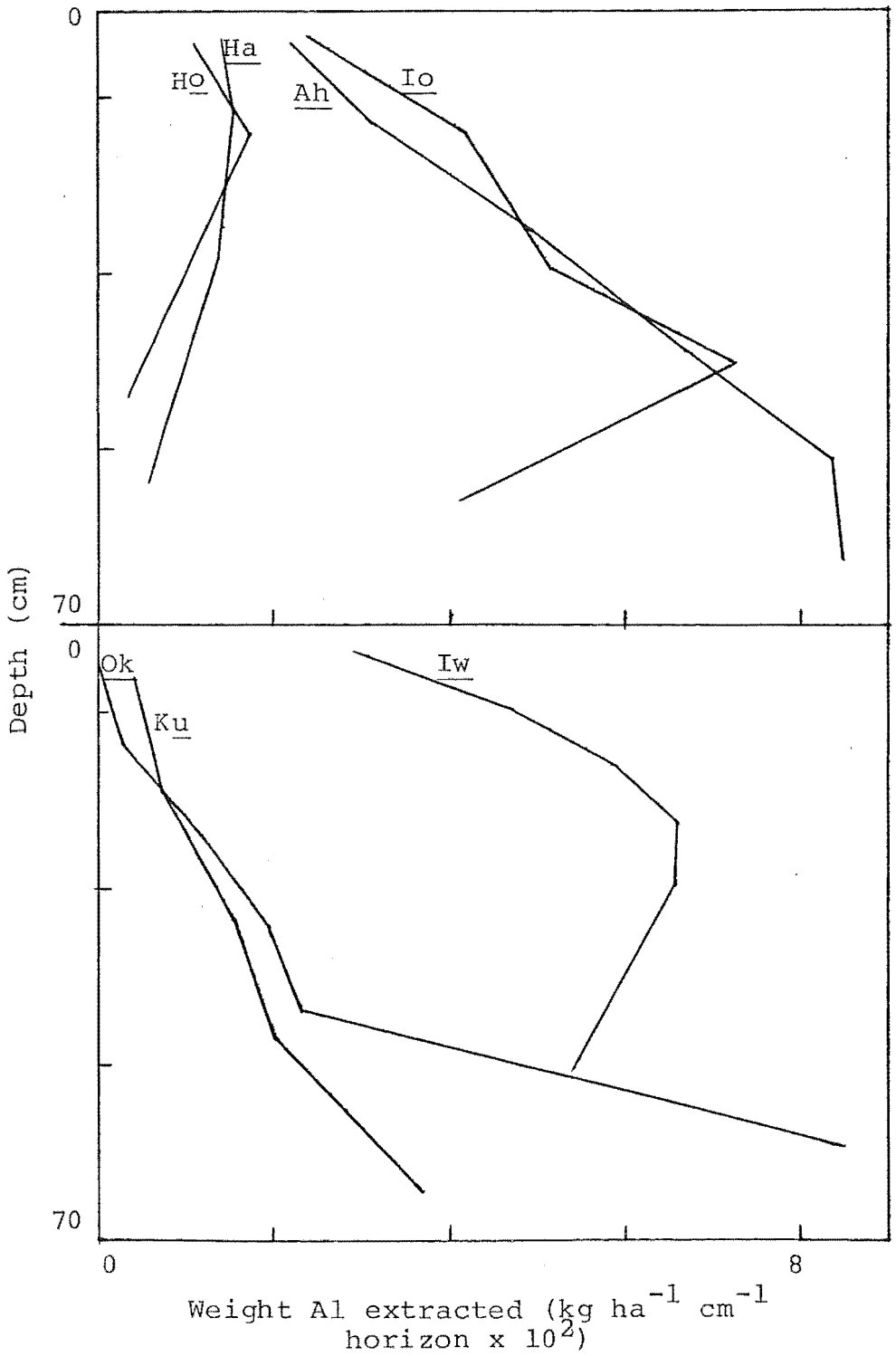

Figure 4.13. Variation in the weight of oxalate extractable Al with depth.

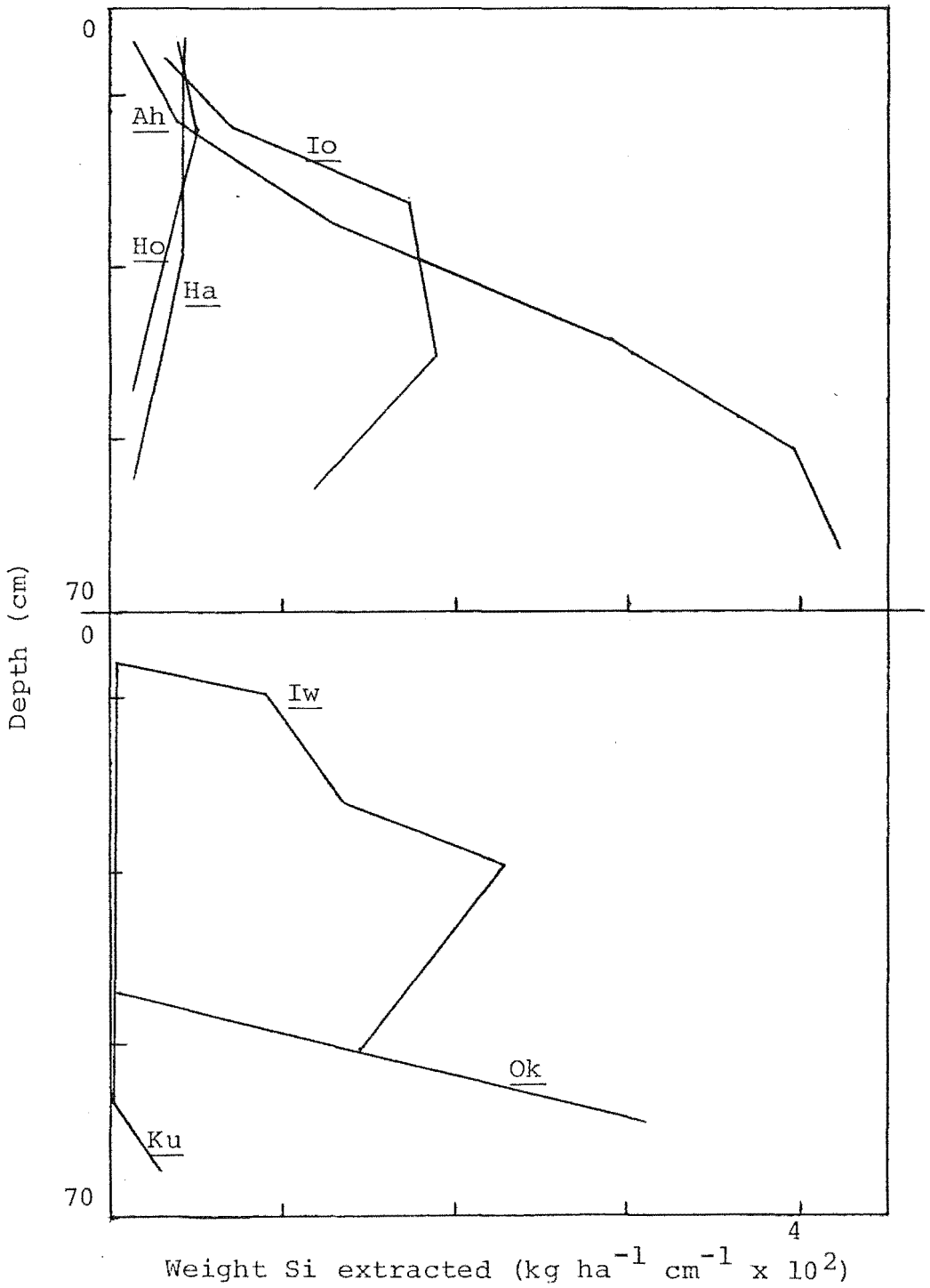

Figure 4.14. Variation in the weight of oxalate extractable Si with depth.

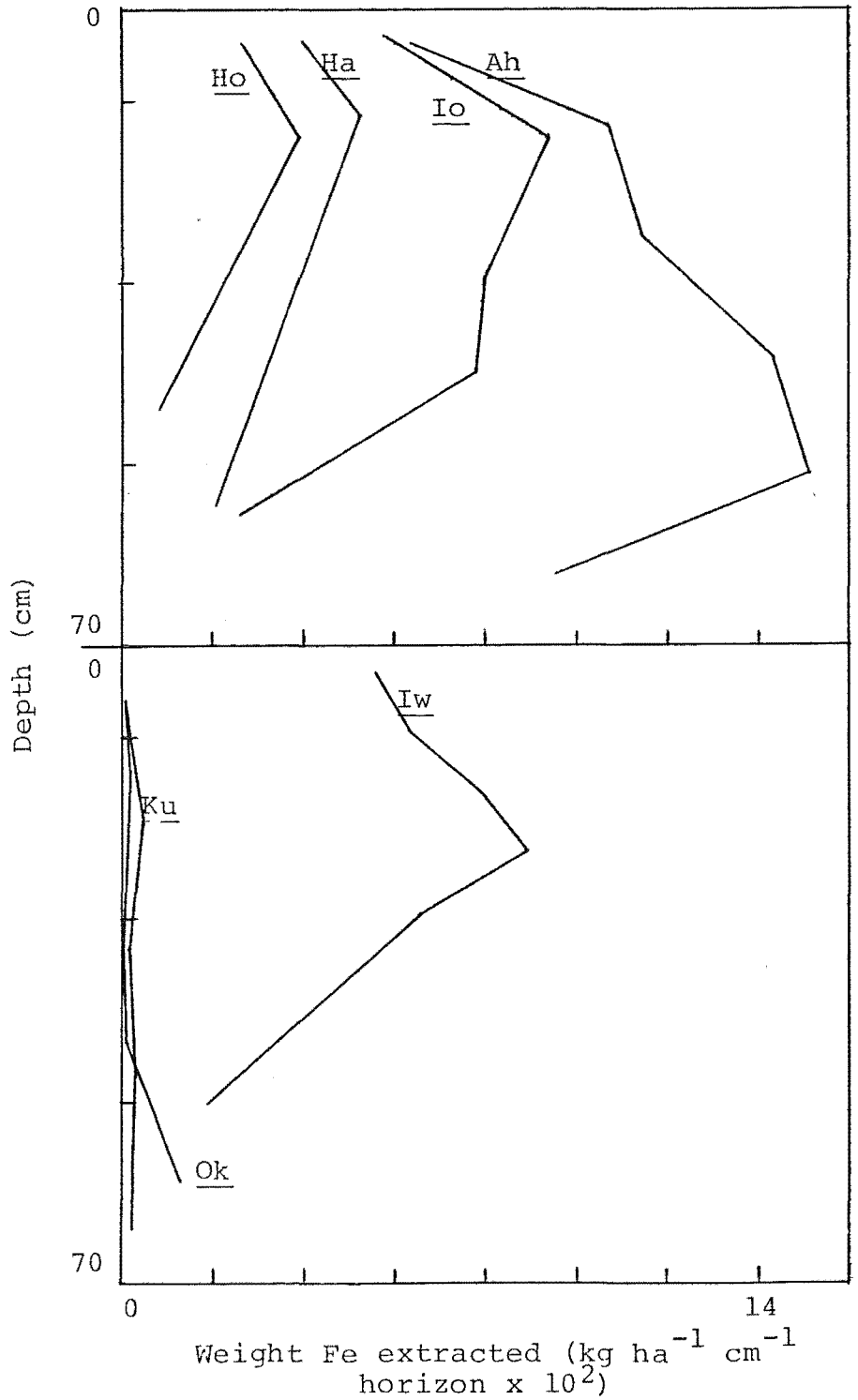

Figure 4.15. Variation in the weight of oxalate extractable Fe with depth.

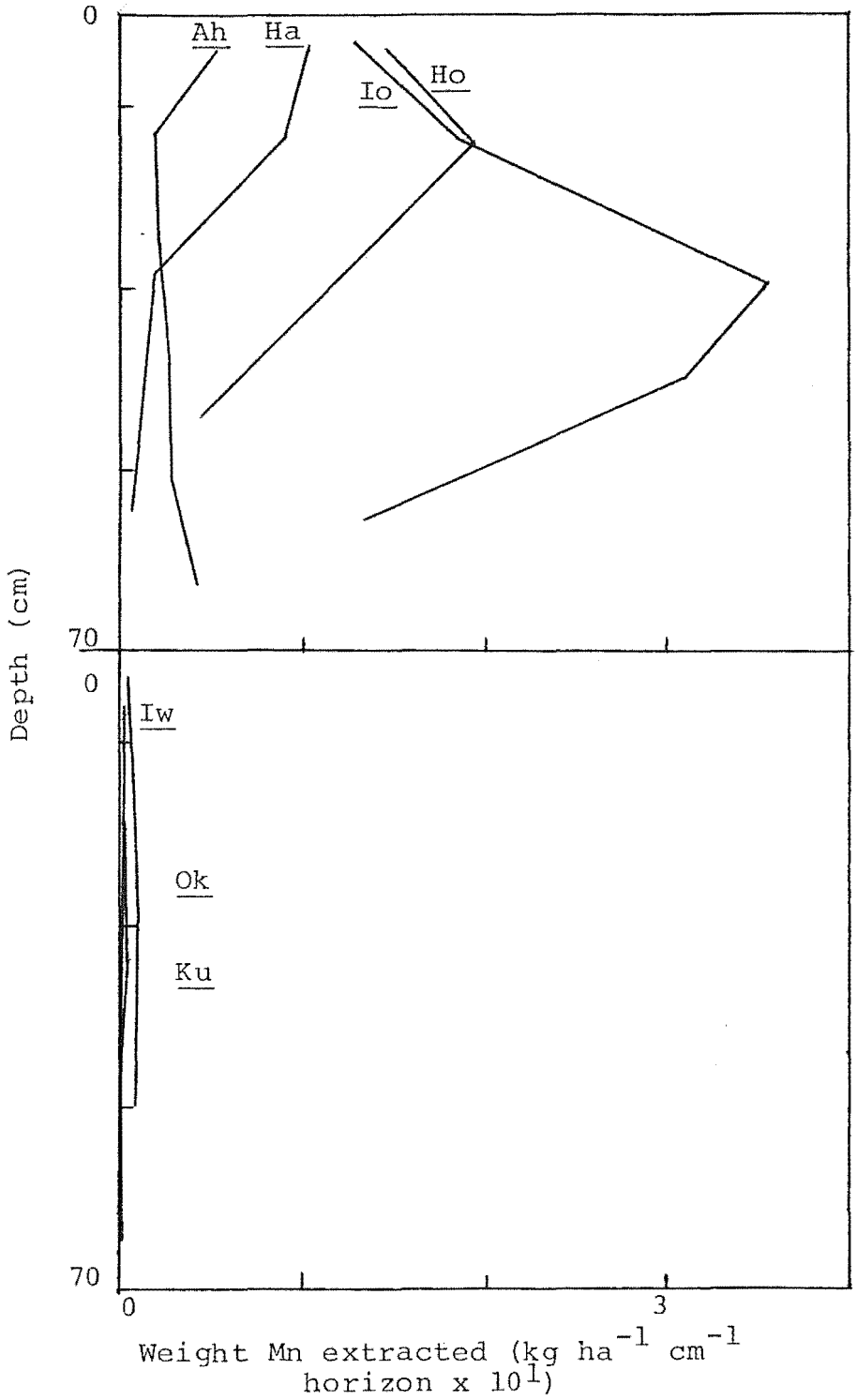

Figure 4.16. Variation in the weight of oxalate extractable Mn with depth.

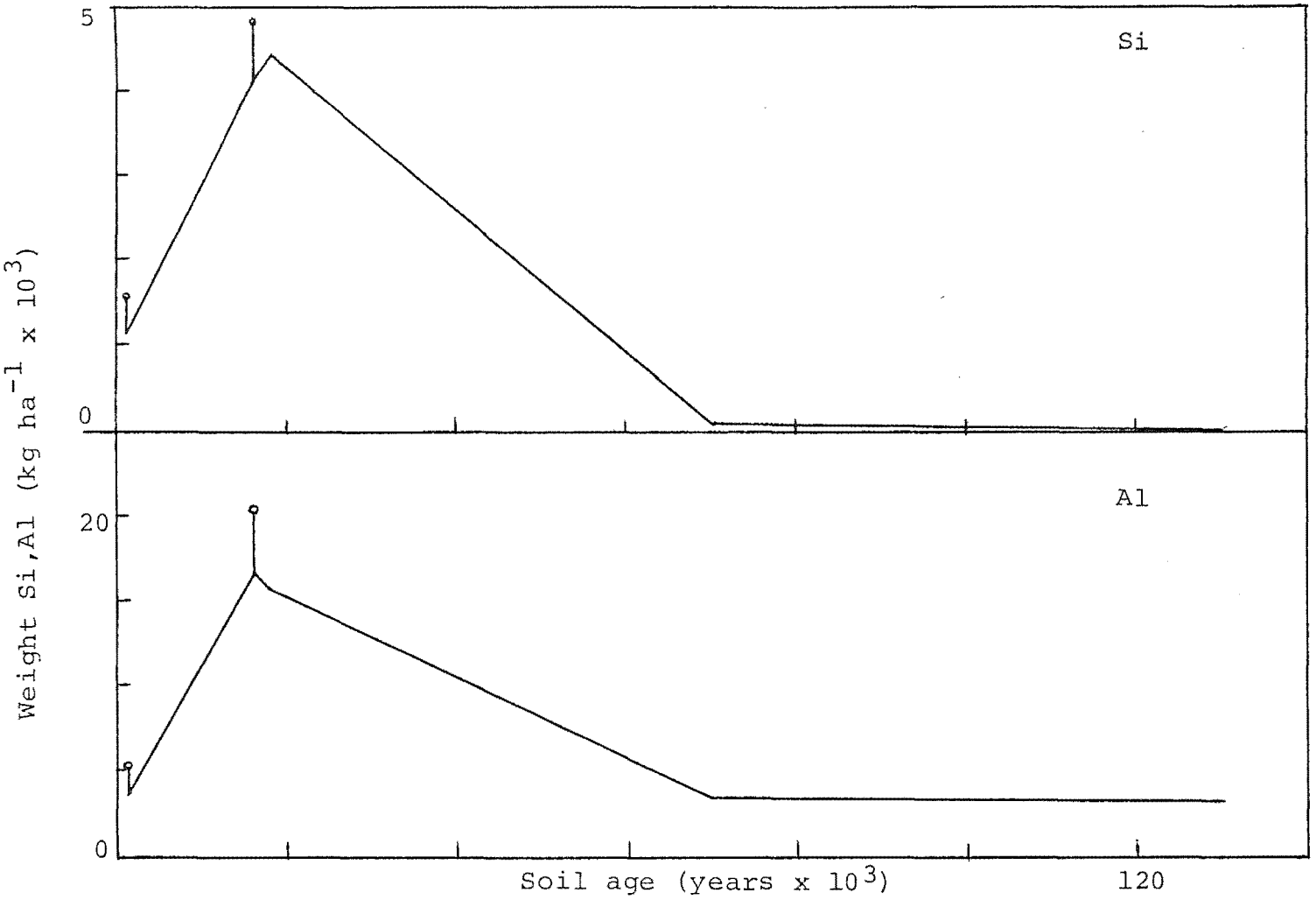

Figure 4.17. Variation in the weight, to 0.38m, of oxalate extractable Al and Si with Soil Age.

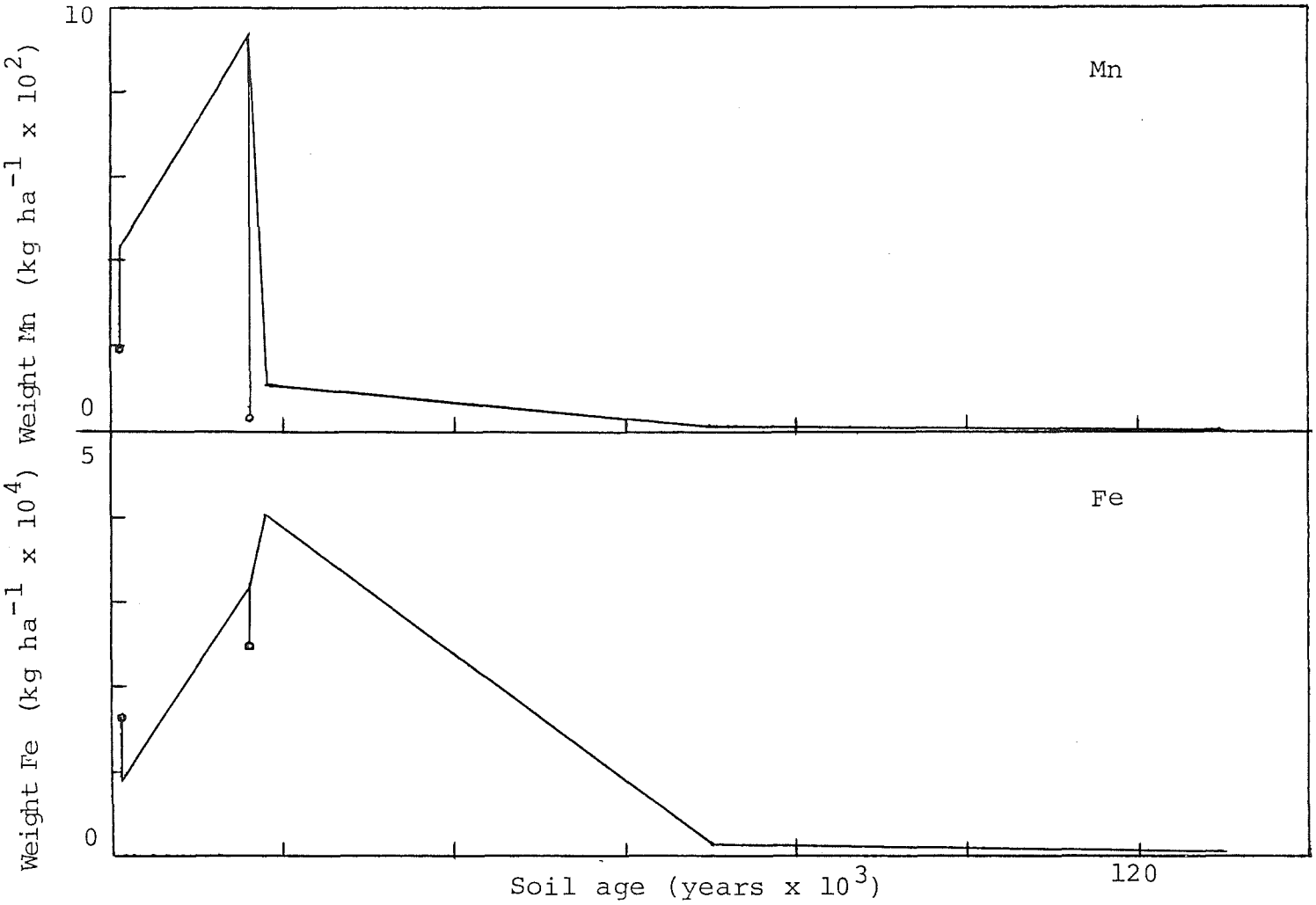

Figure 4.18. Variation in the weight, to 0.38m, of oxalate extractable Mn and Fe with soil age.

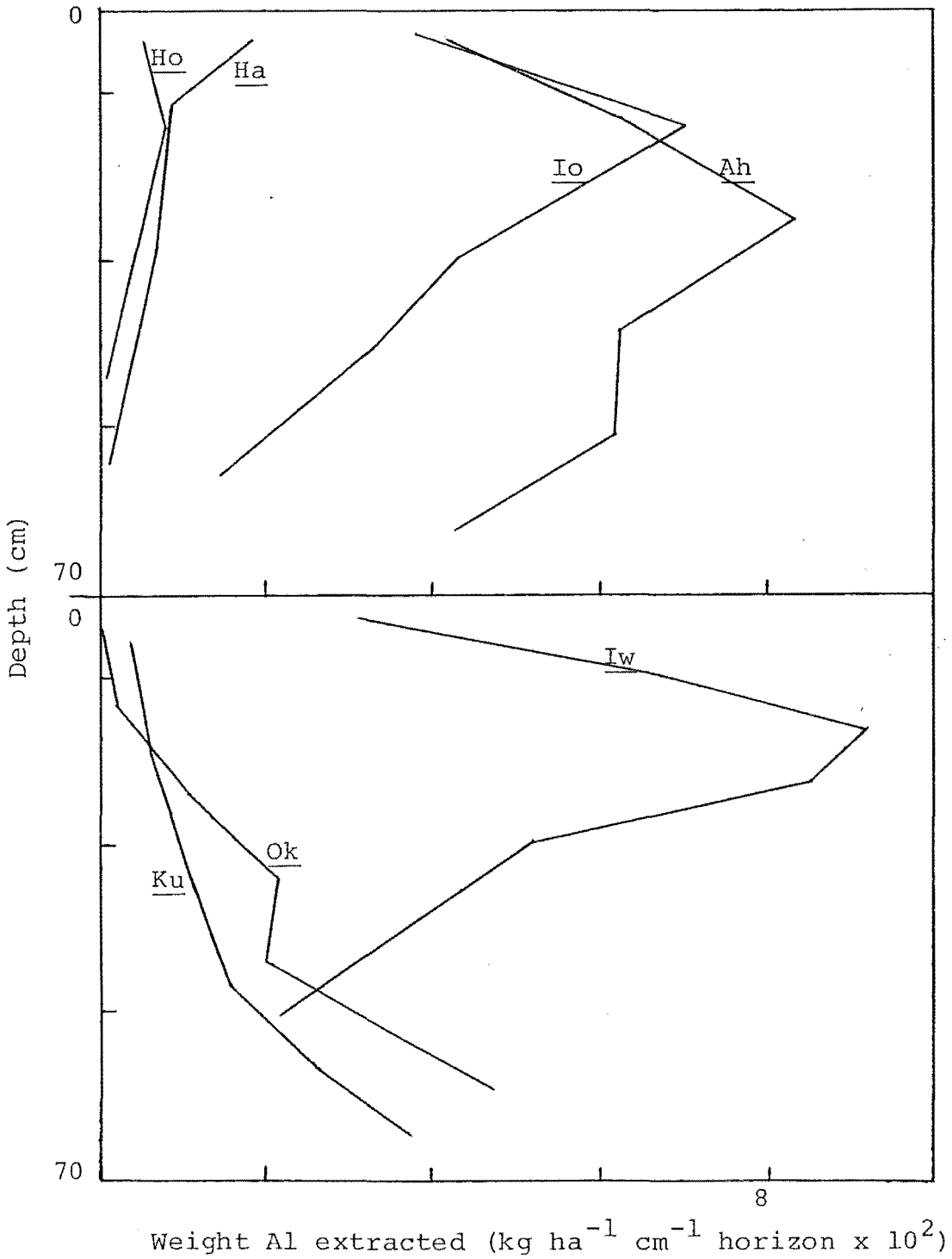

Figure 4.19. Variation in the weight of sodium pyrophosphate extractable Al with depth.

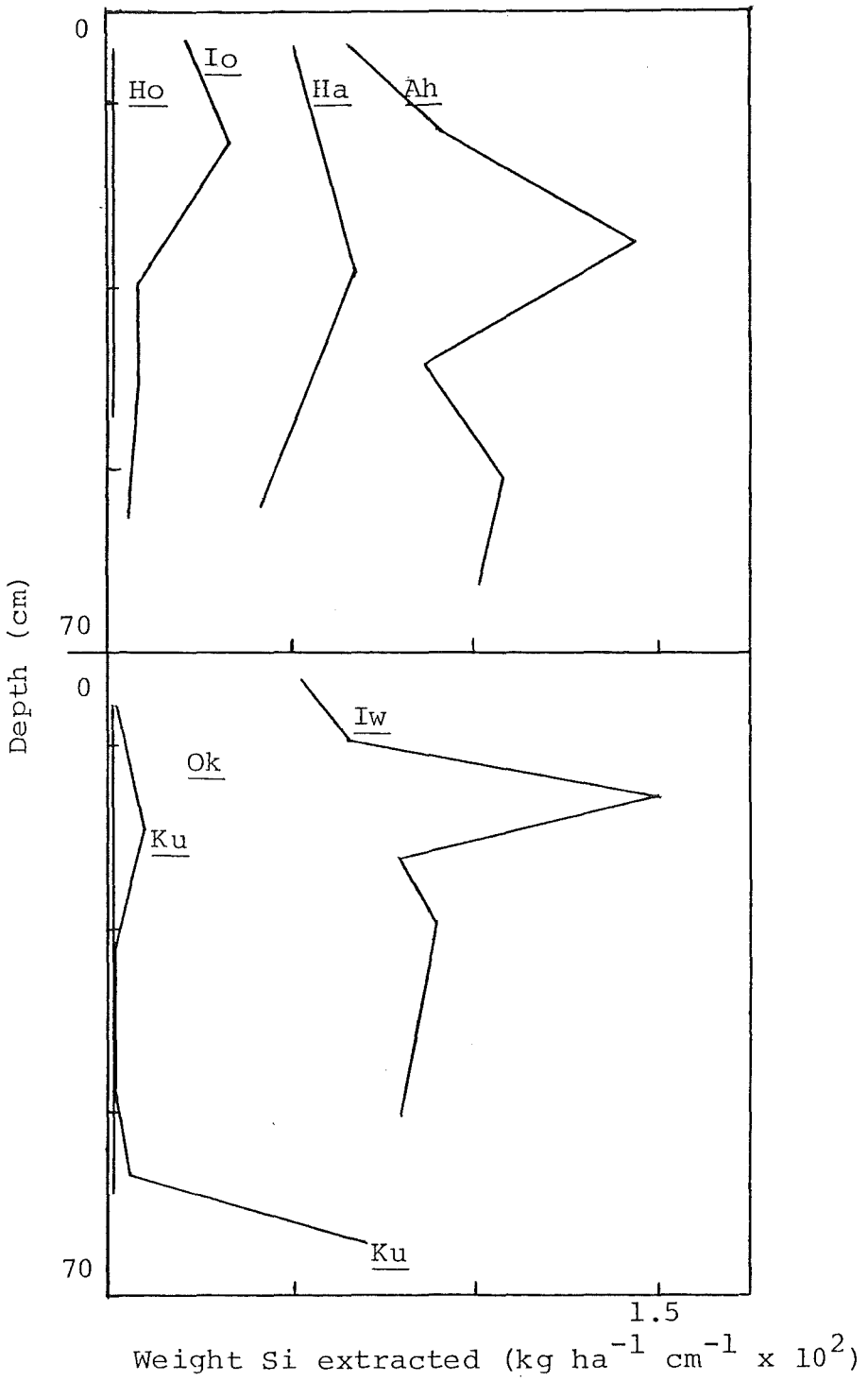

Figure 4.20. Variation in the weight of sodium pyrophosphate extractable Si with depth.

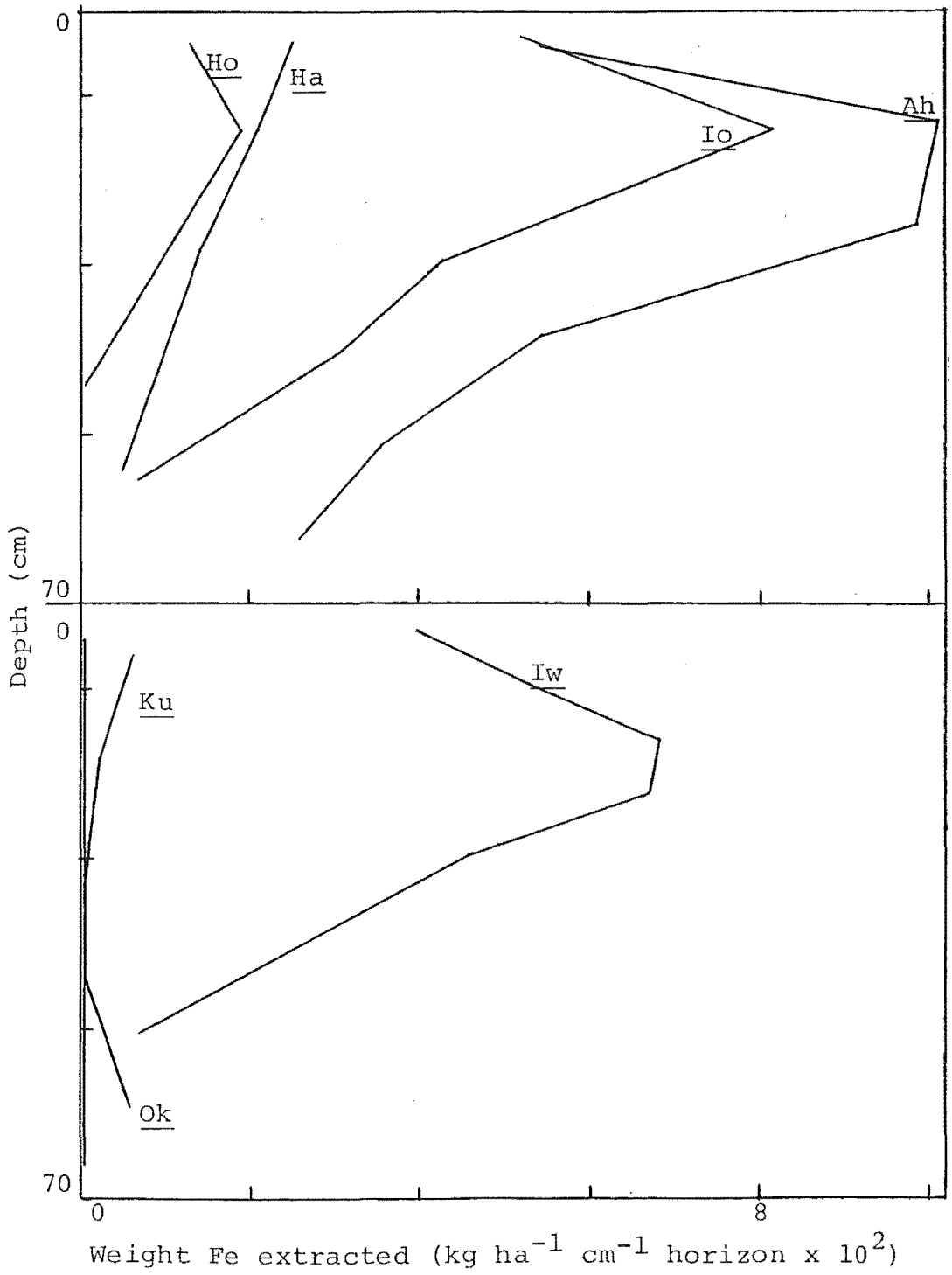

Figure 4.21. Variation in the weight of sodium pyrophosphate extractable Fe with depth.

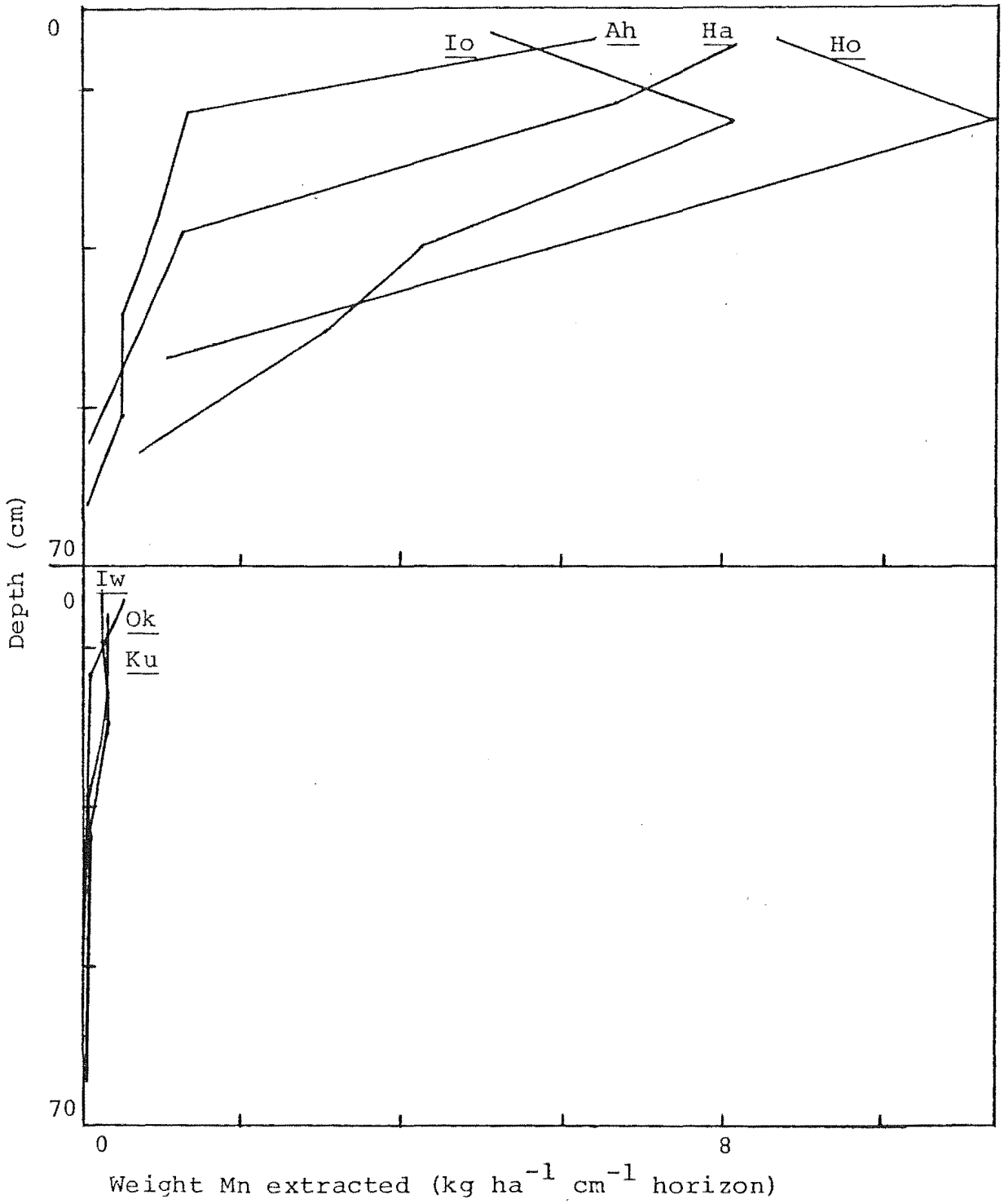

Figure 4.22. Variation in the weight of sodium pyrophosphate extractable Mn with depth.

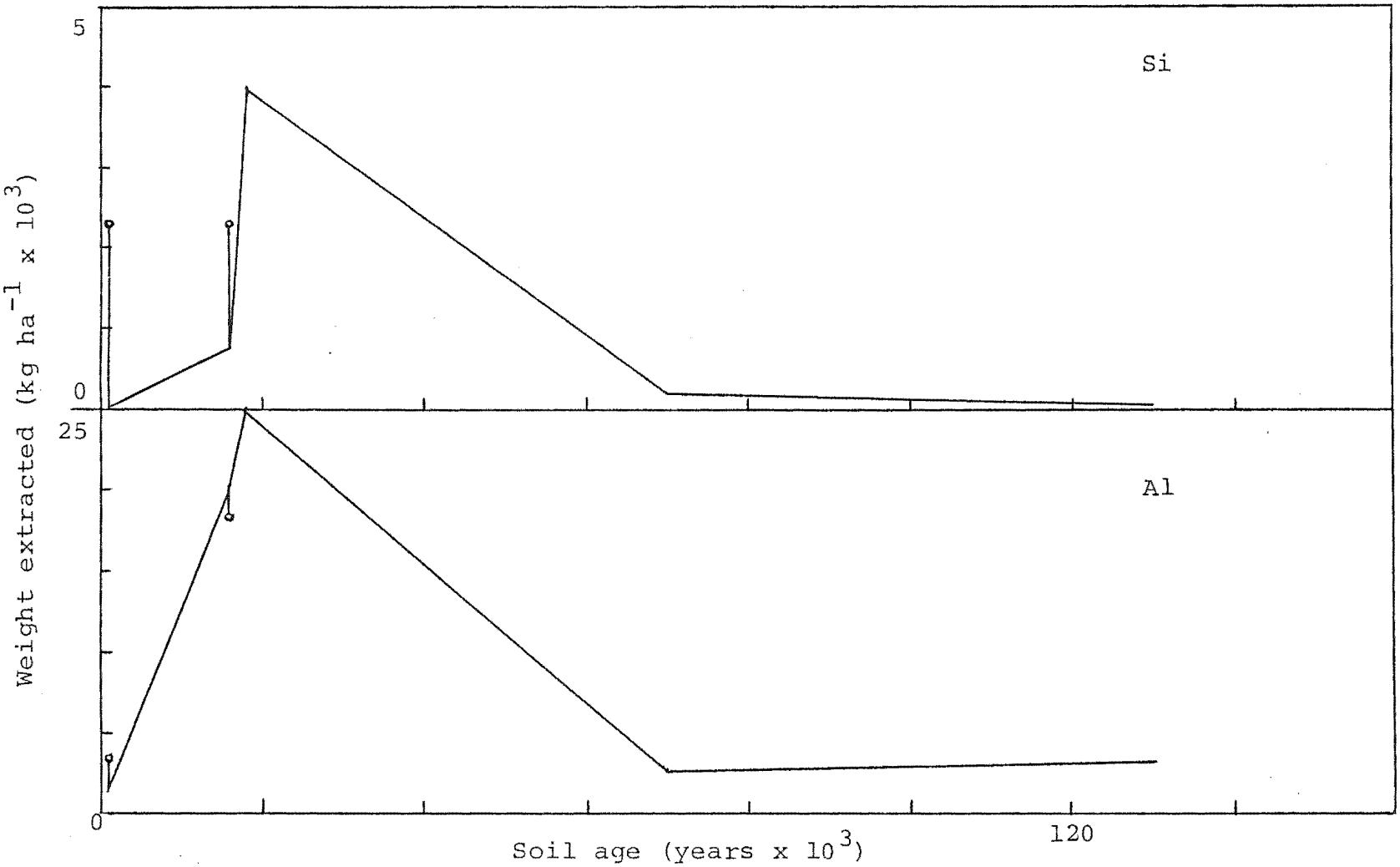

Figure 4.23. Variation in the weight, to 0.38m, of sodium pyrophosphate extractable Al and Si with soil.

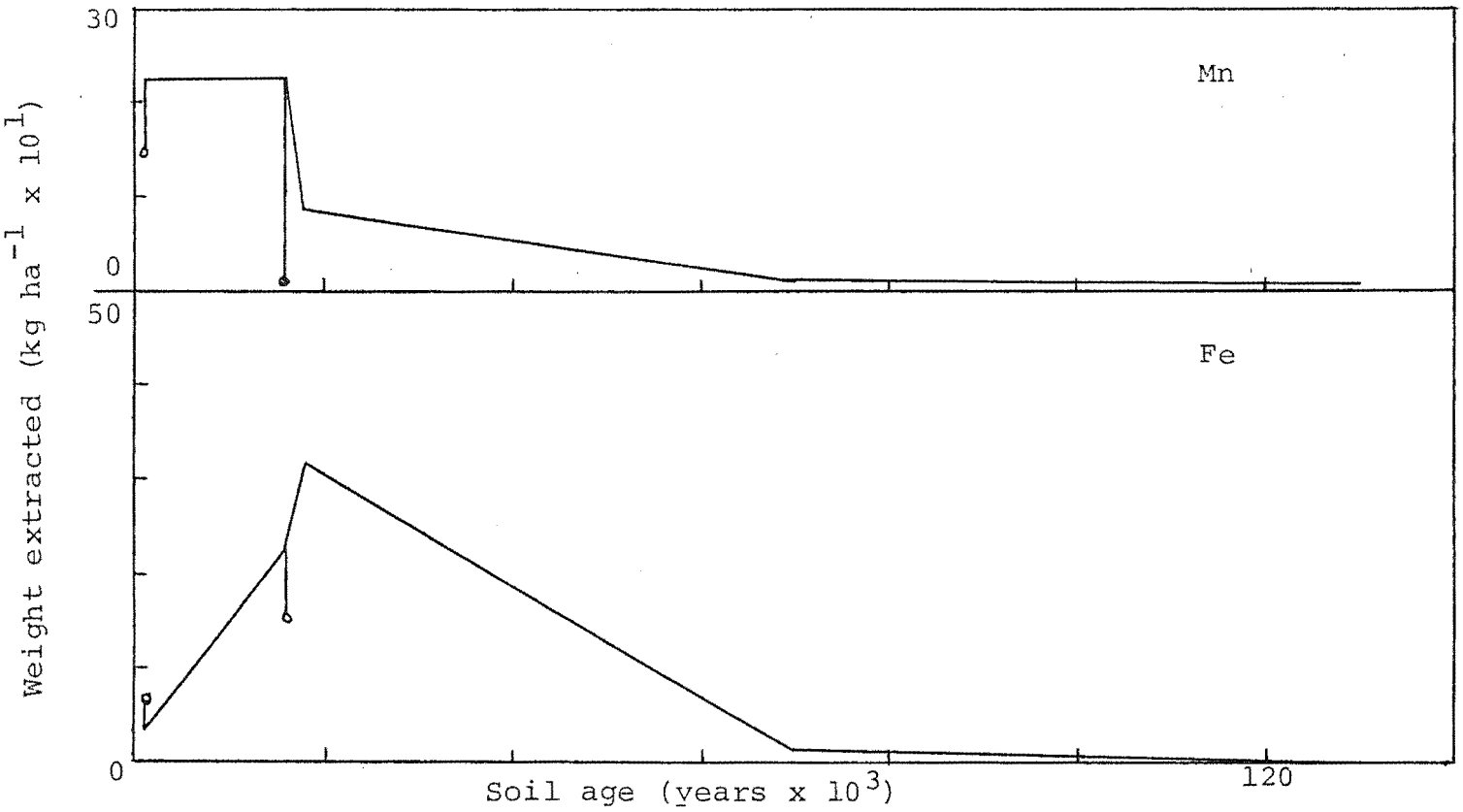

Figure 4.24. Variation in the weight, to 0.38m, of sodium pyrophosphate extractable Mn and Fe with soil age.

APPENDIX 2

(A) PROFILE DESCRIPTIONS OF SOILS OF THE REEFTON CHRONOSEQUENCE

Profile: Ho (hokitika sandy loam).

Location: 100 m south of Waitahu River, 10.5 km east of main Reefton-Inangahua road. (S.38/344337[a]).

Topography: Flat. Highest part of floodplain.

Site Vegetation: Grass and buttercup. 8 m from edge of red beech dominated forest remnant.

Altitude: 190 m

Estimated annual rainfall: 1920 mm.

Profile:

Au1	8 cm	dark brown (10YR 3/4) sandy loam; friable; weakly developed fine granular and crumb structure, grading downwards to fine and medium nutty; no stones; abundant grass and numerous tree roots; diffus smooth boundary.
Au2	12 cm	dark brown (7.5YR 4/3) loamy sand; friable; moderately developed fine and medium nutty structure; few grass or tree roots; distinct, slightly wavy boundary.
C	on	white (7.5Y 8/1) to grey (5Y 6/1) sandy gravel; loose; structureless; no roots.

Parent Material: Silty alluvium over gravels from granite (dominant) and indurated sandstone.

Native Vegetation: Red and silver beech, totara, matai and kahikitea.

Profile: Ha (Hari Hari sandy loam, wetter variant)

Location: 100 m south of Waitahu River, 10.5 km east of main Reefton-Inangahua road (S38/344337).

Topography: Flat. High part of floodplain.

Site Vegetation: Grass and buttercup. 33 m from edge of red beech dominated forest remnant.

Altitude: 189 m Estimated annual rainfall: 1920 mm

Profile:

Ag	7 cm	dark brown (10YR 3/4 sandy loam; friable; moderately developed very fine to medium nut structure; many distinct mottles of dark brown (5YR 3/4); many fine mica flakes; abundant fine roots; diffuse boundary.
ACg	9 cm	dark grey brown (10YR 4/2) loamy sand; friable; weakly developed medium and coarse blocky structure; abundant distinct mottles of dusky red (10R 3/3); few weathered gravels (remains of granite); many fine mica flakes; many medium and fine roots; indistinct boundary.
Cr	25 cm	grey brown (2.5Y 5/2) loamy sand; friable; weakly developed course blocky structure; many fine and medium distinct mottles brown to dark brown (10YR 4/3); many medium and fine roots; distinct boundary.

Cs	1 cm	strong brown (7.5YR 5/6) sand; very friable; few medium gravels (granite and greywacke fragments); sharp boundary.
D	on	Gravels and stones with sand matrix.

Profile: Io (Ikamatua fine sandy loam, older variant).

Location: 140 m north of road to Dauntless mine, 3.1 km east of its intersection with main Reefton-Inangahua road. (S. 38/355334).

Topography: Flat river terrace.

Site vegetation: Forest remnant: dominant red beech (0.5-0.7 m, d.b.h.[b]), some silver beech, pepper tree. Many fallen logs.

Altitude: 198 m Estimated annual rainfall: 1920 mm.

Profile:

OA	3 cm	dark reddish brown (5YR 3/2) peaty loam with much decomposed litter of beech leaves and twigs; distinct boundary.
A	6 cm	dark brown (8.5YR 3/4) fine sandy loam; very friable; moderately developed medium and fine granular and fine and very fine crumb structures; many roots; distinct boundary.
Bs1	16 cm	strong brown (7.5YR 5/6) sandy loam; very friable; moderately developed coarse and medium granular and fine and very fine crumb structures, with patches of medium nutty structure surrounding roots; few roots; indistinct boundary.

Bs2	15 cm	yellowish brown (10YR 5/7) loamy sand; very friable; weakly developed medium and fine nutty structure; few roots; distinct boundary.
C1	6 cm	olive brown (1Y 4/4) gravelly sand; loose; structureless; few medium and small stones of granite and indurated sandstone; no roots; distinct boundary.
C2	on	white (N8) to very dark greyish brown (2.5Y 3/2) sandy gravel; loose; structureless; few small stones of granite and indurated sandstone; no roots.

Parent Material: Silty alluvium over gravels from granite (dominant) and indurated sandstone.

Native vegetation: Red beech (dominant), kamahi, quintinia, rimu, matai and kahikitea.

Profile: Iw (Ikamatua fine sandy loam, wetter variant).

Location: 50 m south of road to Dauntless mine, 3.9 km east of its intersection with main Reefton-Inangahua road. (S 38/361333).

Topography: Flat. Lower-lying area of river terrace.

Site Vegetation: Manuka scrub, grass.

Altitude: 197 m Estimated annual rainfall: 1920 mm.

Profile:

OA	7 cm	dark reddish brown (5YR 2/3) humose sandy loam; very friable; weakly developed fine nutty structure, breaking into moderately developed medium and fine granular and fine

		and very fine crumb; many roots; distinct, wavy boundary.
A	6 cm	dark reddish brown (5YR 2/4) fine sandy loam; friable; weakly developed coarse to fine nutty structure grading to fine and very fine granular and crumb; few roots; indistinct boundary.
Ar	7 cm	dark brown (7.5YR 4/2) to dark yellowish brown (10YR 4/4) and dark reddish brown (5YR 2/4) sandy loam; friable; moderately developed coarse to very fine nutty structure; few roots and worm casts; sharp wavy boundary.
Br1	6 cm	light yellowish brown (10YR 6/4) loamy sand; some iron and humus staining in root channels; very friable; moderately developed coarse and medium granular and fine and very fine crumb structures; few roots; indistinct boundary.
Br2	7 cm	brownish yellow (10YR 6/6) loamy sand; friable; weakly developed coarse to very fine nutty, and fine and very fine crumb and granular structures; rare roots; distinct boundary.
Cr1	7 cm	light yellowish grey (7.5Y 8) to dark brown (10YR 3/3), sandy gravel; loose; structureless; no roots; distinct boundary.
Cr2	on	light olive brown (2.5Y 5/4) gravelly sand; loose; structureless; no roots.

Parent Material: Silty alluvium over gravels from granite (dominant) and indurated sandstone.

Native Vegetation: Red beech (dominant), matai, kahikitea, kamahi, quintinia, rimu.

Profile: Ah (Ahaura silt loam).

Location: 480 m south of road to Dauntless mine, 3.5 km east of its intersection with main Reefton-Inangahua road. (S. 38/355326)

Topography: Flat glacial outwash terrace. Free-draining site in slightly lower part of terrace.

Site Vegetation: Forest remnant: dominant red beech (0.6 - 1.1 m, d.b.h.) with some silver beech. Many stumps, fallen logs and litter mounds. Some grass. Recently opened to stock.

Altitude: 210 m Estimated annual rainfall: 1920 mm.

Profile:

A	8 cm	brown to dark brown (7.5YR 4/4) silt loam; very friable; moderately developed medium and fine nutty structure (surface) grading downwards to moderately developed medium and fine granular and crumb; many roots at surface, few fragments of beech litter surface; indistinct boundary.
AB	10 cm	brown to dark brown (7.5YR 4/4) and yellowish brown (10YR 5/8) sandy loam; very friable; moderately developed medium and fine granular, and fine and very fine crumb

		structures; few roots; distinct boundary.
Bs1	14 cm	brownish yellow (10YR 6/8) sandy loam; very friable; moderately developed coarse to fine granular and fine and very fine crumb structures; few roots; diffuse boundary.
Bs2	13 cm	brownish yellow (10YR 7/8) sandy loam; very friable; ultimate structure is fine and very fine crumb; some tendency to form coarser aggregates that are either nuts or blocks; very few roots; indistinct boundary.
Bs3	12 cm	brownish yellow (9YR 6/6) sandy loam; very friable; massive; breaks to indefinite crumb-like structures; very few roots; distinct boundary.
C1	11 cm	yellowish brown (9YR 5/6) loamy sand; massive; slightly coherent, breaking to indefinite crumb-like structures; very few roots; sharp boundary.
C2	on	light olive brown (3.5Y 5/6) sandy gravel; loose; structureless; few small to large stones of granite (dominant) and indurated sandstone.
Parent Material:		Silty alluvium over gravels from granite (dominant) and indurated sandstone.
Native Vegetation:		Red beech (dominant), rimu, kamahi, quintinia, matai and kahikitea.

Profile: Ku (Kumara silt loam).

Location: 300 m north-east of Reefton railway station. (S. 38/322306).

Topography: Flat, intermediate level, glacial, outwash terrace.

Site Vegetation: Manuka scrub, moss, sedges, grass.

Altitude: 250 m Estimated annual rainfall: 1920 mm.

Profile:

A	12 cm	brown to dark brown (7.5YR 4/2) silt loam; slightly plastic; non sticky; structure-less; many roots; distinct boundary.
Er	14 cm	light brownish grey (10YR 6/2) heavy silt loam; slightly plastic; moderately sticky; massive; moderately coherent; few roots; indistinct boundary.
Br1	15 cm	light grey (7.5YR 7/1) and dark greyish brown (10YR 4/2) silt loam; plastic; moderately stickly; massive; coherent; few roots; distinct boundary.
Br2	12 cm	light grey (7.5YR 7/2) silt loam with dark reddish brown (5YR 2/2) stains along cracks and root channels; slightly plastic; slightly sticky; very weakly developed coarse blocky structure with nutty struct-ure near cracks and some thin platy struct-ure at borrom of horizon; many roots (in patches); distinct boundary.
Br3	8 cm	light grey (7.5Y 7/1) silt loam; non plastic; non sticky; massive; moderately

coherent; few roots; distinct boundary.

Cr on — dark yellowish brown (10YR 3/4) gritty silt among weathering granite stones up to 20 cm in diameter; massive; very hard; few roots.

Parent Material: Silty alluvium (or loess?) over gravels from granite (dominant) and indurated sandstone.

Native Vegetation: Silver pine and mountain beech (dominant), stunted rimu, kamahi and quintinia, and some toa toa, pink pine and yellow-silver pine.

Profile: OK (Okarito loamy sand site).

Location: 600 m north-west of Waitahu Dam. (S. 38/364340).

Topography: Slightly undulating high level glacial outwash terrace. Site is 40 m from edge of terrace, and is slightly higher than the main terrace surface.

Site Vegetation: Manuka scrub, bracken fern, umbrella fern, grass, occasional orchids.

Altitude: 390 m — Estimated annual rainfall: 1920 mm.

Profile:

A 9 cm — dark reddish brown (6YR 3/3) loamy sand; non plastic; non sticky; weakly developed medium and fine nutty structure; few roots; distinct boundary.

Ag 9 cm — dark greyish brown (10YR 4/2) spotted with light grey (7.5Y 6/1) silt loam; firm;

		massive; moderately coherent; very few roots; distinct boundary.
Br1	12 cm	grey (5Y 6/1) silt loam; extremely firm; massive; very coherent; very few roots; patchy boundary.
Br2	8 cm	light grey (6Y 7/1), orange (10YR 6/6) and brown (10YR 3/3) silt loam; very dark brown (7.5YR 2/3) stains on faces of major vertical cracks and of some prisms; very few roots; distinct boundary.
Br3	12 cm	light grey (8.5Y 7/1) silt loam; few strong brown (7.5YR 5/8) mottles; very firm; massive; moderately coherent; no roots; distinct boundary.
C	on	grey (7.5Y 6/1) gritty silt loam; very firm; massive; moderately coherent; many weathered granite stones; no roots.
Parent Material:		Silty alluvium (or loess?) over gravels from granite (dominant) and indurated sandstone.
Native Vegetation:		Stunted forest or scrub of manuka, bog pine, pink pine, yellow-silver pine and mountain beech.

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a All grid references refer to N.Z.M.S. Sheet S. 38.

b d.b.h. means diameter at breast height.

(B) PROFILE DESCRIPTIONS OF SOILS OF BIOSEQUENCE

Profile: Ah - as for chronosequence

Profile: Pod Ah (Ahaura fine sandy loam).

Note: site characteristics for the Pod Ah profile are similar to those listed in Appendix 1 (A) for the Ah profile.

E	12 cm	dark reddish brown (5YR 2/3) silt loam; friable; moderately developed medium and fine nutty and fine and very fine crumb structures; few roots; sharp wavy boundary.
Bs	22 cm	yellowish brown (10YR 5/6) silt loam; very friable; weakly developed medium and fine nutty structure breaking to fine and very fine granular; rare roots; diffuse boundary.

(C) PROFILE DESCRIPTIONS OF SOILS OF TOPOSEQUENCE

Profile: Lower Footslope (L.F.S.) (Gleyed humus podzol).

Location: Northwest Bealey Spur, Upper Waimakariri Basin, (S. 66/109176).

Topography: Lower Footslope (10^{o} slope) of a small (15 x 100 m) ice-cut rock basin on the flattened upper part of the Bealey Spur.

Site Vegetation: Mountain beech forest.

Altitude: 812 m

Profile:

Ar	6 cm	light yellowish grey (10YR 6/2) silt loam; friable, slightly sticky and plastic; massive grading to weakly developed medium nut; few small stones with a pronounced weathering rind; many coarse, medium and fine roots; distinct smooth boundary.
Er	10 cm	light grey (2.5Y 7/1) clay loam; firm, sticky and very plastic; massive; many dark brown (7.5YR 3/3) humus stains on peds; few small humus coated stones showing moderate pitting and rind formation; many medium and finte roots; indistinct boundary.
Brs	4 cm	light yellowish brown (2.5Y 6/3) clay loam; firm, sticky and plastic; massive breaking to fine and medium blocky, pronounced dark reddish brown (5YR 3/3) stains on peds; few small stones and gravels; few fine and medium partly humified roots; indistinct boundary.
Bhrs	6 cm	grey (7.5Y 5/1) silt loam; friable, non-sticky and slightly plastic; massive breaking easily to fine blocky; abundant, pronounced dark reddish brown (5YR 2/3) humus stains; few very fine gravels; many fine roots; distinct smooth boundary.
Br	8 cm	grey (7.5Y 5/1) silt loam; firm; non-sticky and slightly plastic; massive; some dark brown (7.5YR 3/3) humus stains on peds; many partly humified fine roots; distinct

		smooth boundary.
2Cr	13 cm	dark greyish brown (2.5Y 4/2) gravelly sandy loam; compacted gravels with few small stones; few fine roots; indistinct boundary.
Parent Material:		Colluvium, loess and till from indurated sandstone.

Profile: Crest (Podzolized yellow-brown earth).

Location: as for L.F.S.

Topography: Summit profile (6^{o} slope) of a small ice-cut rock basin on the flattened upper part of the Bealey Spur.

Site Vegetation: as for L.F.S.

Altitude: 822 cm

Profile:

E	5 cm	light grey (7.5YR 8/1) silt loam; firm; massive, breaking to medium blocky; distinct brown (7.5YR 3/3) humus stains on ped surfaces; few strongly weathered small stones; few fine and medium roots; distinct smooth boundary.
EB	4 cm	very pale brown (10YR 8/3) silt loam; friable; moderately developed fine and medium nut; few strongly weatherd small stones; few fine and medium roots; indistinct boundary.
Bhs	8 cm	brownish yellow (10YR 6/8) silt loam; friable; weakly developed medium nut; abundant reddish brown (5YR 3/4) iron-

humus coatings on ped surfaces; many fine and medium roots; indistinct boundary.

2Bs 7 cm brownish yellow (10YR 6/6) gravelly silt loam; friable; weakly developed fine blocky; many small stones and medium and coarse gravels; few coarse roots; indistinct boundary.

2Bw 13 cm brownish yellow (10YR 6/6) gravelly silt loam; friable; massive breaking to fine blocky abundant sub-angular and rounded stones and gravels; few fine and medium roots; distinct smooth boundary.

Parent Material: Loess and till from indurated sandstone.

(D) HORIZON DESCRIPTIONS FOR WATERTON SOILS

Horizon:

1Brs 5 cm Indistinct boundary; greyish brown (10YR, 5/2, moist) clay loam; rubbed colour, yellow brown (10YR, 5/4, moist); firm when moist; moderate developed peds, size 10 to 30 mm, few tubular pores; Many Mn concretions; prominent mottling, fine and many, yellowish red in colour (5YR, 5/8).

2Br 22 cm Indistinct boundary; pale olive brown to greyish brown (2.5Y, 5/3, moist) clay loam; very firm when moist; moderately developed; few fine tubular pores; very few fine roots; few concretions, 1 to 5 mm in diameter; prominent mottles, strong brown colour (7.5YR 5/8).

3Brs1	8 cm	Distinct boundary; dark greyish brown (2.5Y 4/2, moist) silt=clay loam; many prominent medium to fine mottles, strong brown colour (7.5YR 5/8); moderately developed; very firm (moist); few fine tubular pores; many Mn concretions, 1 to 15 mm in diameter.
3Brs2	9 cm	Indistinct boundary; dark greyish brown to olive brown (2.5Y 4/3, moist) silt-clay loam; few faint fine mottles, yellowish brown colour (10YR 5/8); moderately developed; very firm when moist; many fine tubular pores; very few fine roots; many Mn concretions, 1 to 2 mm in diamter.

APPENDIX 3

Glossary of Soil Science Terms[6]

A *horizon*. The surface horizon of a mineral soil having maximum organic matter accumulation, maximum biological activity and/or eluviation of materials such as iron and aluminium oxides and silicate days.

aerobic. Occurring only in the presence of molecular oxygen (said of certain chemical or biochemical processes such as aerobic decomposition).

Alluvial soil. A soil developing from recently deposited alluvium and exhibiting essentially on horizon development or modification of the recently deposited materials.

alumino-silicates. Compounds containing aluminium, silicon and oxygen as main constituents.

anaerobic. Living or functioning in the absence of air or free oxygen.

B *horizon*. A soil horizon beneath the A which is characterized by an accumulation of silicate clays, iron and aluminium oxides, or humus, or by a blocky or prismatic structure.

bulk density. The mass of dry soil per unit bulk volume including air space.

C *horizon*. A horizon generally beneath the solum which is relatively little affected by biological activity and pedogenesis and is lacking the properties of the A or B horizon.

cation exchange. The interchange between a cation in solution and another cation on the surface of any surface active material such as clay or organic matter.

cation-exchange capacity. The sum total of exchangeable cations that a soil can adsorb.

chelate. A type of chemical compound in which a metallic ion is firmly combined with a molecule by means of multiple chemical bonds.

clay. A soil separate consisting of particles less than 2 μm in equivalent diameter.

clay mineral. Naturally occurring inorganic material (usually crystalline) found in soils, the particles being of clay size.

concretion. A local concentration of a chemical compound, such as calcium carbonate or iron/manganese oxides, in the form of a grain or nodule of varying size, shape, hardness and colour.

double layer. In colloid chemistry, the electric charges on the surface of the dispersed phase (usually negative), and the adjacent diffuse layer (usually positive) of ions in solution.

eluviation. The removal of soil material in suspension or in solution from a layer or layers of a soil.

friable. A soil consistency term related to the ease of crumbling of soils.

fulvic acid. The mixture of organic substances remaining in solution upon acidification of a dilute alkali extract from the soil.

genesis, soil. The mode of origin of the soil, with reference to the soil forming processes responsible for the development of the soil, from the unconsolidated parent material.

Gley soil. Soil developed under conditions of poor drainage resulting in reduction of iron and other elements and in grey colours and mottles.

humic acid. A mixture of variable or indefinite composition of dark organic substances, precipitated upon acidification of a dilute-alkali extract from soil.

humus. The more or less stable fraction of the soil organic matter remaining after the major portion of added plant and animal residues have decomposed.

hydrous mica. A silicate clay with 2:1 lattice structure, but of indefinite chemical composition since usually part of the silicon in the silica tetrahedral layer has been replaced by aluminium and containing a considerable amount of potassium which serves as an additional bonding between the crystal units, resulting in particles larger than normal in montmorillonite, and consequently, in a lower cation-exchange capacity. Sometimes called illite.

illuvial horizon. A soil layer or horizon in which material carried from a shallower layer has been precipitated from solution or deposited from suspension. The layer of accumulation.

iron-pan. An indurated soil horizon in which iron oxide is the principal cementing agent.

isomorphous substitution. The replacement of one atom by another of similar size and charge in a crystal lattice without disrupting or changing the crystal structure of the mineral.

micronutrient. A chemical element necessary in only very small amounts for the growth of plants.

mineral soil. A soil consisting mainly of, and having its properties determined predominantly by, mineral matter. Usually contains less than 20% organic matter.

organic soil. A soil which contains a high percentage (>20%) of organic matter throughout the solum.

parent material. The unconsolidated and relatively chemically unweathered mineral or organic matter from which the solum of soils is developed by soil forming processes.

particle size analysis. Determination of the various amounts of the different separates in a soil sample.

podzol. A group of soils that develop in a moist climate, especially under coniferous or mixed forest and have an organic mat and a thin organic-mineral layer above a grey leached layer resting on a dark illuvial horizon enriched with amorphous clay.

primary mineral. A mineral that has not been altered chemically since deposition and crystallization from molten lava.

profile, soil. A vertical section of soil through all its horizons and extending into the parent material.

secondary mineral. A mineral resulting from the decomposition of a primary mineral or from the reprecipitation of the products of decomposition of a primary mineral.

soil solution. The aqueous liquid phase of the soil and its solutes consisting of ions dissociated from the surfaces of the soil particles and of other soluble materials.

solum. The upper and most weathered part of the soil profile; the A and B horizons.

till. Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel and boulders intermingled in any proportion.

weathering. All physical and chemical changes produced in rocks, at or near the earth's surface, by atmospheric agents.