CHAPTER - V

CHAPTER 5

LABORATORY INVESTIGATIONS

Major oxides and Trace elements analyses

Chemical analyses of samples from representative members of eight lateritic weathering profiles described earlier was done. Variation diagram of the various element versus the depth have also been given. The increase/decrease in concentration of the various elements compared to the average composition of the parent rock has also been calculated.

Keeping in mind the limited laboratory facilities and time constraint the author has selected eight representative sections for major and trace element studies which are as follows.

(a) Tagadi (b) Thoradi (c) Badi (d) Padwa (e) Morchand (f) Thalsar (g) Devaliya (h) Alang

Sample preparation:

0.5 gm of rock powder is weighed accurately into a platinum crucible together with 1.5 gm of lithium metaborate ($LiBO_4$). The mixture is carefully mixed and then heated upto 900 C for 30 - 45 minutes in a furnace. After cooling, the entire crucible is immersed in a beaker containing 175 ml. of distilled water and 10 ml. of conc. nitric acid. A magnetic bead is placed in the crucible and strring over the surface of the fused mixture began without delay. Complete dissolution should be achieved in 1-2 hours and the solution is then diluted to 250 ml.

XRD Analyses

Minus 230 mesh (ASTM) portions of the powdered bulk of the samples were subjected to XRD studies. The instrument used was Philips X - Ray diffractometer with a copper target and Cu k-alpha radiation. The samples were scanned from 5 to 40 at a speed rate of 2 per minute and having a chart speed of 2 cm per minute, the range being 2 x 1000 c / s. The d - spacing and intensities were calculated and compared with JCPDS standard charts for different minerals.

SECTIONWISE BEHAVIOUR OF MAJOR AND TRACE ELEMENTS

While describing the behavioural pattern of various elements, all the eight sections have been grouped into three classes which are

i) Sections where the bentonite has a lateritic overburden

ii) Sections where the bentonite is devoid of a lateritic overburden but has a bedrock exposed at the base and

iii) Tagadi and Thoradi - where the bentonitic clays have neither a lateritic overburden nor a bedrock at the base.

I. Sections with a lateritic overburden

Morchand (Section-9), Thalsar (Section-10), Alang (Section-11), Devaliya (Section-13).

All these sections have a lateritic overburden at the top, followed by a clay horizon. The XRD analyses (Tables 8 & 15) point out that the bentonite is overlain by a 0.6 to 2 m thick lithomargic horizon having a kaolinitic composition followed at the top by a lateritic horizon.

From the variation diagrams (Fig. 4,7,9 & 11) and analytical data (Tables 6,9,11 & 13) the following anomalies can be noted.

i) The concentration of silica decreases from the bottom to the top. In comparision to the average concentration of Si in the basalt exposed in the study area, Si in all the sections shows a decrease throughout the profile with a maximum decrease in the lateritic horizons (Tables 7,10,12 & 14).

ii) Alin general shows a decreasing upward behaviour. However, at Devaliya and Morchand **Al** shows a slight increase in concentration in the middle parts of the profiles. **Al** shows gains throughout the profile except in the lateritic horizon. The gains increase from top to bottom (Tables 7,10,12 & 14).

iii) **Fe** behaves antipathetically to **Al** and shows an increase in concentration from the bottom to the top. **Fe** shows upward increasing gains throughout the profile (Table 7,10,12 & 14).

iv) **Ti** in general shows an upward increasing trend.

v) **Ca** is present in small amounts throughout the profile and sometimes shows an increase in concentration in the middle parts of the profile.

vi) **Mg** is lost throughout the profile (Table 7,10,12 & 14).

vii) **Zr** shows a gradual increase from the bottom to the top.

viii) **Cr** shows increased concentration in the upper parts of the profile.

ix) **Cu** and **Zn** show a mixed behaviour in all the section with irregular increases and decreases.

x)**Ni** shows decreases throughout the profile at Alang (Table 12). However, at Morchand and Devaliya **Ni** shows slight increases in concentration in the middle parts of the profile (Tables 7 & 14).

xi) The triangular projection (Fig. 5,8,10 & 12) shows that there is a dissolution removal of both **Al** and **Si** resulting in the concentration of **Fe**.

The gradual increase of **Fe** and **Ti** from the bottom to the top and the accumulation of **Zr** in the topmost parts of the profile indicate an in-situ nature of the weathering profile. It can be said that the laterite is an alteration product of the clay which in turn is an in-situ alteration product of the Deccan basalts.

II. Sections without a lateritic overburden but have an exposed bedrock at the base.

Badi (Section-7) and Padwa (section-8).
Here the section exposed consists of a thin soil cover followed by a thick clay horizon which grades down into rock of basaltic composition.

The examination of the anlytical data (Tables 18 & 19) and the variation diagrams (Fig. 14 & 17) reveal the following information.

i) Si shows a gradual decrease in concentration from the bottom to the top. At Badi the concentration of Si increases in the two horizons above the weathered basalt, otherwise it shows losses throughout the profile (Tables 17 & 20).

ii) Al decreases from the bottom to the top and shows gains throughout the clay horizons. It shows a decrease in concentration in the uppermost horizons.

iii) **Fe** shows an increasing upward behaviour.

iv) **Ti** shows an increasing upward behaviour and shows gains throughout the profile.

v) **Ca** shows an increased concentration in the upper horizons at Badi.

vi) **Mg** is lost throughout the profile (Tables 17 & 20).

vii) **Zr** and **Cr** show an increasing upward trend.

viii) **Co** shows a decreasing upward behaviour.

ix) **Ba, Ni** and **Cu** show an irregular behavioural pattern in both profiles.

x) The triangular diagram (Fig. 15 & 18) shows that there is a dissolution and removal of **Si** at the base causing an enrichment of **Al** at the base. Later on both **Al** and **Si** are removed considerably causing a relative enrichment of **Fe**.

The above characteristics point out an in-situ alteration of the Deccan basalts which resulted into the formation of the bentonites.

III. Sections devoid of both a lateritic cover and a bedrock.

Tagadi (Section-4) and Thoradi (Section-5).

The sections exposed at Tagadi and Thoradi consist of a thin soil cover followed by a 9 to 12 m thick clay horizon.

The following anomalies are noted from the analytical data (Table 22 & 23) and variation diagrams (Fig. 20 & 22).

i) **Si** shows a mixed behaviour. At Tagadi its concentration increases from the top, downwards upto 5.5 m. From there it decreases toward the base. However, at Thoradi the bottom horizons an irregularly increasing and decreasing trend.

ii) **Al** also behaves erratically. It increases and decreases irregularly throughout the profile.

iii) **Fe** also shows an irregular trend, the bottom horizons showing irregular increases and decreases.

iv) **Ti** also shows an irregular behaviour.

v) **Ca** and **Mg** are present in small amounts throughout the profile except at a depth of 5.5 m at Thoradid where it shows an increase in concentration because of a calcite vein passing the horizon from where the sample was collected.

vi) All the trace elements show an irregular increase and decrease in concentration throughout the profile. At Tagadi **Zr** and **Cr** show an increasing upward trend from the bottom upto 5 m. The concentration suddenly decreases upwards and shows an irregularly increasing and decreasing trend. At Thoradi no definite pattern for the behaviour of these elements could be established.

The triangular diagram also does not show any regular enrichment pattern (Fig. 21 & 23). The irregular behaviour of almost all the elements points out that the bentonitic clays are not an in-situ product and that they are mechanically reworked type.

TABLE 6 : ANALYTICAL DATA OF A SECTION EXPOSED AT MORCHAND.

Depth	Major elements in %								Trace elements in ppm.						
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
00 -0.5	25.00	18.99	52.58	2.64	0.35	ND	0.34	ND	26.00	110.00	659.00	ND	37.00	4.00	364.00	12.00
0.5-1.0	29.25	21.93	44.14	2.38	1.47	ND	0.39	ND	43.00	138.00	474.00	ND	36.00	2.00	295.00	11.00
1.0-1.8	39.80	26.20	29.63	2.40	1.97	ND	0.62	ND	40.00	128.00	468.00	ND	290.00	2.00	281.00	43.00
1.8-2.5	44.40	33.21	17.52	2.37	1.10	ND	0.43	ND	32.00	250.00	453.00	ND	301.00	1.00	264.00	40.00
2.5-3.5	46.92	36.43	11.69	2.25	1.54	ND	0.51	ND	69.00	317.00	372.00	ND	265.00	1.00	251.00	46.00
3.5-4.5	48.70	38.59	8.24	1.66	1.83	ND	0.72	ND	45.00	236.00	326.00	ND	232.00	T	169.00	14.00
4.5-5.2	50.30	36.42	9.32	1.96	0.93	ND	0.63	ND	32.00	153.00	367.00	ND	119.00	T	223.00	36.00
5.2-6.2	52.42	36.32	7.13	1.85	0.86	ND	0.56	ND	52.00	198.00	248.00	ND	76.00	1.00	243.00	26.00
6.2-7.2	51.63	38.43	5.45	2.12	0.65	ND	0.41	ND	28.00	87.00	213.00	ND	11.00	T	245.00	16.00
7.2-8.2	52.23	37.63	6.13	2.35	0.51	ND	0.63	ND	19.00	135.00	218.00	ND	T	4.00	240.00	19.00
8.2-9.2	52.80	36.40	6.62	2.24	0.45	ND	0.52	ND	32.00	68.00	198.00	ND	9.00	6.00	261.00	28.00

TABLE 7 : THE INCREASE/DECREASE IN % OF THE ELEMENT CONCENTRATIONS WITHIN THE PROFILE AT MORCHAND COMPARED TO THE AVERAGE COMPOSITION OF THE PARENT ROCK.

Depth in M.	Element	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
	Avg.Comp. in parent rock	54.45	24.74	10.18	2.07	0.96	1.065	4.88	T	37.5	118	308	ND	62.5	2	254	33
0-0.5		-54	-23	+416	+27	-63	ND	-93	ND	-30	-6	+212	ND	-41	100	+43	-63
0.5-1.0		-46	-11	+333	+15	+53	ND	-92	ND	+14	+16	+152	ND	-42	0	+16	-66
1.0-1.7		-26	+6	+191	+16	+105	ND	-87	ND	+6	+8	-45	ND	+364	0	+6	+30
1.7-2.5		-18	+34	+72	+14	+14	ND	-91	ND	-14	+111	+47	ND	+381	-50	-12	+21
2.5-3.5		-14	+47	+15	+8	+60	ND	-89	ND	+84	+168	+20	ND	+324	-50	-28	+39
3.5-4.5		-10	+56	-19	-19	+90	ND	-85	ND	+20	+100	+5	ND	+271	ND	-33	-57
4.5-5.2		-7	+47	-8	-5	-3	ND	-87	ND	-14	+29	+19	ND	+90	ND	+27	+9
5.2-6.2		-4	+47	-29	-10	-10	ND	-88	ND	+38	+158	-19	ND	+21	-50	+14	-21
6.2-7.2		-5	+55	-46	+2	-32	ND	-91	ND	-25	-26	-31	ND	-82	ND	-4	-51
7.2-8.2		-4	+52	-39	+13	-46	ND	-87	ND	-49	+14	-29	ND	T	+100	-5	-42
8.2-9.2		-3	+47	-35	+8	-53	ND	-89	ND	-14	-42	-35	ND	-85	+200	-6	-15

ND : Not Determined

T : Trace

FIG : 4a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF SI, Al, Fe AT MORCHAND

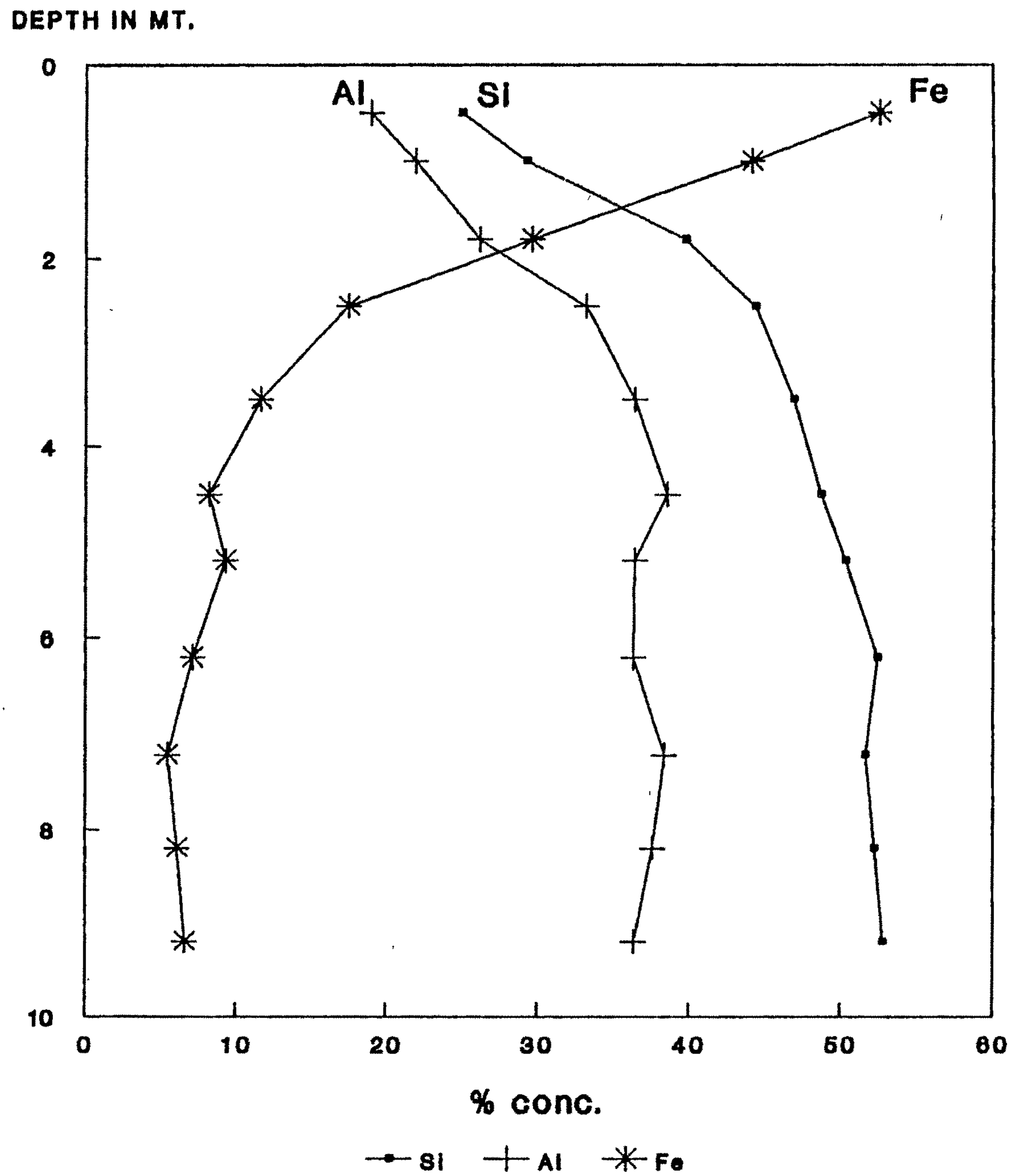


FIG: 4b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Ca, Mg AT MORCHAND

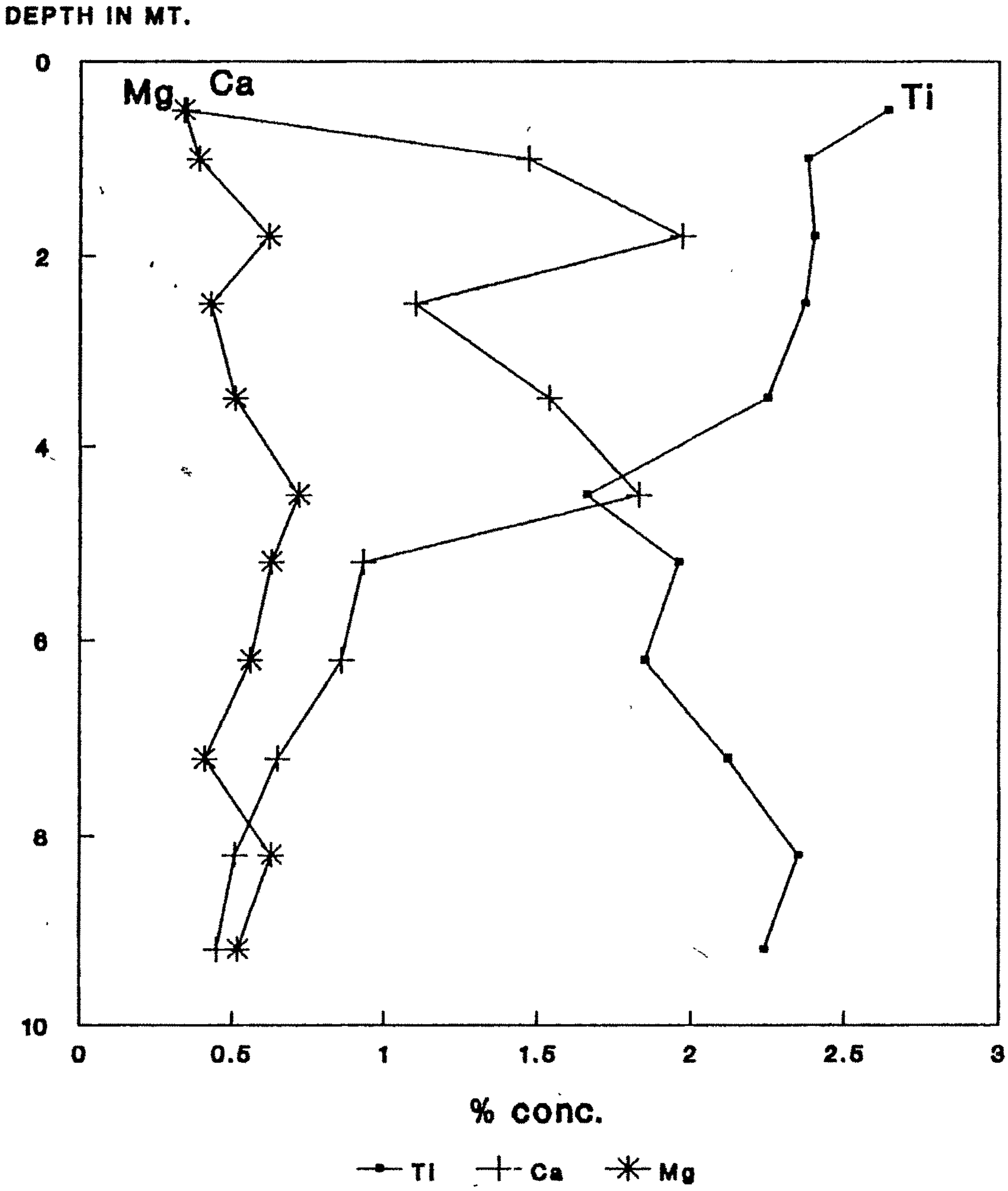


FIG: 4c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT MORCHAND

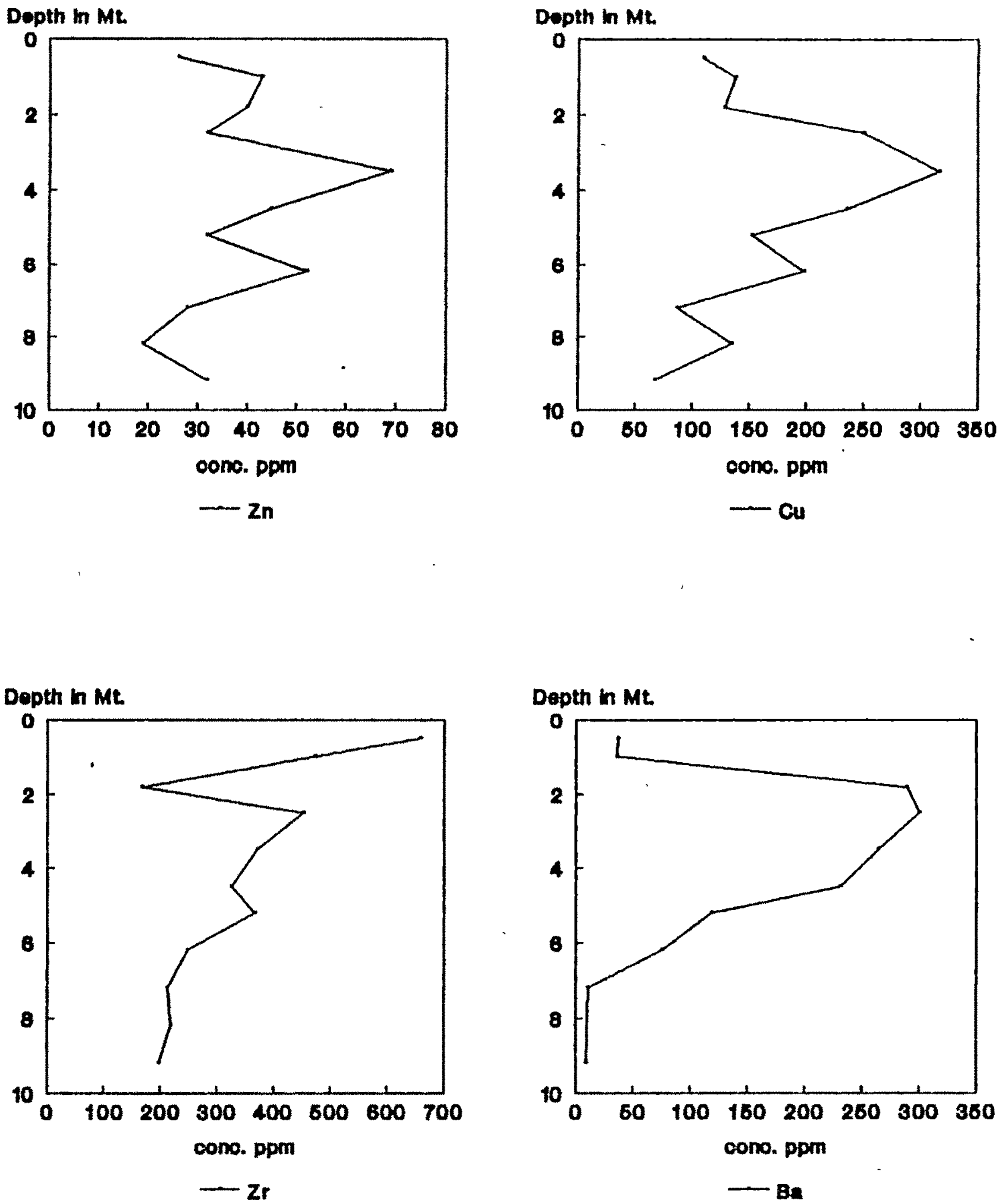
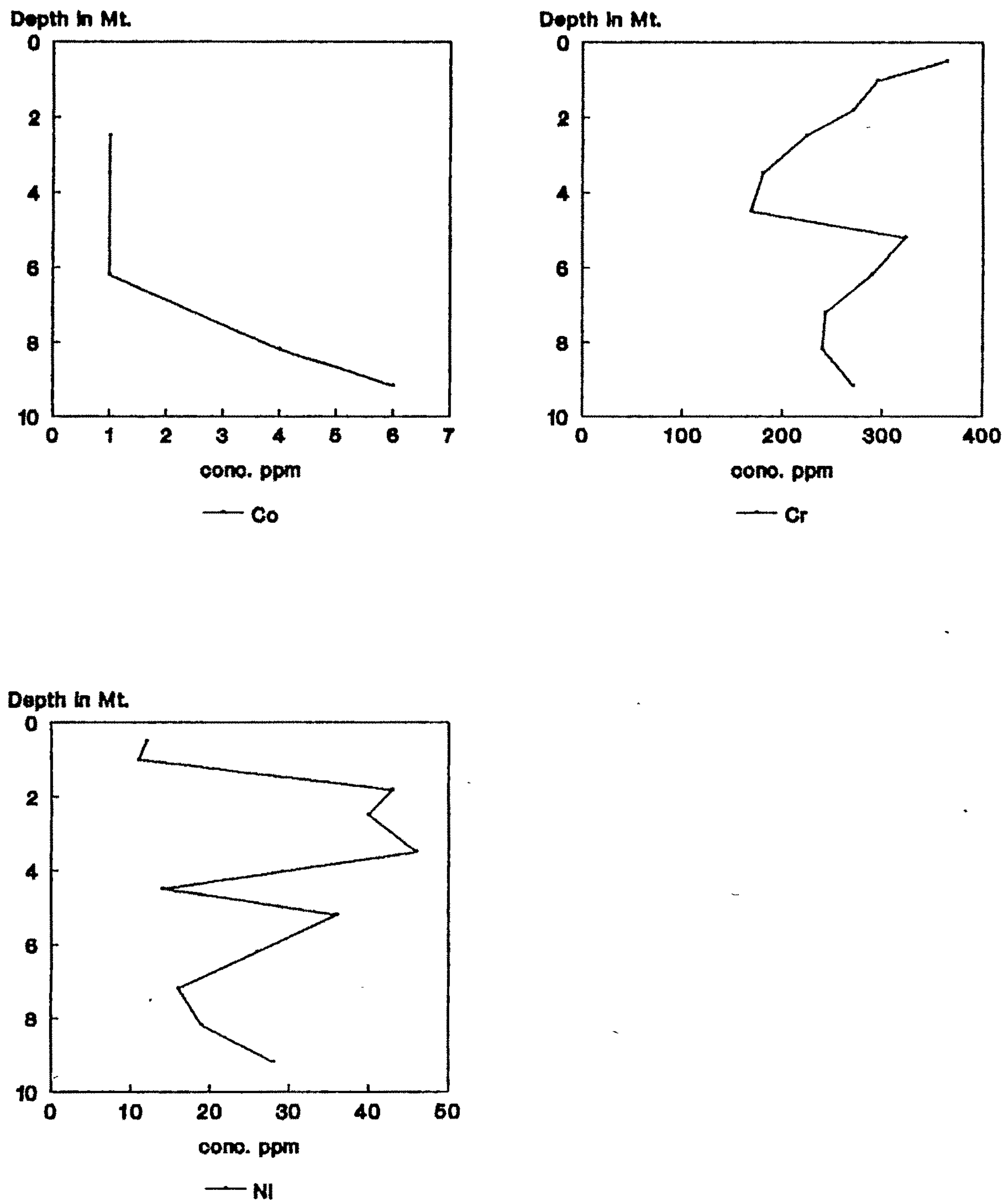


FIG: 4d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT MORCHAND



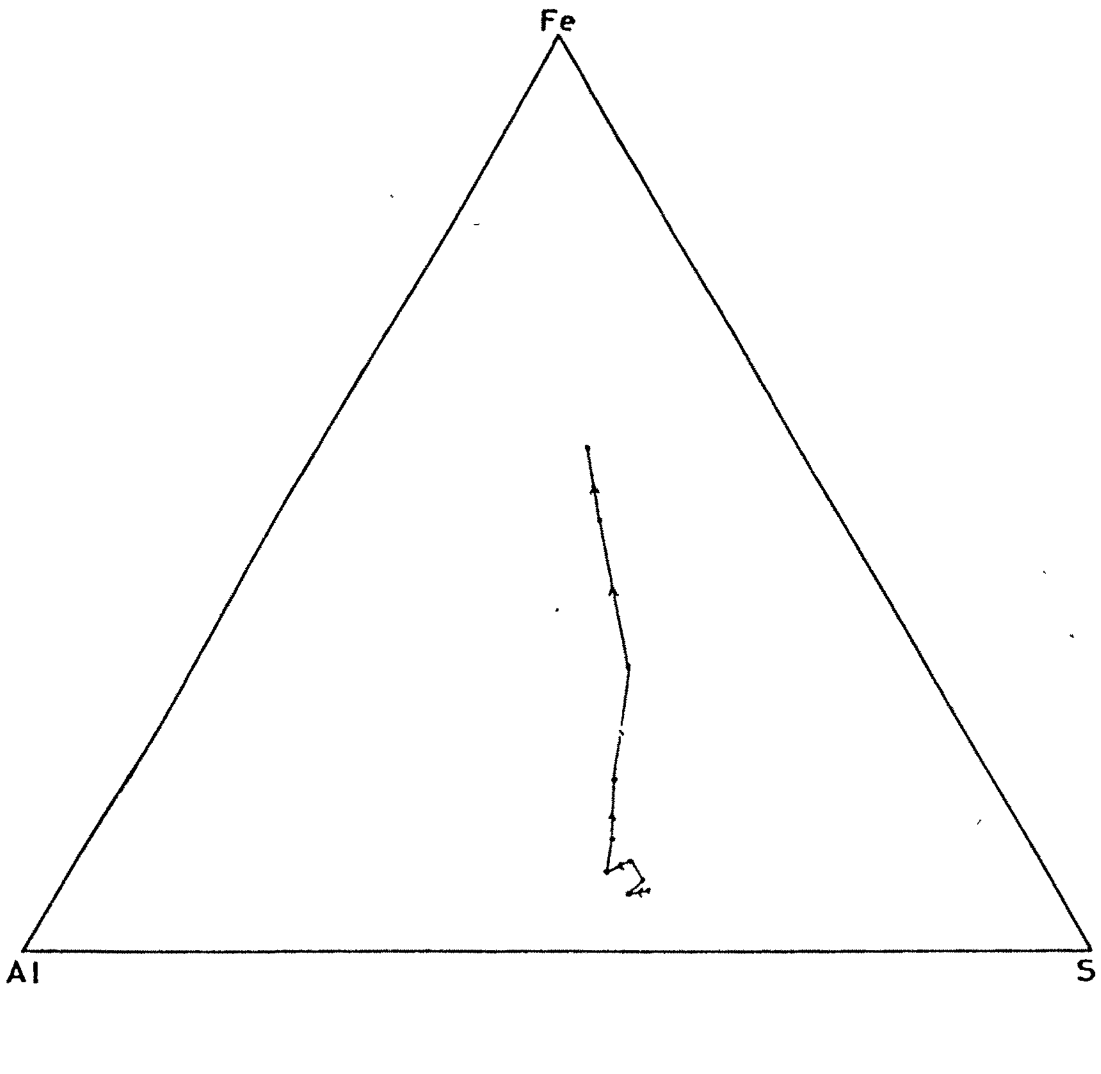


Fig 5 : TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT **MORCHAND**

FIG-6

X-RAY DIFFRACTION TRACES OF VARIOUS HORIZONS OF LATERITE PROFILE AT MORCHAND

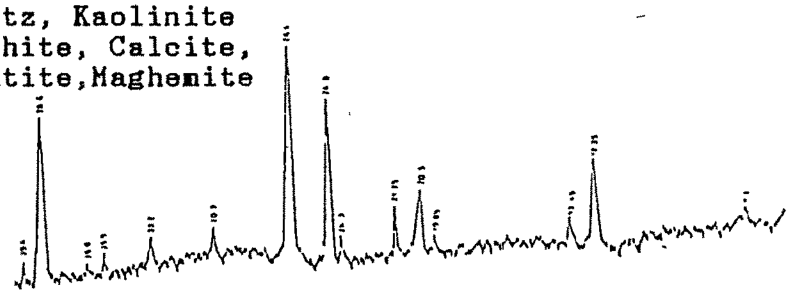
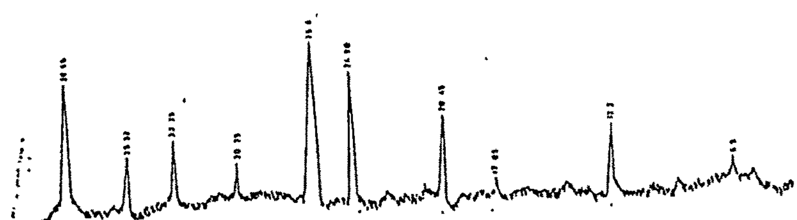
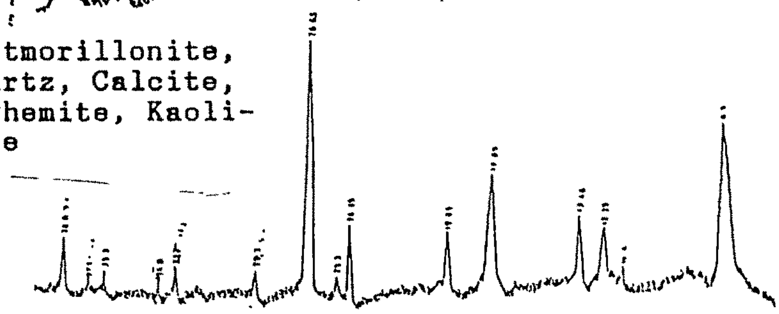
Depth in mt	Horizon	Dominating Minerals	X-ray trace
0 to 1.2m	Laterite	Hematite, Saponite, Maghemite, Kaolinite, Boehmite	
1.2 to 3.5m	Lithomarge	Quartz, Kaolinite Goethite, Calcite, Hematite,Maghemite	
3.5m	Lithomarge-Bentonite Contact	Kaolinite, Montmorillonite, Hematite, Quartz	
3.5 to 9.0m	Bentonite	Montmorillonite, Quartz, Calcite, Maghemite, Kaolinite	

TABLE-8a

X-RAY DATA OF LATERITE HORIZON AT MORCHAND

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
6.8	12.998	2.5	10.42	Saponite
7.6	11.632	3.5	14.58	Maghemite
12.35	7.1957	5.0	20.83	Kaolinite
14.30	6.1935	3.5	14.58	Boehemite
20.45	4.3532	6.0	25.00	Kaolinite
24.30	3.6627	5.0	20.83	Hematite
24.85	3.5900	7.0	29.17	Kaolinite
26.60	3.3510	10.0	41.67	Quartz
29.3	3.0460	5.0	20.83	Calcite
30.3	2.9497	14.0	58.33	Maghemite
33.2	2.6964	24.0	100.00	Hematite
35.60	2.5218	14.0	58.33	Maghemite
38.60	2.3324	6.0	25.00	Kaolinite

TABLE- 8b

X-RAY DATA OF LITHOMARGE HORIZON AT MORCHAND

20	d-Spacing	Intensity		Remarks
		Io	Io	
5.3	16.673	2.0	5.0	Calcite
12.35	7.1957	16.0	40.0	Kaolinite
13.45	6.6074	5.5	13.75	Montmorillonite
19.65	4.5281	3.0	7.5	Calcite
20.50	4.3322	11.5	28.75	Kaolinite
21.25	4.1907	9.0	22.52	Kaolinite
24.30	3.6627	4.0	10.0	Hematite
24.85	3.5900	31.0	77.5	Kaolinite
26.40	3.3759	40.0	100.0	Quartz
30.30	2.9497	5.0	12.5	Maghemite
33.20	2.6964	6.0	15.0	Hematite
35.50	2.5286	4.0	10.0	Maghemite
36.60	2.4551	2.0	5.0	Goethite
38.60	2.3324	31.0	77.5	Kaolinite
39.40	2.2869	3.0	7.5	Quartz

TABLE-8c

X-RAY DATA OF LITHOMARGE/BENTONITE CONTACT AT MORCHAND

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
6.5	13.598	3.5	11.67	Montmorillonite
12.35	7.1957	13.0	43.33	Kaolinite
17.8	4.9828	3.5	11.67	Montmorillonite
20.45	4.3532	15.50	51.67	Kaolinite
24.85	3.5800	24.5	81.67	Kaolinite
26.60	3.3510	30.0	100.0	Quartz
30.25	2.9592	7.0	23.33	Maghemite
33.2	2.6984	11.5	38.33	Hematite
35.52	2.5286	10.0	33.33	Maghemite
38.65	2.3324	22.5	75.00	Kaolinite

TABLE - 8d

X-RAY DATA OF BENTONITE HORIZON AT MORCHAND

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
6.5	13.598	28.5	60.64	Montmorillonite
11.4	7.7617	3.0	6.38	Kaolinite
12.35	7.1957	9.5	20.21	Kaolinite
13.45	6.6074	12.0	25.53	Nontronite
17.85	4.9828	21.0	44.68	Montmorillonite
19.85	4.8338	10.0	21.28	Montmorillonite
24.85	3.5900	14.0	29.79	Kaolinite
25.30	3.5201	3.5	7.45	Anatase
26.65	3.3510	47.0	100.0	Quartz
29.30	3.0480	5.0	10.64	Calcite
33.20	2.6984	5.5	11.70	Hematite
35.30	2.5425	3.5	7.45	Maghemite
37.10	2.4232	2.0	4.26	Montmorillonite
38.6	2.3324	10.0	21.28	Kaolinite

TABLE 9 : ANALYTICAL DATA OF A SECTION EXPOSED AT THALSAR.

Depth	Major elements in %							Trace elements in ppm.								
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
00 -0.5	29.32	18.13	48.68	2.65	0.34	ND	0.36	ND	30.00	141.00	688.00	ND	40.00	2.00	267.00	12.00
0.5-1.0	29.67	18.64	47.43	2.63	0.47	ND	0.41	ND	33.00	152.00	593.00	ND	32.00	1.00	184.00	15.00
1.0-1.7	39.50	26.87	29.72	2.20	0.65	ND	0.46	ND	43.00	238.00	234.00	ND	136.00	1.00	167.00	6.00
1.7-2.5	44.69	28.68	23.67	1.47	0.85	ND	0.38	ND	29.00	322.00	497.00	ND	298.00	2.00	81.00	29.00
2.5-3.2	48.17	32.91	13.79	2.51	1.64	ND	0.49	ND	49.00	176.00	440.00	ND	386.00	2.00	191.00	11.00
3.2-4.2	53.14	34.63	7.96	2.48	0.75	ND	0.67	ND	16.00	286.00	334.00	ND	106.00	1.00	221.00	17.00
4.2-5.0	49.71	36.75	8.97	2.26	0.93	ND	0.72	ND	45.00	348.00	328.00	ND	99.00	1.00	151.00	20.00
5.0-5.5	50.83	37.96	8.11	1.87	0.47	ND	0.69	ND	33.00	25.00	220.00	ND	128.00	1.00	271.00	22.00

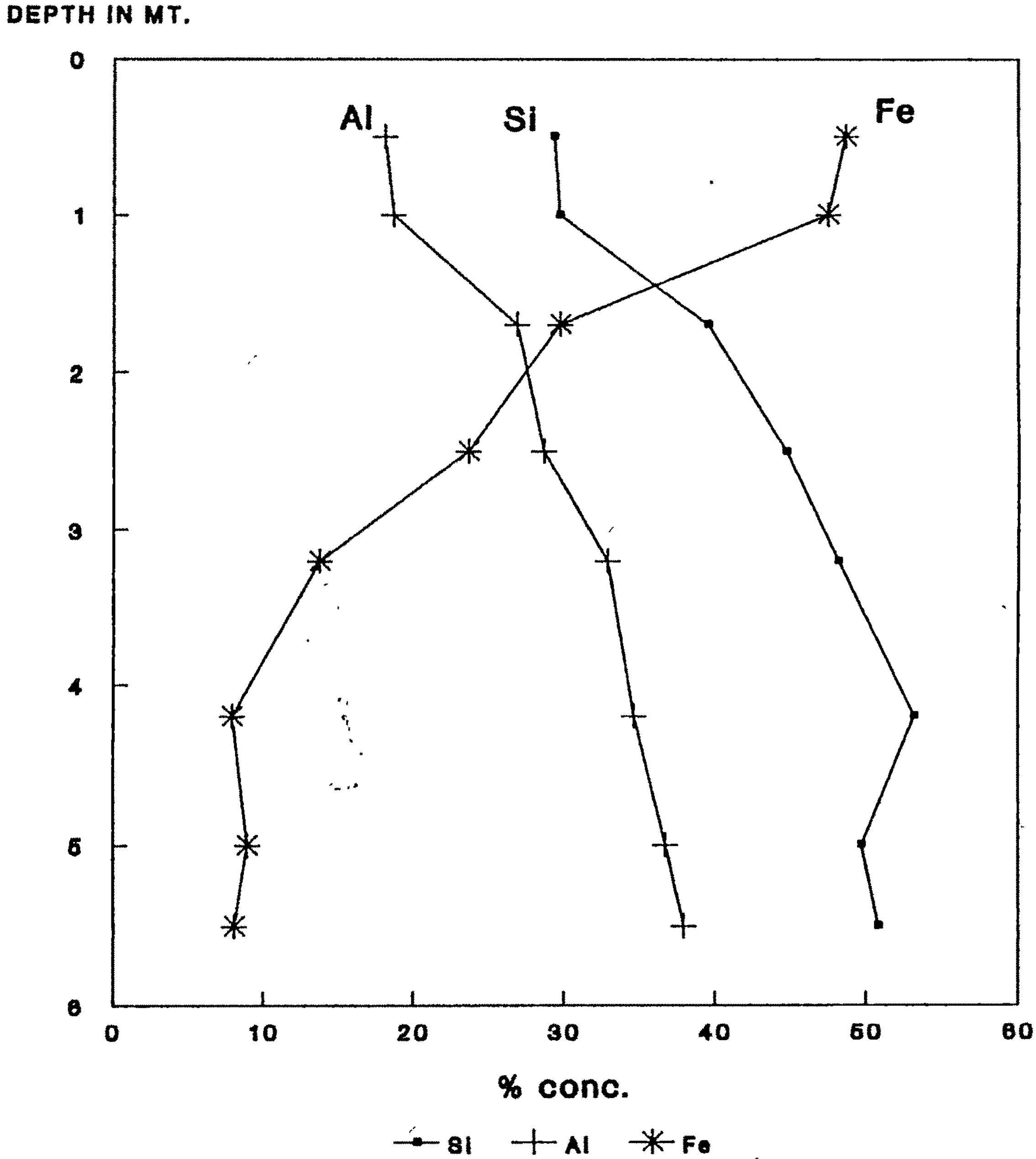
TABLE 10 : THE INCREASE/DECREASE IN % OF THE ELEMENT CONCENTRATIONS WITHIN THE PROFILE AT THALSAR COMPARED TO THE AVERAGE COMPOSITION OF THE PARENT ROCK.

Depth in M.	Element	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
	Avg.Comp. in parent rock	54.45	24.74	10.18	2.07	0.96	1.065	4.88	T	37.5	118	308	ND	62.5	2	254	33
0-0.5		-46	-27	+378	+28	-64	ND	-92	ND	-20	+19	+123	T	-36	0	+5	-63
0.5-1.0		-45	-24	+366	+27	-51	ND	-91	ND	-12	+28	+92	T	-49	-50	-27	-54
1.0-1.7		-27	+8	+192	+6	-32	ND	-90	ND	-14	+101	-24	T	+117	-50	-34	-81
1.7-2.5		-18	+16	+132	-29	+11	ND	-92	ND	-22	+173	+61	ND	+376	0	-68	-12
2.5-3.2		-11	+33	+35	+21	+70	ND	-90	ND	+30	+49	+43	ND	-517	0	-24	-66
3.2-4.2		-2	+40	-22	+20	-21	ND	-86	ND	-57	+142	+8	ND	-69	-50	-13	-48
4.2-5.0		-9	+8	-12	+9	-3	ND	-85	ND	+20	+195	+6	ND	-58	-50	-40	-39
5.0-5.5		-6	+53	-20	-9	-51	ND	-86	ND	-12	-78	-28	ND	-105	-50	+7	-33

ND : Not Determined
T : Trace

FIG: 7a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT THALSAR



F I G : 7b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Ca, Mg AT THALSAR

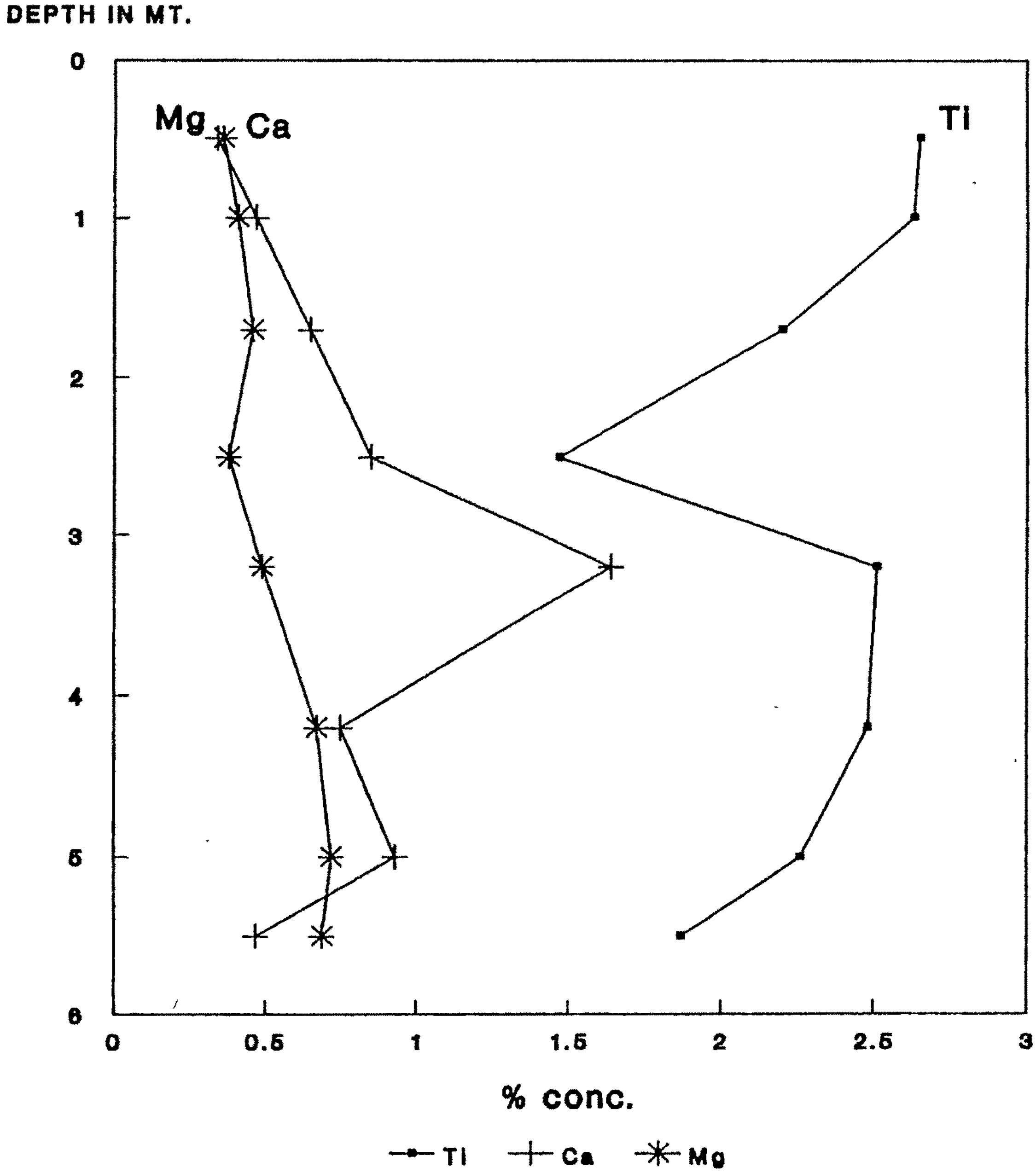


FIG : 7c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT THALSAR

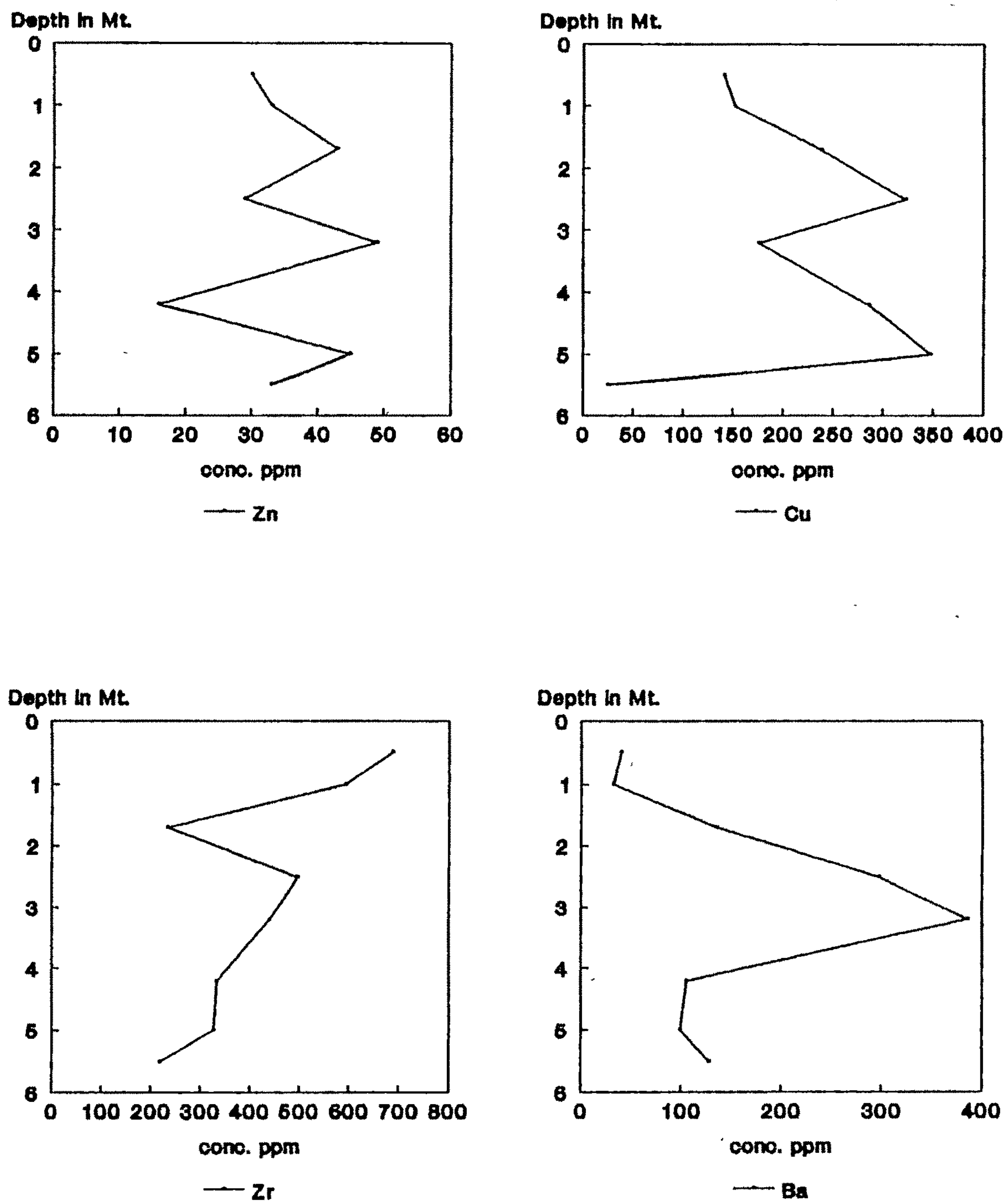
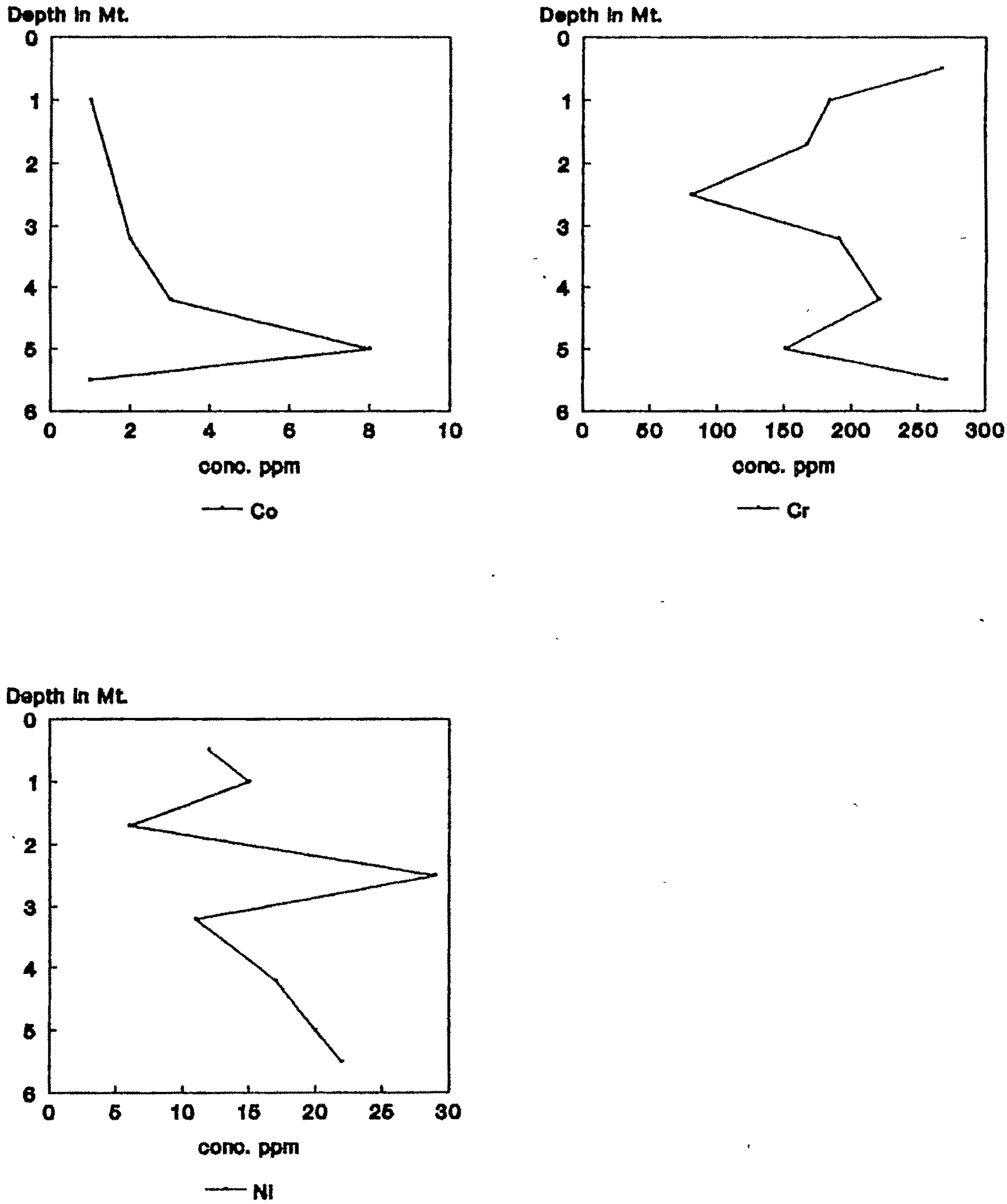


FIG : 7d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT THALSAR



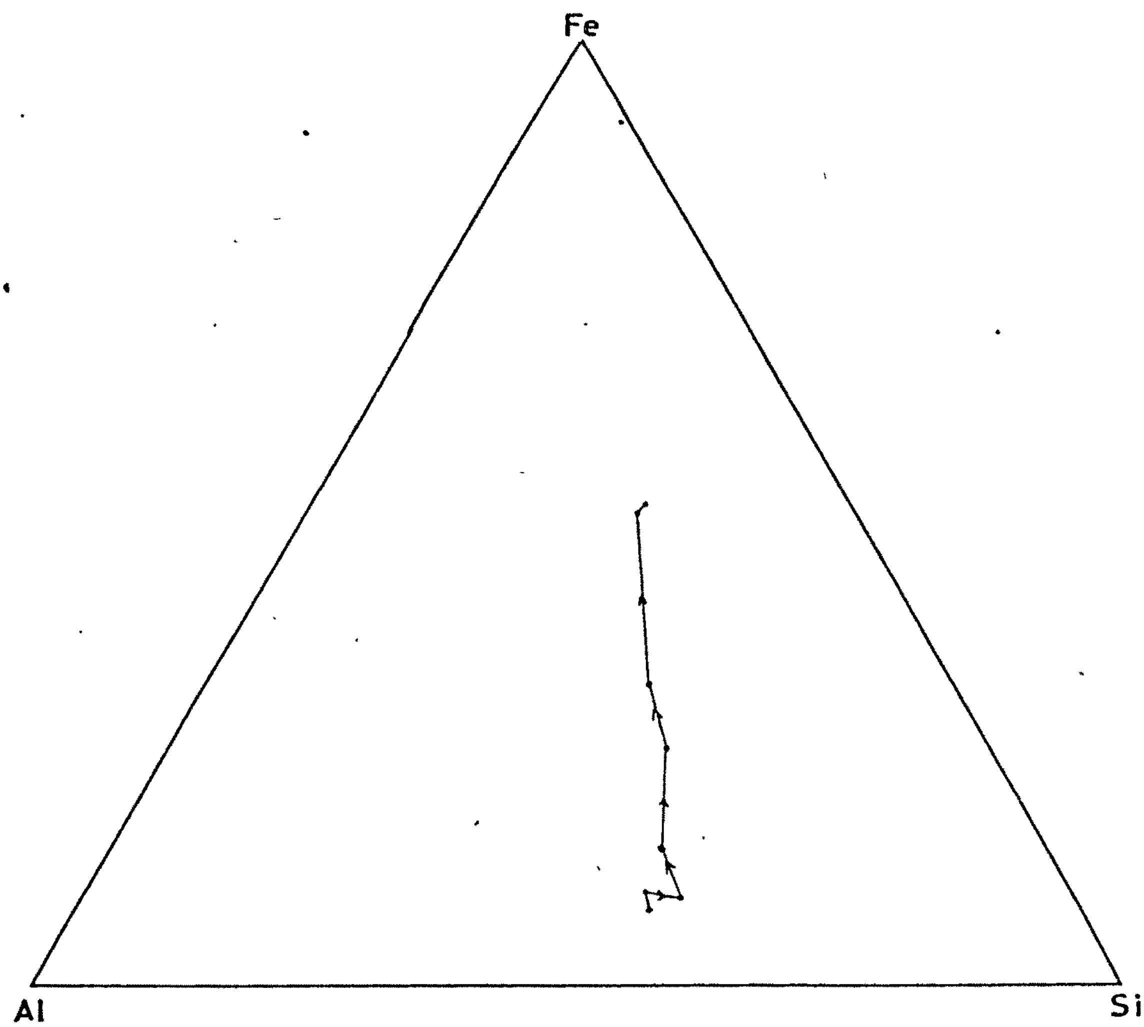


Fig 8 : TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT THALSAR

TABLE 11 : ANALYTICAL DATA OF A SECTION EXPOSED AT ALANG.

Depth	Major elements in %							Trace elements in ppm.								
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
00 -0.5	29.26	17.18	49.69	2.98	0.31	ND	0.31	ND	39.00	129.00	704.00	ND	36.00	7.00	199.00	9.00
0.5-1.2	37.95	19.16	38.51	2.96	0.67	ND	0.16	ND	48.00	231.00	627.00	ND	46.00	6.00	324.00	13.00
1.2-2.0	46.78	28.34	20.03	2.62	1.12	ND	0.85	ND	31.00	66.00	585.00	ND	218.00	6.00	308.00	17.00
2.0-2.5	48.15	29.83	17.11	2.55	0.85	ND	0.95	ND	45.00	131.00	495.00	ND	247.00	8.00	306.00	31.00
2.5-3.0	51.24	30.16	14.63	2.36	0.38	ND	0.86	ND	12.00	276.00	380.00	ND	88.00	7.00	268.00	22.00
3.0-3.8	52.04	33.71	10.16	1.85	0.71	ND	0.91	ND	9.00	172.00	230.00	ND	31.00	6.00	196.00	14.00
3.8-4.3	53.76	33.65	8.15	2.39	1.92	ND	0.65	ND	27.00	131.00	192.00	ND	27.00	8.00	248.00	11.00
4.3-4.8	52.80	36.71	7.04	2.35	0.41	ND	0.36	ND	26.00	108.00	538.00	ND	46.00	6.00	266.00	10.00

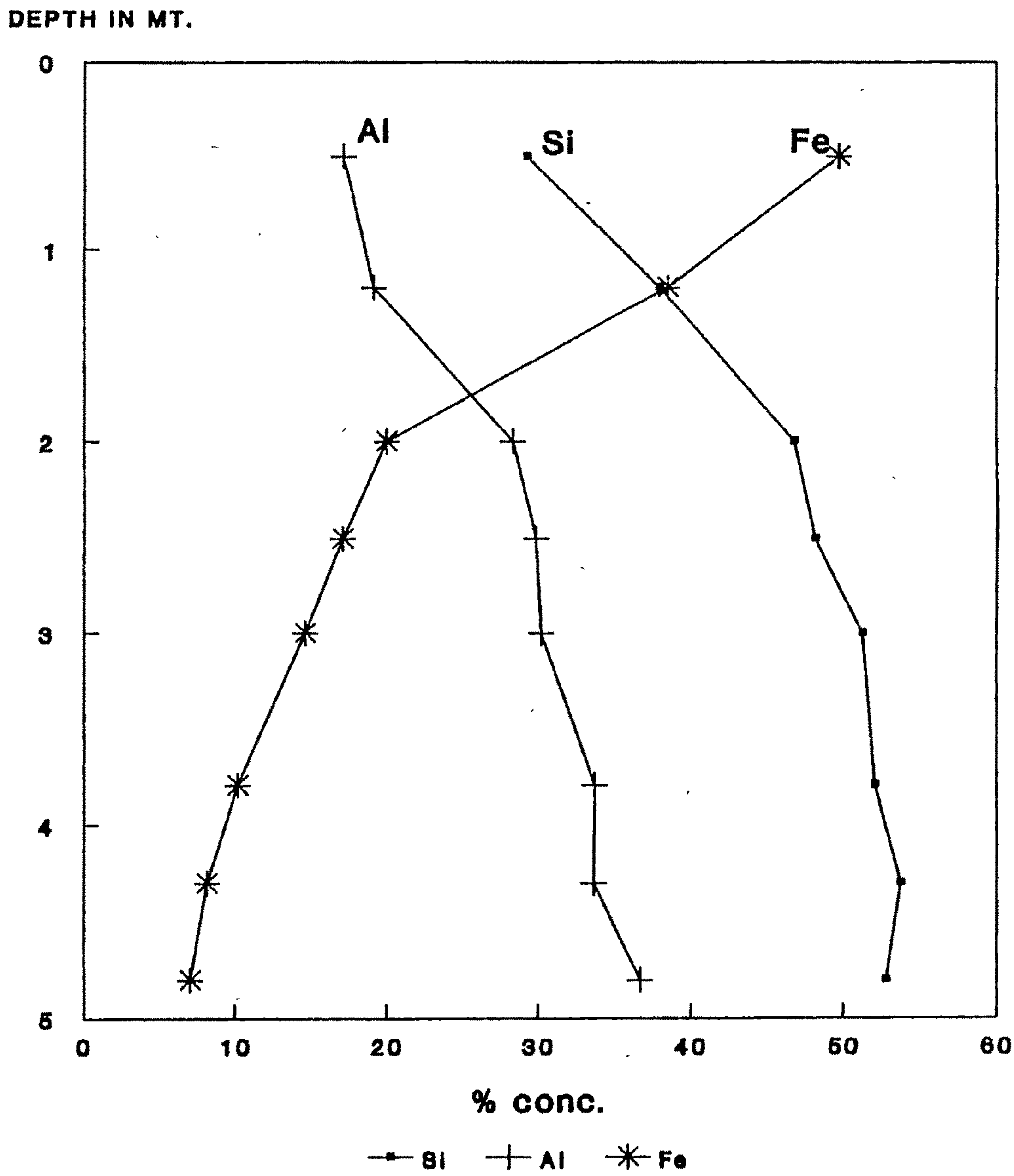
TABLE 12 : THE INCREASE/DECREASE IN % OF THE ELEMENT CONCENTRATIONS WITHIN THE PROFILE AT ALANG COMPARED TO THE AVERAGE COMPOSITION OF THE PARENT ROCK.

Depth in M.	ELEMENTS	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
	Avg.Comp.in parent rock	54.45	24.74	10.18	2.07	0.96	1.065	4.88	T	37.5	118	308	ND	62.5	2	254	33
00 -0.5		-46	-30	+388	+44	-67	ND	-93	T	+4	+9	+128	ND	-42	+250	-21	-72
0.5-1.2		-30	-22	+278	+43	-30	ND	-96	T	+28	+95	+103	ND	-26	+200	+27	-60
1.2-2.0		-14	+14	+96	+26	+16	ND	-82	T	-17	-44	+90	ND	+248	+200	+21	-48
2.0-2.5		-11	+20	+68	+23	-11	ND	-80	T	+20	-11	+60	ND	+295	+300	+20	-6
2.5-3.0		-6	+22	+43	+14	-60	ND	-82	T	-68	+133	+23	ND	+41	+250	+5	-33
3.0-3.8		-4	+36	-0.2	-10	-26	ND	-81	T	-76	+45	-25	ND	-50	+200	-23	-57
3.8-4.3		-1	+36	-20	+15	+6	ND	-86	T	-28	+11	-37	ND	-56	+300	-2	-66
4.3-4.8		-3	+48	-31	+13	-57	ND	-92	T	-30	-8	+74	ND	-26	+200	+5	-69

ND : Not Determined
T : Trace

FIG : 9a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT ALANG



9

FIG : 9b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Ca, Mg AT ALANG

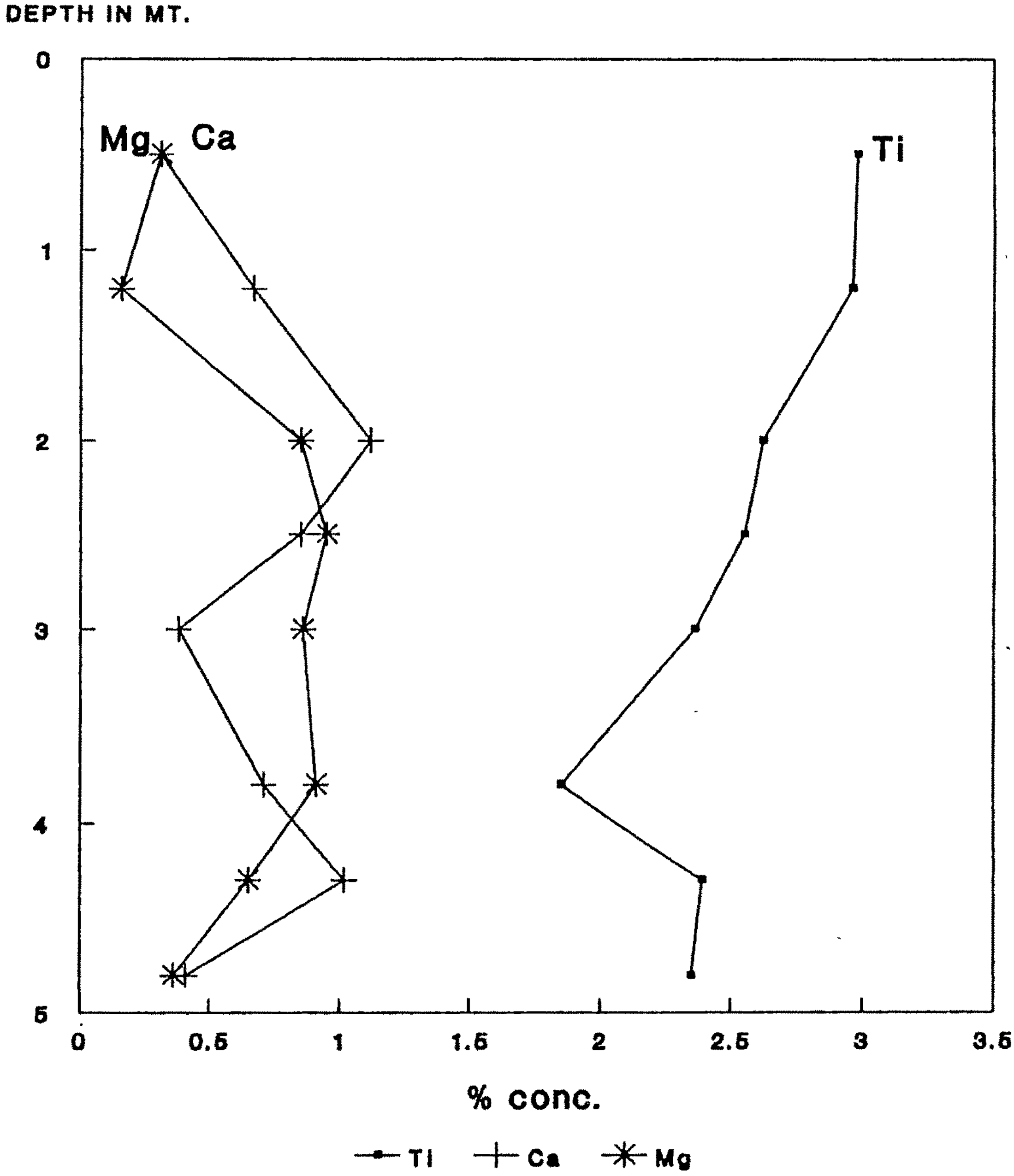


FIG: 9c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT ALANG

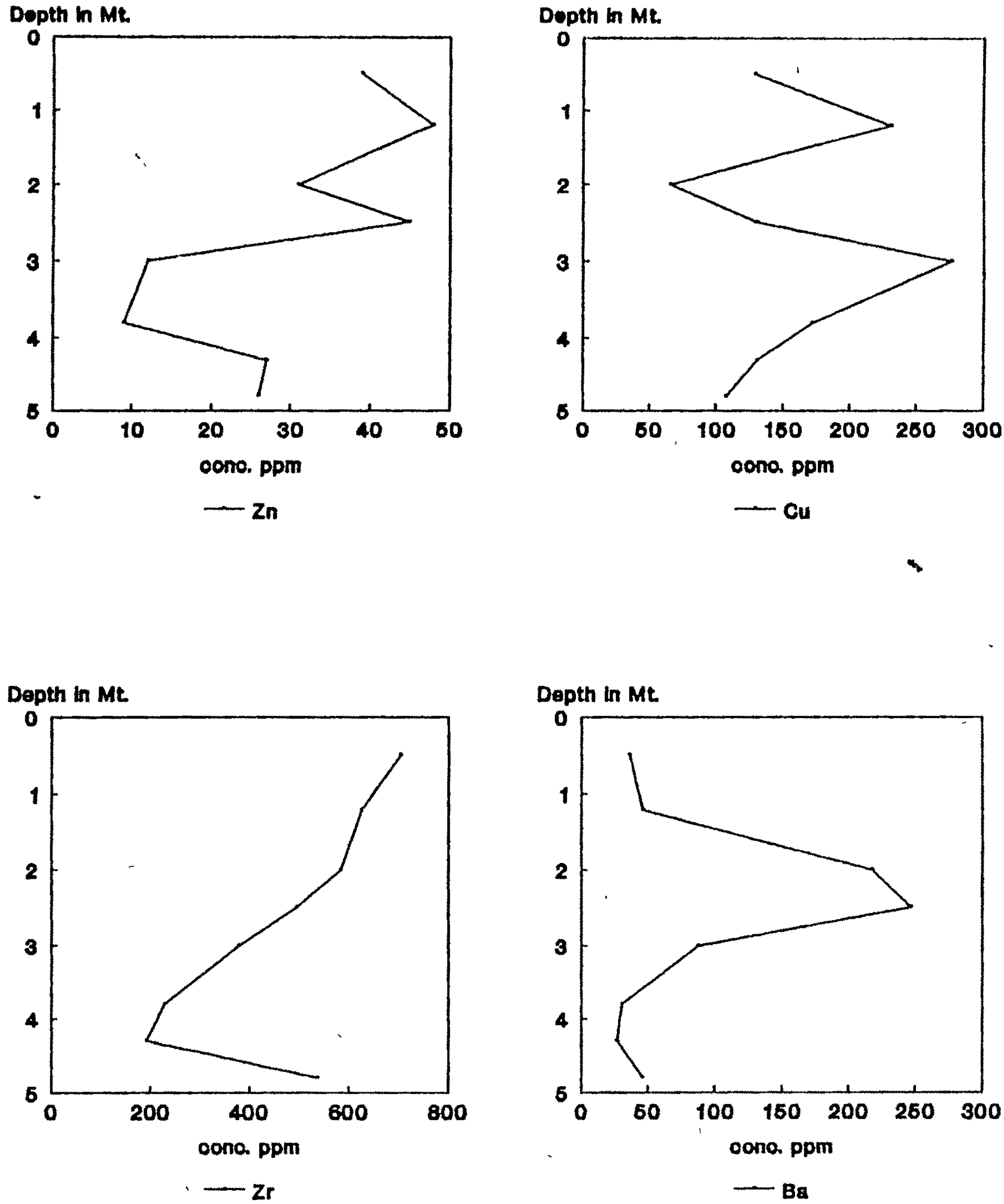
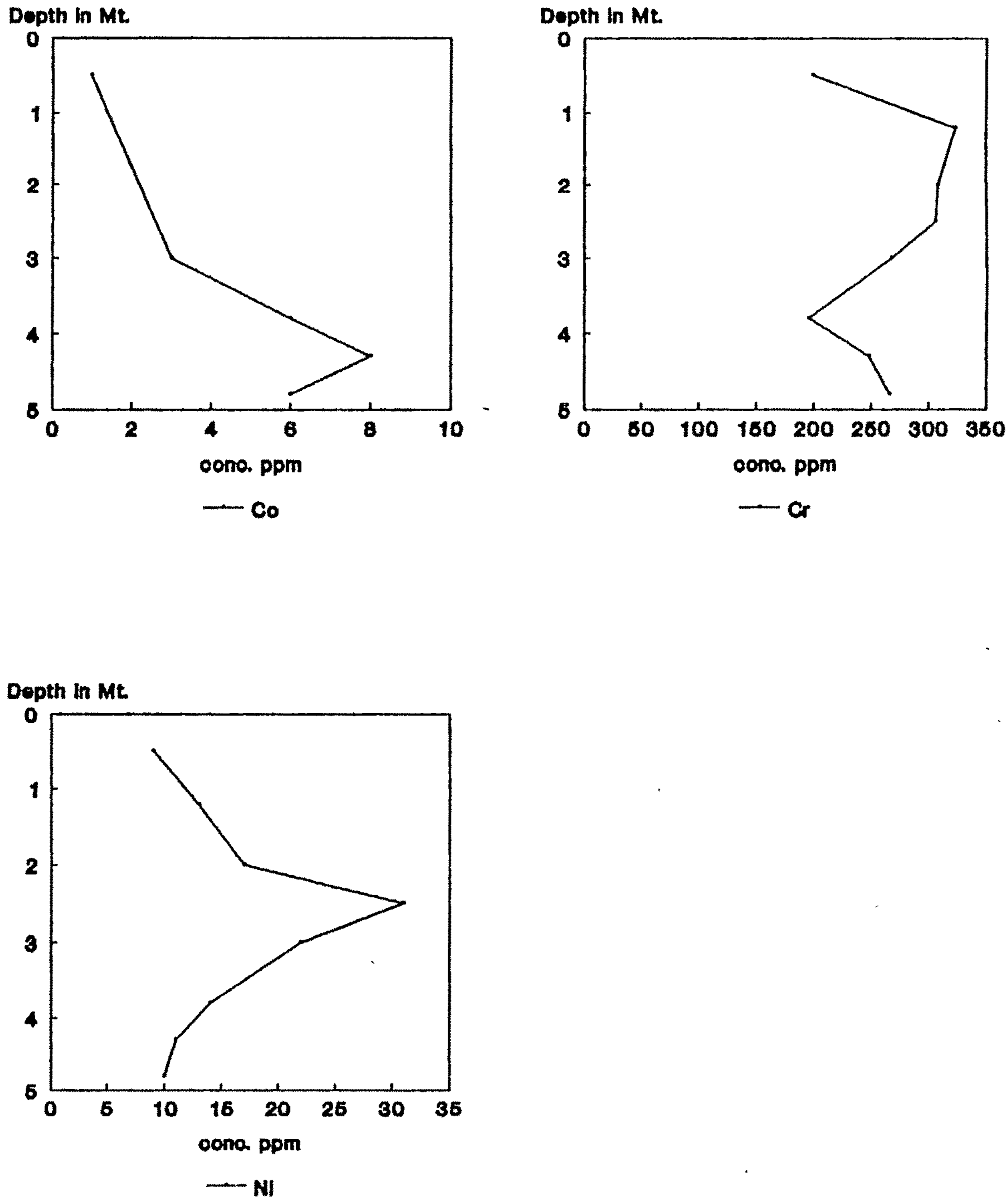


FIG: 9d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT ALANG



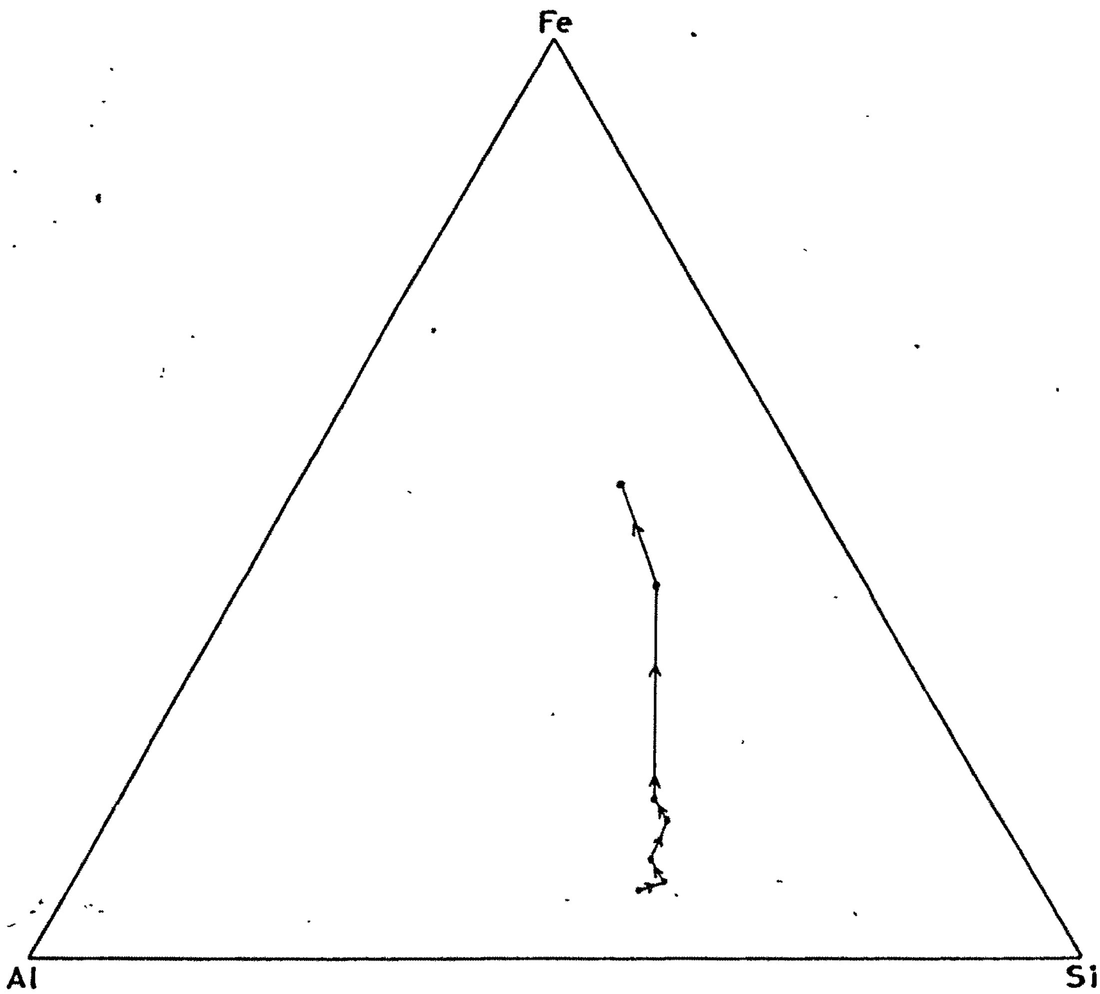


Fig 10: TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT ALANG

TABLE 13 : ANALYTICAL DATA OF A SECTION EXPOSED AT DEVALIYA.

Depth	Major elements in %								Trace elements in ppm.							
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
00 -0.5	28.07	17.73	49.13	3.41	0.48	ND	0.29	ND	26.00	96.00	689.00	ND	37.00	2.00	170.00	9.00
0.5-1.0	39.50	29.09	27.36	2.37	0.63	ND	0.53	ND	42.00	126.00	444.00	ND	62.00	2.00	223.00	10.00
1.0-1.8	46.00	33.68	15.63	1.94	0.72	ND	1.32	ND	36.00	138.00	211.00	ND	132.00	4.00	249.00	28.00
1.8-2.5	49.32	32.37	13.85	2.11	0.68	ND	0.71	ND	91.00	96.00	379.00	ND	151.00	1.00	183.00	42.00
2.5-3.5	52.67	33.96	8.67	2.67	0.83	ND	0.68	ND	18.00	112.00	368.00	ND	86.00	3.00	170.00	29.00
3.5-4.5	53.45	31.63	9.95	2.08	1.21	ND	0.70	ND	9.00	136.00	315.00	ND	76.00	4.00	249.00	36.00
4.5-5.5	51.22	37.71	7.54	1.87	0.69	ND	0.66	ND	15.00	89.00	326.00	ND	38.00	ND	262.00	24.00

TABLE 14 : THE INCREASE/DECREASE IN % OF THE ELEMENT CONCENTRATIONS WITHIN THE PROFILE AT DEVALIYA COMPARED TO THE AVERAGE COMPOSITION OF THE EXPOSED PARENT ROCK.

Depth in M.	ELEMENTS	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
	Comp. in parent rock	54.45	24.74	10.18	2.07	0.96	1.065	4.88	T	37.5	118	308	ND	62.5	2	254	33
0-0.5		-48	-28	+382	+64	-50	ND	-94	ND	-30	-18	+222	ND	-41	0	-32	-72
0.5-1.0		-27	+17	+168	+14	-34	ND	-89	ND	+12	+6	+44	ND	-0.8	0	+12	-69
1.0-1.8		-15	+36	+53	-6	-25	ND	-73	ND	-4	+17	+30	ND	+111	+100	-2	-15
1.8-2.5		-9	+31	+36	+2	-29	ND	-85	ND	+142	-18	+84	ND	+141	-50	-28	+27
2.5-3.5		-3	+37	-15	+28	-13	ND	-86	ND	-52	-5	+81	ND	+38	+50	-33	-12
3.5-4.5		-2	+27	-2.25	+0.5	+26	ND	-85	ND	-76	+15	+64	ND	+21	+100	-2	+9
4.5-5.5		-6	+52	-26	-9	-28	ND	-86	ND	-60	-24	+67	ND	-39	ND	+3	-27

ND : Not Determined

T : Trace

FIG : 11 a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT DEVALIYA

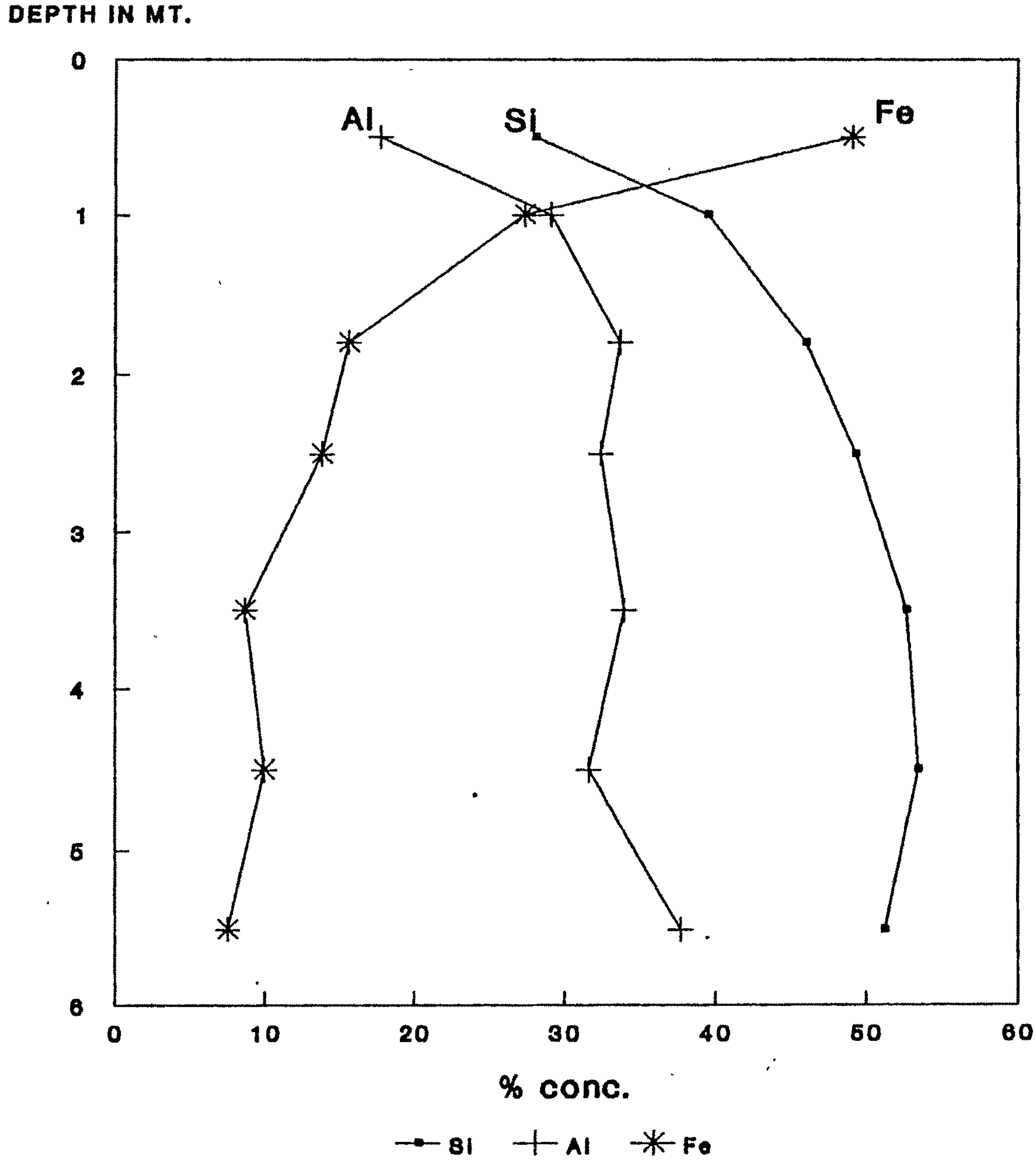


FIG: 11b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Ca, Mg AT DEVALIYA

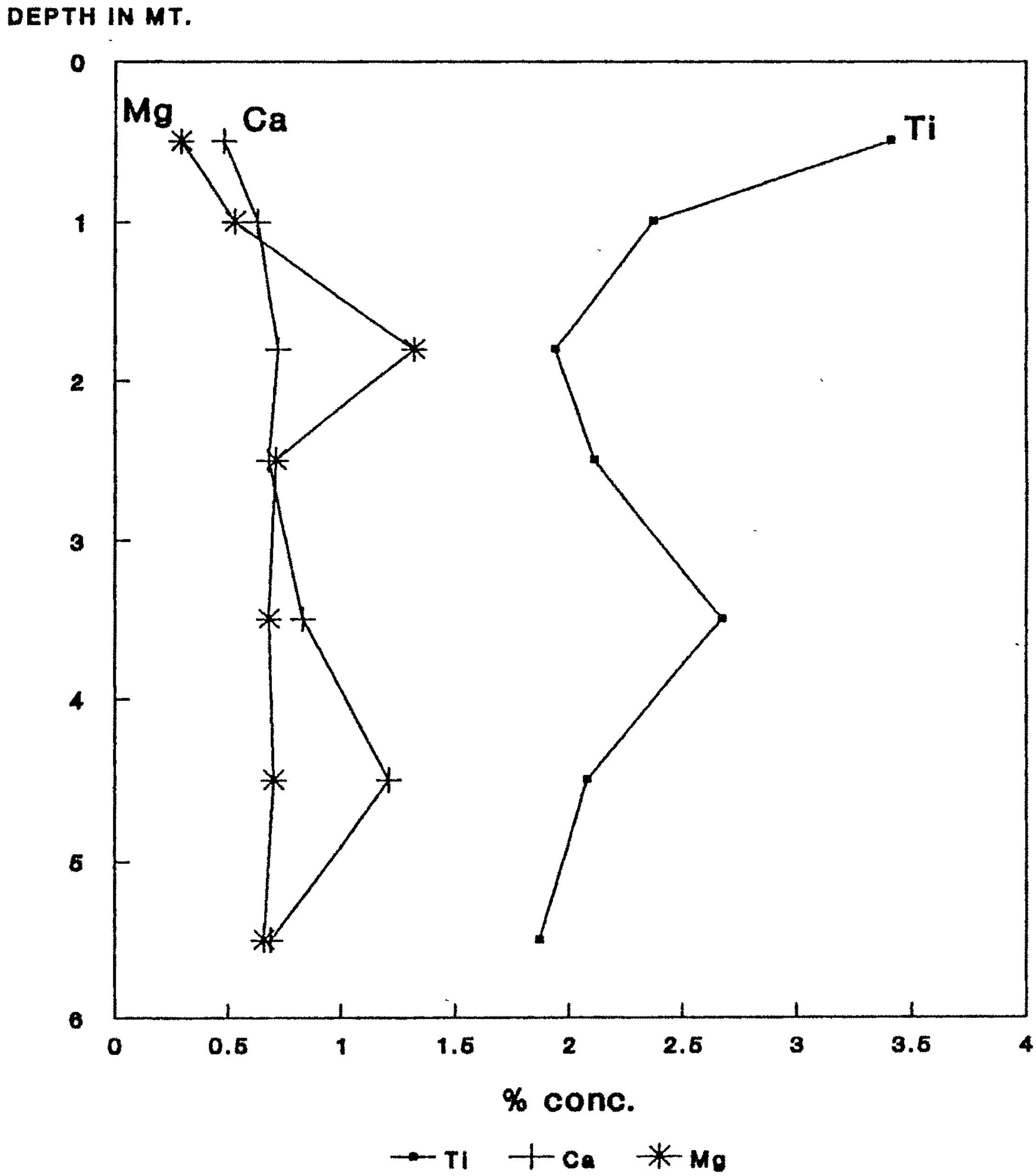


FIG:11c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT DEVALIYA

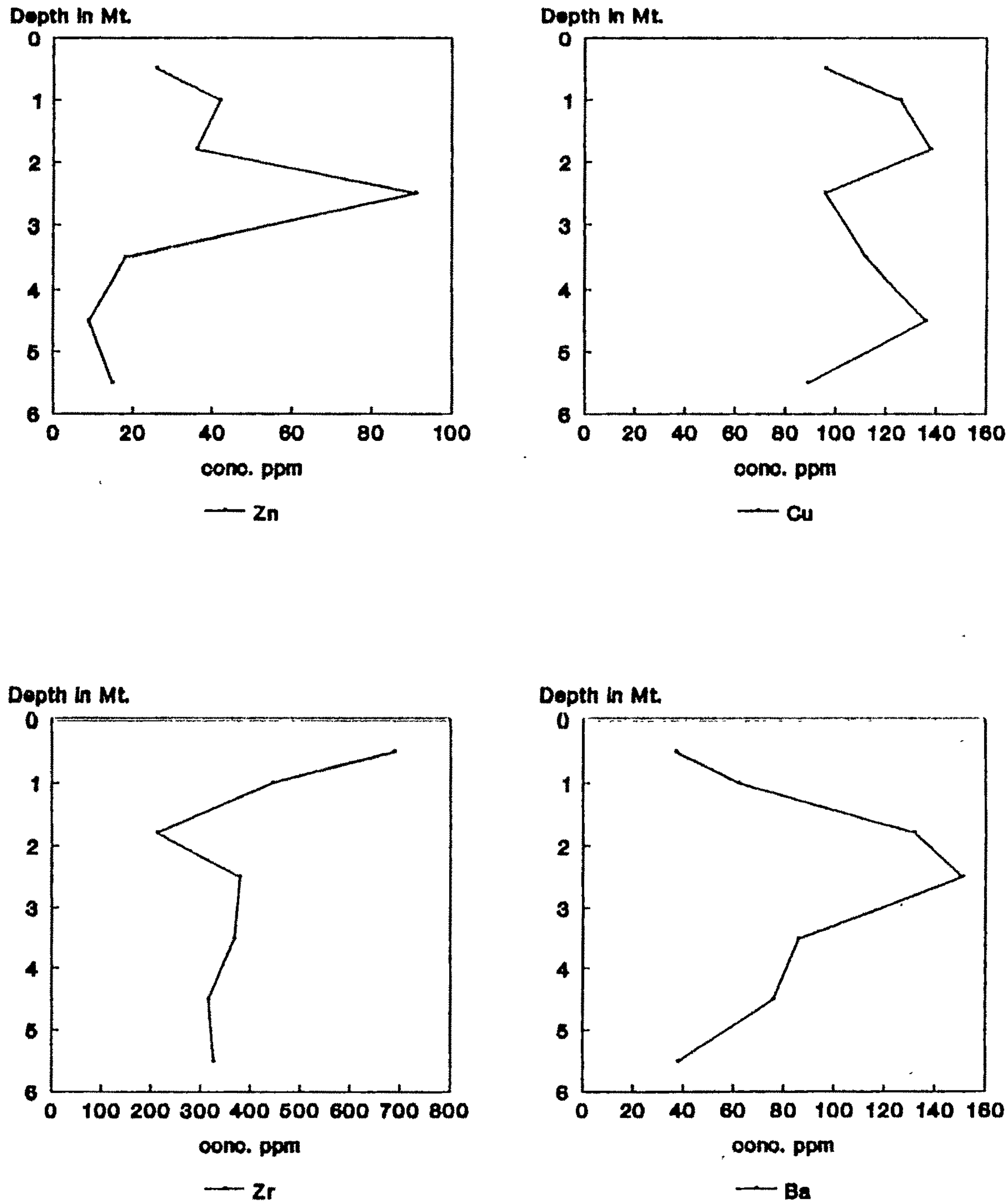
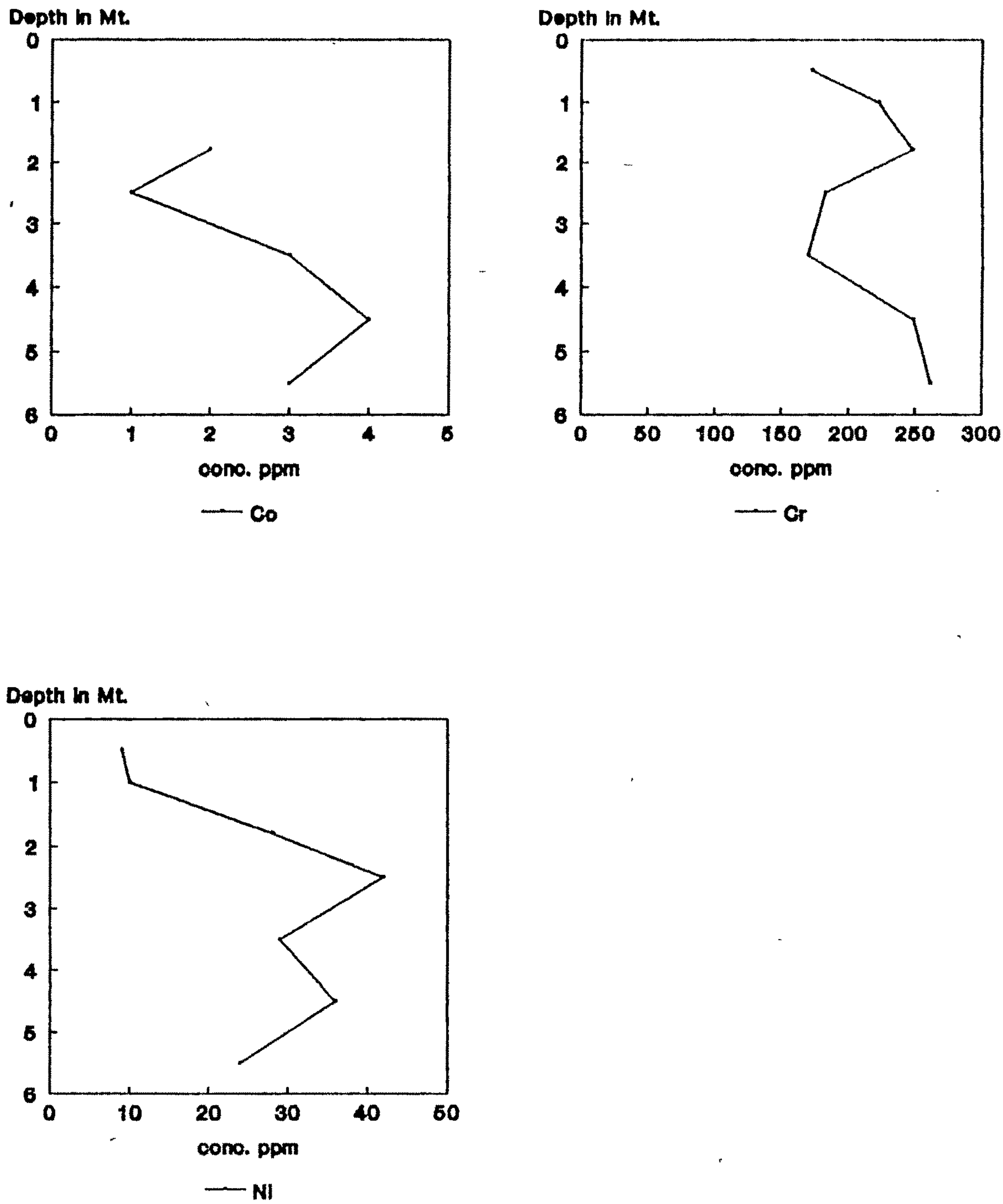


FIG:11d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT DEVALIYA



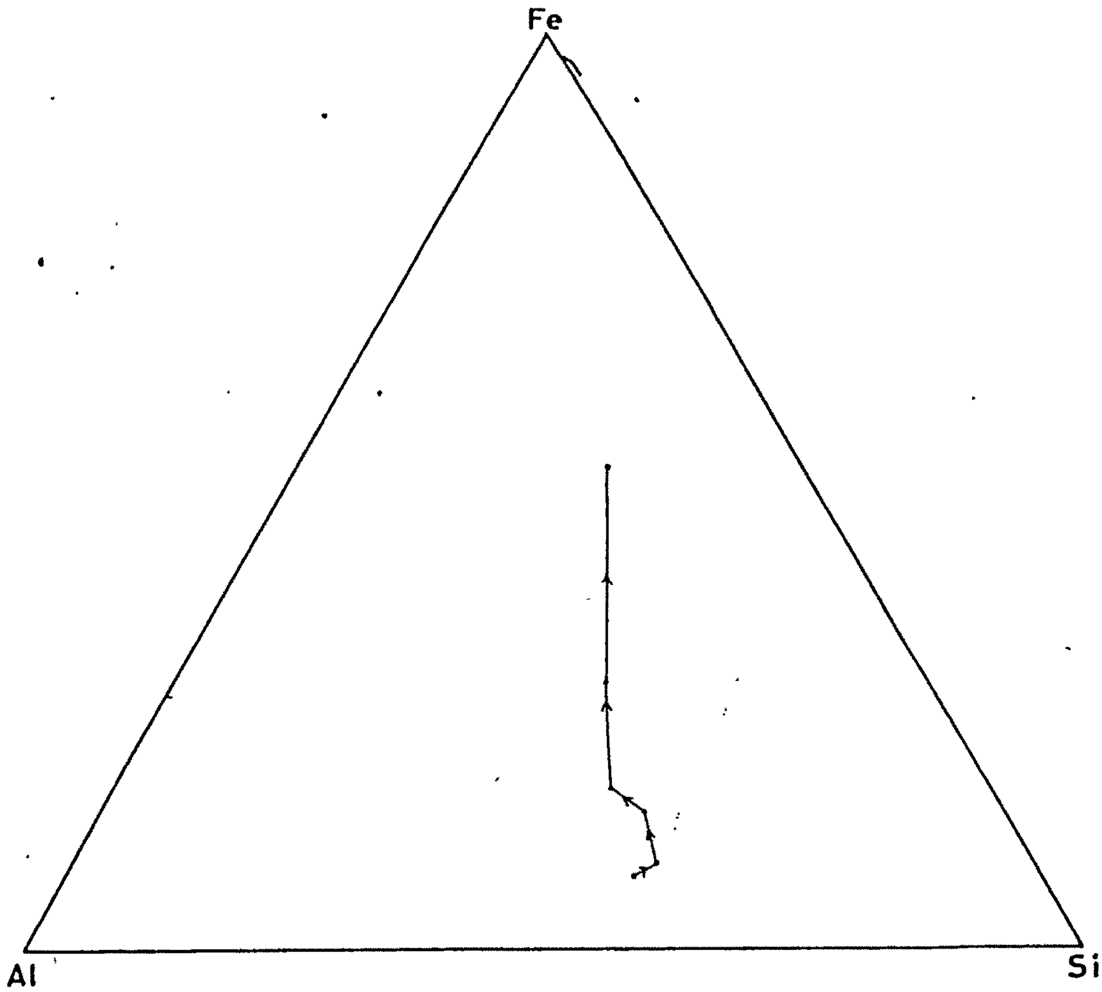


Fig 12 : TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT DEVALIYA

FIG-13

X-RAY DIFFRACTION TRACES OF VARIOUS HORIZONS OF LATERITE PROFILE AT DEVALIYA

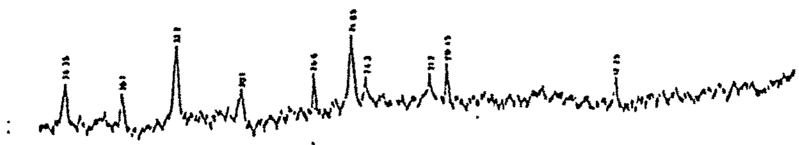
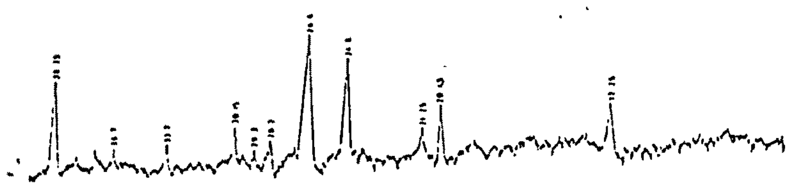
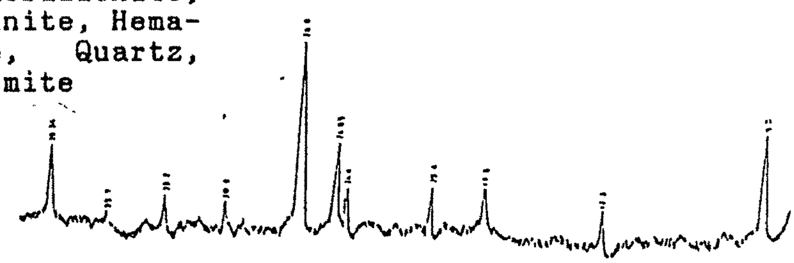
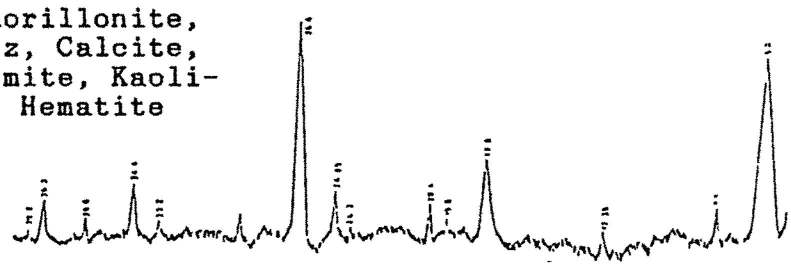
Depth in mt	Horizon	Dominating Minerals	X-ray trace
0 to 0.8m	Laterite	Hematite, Goethite, Quartz, Kaolinite,	
0.8 to 1.5m	Lithomarge	Quartz, Kaolinite Goethite, Calcite, Hematite,Maghemite	
1.5 to 4.5m	Bentonite	Montmorillonite, Kaolinite, Hema-atite, Quartz, Maghemite	
4.5 to 6.5m	Bentonite	Montmorillonite, Quartz, Calcite, Maghemite, Kaoli-nite, Hematite	

TABLE-15a

X-RAY DATA OF LATERITE HORIZON AT DEVALIYA

20	d-Spacing	Intensity		Remarks
		Io	Ic	
12.25	7.1957	6.6	44.00	Kaolinite
20.45	4.3532	7.1	47.33	Kaolinite
21.2	4.1907	5.5	36.67	Goethite
24.3	3.6627	5.1	34.0	Hematite
24.85	3.5900	14.0	93.33	Kaolinite
26.60	3.3510	8.0	53.33	Quartz
30.1	2.9666	6.6	44.00	Hematite
33.2	2.6984	15.0	100.0	Hematite
36.7	2.4467	7.0	46.67	Hematite
36.6	2.4551	3.1	20.67	Goethite
38.34	2.3500	8.0	53.33	Kaolinite

TABLE - 15b

X-RAY DATA OF LITHOMARGE HORIZON AT DEVALIYA

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
12.35	7.1957	9.6	42.67	Kaolinite
20.45	4.3532	10.2	45.33	Kaolinite
21.25	4.1907	6.0	26.67	Goethite
24.8	3.5900	19.0	84.49	Kaolinite
26.6	3.3510	22.5	100.0	Quartz
28.3	3.1534	6.0	26.67	Kaolinite
29.3	3.0480	3.0	13.33	Calcite
30.15	2.9688	6.6	29.33	Maghemite
33.2	2.6984	5.0	22.22	Goethite
36.7	2.4487	4.0	17.78	Hematite
36.6	2.4551	4.0	17.78	Goethite
37.7	2.3860	2.8	12.44	Anatase
38.34	2.3500	17.	77.78	Kaolinite

TABLE-15c

X-RAY DATA OF BENTONITE HORIZON AT DEVALIYA

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
5.0	17.673	20	52.63	Montmorillonite
12.35	7.1957	8.5	22.38	Kaolinite
17.8	4.9828	8.5	22.36	Montmorillonite
20.4	4.3532	9.5	25.0	Kaolinite
24.4	3.6479	9.0	23.68	Hematite
24.85	3.5900	17.0	44.73	Kaolinite
26.6	3.3510	38.0	100.0	Quartz
29.3	3.0480	2.5	6.57	Calcite
30.8	2.9029	6.0	15.78	Maghemite
33.2	2.6984	7.0	18.42	Goethite
35.7	2.5149	3.0	7.89	Hematite
38.34	2.3500	14.0	36.84	Kaolinite

TABLE -15d

X-RAY DATA OF BENTONITE HORIZON AT DEVALIYA

2θ	d-Spacing	Intensity Io	Intensity Ic	Remarks
5.0	17.673	20	52.63	Montmorillonite
7.1	12.450	7	16.27	Illite
12.35	7.1957	5.2	12.09	Kaolinite
17.8	4.9828	16.0	37.20	Montmorillonite
19.6	4.5291	3.5	8.13	Sapnite
20.4	4.3532	7.4	17.20	Kaolinite
24.3	3.6624	2.5	5.81	Hematite
24.85	3.5900	10.0	23.25	Kaolinite
26.60	3.3510	43.0	100.0	Quartz
29.3	3.0480	6.0	13.95	Calcite
33.2	2.6984	4.0	9.30	Goethite
36.6	2.4551	4.5	10.46	Goethite
38.3	2.3500	8.0	18.60	Kaolinite
39.2	2.2981	2.5	5.81	Calcite

TABLE 16 : ANALYTICAL DATA OF A SECTION EXPOSED AT BADI.

Depth	Major elements in %							Trace elements in ppm.							
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
00 -1.0	36.96	23.73	35.08	2.78	1.35	ND	0.12	ND	32.00	89.00	496.00	ND	22.00	7.00	390.00	14.00
1.0-2.0	43.03	23.37	28.40	2.58	1.88	ND	0.72	ND	30.00	94.00	430.00	ND	42.00	9.00	380.00	15.00
2.0-2.8	47.77	25.05	22.01	2.14	2.26	ND	0.74	ND	36.00	103.00	380.00	ND	88.00	ND	360.00	17.00
2.8-3.5	50.13	24.95	19.16	2.32	2.12	ND	0.75	ND	38.00	216.00	321.00	ND	156.00	ND	326.00	20.00
3.5-4.3	51.66	25.33	17.58	2.52	1.97	ND	0.91	ND	37.00	216.00	360.00	ND	202.00	ND	267.00	22.00
4.3-5.1	51.50	29.45	14.10	2.10	1.95	ND	0.80	ND	43.00	275.00	296.00	ND	213.00	2.00	274.00	33.00
5.1-6.0	49.04	30.89	15.18	2.35	1.76	ND	0.75	ND	36.00	318.00	213.00	ND	350.00	2.00	280.00	29.00
6.0-7.0	54.05	27.43	13.91	2.36	1.20	0.53	0.52	ND	29.00	232.00	283.00	ND	80.00	3.00	228.00	31.00
7.0-8.0	55.28	27.66	11.91	2.26	1.09	0.77	1.01	ND	21.00	98.00	210.00	ND	76.00	2.00	223.00	36.00
8.0-9.0	55.29	27.32	11.19	2.31	0.99	0.56	2.29	ND	24.00	109.00	184.00	ND	90.00	2.00	212.00	27.00
10.2	54.08	24.85	10.38	2.01	0.95	1.10	4.87	T	32.00	130.00	256.00	ND	62.00	3.00	240.00	35.00

TABLE 17 : THE INCREASE/DECREASE IN % OF THE ELEMENT CONCENTRATIONS WITHIN THE PROFILE AT BADI COMPARED TO THE COMPOSITION OF THE EXPOSED PARENT ROCK.

Depth in M.	Element	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
	Avg.Comp. in parent rock	54.45	24.74	10.38	2.01	0.95	1.065	4.87	T	32	130	256	ND	62	3	240	35
0-1.0		-31	-4	+238	+38	+42	ND	-97	ND	0	-31	+94	ND	-64	+133	+62	-60
1.0-2.0		-20	-6	+173	+28	+98	ND	-85	ND	-6	-28	+68	ND	-32	+200	+58	-57
2.0-2.8		-11	+1	+112	+6	+137	ND	-85	ND	+12	-21	+48	ND	+42	ND	+50	-51
2.8-3.5		-7	+0.4	+89	+15	+122	ND	-84	ND	+18	+66	+25	ND	+151	ND	+36	-43
3.5-4.3		-4	+2	+69	+25	+106	ND	-81	ND	+15	+66	+1	ND	+225	ND	+11	-37
4.3-5.1		-5	+18	+36	+4	+104	ND	-83	ND	+34	+111	+15	ND	+243	-33	+14	-6
5.1-6.0		-9	+24	+46	+17	+84	ND	-84	ND	+12	+144	-17	ND	+464	-33	+16	-17
6.0-7.0		-0.3	+10	+34	+17	+25	-52	-89	ND	+9	+78	+10	ND	+29	0	-5	-11
7.0-8.0		+2	+11	+15	+12	+13	-30	-79	ND	+34	-24	-18	ND	+22	-33	-7	+3
8.0-9.0		+2	+10	+8	+15	+4	-49	-53	ND	+25	-16	-28	ND	+45	-33	-11	-23

ND : Not Determined
T : Trace

FIG: 14a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT BADI

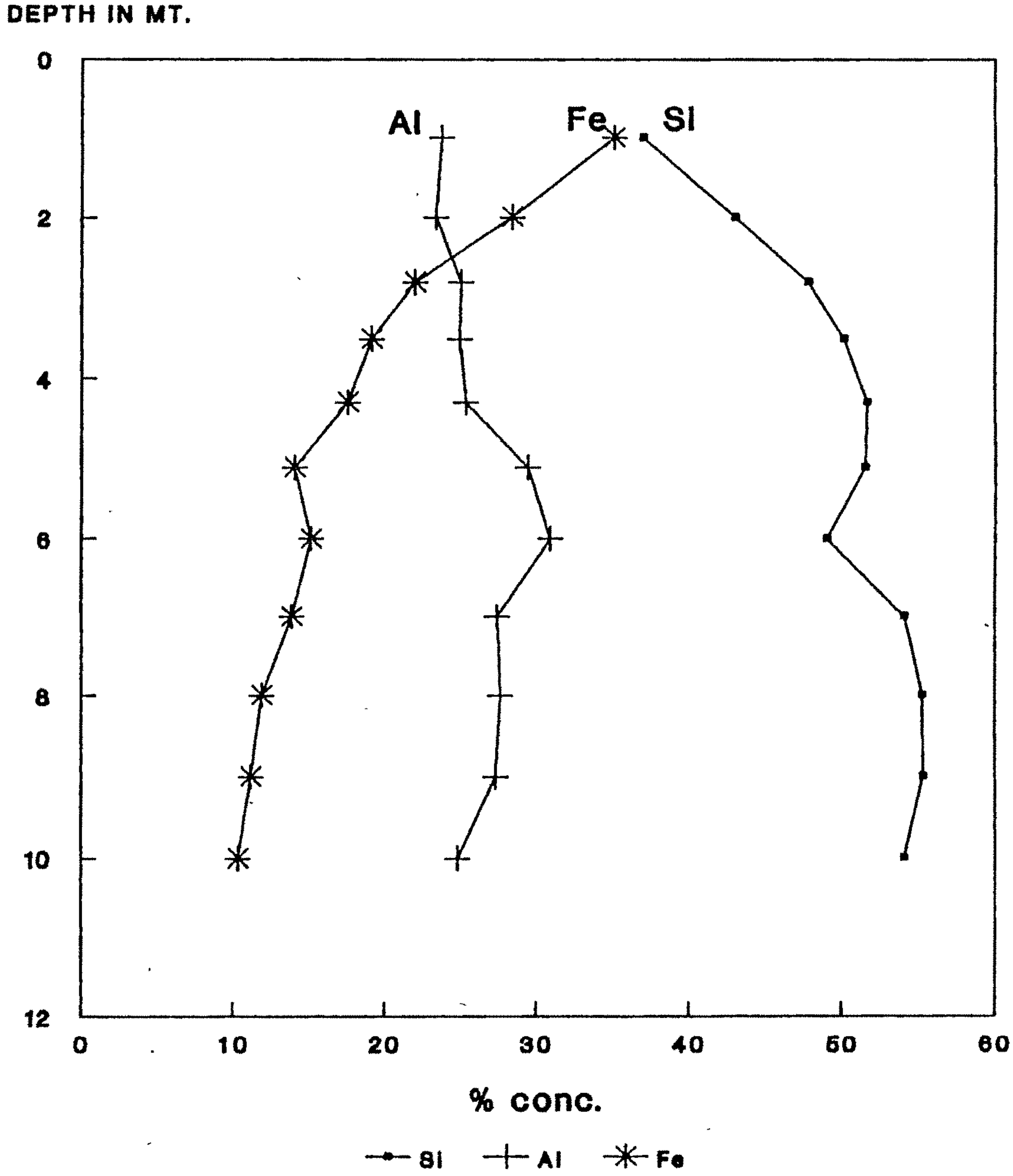


FIG: 14b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TI, Ca, Mg AT BADI

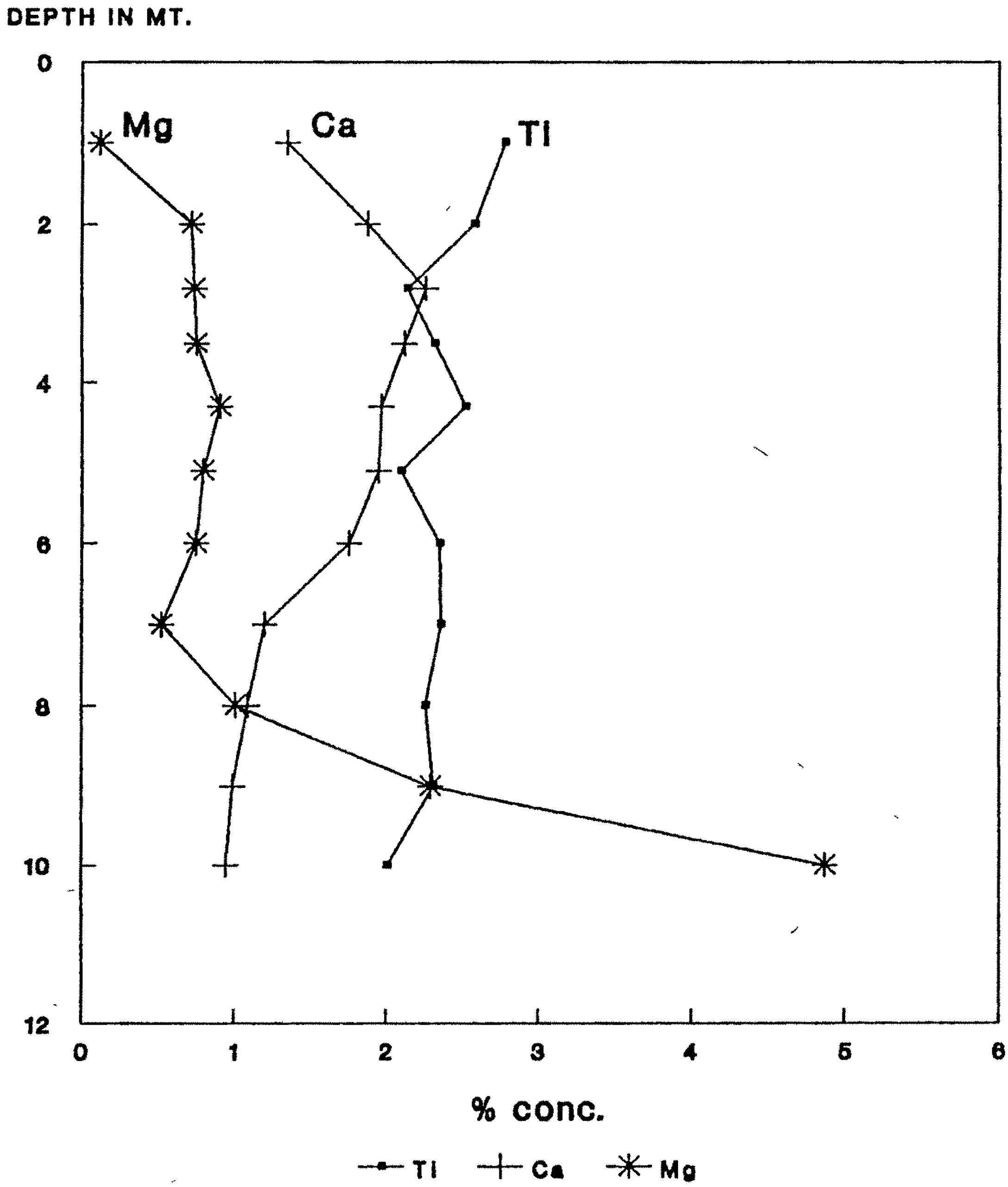


FIG: 14c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT BADI

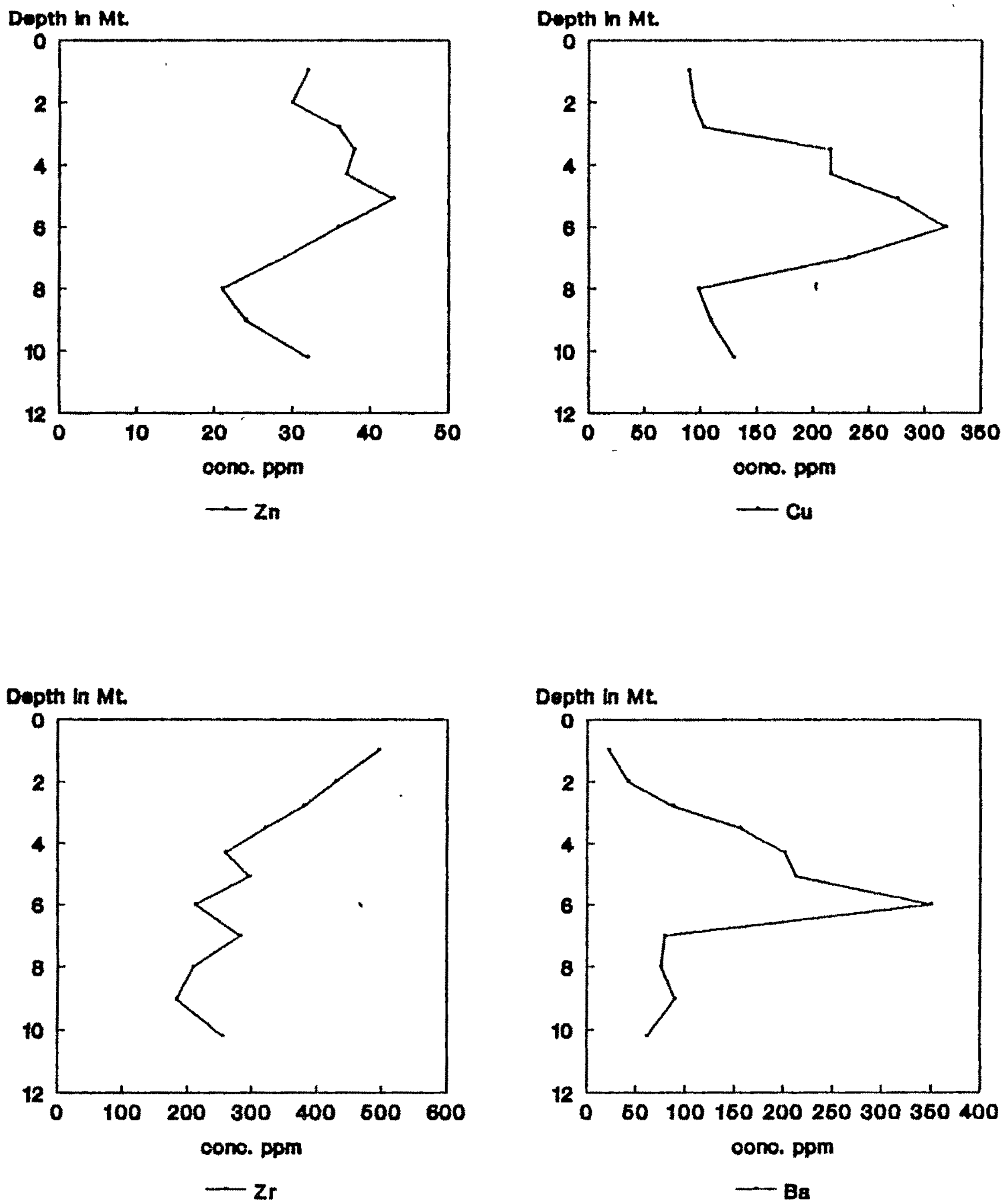
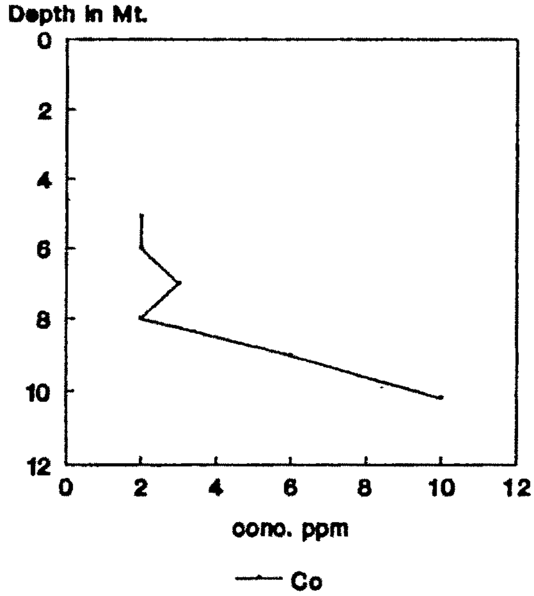
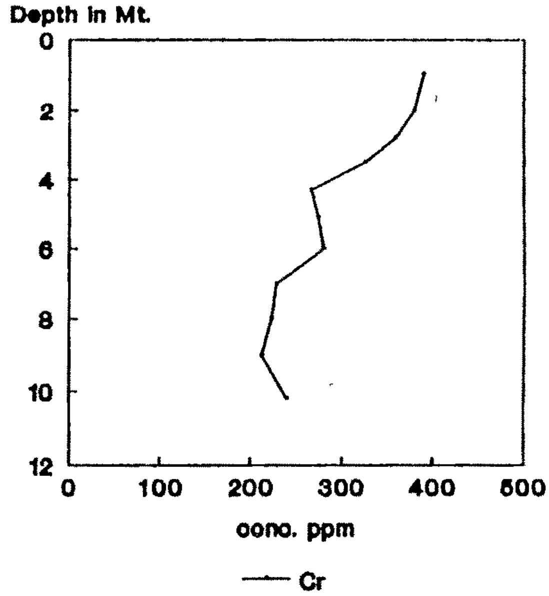
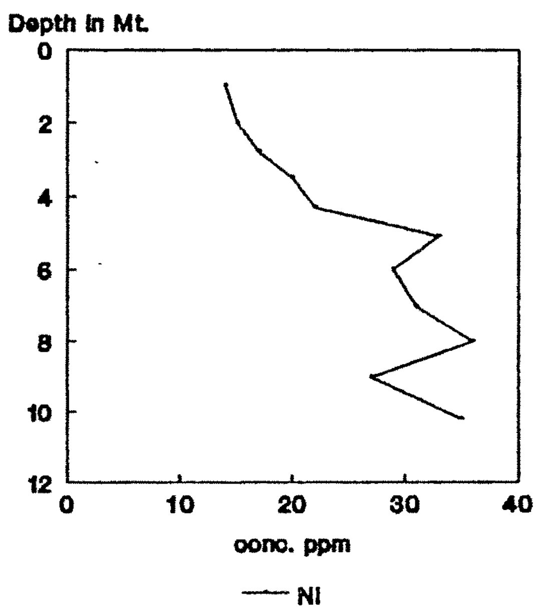


FIG: 14d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT BADI







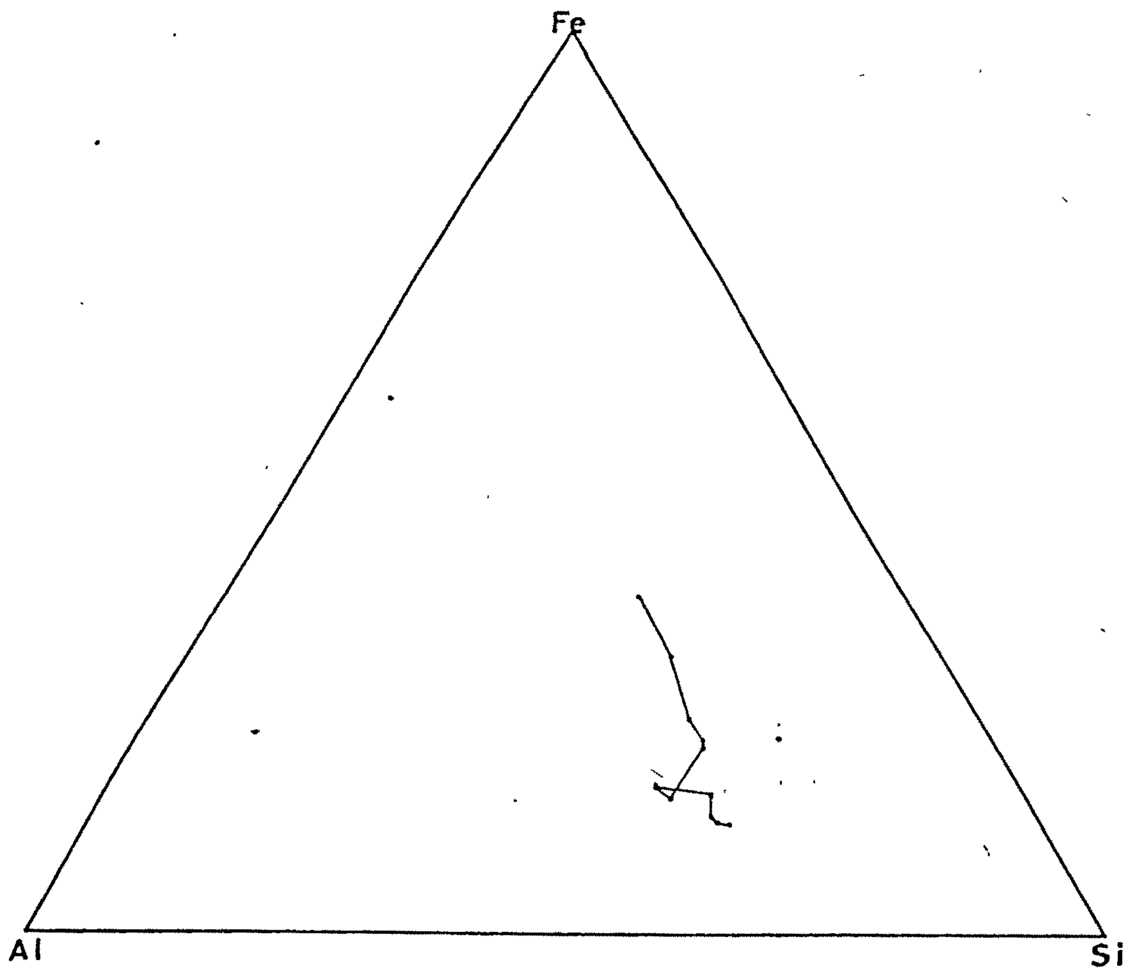


Fig.15: TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT BADI.

FIG-16

X-RAY DIFFRACTION TRACES OF VARIOUS HORIZONS OF LATERITE PROFILE AT BADI

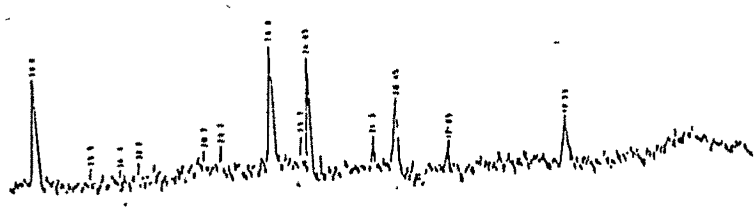
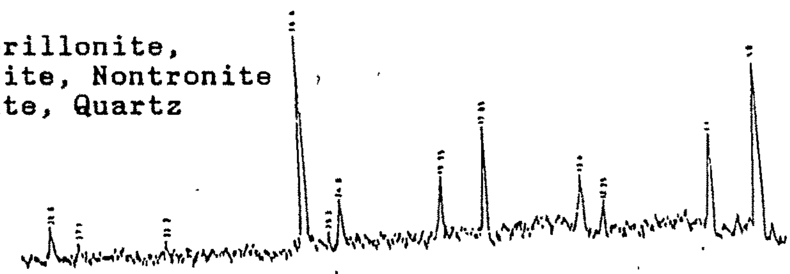
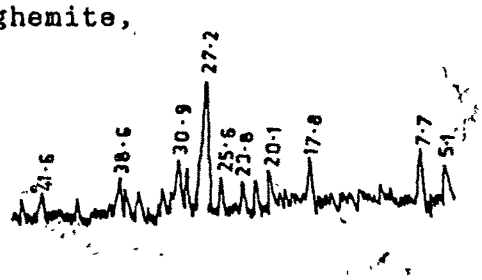
Depth in mt	Horizon	Dominating Minerals	X-ray trace
2.00m	lithomarge Bentonite contact	Kaolinite, Anatase, Illite, Maghemite, Calcite	
2.00 to 10.0m	Bentonite	Montmorillonite, Kaolinite, Nontronite Goethite, Quartz	
10.0 to 10.5m	Basalt	Augite, Ilmenite, Sphene, Maghemite, Forsterite	

TABLE -18a

X-RAY DATA OF WEATHERED BASALT AT BADI

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
5.1	17.3270	14.0	29.16	Saponite
7.7	11.4811	18.5	38.54	Maghemite
17.8	4.9828	19.0	39.58	Montmorillonite
20.1	4.4175	8.0	16.66	Nontronite
21.1	4.2014	10.5	21.87	Sphene
21.3	4.1713	13.5	28.12	Kaolinite
23.0	3.8667	11.5	23.95	Calcite
23.8	3.7385	12.5	26.04	Ilmenite
25.6	3.4795	12.0	25.00	Nontronite
26.8	3.3284	31.0	18.75	Quartz
27.2	3.2784	48.0	100.0	Sphene
27.4	3.2549	18.5	38.54	Augite
27.8	3.2090	12.0	25.00	Maghemite
29.1	3.0685	14.5	30.28	Nontronite
29.7	3.0079	18.0	37.50	Augite
34.3	2.6143	8.0	16.66	Beidellite
35.1	2.5565	12.0	25.00	Kaolinite
39.2	2.2980	4.0	8.33	Calcite
42.7	2.1174	1.0	2.08	Augite

TABLE-18b

X-RAY DATA OF BENTONITE/LITHOMARGE CONTACT AT BADI

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
12.50	7.0810	9.2	39.66	Kaolinite
17.85	4.9826	6.5	28.02	Montmorillonite
20.45	4.3532	13.8	59.48	Kaolinite
21.30	4.1713	7.0	30.17	Kaolinite
24.85	3.5900	22.0	94.83	Kaolinite
25.3	3.5201	6.0	25.86	Anatase
26.60	3.3510	23.2	100.0	Quartz
29.3	3.0480	5.0	21.55	Calcite
30.2	2.9582	4.0	17.24	Maghemite
33.2	2.6984	4.5	19.40	Hematite
34.4	2.6069	3.0	12.93	Illite
35.5	2.5286	3.5	15.09	Maghemite
38.60	2.3324	20.5	88.36	Kaolinite

TABLE-18c

X-RAY DATA OF BENTONITE HORIZON AT BADI

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
5.0	17.673	33.2	80.98	Montmorillonite
7.1	12.450	19.0	46.34	Illite
12.35	7.1957	7.0	17.07	Kaolinite
13.45	6.6074	11.2	27.32	Montmorillonite
19.95	4.4615	21.0	51.22	Montmorillonite
24.85	3.5900	9.0	21.95	Kaolinite
25.3	3.5201	4.0	9.76	Anatase
26.60	3.3510	41.0	100.0	Quartz
33.2	2.6964	3.5	8.54	Goethite
37.1	2.4232	4.0	9.76	Montmorillonite
38.60	2.3324	7.5	18.21	Kaolinite

TABLE 19 : ANALYTICAL DATA OF A SECTION EXPOSED AT PADWA.

Depth	Major elements in %							Trace elements in ppm.								
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
0-1	45.66	24.17	25.07	2.86	1.43	T	0.42	T	38.00	117.00	631.00	ND	41.00	3.00	368.00	12.00
1-2	46.45	26.61	22.42	2.48	0.84	T	0.53	T	41.00	131.00	431.00	ND	62.00	2.00	291.00	8.00
2-3	49.21	34.32	12.11	2.24	0.75	T	0.55	T	29.00	86.00	541.00	ND	71.00	3.00	314.00	20.00
3-4	52.67	33.08	9.62	2.18	1.10	T	0.61	T	23.00	62.00	414.00	ND	66.00	1.00	280.00	28.00
4-5	51.92	35.94	6.68	2.34	0.83	0.63	0.72	T	32.00	71.00	379.00	ND	59.00	T	215.00	28.00
5-6	54.83	24.64	9.98	2.13	0.98	1.03	4.89	T	43.00	107.00	360.00	T	63.00	1.00	269.00	32.00

TABLE 20 : THE INCREASE/DECREASE IN % OF THE ELEMENT CONCENTRATIONS WITHIN THE PROFILE AT PADWA COMPARED TO THE COMPOSITION OF THE EXPOSED PARENT ROCK.

Depth in M.	ELEMENTS	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
	Comp. in parent rock	54.83	24.64	9.98	2.13	0.98	1.03	4.89	T	43	107	360	T	63	1	268	32
0-1		-17	-2	+151	+34	+46	T	-91	T	-11	+9	+75	ND	-35	+200	+37	-62
1-2		-15	+8	+124	+16	-14	T	-89	T	-41	+22	+19	ND	-1	+100	+8	-75
2-3		-10	+39	+21	+5	-23	T	-89	T	-32	-19	+50	ND	+12	+200	+17	-37
3-4		-4	+34	-3	+2	+12	T	-87	T	-46	-42	+15	ND	+4	0	+4	-12
4-5		-5	+46	-33	+10	-15	-39	-83	T	250	-33	+5	ND	-6	T	-19	-12

ND : Not Determined
T : Trace

FIG: 17a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT PADWA

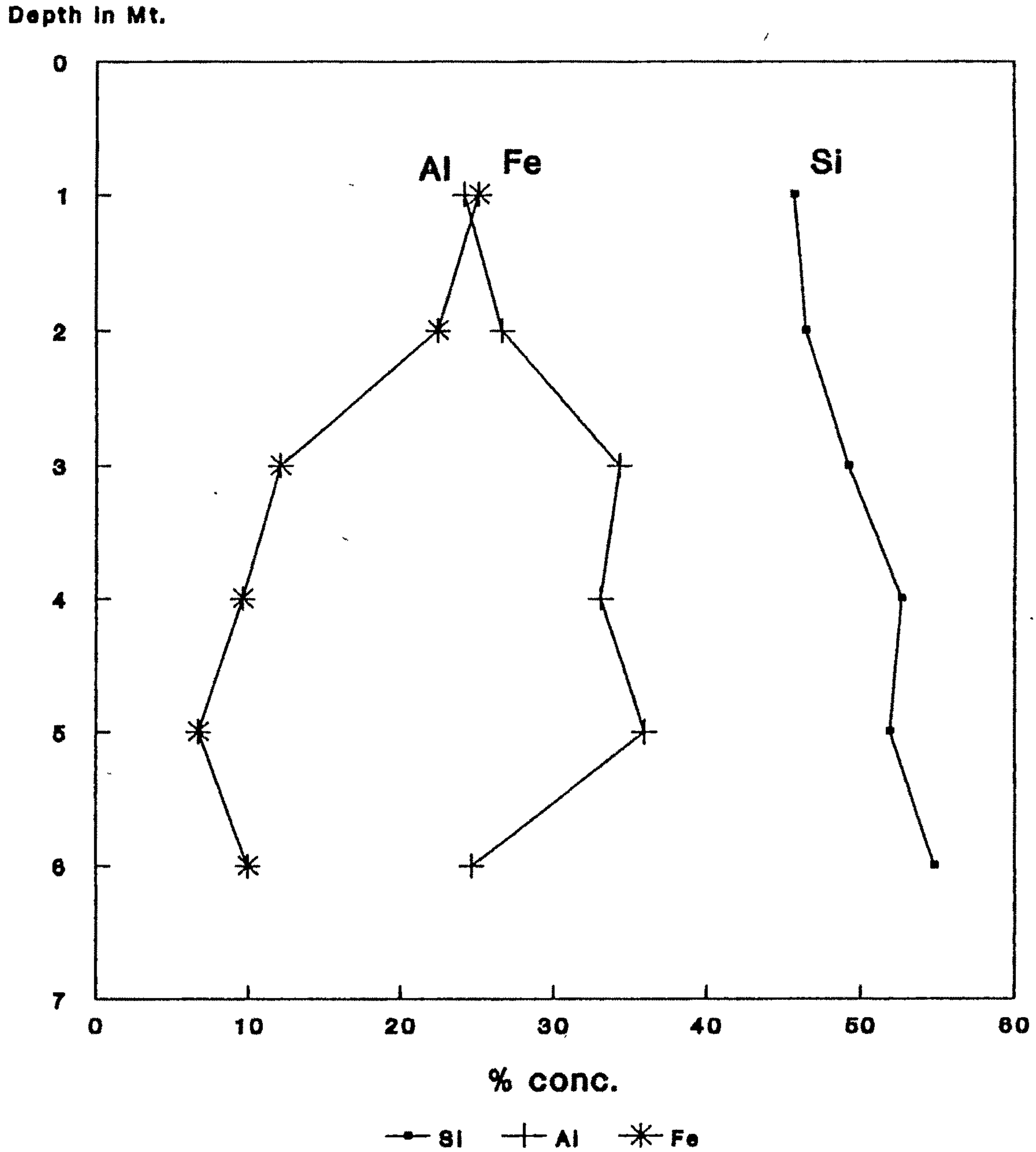


FIG : 17 b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Ca, Mg AT PADWA

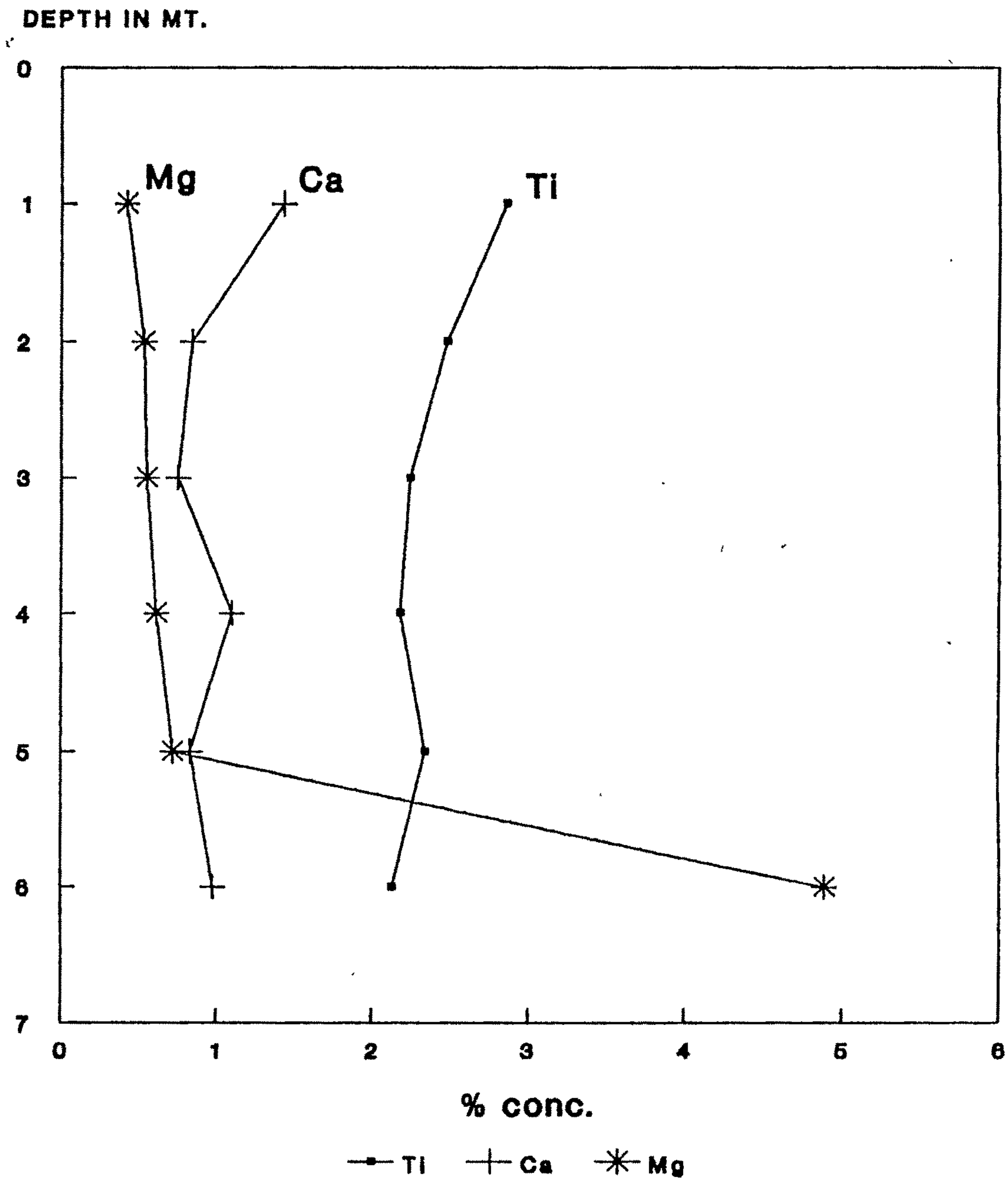
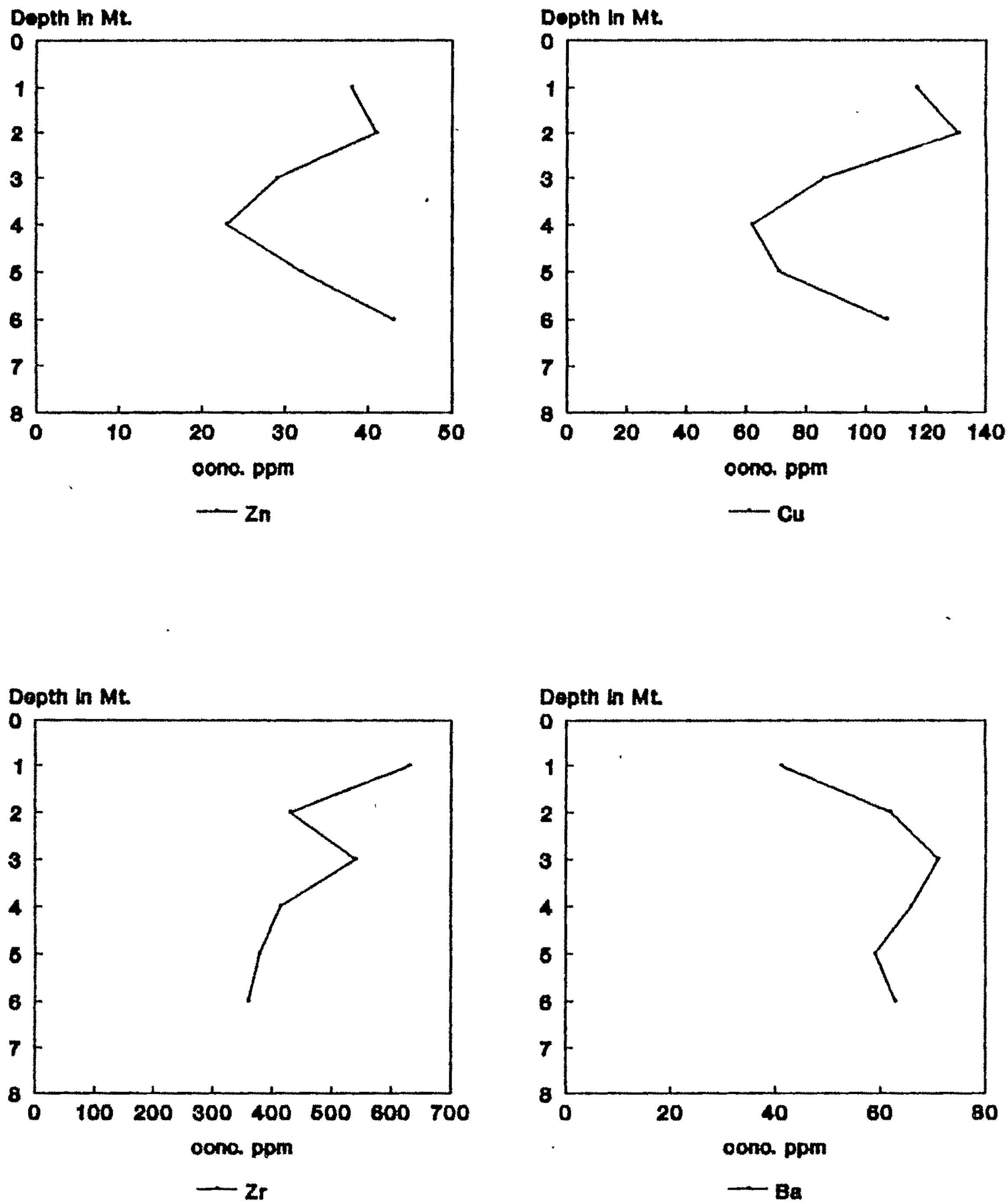


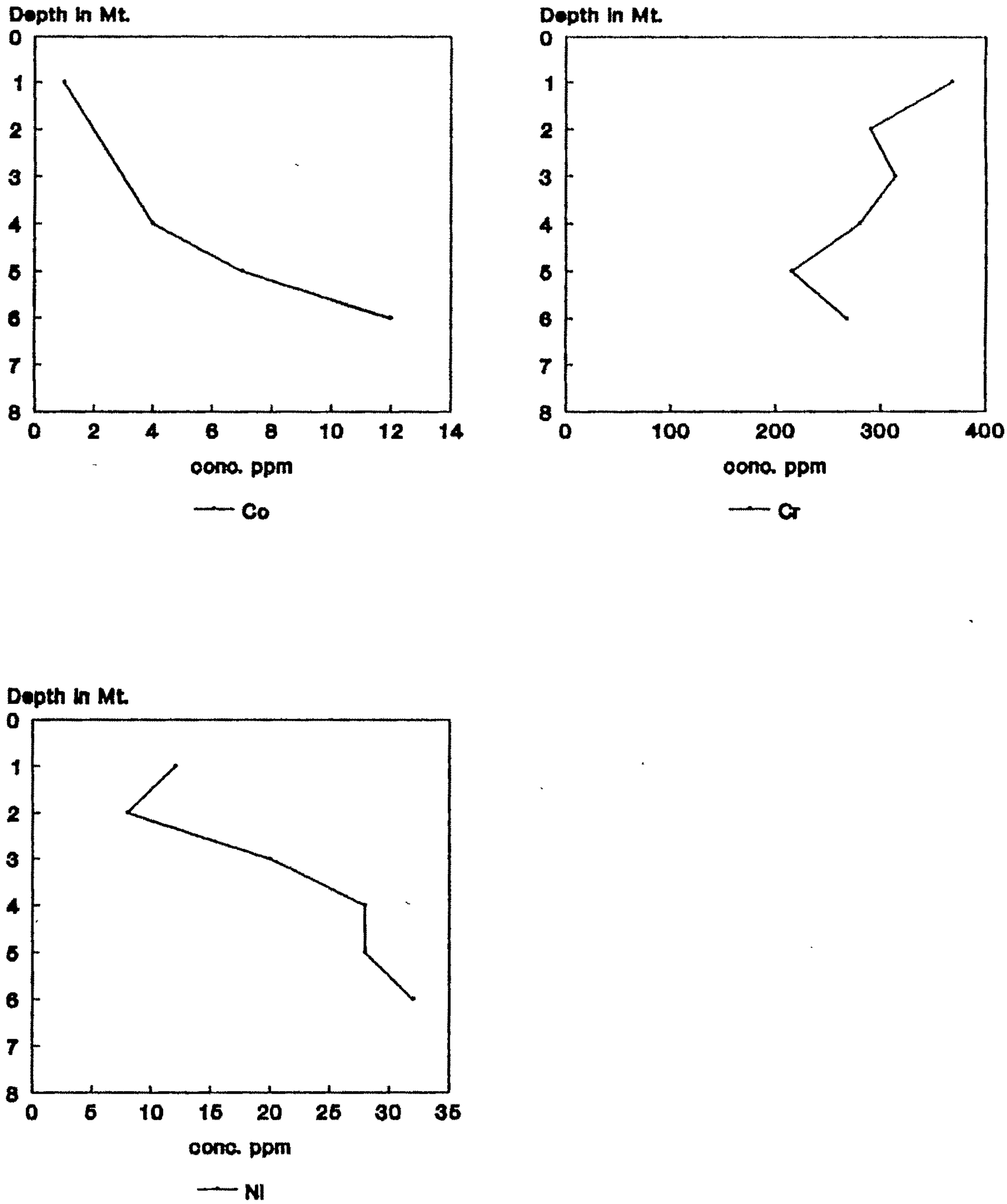
FIG : 17c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT PADWA



F I G : 17 d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT PADWA



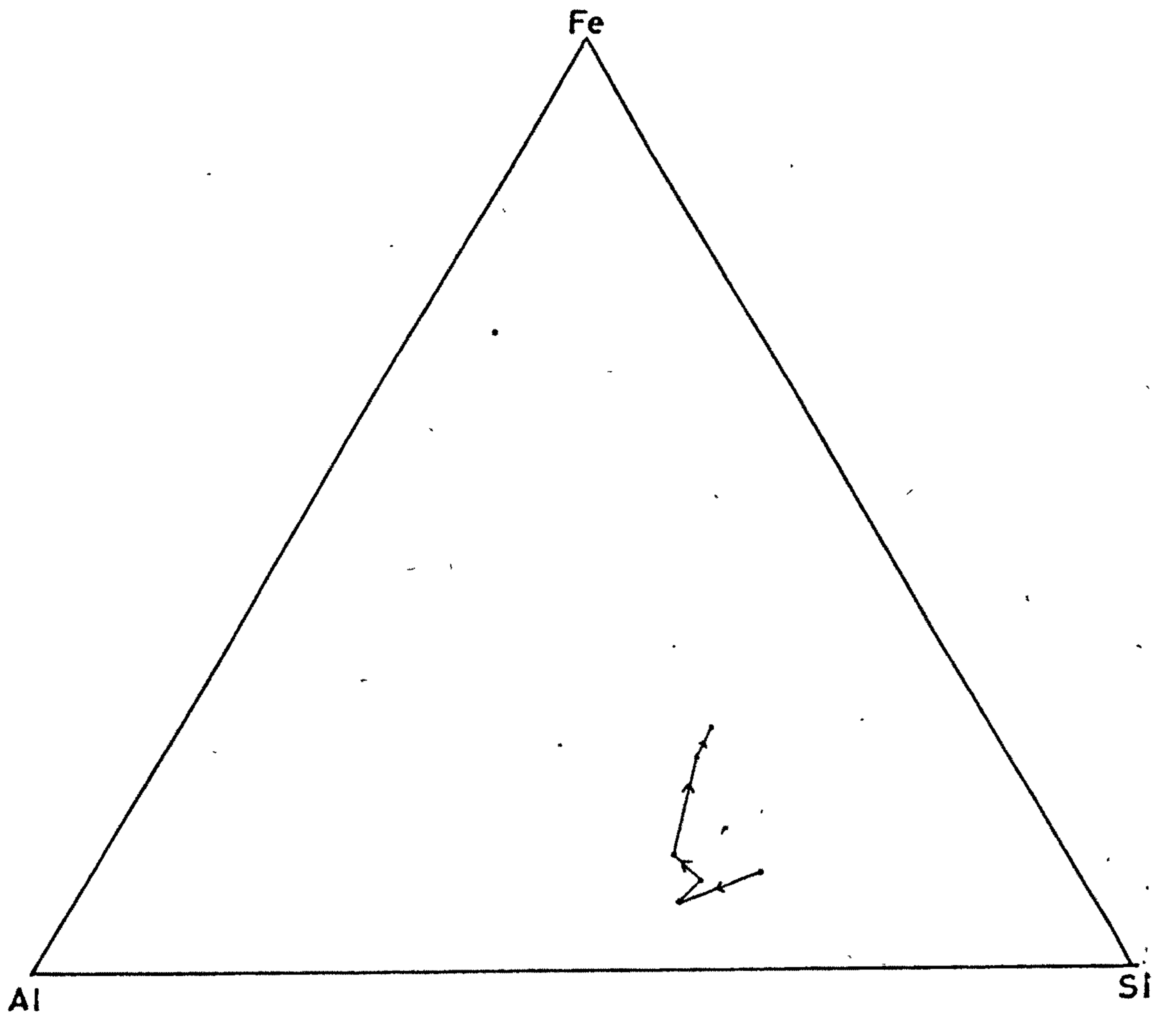


Fig 18: TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT **PADWA**

FIG-19

X-RAY DIFFRACTION TRACES OF VARIOUS HORIZONS

OF LATERITE PROFILE AT PADWA

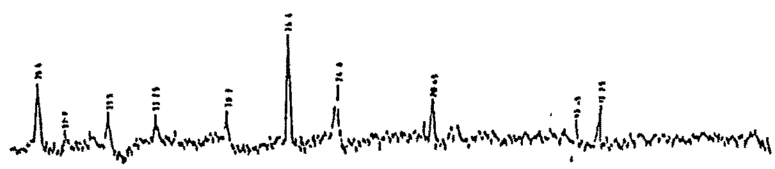
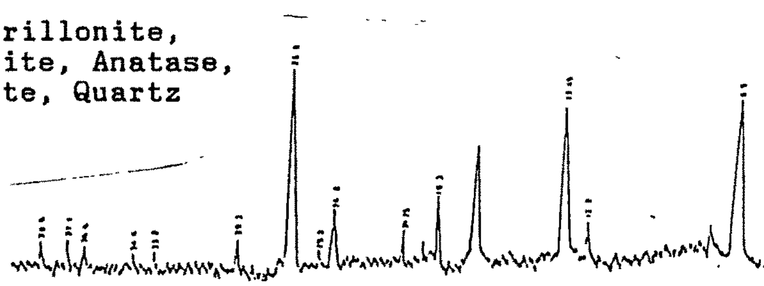
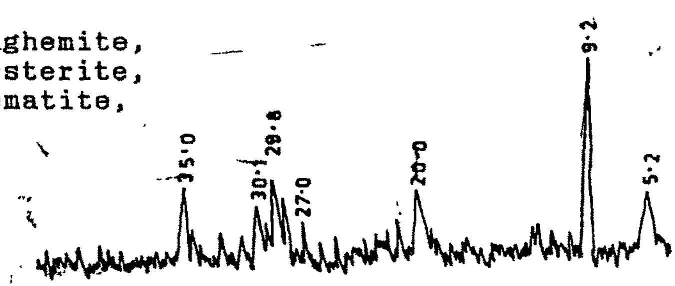
Depth in mt	Horizon	Dominating Minerals	X-ray trace
0.5 to 2.5	lithomarge	Kaolinite, Nontronite, Maghemite, Hematite, Quartz, Anatase	
2.50 to 6.2m	Bentonite	Montmorillonite, Kaolinite, Anatase, Goethite, Quartz	
6.20 to 7.5m	Basalt	Augite, Maghemite, Sphene, Forsterite, Anatase, Hematite, Fayalite	

TABLE-21a

X-RAY DATA OF LITHOMARGE HORIZON AT PADWA

2θ	d-Spacing	Intensity Io	Io	Remarks
12.25	7.2545	8.1	38.57	Kaolinite
13.45	6.6074	5.0	23.81	Nontronite
20.45	4.3532	8.9	42.38	Kaolinite
24.85	3.5900	11.5	54.76	Kaolinite
26.60	3.3510	21.0	100.0	Quartz
30.2	2.9592	6.5	30.95	Maghemite
33.2	2.6984	6.0	28.57	Hematite
35.5	2.5266	7.5	35.71	Maghemite
37.7	2.3860	4.0	19.05	Anatase
38.6	2.3324	13.0	61.90	Kaolinite

TABLE-21b

X-RAY DATA OF BENTONITE HORIZON AT PADWA

20	d-Spacing	Intensity Io	Io	Remarks
6.5	13.598	29.0	76.31	Montmorillonite
12.35	7.1957	7.0	18.42	Kaolinite
13.45	6.6074	29	76.31	Montmorillonite
17.8	4.9826	22	57.89	Montmorillonite
19.31	4.5986	12	31.58	Montmorillonite
20.45	4.3532	4.0	10.53	Kaolinite
21.25	4.1907	7.0	18.42	Goethite
24.85	3.5800	11.0	28.95	Kaolinite
25.3	3.5201	3.0	7.89	Anatase
26.60	3.3510	38.0	100.0	Quartz
29.3	3.0480	6.0	15.79	Calcite
33.2	2.6984	4.0	10.53	Goethite
34.4	2.6069	4.0	10.53	Illite
36.6	2.4551	5.0	13.16	Goethite
37.1	2.4232	6.0	15.79	Montmorillonite
38.60	2.3324	5.0	13.16	Kaolinite

TABLE-21c

X-RAY DATA OF WEATHERED BASALT AT PADWA

2θ	d-Spacing	Intensity		Remarks
		Io	Ic	
5.2	16.9954	30.01	38.19	Saponite
5.8	15.237	18.5	23.47	Nontronite
9.2	9.6122	78.8	100.00	Nontronite
11.8	7.4955	15.7	19.92	Saponite
12.1	7.3142	19.9	25.25	Saponite
12.6	7.0251	19.0	24.11	Maghemite
14.8	5.9854	15.2	19.28	Montmorillonite
16.9	5.2461	15.2	19.28	Fayalite
20.0	4.4394	28.1	35.65	Montmorillonite
21.0	4.2302	20.2	25.63	Sphene
24.3	3.6627	13.6	17.25	Hematitete
25.2	3.5339	17.0	21.57	Anatase
27.6	3.3072	18.4	23.35	Montmorillonite
28.7	3.1104	27.2	34.51	Nontronite
29.8	2.9980	24.2	30.71	Montmorillonite
30.1	2.9688	16.8	21.23	Augite
35.0	2.5636	29.5	37.43	Nontronite
39.7	2.2703	9.9	12.56	Sphene
40.0	2.2325	10.7	13.57	Ilmenite
40.6	2.2220	9.3	11.80	Forsterite
44.1	2.0534	9.9	12.56	Augite

TABLE 22 : ANALYTICAL DATA OF A SECTION EXPOSED AT TAGADI.

Depth	Major elements in %								Trace elements in ppm.							
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
00 -1.5	44.87	19.98	29.76	2.65	1.52	ND	0.36	ND	28.00	103.00	100.00	270.00	38.00	3.00	369.00	10.00
1.5-2.4	46.50	24.41	22.36	2.37	2.13	ND	0.53	ND	41.00	130.00	462.00	ND	37.00	2.00	212.00	9.00
2.4-3.0	49.50	26.89	19.99	1.18	1.63	ND	0.37	ND	27.00	297.00	150.00	ND	303.00	1.00	203.00	40.00
3.0-3.4	49.67	26.69	18.95	1.18	1.36	ND	0.46	ND	59.00	317.00	227.00	ND	676.00	1.00	169.00	48.00
3.4-4.4	49.86	32.05	14.98	1.51	0.59	ND	0.31	ND	13.00	90.00	261.00	ND	106.00	7.00	160.00	14.00
4.4-5.0	53.50	18.30	22.94	2.67	1.11	ND	0.49	ND	68.00	613.00	999.00	ND	70.00	15.00	405.00	34.00
5.0-5.5	56.63	18.07	19.87	2.46	1.47	ND	0.52	0.15	42.00	130.00	610.00	ND	77.00	6.00	347.00	27.00
5.5-6.2	53.45	29.81	10.85	2.51	1.43	ND	0.86	0.12	27.00	68.00	527.00	ND	ND	ND	243.00	14.00
6.2-7.0	51.63	28.61	14.67	2.63	1.34	ND	0.65	ND	27.00	77.00	367.00	ND	11.00	ND	240.00	10.00
7.0-8.0	52.59	26.98	16.16	1.74	0.86	ND	0.69	ND	52.00	326.00	307.00	ND	9.00	ND	270.00	9.00
8.0-9.0	49.70	35.16	10.35	2.48	1.26	ND	0.88	ND	9.00	89.00	184.00	ND	ND	ND	276.00	11.00

FIG: 20 a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT TAGADI

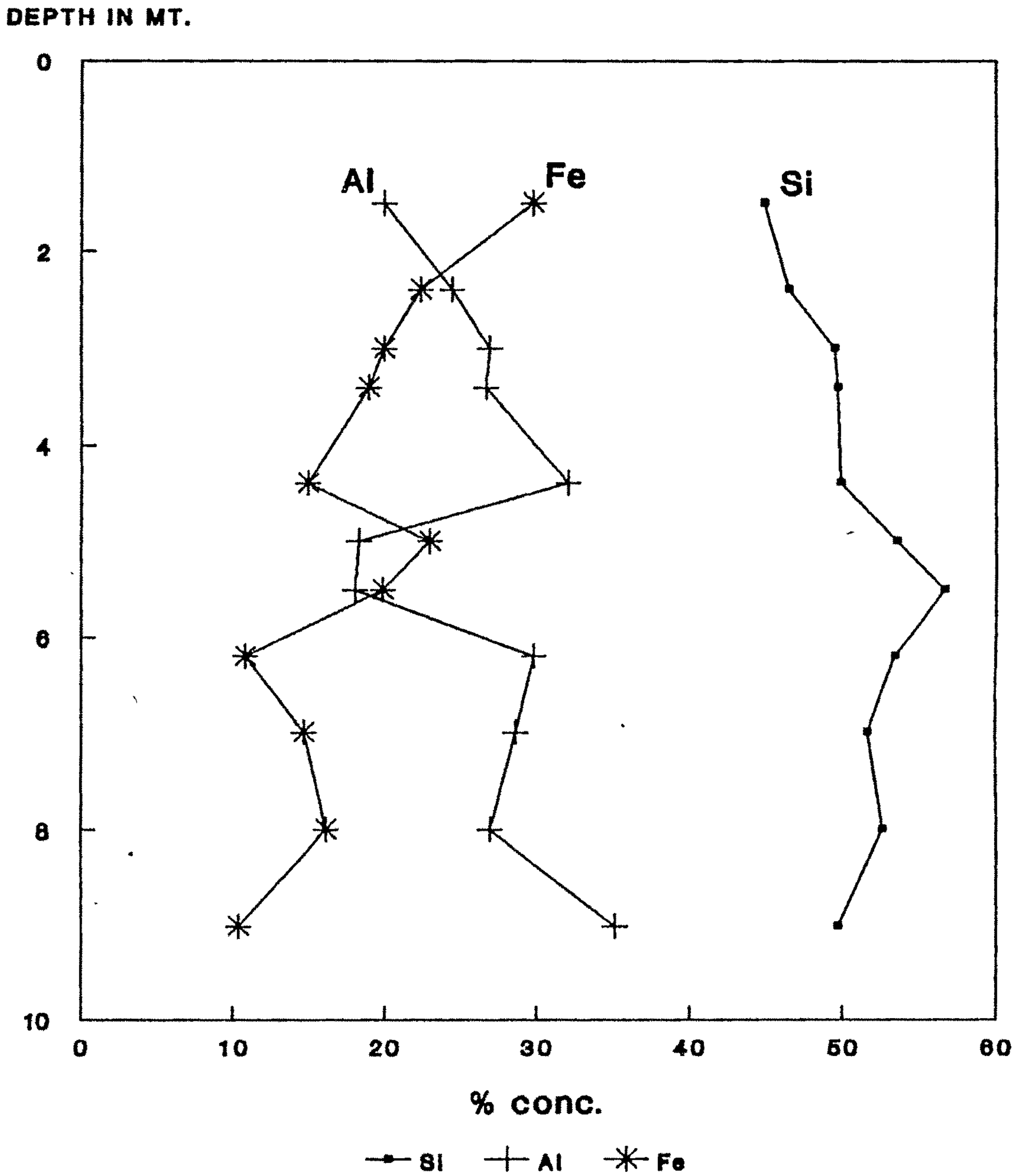


FIG: 20b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Ca, Mg AT TAGADI

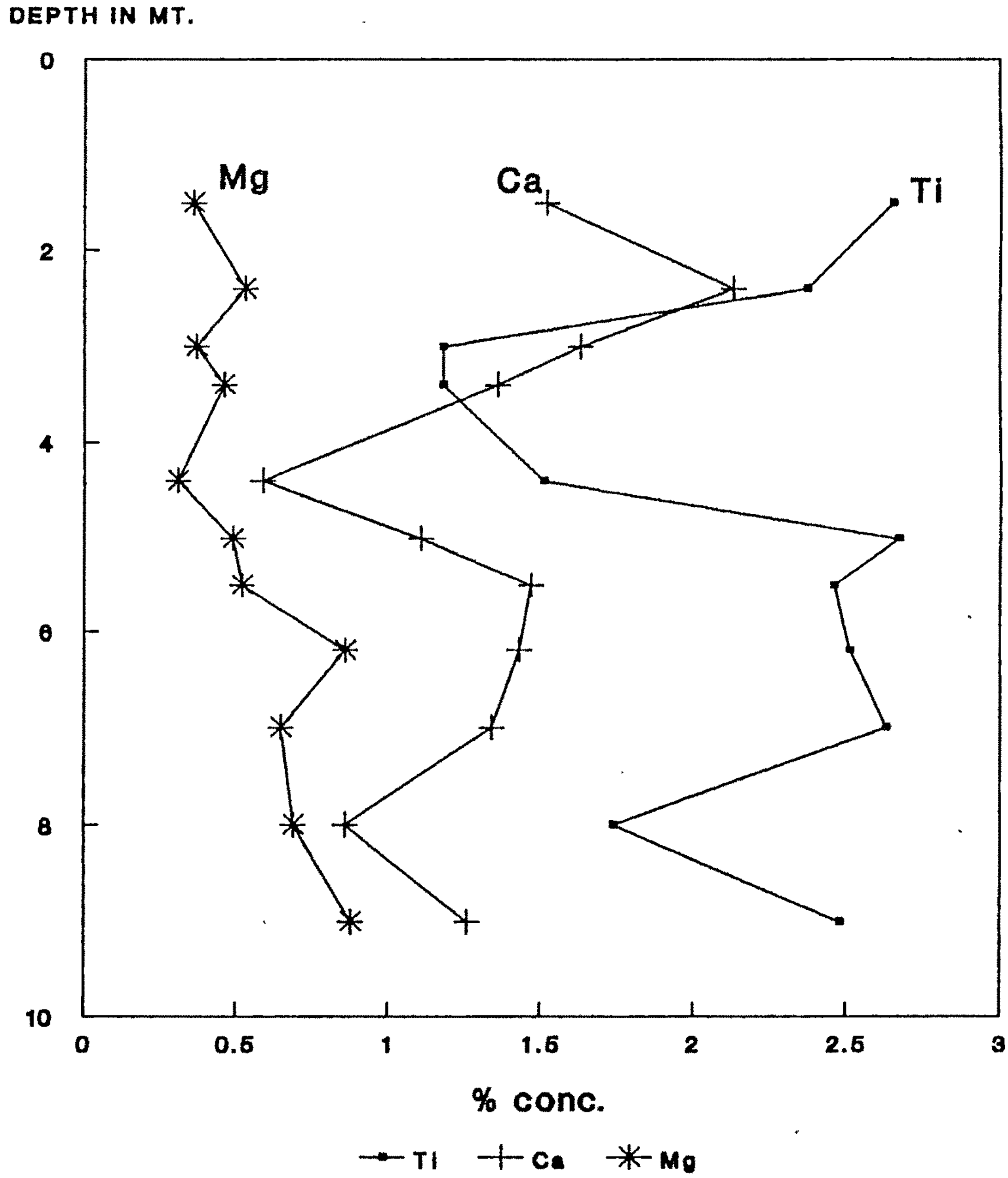


FIG: 20c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT TAGADI

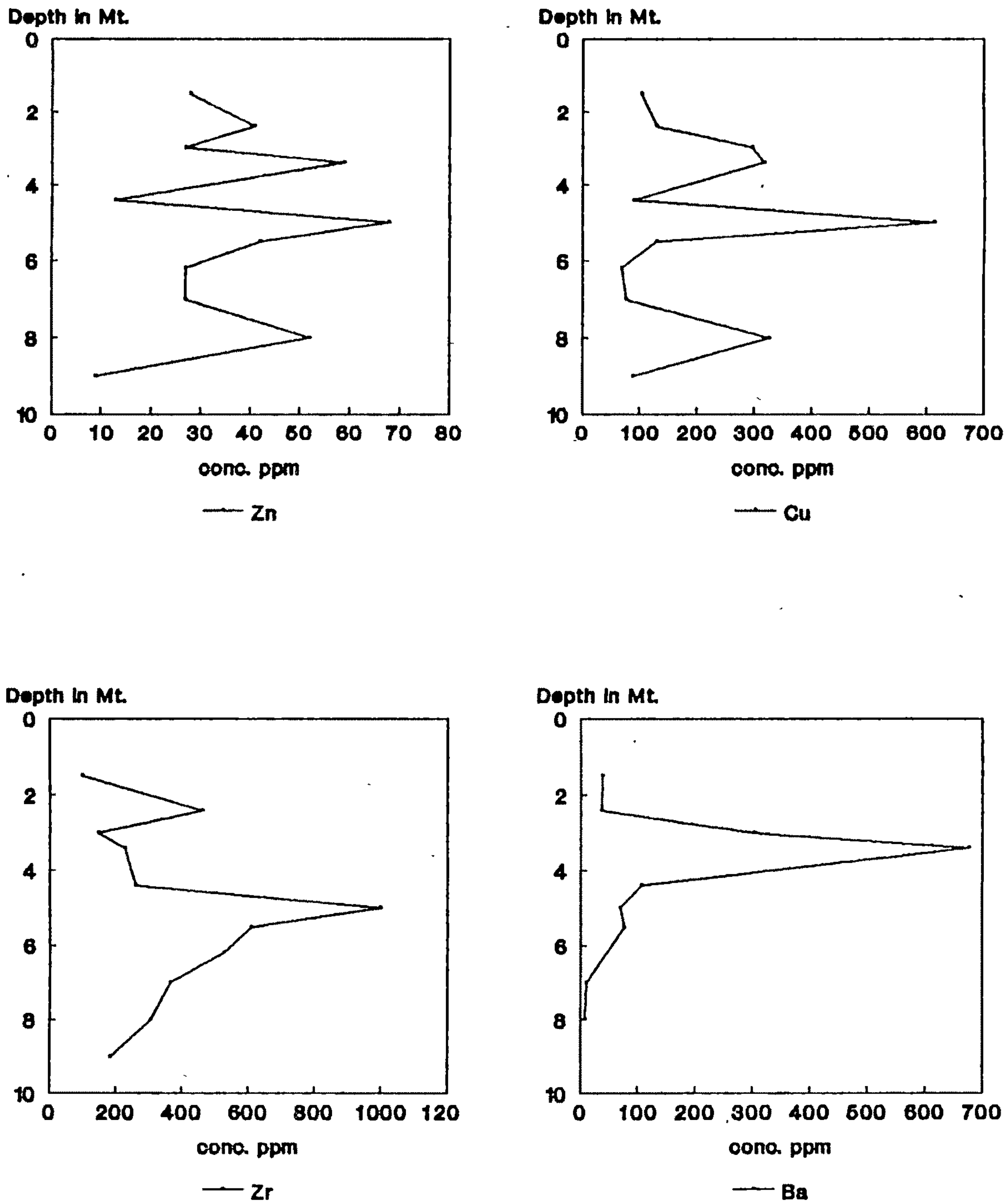
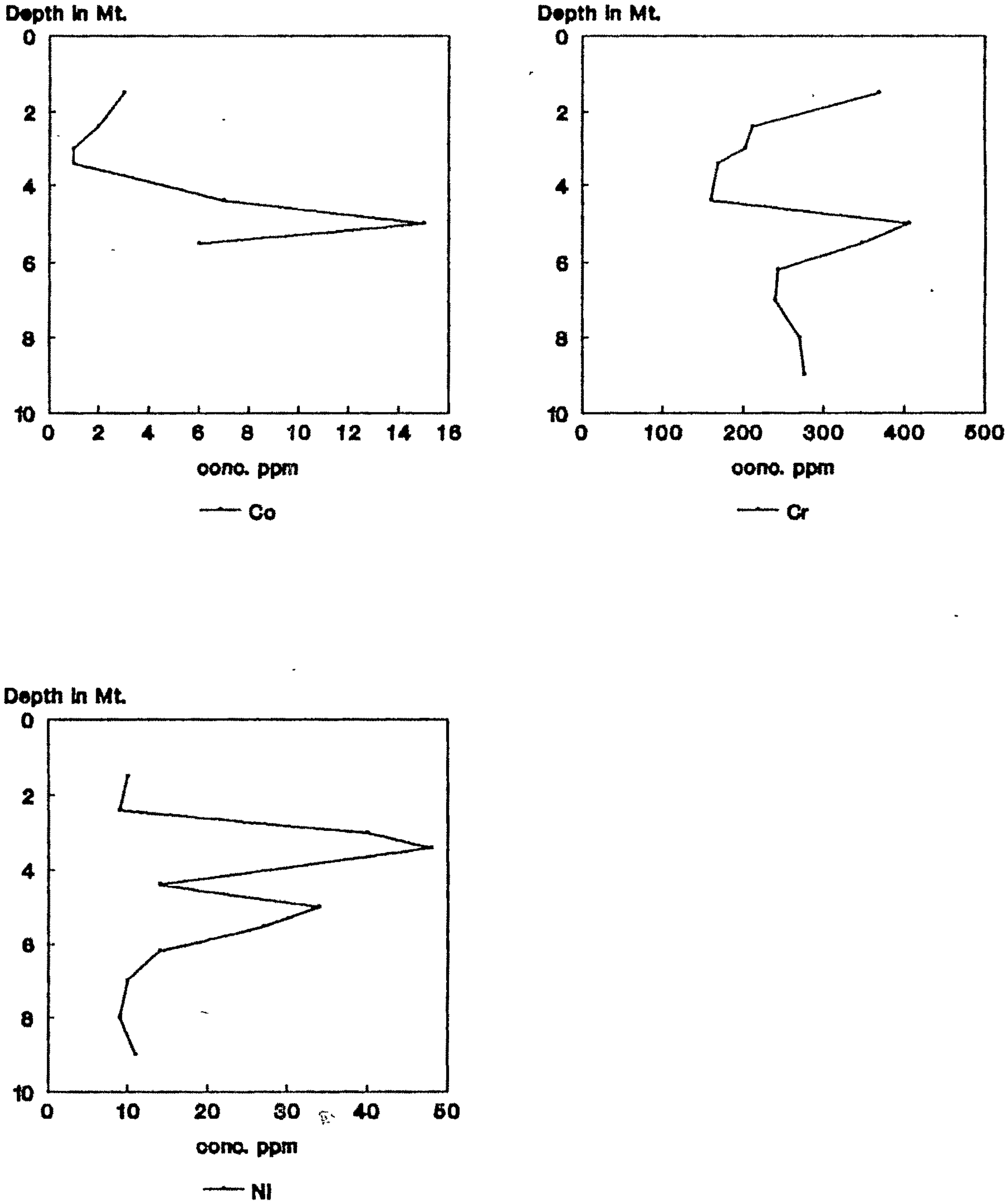


FIG : 20 d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT TAGADI



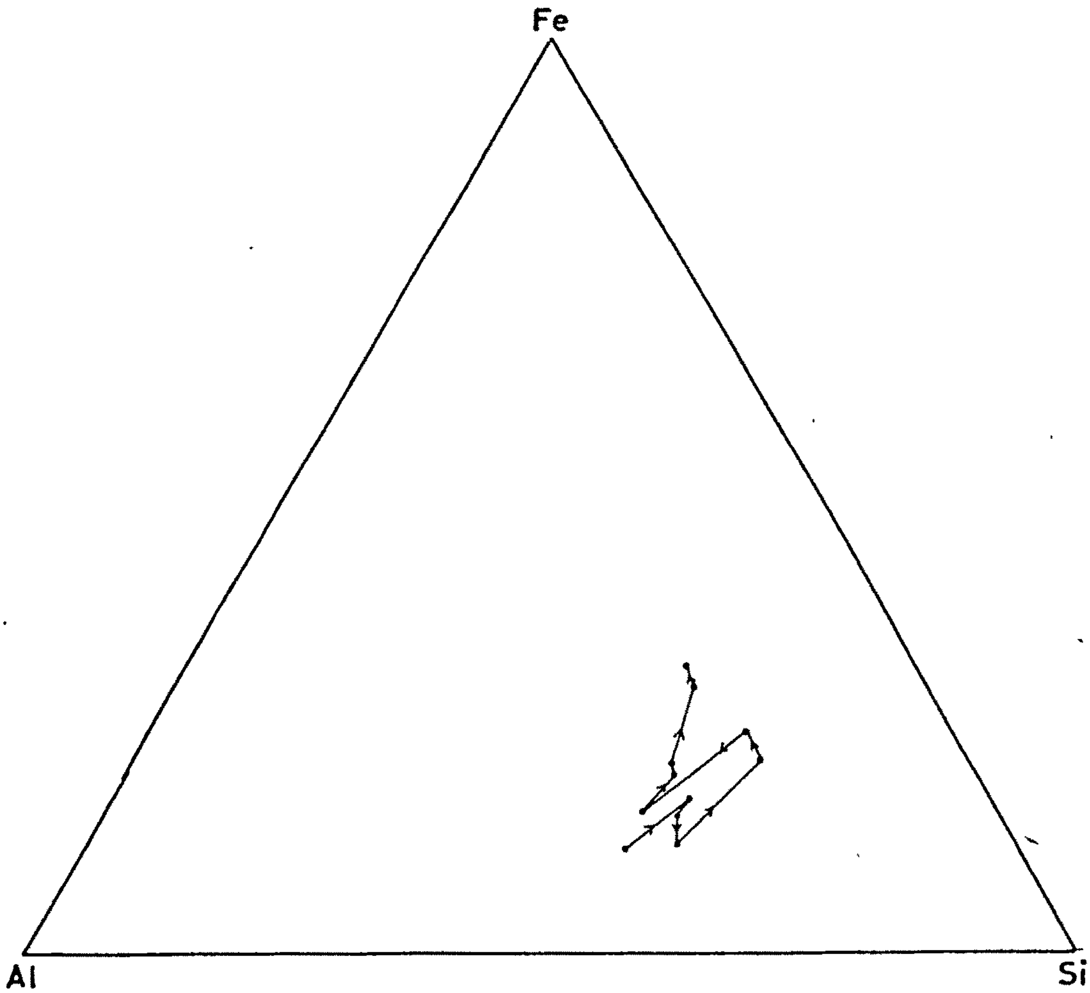


Fig. 21: TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT **TAGADI**

TABLE 23 : ANALYTICAL DATA OF A SECTION EXPOSED AT THORADI.

Depth	Major elements in %							Trace elements in ppm.								
in mt.	Si	Al	Fe	Ti	Ca	K	Mg	Mn	Zn	Cu	Zr	Pb	Ba	Co	Cr	Ni
01 -3.8	44.46	15.36	32.34	1.66	0.76	T	5.20	T	17.00	230.00	235.00	ND	34.00	ND	197.00	11.00
3.8-4.5	49.79	17.04	25.02	1.83	0.73	T	5.18	0.20	17.00	132.00	304.00	ND	74.00	7.00	240.00	17.00
4.5-5.0	51.42	16.19	20.75	2.08	3.46	0.31	5.59	T	15.00	47.00	395.00	ND	2.00	ND	154.00	6.00
5.0-5.5	27.52	7.32	18.29	1.38	39.86	T	5.60	T	ND	60.00	152.00	ND	4.00	2.00	83.00	6.00
5.5-6.5	53.31	38.20	2.26	0.59	0.74	1.39	3.47	T	15.00	105.00	48.00	ND	102.00	ND	62.00	6.00
6.5-7.2	58.29	27.70	7.46	2.13	0.65	T	4.59	T	7.00	106.00	343.00	ND	ND	ND	184.00	12.00
7.2-8.0	54.31	37.84	1.83	2.79	2.98	ND	0.23	T	5.00	16.00	772.00	ND	1.00	ND	154.00	19.00
8.0-8.5	52.20	35.61	7.94	2.51	1.23	ND	0.34	0.14	ND	36.00	906.00	ND	17.00	4.00	166.00	13.00
8.5-9.5	48.88	32.53	11.36	2.63	0.46	ND	4.13	0.05	7.00	22.00	537.00	ND	ND	0.10	264.00	22.00
9.5-11.5	53.73	36.29	5.29	3.29	1.10	ND	0.29	T	2.00	9.00	605.00	ND	ND	T	267.00	23.00
11.5-12	50.38	18.33	94.54	2.33	1.49	0.27	2.49	0.13	136.00	98.00	292.00	ND	83.00	15.00	129.00	50.00
12-12.5	60.99	26.31	4.11	2.69	1.07	0.23	4.56	T	ND	3.00	391.00	ND	ND	ND	144.00	25.00

FIG: 22a

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Si, Al, Fe AT THORADI

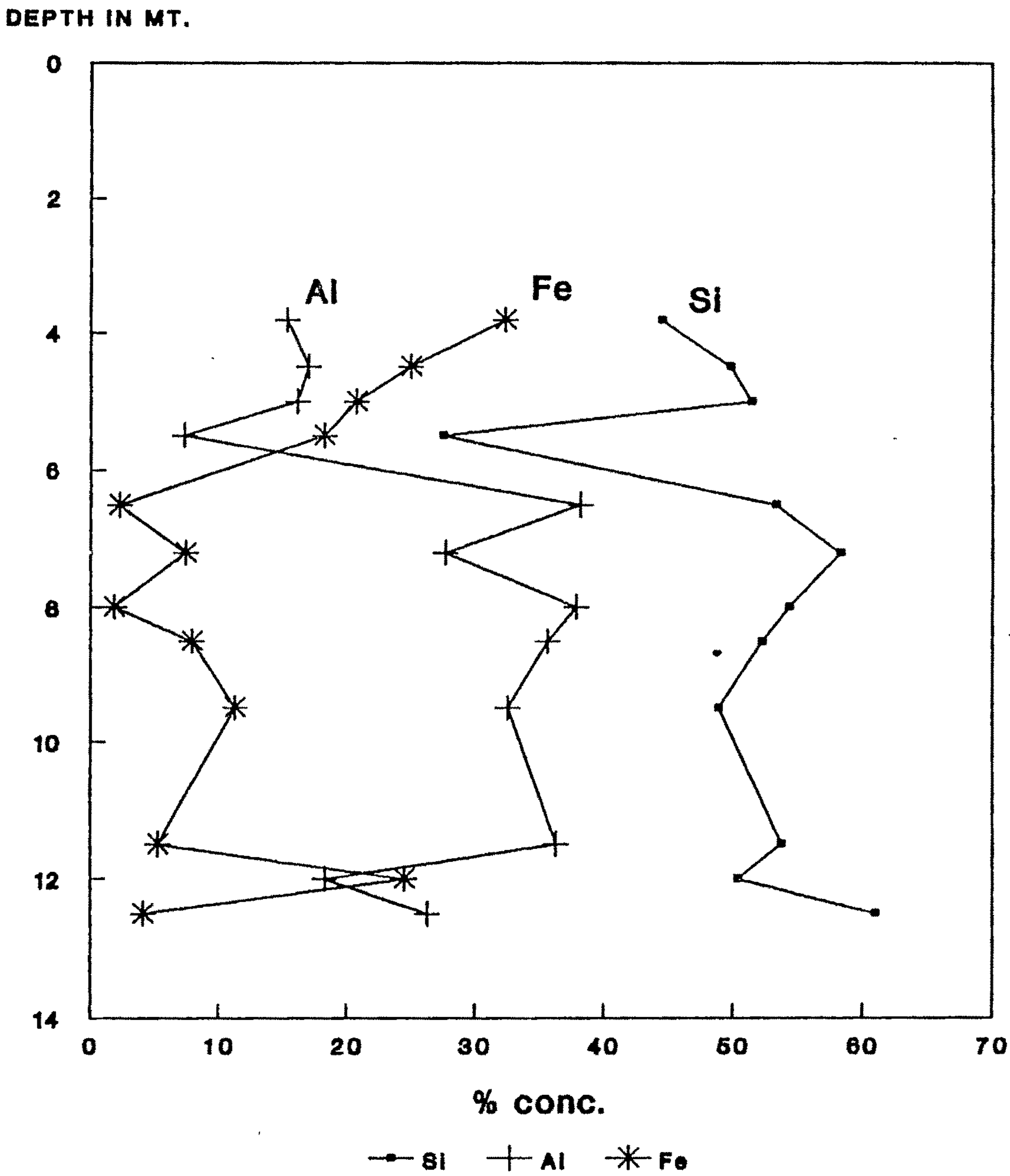


FIG: 22b

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ti, Mg AT THORADI

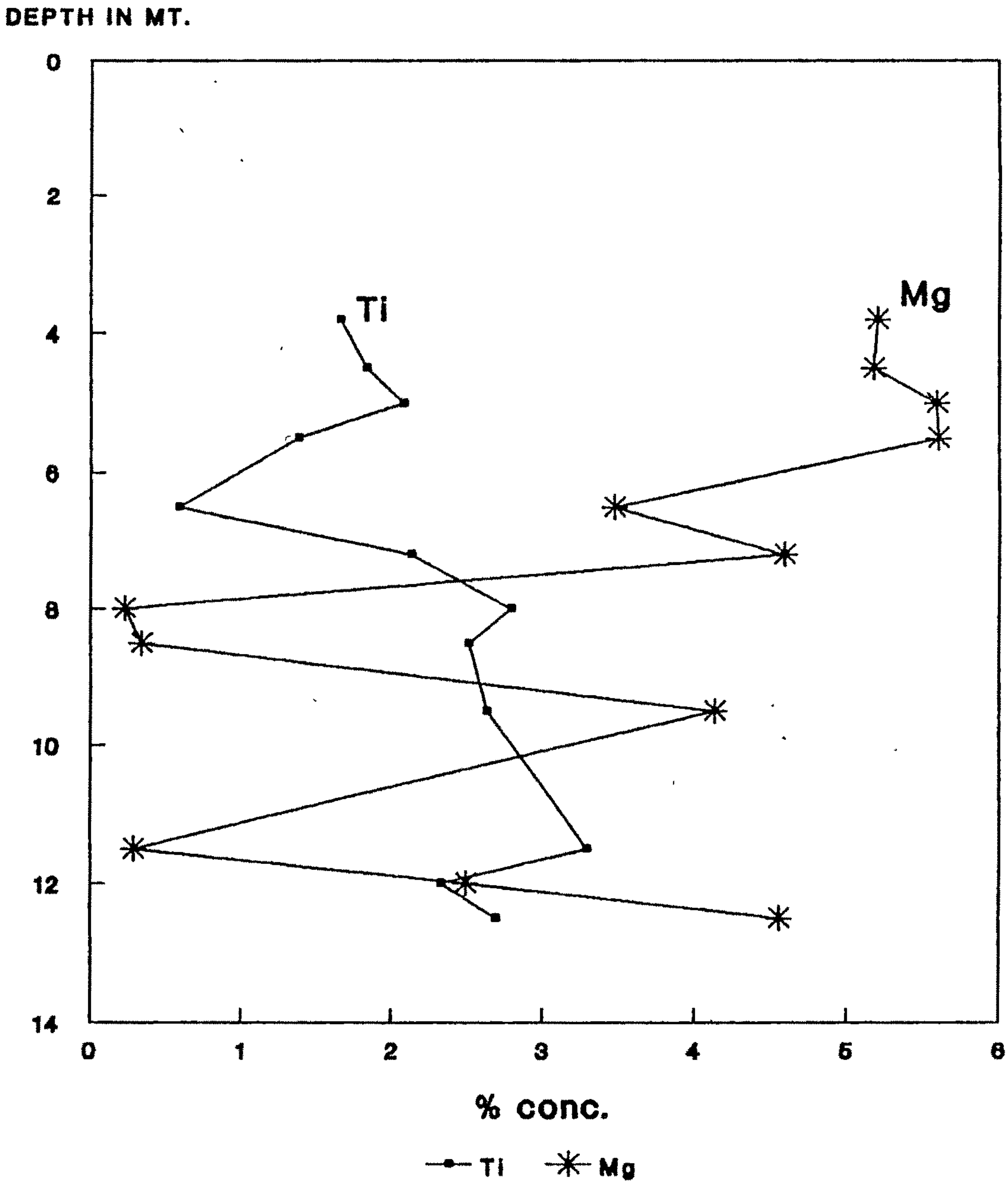


FIG: 22c

VARIATION DIAGRAM SHOWING THE MOVEMENT OF Ca AT THORADI

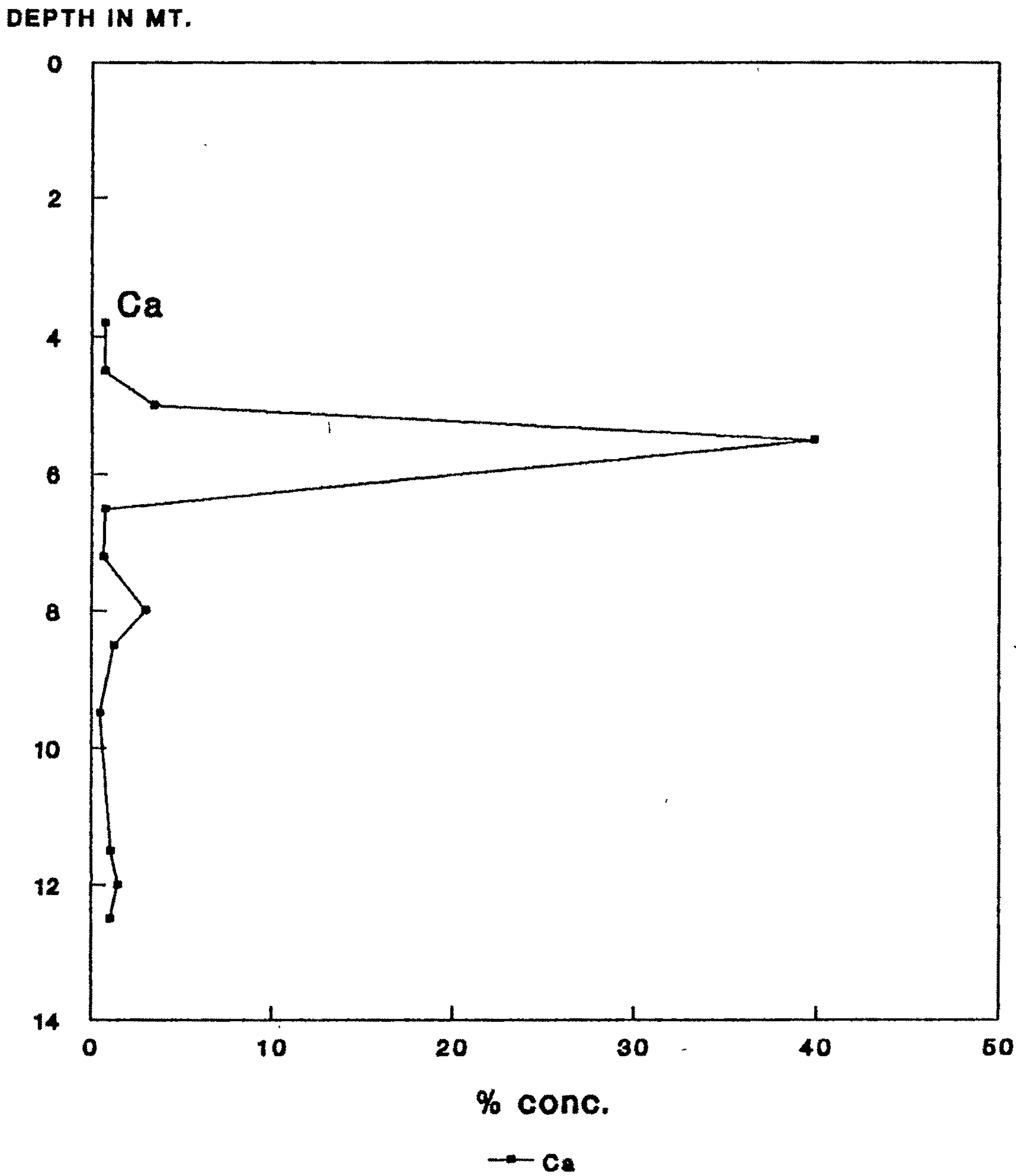


FIG: 22 d

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT THORADI

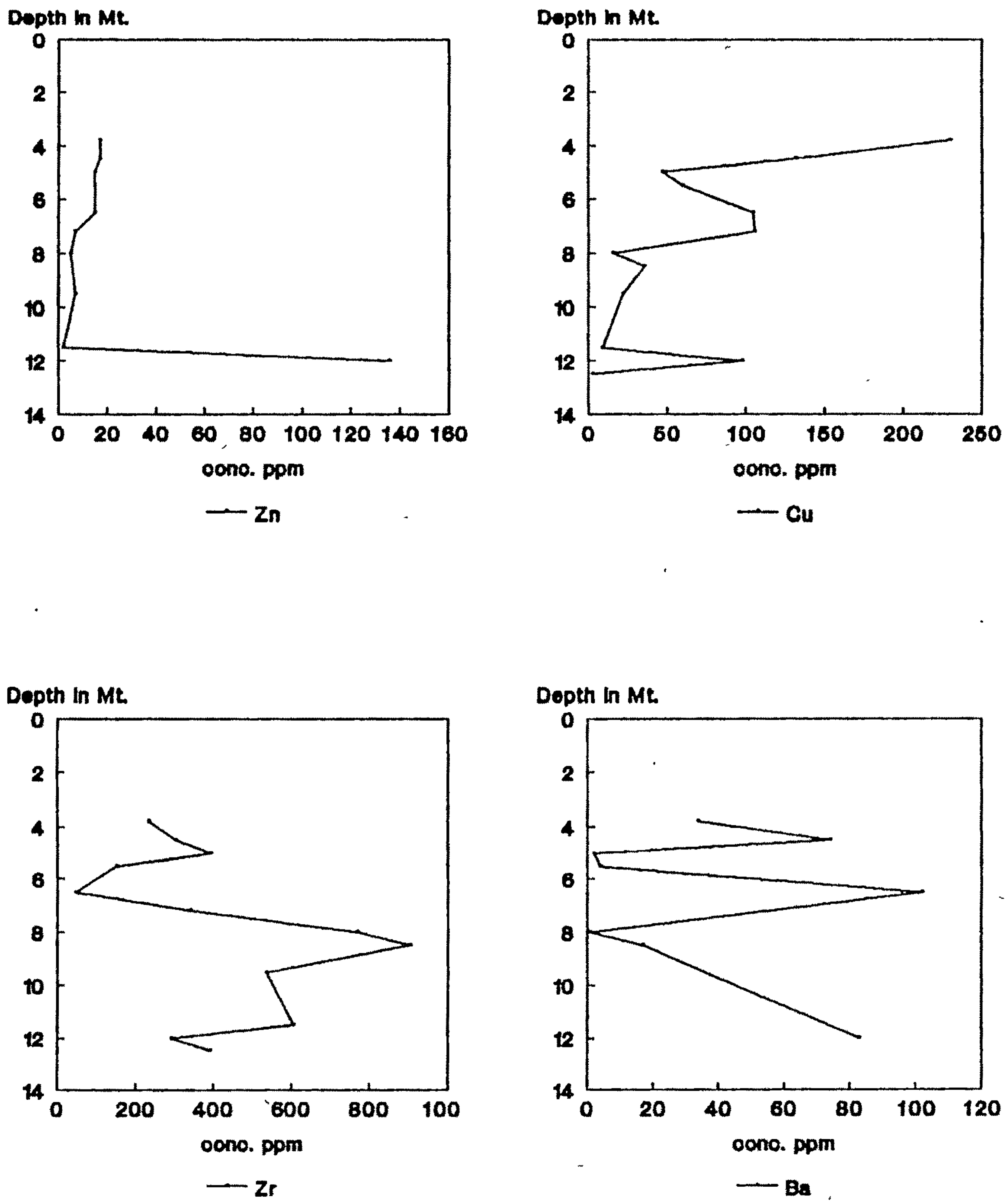
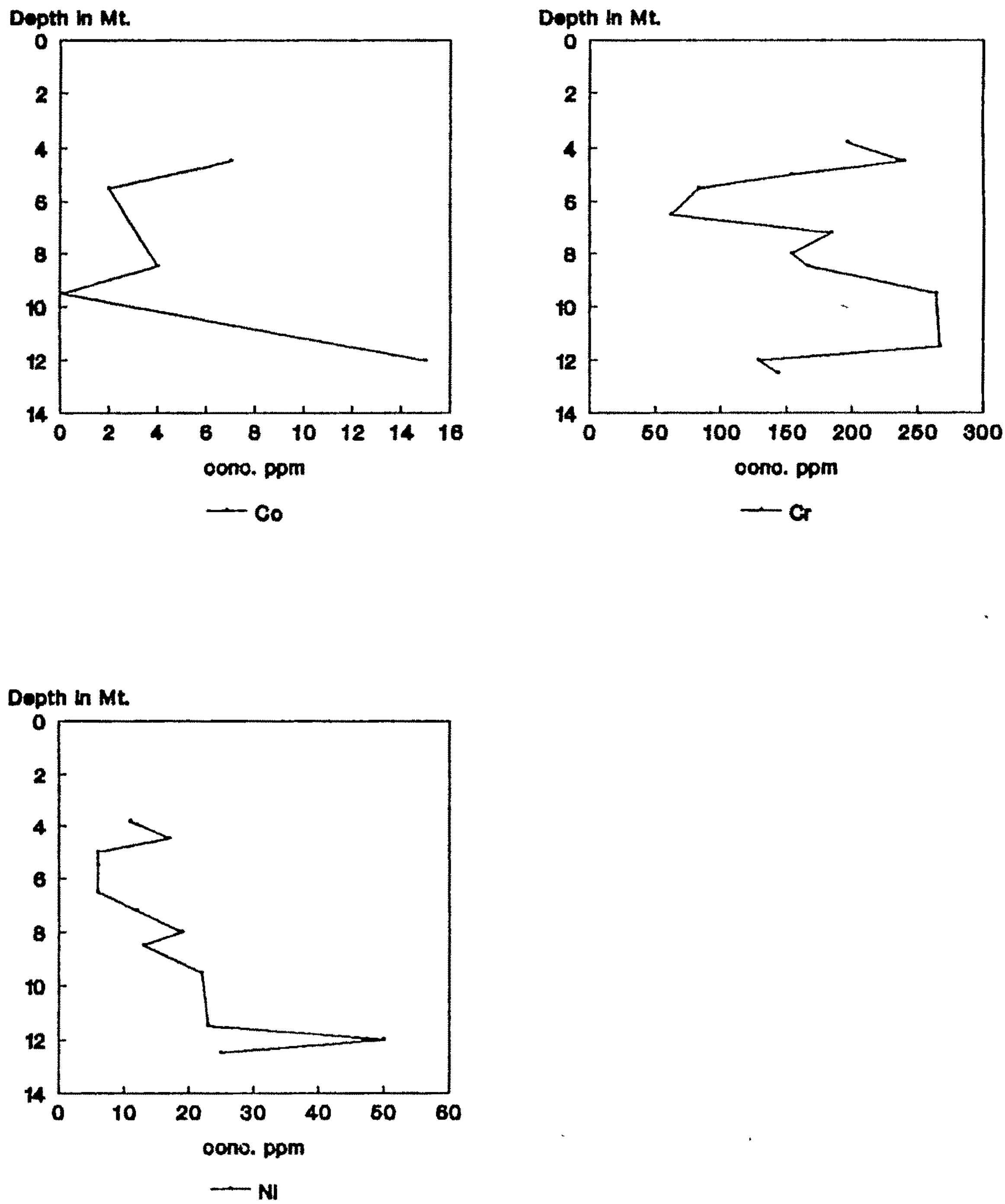


FIG : 22e

VARIATION DIAGRAM SHOWING THE MOVEMENT OF TRACE ELEMENTS AT THORADI



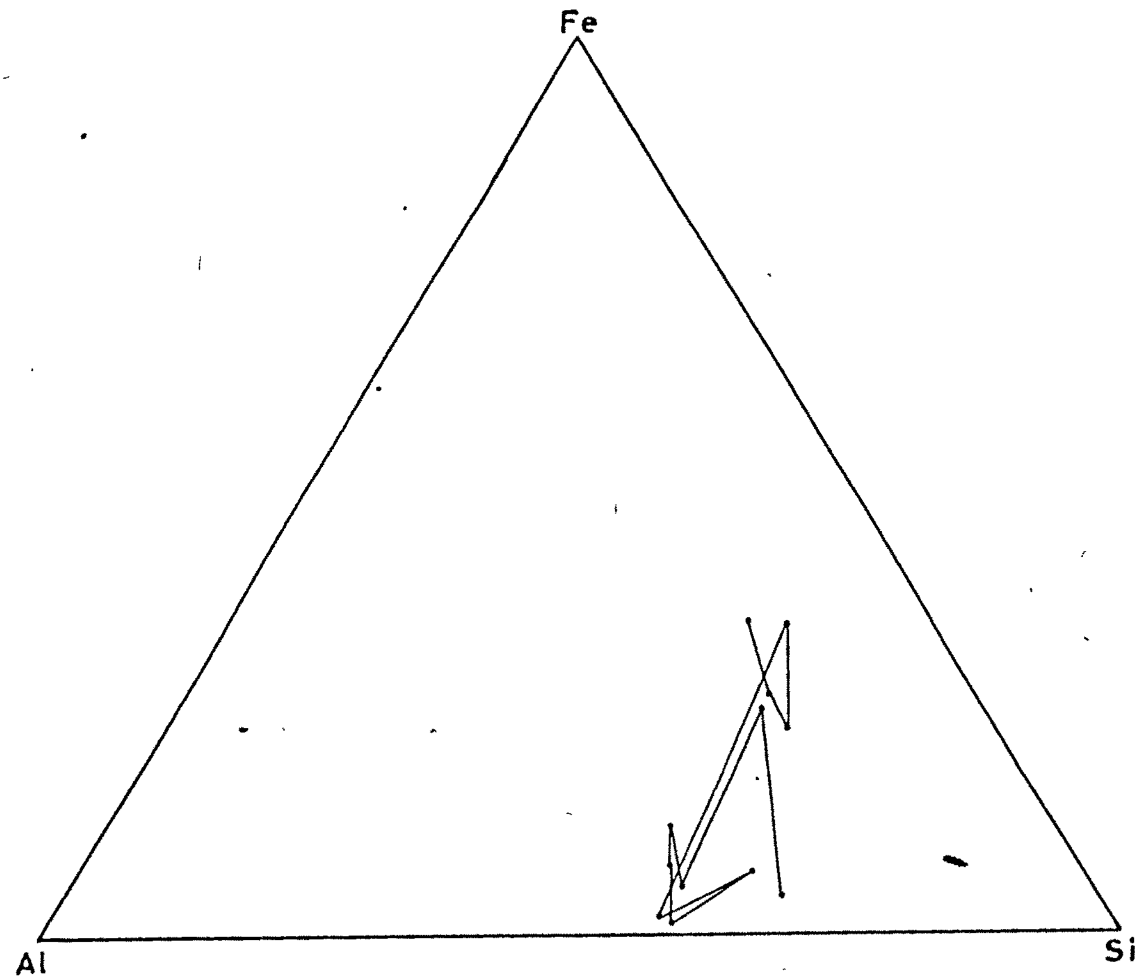


Fig 23: TRIANGULAR DIAGRAM REPRESENTING VARIATION IN CHEMICAL COMPOSITION OF THE SECTION AT THORADI

DISCUSSION

Variation within any element pattern of the eight profiles, in a first instance, is related to variations in the former parent material. Therefore, it may be difficult to explain the minor changes within the element patterns.

The analytical data as well as the plots of the sections at Thalsar, Devaliya, Morchand and Alang reveal that there is a progressive increase in iron content with a corresponding decrease in silica and alumina towards the top. The marked difference in **Fe/Al** concentrations in the top portions of the profiles is certainly a result of intensive weathering that favours more accumulation of iron than the enrichment of aluminium. The rapid increase of iron of atleast 200% to 400% (Tables 7,9,12 & 14) indicates a more intensive weathering.

Si is mobile throughout the profile, the maximum being in the lateritic horizon. The increased mobility in this zone can be indicative of free drainage conditions. Further, minimum mobility is observed at some places in the near bottom horizon i.e. in the bentonitic horizon indicating that quite a lot of silica must be going into the reconstitution of the neo-formed mineral assemblages and that the drainage must have been sluggish in contrast to the free drainage conditions in the upper horizons. It can be inferred that the drainage intensity increases towards the top due to silica removal (Altschuler, Dwornik & Kramer,1963). The profiles show a gradual vertical and lateral facies change from siallites to ferallites.

The concentration of Ti increases upwards in the profile indicating the residual nature of the laterite (du Bois & Jeffery, 1955; Hanlon, 1945).

The rapid vertical variation in the thickness of horizons and the element concentrations can be attributed to local factors.

The foregoing discussion suggests that in these four sections, the lower zone is of leaching and upper zone is of concretion. These profiles represent the in-situ or primary types of bentonites.

The irregular increase and decrease of Si, Al and Fe in the sections at Thoradi and Tagadi clearly indicate that it differs from the sections observed at Badi, Alang, Devaliya and Morchand. The sudden changes in various element concentration can only be explained by assuming their reworked nature. Thus the profile exposed at Thoradi and Tagadi represent a reworked type of bentonite.

Each trace element is characterised by its occurrence in a particular mineral which ultimately depends upon the concentration and nature of the parent rock. Ba and Pb generally are present in potassium minerals biotite and potash feldspar. Mn, Co and Ni are generally confined to olivine. Pyroxenes are enriched in Cr. Thus it can be summarised that majority of the trace elements are confined to plagiclase feldspars, pyroxenes and olivine. All these three minerals are essential constituents of the Deccan basalts.

Schroll and Sauer (1968) plotted the **Cr/Ni** ratios of some bauxitic profiles from Austria. The bentonites under investigation, when refered to mean values of different rocks obtained by Turekia and Wedepohl (1961), indicate that the bentonites have originated from the basaltic rocks.

Zr in most of the profiles increases upwards in the profile. It is allied to titanium in its properties (Read, 1947). Zirconium appears as zircon which is a resistant mineral and accumulates upwards in the profile as evident in all the profiles except at Thoradi and Tagadi. Thus it suggests a residual nature of the profiles at Badi, Thalsar, Devaliya, Morchand, Alang and Padwa.

Cr is an extremely resistant element (de Vletter,1955). Iron and chromium behave similarly in the profile (Frasche, 1941; McFarlane, 1969). Both increase upwards as seen at Badi, Thalsar, Morchand and Padwa. Its increase upwards is a further indication of the residual nature of the profiles.

de Vletter (1955) suggested that chromium may work itself down the profile due to its high specific gravity.

Ni is concentrated at the lower portions of the profile in almost all the sections, because at the top it goes into solution (Fischer, 1958; de Vletter, 1955). The only exception is at Morchand where **Ni** is concentrated in the middle parts of the profile. In almost all the sections **Ni** shows an increased mobility throughout the profile with a maximum in the upper horizons. The increased mobility in the upper horizons oan be suggestive that Ni went into solution at the top, and was carried along with the circulating waters, but neither magnesia nor silica were stable in those profiles resulting in no deposition at Padwa, Badi, Alang and Thalsar and slight redeposition at Morchand and Devaliya (Fischer, 1958; de Vletter, 1955).

The behaviour of Ba, Zn and Cu is very erratic and not properly understood. This may be due to some local conditions.

TESTS FOR DETERMINING THE INDUSTRIAL UTILITY

The bentonite samples collected from different mines were analysed according to IS : 6186 - 1971 (Specification for bentonites).

I. Swelling Index

2.0 gm of dried bentonite is added in 20 approximately equal proportions at intervals of two minutes to 100 ml solution of sodium lauryl sulphate (1% w/v) contained in 100 ml measuring cylinder. The material shall satisfy the requirement of the test if it swells to an apparent volume of not less than 24 ml in 24 hours.

Results:

TABLE 24

	Location	:	Swelling Index
1.	Thoradi	:	4.8
2.	Thalsar	:	8.9
3.	Tagadi	:	5.5

4.	Badi	:	11.5
5.	Padwa	:	12.7
6.	Budhel	:	11.4
7.	Morchand	:	14.8
8.	Devaliya	:	13.3
9.	Mathwada	:	12.4
10.	Alang	:	9.4
11.	Rajpara	:	11.2
12.	Sakhavadar	:	12.3

II. Gel Formation Value

1.4 gm of dried bentonite is mixed with 2.6 gm of alumina and 0.2 gm of MgO and shaken with 100 ml water for one hour in a stoppered measuring cylinder. The contents are allowed to stand for 24 hours. The volume of the supernatant liquid is measured and substracted for 100 ml. This roughly gives the gel index.

Results:

TABLE 25

	Location	:	Gel Formation Value
1.	Thoradi	:	19
2.	Thalsar	:	23
3.	Tagadi	:	16
4.	Badi	:	17
5.	Padwa	:	21
6.	Budhel	:	25
7.	Morchand	:	16

8.	Devaliya	:	17
9.	Mathwada	:	22
10.	Alang	:	15
11.	Rajpara	:	18
12.	Sakhavadar	:	20

III. Base Exchange Capacity

The method comprised leaching of 5 gm sample of bentonite by agitation in a standard 200 cc centrifuge bottle with 100 cc 1 N ammonium acetate $(NH_4C_2H_3O_2)_2$ for a period of 30 to 40 min. a revolving laboratory mixing rolls by rotating at 15 rpm. After the leaching, the contents were centrifuged at the rate of about 2000 rpm until the solution became clear. Time for such centrifuging varied from 10 minutes to 60 minutes for different samples. The clear solutions was removed by decantation. Another 100 cc leach liquor was added to the residue at the bottom of the centrifuging bottle, the clay mass was dispersed by shaking and the agitation and centrifuging operations were repeated. After decantation the residue obtained from leaching with ammonium acetate was treated with successive 100 cc portions of 80% neutral ethyl alcohol and same agitation and centrifuging procedures were repeated.

Washing was repeated till the last traces of the excess leach liquor disappeared as tested by Nessler's reagent. The residue obtained in this manner were analysed for NH_4 by qualitative micro-kjeldhal's method.

Results:

TABLE 26

	Location	:	Base Exchange Capacity in meq/100 gm
1.	Thoradi	:	48.36
2.	Thalsar	:	51.29
3.	Tagadi	:	39.50
4.	Badi	:	44.29
5.	Padwa	:	38.54
6.	Budhel	:	42.46
7.	Morchand	:	54.59
8.	Devaliya	:	49.11
9.	Mathwada	:	50.55
10.	Alang	:	51.42
11.	Rajpara	:	46.67
12.	Sakhavadar	:	44.92

IV. pH

2.0 gm of bentonite is added to 100 ml of water and mixed thoroughly. The pH is measured by using glass electrodes.

Results:

TABLE 27

	Location	:	pH at working temperature
1.	Thoradi	:	10.3
2.	Thalsar	:	9.9
3.	Tagadi	:	8.6

4.	Badi	:	9.4
5.	Padwa	:	9.7
6.	Budhel	:	11.4
7.	Morchand	:	7.4
8.	Devaliya	:	8.3
9.	Mathwada	:	8.5
10.	Alang	:	9.2
11.	Rajpara	:	10.7
12.	Sakhavadar	:	9.1

V. Filtration Loss

Each part of the mud cell of the filter press should be clean and dry. A paste is made of 7 gm of the dried material with 93 ml of water with the electric stirrer and allowed to age for 24 hrs. at 30° C. The freshly stirred sample is poured into the cell and the temperature is maintained throughout the experiment at 30° C. A dry graduated cylinder is placed under the drain tube to receive the filtrate. Close the release valve and adjust the regulator so that a pressure of 7 kg/cm3 is applied in 30 seconds or less. The test period begins at the time of pressure application. At the end of 30 minutes, the volume of the filtrate is measured, and is reported as millilitres as the filtration loss in 30 minutes at 76 kg/cm3 pressure.

Results:

TABLE 28

	Location		Filtration Loss
1.	Thoradi	:	38
2.	Thalsar	:	49
3.	Tagadi	:	54
4.	Badi	:	66
5.	Padwa	:	59
6.	Budhel	:	75
7.	Morchand	:	69
8.	Devaliya	:	76
9.	Mathwada	:	74
10.	Alang	:	59
11.	Rajpara	:	62
12.	Sakhavadar	:	61

VI. Moisture Content

A sufficient quantity of tampered sand mixture is taken in a standard sand rammer. After levelling the sand in the container, the head of the rammer is gently lowered till it rests on the surface of the sand. The rammer is slowly raised to its full height and then released. This is repeated two more times, making a total of three rams to get the standard test specimen which should be 50.8 ± 0.3 mm in height and 50.8 mm in diameter.

After the preparation of the sample, 100 gm of the sample is taken in a porcelain dish and dried in an oven between 105 to 110° C for about one hour. Then it is cooled at room temperature and washed. This process is repeated until a constant weight is attained. The percentage moisture is calculated by the following formula

Moisture % = A/B x 100

where A = loss of weight of the sample in gm on heating
and
B = weight in gm of the sand sample before heating

Results:

TABLE 29

	Location	:	**Moisture Content in %**
1.	Thoradi	:	4.83
2.	Thalsar	:	6.39
3.	Tagadi	:	5.75
4.	Badi	:	4.86
5.	Padwa	:	3.98
6.	Budhel	:	4.32
7.	Morchand	:	2.78
8.	Devaliya	:	5.66
9.	Mathwada	:	4.96
10.	Alang	:	6.95
11.	Rajpara	:	8.34
12.	Sakhavadar	:	4.11

VII. Fineness (Dry)

200 gm of the powdered bentonite is dried. 50 gm of the dried sample is seived in the normal manner using 150 micron and 75 micron seives for 15 minutes. The amount of bentonite retained on the seives is then weighed. These weights are substracted from

the amount of bentonite taken and reported as percent weights of bentonite passing through 150 micron and 75 micron IS seives respectively.

Results:

TABLE 30

	Location	:	Dry Fineness 75 micron passing in %	Dry Fineness 150 micron passing in %
1.	Thoradi	:	73.76	99.46
2.	Thalsar	:	69.43	99.74
3.	Tagadi	:	86.34	99.78
4.	Badi	:	76.99	99.95
5.	Padwa	:	76.94	99.86
6.	Budhel	:	77.64	99.74
7.	Morchand	:	64.38	99.23
8.	Devaliya	:	70.53	99.80
9.	Mathwada	:	84.97	99.96
10.	Alang	:	85.65	99.92
11.	Rajpara	:	74.98	99.48
12.	Sakhavadar	:	81.75	99.17

VIII. Fineness (wet)

10 gm of dried sample of bentonite is kept in a 500 ml bottle and 350 ml of water is gradually added to it. The mixture is seived through 45 micron IS seives then washed, dried and weighed. The weight of the residue obtained on 45 micron IS seive is substracted from the amount of clay taken and the result is reported as percent weight passing through 45 micron IS seive.

Results:

TABLE 31

	Location	:	Wet Fineness 45 micron passing in %
1.	Thoradi	:	82.80
2.	Thalsar	:	84.35
3.	Tagadi	:	86.29
4.	Badi	:	85.34
5.	Padwa	:	91.65
6.	Budhel	:	87.34
7.	Morchand	:	85.97
8.	Devaliya	:	85.03
9.	Mathwada	:	90.18
10.	Alang	:	84.38
11.	Rajpara	:	88.74
12.	Sakhavadar	:	79.89

IX. Specific Gravity

Specific gravity was determined with respect to kerosene using specific gravity bottle.

$$\text{Specific gravity of the bentonite with respect to kerosene} = \frac{\text{weight in air}}{\text{weight in air} - \text{app. weight in kerosene}}$$

Results:

TABLE 32

	Location	:	**Specific Gravity**
1.	Thoradi	:	2.36
2.	Thalsar	:	2.41
3.	Tagadi	:	2.48
4.	Badi	:	2.61
5.	Padwa	:	2.38
6.	Budhel	:	2.49
7.	Morchand	:	2.42
8.	Devaliya	:	2.61
9.	Mathwada	:	2.53
10.	Alang	:	2.64
11.	Rajpara	:	2.38
12.	Sakhavadar	:	2.39

From the analytical data it is inferred that the bentonites of the study area are suitable for foundry industry, in drilling as a drilling mud, and in various chemical and cosmetic industries.