

CHAPTER 6 - CONCLUSIONS

In this thesis, the sedimentary geochemistry at two contrasting sites at the Oman Margin have been investigated in some detail. Most investigations of the role of electron acceptors in the diagenetic degradation of marine OM have concentrated on sediments with relatively low organic carbon contents (Froelich et al. 1979; Wolff et al. 1995; Slomp et al. 1997). On the other hand, those studies concerned with organic rich sediments have generally concentrated on the characterisation and reactivity of the OM itself (e.g studies of Peru Margin, Henrichs et al. 1984; Patience et al. 1990; Lückge et al. 1996). The role of microbial reduction of Fe (III) to Fe (II) has been investigated in this study because of its influence on iron geochemistry and also because Fe(III) is one of the most abundant potential electron acceptors for organic matter decomposition in aquatic sediments and subsurface environments (Lovely, 1991). Fe (III) and Mn(IV) reduction in the oxidation of organic matter are generally only geochemically significant processes in anoxic environments. This thesis has therefore concentrated on the OM rich sediments from the Arabian Sea in order to gain an understanding of OM diagenesis and of the geochemistry of the electron acceptors, Mn and Fe. The chosen sites were from the most intense part of the Oxygen Minimum Zone at 400 m, i.e. on the continental slope, and secondly in much deeper abyssal water at the base of the continental margin, where bottom waters were oxygenated. The geological setting and sedimentation processes at the latter sites have resulted in a very complex pattern of sedimentation, whereas at the OMZ, the sediments were fine muds of seemingly uniform composition.

The main hypothesis to be tested by the study of these sediments were as follows:

1. To assess whether the solid state speciation technique for trace metals yields data that are “geochemically consistent” for organic rich sediments.
2. To determine whether there is any relationship between the diagenetic fate of OM reactive fractions (namely hydrolysable amino acids and carbohydrates) and the trace metal solid state speciation, as was, for example, observed in turbidic sediments from the Maderira Abyssal Plain (Sutton, 1996).

The identification of a highly enriched layer of “new” manganese oxides (Mn_3) in sediments from the abyssal sites was ascribed to their bacterial reduction, upward migration and reprecipitation. The apparent “non-reactivity” of the more recalcitrant Mn fractions identify by sequential leaching demonstrates the value of the solid state speciation technique. The sequential extraction technique certainly provided an insight into the geochemistry of the sediments, and suggested, for example, the “reactive” profile observed for “new” iron oxides did **not** reflect bacterial processes; rather the Fe_3 is a non-participating passenger in the recycling of the Mn_3 “new oxides”. Unfortunately, the solid state speciation technique did **not** provide information on reactive metals in the sediments from the OMZ, largely because these had apparently been removed. However, the study of the organic geochemistry of these sediments showed that they were not highly diagenetically active, and that the OM in the sediments was relatively degraded. The reasons for this are not clear, but may reflect the residence time of the OM in the water column. Whatever the explanation, there is certainly no relationship between reactive or non-reactive trace metal fractions and the organic geochemistry of the sediments.

In summary, the more specific conclusions regarding the geochemistry of sediments at the Oman Margin were as follows:

1. The speciation signature of trace metals (Mn, Fe and Cu) vary in the abyssal sediments and can be related to the depositional environment.
2. The two contrasting environments at the Oman Margin show distinct diagenetic behaviour of trace metals.
3. The reactive form of solid phase Mn showed a “classic” feature of enrichment in the upper layer of the sediments at the abyssal site. This revealed the presence of an oxidising sedimentary layer which acts as a Mn trap during its recycling.
4. A similar processes was not observed in the OMZ which probably reflects the depletion of Mn in the reducing sediments.
5. There is no evidence that during microbial OM degradation Fe is utilised as an electron acceptor.
6. Although the OM contents of the sediments from the OMZ are higher than those of the abyssal sediments, normalised values of THAA and THCH suggest that the former are considerably more refractory. Indeed, the OMZ sediments appear to have similar relative abundances of these organic constituents to sediments from the oligotrophic north Pacific (Lallier-Vergès and Alberic, 1990).

6.1. RECOMMENDATIONS FOR FUTURE WORK

1. Pore water analyses should be carried out in order to understand the distribution of trace metals between the dissolved and particulate phases, and to calculate the metal fluxes from the sediments to allow the establishment of a diagenetic model for manganese and iron.
2. Similar analyses could be extended from shelf to deep water and model could be developed to understand the metal transport from shelf to abyssal depths and also horizontal and vertical mixing processes.
3. A detailed study of iron mineralogy and its speciation in pore water and solid phases could provide a better understanding of its control and its reactivity with OM. Furthermore this would provide a record of the biogeochemical reactions and transport processes during early diagenesis.
4. Further studies on the biochemistry and microbial ecology of metal reduction would enhance the understanding of the factors controlling the rate and extent of redox-processes in the sediment.
5. Radiometric dating should be done in each section in order to calculate the sediment accumulation rate and organic matter flux into the sediment. The processes influencing the compositional variations and their relative importance are necessary to consider the absolute mass accumulation rates of these components through time. The accumulation rates of organic carbon and TOC values are mainly linked to the sedimentation rate. TOC concentrations transformed into mass accumulation rates of TOC can be used for the interpretation of changes in preservation conditions or supply of OM (Lückge *et al.*1996). Accumulation rates are more useful to differentiate between terrigenous and marine-derived organic carbon (*e.g.* Stein and

Littke, 1990). The calculation of mass accumulation rates of total organic carbon (MARTOC) used by van Andel et al. (1975) could be applied to understand further insight into the supply and preservation of OM (Stein et al. 1989). In this context, sedimentation rate and physical data required as explained by Suess et al. 1988 and Prell et al. 1989.

6. The characterisation of OM compositions using different technique may be used for better understanding of their reactivity during the redox-processes in the sediment. The organic carbon remineralization rate in marine sediments correlates very closely with carbon flux to the sediment surface. The extent of organic matter remineralization and factors responsible for difference in rate needs to be known. Certain fractions of constituent of sedimentary OM are rapidly decomposed, while others are resistant to decompose. So, the compositions of individual compounds making up the fractions of THAAs and THCHs, fatty acids should be identified (Haddad, 1989; Henrichs, 1993).

APPENDIX-A

Instrumental Parameters for Graphite Furnace AAS

Copper

Wavelength (nm) 324.8; Slit width (nm) 0.7

Integration time = 1.5 seconds ; 20 μ L sample

Stage 1

Step	Temp. ($^{\circ}$ C)	Ramp (s)	Hold (s)	Gas	Read
1	140	20	20	300	
2	250	10	10	300	
3	900	10	15	300	
4	2000	0	1	50	-0.1
5	2200	1	1	300	

Stage 2

Step	Temp. ($^{\circ}$ C)	Ramp (s)	Hold (s)	Gas	Read
1	150	20	25	300	
2	450	10	15	300	
3	900	10	10	300	
4	2000	0	1	50	-0.1
5	2300	1	1	300	

Stage 3

Step	Temp. ($^{\circ}$ C)	Ramp (s)	Hold (s)	Gas	Read
1	150	10	25	300	
2	400	15	15	300	
3	900	10	15	300	
4	2000	0	1	80	0.0
5	2300	1	1	300	

Stage 4

Step	Temp. (⁰ C)	Ramp (s)	Hold (s)	Gas	Read
1	150	10	25	300	
2	450	20	15	300	
3	900	10	15	300	
4	2000	0	1	50	-0.1
5	2300	1	1	300	

Stage 5

Step	Temp. (⁰ C)	Ramp (s)	Hold (s)	Gas	Read
1	170	15	20	300	
2	450	20	15	300	
3	900	10	15	300	
4	2000	0	1	200	0.0
5	2500	1	1	300	

APPENDIX-B
Data for Core 12687#8 and 12687#10

Table - B.1.1 - Water content and Particle-size compositions in both cores.

Core: 12687#8					Core: 12687#10			
Depth (mm)	% Water content	Clay (%)	Sand (%)	Silt (%)	% Water content	Clay (%)	Sand (%)	Silt (%)
0-10	88.3	N.A	N.A	N.A	88.4	N.A	N.A	N.A
10-20	80.8	13	15	72	85.2	21	10	69
20-30	77.3	13	15	72	79.6	13	8	79
30-40	73.5	14	17	69	75.6	15	8	77
40-50	71.9	14	18	68	72.6	20	14	66
50-60	70.4	13	19	68	71.4	17	10	73
60-70	69.5	15	17	68	71.0	19	10	71
70-90	68.1	10	20	70	71.0	24	11	65
90-110	63.5	11	17	62	70.6	9	10	81
110-130	25.8	2	77	21	53.8	12	30	58
130-150	27.2	2	87	11	31.5	6	44	50
150-170	32.2	2	85	13	33.2	5	56	39
170-190	26.6	4	79	17	28.1	4	66	30
190-210	59.3	13	14	73	35.7	6	66	28
210-230	58.8	14	3	83	46.7	12	46	42
230-250	57.3	15	13	72	59.4	20	16	64
250-270	56.4	18	15	67	58.5	20	14	66
270-290	53.5	16	6	82	58.1	23	9	68
290-310					57.7	22	10	68
310-330					56.6	18	11	71

N.A - Not Analysed

Table - B.1.2 - Concentrations of Major elements as wt. (%) in core: 12687#8.

Depth (mm)	Concentration (%)					
	CaO	MgO	K ₂ O	TiO ₂	Al ₂ O ₃	SiO ₂
0-10	0.64	3.99	1.65	0.63	10.06	74.07
10-20	0.72	3.05	1.62	0.50	9.17	76.06
20-30	0.71	4.15	1.69	0.65	9.83	75.64
30-40	0.66	4.02	1.58	0.59	9.77	73.12
40-50	0.71	4.00	1.65	0.61	9.86	75.64
50-60	0.70	3.88	1.64	0.59	9.49	74.04
60-70	0.79	4.42	1.69	0.62	9.97	76.22
70-90	0.69	3.89	1.48	0.57	9.39	74.49
90-110	0.83	3.41	1.44	0.53	8.68	70.18
110-130	1.36	1.66	1.91	0.61	8.68	92.93
130-150	1.09	1.48	2.25	0.36	8.16	101.71
150-170	1.21	1.65	2.13	0.48	8.21	98.41
170-190	1.19	1.59	2.04	0.58	8.45	97.67
190-210	0.93	5.39	1.99	0.71	12.01	75.33
210-230	0.85	5.03	2.16	0.74	13.18	78.18
230-250	0.81	4.57	1.89	0.65	10.86	68.94
250-270	1.02	4.79	1.95	0.69	11.97	73.19
270-290	0.93	4.97	2.04	0.71	12.44	74.28

Table - B.1.2.1 - Concentrations of Major elements as wt. (%) in core 12687#10.

Depth (mm)	Concentration (%)					
	CaO	MgO	K ₂ O	TiO ₂	Al ₂ O ₃	SiO ₂
0-10	1.45	7.32	3.0	1.06	18.62	110.18
10-20	0.44	2.47	1.1	0.37	6.21	38.45
20-30	0.76	4.24	1.82	0.64	10.65	65.80
30-40	0.64	3.96	1.61	0.59	9.70	63.98
40-50	0.74	4.19	1.71	0.59	9.96	68.40
50-60	0.75	4.41	1.68	0.61	9.86	67.96
60-70	0.75	4.14	1.64	0.58	9.53	66.40
70-90	0.81	3.77	1.51	0.54	9.02	64.03
90-110	0.63	4.30	1.55	0.56	8.91	63.55
110-130	1.20	3.38	1.80	0.73	9.62	70.85
130-150	1.43	2.80	2.04	0.59	9.45	81.98
150-170	1.28	2.65	2.09	0.53	9.16	82.69
170-190	1.48	2.12	2.00	0.56	8.24	87.26
190-210	1.38	2.10	2.00	0.59	8.30	91.49
210-230	1.45	2.92	2.08	0.88	9.47	88.55
230-250	0.92	4.78	2.14	0.71	11.03	75.59
250-270	1.00	5.13	2.30	0.74	11.93	78.50
270-290	0.97	5.03	2.23	0.71	10.88	72.52
290-310	1.00	5.56	2.31	0.77	11.84	77.85
310-330	1.05	5.44	2.29	0.72	10.89	72.34

Table - B.1.3 - Concentrations of Manganese in each operationally-defined fractions: Core 12687#8.

Depth (mm)	Concentration (µg/g)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-10	11.0	149.2	7895.1	105.5	21.3	8182.1
10-20	10.8	105.2	9604.5	105.8	16.5	9842.8
20-30	9.7	204.2	7045.2	120.3	20.7	7400.1
30-40	24.1	188.2	920.2	44.8	25.7	1203.0
40-50	49.1	193.0	243.3	48.1	19.8	553.9
50-60	70.5	242.7	438.9	56.7	22.6	831.4
60-70	57.6	234.2	221.9	53.3	16.7	583.7
70-90	50.9	161.7	74.7	48.4	14.2	349.9
90-110	24.2	101.2	27.2	29.4	18.0	200.0
110-130	10.9	61.1	8.1	14.1	5.8	100.0
130-150	10.2	45.2	8.4	8.6	6.6	79.0
150-170	12.8	44.2	6.5	10.6	5.2	79.3
170-190	10.4	45.6	5.8	16.1	4.2	82.1
190-210	20.3	122.2	32.4	51.7	17.7	244.3
210-230	21.7	33.6	25.6	52.3	20.7	153.9
230-250	33.7	142.1	11.0	41.5	21.6	249.9
250-270	27.2	137.0	25.4	48.2	21.7	259.5
270-290	36.5	157.3	15.7	50.5	15.7	275.7
Mean	27.3	131.6	1478.3	50.3	16.4	1703.9
Each stage(%)	1.6	7.7	86.8	3.0	1.0	

N.D - Not Detectable

Table - B.1.3.1 - Concentrations of Manganese in each operationally-defined fractions: Core 12687#10.

Depth (mm)	Concentration (µg/g)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-10	N.D	186.5	4751.1	77.8	N.D	5051.4
10-20	N.D	157.9	6379.7	120.9	N.D	6658.5
20-30	N.D	189.9	9319.9	234.8	N.D	9744.6
30-40	31.2	252.2	2106.9	116.0	N.D	2506.3
40-50	58.5	204.0	244.3	100.6	N.D	607.4
50-60	59.2	154.1	N.D	85.7	N.D	299.0
60-70	55.5	114.3	N.D	67.2	N.D	237.0
70-90	45.2	100.6	N.D	42.1	N.D	187.9
90-110	31.8	90.6	N.D	47.3	N.D	169.7
110-130	27.1	93.6	N.D	43.3	N.D	164.0
130-150	13.0	86.9	N.D	32.1	N.D	132.0
150-170	13.2	80.1	N.D	34.4	N.D	127.7
170-190	9.8	69.6	N.D	26.0	N.D	105.4
190-210	11.9	63.3	N.D	24.1	N.D	99.3
210-230	23.9	80.6	N.D	72.0	N.D	176.5
230-250	26.7	85.5	N.D	95.0	N.D	207.2
250-270	26.7	83.6	N.D	79.7	N.D	190.0
270-290	26.7	96.7	N.D	84.0	N.D	207.4
290-310	24.6	102.9	N.D	97.7	N.D	225.2
310-330	32.0	112.9	N.D	103.9	N.D	248.8
Mean	25.9	120.3	1140.1	79.2	N.D	1365.5
Each stage(%)	1.9	8.8	83.5	5.8		

N.D - Not Detectable

Table - B.1.4 - Concentrations of Iron in each operationally-defined fractions:
Core 12687#8.

Depth (mm)	Concentration (µg/g)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-10	N.D	N.D	407.7	824.6	739.9	1971.7
10-20	N.D	N.D	449.8	1004.3	750.1	2204.2
20-30	N.D	N.D	408.1	1296.5	767.5	2472.1
30-40	N.D	N.D	224.9	864.4	994.3	2083.6
40-50	N.D	N.D	72.0	429.7	904.9	1406.6
50-60	N.D	N.D	76.6	337.7	841.3	1255.6
60-70	N.D	N.D	61.1	816.0	912.9	1790.0
70-90	N.D	N.D	33.1	1039.7	1219.3	2292.1
90-110	N.D	N.D	N.D	462.8	N.A	462.8
110-130	N.D	N.D	22.4	217.4	630.3	870.1
130-150	N.D	N.D	14.3	102.3	603.3	719.9
150-170	N.D	N.D	17.0	163.5	657.4	835.2
170-190	N.D	N.D	11.7	402.6	522.5	942.1
190-210	N.D	N.D	17.5	720.6	859.5	1591.8
210-230	N.D	N.D	N.D	792.8	1183.7	1994.0
230-250	N.D	N.D	N.D	311.4	888.5	1199.9
250-270	N.D	N.D	N.D	720.1	1179.8	1899.0
270-290	N.D	N.D	N.D	1283.0	1264.0	2547.0
MEAN	N.D	N.D	101.7	655.0	828.8	1585.5
Each stage (in %)	N.D	N.D	6.4	41.3	52.3	

N.D - Not Detectable

N.A - Not Analysed

Table - B.1.4.1 - Concentrations of Iron in each operationally-defined fractions:
Core 12687#10.

Depth (mm)	Concentration (µg/g)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-10	N.D	N.D	507.6	4546.0	273.9	5327.5
10-20	N.D	N.D	561.6	4548.0	345.7	5455.3
20-30	N.D	N.D	483.7	3877.0	303.5	4664.2
30-40	N.D	N.D	464.8	4574.0	373.3	5412.1
40-50	N.D	N.D	146.4	3803.9	491.9	4442.2
50-60	N.D	N.D	37.5	3711.9	533.8	4283.2
60-70	N.D	N.D	49.7	2961.0	509.9	3520.6
70-90	N.D	N.D	20.7	2166.3	1190.8	3377.8
90-110	N.D	N.D	3.0	2543.7	1762.1	4308.8
110-130	N.D	N.D	25.0	1613.5	1273.6	2912.1
130-150	N.D	48.2	21.0	1556.3	637.9	2263.4
150-170	N.D	41.1	17.4	1106.2	863.9	2028.6
170-190	N.D	39.0	16.1	840.2	648.5	1543.8
190-210	N.D	N.D	7.6	886.2	784.0	1677.8
210-230	N.D	N.D	3.0	3304.9	1014.2	4322.1
230-250	N.D	N.D	N.D	5117.8	851.0	5968.8
250-270	N.D	N.D	N.D	3186.7	868.8	4055.5
270-290	N.D	N.D	N.D	3067.9	748.6	3816.5
290-310	N.D	N.D	N.D	3730.4	731.5	4461.9
310-330	N.D	N.D	N.D	4552.2	678.8	5231.0
MEAN	N.D	6.4	118.3	3084.7	744.3	3953.7
Each stage(%)	N.D	0.2	3	78	18.8	

N.D - Not Detectable

Table - B.1.5 - Concentrations of Copper in each operationally-defined fractions:
Core 12687#8.

Depth (mm)	Concentration ($\mu\text{g/g}$)				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
0-10	N.D	N.D	N.D	N.D	20.7
10-20	N.D	N.D	N.D	N.D	20.3
20-30	N.D	N.D	N.D	N.D	23.3
30-40	N.D	N.D	N.D	N.D	22.0
40-50	N.D	N.D	N.D	N.D	23.7
50-60	N.D	N.D	N.D	N.D	23.4
60-70	N.D	N.D	N.D	N.D	23.2
70-90	N.D	N.D	N.D	N.D	21.8
90-110	N.D	N.D	N.D	N.D	9.6
110-130	N.D	N.D	N.D	N.D	1.8
130-150	N.D	N.D	N.D	N.D	2.3
150-170	N.D	N.D	N.D	N.D	3.5
170-190	N.D	N.D	N.D	2.1	3.3
190-210	N.D	N.D	N.D	2.3	24.3
210-230	N.D	N.D	N.D	3.4	21.1
230-250	N.D	N.D	N.D	4.5	25.8
250-270	N.D	N.D	N.D	4.2	20.7
270-290	N.D	N.D	N.D	5.8	17.3

N.D - Not Detectable

Table - B.1.5.1 - Concentrations of Copper in each operationally-defined fractions: Core 12687#10.

Depth (mm)	Concentration ($\mu\text{g/g}$)				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
0-10	N.D	N.D	N.D	3.8	21.1
10-20	N.D	N.D	N.D	4.7	23.8
20-30	N.D	N.D	N.D	1.6	24.5
30-40	N.D	N.D	N.D	N.D	26.0
40-50	N.D	N.D	N.D	N.D	27.6
50-60	N.D	N.D	N.D	N.D	30.8
60-70	N.D	N.D	N.D	N.D	28.9
70-90	N.D	N.D	N.D	N.D	28.6
90-110	N.D	N.D	N.D	N.D	27.4
110-130	N.D	N.D	N.D	N.D	11.6
130-150	N.D	N.D	N.D	2.4	4.1
150-170	N.D	N.D	N.D	1.9	3.4
170-190	N.D	N.D	N.D	1.3	1.8
190-210	N.D	N.D	N.D	1.6	4.6
210-230	N.D	N.D	N.D	2.2	21.5
230-250	N.D	N.D	N.D	2.9	27.2
250-270	N.D	N.D	N.D	2.6	25.7
270-290	N.D	N.D	N.D	3.3	24.8
290-310	N.D	N.D	N.D	2.8	30.7
310-330	N.D	N.D	N.D	7.7	23.3

N.D - Not Detectable

Table - B.1.6 - Total Organic Carbon (TOC), Total Nitrogen (TN), C:N ratio and Carbonate content (%): Core 12687#8.

Depth (mm)	TOC (%)	TN (%)	C:N ratio	%Carbonate (W/W)
0-10	2.162	0.274	7.9	57.2
10-20	1.950	0.227	8.6	44.0
20-30	2.240	0.277	8.1	51.2
30-40	2.223	0.272	8.2	52.6
40-50	2.274	0.267	8.5	53.1
50-60	2.542	0.299	8.5	52.2
60-70	2.332	0.273	8.5	51.8
70-90	3.113	0.349	8.9	53.1
90-110	3.337	0.353	9.5	56.9
110-130	0.185	0.016	11.9	46.3
130-150	0.163	0.011	14.7	45.9
150-170	0.343	0.028	12.2	56.8
170-190	0.356	0.033	10.8	44.8
190-210	1.781	0.218	8.2	49.4
210-230	1.609	0.189	8.5	49.7
230-250	1.575	0.188	8.4	51.6
250-270	1.870	0.231	8.1	52.2
270-290	1.556	0.170	9.2	54.6

Table - B.1.6.1 - Total Organic Carbon (TOC), Total Nitrogen (TN), C:N ratio and Carbonate content (%): Core 12687#10.

Depth (mm)	TOC (%)	TN (%)	C:N ratio	%Carbonate (W/W)
0-10	2.682	0.346	7.8	57.8
10-20	2.402	0.294	8.2	54.7
20-30	2.330	0.276	8.4	52.5
30-40	2.960	0.340	8.7	52.0
40-50	2.705	0.304	8.9	50.8
50-60	2.986	0.334	8.9	51.8
60-70	2.945	0.331	8.9	51.0
70-90	3.894	0.422	9.2	54.1
90-110	4.416	0.451	9.8	57.9
110-130	1.829	0.173	10.6	54.6
130-150	0.181	0.019	9.3	52.0
150-170	0.376	0.035	10.9	52.1
170-190	0.198	0.019	10.1	51.4
190-210	0.722	0.053	10.1	52.4
210-230	0.975	0.112	8.7	49.1
230-250	1.827	0.219	8.4	48.5
250-270	1.587	0.216	8.2	48.2
270-290	1.413	0.168	8.4	55.6
290-310	1.542	0.179	8.7	51.0
310-330	1.591	0.181	9.1	51.9

Table - B.1.7 - Total hydrolysable amino acids, carbohydrates and mole percentage: Core 12687#8

Concentration (μmolg^{-1})			% mole			
Depth (mm)	THCH	THAA	TaaC	Tsug-C	(Taa+Ts) OC	TaaN
0-10	24.3	61.1	11.1	8.1	19.2	50.9
10-20	25.5	26.5	5.3	9.4	14.7	26.7
20-30	28.4	45.5	8.0	9.1	17.1	37.5
30-40	27.7	53.0	9.3	9.0	18.3	44.5
40-50	25.9	55.1	9.5	8.2	17.7	47.1
50-60	27.4	35.8	5.5	7.8	13.3	27.4
60-70	19.6	31.4	5.3	6.1	11.3	26.3
70-90	27.3	46.5	5.8	6.3	12.2	30.4
90-110	25.1	39.5	4.6	5.4	10.1	25.6
110-130	2.4	3.9	8.3	9.3	17.6	55.7
130-150	2.5	2.8	6.7	11.0	17.8	58.2
150-170	3.8	3.1	3.5	8.0	11.5	25.3
170-190	3.3	2.4	2.6	6.7	9.3	16.6
190-210	17.8	10.8	2.4	7.2	9.6	11.3
210-230	14.8	9.3	2.3	6.6	8.9	11.2
230-250	15.2	15.0	3.7	6.9	10.7	18.2
250-270	11.7	11.7	2.5	4.5	7.0	11.6
270-290	8.5	6.1	1.5	3.9	5.5	8.2

Table- B.1.7.1 - Total hydrolysable amino acids, carbohydrates and mole percentage: Core 12687#10.

Depth (mm)	Concentration (μmolg^{-1})		% mole			
	THCH	THAA	TaaC	Tsug-C	(Taa+Ts) OC	TaaN
0-10	11.4	14.3	2.1	3.1	5.1	9.4
10-20	28.7	67.8	11.1	8.6	19.7	52.7
20-30	28.6	42.9	7.2	8.8	16.0	35.5
30-40	28.3	30.4	4.0	6.9	10.9	20.4
40-50	23.9	53.2	7.7	6.4	14.1	40.0
50-60	27.7	38.6	5.1	6.7	11.7	26.4
60-70	33.5	31.7	4.2	8.2	12.4	21.9
70-90	32.4	54.1	5.4	6.0	11.4	29.3
90-110	32.5	40.8	3.6	5.3	8.9	20.7
110-130	18.9	28.1	6.0	7.4	13.5	37.1
130-150	4.1	5.5	11.9	16.3	28.2	66.1
150-170	2.5	6.9	7.2	4.8	12.0	45.0
170-190	2.8	3.2	6.3	10.2	16.5	38.5
190-210	3.2	9.6	5.2	3.2	8.4	41.4
210-230	7.8	19.0	7.6	5.8	13.4	38.8
230-250	11.9	28.2	6.0	4.7	10.7	29.4
250-270	10.5	19.0	4.7	4.8	9.5	20.1
270-290	10.3	23.0	6.4	5.2	11.6	31.3
290-310	12.0	18.9	4.8	5.6	10.4	24.1
310-330	11.4	27.3	6.7	5.2	11.9	34.5

APPENDIX - C

Table - C.1.1 - Concentrations of Iron in each operationally-defined fractions:
Core
12690 #1.

Depth (mm)	Concentration ($\mu\text{g/g}$)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-5	N.D	N.D	N.D	408.9	365.9	774.8
5-10	N.D	N.D	N.D	424.4	704.1	1128.5
10-20	N.D	N.D	N.D	419.3	565.2	984.5
20-30	N.D	N.D	N.D	421.2	792.2	1213.4
30-40	N.D	N.D	N.D	397.8	746.2	1144.0
40-50	N.D	N.D	N.D	406.1	740.0	1146.7
50-60	N.D	N.D	N.D	421.6	617.9	1039.0
60-70	N.D	N.D	N.D	410.9	760.3	1171.2
70-90	N.D	N.D	N.D	474.8	1022.5	1497.3
90-110	N.D	N.D	N.D	520.4	1657.2	2177.6
110-130	N.D	N.D	N.D	628.3	1838.1	2466.4
130-150	N.D	N.D	N.D	483.3	1455.7	1939.0
MEAN	N.D	N.D	N.D	451.4	938.8	1390.2
Each stage (in %)	N.D	N.D	N.D	32.5	67.5	

N.D - Not Detectable

Table - C.1.2 - Concentrations of Iron in each operationally-defined fractions:
Core
12692 #1.

Depth (mm)	Concentration ($\mu\text{g/g}$)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-5	N.D	N.D	N.D	1621.5	434.5	2056.0
5-10	N.D	N.D	N.D	1469.8	686.1	2155.9
10-20	N.D	N.D	N.D	1443.9	623.2	2067.1
20-30	N.D	N.D	N.D	1338.6	717.3	2055.9
30-40	N.D	N.D	N.D	1082.2	914.2	1996.4
40-50	N.D	N.D	N.D	891.0	968.0	1859.0
50-60	N.D	N.D	N.D	941.0	1060.8	2001.8
60-70	N.D	N.D	N.D	789.7	1091.7	1881.4
70-90	N.D	N.D	N.D	550.1	856.1	1406.2
90-110	N.D	N.D	N.D	470.3	897.7	1368.0
110-130	N.D	N.D	N.D	490.2	806.2	1296.4
130-150	N.D	N.D	N.D	507.5	907.0	1414.5
MEAN	N.D	N.D	N.D	966.3	830.2	1796.6
Each stage (in %)	N.D	N.D	N.D	53.8	46.2	

N.D - Not Detectable

Table - C.1.3 - Concentrations of Iron in each operationally-defined fractions:
 Core
 12695#2.

Depth (mm)	Concentration ($\mu\text{g/g}$)					
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
0-5	N.D	N.D	N.D	579.2	416.8	996.0
5-10	N.D	N.D	N.D	563.9	470.4	1034.3
10-20	N.D	N.D	N.D	747.7	584.1	1331.8
20-30	N.D	N.D	N.D	787.4	702.5	1489.9
30-40	N.D	N.D	N.D	395.8	606.9	1002.7
40-50	N.D	N.D	N.D	383.7	814.7	1198.4
50-60	N.D	N.D	N.D	415.6	836.2	1251.8
60-70	N.D	N.D	N.D	598.5	1160.2	1758.7
70-90	N.D	N.D	N.D	497.5	1534.6	2032.1
90-110	N.D	N.D	N.D	446.6	1736.1	2182.7
110-130	N.D	N.D	N.D	488.4	2379.3	2867.7
130-150	N.D	N.D	N.D	481.9	1922.7	2404.6
MEAN	N.D	N.D	N.D	532.2	1097.0	1629.2
Each stage (in %)	N.D	N.D	N.D	32.7	67.3	

N.D - Not Detectable

Table - C.1.4 - Total Organic Carbon (TOC), Total Nitrogen (TN), C:N ratio and Carbonate content (%): Core 12690#1.

Depth (mm)	TOC (%)	TN (%)	C:N ratio	%Carbonate (W/W)
0-5	4.709	0.591	8.0	65.2
5-10	6.022	0.775	7.8	61.8
10-20	6.644	0.791	8.4	59.1
20-30	6.846	0.519	13.2	58.4
30-40	6.915	0.812	8.5	58.4
40-50	7.489	0.900	8.3	56.4
50-60	5.295	0.618	8.6	54.3
60-70	5.300	0.617	8.6	54.1
70-90	4.246	0.501	8.5	52.5
90-110	5.885	0.693	8.5	49.9
110-130	6.134	0.708	8.7	48.7
130-150	4.876	0.566	8.6	53.9

Table - C.1.5 - Total Organic Carbon (TOC), Total Nitrogen (TN), C:N ratio and Carbonate content (%): Core 12692#1.

Depth (mm)	TOC (%)	TN (%)	C:N ratio	%Carbonate (W/W)
0-5	6.490	0.823	7.9	64.1
5-10	4.944	0.633	7.8	63.7
10-20	7.248	0.886	8.2	61.2
20-30	7.002	0.833	8.4	59.4
30-40	5.830	0.674	8.7	59.0
40-50	6.521	0.751	8.7	58.4
50-60	7.318	0.997	7.3	55.8
60-70	7.293	0.882	8.3	53.7
70-90	7.100	0.805	8.8	52.3
90-110	6.614	0.790	8.4	56.3
110-130	5.445	0.667	8.2	58.6
130-150	6.571	0.527	12.5	52.7

Table - C.1.5 - Total Organic Carbon (TOC), Total Nitrogen (TN), C:N ratio and Carbonate content (%): Core 12695#2.

Depth (mm)	TOC (%)	TN (%)	C:N ratio	%Carbonate (W/W)
0-5	4.964	0.639	7.8	62.0
5-10	6.139	0.806	7.6	60.6
10-20	4.345	0.550	7.9	63.7
20-30	5.999	0.690	8.7	55.3
30-40	5.566	0.670	8.3	54.3
40-50	4.855	0.552	8.8	53.6
50-60	4.675	0.494	9.5	53.7
60-70	6.165	0.700	8.8	51.7
70-90	4.539	0.576	7.9	50.9
90-110	5.746	0.681	8.4	47.7
110-130	6.331	0.737	8.6	53.5
130-150	4.395	0.470	9.4	61.1

Table- C.1.6 - Total hydrolysable amino acids, carbohydrates and mole percentage: Core 12690#1.

Depth (mm)	Concentration (μmolg^{-1})		% mole		
	THCH	THAA	TaaC	TaaN	(Tsug.+Taa) OC
0-5	13.4	141.3	7.2	54.6	9.3
5-10	19.0	81.9	3.3	24.1	5.5
10-20	27.3	98.9	3.6	28.6	6.5
20-30	32.6	150.9	5.3	66.4	8.7
30-40	29.9	114.4	4.0	32.2	7.1
40-50	37.0	102.7	3.3	26.1	6.8
50-60	25.8	109.6	5.0	40.5	8.5
60-70	16.6	90.4	4.1	33.5	6.3
70-90	31.9	95.7	5.4	43.6	10.8
90-110	25.5	132.1	5.4	43.5	8.5
110-130	24.2	119.5	4.7	38.6	7.5
130-150	21.4	91.7	4.5	37.0	7.7

Table- C.1.7 - Total hydrolysable amino acids and mole percentage: Core 12692#1

Depth (mm)	Concentration (μmolg^{-1})	% mole	
		TaaC	TaaN
	THAA		
0-5	109.1	6.6	30.3
5-10	145.6	11.5	52.5
10-20	103.0	5.6	26.6
20-30	159.3	8.9	43.7
30-40	110.3	7.4	37.4
40-50	106.8	6.4	32.5
50-60	101.4	6.1	23.2
60-70	81.3	5.4	21.1
70-90	119.5	7.6	33.9
90-110	87.0	6.5	25.2
110-130	74.9	6.5	25.7
130-150	123.2	8.8	53.4

Table- C.1.8 - Total hydrolysable amino acids and mole percentage: Core 12695#2

Depth (mm)	Concentration (μmolg^{-1})	% mole	
		TaaC	TaaN
	THAA		
0-5	112.6	5.4	40.3
5-10	87.2	3.4	24.7
10-20	97.4	5.4	40.5
20-30	149.9	6.0	49.6
30-40	81.7	3.5	27.9
40-50	90.8	4.5	37.6
50-60	73.8	3.8	34.1
60-70	81.9	3.2	26.7
70-90	90.5	4.8	35.9
90-110	112.6	4.7	37.8
110-130	75.1	2.8	23.3
130-150	78.0	4.3	37.9

APPENDIX-D

Figures showing the relationship between Fe and Mn (Stages 1-5) vs THCH and THAA in cores 12687#8, 12687#10, 12690#1, 12692#1 and 12695#2. (Figs. 5.22-5.25; 5.27-5.33- not significant).

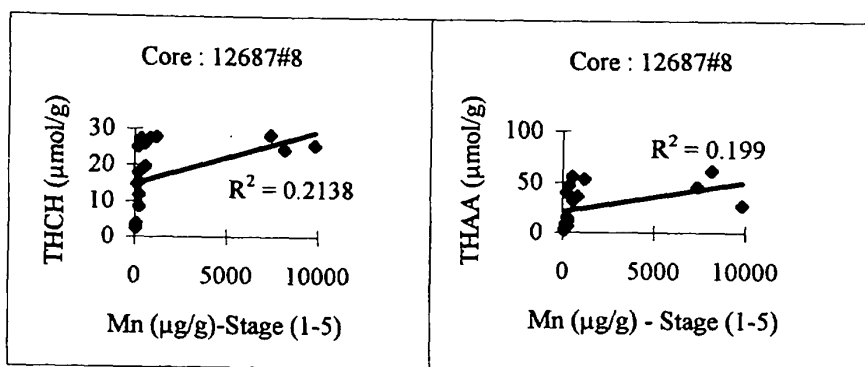


Fig. 5.22

Fig. 5.23

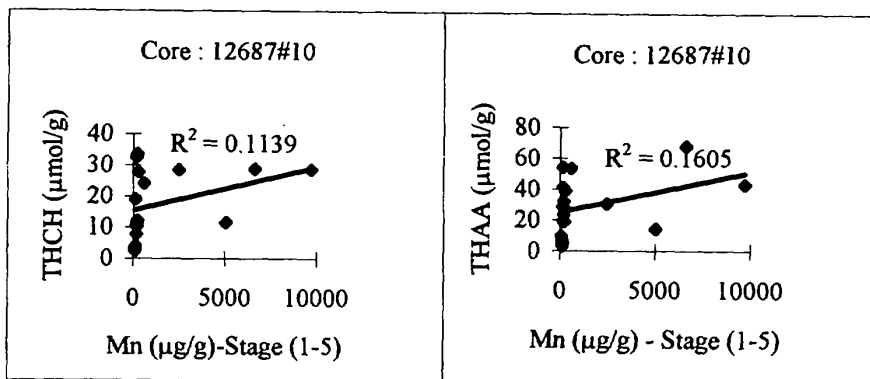
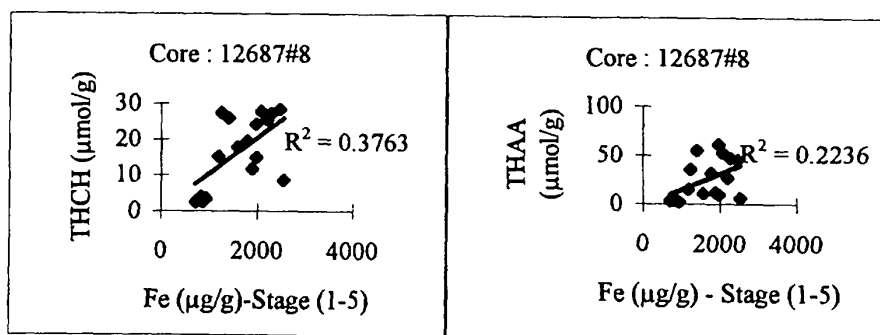


Fig. 5.24

Fig. 5.25



$p < 0.05$

Fig. 5.26

Fig. 5.27

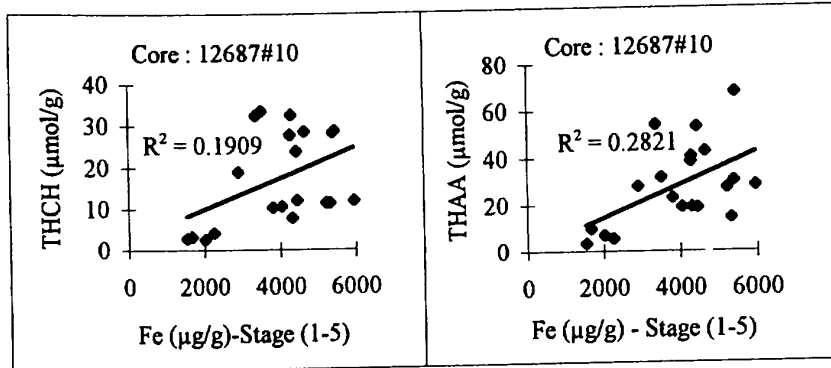


Fig. 5.28

Fig. 5.29

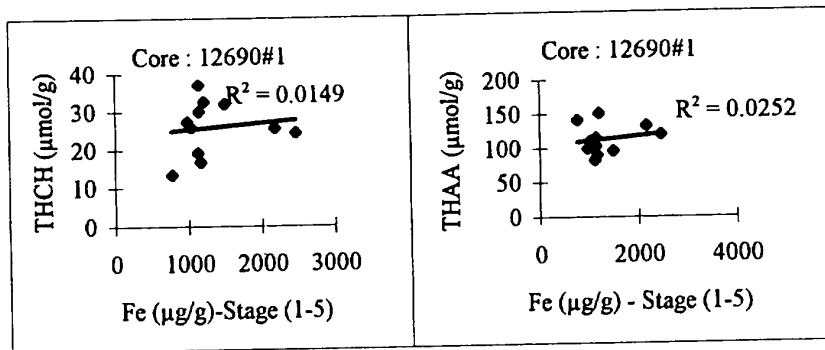


Fig. 5.30

Fig. 5.31

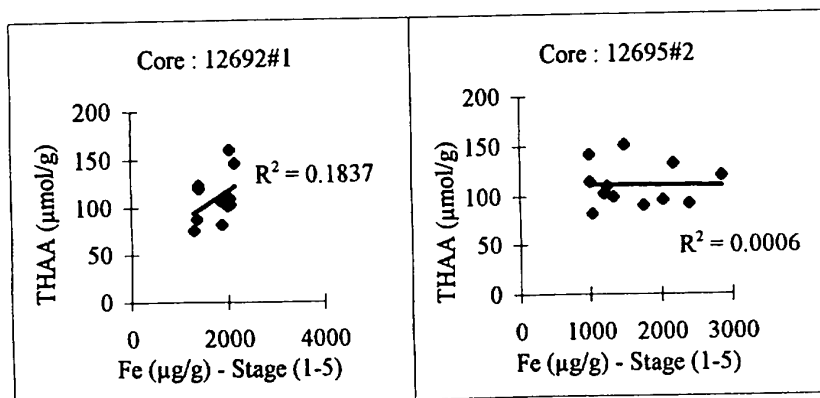


Fig. 5.32

Fig. 5.33

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