SEDIMENT INVESTIGATIONS

IN THE EASTERN MEDITERRANEAN SEA

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ABSTRACT

Cores from seventy one stations occupied on four different cruises to the eastern Mediterranean and the Aegean Sea, have been subjected to sedimentological and geochemical analyses. The cores were also described megascopically and microscopically.

Grain size analyses have been carried out on ninety samples, including most of the surface sediments (0-5 cm), and a selected group of the buried sediments and indicate the predominance of silty sediments in the region. Maps have been constructed showing the distribution of sands, silts and clays for both the surface layer and buried sediments. Five hundred and ten samples were analysed by atomic absorption spectrophotometry after digestive attack by nitric, perchloric and HF acids. One hundred and five size fractions were analysed chemically in the same way as the total samples and the concentrations of Ca, Al, Mg, Fe, Mn, Cu, Pb, Zn, Co, Cd, Cr, Ni and Ti were determined. Chemical partition studies were also carried out on a selected group of samples in order to understand the partition of elements between the different phases. Additionally, the calcium carbonate and organic carbon content were determined in surface layer sediments.

Geochemical distribution maps have been drawn for the surface layer sediments showing the distribution patterns of the $CaCO_3$, Ca, Al, Mg, Fe, Mn, Cu, Pb, Zn, Co, Cd, Cr, Ni, Ti and organic carbon. For the buried sediments, frequency distribution charts were developed, showing the vertical variations in the concentrations of $CaCO_3$ and of the same group of elements, studied in the surface layer.

The lithological and geochemical variations in the sediments can generally be explained by differences in the depositional environment and provenance, except in the trench area south and southeast of the island of Crete, where local factors are more important. Manganese is an exception throughout the area, and its distribution seems to be affected by secondary mobilisation and precipitation processes.

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CHAPTER 1

INTRODUCTION

Geographically, the eastern Mediterranean is situated between three continents. It is characterized by extreme geographic changes, variability of sea floor topography and relief, diversity of climate and coastline, and by its deep sea basins and trenches. It comprises the Aegean and Ionian Seas, the Levantine Basin with its trenches, the Mediterranean Outer Ridge (or the Mediterranean Rise), and the island arc configuration south of the Aegean (the Hellenic Island Arc).

The geology of the eastern Mediterranean Sea has a diverse and complex nature. Generally, it is a semi-closed basin. The basin is a long,elongated furrow between two converging lithospheric plates. It contains a large submarine fan, a ridge, a trench island arc system and numerous small abyssal plains and isolated basins. In the Hellenic Arc, there is a volcanic province with an active submarine volcano 'Santorini' in the south-central Aegean Sea. Tectonically, the area is believed to be a zone of subduction.

Structurally, the Hellenic Island Arc is the most remarkable feature in the region. It extends from the mountain chains on the mainland of Greece and passes through the Ionian Islands, Peloponnisos, Kithira, Andkithire, Crete, Kasos, Karpathos, Rhodes and on into Western Turkey. It includes both deep linear trenches and depressions that parallel the arc, and a broad outer ridge, described by Stride et al. (1977) as Hellenic, Calabrian and Cyprus outer ridges and previously known as the Mediterranean Ridge or East Mediterranean Ridge.

Between the islands and the ridge there is a large depression more than 1,500 km in length, the Hellenic Trough.

Stratigraphically, the area's complex nature has led to difficulty in correlation between sediment cores. Distinguishing the time-stratigraphic units and the relative ages of sediments is not easy. Cores contain volcanic ashes, sapropels, pelagic and hemi-pelagic lutites, marl oozes and turbidites. The correlation between sediments is based largely upon the volcanic ashes and sapropels formed when the area suffered repeated episodes of deep water stagnation when bottom-dwelling fauna were completely obliterated. In addition the intercalated tephra layers provide material for absolute age determinations.

Sedimentologically, the basin is characterised by a high rate of sediment input. The sediments are a poorly sorted mixture predominantly of clays, quartz, feldspars and heavy minerals. Each source area seems to be characterised by a certain mineral assemblage (McCoy 1974). The mechanism and paths of dispersal result in different types of sediments in different areas. The dispersal mechanisms are surface currents, suspended sediment plumes off the Nile delta and turbidity currents. The dispersal paths may be long, as in the southern part of the basin due to its smooth physiography, or short, such as in the northern part because of the irregular physiography of the small basins and trenches which prevent the lateral dispersal of the sediments. Certainly, the sedimentation in the region is a reflection of its environmental conditions.

The present study is of the middle part of the eastern Mediterranean Sea and the Aegean Sea. The study area includes the Strabo and Pliny trenches to the south of Crete and the Cyclades Volcanic Arc to the north, where Santorini is present.

The area sampled is located between longitudes 22°E and 29°E and between latitudes 34°N and 40° 30' N. Figure (1) is a location map of the study area. The sediment investigations were aimed at defining the transport and distribution of silt and clay, and to compare and contrast the geochemistry of the different types of sediments in the region.

A total of 71 sediment cores have been studied during the present work. This material was collected during four different cruises of the RRS Shackleton to the eastern Meditarranean. The first cruise was in mid.1972, during which material was collected from various parts of the Aegean Sea. The second cruise was in the same year during November and December. During this cruise, material was collected from the vicinity of Crete and some Aegean Islands. The third cruise was in 1974 during which material was collected between the islands of Thera and Milos. Additional material was provided from cruise 11A/1977 during which material was collected far south of the Hellenic Island Arc in the Outer Ridge area and between the deeps. Additional material was also provided from the H.S. Plias cruise of 1973 and from cruise number 33 of the German research vessel Meteor. Table (1) gives the complete details of the collection of material used in this study. Figure (2) shows the location of the core samples collected during the four cruises of the RRS Shackleton and the other material used in this study.

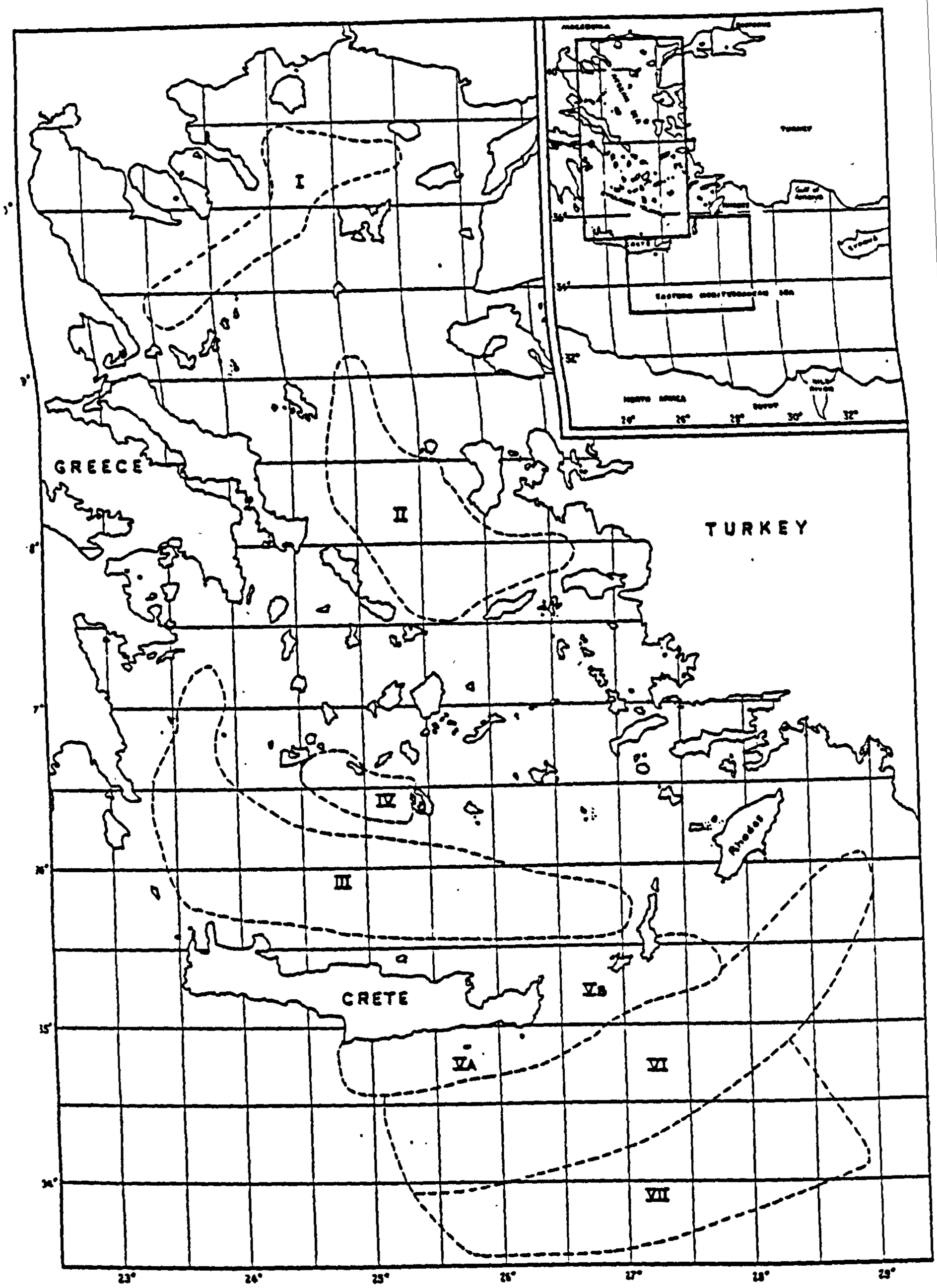


Fig. 1 Location map of the study area, with index to the geographical areas.

(I) Northern Aegean area

(II) Middle Aegean area

(III) Southern Aegean area

(IV) Santorini-Milos area

(VA) Crete continental-shelf area

(VB) Cretan strait and Karpathos shelf area

(VI) The trench zones and deeps area

(VII) The Outer Ridge area

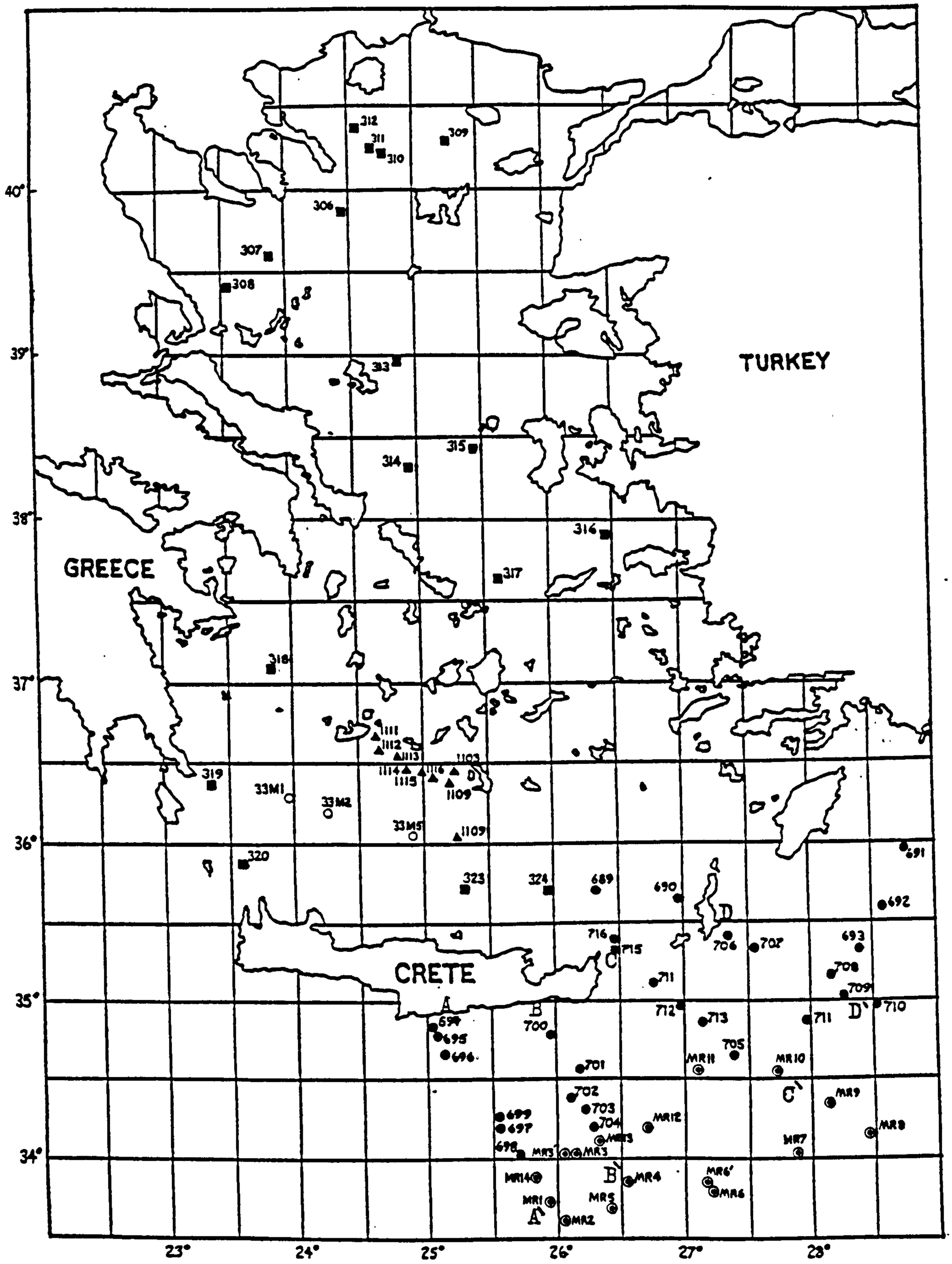


Fig. 2 Location map of the core samples used in this study.

■ Group 1, collected on cruise 5/72 of the RRS Shackleton

● Group 2, collected on cruise 6/72 of the RRS Shackleton

▲ Group 3, collected on cruise 1/74 of the RRS Shackleton

○ Group 4, samples from cruise 33M of the German vessel Meteor

◉ Group 5, collected on cruise 11A/77 of the RRS Shackleton

TABLE (1)

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Position Lat. (N)	Position Long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
1	Shackleton 6/72	S689	35° 42.90'	26° 18.20'	GC	2286	119.5	North of Crete
2	"	S690	35° 39.30'	26° 58.80'	GC	2561	75.4	W. of Scarpanto
3	"	S691	35° 56.60'	28° 45.10'	GC/W	4454	88.2	East of Rhodes
4	"	S692	35° 36.01'	28° 34.01'	GC/W	3728	17.1	E. of Scarpanto
5	"	S693	35° 20.13'	28° 22.37'	GC/W	2473	118.2	E. of Scarpanto
6	"	S694	34° 52.60'	25° 00.70'	GC/W	1915	101.2	South of Crete
7	"	S695	34° 49.00'	25° 03.50'	GC/W	2507	60.9	South of Crete
8	"	S696	34° 42.00'	25° 08.60'	GC	1528	79.2	South of Crete
9	"	S697	34° 15.11'	25° 30.51'	GC/W	3945	166.6	South of Crete
10	"	S698	34° 03.70'	25° 42.50'	GC/W	2677	124	South of Crete
11	"	S699	34° 17.00'	25° 30.00'	PC/GC GC as trigger	3958	Trigger 70.7 S1 150.5 S2 144.4 S3 149.8 S4 112.7	South of Crete

TABLE (1) Cont.

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Position Lat. (N)	Position Long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
12	Shackleton 6/72	S700	34° 49.30'	25° 58.85'	GC	1050	96.3	South of Crete
13	"	S701	34° 36.00'	26° 10.00'	GC	3598	73.1	South of Crete
14	"	S702	34° 24.50'	26° 06.00'	GC/W	4394	159.0	South of Crete
15	"	S703	34° 21.00'	26° 13.00'	GC as Trigger	4382	102.4	South of Crete
16	"	S704	34° 14.00'	26° 16.20'	GC	3178	152.9	South of Crete
17	"	S705	34° 41.00'	27° 24.00'	GC/W	3157	178.6	S.E. of Crete
16	"	S706	35° 25.50'	27° 22.00'	PC/GC	2012	S1 140.8 S2 101.5	East of Crete Near Scarpanto to its east
19	"	S707	35° 20.50'	27° 33.50'	GC/W	1220	91.7	"
20	"	S708	35° 10.80'	28° 08.90'	GC/W	2232	26.0	Far E. of Crete

TABLE (1) Cont.

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Position Lat. (N)	Position long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
21	6/72 R.R.S. Shackleton	S709	35° 01.00'	28° 15.50'	GC	3359	S1 134.7 S2 128.3	Far E. of Crete
22	"	S711	34° 53.50'	27° 59.00'	GC	2581	49.8	"
23	"	S712	35° 00.00'	26° 59.50'	GC/W	3025	153.9	East of Crete
24	"	S713	34° 53.50'	27° 09.30'	GC	2044	124.5	"
25	"	S714	35° 09.40'	26° 46.90'	GC/W	1851	102.5	"
26	"	S715	35° 21.80'	26° 28.50'	GC	871	58.6	"
27	5/72 R.R.S. Shackleton	306	39° 50.70'	24° 27.50'	GC & HF	1198	148.5	Northern Aegean
28	"	307	39° 35.40'	23° 53.00'	"	1278	153	"
29	"	308	39° 24.20'	23° 32.00'	"	1248	208.5	"
30	"	309	40° 15.80'	25° 16.40'	"	1506	181.5	"
31	:	310	40° 12.05'	24° 47.29'	"	827	156	"

TABLE (1) Cont.

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Position Lat. (N)	Position Long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
32	5/72 R.R.S. Shackleton	311	40° 13.50'	24° 41.20'	GC & HF	926	178	Northern Aegean
33	"	312	40° 20.20'	24° 34.30'	"	751	195	"
34	"	313	38° 56.30'	24° 53.03'	"	860	175	Middle Aegean
35	"	314	38° 17.58'	24° 56.59'		784	229	"
36	"	315	38° 24.80'	25° 27.20'	"	928	158	"
37	"	316	37° 51.5	6° 26.32	"	1149	182.5	
38	"	317	37° 37.70'	25° 36.40'	"	860	178	Middle Aegean in Cyclades Arch'
39	"	318	37° 05.00'	23° 49.70'	"	909	199	"
40	"	319	36° 21.75	23° 21.75	"	1130	168	"
41	"	320	35° 54.10'	23° 35.10'	"	1265	180.8	Southern Aegean North of Crete
42	"	323	35° 44.10'	25° 17.40'	"	1210	137	
43	"	324	35° 43.10'	25° 58.90'	"	2180	110.5	"

TABLE (1) Cont

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Position Lat. (N)	Position Long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
44	6/74 R.R.S. Shackleton Leg 4	1108	36° 27.90'	25° 14.10'	GC	119	42.0	Between Santorini and Milos
45	"	1109	36° 23.40'	25° 11.70'	GC	425	42.5	"
46	"	1110			GC		90.6 +10 cm (top lost)	"
47	"	1111	36° 40.90'	24° 38.50'	GC	256	136.00	"
48	"	1112	36° 35.70'	24° 39.50'	GC	228	43.00	"
49	"	1113	36° 32.80'	24° 47.30'	GC	378	80.00	"
50	"	1114	36° 30.10'	24° 53.50'	GC	518	50.00	"
51	"	1115	36° 28.30'	24° 59.40'	GC	530	28.6	"
52	"	1116	36° 25.80'	25° 06.00'	GC	450	20.0	"
53	"	1119	36° 03.70'	25° 14.20'	GC	1791	46.5	"

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Lat. (N)	Long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
54	Meteor 33	33 M1	35° 17.20' sphinct corer	23° 58.40'	PC sphinct	890	350	Southern Aegean Sea
55	"	33 M2	36° 11.88' sphinct corer	24° 15.72'	PC sphinct	885	295	Southern Aegean Sea
56	"	33 M5	36° 03.40' sphinct corer	24° 54.50'	PC sphinct	1400	260	"
57	Shackleton 11A/77	MR1	33° 44.95'	25° 56.99'	GC	2753	179	South of the Island of Crete
58	"	MR2	33° 37.24'	26° 03.09'	"	2482	179	"
59	"	MR3	34° 01.96'	26° 07.93'	"	3309	63	"
60	"	MR3'	34° 01.40'	26° 06.24'	"	2959	188	"
61	"	MR4	33° 52.4	26° 30.4	"	2841	220	"
62	"	MR5	33° 42.24	26° 25.03'	"	2788	122	"
63	"	MR6	33° 49.1	27° 12.3'	"	2546	10	"

TABLE (1) Cont

Location and other details of the collection of material used in this study

Serial Number	Cruise	St. No.	Position Lat. (N)	Position Long. (E)	Type of Core	Depth in Meters	Core length in cms.	Area
64	Shackleton 11A/77	MR6'	33° 50.79	27° 12.95'	GC	2474	228	South of the Island of Crete
65	"	MR7	34° 00.06	27° 52.08	"	2683	183.5	"
66	"	MR8	34° 09.64	28° 28.4	"	2983	191	"
67	"	MR9	34° 21.15	28° 08.85	"	2451	193.6	"
68	"	MR10	34° 33.25	27° 44.51	"	2586	188.6	"
69	"	MR11	34° 34.13	27° 07.93	"	1017	185.7	"
70	"	MR12	34° 12.06	25° 42.16	"	3385	207	"
71	"	MR13	34° 05.97	26° 20.65	"	2885	104	"
72	"	MR14	33° 54.0	25° 50.00	"	2703	176	"

Key to Abbreviations: GC = Gravity Core PC = Piston Core W = Water

CHAPTER II PREVIOUS INVESTIGATIONS

Since the year 1890, the eastern Mediterranean has been the scene of many research cruises from different countries. The first was the Austrian Expedition of the ship Pola during the years 1890-1893, followed fifteen years later by the Danish Expedition of the ship Thor during the early years of this century (1908-1910). Data from these early cruises were reported by Windt and Berwerth (1904) and Boggild (1912). These workers gave a mineralogical description of the sediments and a study of their calcium carbonate content.

In the years 1947-1948, the Swedish Deep Sea Expedition of the Albatross passed through the Mediterranean Sea. During this Expedition, long piston cores were collected from the eastern Mediterranean Sea and tephra layers were discovered in the region. Data from this expedition were reported by many authors, such as Kullenberg (1952), Jerlov (1953), Mellis (1954), Parker (1955, 1958), Dupliax (1958) and Olausson (1960, 1961) mostly in the reports of the Swedish Deep Sea Expedition.

The work of the Swedish Deep Sea Expedition was followed during the next three decades by a series of cruises from different countries to the eastern Mediterranean. These include cruises 10 and 14 of the Vema in 1956 and 1958; cruises of the Russian research vessel Academik S. Vavilov during the years 1959-1969; the MEDOC cruises of 1969; the DSDP cruise of the Glomar Challenger; the U.S. Navy cruises of the Merchant Marine before 1972; the NERC cruises of the RRS Shackleton in 1972, 1974 and 1977 and H.S. Plias in 1973; the cruises of the German research vessel Meteor; the W.H.O.I. cruises; the Chain cruise 61; various cruises of R.R.S. Discovery and many other cruises for different oceanographic institutes in different countries.

As a result of these works extensive reports have been published on different geologic aspects of the eastern Mediterranean Sea, including its bathymetry, sedimentology, stratigraphy, palaeontology, climatology and beaches. Investigations in the field of geochemistry, however, are rare, and the present work seeks to redress this balance.

The first sounding of the deep basins in the region was conducted by the ship Pola during the Austrian Expedition of 1890-1893,(Koczy, 1956). Many other studies were mainly concerned with the study of local nearshore areas, such as; off the Egyptian coast(D'Arrigo, 1936, Doeglas, 1950; and Pfannenstiel, 1952, 1960); Lebanon(Goedicke, 1972); Cyprus (Gregory, 1931); South of Crete(Shepard and Dill, 1966); south of Rhodes(Hersey, 1965) and south of Greece(Goncharov and Mikhailov, 1963, 1964 and Hersey, 1965). The first regional bathymetric study was conducted by the Swedish Deep Sea Expedition in 1947-1948, Koczy (1956, 1960); and the first bathymetric chart was made by Pfannenstiel (1960). Mikhailov in 1965 and Emery et al. in 1966 collected more precise data, and Kredzemnove More in 1966 published a detailed bathymetric chart of the area. More bathymetric studies were published by the U.S. National Oceanographic office in 1967, Watson and Johnson (1969); Maley and Johnson (1971); and Allan and Morelli (1971). In 1972, a new physiographic and bathymetric chart of the entire Mediterranean was published by the U.S. Navy Oceanographic office Carter et al. (1972). In 1973, another regional chart of the entire Mediterranean was published by the department of hydrography of the British Navy. By that time, a group of bathymetric studies was compiled and published from different local oceanographic

institutes in the eastern Mediterranean, Allan et al (1964); Mikhailov (1965); Ryan (1969); Ryan et al. (1971); Belderson et. al. (1972); Sigal et al. (1973); and Hicke et al. (1974). These maps described in considerable detail the complex submarine topography of the area. Stride, Belderson and Kenyon (1977) published an extensive survey of the eastern half of the Mediterranean Sea. They used a long range side-scan sonar as well as an air-gun sub-bottom profiler and a narrow beam echo-sounder and described the broad medial swell in the floor of the Eastern Mediterranean as Hellenic, Calabrian and Cyprus Outer Ridges.

The beach and near shore sediments from different localities in the region have been described by many workers:- from Egypt (Hilmy, 1951 ; Nakhla ,1958 ; El-Hinnawi, 1964 ; Kholief et al. 1969 ; Shukri and Philip, 1956 and 1961 ; El-Wakeel, 1964 and Zaghloul and Kamel, 1965), from the Lebanon (Fevert and Sanlanville, 1965 and Emery and George, 1963); from Turkey (Taillefer 1964); from the islands of Rhodes and Karpathos (Alexanderson 1969); from the island of Crete (Boekschoton 1962, 1963); from the Greek mainland (Mistardis, 1963, 1964); and from Israel (Emery and Neav, 1960 ; Schatter, 1967 ; and Gavish and Friendman, 1969). Goudie (1969) discussed the age and distribution of the Mediterranean beach deposits in general. Most of these workers have given a description of the near shore sediments from different areas and indicated from the study of heavy minerals, pollen, and clay minerals, the sediment transport paths to the east and north of the Nile delta,and proved that Nile sediments reach as far as the beaches of Lebanon and Israel. Similar studies to the west of the delta indicate dispersal

of Nile sediment to the west (Shukri and Philip, 1956 ; El-Wakeel, 1964 ; Zaghloul and Kamel, 1965). Sediments to the north east of the Nile delta have been studied by Einsele (1967); Almagor (1967) and Reiss et al (1971). Their studies show that the sediments are not characterized by turbidite sequences. However, studies on the heavy mineral assemblages and the clay minerals kaolinite and montmorillonite in the surface sediments from the Herodotus abyssal plain by Ryan et al (1973), suggested that turbidity currents are and have been the transporting mechanism. Sediment dispersal mechanisms may be related to the extensive suspended sediment plumes off the Nile delta as described by Jerlov (1953). Other studies have shown that clay minerals and heavy mineral assemblages in the bottom sediments are typical of the Nile derived assemblages (Venkatarathnam and Ryan, 1971 ; Nir and Nathan 1971 ; Emelyanov 1965, 1972). Aeolian transport may also be important in the transport of clay minerals from North Africa (Venkatarathnam and Ryan, 1971).

Only a few studies have been concerned with the general distribution of sediments in the deep sea. Nekritz (1963) Emelyanov (1965, 1972) and McCoy (1974) all studied the distribution of different types of sediments in the region. The last author studied, in detail, the distribution of ashes and sapropels in some parts of the area, but the regional distribution of different types of sediments was still not adequately known at the commencement of the present work. The reports of the Swedish Expedition of 1947-1948 provided the first sedimentologic description of deep-sea sediments from the area (Kullenberg, 1952;

Jerlov, 1953 ; Mellis, 1954 ; Parker 1955 , Dupliax, 1958 and Olausson 1960, 1961). The sediment and the structural features of the region were also described later by Emery and Bentor (1960), Emery et al (1966), Ryan et al (1965), Ludwig et al (1965), Hersey (1965), and Ninkovich and Heezen (1965). Russian studies of the sediments have been summarized by Fomin (1965) and Emelyanov (1972). Emelyanov (1965) studied the granulometry and carbonate distribution. Rateev et al (1966) studied the clay minerals in different parts of the Mediterranean and Biscaye (1964) and Chamley (1968) analyzed a few samples from the area. Chamley (1971) summarized the scattered results of the work of several authors and added some analyses on the eastern Mediterranean. In the same year Venkatarathnam and Ryan did some studies on the clay minerals in the area. Stanley (1972) edited a multi-authored, multi-disciplinary, reference volume on the area. Most of the sediment investigations made by individual programmes in different countries were summarized in this volume. McCoy (1974) reviewed most of the previous sediment investigations and studied the late Quaternary sedimentation in the eastern Mediterranean at large.

Most of the textural studies on sediments from both the Aegean and eastern Mediterranean have been concerned with grain size analysis giving the percentages of sand, silt, and clay in sediments from different localities. Blanc (1958, 1964) and Blanc and Froget (1967) did this for sediments from the Aegean Sea. Sediments from other localities in the eastern Mediterranean were studied by D'Arrigo (1936); Doeglas (1950's); Yemelyanov

(1961); Almagor (1964, 1967); Einsele (1967) and Korenva (1971). Textural studies on a regional scale have been carried out by Emelyanov (1965) and McCoy (1974) who both indicated a general trend of increasing clay percentages from nearshore to deeper areas. The inclusion of the carbonate fraction in these studies, however, causes great difficulty in the interpretation of the textural relationships. Such data are not of great use in the study of the distribution, dispersal and origin of terrigenous sediments.

Volcanic ash layers were discovered in the eastern Mediterranean by the Swedish Deep Sea Expedition of 1947-1948. Mellis (1954) described and correlated two tephra layers in seven of the Albatross cores south of Crete. He suggested Santorini as the source for the upper layer and speculated that ash horizons may be used as time-stratigraphic units. Olausson (1960, 1961) emphasized that many more than two horizons occured in the Albatross cores. A few years later, Ninkovitch and Heezen (1965, 1967) and Keller (1971) described an additional widespread tephra horizon. The former authors described and correlated the two first found ash horizons in 21 cores from the Albatross, Vema 10 and Vema 14 cruises and distinguished two different tephra falls. Olausson (1971) questioned their correlation but other workers supported them; Keller (1971); Ninkovitch and Hays (1971), and Keller and Ninkovitch (1972). The later workers added some changes in the tephra identifications. McCoy (1974) studied the stratigraphy of the volcanic ash and identified six different ash layers in the region and considered there to be sources other than Santorini.

Sapropels have also been used in correlation between cores in the eastern Mediterranean. Both Olausson (1961) and Ryan (1969) have based their correlations on the uppermost sapropel although other workers had put some restrictions on its use in this respect (Emiliani, 1955 ; and Hicke et al., 1974). The occurence of sapropelic layers in the region has been important in the study of the late Quaternary environment. Kullenberg (1952) recognized the sapropelic sequence in the Albatross cores as representing stagnant conditions, and Olausson (1961) has described nine distinct sapropelic layers. It is believed that the area had suffered repeated episodes of deep water stagnation. Bradly (1938) suggested that sapropelic muds would be deposited during stagnant (aneorobic) conditions and predicted that varv-like lamination might form under such conditions. He stated that the oceanographic regime in the eastern Mediterranean Sea might be changed during lowered sea level stands during pluvial or glacial stages. This could happen primarily due to reversal of the surface current flow through the Straits of Gibraltar and severely restricted bottom-water circulation east of the Straits of Sicily. However, the fact of the current reversal in the Straits of Gibraltar is still subject to debate. The hypothesis that a reversal of currents occured through the Strait at the end of the Würm was proposed by Vergnaud-Grazzini and Bratolini (1970); Valette (1972); Huang et al (1972); and Huang and Stanley (1972, 1974). At the same time, other workers questioned the hypothesis; Diester-Haas (1973b, 1974) and Sonnenfeld (1974). Olausson (1961) has pointed out that sapropelic layers were not deposited during cooler pluvial stages, but rather post-dated these cooler stages as indicated by radio carbon data and foraminiferal studies of

the upper sapropelic layer. On the other hand, he suggested that the deep water stagnation phase could result from a stable density stratification of the water column caused by the presence of a fresh water layer, or a low density layer, on the surface. The presence of a surface layer,according to Olausson's hypothesis, would originate from melt-water from glaciers, general warming of surface waters or through displacement between the Black Sea and Mediterranean waters. A surface layer might form from one of these three effects or any combination of them. Other workers have generally agreed with Olausson but not on all points. The relationship between sapropel deposition and sea level changes was noted by Ryan (1969) who believed that stagnation would have occured later during the warming trend when greater volumes of glacial melt-water would have entered the Mediterranean.

The sedimentation rates during the last few thousand years in the E. Mediterranean have been calculated by some authors based on the age of the upper most sapropel or the upper tephra layer; Mellis (1954) and McCoy (1974). The youngest recognisable stratigraphic horizon in the eastern Mediterranean is the upper-most sapropel. Based on dating of this layer, McCoy calculated an average sedimentation rate for the post Boreal substage of about 10 cm/10^3 years, but he noticed significant variations corresponding to major modern sources of terrigenous sediment supply. However, as the eastern Mediterranean is surrounded by many volcanoes, there is usually the possibility of the ash horizons in the sediments being used for dating purposes. It is possible to calculate the rate of sedimentation if it is assumed that the upper ash horizon in the E. Mediterranean was derived from the Santorini eruption of 1400 B.C. Using this as a marker it is

possible to calculate the age of other ash horizons and sapropelic layers.

C^{14} dating in the eastern Mediterranean has been carried out by many workers for the upper part of the deep-sea stratigraphic section; Rubin and Suess (1955); Olsson (1959); Olson and Broecker (1961); Menzies et al (1961); Einsele and Werner (1968), Vergnaud-Grazzini and Herman-Rosenberg (1969); Pastouret (1970a,b) Opdyke et al. (1972) and Milliman and Muller (1973). Extrapolation of the C^{14} dates to older stratigraphic horizons in cores has resulted in disparity in the age estimates. Olausson (1961, 1965); Ryan (1969, 1971) and Ryan et al (1971) estimated that nine metres of core represents approximately 40,000 years while Herman (1971a,b, 1972) estimated 55,000 years for an equivalent length of core. These contrasting estimates have prevented any adequate regional correlation between cores within the region.

The calcium carbonate content of E. Mediterranean sediments has been studied by many authors, in deposits from both near-shore and deep sea areas. Quantitative determinations of $CaCO_3$ in sediments from beach zones have been reported in many publications; in beach and shelf sediments from the Aegean, (Boggild, 1912 , Blanc, 1958, 1964 ; Chamley, 1963 ; and Blanc and Froget, 1964); from the Egyptian coast beach sediments. (Hilmy, 1951 ; Shukri and Philip, 1956a); from Nile shelf sediments (Anwar and Mohamed, 1970); and from the Lebanon (Emery and George, 1963). Other workers determined the carbonate content in deep sea sediments from the Aegean and eastern Mediterranean (Blanc, 1958, 1964 ; Olausson, 1960, 1961 ; Chamly, 1963 ; Blanc and Froget, 1964 ; Opdyke et al, 1972; and Delauze, 1966). Later Venkatarathnam and Ryan (1971) and Venkatarathnam and Ryan et al (1972) included most of the above mentioned data in a regional compilation of

the carbonate data. They concluded that $CaCO_3$ distribution in the eastern Mediterranean sediments reflects varying degrees of dilution by current transported and aeolian non-carbonate terrigenous detritus. They gave examples of low carbonate values off the Nile which reflect the very high rate of fluvial sediment input in the area in the past. Milliman and Muller (1973) drew attention to the high Mg-calcite content of the eastern Mediterranean sediments and stated that some of the aeolian transported material could be carbonate. The high Mg-calcite content in some eastern Mediterranean sediments was also noted by Milliman and Muller (1973) who described some enriched zones within cores where the Mg-calcite content was up to 12 mole % Mg, and in some cases, dolomite was present. They suggested that the relatively high temperatures and salinities of bottom waters during warm periods could lead to the formation of dolomite. They considered that the inorganic precipitation of carbonates would be enhanced under these circumstances. Also Schmalz (1969) and Friedman (1972) both predicted such physico-chemical conditions in the eastern Mediterranean Sea and noted that high Mg-calcites might have been formed within the region as a result of sea level lowering with restricted vertical and horizontal water circulation.

Few workers have studied the chemical composition other than $CaCO_3$ content of sediments from the Aegean and eastern Mediterranean. Some analyses have been reported by Emelyanov (1965, 1972), Venkatarathnam and Ryan (1971) and Smith and Cronan (1975). Other work has been concerned with the chemical composition of sediments from the Santorini area, Butuzova (1969). Emelyanov (1965, 1972) studied the chemical composition of different sediment types from the entire Mediterranean. He determined the silica and organic carbon, as well as a few other constituents.

The palaeontology of the sediments from the eastern Mediterranean region has been studied by several authors. Todd (1938) studied the foraminifera from deep sea cores in the area. Parker (1955, 1958) studied the distribution and abundance of the foraminifera in 16 long cores. Herman (1966, 1971a, b and 1972) and Herman et al (1969) studied planktonic fauna and palaeotemperatures, and attempted absolute age determination on the sediments. Many workers attempted to define a regional time-stratigraphic horizon (Parker 1958, Olausson 1961; Ryan 1969, 1972, Ryan et al 1971 and McCoy 1974). Berger (1971) questioned the use of micropalaeontological criteria in this regard except where cores are closely spaced.

Palaeoclimatological studies have been carried out by some workers. Vertical variations in the biota assemblage and oxygen isotope ratio measurements have been used to delineate relative changes in water and atmospheric temperature. Koreneva (1971) and Rossignal and Pastouret (1971) studied vertical variations of pollen in some cores. Other workers studied the vertical variation and relative abundance of pteropods and planktonic foraminifera species in cores as an aid to palaeoclimate determinations, (Parker, 1955, 1958; Herman 1971a,b, 1972; Vergnaud-Grazzini and Herman-Rosenberg 1969 and Pastouret 1970a,b). Their work gave an approximation of the paleoclimatological changes in the Mediterranean region. The palaeoclim - atological reconstructions based on oxygen isotope ratio measurements (Emiliani 1955 and Vergnaud-Grazzini and Herman-Rosenberg 1969) are all in agreement with criteria derived from micropalaeontological studies.

Palaeomagnetic measurements have been studied by some authors; Ryan (1969, 1972); Heye (1970); Ryan et al (1971); and Opdyke et al (1972). Generally, these palaeomagnetic measurements do not show any major reversals.

The geophysical and palaeogeophysical setting of the eastern Mediterranean has been summarized by Ryan (1969), Erickson (1970), Ryan et al (1971), Lort (1971), Mackenzie (1970, 1972), Smith (1971) and by Dewey et al (1973).

The circulation patterns in the region have been studied by many workers, among them are Nielson (1912), Pollack (1951), McGill (1961), Wust (1961b), Moskalenko and Ovenhinnikov (1967) and Ovenhinnikov and Plakin (1965).

CHAPTER III

METHODS OF STUDY

3.1 Shipboard Procedure:

The material used in this study comprises sediment cores collected from the vicinity of the Island of Crete and to its south from the trench area and around the Hellenic Outer Ridge area. Material was also collected from all parts of the Aegean Sea.

An RVB gravity corer with an open barrel and tulip core catcher was used for collecting cores during cruises of the R.R.S. Shackleton.

Coring operations at sea followed a standard method, but because the corer may produce a serious disturbance in cores it was important to recognize and minimize such disturbances. Core shortening for example (the relationship between the length of core recovered and the amount of penetration by the corer into the bottom) can result from compaction.

It is practically impossible to accurately position and maintain the corer at the sediment water interface, and this is largely responsible for the disturbance. However, most of the core recovered was full length, and the system operated well.

It is supposed that all cores were taken vertical, taking the bedding plane perpendicular to the walls of the core as having been horizontal in their natural state.

3.2 Gross Core Treatment and Laboratory Procedures:

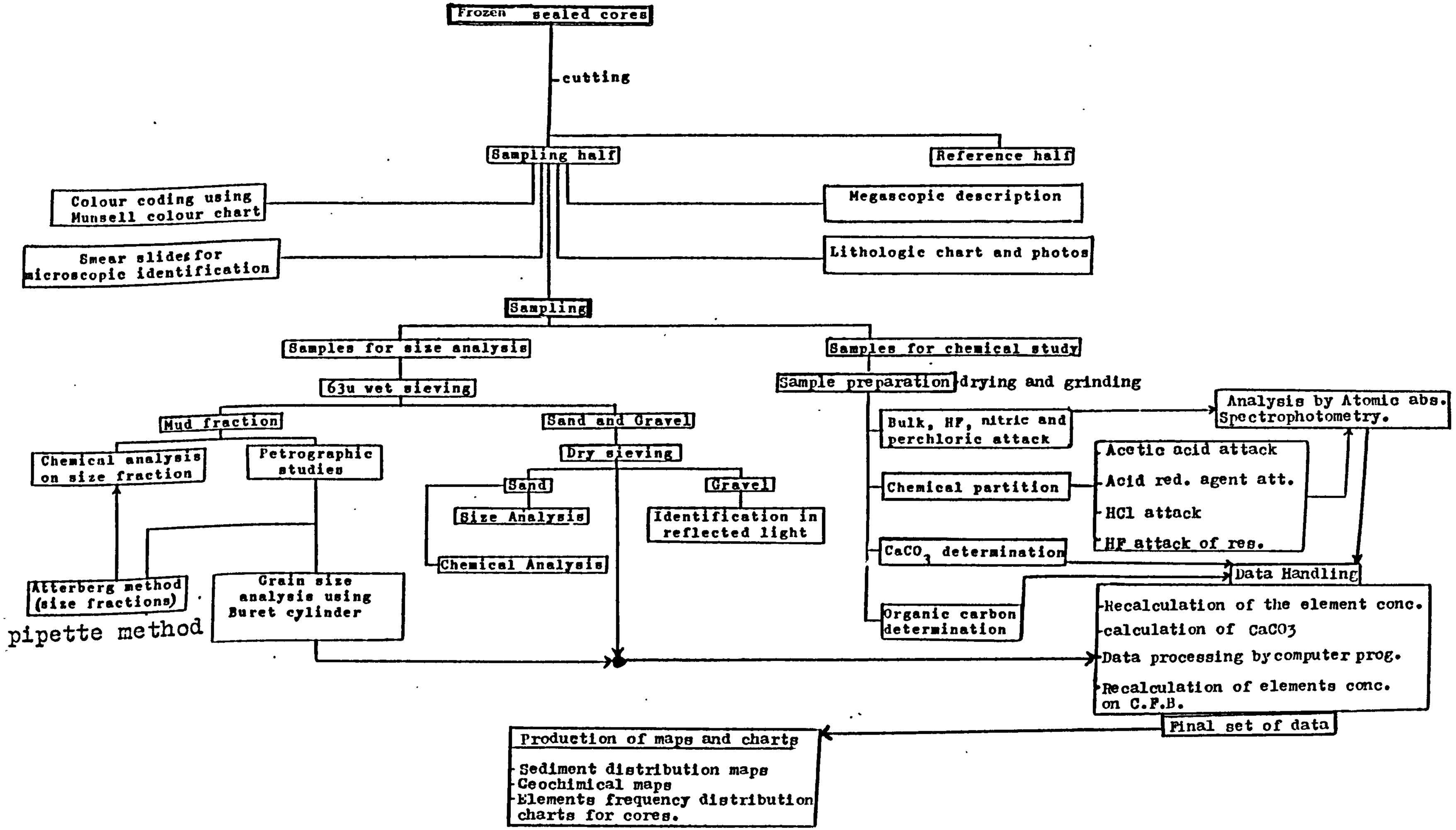
Cores were sealed with plastic tape immediately after collection and they were stored in a deep freezer. They were thawed, split, measured, described, sampled and colour coded using Munsell Colour Charts (1954). The cut surface was cleared using a pallet knife. After splitting one half was used for sampling and the other was sealed in a plastic D-tube and kept as a reference half.

The descriptive system followed was that given by Rusnak and Luft (1963) for the megascopic description of marine sediment cores. Figure 3 is a flow chart of the laboratory work. It shows the gross core treatment and the procedures followed on all samples.

Electro-osmotic cuting was used in some cases for taking slices of sediment from cores for X-radiography.

The aim of the present work is to investigate the concentration of trace elements in the deep sea sediments in the vicinity of Crete, Scarpanto (Karpathos) and Rhodes; and to determine the variations in these concentrations and their relationship to the environment

Figure 3 Flow Chart of Laboratory Work



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the pipette method

3.3. Sampling:

Samples were taken from the cores at both fixed and varying intervals for the purpose of chemical analysis and grain size analysis. Equal volume samples were taken from top to bottom at 25 cm intervals or in places where lithologic changes were observed. Some cores were sampled at closer intervals in sections of particular interest. Samples were always taken from near top and bottom of each core (the latter may give an indication of what may be present immediately below the cored section).

Usually samples were taken from the top and bottom of the major lithologic units. Samples were also taken from the middle of the thick lithologic units. Sample data were plotted on core charts.

3.4 Smear Slides:

A rapid method of examining sediments is the study of smears to get a general idea of the composition and texture. Small spot samples were taken and placed on a clean microscope slide. A drop of de-ionised water was then added and the sample was smeared. After it had dried thoroughly on a hot plate, the sample was mounted under a cover slip with "Canada Balsam" as mounting media. Smears were made from the same locations as the chemical or size analysis samples in the sampled half of the cores, or the corresponding location in the reference half. Smears were always taken from the tops and bottoms of cores, and in major lithologic units. The components were

identified with the use of both petrographic and binocular microscope.

3.5 Grain Size Analysis

The granulometric analysis of the sediments was carried out following the procedure given by Fabricius and Muller (1969). Analyses were done in two steps. The sand and mud fractions were separated by wet sieving using a 63u stainless steel sieve, and then two different procedures, (A & B), were followed. The sand fraction was dry sieved using half-Phi scale sieves. For the mud fraction the 'burette Cylinder' was used. The results obtained from the two procedures were combined using an Algol-computer programme. The two procedures are summarised in the following:-

1. A sample of 20 - 25 grammes was taken from all the surface layers in the cores (0-4 cm) & some selected samples representing different types of sediments were also taken. Samples were kept wet in a sealed plastic vial until the time of analysis. A few drops of de-ionised water were added when necessary.

2. 10 - 15 grammes of the sample were wet sieved, using a 63u stainless steel sieve in order to separate the sand and mud fractions.

3. The sand fraction was dried at 50 - 60°C, weighed and kept for further analysis. (see procedure B)

4. The mud fraction was stired electrosonically in a beaker using 'ammonia water' for 15 minutes, and then procedure A was followed.

(A) The Burette Cylinder Methcd.

(size analysis of the silt and clay fractions)

The method increases the efficiency of grain size analysis of samples with a high silt and clay content, because of its speed and the electronic computation of the data.

In the apparatus a burette is attached to the outside of a wide sedimentation cylinder so no turbulence of the suspension can be caused by withdrawal. The method is semi-automatic and the burette is self-leveling. A correction of the dead volume (less than 2%) is included in the computer programme. One advantage of this method is that the settling time for the 2u fraction is half of that of the pipette methods.

The operation of the apparatus is similar to that of the pipette apparatus (Anderson et al.,1929), but the system works quickly and semi-automatically. Each fraction is withdrawn by turning the lever of the three-way stopcock to the 'rise' position. To empty the burette,the stopcock is turned into the 'out' position and the fraction withdrawn is collected in a dish. Any drop of the suspension remaining in the tube can be flushed by distilled water. Each fraction lowers the water column in the cylinder by the volume of the withdrawal. The reduction of the settling height is compensated by a shorter timing for each withdrawal (Table 2) and the volume differences of each withdrawal are corrected in the computer programme.

Details are as follows:

1. After the mud fraction was stirred for 15 minutes, in ammonia water, it was transfered into the burette cylinder shaken hard, a zero-fraction was withdrawn and time was recorded.

2. Room temperature was maintained at 20°C and a fraction was withdrawn at certain time intervals to represent the Ø fractions wanted (Table 2).

3. All the fractions withdrawn were kept in weighed glass dishes dried in the oven and then weighed again.

4. The weights of the different fractions were recorded on a special sheet.

5. A special time-table was prepared and the writer was able to manage the running of 15 samples at a time. A total of 90 samples were analysed using this technique.

Procedure 'B'

Size analysis of the sand fraction

1. Ninety samples were analysed using the whole of the separated sand fraction. Samples were dried at a temperature of 50 - 60°C.

Table (2) Times of fraction withdrawal for the different phi-steps using the burette cylinder method.

(laboratory temperature 20°C)

phi	mm	Time h	min	sec	Factor of volume reduction (F)
4	0.0625	-	-	56	
5	0.0313	-	3	40	1.012
6	0.0156	-	14	30	1.025
7	0.0078	-	57	13	1.039
8	0.0039	3	45	50	1.054
9	0.0020	14	51	45	1.071
					1.090

2. Samples were then sieved in a set of sieves of 63, 88, 125, 177, 250, 354, 500, 707, 1,000, 1,440, 2,000, 2,828 and 4,000µ (microns) diameter. Sieving was carried out for 10 minutes.

3. The weights of the size-grades and sieving loss were calculated and recorded on the sample sheets.

The results of procedures 'A' and 'B' were all recorded on computer sheets and a special Algol-programme was used (Fabricius and Mullen, 1969). This programme was developed to compute the entire set of data from the granulometric analysis. The range of grain size (or grain size equivalents) is from -6 phi to +9 phi (from 64 mm to 2µ). The grain size interval is half phi. Because burette analysis was obtained as one-phi steps, all fractions (finer than +4 phi) are split into half by the computation. The fraction finer than +9 phi (2µ) is presumed to be limited to the interval between +9 and +11 phi. This helps to obtain a smooth curve and to avoid artificial modes.

The output of the computer programme gives the data printed in four columns.

Column 1: gives the grain diameter or grain size equivalents in microns

Column 2: gives the grain diameter in half-phi units

Column 3: gives the frequency

Column 4: gives the cumulative frequency

Several statistical items are calculated based on equations given by Trask (1932), Folk (1965) and standard text books on statistics e.g. Heinhold and Gaede (1964). The following are the main statistical parameters calculated.

1. Mean values: (a) median (Md); (b) mean; (c) graphic mean size (M_Z) Folk (1965)

2. Coefficient of deviation:

   (a) The standard deviation

   (b) The inclusive graphic standard deviation, after Folk (1965). This is an approximation of the statistical standard deviation.

   (c) Trask's sorting coefficient (S)

   (d) 1. The graphic standard deviations

   2. Phi quartile deviation

3. Skewness: (a) statistical skewness

   (b) inclusive graphic skewness

4. Kurtosis (a) kurtosis

   (b) graphic kurtosis (Folk) (K_G)

In addition the percentages of gravel, sand, silt and clay are given.

These statistical parameters are used as indices of textural maturity and as a possible means of distinguishing different populations. Frequency curves and cumulative curves as well as other diagrams have been used to interpret the granulometric data.

3.6 CHEMICAL ANALYSES

Chemical analyses were carried out in order to determine Fe, Mn, Al, Cu, Pb, Zn, Ca, Ni, Ti, Cd, Co, Cr, and Mg.

Sample Preparation: Prior to the chemical analysis the samples were dried and ground using an agate mortar. The Aegean samples were freeze dried before grinding and the Crete sediments were oven dried at 40°C. Samples were then kept in closed plastic vials until the time of analysis.

Analytical techniques: All samples were attacked by a combined hydrofluoric perchloric and nitric acid digestion involving double fuming with $HClO_4$. All attacks were carried out in P.T.F.E.* beakers. Usually, about 200-250 mg. of the finely ground sample was weighed out and 8 to 10 ml. of HF plus 6 to 7 1:1 perchloric nitric mixture were then added. Beakers were put on a hot plate and the temperature was raised to 200°C and left for about 45 minutes. The temperature was then lowered and 2 ml. more of HF was added and the temperature was raised again for a few minutes. The temperature was then lowered to 100°C and beakers were left for approximately 12 hours or until near dryness was achieved. An additional 2 ml. of $HClO_4$ was then added and the temperature was raised again and the samples were fumed to dryness. Finally, beakers were washed with 5 ml of 6 molar HCl and brought up to volume so that the final solution was approximately 1M HCl. All chemical analysis was carried out on a Perkin-Elmer 403 A.A.S. Dilution to 10x or 100x were carried out where necessary.

*polytetrafluoro-Ethylene

Determinations were carried out in duplicate for all the surface sediments and on selected samples of the buried sediments. The rest were carried out singly.

Geochemical Partition studies:

In order to better understand the distribution of elements in the sediments, chemical partition work was carried out on a selected group of samples. Samples were analysed from the top, middle and bottom of cores. The methods employed were adapted from the techniques given by Chester and Hughes (1967). Two methods were followed (A) for Crete sediments the bulk sediment samples were attacked by the various reagents, (B) for the Aegean and Santorini sediments the attacks were carried out sequently one after the other using the residue from each attack.

Technique (A)

The methods suggested by Chester and Hughes (1967), and Cronan and Garrett (1973) were used.

(i) The Acetic Acid Attack

10 mls. of 25% glacial acetic acid were added carefully to 1 grm. of the dry ground sample in a flask with stopcock. Samples were shaken for four hours and allowed to settle. Samples were then filtered through previously dried and weighed filter paper using a millipore filtering apparatus. The

filtrate was collected and placed in a 25 ml. graduated flask together with the washings of the residue. The solution was made up to the mark with D.I.W. and then analysed using Atomic Absorbtion. The filter paper and residue were dried in a dessicator to constant weight. The residue was kept for further analysis. Weight loss was calculated and recorded.

(ii) The Combined Acid-Reducing Reagent Attack

A mixed reagent of hydroxylamine hydrochloride and acetic acid was used to attack the sediment samples. 50 ml. of the mixed reagent was carefully added to 1 grm. of dry sample. Samples were left for four hours, shaking occasionally. Samples were then filtered through previously weighed and dried milli-pore filter membranes. The filtrate was collected together with the D.I.W. used to wash the residue and evaporated in a conical flask.

When approximately 10 mls. of the filtrate was left, nitric acid was added drop by drop until the solution was no longer effusive. A few more drops of nitric acid were then added and the solution was further evaporated to about 5 mls. and then allowed to cool. The solution was made up in a 50 ml. graduated flask, with molar HCl, and then analysed using Atomic Absorbtion. The filter paper and residue were dried in a dessicator to constant weight and the residue was kept for further analysis. Weight loss was calculated and recorded. The mixed reagent was made up from 25 grms. of Hydroxylamine Hydrochloride dissolved in 100 ml. D.I.W. and 35% v/v glacial acetic acid, mixed in the ratio of 150 ml. of Hydroxylamine Hydrochloride to 350 ml. acetic acid.

(iii) Hydrochloric Acid Attack

10 mls. of 50% HCl were carefully added to 1 grm. of the dry ground sample in a beaker. Beakers were covered by a watch-glass, heated until just below boiling and refluxed until the solution became clear dark orange. The solution was allowed to cool and was filtered through the millipore arrangement using a previously dried and weighed filter membrane. D.I.W. was used for washing the beaker and residue and the solution was made up in a 25 ml. graduated flask. The filter paper and residue were dried to a constant weight in a dessicator and the residue was kept for further analysis by HF attack. Weight loss was calculated and recorded.

Technique (B)

In this technique, the steps described in the three procedures of Technique (A) were followed but instead of using new samples in each attack, the residue of the acetic acid attack was used in the combined acid-reducing agent attack and the residue from the latter was attacked by HCl.

Calcium Carbonate

The calcium carbonate content of the sediment samples was calculated from the Ca determinations. This data is used here as criteria for the carbonate fraction of the sediments being aware of the fact that Mg-calcite is an important constituent of the sediments in the eastern Mediterranean Sea (Milliman and Muller, 1973). Although calcium is present mostly,

in the $CaCO_3$ in the sediments, some may be present in the non-carbonate fraction.

For comparison, the carbonate content of the surface sediments and a selected group of other samples was determined by one of two methods. On all the surface samples, this was determined by acid attack using a LECO system to determine the weight of CO_2 evolved by the reaction. For selected samples 25% acetic acid attack shaking for four hours was used. The weight loss after treatment was calculated as a percentage of calcium carbonate.

Organic Carbon

The total carbon content of the selected samples was determined using a LECO induction furnace. The carbonate carbon was calculated using the values determined from the LECO acid attack, and the differences between these two values is considered to be organic carbon. This technique was applied to all the surface sediments in the study area and to a few selected samples of the buried sediment.

3.7 Data Processing:

Both the size analysis and chemical analyses data were processed using computer programmes.

The size analysis data were processed using a procedure which gives the percentage weight of all the half phi fractions between -6 and 11 phi, as well as the corresponding cumulative percentage. In addition it calculates all the size parameters for every sample, besides the weight percentage of the main

size fractions, gravel, sand, silt and clay. These size fractions were plotted on maps and a general map for the sediment type was developed, using Folk's classification (1954). All these data are shown in Chapter (V) and in appendix (1).

The chemical analyses data were calculated using an Imperial College computer programme (programme AABIN), to calculate the element concentration as percentage or ppm. The programme also recalculated the new data on carbonate free basis. It calculates the equivalent calcium carbonate using the estimated calcium percent. It was taken into consideration that part of the calcium is non-carbonate calcium before calculating the carbonate equivalent. .

For the elements that are affected by the high calcium concentration in the atomic absorption analyses, a special calcium interference value was taken into consideration for every element. A distribution map was produced for Ca CO_3 and all elements determined, in the surface sediments. For the buried sediments a geochemical log-chart was produced for every core showing the vertical distribution of Ca CO_3 as well as all the elements determined. For all details see Chapter VI and appendix II.

CHAPTER IV

GENERAL GEOLOGY

OF THE EASTERN MEDITERRANEAN SEA

The general geology of the Circum-Mediterranean has been described by several authors, including Ktenas (1923), Klemme (1958), Kummel (1961), Aubouin(1965), Holmes (1965), Brinkmann (1969) Nesteroff et al (1972), and Stride, Belderson and Kenyon (1977).

Aubouin (1965) and Holmes (1965) have attempted a synthesis based on concepts including plate tectonics. The authors describe a combination of vertical movements and the growth of continents by accretion of mountain belts around stable nuclei.

4.1 The General Physical Setting and Bathymetry , Including the Major Physiographic Provinces of the Eastern Mediterranean Sea.

The eastern Mediterranean Sea is a semi-closed basin. It is isolated from the Black Sea and subdivided into distinct depositional traps by tectonic blocks, submarine ridges and island arcs or major peninsulas. It comprises the Aegean and Ionian Seas; the Levantine Basin with its trenches, and a broad medial swell in its floor described as Hellenic; Calabrian and Cyprus Outer Ridges (Stride, Belderson and Kenyon , 1977); and the Island Arc configuration south of the Aegean (the Hellenic Arc). The region is characterised by its deep sea basins and trenches and high variability of sea floor topography and relief.

In the 1950's Harrison performed a gravity survey in the eastern Mediterranean. Goncharov and Mikhailov (1963), Allan et al (1964) and Maley and Johnson (1970) have conducted bathymetric surveys from which major phsiographic provinces have been defined. Goncheroc and Mikhailov (1963) presented bathymetric results of the cruise of the Russian research vessel "Academician C. Vavilov". The most dominant feature of the physiography is the Hellenic Arc extending from the mountains of Greece, through the islands of Kithera, Crete, and Rhodes and on towards western Turkey. Components of this arc include the Outer Mediterranean Ridge, separated from the Cretan Arc (Maley and Johnson 1970) by deep parallel trenches (Pliny and Strabo) and steep sided mountains (Anaximander and Ptolemy) of the Hellenic Trough (Emery et al.,1966). In 1972 a new bathymetric chart of the Mediterranean Sea was compiled at the U.S. Naval Oceanographic Office, and a series of seven physiographic maps and descriptive texts were prepared to accompany the chart. Carter et al.(1972) summarized the most significant aspects of the Mediterranean Sea floor as:-

1. A series of N.W. - S.E. trending rdiges and valleys on the Nile Fan which were once thought to be abyssal hills.
2. An extensive regional variation in shelf width and shelf edge depths, and a considerable deviation from the normally accpeted shelf gradient (often in excess of 1:40) and relief.
3. A Mediterranean Ridge, which may be more properly called the Mediterranean Rise.
4. Shelf edge depths are quite variable and depend primarly on shelf width.

Newly discovered features were discussed in the text of the U.S. Naval Bathymetric Chart, including many small troughs in the Aegean and newly reported sill depths.

The continental shelves in the eastern Mediterranean Sea are narrow. The average width is about 6 km. and usually it is less than 15 km. wide (Emery et al., 1966). The large morphological feature in the region is The Hellenic Outer Ridge (centrally located with the Nile cone and the Herodotus abyssal plain to its south and the Hellenic Trench area to the north). In the deeper portions of the basin it follows a curved trend. The water depth at the shelf edge varies considerably from 20 m to 300 m; these depths generally increase with increasing shelf widths (Carter et al., 1972). The continental slopes average 4° (Emery et al., 1966) but may be steep locally such as south of Crete where slopes range up to 40° in the Hellenic Trench area. Off the African Coast, slopes are about 10°. Geophysical evidences show that most of the slopes are fault scarps or fault controlled,(Mikhailov, 1965). Off Greece and Crete similar features were noticed by Goncharov and Mikhailov (1966) and off Lebanon by Emelyanov et al (1965).

Both the continental shelves and slopes are mantled by sediments. Rock outcroppings are known in few places off Israel, (Emery and Bentor 1960), Lebanon(Boulos1962 ; Carlisle ,1962) and southwest of Turkey,(Bass, 1961).

The sill depths between the islands of the Cretan Arc do not exceed 1000.m except between Scarpanto and Rhodes (Maley and Johnson 1971). Between this outer arc and the inner Cyclades volcanic arc lie several deep basins , the deepest being 2680 m (Maley and Johnson, 1971). This inner volcanic arc is

variously named the Cyclades Arc (Maley and Johnson, 1970), the South Aegean Volcanic Arc (Nicholls, 1970), or the Hellenic volcanic arc (Ninkovich and Hays, 1972) and is marked by such volcanos as Santorini and fumaroles on several of the islands (Georgalas, 1962). Depths around the Cyclades Arc rarely exceed 200 m apart from a basin (exceeding 1,200 m) near the northwest limb of the island of Falconera (Maley and Johnson, 1971). To the north of the Cyclades Arc the depth is generally less than 200 m, this represents the continental shelf of the southern Aegean, with an aseismic central Aegean plateau (Ryan, 1969).

The major physiographic provinces of the Eastern Mediterranean and their numerous smaller features were discussed in detail by Emery et al (1966) and Herman (1972). They can be combined into three major provinces.

The Nile Cone Province, extends from the shelf and slope of Egypt, across the continental rise, to a narrow, elongated abyssal plain (Emery et al, 1966). Numerous channels cut across the cone, forming a large distributary system that leads to the abyssal plain (Ryan et al., 1966).

The Central Levantine Province, comprises numerous abyssal hills in a narrow elongate abyssal plain and a Median Ridge, which extends from Italy, passes between Crete and Libya, and curves north eastward to Cyprus.

The Aegean Province, extends between the Ionian Sea and Western Turkey. It contains depressions extending from the Ionian Islands south of Crete and Rhodes, into the Gulf of Antalya forming the Hellenic Trough. The greatest depth in the Mediterranean (5092 m) occurs in one of these depressions (Ryan et al.,1966).

4.1a The Nile Cone Province:

The Nile Cone is an immense, fan-shaped sedimentary deposit as much as 3,000 m thick (Harrison, 1955) with gentle slopes of 1° or less (Emery et al., 1966). Geographically, it is considered as two fans, the Damietta and Rosetta Fans that are separated by a north-south trending range of abyssal hills (Emery , et al., 1966). Carter et al. (1972) described the deeply-dissected ridge. The eastern fan, the Damietta Fan, extends along the base of the continental slope of the Levantine coast as far north as Lebanon where it forms a small semi-enclosed basin, the Phoenician Basin (Goncharov and Mikhailov, 1964). The upper, shallower, portion of this fan, near the shelf break is characterized by irregular surface. The Rosetta Fan, continues northward onto the Herodotus Abyssal Plain. This abyssal plain is a narrow, sinuous feature that lies between the Mediterranean Outer Ridge and the Nile Cone and is the largest such feature in the eastern basin. To the east and west, the abyssal plain becomes a narrow trough, continuing eastwards between the large Eratosthenes Seamount and Cyprus to the Phoenician Basin, and westwards between the Mediterranean Outer Ridge and the continental slope of North Africa to the Ionian Sea. South of Turkey there is a small abyssal plain separated from the Mediterranean Outer Ridge by a group of seamounts , the Anaximander Mountains.

4.1b Physiography of the Central Levantine Province

The Ionian and Levantine basins are the two major basins in the eastern Mediterranean separated by a line from Ras el-Hilal on the Libyan coast passing by Gavdhos island to the island of Crete. The predominant topographic feature of this

region is the Hellenic Outer Ridge (Stride et al., 1977). The Levantine is bordered on the north by Crete, the Dodecanese Islands and Turkey, on the east it is bordered by Syria, Lebanon and Israel, and to the south by Egypt and Libya. Cyprus is located in the north-east quadrant of the basin. The following is a description of the continental shelves, slopes, rises and associated features in the province.

The Continental Shelf of the levantine basin

Because of the frequent variation in depth, the information on the shelf depth is not sufficient to fully characterize that feature. Emery and Bentor (1960) studied the Israeli continental shelf. Generally, the shelf edge depths increase with the increase in shelf width. There is no significant island shelf along the southern coasts of the islands of the Cretan Island Arc. On the northern side of Cyprus the shelf averages 1 km wide and the shelf break is about 20 m deep. A shelf of more than 70 km has been built by the sediments of the Nile River (Emery et al.,1966) and the shelf break is at 260 m. Beyond the western edge of the Nile Fan, the continental shelf is irregular and the average width is 7 km. Murchison (1972) described the continental shelf of this region.

The Continental Slope of the levantine basin

Along the Turkish Coast there is a gradient of slope ranging from 1:24 to 1:10. In the Gulf of Iskenderun, sediments of the adjacent rivers modify this slope. Along the Lebanon - Israel Coast, the gradient ranges from 1:7 to 1:21 (N-S), (Emery et al., 1966). Akziv, Gaza and Beirut are three canyons that incise the eastern end of the Levantine Basin.

Along the Egyptian coast the continental margin is occupied by the Nile Fan (320 km. wide) and extends from the shelf 160 km out to depths of 2,800 m and 1,600 m from west to east. This fan can be divided into two fans: the western part has several canyons the largest being the Alexandria Canyon. The eastern part has a series of ridges and valleys.

Along the Libyan Coast there is a well developed continental slope incised by several canyons and the gradient is 1:35 to 1:10, the steepest being near the Nile Fan. Off the Cretan Island Arc, the slope is a complex island margin bisected by several deep depressions trending N.E. and parallel, the Trench and the Mediterranean Outer Ridge.

The Hellenic Outer Ridge

This feature was previously variously named and known as the Mediterranean Ridge, East Mediterranean Ridge or the Mediterranean Rise (Carter et al., 1972) and is renamed as the Hellenic Outer Ridge by Stride et al. (1977). It is a broad low arch averaging 150 km. in width, located midway between the Cretan Island Arc and Africa. Geophysical evidence indicates that this system is not typical of other mid-ocean ridge or rise systems, and it does not have a spreading origin. (Ryan et al., 1970 and Wong et al., 1971). It is the most pronounced physiographic feature of the eastern Mediterranean Sea and is described as a thick welt 3 to 8 km (Woodside and Bowin, 1970); Rabinowitz and Ryan 1970; Moskalenko 1966) of sediment and sedimentary rocks (Moskalenko 1963; Allan et al. 1964; Hersey 1965; Vogt and Higgs 1969; Ryan, Hsu et al. 1973) that extends over 1,600 km from the Ionian Sea (Ryan and Heezen 1965) to west of Cyprus, where a wide depression or furrow

(Giermann 1966) may separate it from Cyprus. The ridge is approximately 150 km wide with a maximum width of over 240 km. Depths along the crest range from 1,500 to 2,500 meters, producing a relief of over 1,000 meters above the surrounding sea floor with slopes of about 6° (Emery et al. 1966). Maximum relief lies in the area between Crete and Cyrenaica.

The surface morphology of the ridge flanks was described by Emery et al. (1966) as a 'cobblestone topography' because of numerous, closely-spaced hills, with 100-300 m of relief. Both Emery et al. (1966) and Ryan (1969) noted that the average height and spacing between these hills decreased from the southern to the northern flanks. Newer data have shown that these hills are a series of sub-parallel ridges (Sigl et al., 1973 and Hicke et al., 1975) and curvilinear escarpments, suggesting block faulting (Belderson et al., 1972). There is a considerable variation in trend, with some ridges and scarps being parallel to the ridge axis and others perpendicular to it (National Inst. Ocean. 1972). The northern ridge flank is truncated by the central Mediterranean Wall (Goncharov and Mikhailov, 1964) - a 500-800 m high, north-facing escarpment that is apparently continuous from west of the Peloponnese to south of Rhodes and Turkey. The Hellenic Outer Ridge which is a part of the Mediterranean Ridge is the most dominant rise in the province. Its western end is south of the foot of Italy, it trends south east to its high point of 1,330 m north of Ras el-Hilal, Libya and then changes trend to east north east and terminates west of Cyprus. The crest of this rise is about 700 m above the abyssal plains (Emery et al., 1966).

Trenches, Rises and Basins of the Levantine Sea

Two sub-parallel trenches lie south east of Crete and Karpathos, an outer trench (the Strabo Trench) and an inner trench, (the Pliny Trench). Both appear to be separated by a sill with low relief south east of Crete. They lay between the Mediterranean Rise and the Ptolemy sea mounts. Also, there are several minor basins within the Levantine Basin. These are the low areas of segments of several features, such as the Mediterranean Rise or the Continental Margin itself, of these basins are the Herodotus Basin, the Cyprus Basin, the Antalya and the Rhodes Basins. The Cilicia Plateau is located north of Cyprus and south of Turkey. The Strabo Trench may be an extension of the Rhodes Abyssal Plain, the large circular basin within the open bay between Rhodes and south western Turkey. South of Crete, neither trench exists as a bathymetrically distinct and continuous feature. Rather the Hellenic Trench system is marked here by a wide, arcuate and deep furrow adjacent to a high submarine ridge, the Ptolemy Mountain. The Pliny Trench, (deeper at 4,384 m) is located along the southern edge of the complex island margin. It is about 200 km long and has many small sediment filled basins along its course. (Wong et al. 1971). The trend of the Strabo Trench is parallel to Pliny Trench to the south. Depth is in the range of 3,000 m to 3,200 m. A south east trending series of unnamed depressions connects with the east end of the Strabo Trench.

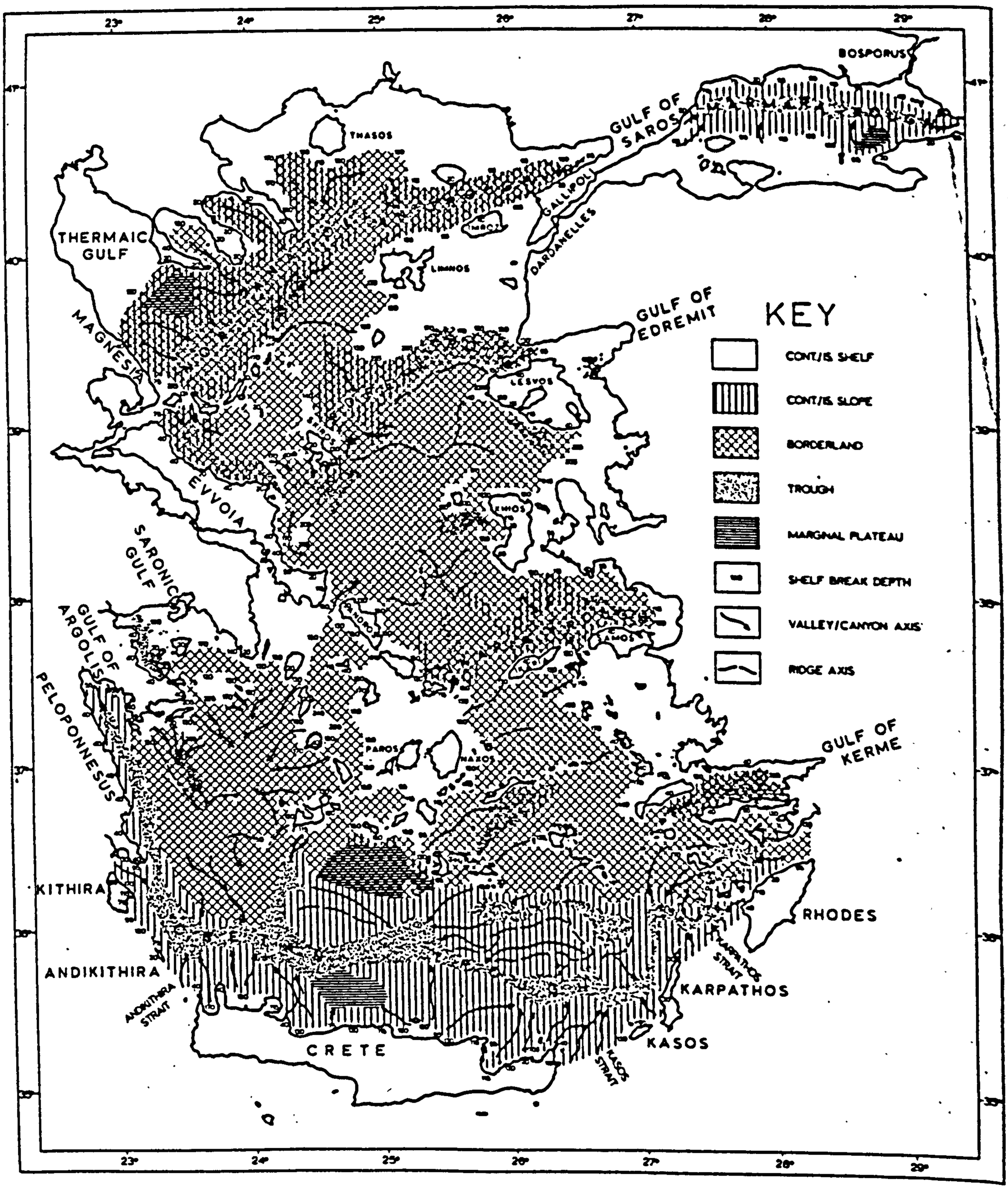
The Central Mediterranean Wall forms a boundary between the ridge and the arcuate Hellenic Trench system. This trench system is a series of discontinuous deep basins, trenches, and narrow ridges that extend from northern Greece to southwestern Turkey. The deepest depth recorded in the Mediterranean has been measured here in a small basin southwest of the Peloponnesus, 5,121 m (Goncharov and Mikhailov, 1964); 5,092 m (Hersey, 1965).

The Cretan Basin

The Cretan Basin is bordered with a generally poorly developed shelf area. The slope N.W. of Crete extends from the shelf edge to the trough margin at 1,200 m and to the north there is a series of valleys and ridges that grade into the trough from both sides. The slope along the Aegean borderland is precipitous, in some areas and there is an escarpment that extends to 2,400 m off the west coasts of Kasos and Karpathos. The slope is connected with the trough by a marginal plateau and lies between 800 and 1,200 m depth.

The Cretan Trough is a large arcuate feature associated with the island arc system, which includes the Mediterranean Outer Ridge , the Hellenic Trough north of the ridge, Kithira, Crete, Rhodes and the inner volcanic island arc (150 - 200 km. north of Crete) This system was described as a typical island arc by many authors (Vogt and Higgs, 1969; Maley and Johnson 1971; and Whitney,1972). North of the Cretan Trough there is a subordinate trough separated from the larger one by U-shaped ridge on which numerous small islands are located.

The Hellenic Arc is the most dominant physiographic feature in the eastern Mediterranean. It extends from the mountains of Greece, the islands of Kithira, Crete and Rhodes towards



Map 2 Physiographic map of the Aegean Sea and related basins.

(after Cater et al. 1972)

Western Turkey. It is separated from the Mediterranean Outer Ridge by deep parallel trenches and steep sided mountains(the Hellenic Trough). The Cyclades Arc is an inner volcanic arc, variously named as The Cyclades Arc (Maley and Johnson, 1970) or the south Aegean Volcanic Arc (Nicholls 1970) or the Hellenic Volcanic Arc (Ninkovich and Hays, 1972).

4.1c The Aegean and Related Seas

The Aegean Basin between Greece and Turkey is characterised by a borderland with about 200 islands and a series of N.E. - S.W. troughs. This basin is connected with the Ionian Basin through the Gulf of Corinth which has a 56 m sill depth west of it, and an 8 m deep canal at its western end. (Heezen et al.,1966). The Cretan basin is located south of the Aegean basin, the bottom gradient increases to the south and the inflection point varies from 500 to 1,000 m in depth. The Cretan Island Arc, containing Kithira, Crete, and Rhodes, forms the southern boundary of the basin.

North east of the Aegean Sea is the Marmara basin and is joined to it by the Dardanelles. Its main feature is a trough associated with the Anatolian trough which cuts across the northern Aegean borderland.

Whitney (1972) described the shelf surrounding the deeper parts of the Aegean basin, as wide and deep, with a shelf break in embayment areas , and narrow with a shallow shelf break off headlands. Nekritz (1963) compiled data from nautical charts and described the Aegean Islands as being fringed with narrow bands of sands, gravels and rocks, with scattered patches of shell and coral. In the Cyclades Passes (e.g. Naxos and Paros) accumulation of sand and shell

occur. The Aegean borderland has a general N.W. - S.E. trend and is divided into two parts by the Cyclades Islands, eastern and western. The Anatolian Trough is located at the northern end extending from the Gulf of Saros to the Megnisia Peninsula.

The Aegean Sea can be subdivided into three broad physiographic areas: a southern area, the central plateau, and a northern area (Malley and Johnson 1971). The southern area is dominated by the Cretan Trough, a long deep feature that parallels the trend of the Hellenic Trough, and extends from the Peloponnesus to north of Karpathos.

The central plateau is a broad, wide, relatively shallow, plateau dotted by the numerous islands of the Cyclades and by submarine hills that create numerous small basins (Emery et al., 1966).

The northern area is also marked by a long, narrow trough, the Anatolian Trough (Maley and Johnson,1971) or the northern Aegean Trough (Melguen and Needham,1973) which extends along the entire base of the Macedonian (northern Greece) continental slope.

4.2 The Regional Structure and Tectonics of the Eastern Mediterranean Basin:

The morphology of the Eastern Mediterranean basin is typical of that of an island arc complex, (e.g.

the Java Arc, Maley and Johnson, 1970). The results of the works of various groups including Emery et al.(1966); Ryan (1969); Vogt & Higgs (1969); Caputo et al.(1970); and McKenzie (1972) have served to elucidate the complex problems of structure and seismicity of the eastern Mediterranean. McKenzie (1970, 1972) examined the focal mechanisms and epicentres of the earthquakes in the eastern Mediterranean and concluded that, in addition to the major Eurasian and African plates, two smaller plates are operative in the area. The first, the Aegean Plate, includes part of mainland Greece, the Aegean Sea, plus part of western Turkey and is actively overthrusting the Mediterranean sea floor causing a downwarping of the African Plate in a subduction zone to the south of Crete. Most of Turkey and Cyprus moves as the Turkish Plate, the second small plate of the system. According to McKenzie (1970) the closing rate between the Aegean and African Plates is of the order of 3.5 cm/yr which is not far removed from an earlier suggested figure of 2.6 cm/yr (Le Pichon, 1968).

The depth distribution of earthquake foci indicates that the southern boundary of the Aegean Plate is a gently dipping seismic plane (at an angle

of about 30°). It could be referred to as Benoff Zone, (Caputo et al., 1970; Karnik, 1972, Comninakis & Papazachos, 1972). Large negative free air gravity anomalies to the south of Crete, and positive anomalies over the Aegean, also conform to this hypothesis. Rabinowitz and Ryan (1970) account for the low heat profile and gravity anomalies with a model which invokes the thickening of the sedimentary layer, seaward of Crete, by crustal shortening which began approximately 6 to 8 million years ago. Associated with the region of crustal shortening is the Mediterranean Outer Ridge, which was considered to be a possible spreading ridge (Emery et al, 1966). This idea has now been rejected as the low heat flow and the undistributed magnetic anomalies are not characteristic of such a spreading axis. Body waves do not appear to be attenuated by the Mediterranean Ridge (Comninakis & Papazachos, 1972) and consequently Papazachos & Comninakis (1971) considered this ridge to be the starting point of the underthrust zone and a region of compression (also Ryan, 1969; Vogt & Higgs, 1969).

Petrographic evidence may also be cited for support of the island arc hypothesis. Nicholls (1970), Ninkovich & Hays (1972), and Pichler and Kussmaul (1972) all generally agree that the K_2O/SiO_2 ratios for the lavas of the Cyclades Arc are compatible with the model of partial melting within, or along the margin of a descending plate. This calcalkaline suite of rocks also conforms to the requirements of formation proposed by Sugisaki (1972) which include a closing rate of greater than 2.5 cm/yr and melting at a depth greater than 70 km.

4.2a The subsidence of the Aegean and the formation of the Aegean Sea:

McKenzie (1972) believes that relative movements caused a stretching apart of Greece and Turkey in Miocene times, resulting in a thinning of the crust by normal faulting and subsequent subsidence to form the present shallow sea. Holmes (1965) considers the islands to be horsts and the sea between to occupy regions of collapse which occurred in the late Tertiary. Paleontologic evidence also suggests a late Tertiary collapse (Pfannenstiel, 1960) with the influx of the sea being a gradual process over the Pliocene (Charlesworth, 1957).

4.3 Volcanism

Deposition of volcanic ash layers, turbidites and slump deposits suggests that the eastern Mediterranean has been tectonically active for a long time. Volcanic eruptions have contributed wide spread tephra layers in the region. Santorini is one of the greatest volcanoes in the region with fumaroles on several islands. It stands above sea level as a group of islands in the southern most Cyclades, about 120 km north of Crete.

4.3a Santorini Eruptions

The geology and tectonics of Santorini have been discussed by many authors, among them are Fouque(1879), Ktenos (1925), Washington (1926), Oekonomidis (1932), Reck (1936), Williams (1941, 1942), Georgalos & Popastamatious (1951) and others. Williams classified the volcano as "Krakatoa type". It lies as a group of islands which form an arc of apparently extinct volcanoes in the Aegean Sea. The original Island of Santorini as it existed before the formation of the volcano, was composed of a metamorphic assemblage of marbles and schists, which are

now found on Thera island.

Since the end of the tertiary the volcano gradually grew by successive eruptions, and during post-glacial times, a large volcanic island called Stronghyli was built up. In 1400 B.C. a powerful eruption took place and destroyed the island leaving as remnants, Thera, Therasia and Aspronisi covered with a 30 m thick tephra layer.

After these Minoan times, submarine eruption occurred intermittently until 197 B.C. when Kameni Island appeared. Successive eruptions occurred afterwards and now Santorini has taken on a new stronghyli form. Since there are two tephra-layers in the deep sea sediments, a reasonable inference is that Santorini Volcano twice developed the round stronghyli form and twice collapsed, first in the late pleistocene (lower tephra) and second during Minoan times (upper tephra layer).

Using the two tephra layers and the known historical eruptions Ninkovich and Heezen (1965) determined cyclic evolution of three successive cycles of eruptions.

1. Eruption in the late glacial period, ejecting enormous quantity of tephra to give the lower layer in deep sea sediments of this region.
2. The Accumulate under the volcano caused explosion and ejection of enormous quantity of tephra to give the upper layer in the deep sea sediments of this region.
3. The filling of Caldera may in the future bring about the formation of a new stronghyli island and a third big eruption.

4.4. Igneous and Metamorphic Formations in the Region:

Intrusives occur throughout the region. Rentz et al (1954) reported several outcrops of basic intrusives, described by many others as ophiolites, serpentinites or basic Alpine intrusives. The exact relationship to the alpine orogensis is not clear. Also acidic intrusives of Tertiary age are recorded in the region.

This region "including the Cyclades Arc, the central Aegean Plateau, the Attic Cyclades Massif (Rentz et al., 1954)" is characterised by a major formation of complex metamorphic rocks, consists of schists and gneisses with some interbedded marbles (Zachos & Maratos, 1965). Probably the age is paleozoic, but Anastopoulos (1963) reports the discovery of fossilised limestone on Antiparos of Permain age and on the basis of this classified the formation as Permian in age.

Regional and dynamic metamorphism (Anastopoulos, 1963) probably occurred in the Cretaceous or early Tertiary as part of the Alpine orogeny which is considered to be the result of net movements between the continental fragments subsequent to the opening of the Atlantic in the Jurassic.

Several outcrops of basic "intrusives" (Rentz et al. 1954), occurring throughout the region (Zachos & Maratos, 1965), are described as ophiolites (Marinos & Petrasheck, 1956; Aubouin, 1965), serpentinites (Klemme, 1958), or basic Alpine intrusives (Zachos & Maratos, 1965). Although intimately related to the Alpine orogenesis, the exact relationship is not clear.

Extrusive volcanic rocks throughout the area, particularly those of the Cyclades Arc, have received considerable attention in the last few years (Nicholls, 1970; Ninkovich & Hays, 1972;

Pichlre & Kussmaul, 1972) because of their relationship with postulated active subduction zones. Nicholls (1970) describes four groups of lavas on Santorini, all of which may be broadly termed calc - alkaline. The oldest of these groups is considered to be Pliocene in age and related petrographically to other occurrences throughout the Cyclades Arc. The Quaternary basalts, however, are less siliceous and develop fewer hydrous minerals than their Pliocene equivalents. This could indicate that the fractional crystallisation of this younger group took place under conditions of relatively low water and oxygen fugacities. Perhaps these conditions would also result in the low trace metal concentrations in these basalts (Pichler & Kussmaul, 1972) . Further Tertiary and Quaternary lavas and welded tuffs are reported on the other islands of the Cyclades Arc, including Antiparos (Pliocene rhyolitic lavas - Anastopoulos, 1963), but Santorini is the only volcano to have been active in historical times (Ninkovich & Heezen, 1965).

4.4a Mineralization: general description

Zachos and Maratos (1965) have compiled the reported occurrences of mineralization in the form of a metallogenetic map of Greece. From this map it is clear that the areas of interest in the Aegean are those of lead and zinc, iron and manganese, gold and silver, chromite, and emery. Except chromite and emery they are considered to be genetically related to the acidic intrusives and lavas of the Pliocene/ Miocene (Marinos, 1948; Frangato, 1951; Marinos & Petrashech, 1956; Anastopoulos, 1963; Marakis, 1968). The chromite on Andros occurs in the basic Alpine intrusives (Zachos &

Maratos, 1965), whereas the emery of Naxos probably stems from the metamorphism of Bauxite (Papastamatiou, 1951). The mineralisation of the southern Aegean is normally grouped into one province (Marinos, 1948; Marinos & Petrashech, 1956) Laurium..

4.4b Mineralization:Laurium Province

The formation at Laurium consists of complex metamorphics of the Attic - Cyclades massif which Marinos & Petrasheck (1956) divided into two groups - an overthrust nappe and an autochtonous unit both consisting of marbles, dolomites, schists, and phyllites. Intersecting both units are the granodioritic dykes (usually with hornblende) and associated mineralisation. Apparently the ascent of the mineralising fluids was post-magmatic to an extent, the latest phase being in the Miocene (and perhaps later in other parts of the Cyclades).

Deposition of the ore minerals appears to be structurally controlled as deposits form along the contact between the marbles and the schists, especially where the schists form the hanging wall. The primary ores include an iron-manganese assemblage of ankerite and rhodochrosite, with associated barite, fluorite, and quartz, present in both the nappe and the autochton; and a mixed sulphide assemblage of sphalerite, pyrite and galena with associated copper, arsenic, cadmium, bismuth, nickel, cobalt, gold and silver ores. These mixed sulphides are confined mainly to the autochtonous unit and are often oxidised to cerrussite, smithsonite, anglesite and malachite.

Mining began at Laurium earlier than 1000 B.C. and yet still remains a viable ore reserve today.

4.5 Sediments of the Eastern Mediterranean

In the whole Mediterranean Sea there are three main distinguishable lithologic units. All are of the Neogene series and have been described by Nesteroff et al., (1972) after the examination of the Glomar Challenger cores in the area (Leg 13 of the DSDP). They are as follows:-

The Lower Unit:- This unit is composed mainly of Blue Marl with a poor or dwarfed fauna, similar to Blue Marl on land of the same age (Langhian, Serravalian, Tortonian). This suggests that the Vindobonian Tethys received a uniform type of sedimentation.

The Second Unit:- This unit comprises evaporitic series of Messinian age, interbedded with sharp contacts separating lower and upper units. Also it is very similar to Messinian Evaporites around the Mediterranean.

The Upper Unit:- This last unit is composed of Hemipelagic Ooze of pliocene and Quaternary age.

Nesteroff et al., (1972) examined some distinctive characteristics of brackish and lagoonal fauna, stromatolitic structures and isotopic analysis. They concluded that evaporites were deposited in shallow water, and suggests that the Mediterranean Sea was isolated from the world ocean during the Messinian, and then evaportation turned this sea into a dessication basin with salt deposition.

In the Pliocene, sea water invaded the dry basin and open sea conditions and sedimentation were resumed. Therefore, the lithologic uniformity of the major Neogene marine formations is the result of tectonic events.

Deposition of sediments in the eastern Mediterranean was controlled primarily by regional tectonic activity, especially in the late Quaternary. This is indicated by the presence of volcanic ash

layers, turbidites and slump deposits interbedded with pelagic sediments. Climatic changes were of subordinate importance in this regard.

4.5a Sediment Types:-

Herman (1972) described the different types of sediments in the region.

Five main sediment types are encountered in cores of this province.

These are:-

(1) Terrigenous clastics

(2) Displaced sediments

(3) Sapropelic deposits

(4) Volcanic ash

(5) Calcareous oozes

4.5b Paleosol derived sediments

Climatic changes on land can be inferred from chemical and geological weathering of soils. In the eastern Mediterranean, a sequence of reddish and rose-brown hemipelagic lutites are found. Butzer (1963) has mentioned that in North Africa and Italy the red soils were frequently stripped by sheet flow and incorporated in the colluvial silts (limons rouges) that blanket the lowland plains. These heterogeneous beds are commonly detrital horizons and are found intercalated with littoral sediments, (Ryan, 1972). Because they record periods of slope wash, possibly by torrential rains and floods following seasonal droughts, it is equally likely that the limons rouges are washed into the sea. Butzer shows that stratigraphically these soils date from glacio-eustatic emergencies.

4.5c Origin and Dispersal of Sediments in the eastern Mediterranean Sea.

Sources of sediments:-

The principal sediment sources in the eastern Mediterranean are:

(1) Nile River detritus, which is carried north-east along coast of Israel, Lebanon and Syria.

(2) Sediments from the south-eastern Aegean Sea, and possibly the coast of Turkey, which are carried by the Levantine intermediate water into the Hellenic Trough.

(3) Sediment from the south-western Aegean, which is carried by bottom currents westward between Crete and Peloponnesus, into the Hellenic Trough.

(4) Sediments from the Adriatic Sea, transported by cold bottom currents into the Ionian Basin.

(5) Detritus from Northern Africa, transported by winds and which, because of the lack of dilution by current-transported detritus, constitutes a major detrital source for sediments of the Mediterranean Ridge and south-western Levantine Basin.

(6) Pelagic plants and animal tests, which are relatively abundant along the Mediterranean Ridge.

Venkatarathnam et al., (1972) analysed Holocene sediments from the eastern Mediterranean for calcium carbonate concentration, fine fraction mineralogy, Rb/Sr. ratio, and Rb-Sr. "apparent age", and for concentrations of four transition metals (Cu, Mn, Zn & Fe). Because of possible ambiguities in resolving sediment sources with similar mineralogies, the clay mineral characteristics were analysed by Q-mode factor analysis by them.

They found that the major sources of aluminosilicate detritus to the sediments of the eastern Mediterranean, are suggested by distinctive clay mineral assemblages. They named the assemblages after the regions where they are most prominently developed (Nile, South-Eastern Aegean, Kithira, Messina, Sicilian, and a kaolinite-rich assemblage characteristic of the Mediterranean Ridge and the South-Western Levantine Basin, Venkatarathnam and Ryan, 1971). Q-mode factor analysis resolved three factors which account for 98% of the variability in the data, and which are consistent with the sediment sources suggested by the mineral assemblages. Rb/Sr ratios and Rb-Sr "Apparent Ages" also confirm these sources.

The concentration of calcium carbonate is highest in the areas influenced by eolian sediments (the Mediterranean Ridge and South-Western Levantine Basin) because of the lack of dilution by current-transported aluminosilicate detritus.

The concentration of iron appears to be entirely related to the sources of aluminosilicate detritus with $CaCO_3$ acting only as a diluent. They did not distinguish between biogenic and detrital control of the distribution of Cu, Mn and Zn.

Dispersal:

The dispersal of sediments is affected by currents. The sediments in the eastern-most Levantine Basin and the Nile Cone are clearly derived from the Nile source. The dispersal of these Nile sediments is affected by the easterly directed surface currents, which are part of the Main Mediterranean counter-clockwise gyre. Zarudzki et al. (1969) observed that the thickness of unconsolidated sediments increases eastward, across the Nile Cone. Emery and George (1963) noted the transportation of the Nile sand, (even coarse) as far as the shore of Lebanon.

Venkatarthnam et al. (1971) noted that the dispersal of Nile sediments is affected by the easterly surface currents. The presence of low amounts of $CaCO_3$ in the Eastern Nile cone, and the Eastern Levantine Basin provides further support for this view.

Differentiation of Nile sediments seems to have occurred as the finer-sized smectite is transported further eastward, relative to other clay minerals. Little sediment is directly transported across the Ridge into the Northern Levantine Sea. The extension of well crystallized smectite from the south-east Aegean Sea, onto the Mediterranean Ridge, south-east of Crete, is the result of transport by intermediate water from the Aegean. The deep cold water mass spilling out of the Aegean sea is responsible for this type of dispersal, especially in the case of clay minerals dispersion.

Rateev et al. (1966) published a general survey of clay minerals in the surface sediments of the Mediterranean. It was based only on 55 samples. Venkatarathnam & Ryan (1971) analysed the 2 micron size fraction of the surficial sediments of the eastern Mediterranean and from the results established six particular mineral assemblages and thence identified the major dispersion mechanisms in the area. These circulation patterns seemed to agree with those of Moskalenko & Ovchinikov (1965) in that the outflow from the Aegean into the Mediterranean is occurring in the surface and deep waters in the southwest, and in the intermediate waters to the southeast. Inflow of water into the Aegean occurs in the surface flow in the southeast as part of the anticlockwise gyre in the eastern Mediterranean.

4.5d Factors controlling Sedimentation

The topographic, structural, stratigraphic and climate frame-work aid the understanding of marine sedimentation in the eastern Mediterranean. According to Fairbridge (1972) the quaternary sedimentation in the Mediterranean was controlled by tectonic factors, paleoclimates and sea level changes. The following is a summary of the conclusions of Fairbridge.

(a) Tectonic Changes

Vertical movements, in places exceeds 2 km during the last two million years (1 mm/ 1 yr.). Subordinate strike-slip faulting is active, mainly in an E-W sinistral sense, and not dominantly dextral, as commonly claimed. Active subduction is limited to the eastern basin.

(b) Paleoclimatic Oscillations

The long-established concept of pluvial maxima coinciding with glacial maxima is now positively rejected. Maximum cold is followed by maximum aridity - loss of vegetation, solifluction, stream loading and terrace building. Only the transitional phases toward the beginning and end of each glacial cycle would be marked by increasing terrigenous supply to the deep sea, facilitated by drop of sea level and turbidity currents, as well as eolion activity. Paleosols of red and brown types mark inter-glacial, warm-humid intervals, at which time the vegetational cover would inhibit large-scale erosion and supply to the deep sea. In spite of the recognition of multiple oscillations, four major glaciations still dominate the record.

(c) Eustatic Oscillations

Contemporary sea-level trends are disclosed by tide-gauge

bounded with narrow bands of sand, gravel and rock with scattered patches of shell and coral. In the channels between large islands such as Maros and Paros (according to Blanc, 1969), a variety of sedimentary types occur including shell sand accumulations and herbiers. In these channels, Quarternary formations are dominant. Fine sands and silt are absent and sand grains consist of rounded quartz from the exposed beaches, angular quartz (with metallic inclusions) together with weathering products from the adjacent land constitute the channel sediments.

Clay minerals in the less than 2 μ size fraction include Smectite (30%), Illite (40%), Kaolinite (less than 15%) and Chlorite (12% plus) (Venkatarathnam & Ryan, 1971).

Cores from the Aegean abyssal plains to the north of Crete, Scarpanto and Rhodes have sediment sequences which are typical of the eastern Mediterranean and consist largely of pelagic carbonate sediments, calcareous lutites) - Opdyke et al., (1971), with abundant coccoliths foraminifera and pteropods. Interstratified with these calcareous sediments are sapropelic muds, ash layers (Tephra) (Olausson, 1960; Ninkovich & Heezen, 1965; Emery et al., 1966; Pastouret, 1970; Ryan, 1969; Opdyke et al., 1971), and occasional turbidite sequences (Blanc & Froget, 1967).

4.6a Santorini Sediments

The sediments from the Santorini caldera have received a little more attention than Aegean sediments in general because of the present formation of iron rich sediments around the Kameni Islands at the centre of the caldera. According to Butuzova (1966), these sediments form the west side of Nea Kameni in two layers

with a total thickness of up to 70 cm. The upper layer, 24 to 40 cms thick, is a bright orangey-red, very fine mud of ferric hydroxide gel with some volcanic fragments. Underneath is a zone of greenish black mud with ferrous minerals which include hydroxides (the main mineral form), carbonates, sulphates, and sulphides (mainly hydrotroilite and pyrite). The iron minerals are thought to originate as carbonates and bicarbonates which are subsequently oxidised to form ferric hydroxide gels. Fumarolic H_2S then reacts with the gel to reduce it to the ferrous state. Puchelt (1972) agrees with the structure described by Butuzova (1966) but believes the lower layer to be dominant in ferrous silicates rather than hydroxides.

Of considerable interest are the lack of titanium and very low values of vanadium, copper, chromium, cobalt, and barium, plus the high amounts of boron (0.64% and 0.26% in the upper and lower layers respectively) reported by Butozova for the iron rich sediments. Manganese is also very low, apparently because of it's high chemical mobility which causes precipitation further away from the fumeroles. At these sample locations the manganese concentrations are of the order of 200 times greater than in the iron rich sediments. Butuzova (1966) does not mention whether the low copper is due to similar mobilisation and association with the manganese or not.

Not suprisingly, these sediments also contain volcanic detrital minerals such as hornblende, augite, hypersthene, glass and ilmenite (Blanc, 1969).

4.7 Granulometric and Mineralogic Composition:

Based on the study of 55 samples. Rateev et al. (1966) published a survey of clay minerals in the surface sediments of the

Suspensions over the submarine delta of the Nile are characterised by the abundance of fine-pelitic (1-3 μ) material, represented by isotropic, and rarely anisotropic flakes. In the arc between Cyprus and Turkey, the suspensions do not differ much from those of the Aegean Sea.

High concentrations of corroded sandy particles (2-30 μ) have been found in the southern part of the east Mediterranean Sea. According to Bernard (1959), the sand grains are eolian and are delivered to the sea from the African Desert.

According to Emelyanov and Shinkus (1972), 5.1% of the suspended matter in the Mediterranean Sea is Ca CO_3; 47.5% total silica; 39% amorphous silica; 14.2% Fe and 0.162% Mn.

CHAPTER V

SEDIMENTOLOGY

5.1 Introduction

As a sedimentary basin, the eastern Mediterranean Sea is of particular interest for the study of its sediments and the processes by which they were formed. The sedimentation in the region is among other things, a reflection of the environmental conditions. Sedimentological study of the surficial and buried sediments, reveals most of the characteristic geological events of the recent past in the region.

The region is characterized by a high rate of sediment input. Sediments are introduced from the surrounding borderlands by rivers and streams and from aeolian sources. Each source area is characterized by a certain mineral assemblage (Venkatarathnam and Ryan, 1971). The desert sand, for example, is characteristic of an aeolian source. The sediments in the eastern Mediterranean are characterized by the occurence of numerous volcanic ash layers, sapropels or sapropelic layers, turbidites, displaced sediments and slump deposits interbedded with normal pelagic sediments. Layers of ash and sapropelic sediments are dominant in the upper part of the Quaternary sediments. Calcareous silty lutites and oozes predominate on the deep-sea floor as a modern surface sediment layers, while sediments on the continental shelves have considerably different mineralogic compositions and textural characters. In the central part of the Levantine basin, cores are characterized by the intercalation of normal pelagic sediments with terrigenous silts and sands. In the southern Aegean basin, normal sediments are intercalated with ash and pumice fragments near the volcanic islands.

In the present study, the Aegean Sea sediments are classified as Northern, Middle and Southern Aegean sediments. Sediments from the area between the islands of Milos and Santorini are not included with the southern Aegean group, and are described as a separate group because of their large content of volcanic deposits (Fig. 4). Most sediment cores from the southern Aegean and the vicinity of Crete contain the upper tephra layer (see Chapter IV page 56). Longer cores contain the lower tephra as well. Many other ash layers intervene between the different sediment layers. Radiolaria and diatom rich layers occur in sediments containing volcanic ash. Cores from the southern Aegean area were also found to contain turbidites layers.

Study of the processes of sedimentation in the area shows evidence of the following processes:

1. Active volcanism
2. Biogenic sedimentation
3. Chemical processes of sedimentation
4. Diagenetic redistribution of elements in the upper layers of sediments
5. Local stagnation of the deep water layers in the deeps (e.g. core no. MR 5).

Deposition during the late Quaternary in the eastern Mediterranean was controlled by two main factors, the regional tectonic activity and climatic changes. The regional tectonic activity was the main controlling factor. This is indicated by the presence of displaced sediments, slump deposits (Fig. 5), volcanic ash layers (Fig. 4), and by the presence of some turbidites interbedded with pelagic sediments. Climatic changes are believed to have also been important in controlling sedimentation during the recent geological past in two ways:

Fig. 4: Photo of Cores No. 1112 and 1108 from the vicinity of the volcanic islands Thera and Milos containing pumice and ash

A)1112 B)1108

These are examles of marine volcanic deposits containing layers of ash and pumice rich sediment. Thin layers of glass shards and pumiceous debris are mixed with nonvolcanic marine sediments such as calcareous lutites, which predominate near the top of core. Pumice is the most important component. Most of the pumiceous sedimet is of the long-tube variety.



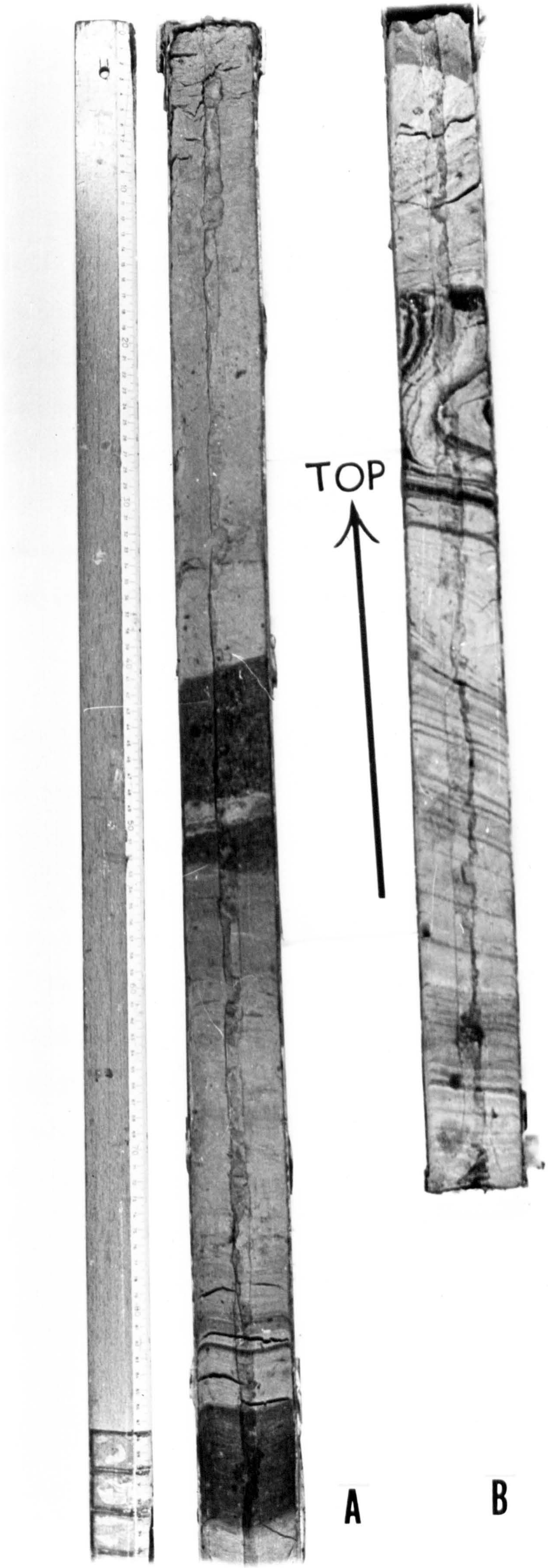
A

TOP



B

Fig. 5: A Photo ofaslumped deposit found south of the island of Crete (Core photo B)


TOP
A
B

i) It affects the relative supply of wind blown and fluvial materials to the sediments.

ii) It alters the sedimentary regime by causing periods of bottom water stagnation, when the melting of glaciers causes excessive pluvial run-off and the formation of density stratification of the waters, that prevents sinking of oxygenated surface waters.

Other factors controlling sedimentation have been of subordinate importance during the Holocene. Factors such as source area lithology and sea level variation. McCoy (1974) has suggested that man might be a new factor in influencing sedimentation in the region.

5.2 Sediment Classification

The Principal types of recent bottom sediments in the eastern Mediterranean Sea

Five main types of sediments have been found in the present work

1. Calcareous ooze
2. Terrigenous sediments
3. Volcanic deposits
4. Sapropelic deposits
5. Displaced sediments

These five principal types of sediments are discussed in detail, supported by a complete megascopic and microscopic study of cores from the different parts of the eastern Mediterranean. A granulometric study has also been carried out on the sediments.

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5.2a Calcareous Ooze:

Calcareous ooze consists largely of skeletal remains of planktonic foraminifers, pteropods, heteropods and coccolithophorids. The skeletal structures are of calcite and aragonite. Benthonic foraminifers are generally minor contributors to the sediments, they form less than 5% of the fauna in the coarse fraction. The average carbonate content of the surface sediments studied in this work is 36.19% (table 3). Ryan et al.(1966) estimated an average of 40% carbonate in the surface sediments of their Mediterranean cores. In the coarse fraction (larger than 1 mm in diameter), shells of foraminifers and pteropods are the chief contributors. According to Herman (1972) they form up to 90% of the planktonic fauna in the coarse fraction of the eastern Mediterranean sediments. On the other hand they are not common in older sediment layers, due to modification by post-depositional solution. The grain size of the calcarous oozes studies is often unimodal. The main mode is in the silt range, very frequently close to the clay range.

Table 3 The range and average of $CaCO_3$ in the Eastern Mediterranean and Aegean Seas Sediments*

	Range %	Average %
Northern Aegean	14.14 - 20.02	16.425
Middle Aegean	21.67 - 39.02	32.28
Southern Aegean	36.72 - 46.35	42.215
Santorini Area		
A. Close to the islands	29.07 - 61.58	45.31
B. Away from the islands	48.61 - 53.36	50.863
South of Crete shelf sediments	21.49 - 33.66	26.00
East of Karpathose	27.49 - 35.41	31.45
For the entire eastern Mediterranean and Aegean	14.14 - 61.58	36.189

* For the sediments of the surface layer only

5.2b Terrigenous clastics:

Terrigenous silty lutites of grey colour predominate in some parts of the Aegean Sea and in the southern eastern Mediterranean. In the northern Aegean Sea thick layers of dark grey terrigenous sediments occur. The sediment is predominantly dark grey to olive-grey silt, with disseminated organic debris. Because of high rates of clastic sedimentation, calcareous skeletal remains of foraminifers. pteropods or heteropods are scarce. Microscopic examination of these sediments, has shown that most silt and sand particles are composed of mica and quartz.

In the Levantine basin iron oxide stained quartz indicates that wind blown desert sand is transported from north Africa. Sand sized grains of quartz with frosted surface are also found in the area. By contrast, elsewhere terrigenous silty lutites are predominantly supplied by large drainage networks, draining into the northern Aegean Sea and southern eastern Mediterranean Sea. The sediment type grades into calcareous lutites and calcareous ooze towards the deep basins.

Rock fragments are rare in the sediments studied. Few fragments are found in the sand-sized fraction from sediments near Crete. Ryan et al.(1973) described rock fragments from samples to the south of Crete forming up to 22% of the sediment. Such values have not been found in this study.

5.2c Volcanic Deposits:

Volcanic ash and pumice have been produced by several volcanic eruptions on the islands of Milos, Santorini and elsewhere in the eastern Mediterranean. The multiplicity of volcanic sources has been recognized by McCoy (1974) and Bond

(1976). Thin layers of volcanic ash and pumiceous debris have been found in many cores studied in this work. These layers generally constitute only a small part of the local sedimentary sections, but they are usually valuable as an aid to regional correlation, and as an indicator of the nature of the volcanic activity.

Numerous volcanic ash layers are present in cores from the southern Aegean Sea. Six layers were found in one such core (core no. 316). Glass shards are found intercalated with other types of sediments in areas south of Crete and throughout the Aegean Sea. They have been recorded in the surface sediments in most parts of the entire eastern Mediterranean.

Volcanic eruptions, particularly those of Santorini, have contributed widespread tephra layers to the eastern Mediterranean Sea. Mellis (1954) and Ninkovich and Heezen (1965) identified two tephra layers, a lower layer and an upper one. They suggested that both layers originated from Santorini eruptions and were distributed by winds. The tephra is composed of colourless fine-grained frothy ash. They are rarely found as a clear and easily identified layer in cores. They are either mixed with pumice (Fig. 4) or associated with normal ooze and sometimes with radiolaria and/or diatom rich sediment. pteropods are also found in ash layers, sometimes in high concentrations. As mentioned, the Santorini tephra layers are mostly found as colourless ash, but black, dark brown volcanic ash is also sometimes found. The lower tephra, which was deposited during the last glacial period, is found in core no. 316 at a depth of 171.5 cm. According to Herman and Granizzi (1969) its age is about 27,000 years. The upper tephra is

recorded in the same core at a depth of 42 cm.

A granulometric study on the volcanic sediments in the area between the islands of Milos and Thera shows that the sediments are poly-modal (Fig. 13 IIA, B & C) having a mode in the medium silt range and another in the coarse sand, plus a weak mode in the gravel range.

Pumice is found in cores collected from the area between the two islands, and in other parts of the southern Aegean Sea. Its presence or absence in the sediment cores could not always be confirmed by simple examination of the core. Some cores contain pumice layers which could be easily recognized by cursory examination. However, in other cores only careful study using a hand lens and/or grain size analysis revealed the presence of small fragments of pumice which could not be seen by the naked eye. The features of the pumice help to interpret their origin and history in the sediments. Pumice of the long tube variety has sufficient permeability to become water logged quickly and settle to the sea floor, close to its volcanic source (Fiske, 1969). The other more familiar variety of pumice which contains round, non-connected, bubbles usually remains buoyant for long periods of time and can become separated from the other volcanic deposits. It spreads over very wide areas before being deposited. This causes great difficulty in recognizing its source. From this study it is clear that the thickness of the pumice layers decreases in all directions away from volcanic islands.

Pumice in the sediments can be supplied directly by volcanic activity, or be eroded from unconsolidated pyroclastic deposits and redeposited. In the eastern Mediterranean, both pyroclastic and epiclastic pumice exists.

5.2d Sapropelic layers:

Sapropelic layers occur throughout the eastern Mediterranean and southern Aegean Seas. The uppermost sapropelic layer is easily recognizable and has been extensively sampled. Sapropels are dark in colour due to their high content of finely disseminated organic matter and iron sulphides. Pteropods and planktonic foraminifers are abundant and better preserved than in sediments laid down during aerobic conditions.

If sapropels are not present as easily identified dark layers, they may occur as layers of variable grey colours. The latter is dominant in most parts of the eastern Mediterranean Sea. This variety of grey sapropel could be confused with other types of sediments, particularly the grey variety of terrigenous sediments. Sapropels are characterized by their high carbon content. According to Ryan et al.(1966) the average carbon content is 10 - 40 times that in oxidized deposits.

The times of deposition of sapropelic muds were synchronous throughout the deep-water basins of the eastern Mediterranean. They reflect stagnant conditions which occured during the warming trends of the post-glacial periods. During these periods the water circulatory system was changed and the Mediterranean suffered periods of stagnation in its deep waters.

5.2 e Displaced Sediments:

Turbidites and slump deposits are widespread in the eastern Mediterranean. Individual turbidite units are distinctive in cores by their changes in texture. Slumps are recorded in the area even on a small scale. Deformed structures are found in the area, some of which are tectonic, others are purely sedimentary. These deformations probably

occured in superficial sediments. Deformed structures are common in the central Levantine basin and near the trench zone. A thick turbidite sequence occurs in the Pliny Trench and the central part of the Levantine Sea. High percentages of turbidites are found in the Aegean Sea and different parts of the eastern Mediterranean. They are less common in the southern Aegean and south of the trenches near the Mediterranean Ridge (the Hellenic Outer Ridge).

A slump can have either a seismic or a sedimentary origin. The slump found in core no. 701 south of Crete (Fig. 5, 6) could be of either type. The core is from the subduction zone area which is tectonically unstable, so this slump could have been formed as a result of earthquake activity.

The slumped sequence is found at 16.5 - 30.5 cms from the top of the core, a depth probably corresponding to the Santorini eruption of, 1,500-1,700 B.C. If we assume a sedimentation rate of 10 cm/10^3 and keep in mind the well known phenomena of an earthquake before a volcanic eruption; it could be argued that the slump was formed by seismic waves, which shook the area before the eruption. The other possibility is that the slump was formed by gravity sliding of the sediments on the slope of the trench.

5.3 Granulometric Study of the eastern Mediterranean Sediments

In order to elucidate the size characteristics of the sediments and to study the distribution pattern of the different grain size fractions, a complete granulometric study has been carried out on sediments from all parts of the eastern Mediterranean Sea. The environments studied include deeps, trenches, sills and continental shelves. The fine and coarse fractions of both surficial and buried sediments have been

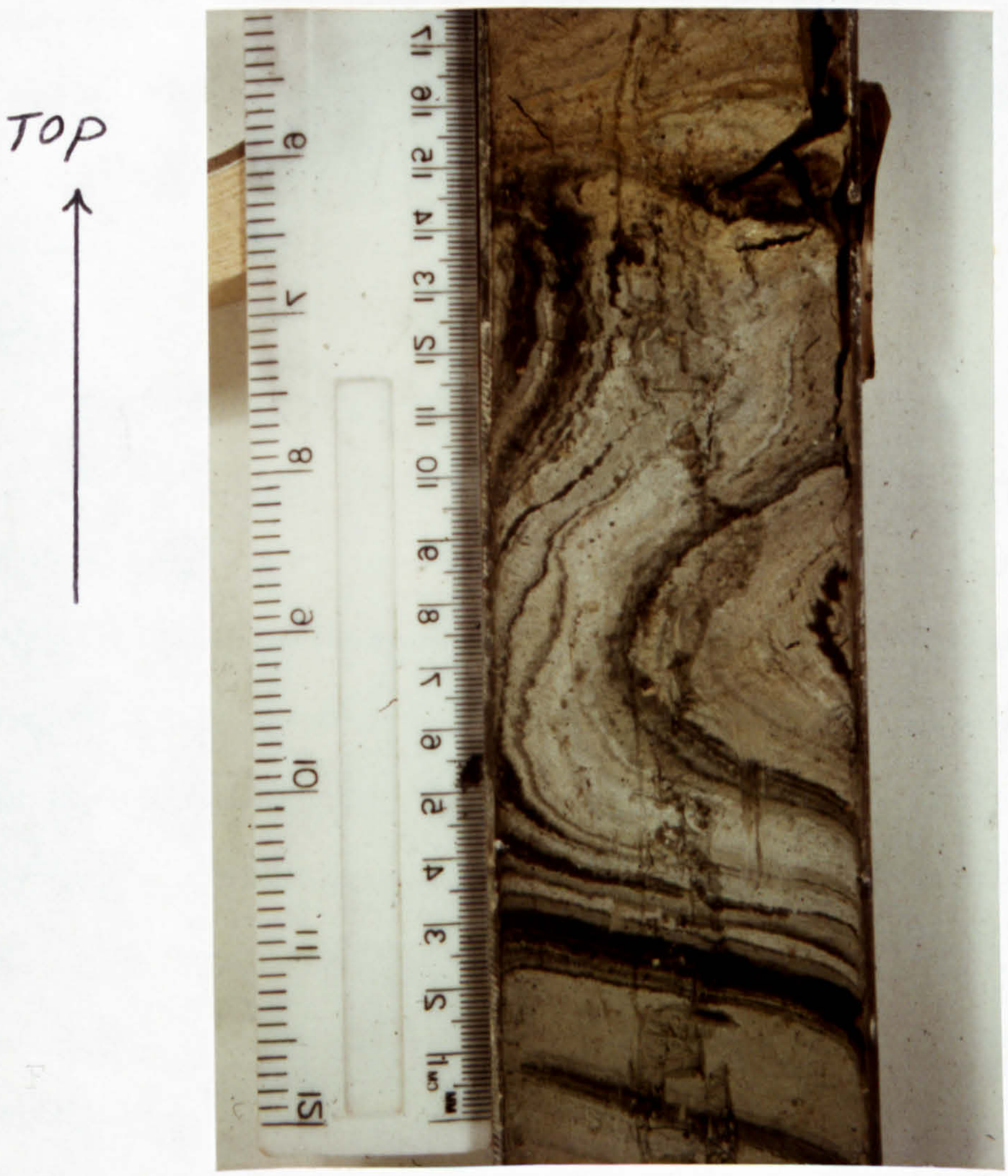


Fig. 6 A photo of core no. 701 south of Crete showing the slumped zone at 16.5 - 30.5 cms from top of core

analysed. Their areal distribution and correlation with major physiographic features is shown (Figs. 7, 8 & 9). The complete size characteristics of the different types of sediments are defined (Appendix 1), so a comparison can be made with other environments in other parts of the world.

(A) Surface Sediments

5.2 Texture:

5.2a Sands:

The surface sediments are generally low in sand (Fig. 7). The northern Aegean sediments contain less than 7% sand, the middle Aegean less than 5%, the southern Aegean less than 4%. Sediments in the Hellenic volcanic arc are characterized by a higher sand content. Off Santorini they have more than 33% sand and generally more than 10% in the region between Thera and Milos. Sediments off the islands are rich in sand. Between Thera and Milos the sand content decreases away from the islands, (Fig. 10B). The relation between the distance from the islands and the percent of sand in the surface sediment (Fig. 10A), shows that the sediments on the continental shelves are generally higher in their sand content, than sediments from the deeps, with one exception near the Strabo trench. This is quite understandable because the Strabo trench contains turbidites. Low percentages of sand are typical of sediments from the central basins, grading into higher percentages on the continental shelves and slopes (Fig. 7). This is due to their proximity to land and fluvial sediment sources.

5.2b Silt

The distribution of the silt fraction in the sediments analysed in this study, shows that, low silt percentages are

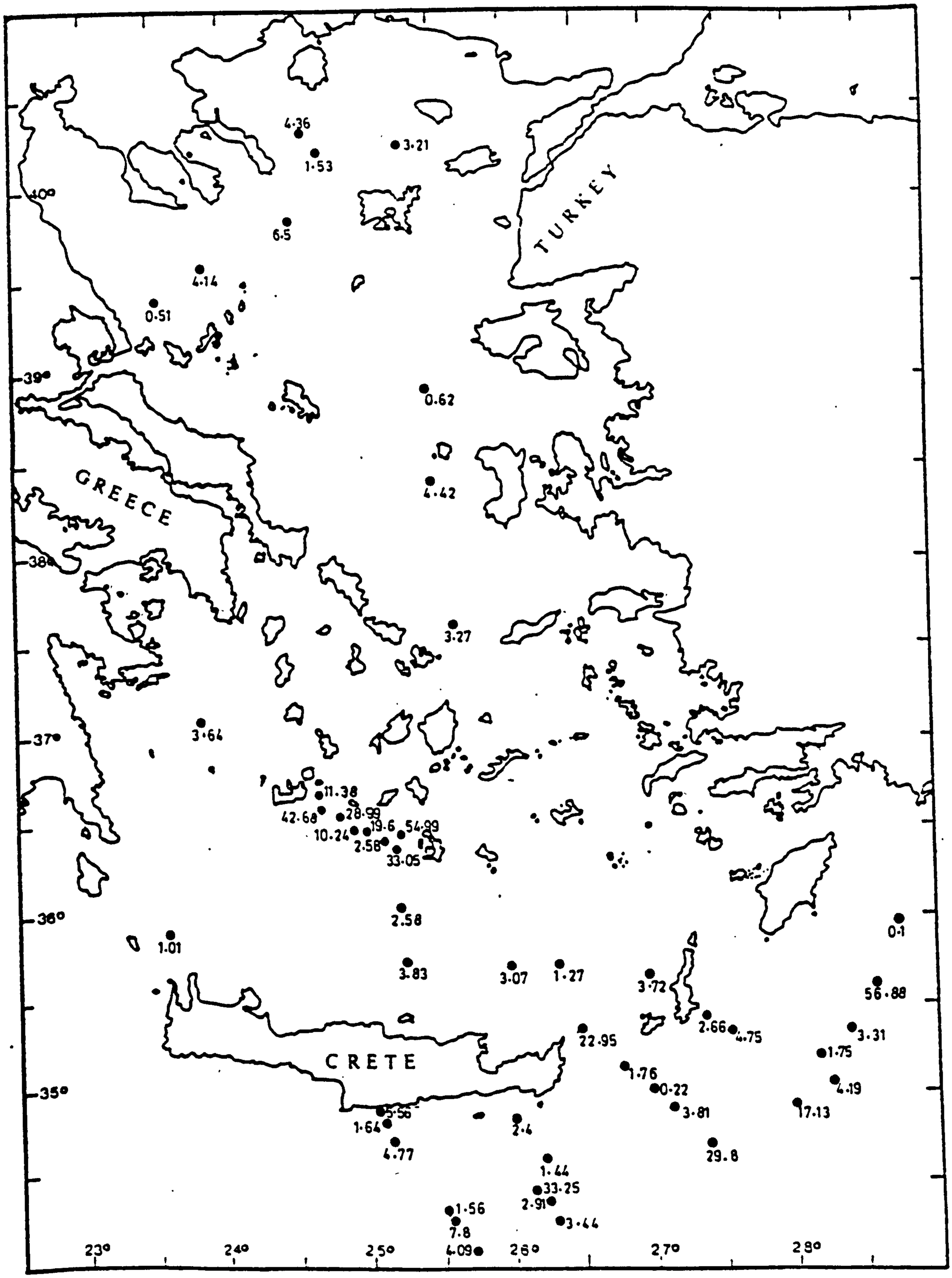


Fig.7: The distribution of sand in the surface sediments of the Eastern Mediterranean and Aegean Seas (in percent)

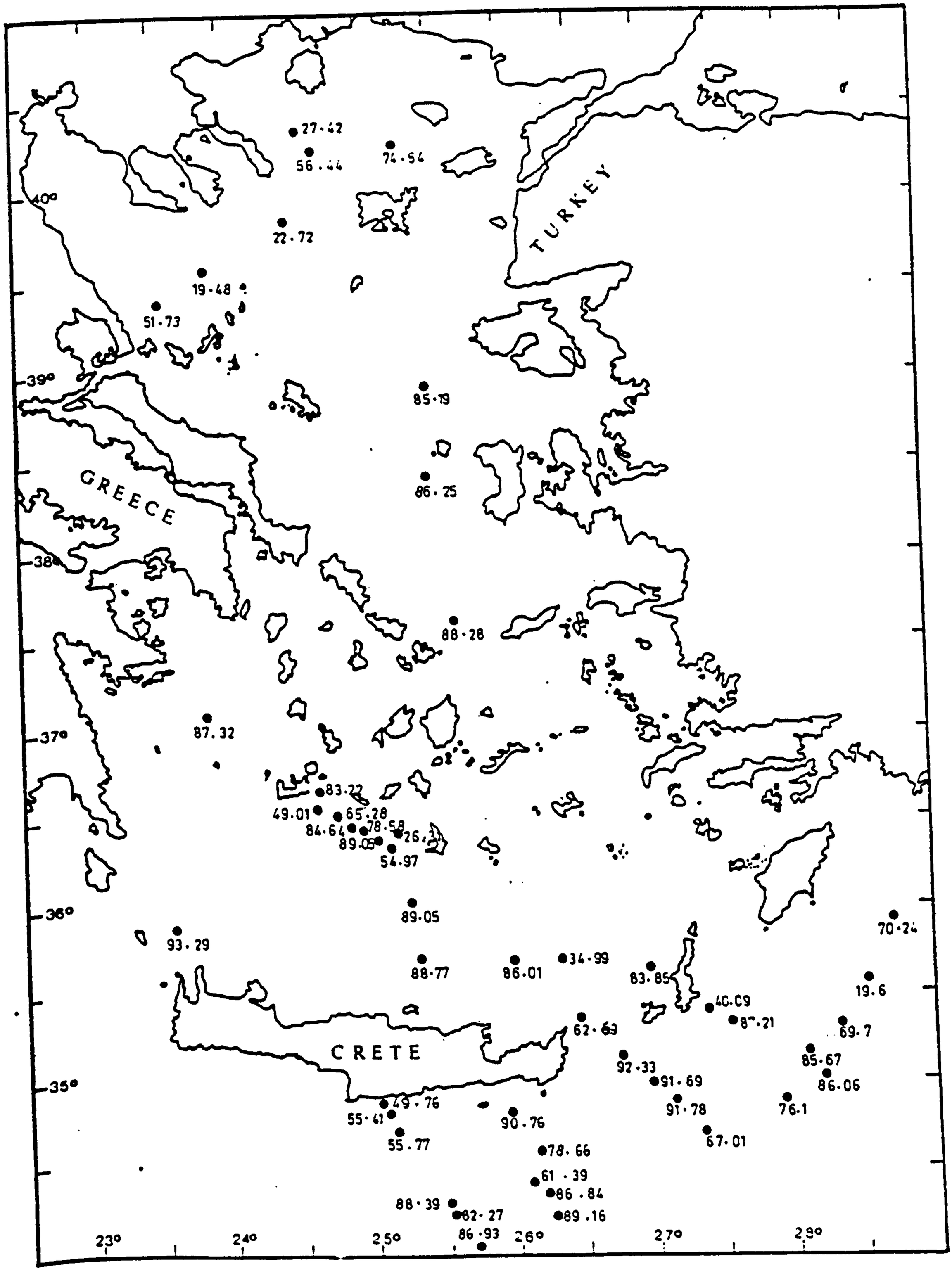


Fig. 8: The distribution of silt in the surface sediments of the Eastern Mediterranean and Aegean Secs (in percent)

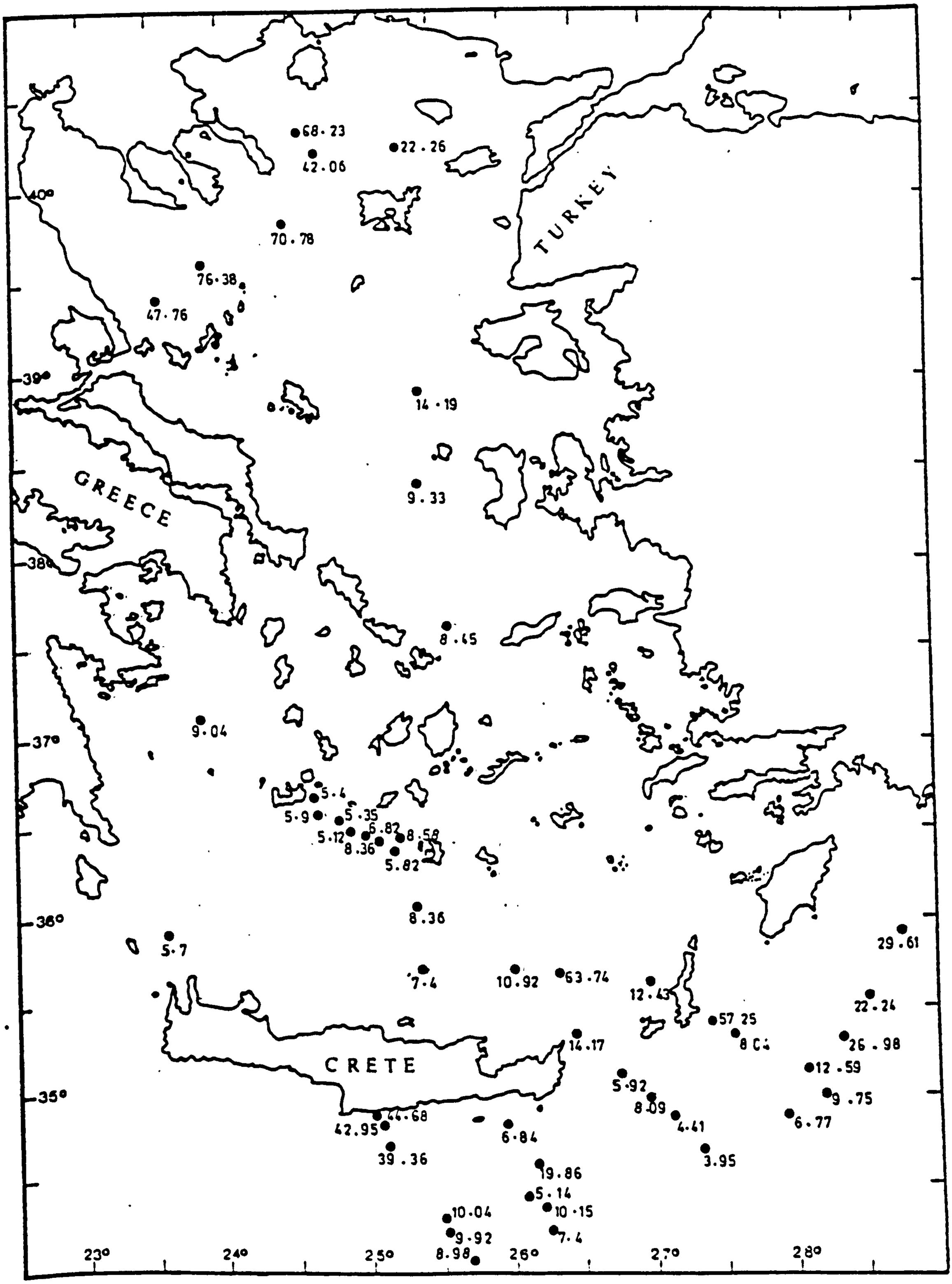


Fig.9 : The distribution of clay in the surface sediments of the Eastern Mediterranean and Aegean Seas (in percent)

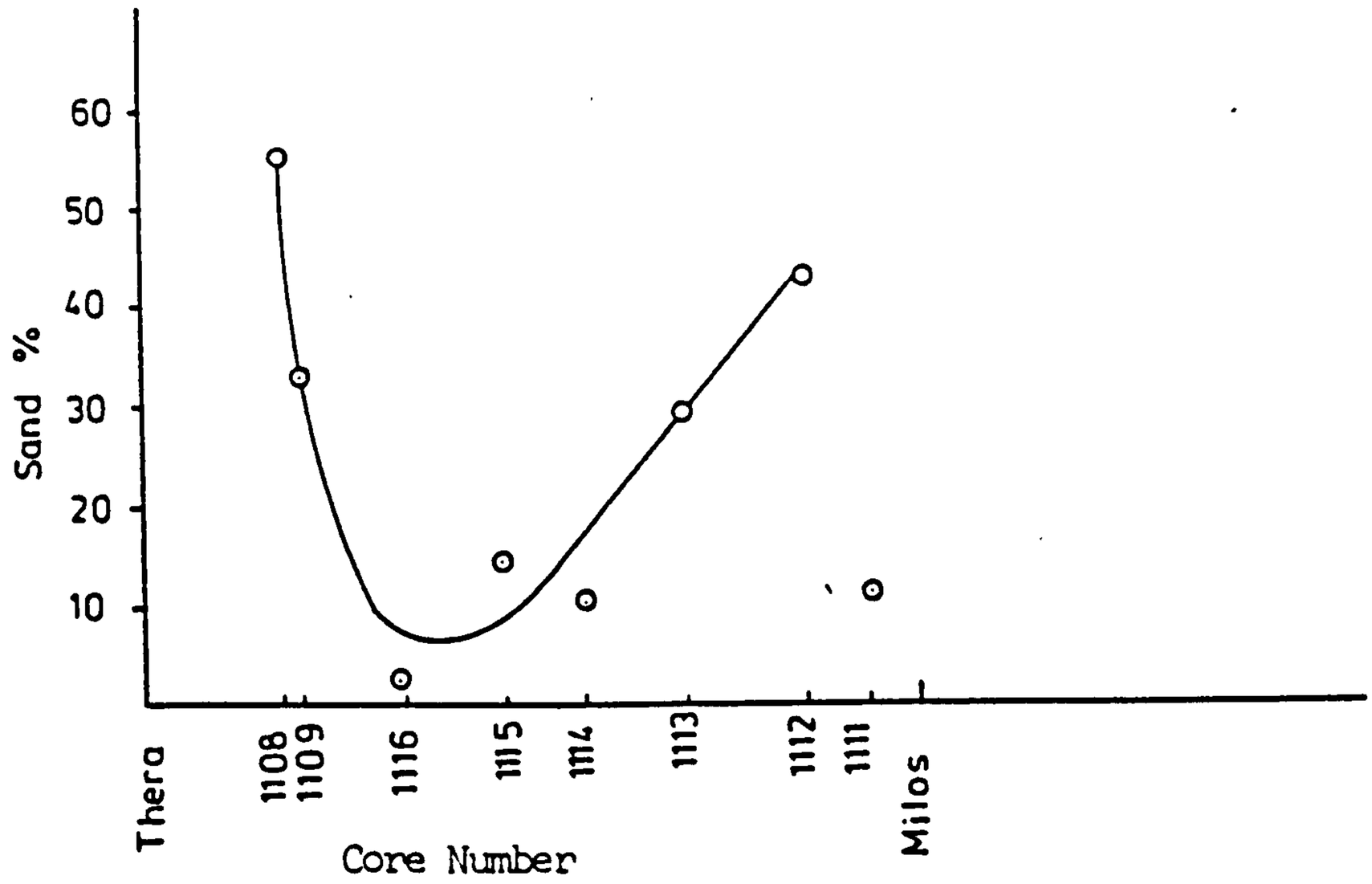


Fig. 10(A)

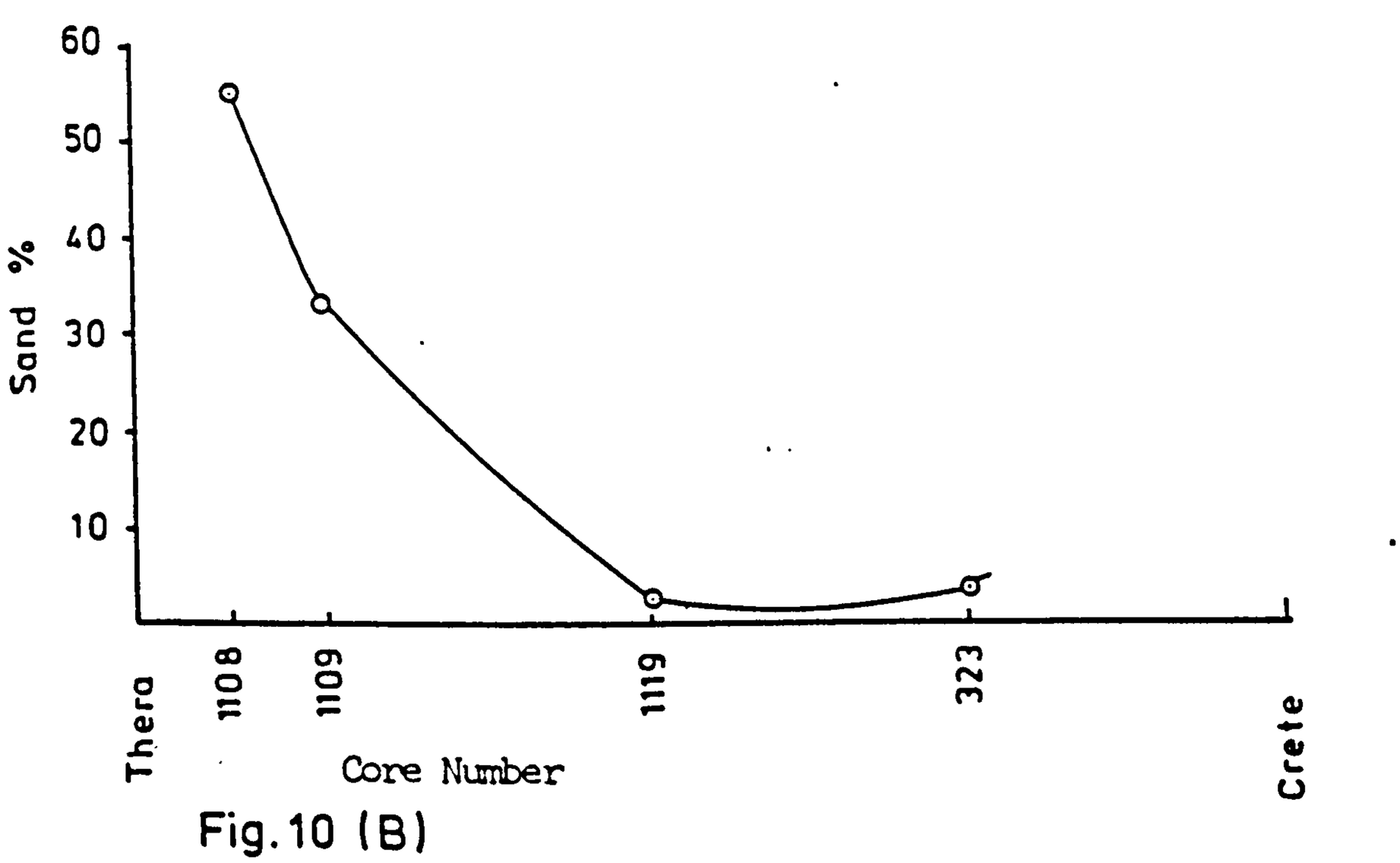


Fig. 10 (B)

Fig. 10 (A) & (B). The relation between distance from the islands and the percent of sand in the surface sediments around the volcanic arc area, in two different directions

(A) along a line between Thera and Milos

(B) along a line between Thera and Crete

characteristic of continental shelves and slopes (Fig. 8), while abyssal sediments are generally higher in their silt content (Fig. 8). In the middle Aegean the average silt content is 86.58%. Also the sediments of the southern Aegean have a similar high average (79.3%). In the Cyclades Island Arc, sediments have a silt content in the range of 26.3 to 89%, and the pattern of distribution is generally the reverse of the pattern noticed for sand, with the highest percentages away from the volcanic islands. Northern Aegean sediments from the continental shelf have a low silt content compared to other areas.

5.2c Clay:

The eastern Mediterranean sediments studied are generally low in clay content with the only exception being in the northern Aegean Sea. The middle Aegean surficial sediments have a clay percentage range of 8.45 - 14.19, averaging 10.64%, while the average in the northern Aegean is 54.57%. Sediments from the Cyclades arc are very low in their clay content, and so are those in the southern Aegean. South of Crete the shelf sediments have high percentages of clay which decrease south towards the trench zone (Fig. 9).

5.2d Sand: Silt: Clay Ratios (Fig. 11)

The sediments have been described and classified on the basis of their sand, silt and clay ratios (Folk, 1965) (Fig. 11). The surface sediments in both the Aegean Sea and central Levantine Sea are generally mud or silt, with one exception in the volcanic arc area between the islands of Milos and Santorini, where sediments are mostly silty sands, or sandy silt. The decrease in the proportion of sand in the sediments away from

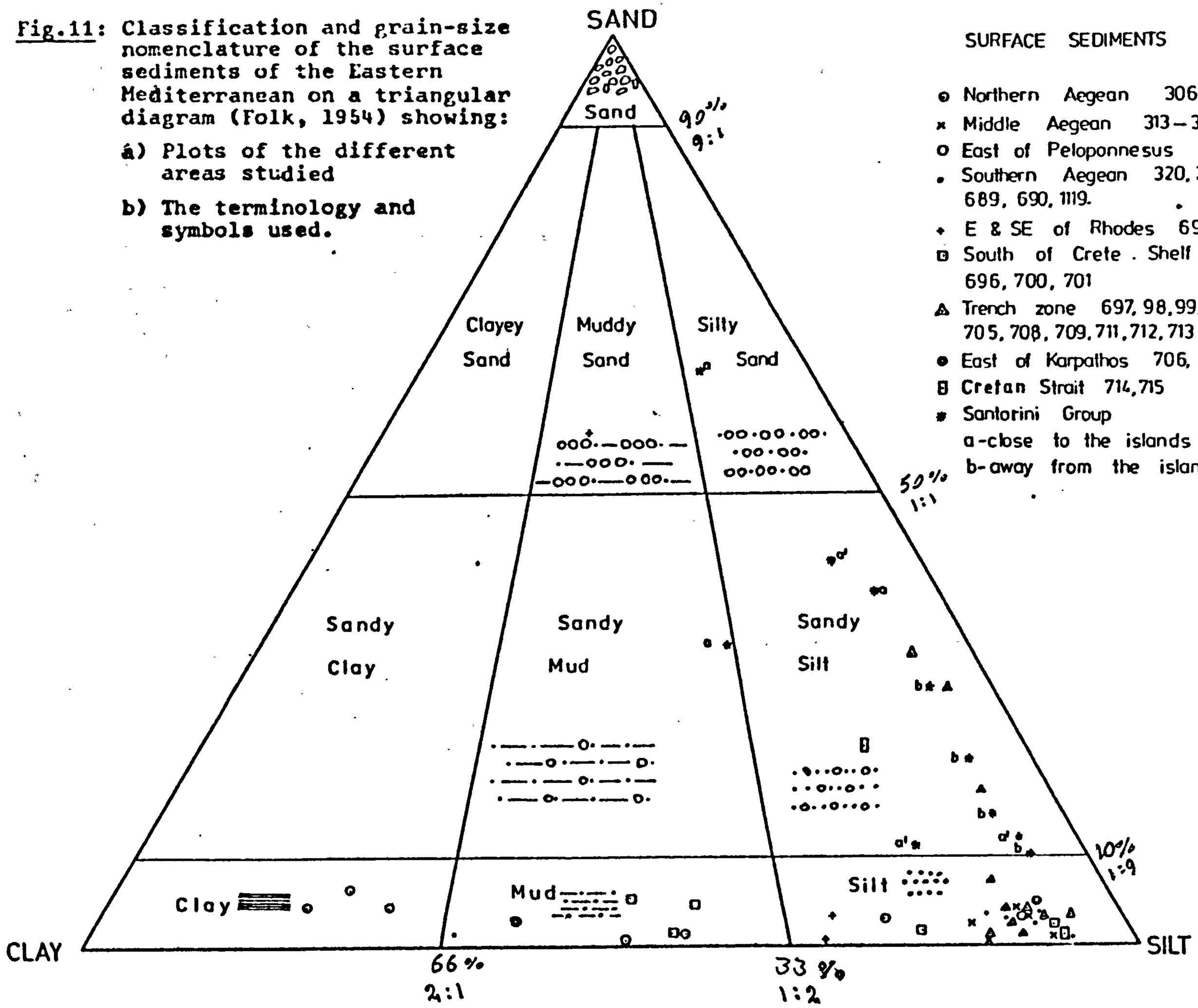


Fig.11: Classification and grain-size nomenclature of the surface sediments of the Eastern Mediterranean on a triangular diagram (Folk, 1954) showing:

a) Plots of the different areas studied

b) The terminology and symbols used.

SURFACE SEDIMENTS

- ⊙ Northern Aegean 306 – 312
- × Middle Aegean 313 – 317
- o East of Peloponnesus 318 –319
- • Southern Aegean 320, 23, 24, M1, M2, M3, 689, 690, 1119.
- ✦ E & SE of Rhodes 691, 92, 93
- ⊡ South of Crete . Shelf seds. 694, 695, 696, 700, 701
- ⧋ Trench zone 697, 98, 99, 702, 703, 704, 705, 708, 709, 711, 712, 713
- ● East of Karpathos 706, 707
- ⊟ Cretan Strait 714, 715
- ✱ Santorini Group
  a-close to the islands a=Thera, a'=Milos
  b-away from the islands

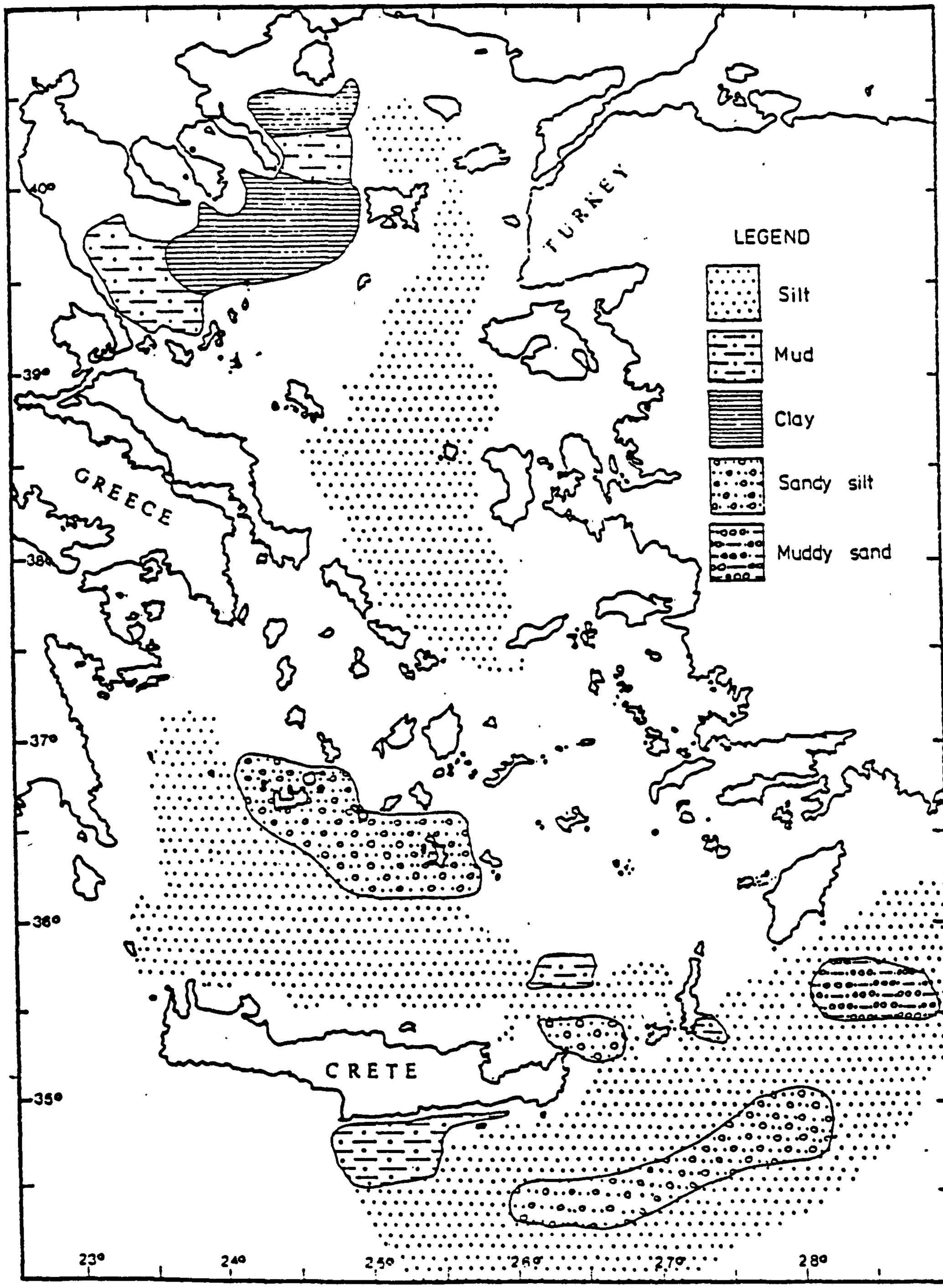


Fig.12: A sediment distribution map of the areas studied in the Eastern Mediterranean and Aegean Seas.
The grain size distribution represented here is for the surface layer only - the top 5cms - using Folk's classification (1954).

the continental shelf is clear, as is seen from the distribution map (Fig. 12) and the curves (Figs. 10, A, B), and so is the increase of silt. There is a high clay concentration in the northern Aegean which is not easily explained. It could be due to local sediment input or to deposition in a low energy environment.

Coarse-grained sediments occur in shallow waters and also on submarine highs, probably as a result of winnowing. Coarse grained sediments are also found sometimes in deep areas especially in the straits and near the Strabo trench, in submarine canyons and trenches. This distribution is probably due to turbidity current activity or locally high bottom currents. On the other hand fine-grained sediments prevail in deep areas (abyssal plains). The textural changes from shelf to abyssal environments appear to be primarily due to the selective transport of sand, silt and clay. Sands are retained in the shallow water zones whilst silts and clays are transported to deeper waters.

5.3 Size parameters of the surficial sediments of the eastern Mediterranean and Aegean Seas

The following is a review of the statistical parameters calculated for the surface sediments in the study area. Positions of the surface samples used in this study are illustrated in figure 2. The raw data for the different size fractions and the different statistical parameters are given in appendix (1). Data were plotted on graphs (Figs. 13 1A, 1B, 1C, II, III, IV, V & VI), even though computer obtained statistical parameters are available (table 4), because by not drawing curves one does not get such a good feel for the data. In

(Cont. on page 113)

Fig.13 Examples of the size frequency curves of the sediments analysed from the eastern Mediterranean and the Aegean Seas and their size composition represented by cumulative curves are given on page 95 to 112. The curves represent the surface sediments, the analysis of which is given in appendix I. Sediments are grouped according to classification described in Fig. 11. The types of size frequency distributions present are:

1A South of Crete shelf sediments

The sediments (on the inner shelf) are often bimodal, one of the modes is in the silt range and the other is in the clay range (694-1 and 695-1). On the outer shelf sediments are unimodal having a sharp peak in the silt range (700-1 and 701-1).

It is noticed that sediments change from bimodal to unimodal getting away from the shelf. Sample no. 696-1 represents this transition having a wide mode between the silt and clay.

IB South of Crete trench sediments

These are unimodal, with a sharp peak in the silt range, often in the medium silt.

IC East of Rhodes and Karpathos

Sediments here are found to have a mode in the clay range or on the limit between the silt and clay fractions. One main, wide sample is found to have a bimodal distribution with one mode in the sand range and another in the clay.

II Santorini Sediments

A & B These are the surface sediments close to the islands of Thera and Milos. The curves are often bimodal with one mode in the coarse sand and another in the medium silt.

Some are polymodal having the same two modes and a third one in the gravel range.

II C Sediments away from the volcanic islands

The silty nature of these sediments are quite clear from the curves. They are bimodal with a very strong mode in the medium silt range and a weak mode in the sand range.

IIIA The Southern Aegean sediments

The sediments in this area are strongly unimodal. The mode is in the silt range again, except in one sample only, where it shifted towards the clay range.

IIIB Sediments from south of Paloponnesus are found to be similar to the southern Aegean group.

IV The Middle Aegean sediments

The sediments in this area are very strongly unimodal and again the mode is in the silt range.

V The Northern Aegean sediments

Two groups were studied, one from depth less than 1,000m and the other from depth more than 1,000m. In both groups the sediments are clayey in nature having a strong mode in the clay or the very fine silt. Sometimes a weak mode is found in the sand range.

V1 The Cretan strait sediments

Two samples were analysed from the Cretan strait, one is found to have the silty nature as most sediments in the surrounding areas, with a very strong mode in the medium silt. The other sample is bimodal having a mode in the silt range and another in the coarse sand.

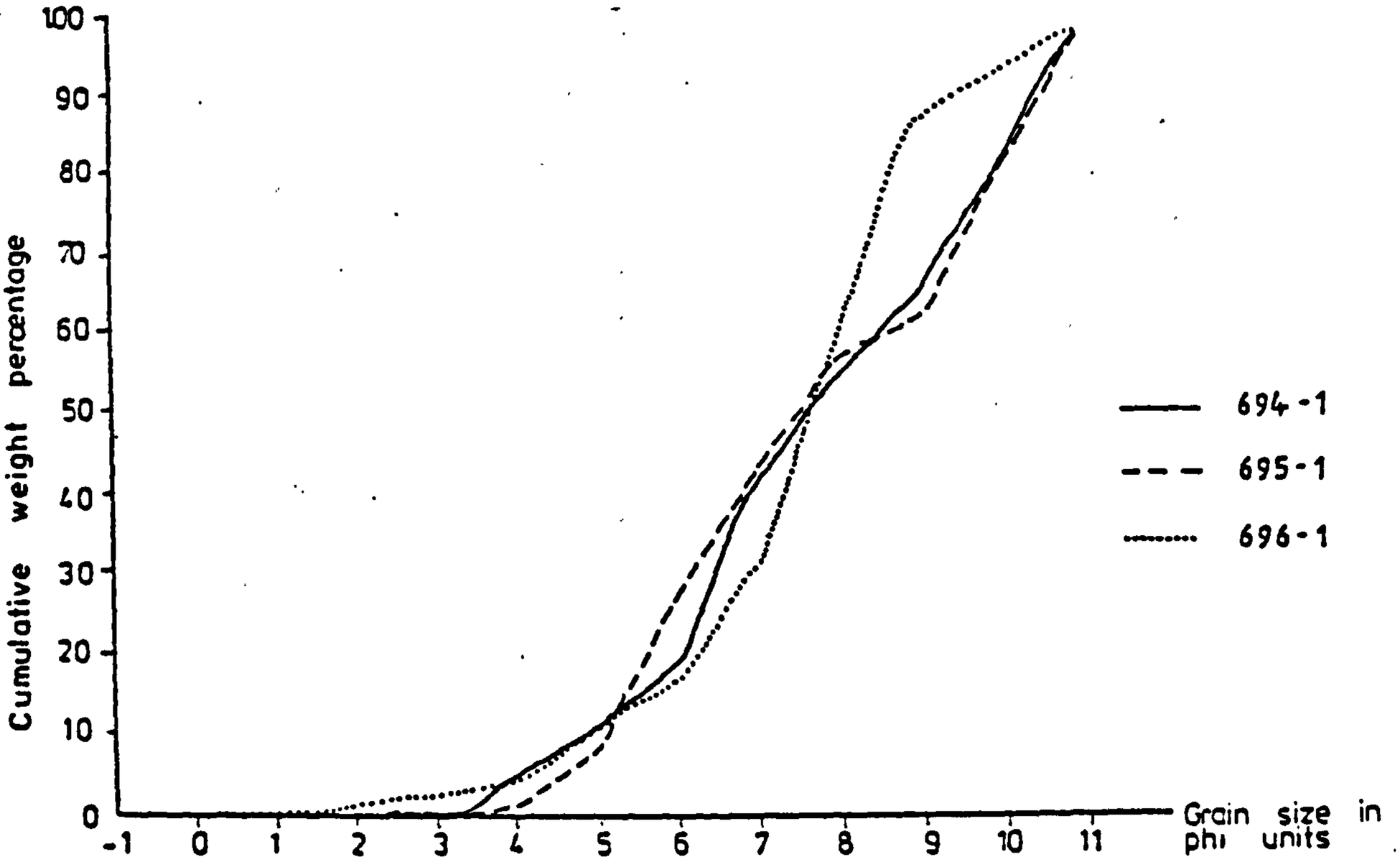
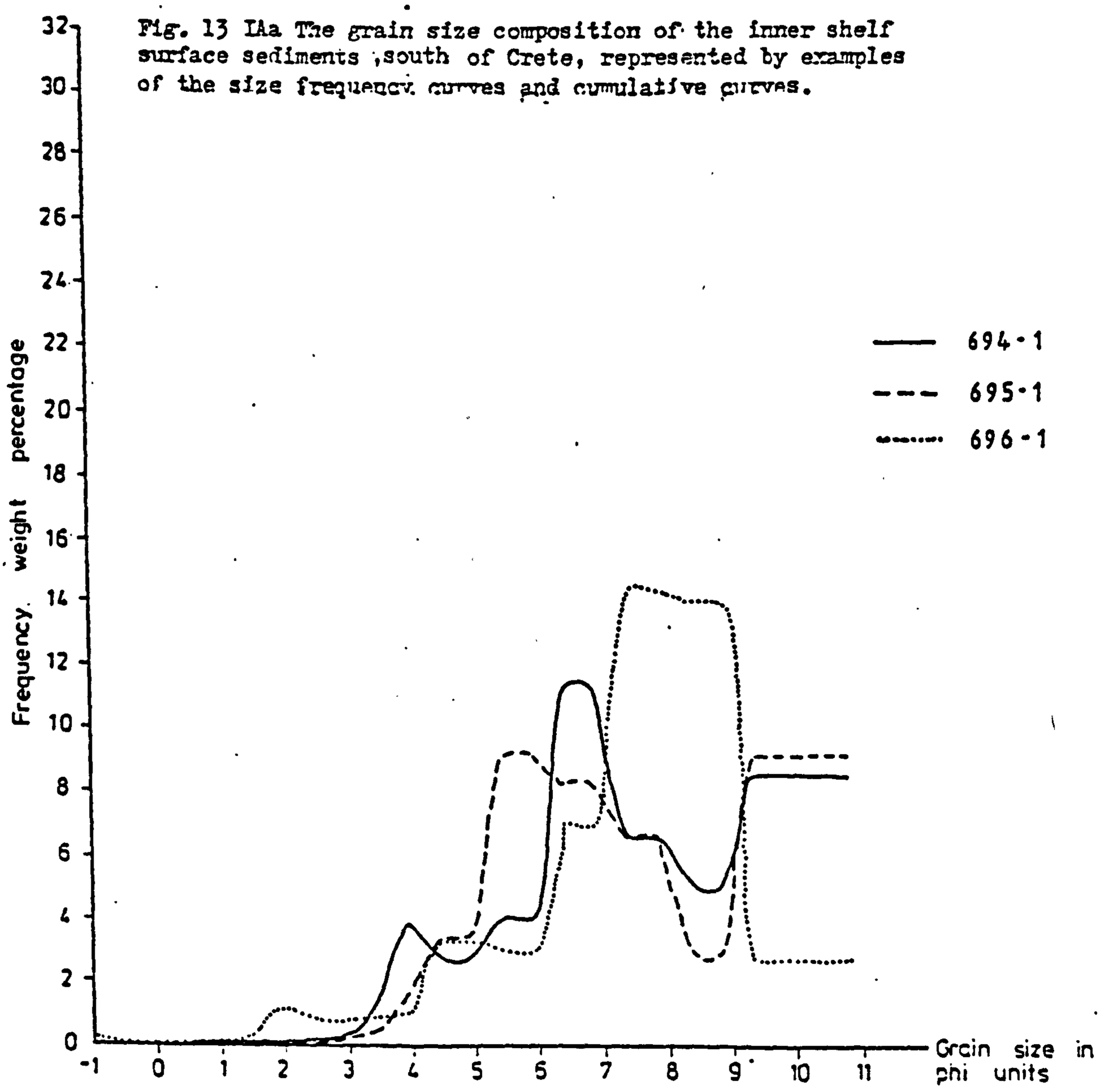


Fig. 13 IAa The grain size composition of the inner shelf surface sediments ,south of Crete, represented by examples of the size frequency curves and cumulative curves.



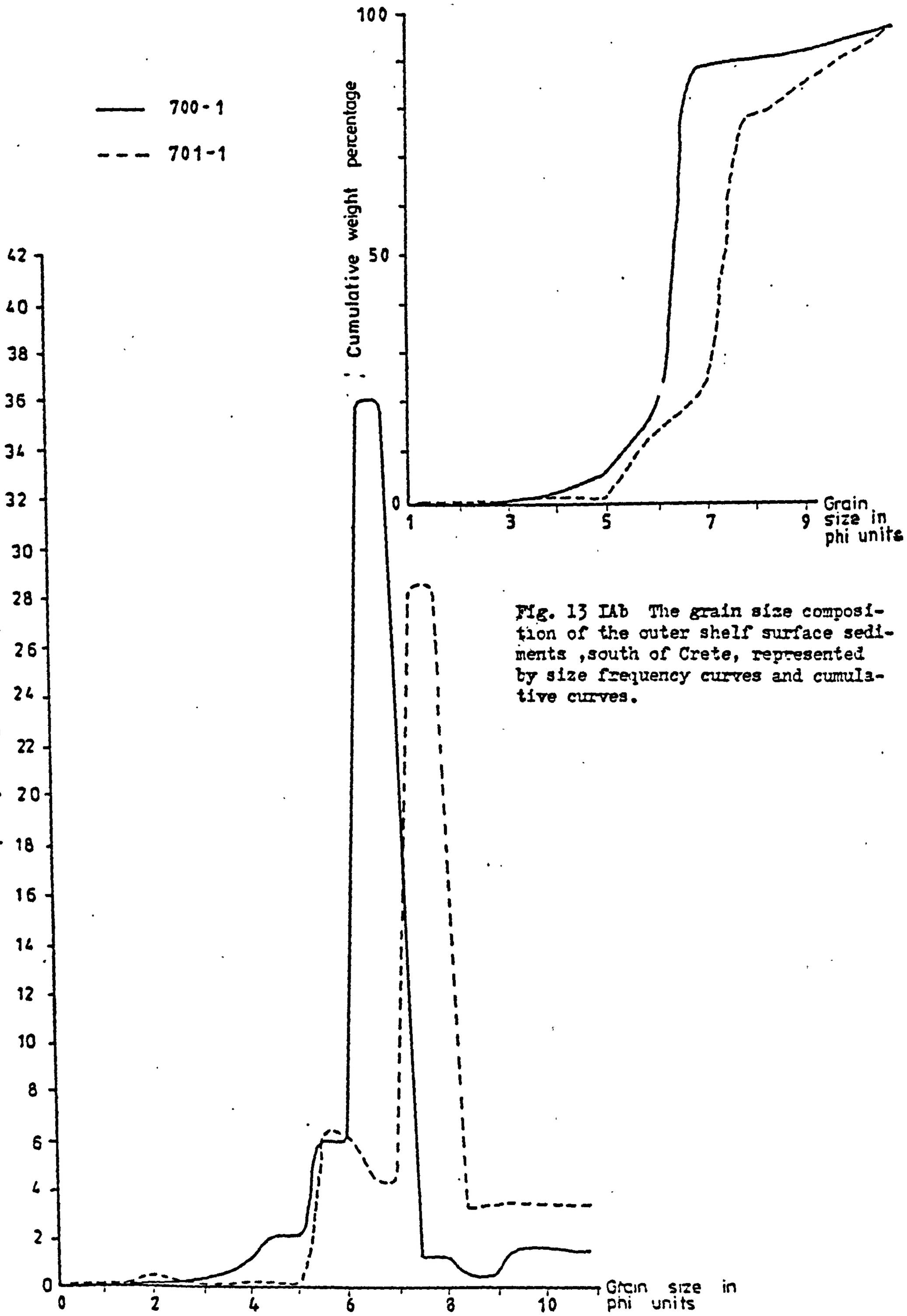


Fig. 13 IAb The grain size composition of the outer shelf surface sediments ,south of Crete, represented by size frequency curves and cumulative curves.

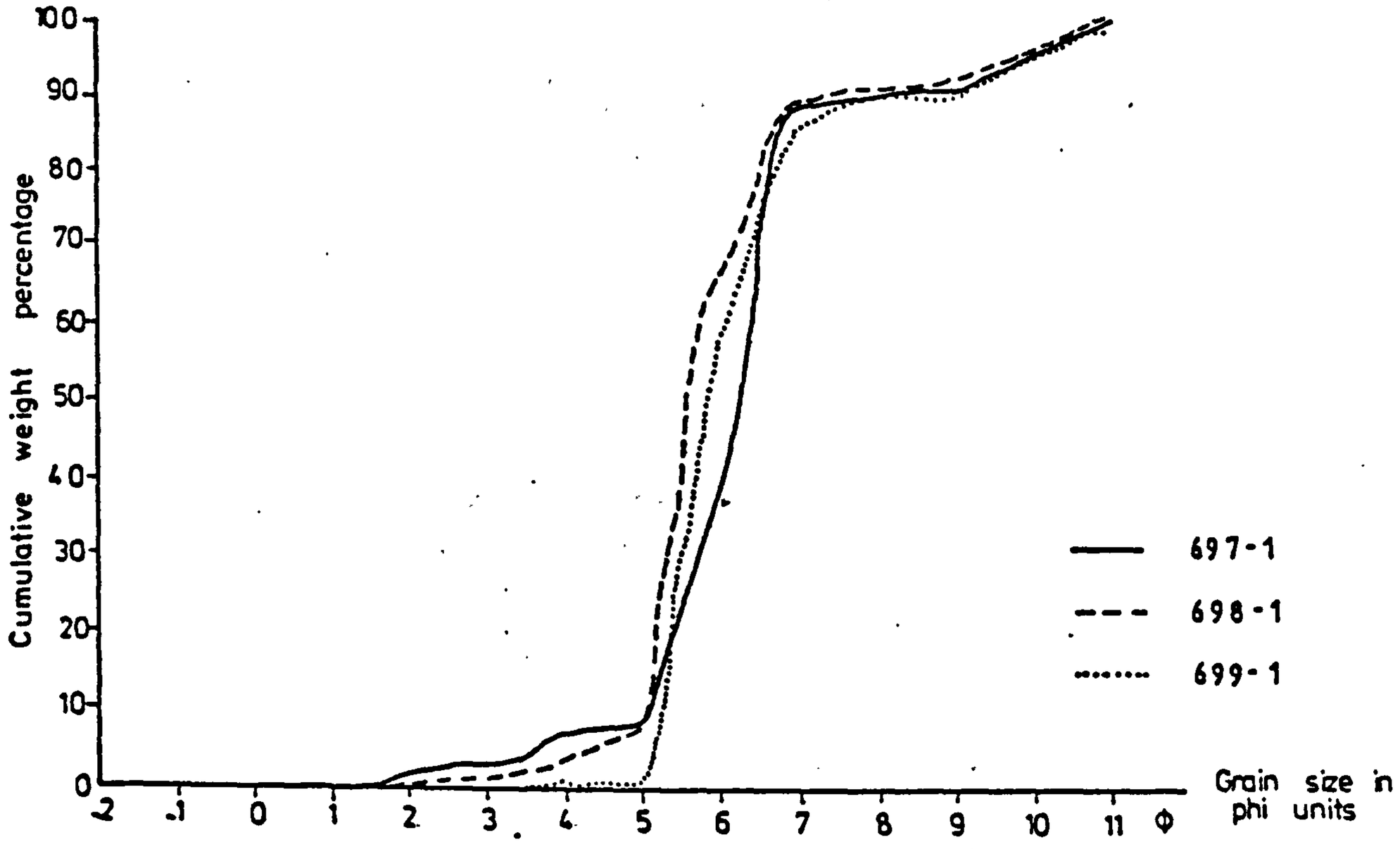
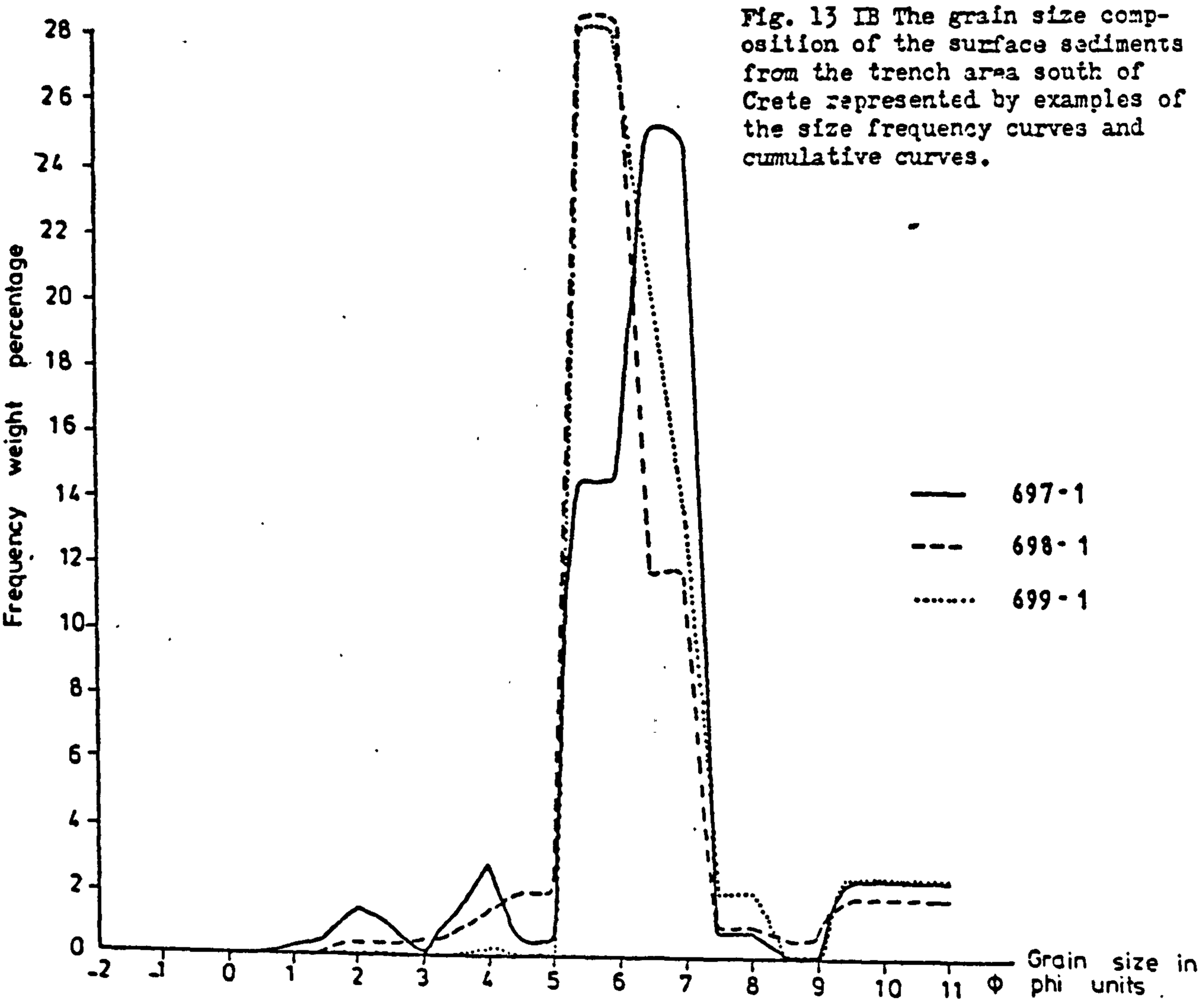


Fig. 13 IB The grain size composition of the surface sediments from the trench area south of Crete represented by examples of the size frequency curves and cumulative curves.



South of Crete trench zone
(B) 702, 703, 704 & 704-2

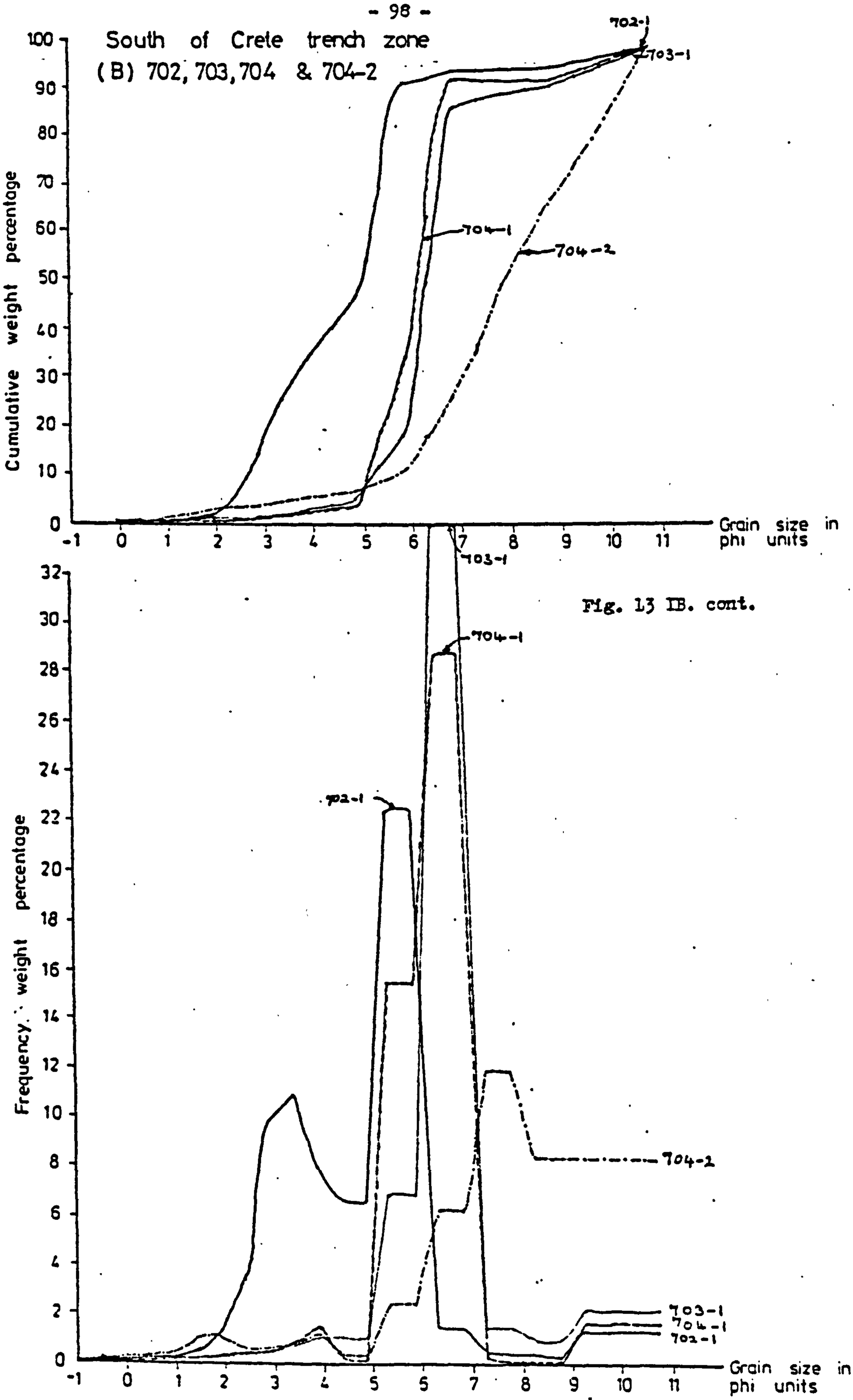


Fig. 13 IB. cont.

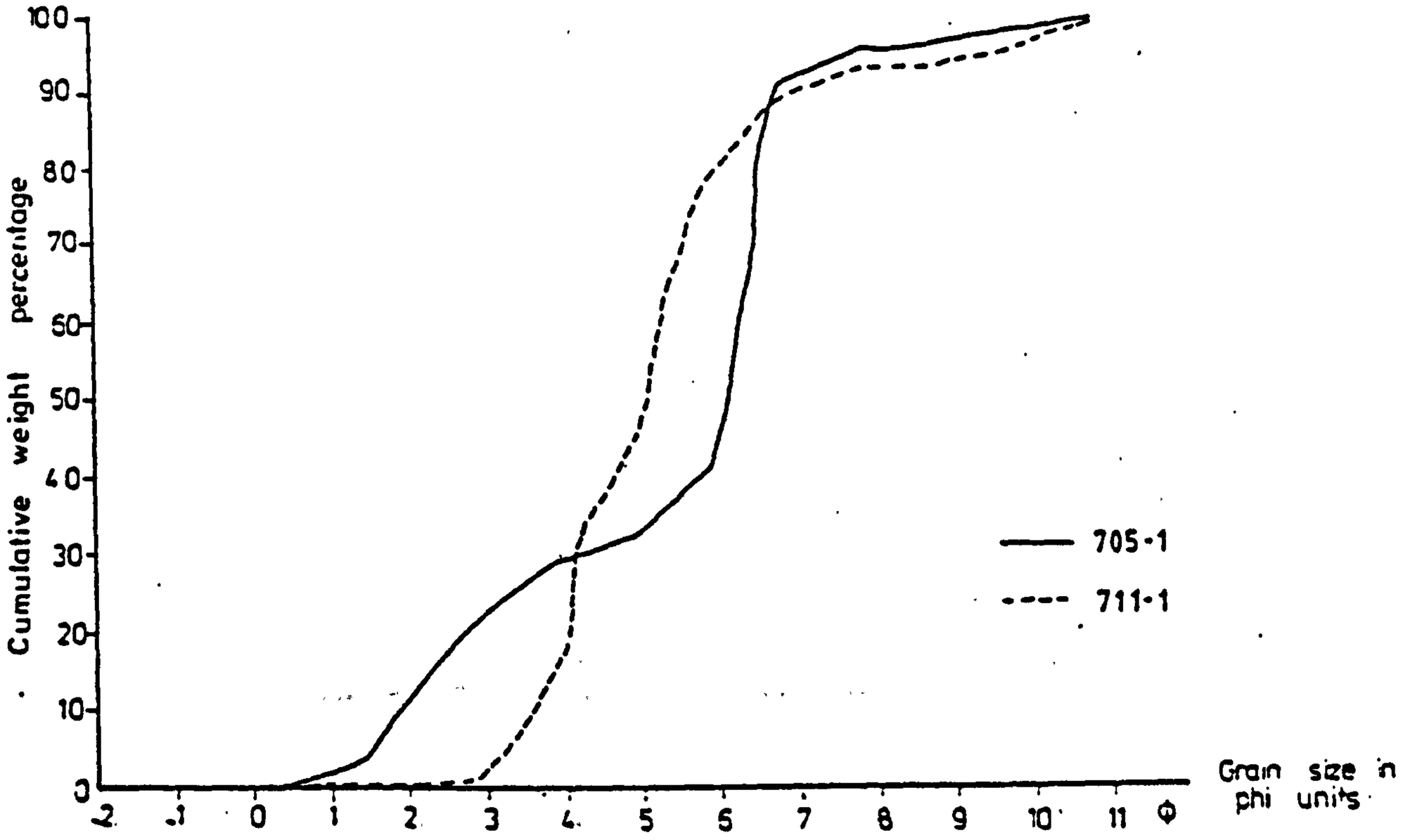
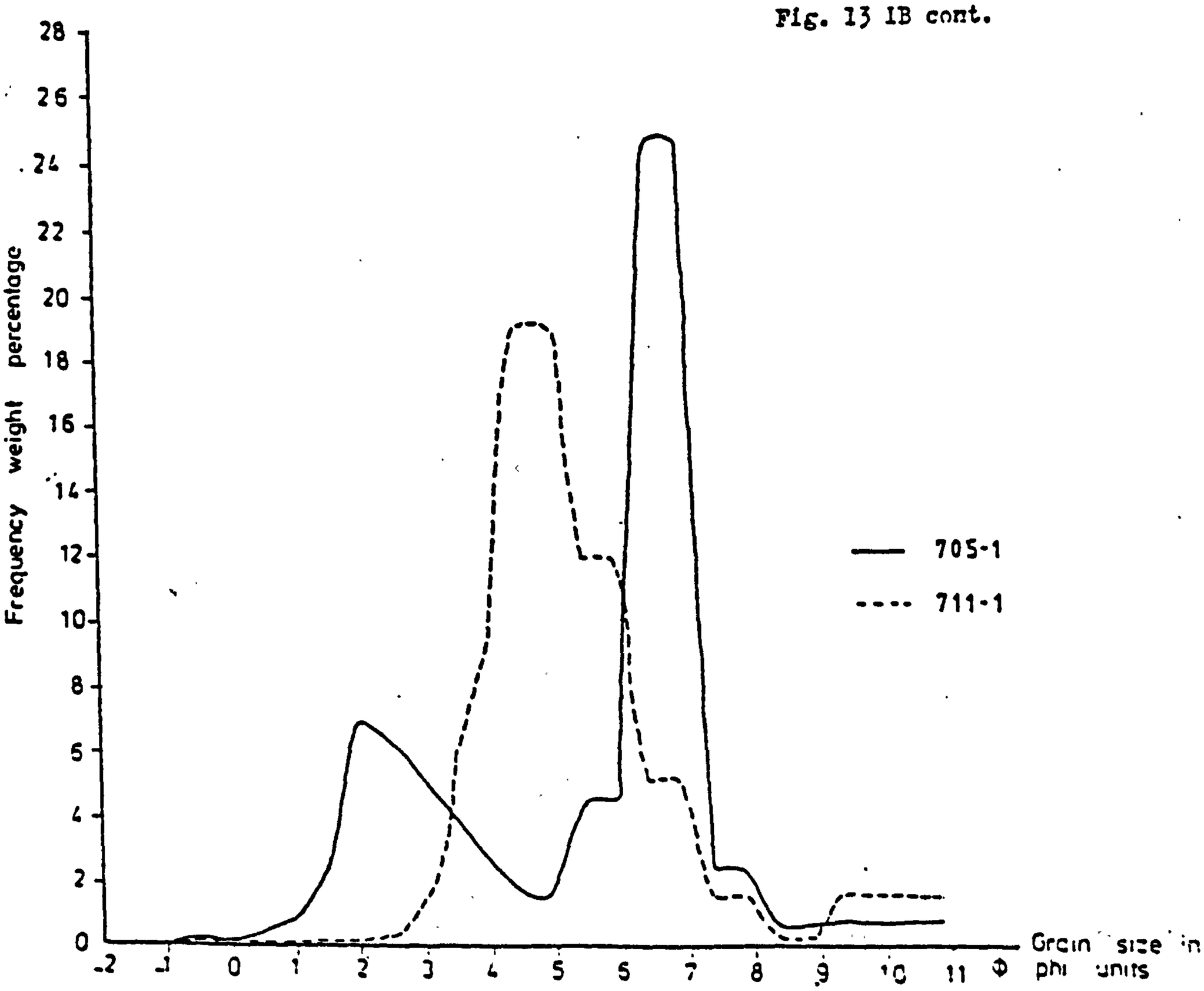


Fig. 13 IB cont.



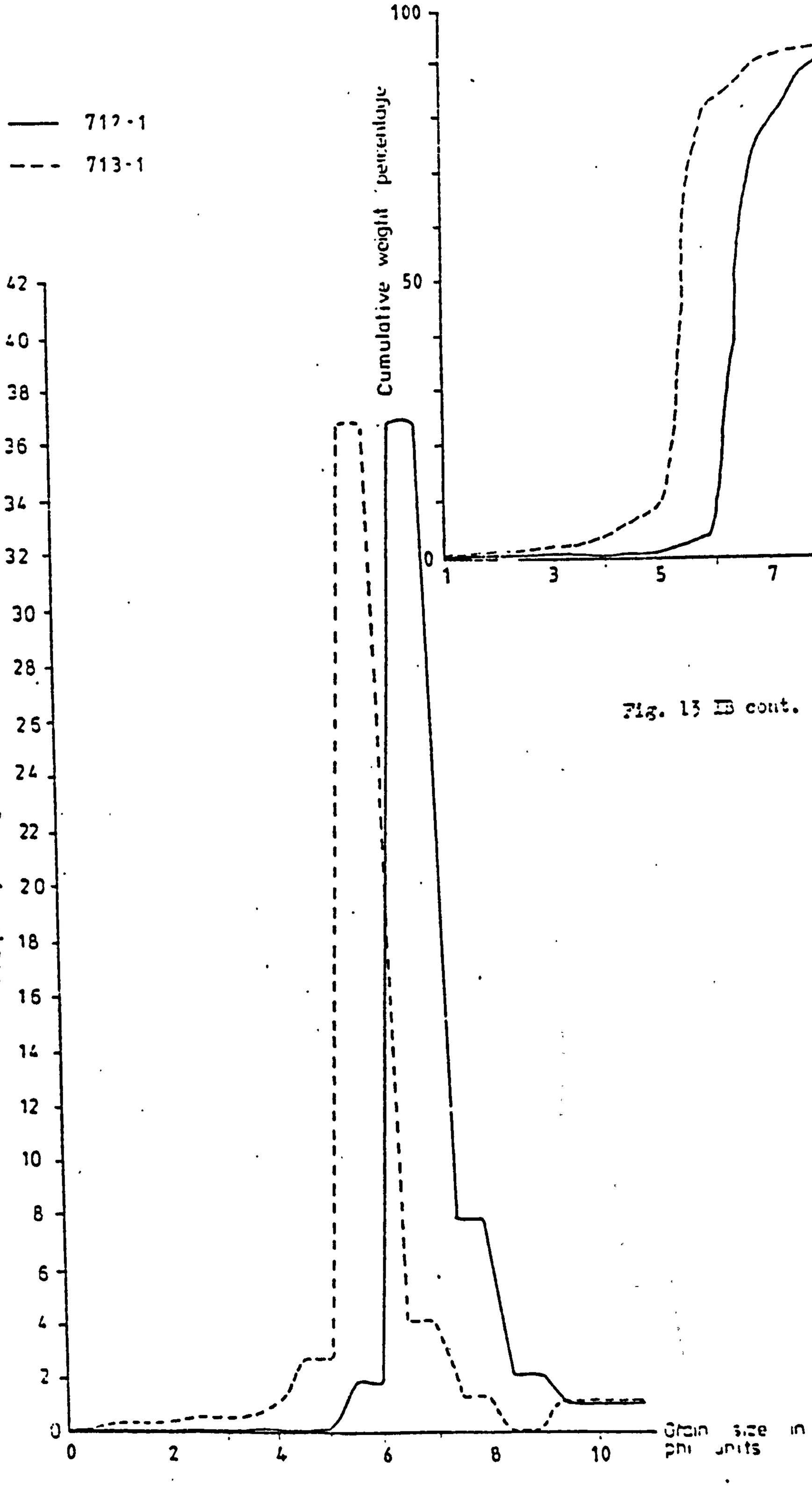

712-1
713-1
Frequency weight percentage
42
40
38
36
34
32
30
28
25
24
22
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
Grain size in phi units
Cumulative weight percentage
100
50
0
1
3
5
7
9
Grain size in phi units

Fig. 13 B cont.

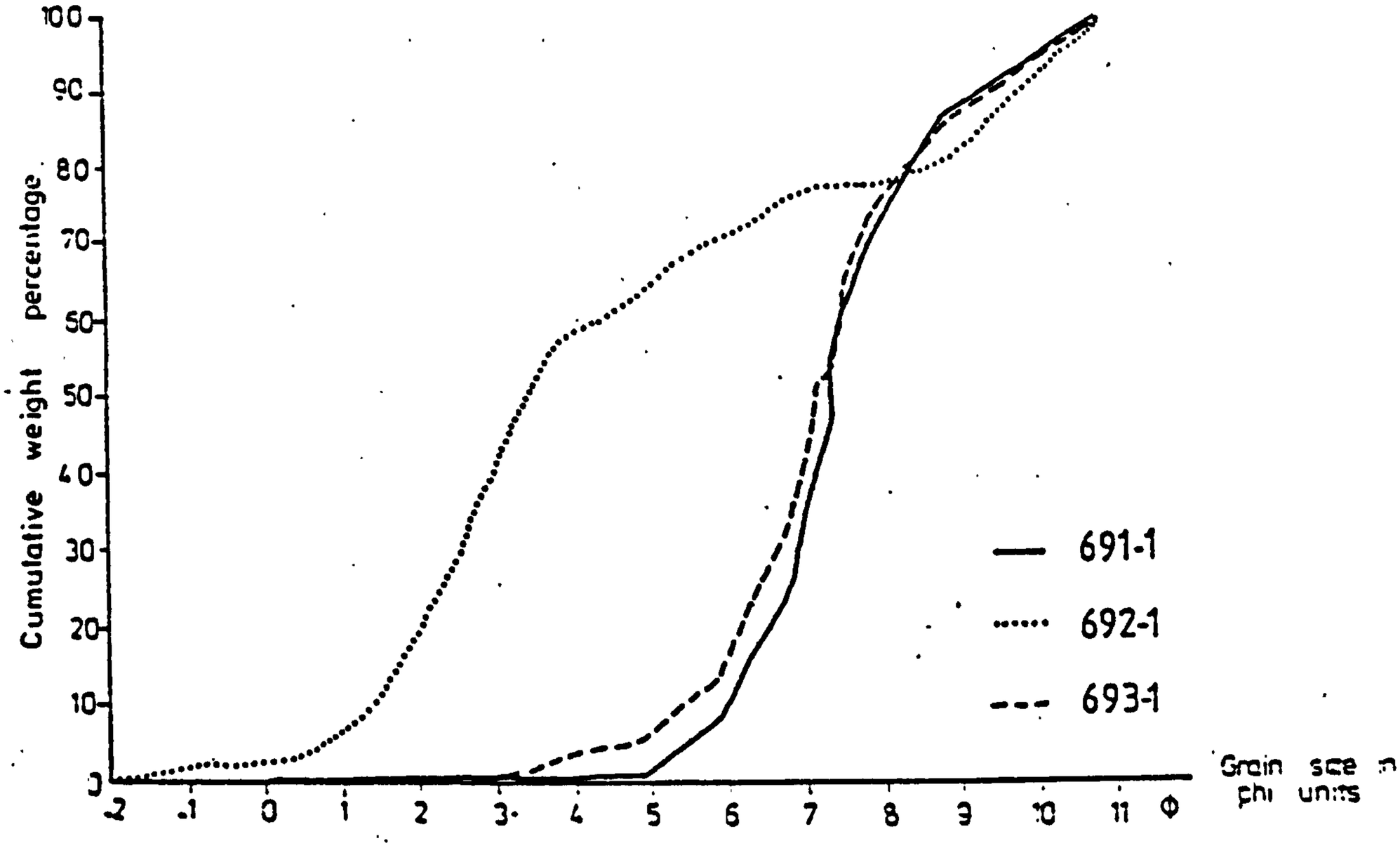
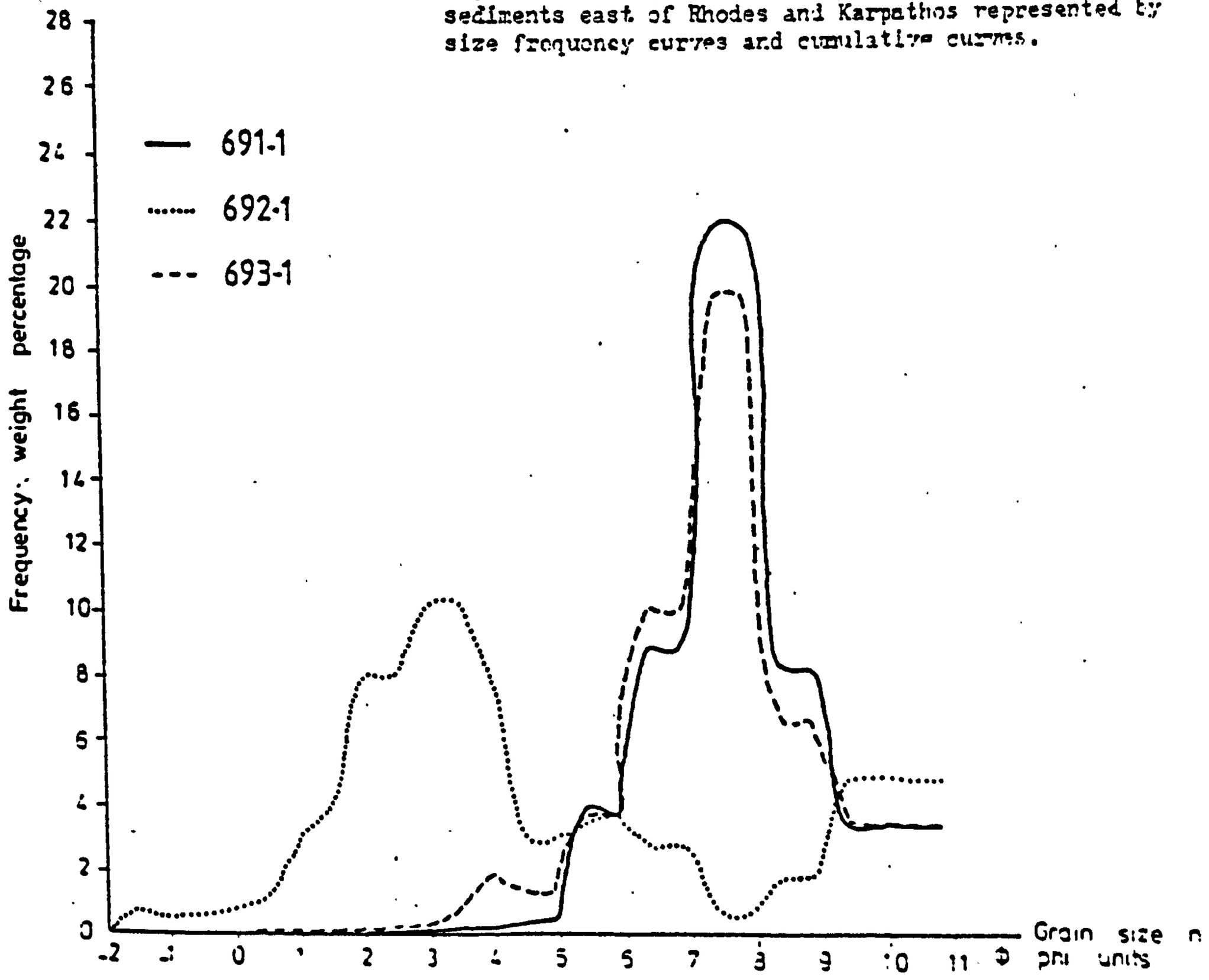


Fig. 13 IC The grain size composition of the surface sediments east of Rhodes and Karpathos represented by size frequency curves and cumulative curves.



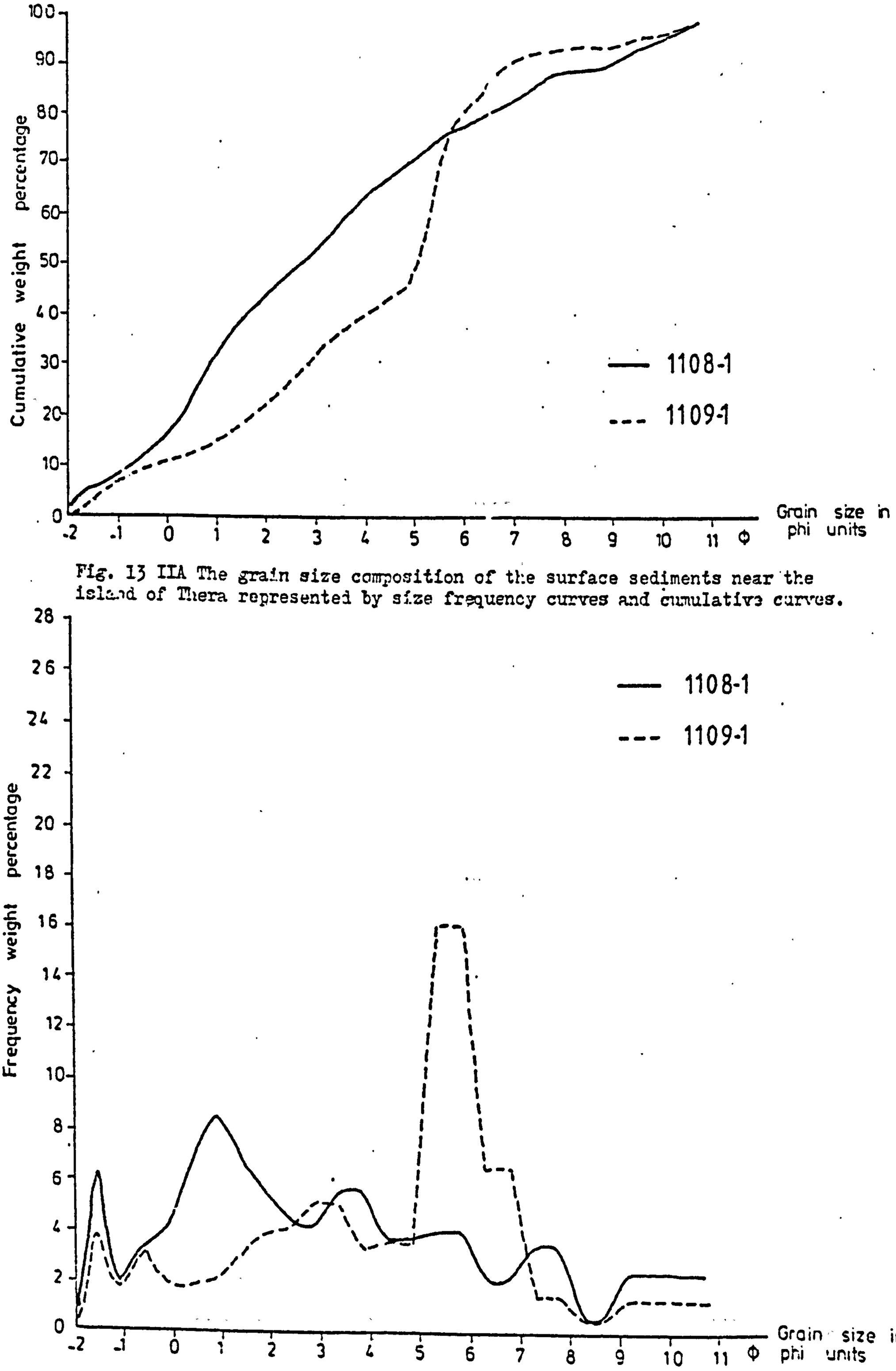


Fig. 13 IIA The grain size composition of the surface sediments near the island of Thera represented by size frequency curves and cumulative curves.

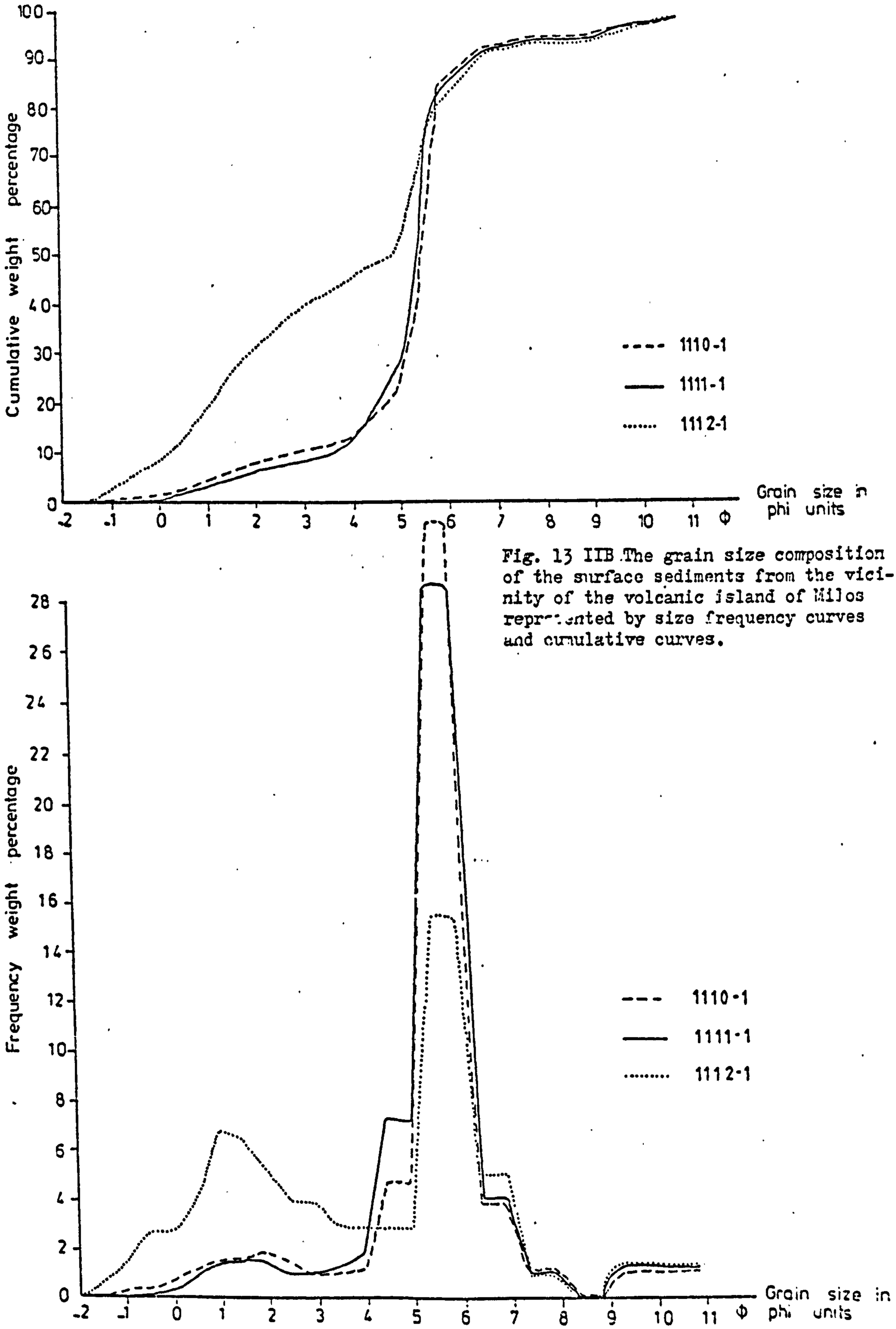


Fig. 13 IIB The grain size composition of the surface sediments from the vicinity of the volcanic island of Milos represented by size frequency curves and cumulative curves.

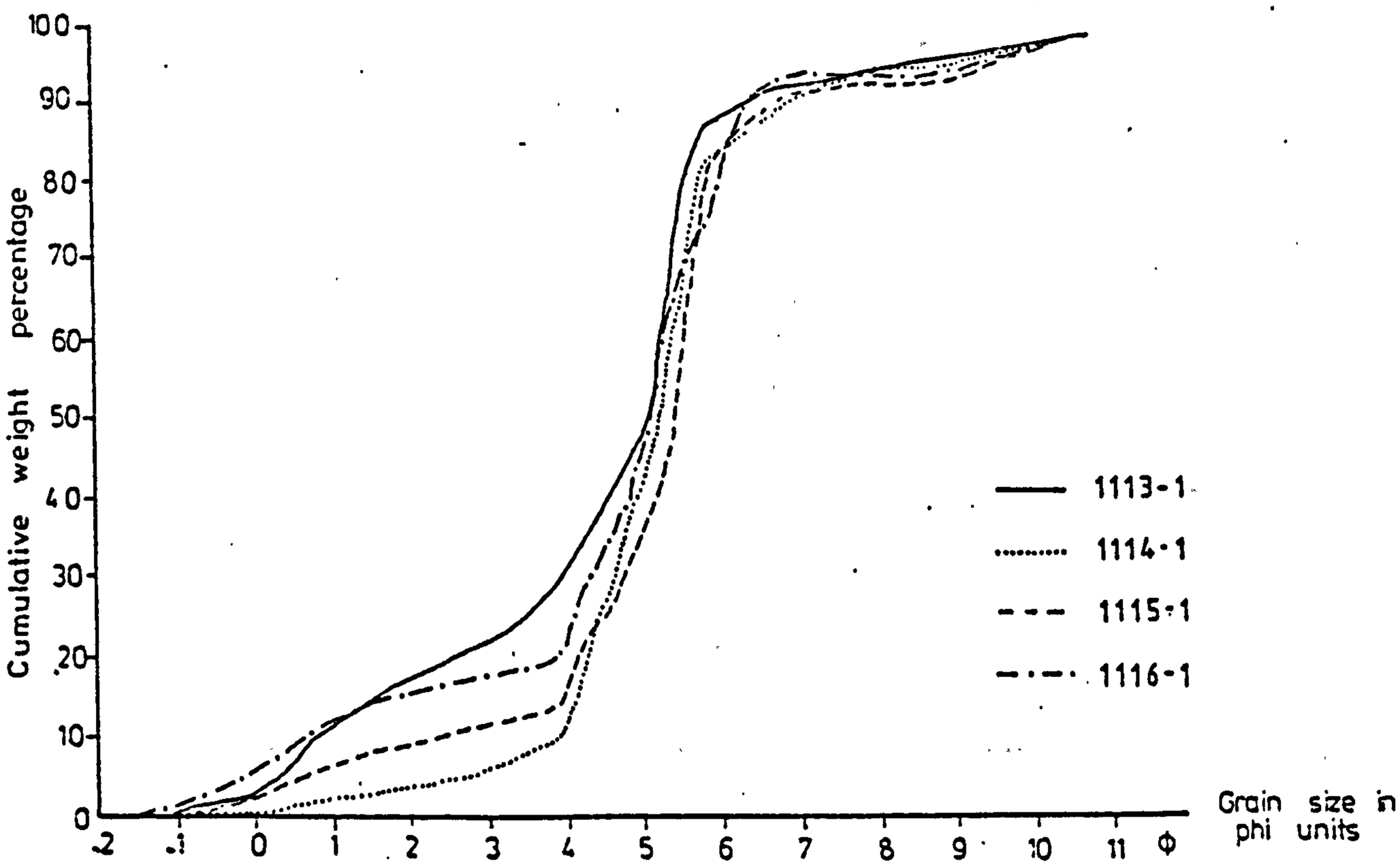
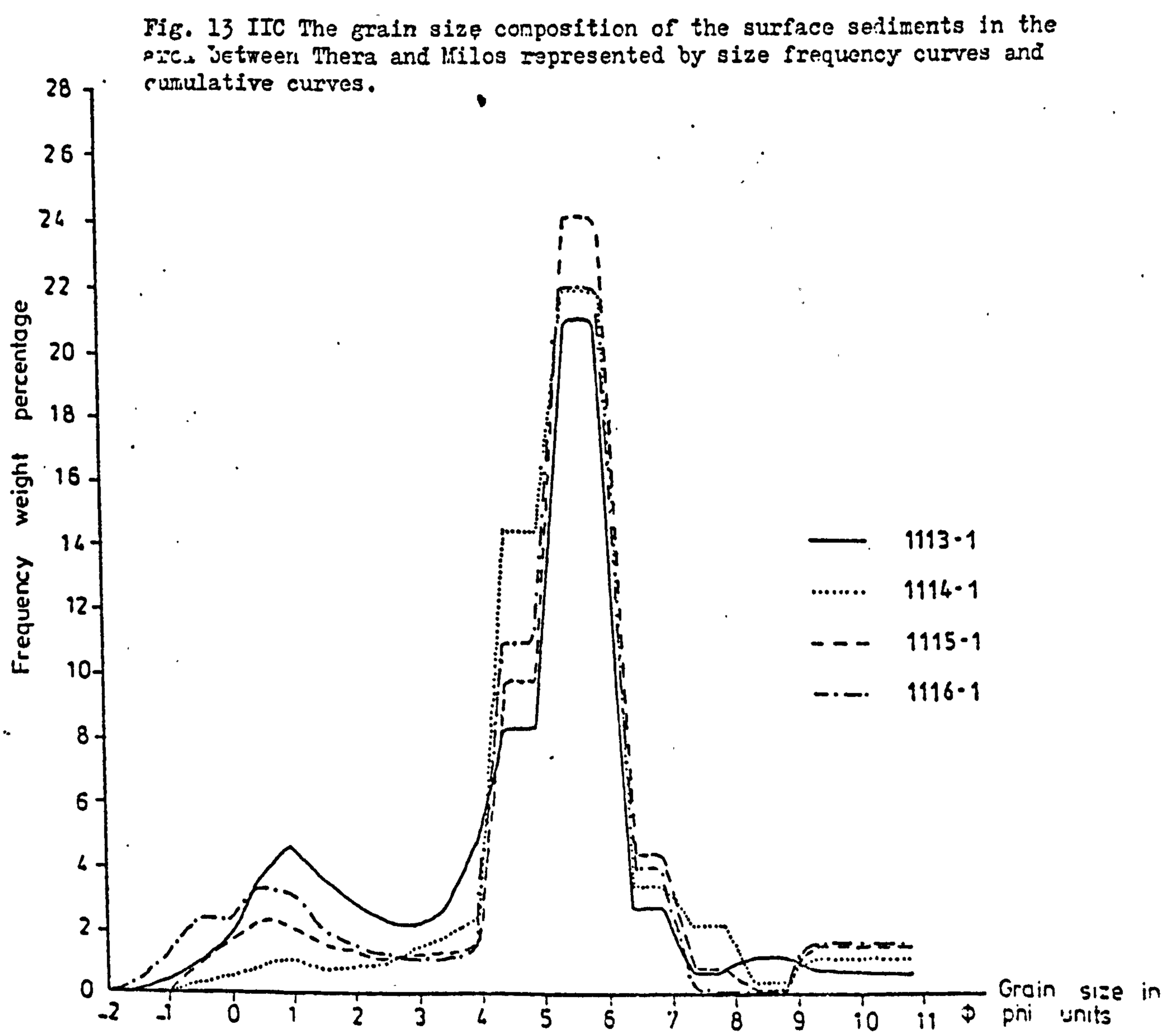


Fig. 13 IIC The grain size composition of the surface sediments in the area between Thera and Milos represented by size frequency curves and cumulative curves.



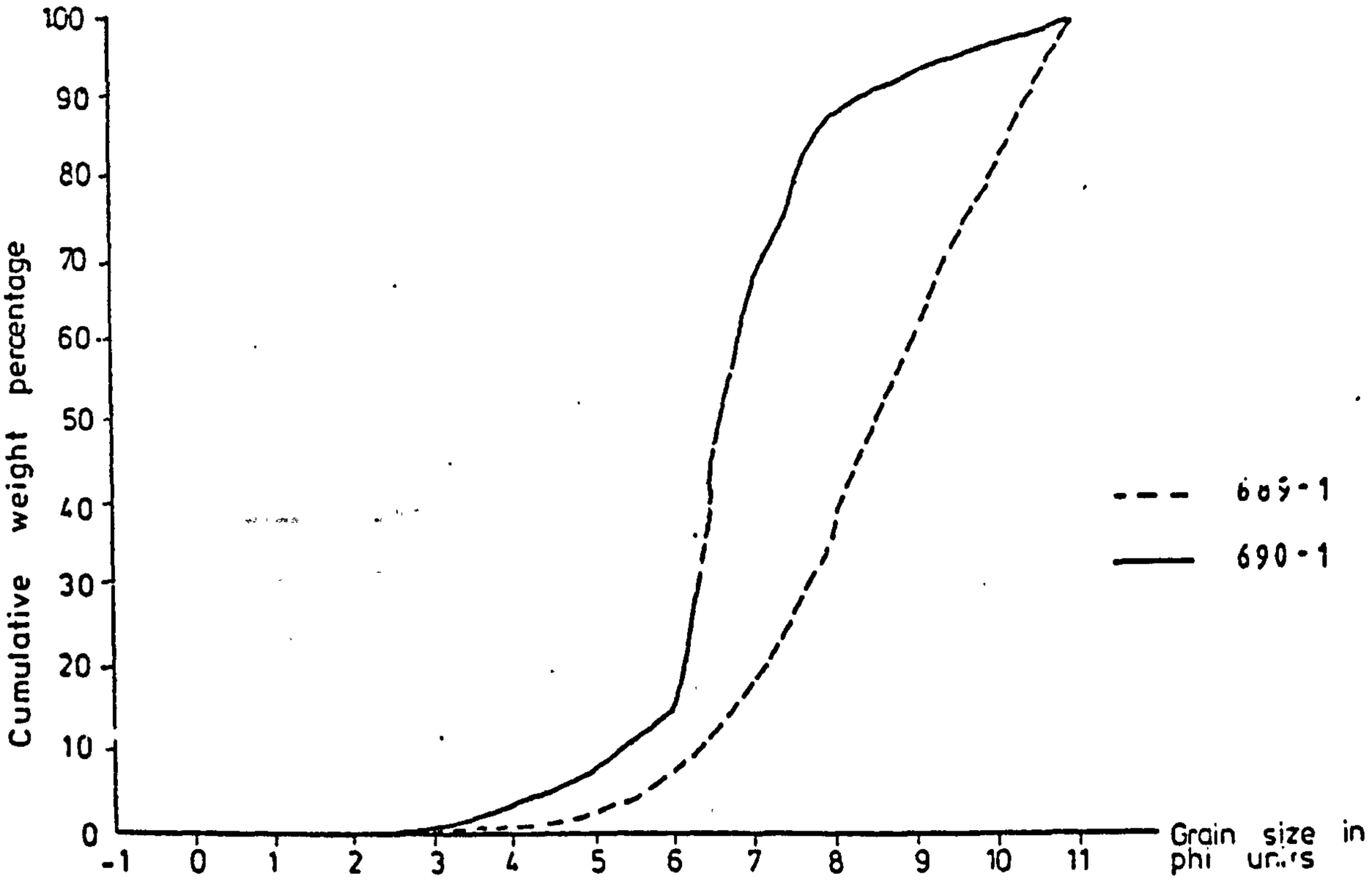


Fig. 13 IIIA The grain size composition of the surface sediments of the southern Aegean sea, represented by size frequence curves and cumulative curves.

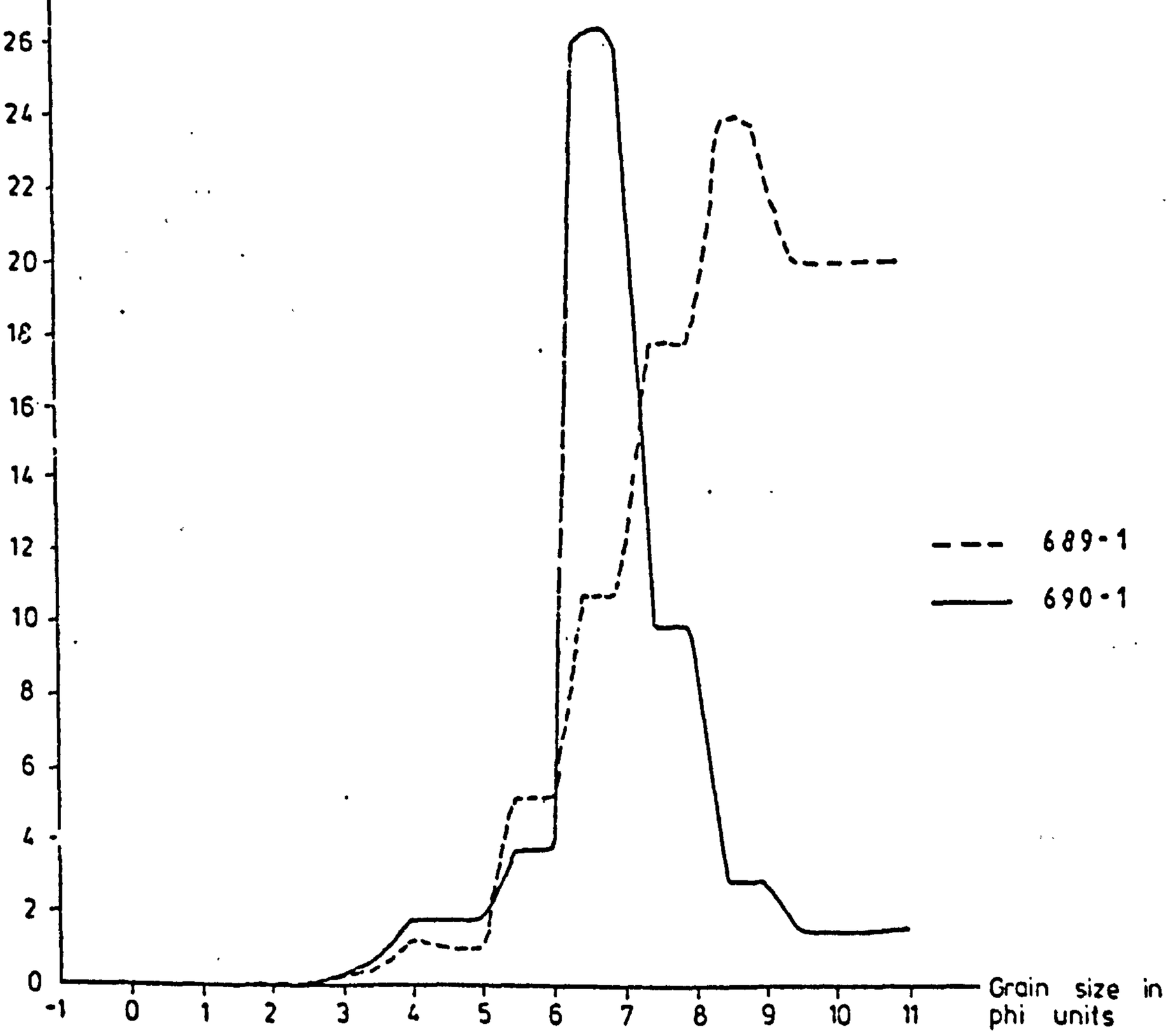
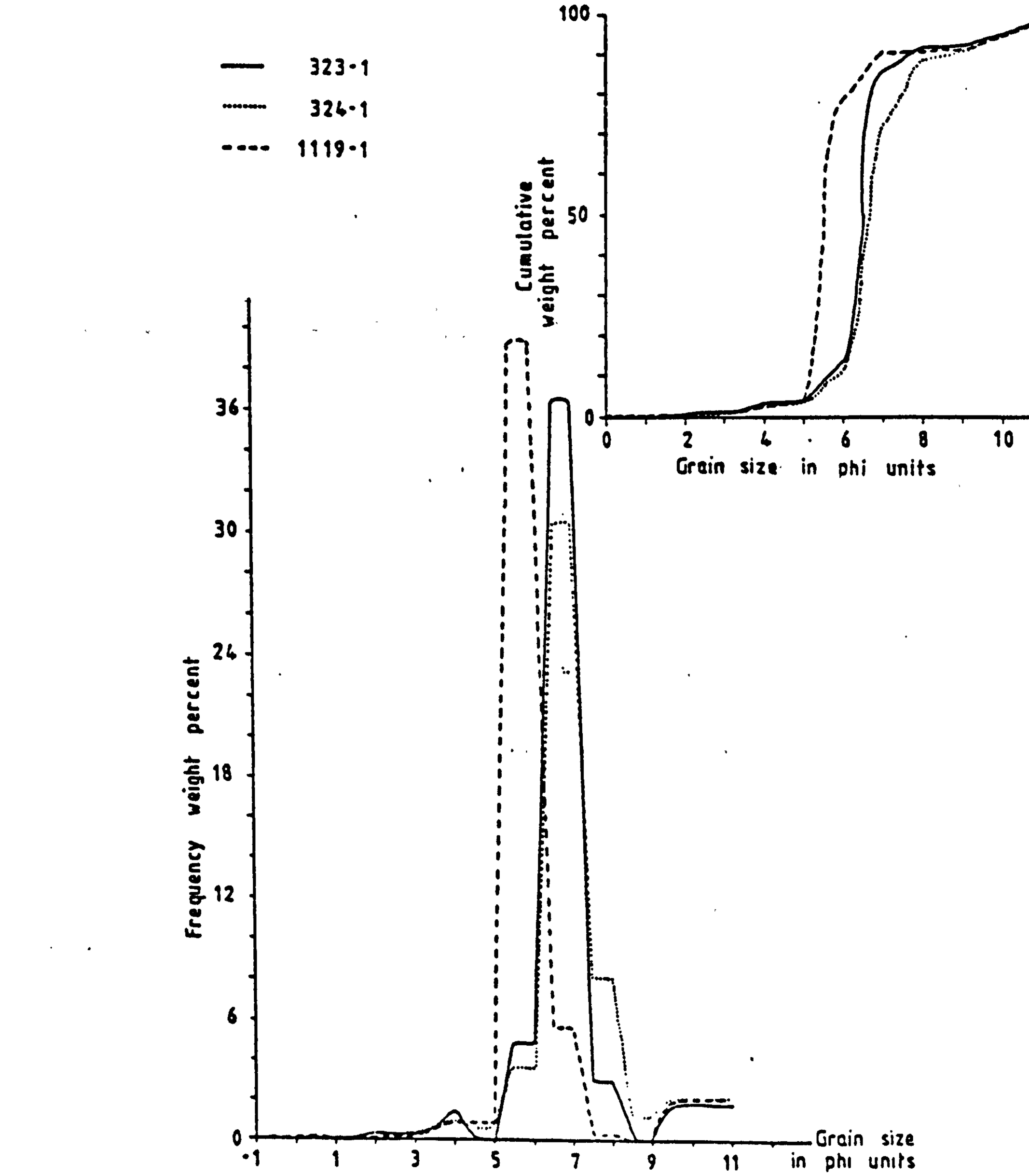


Fig. 13 IIIA cont.



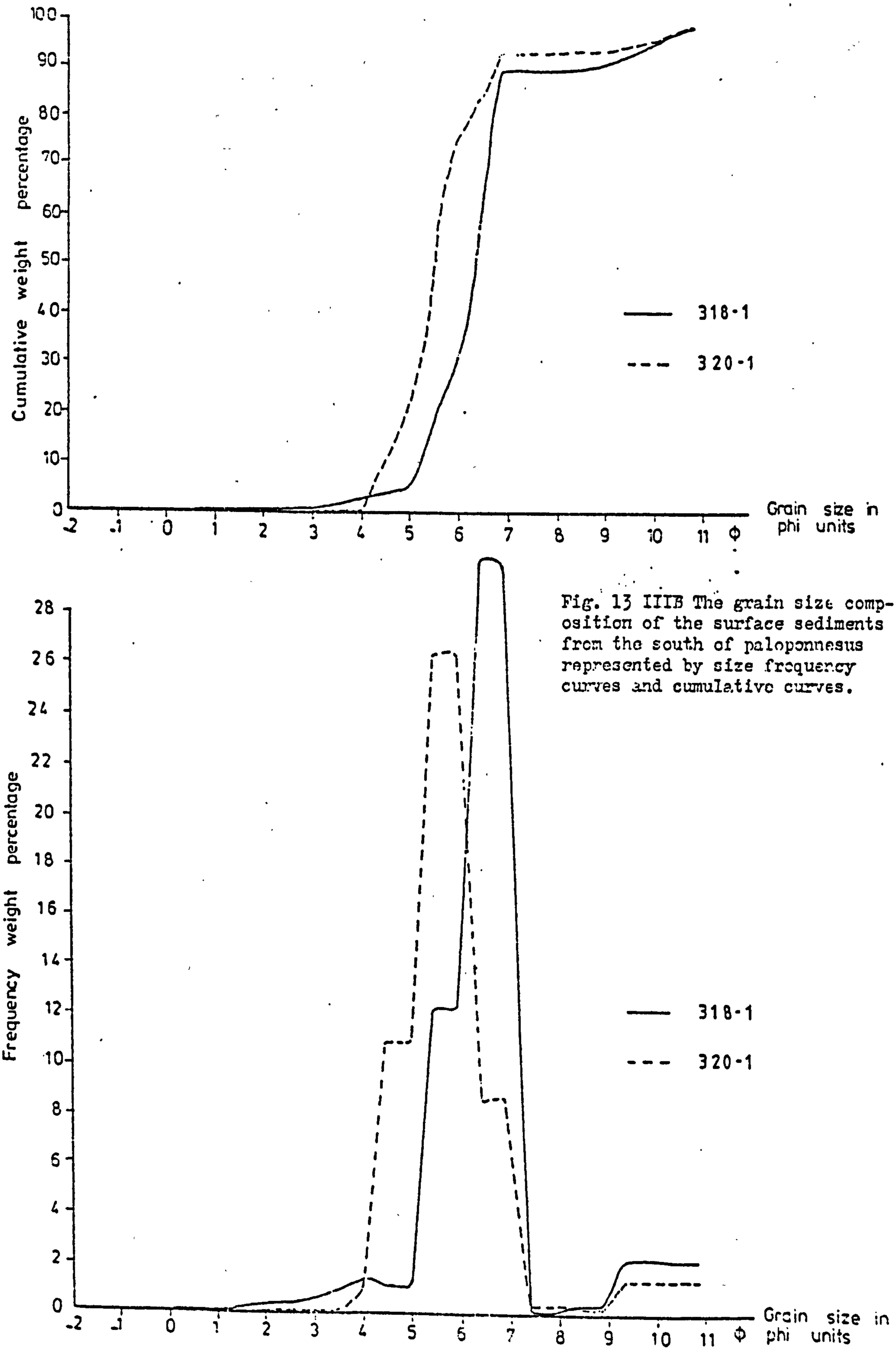
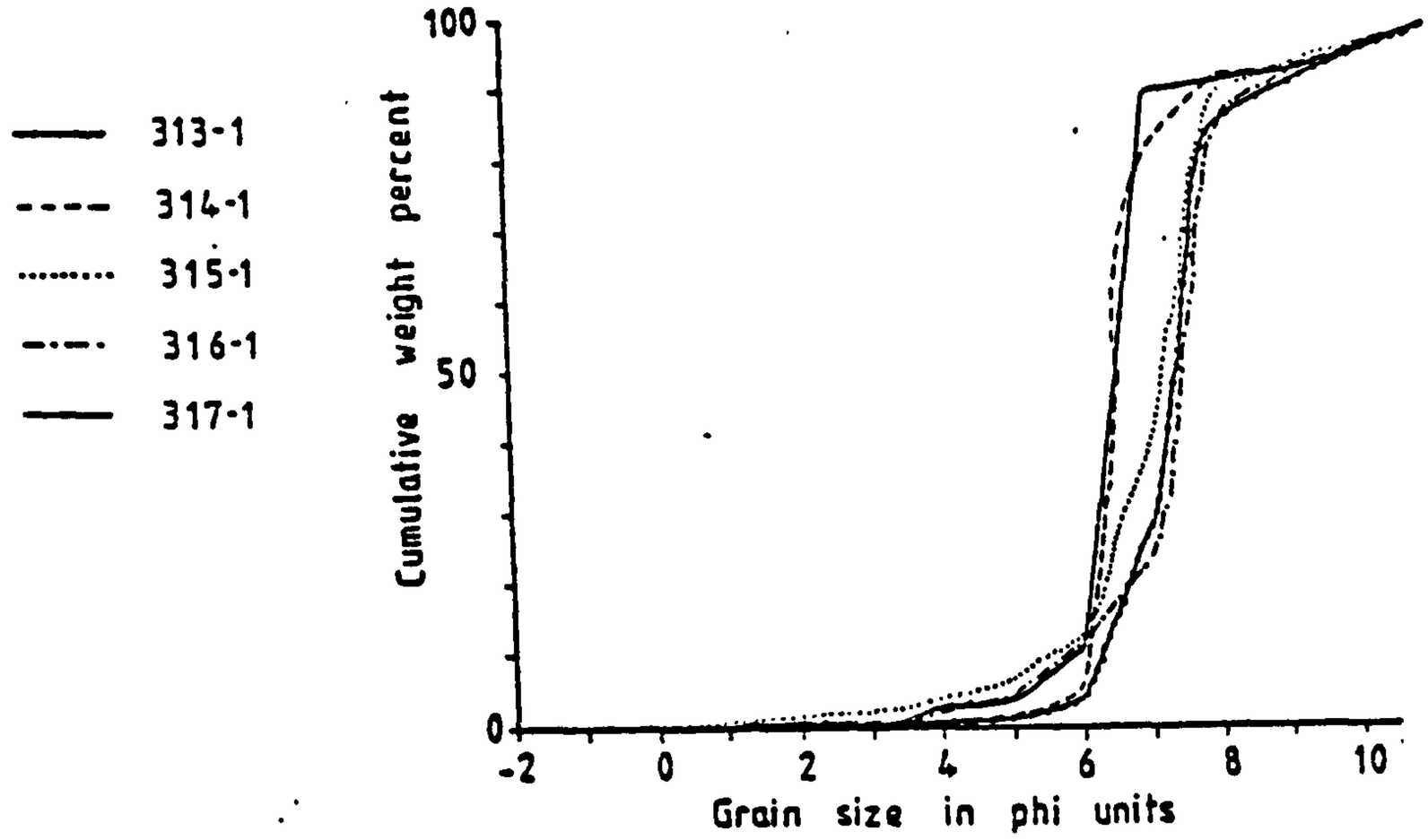


Fig. 13 IIIB The grain size composition of the surface sediments from the south of paloponnesus represented by size frequency curves and cumulative curves.



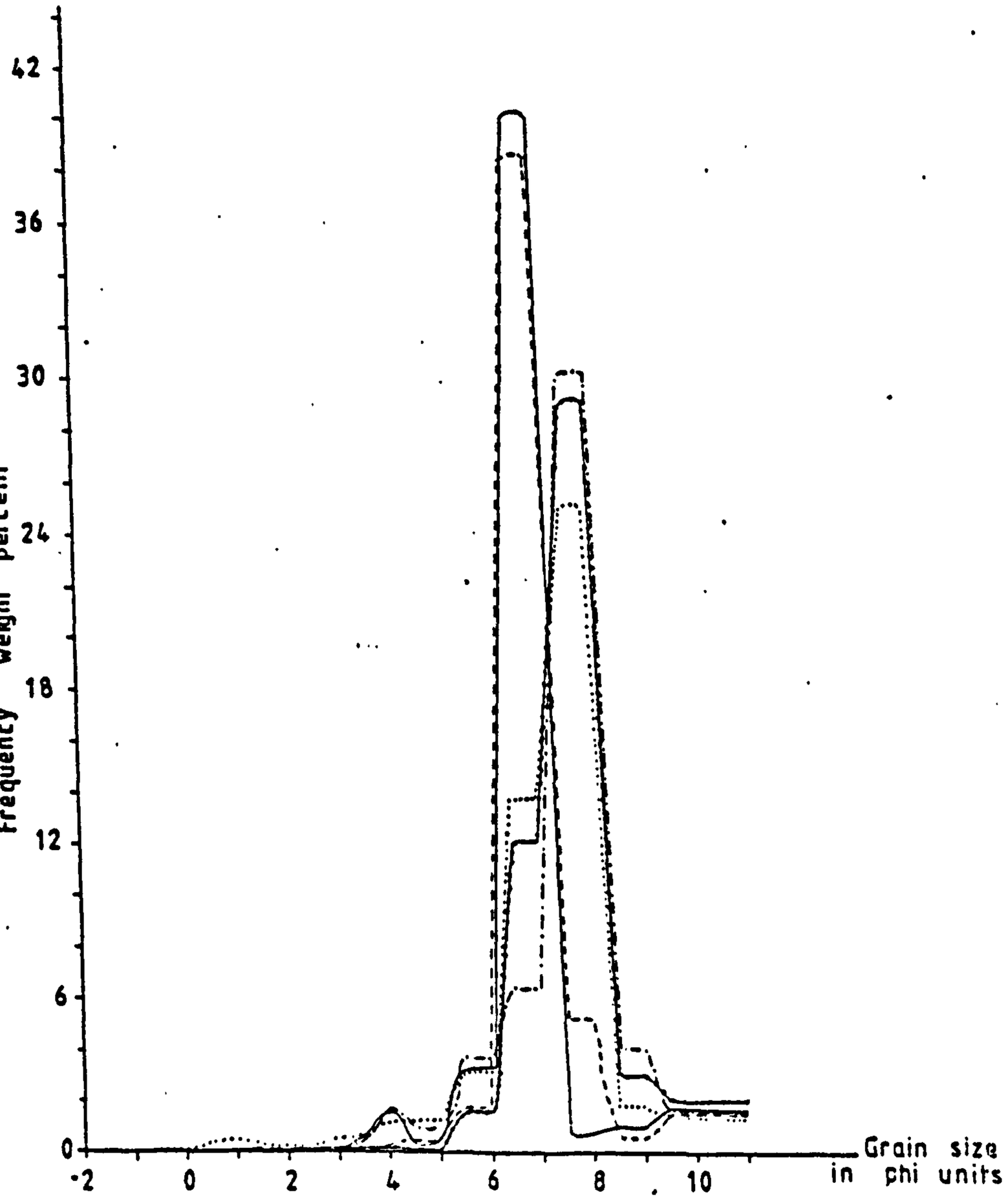


Fig. 13 IV The grain size composition of the surface sediments of the middle Aegean sea represented by size frequency curves and cumulative curves.

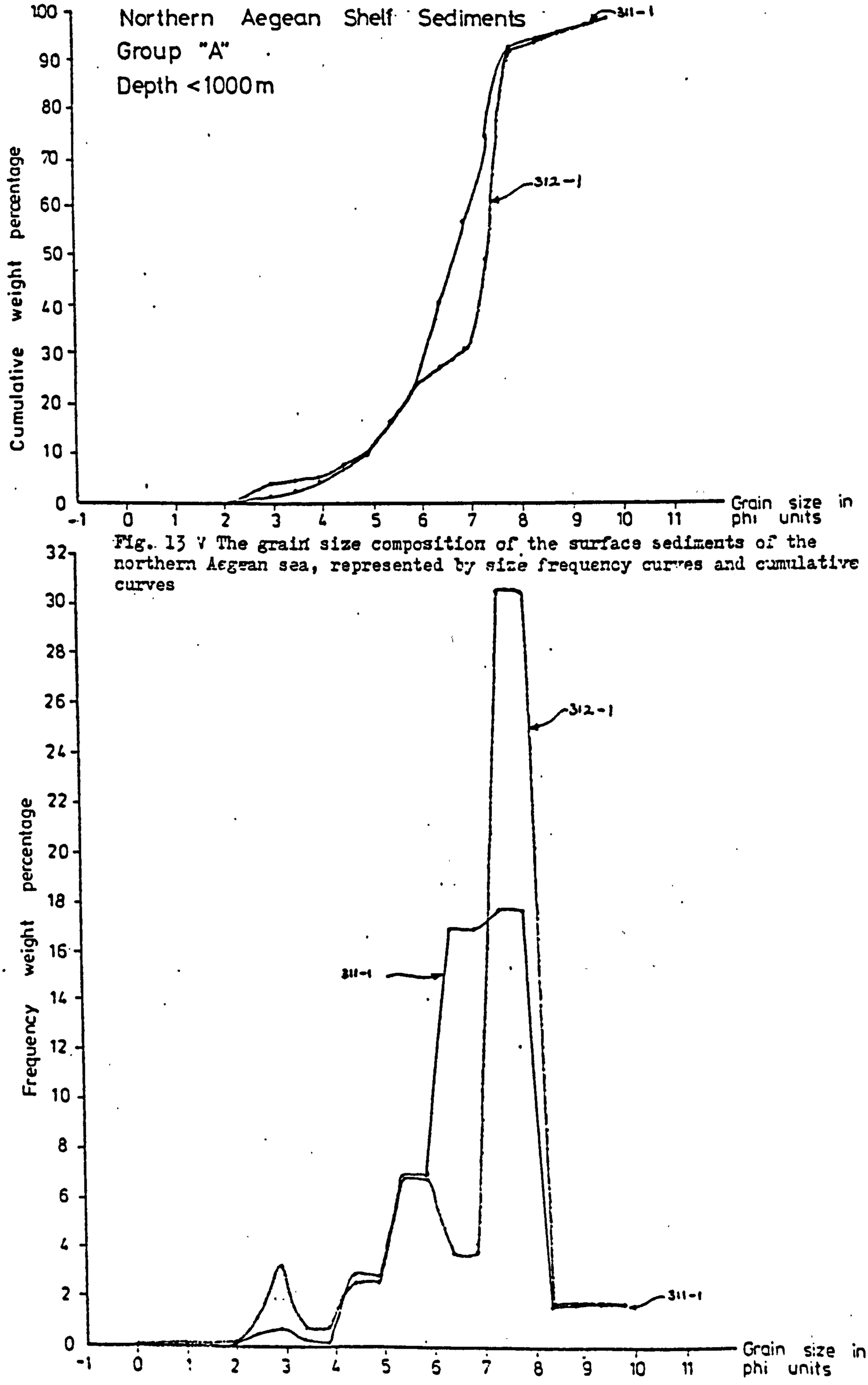


Fig. 13 : The grain size composition of the surface sediments of the northern Aegean sea, represented by size frequency curves and cumulative curves

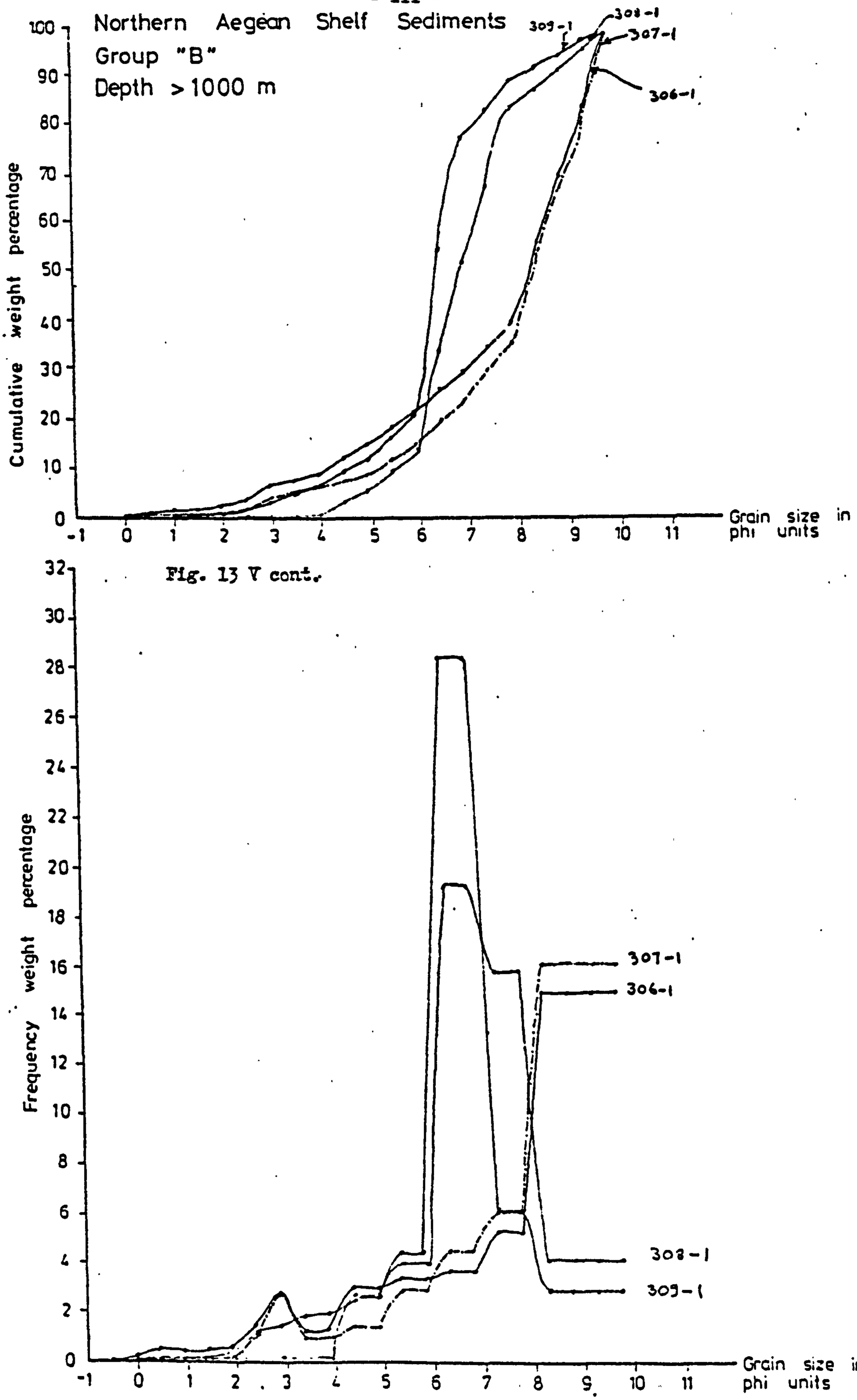

Northern Aegean Shelf Sediments
Group "B"
Depth >1000 m
Cumulative weight percentage
100
90
80
70
60
50
40
30
20
10
0
-1 0 1 2 3 4 5 6 7 8 9 10 11
Grain size in phi units
309-1
308-1
307-1
306-1
Frequency weight percentage
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
307-1
306-1
308-1
309-1

Fig. 13 V cont.

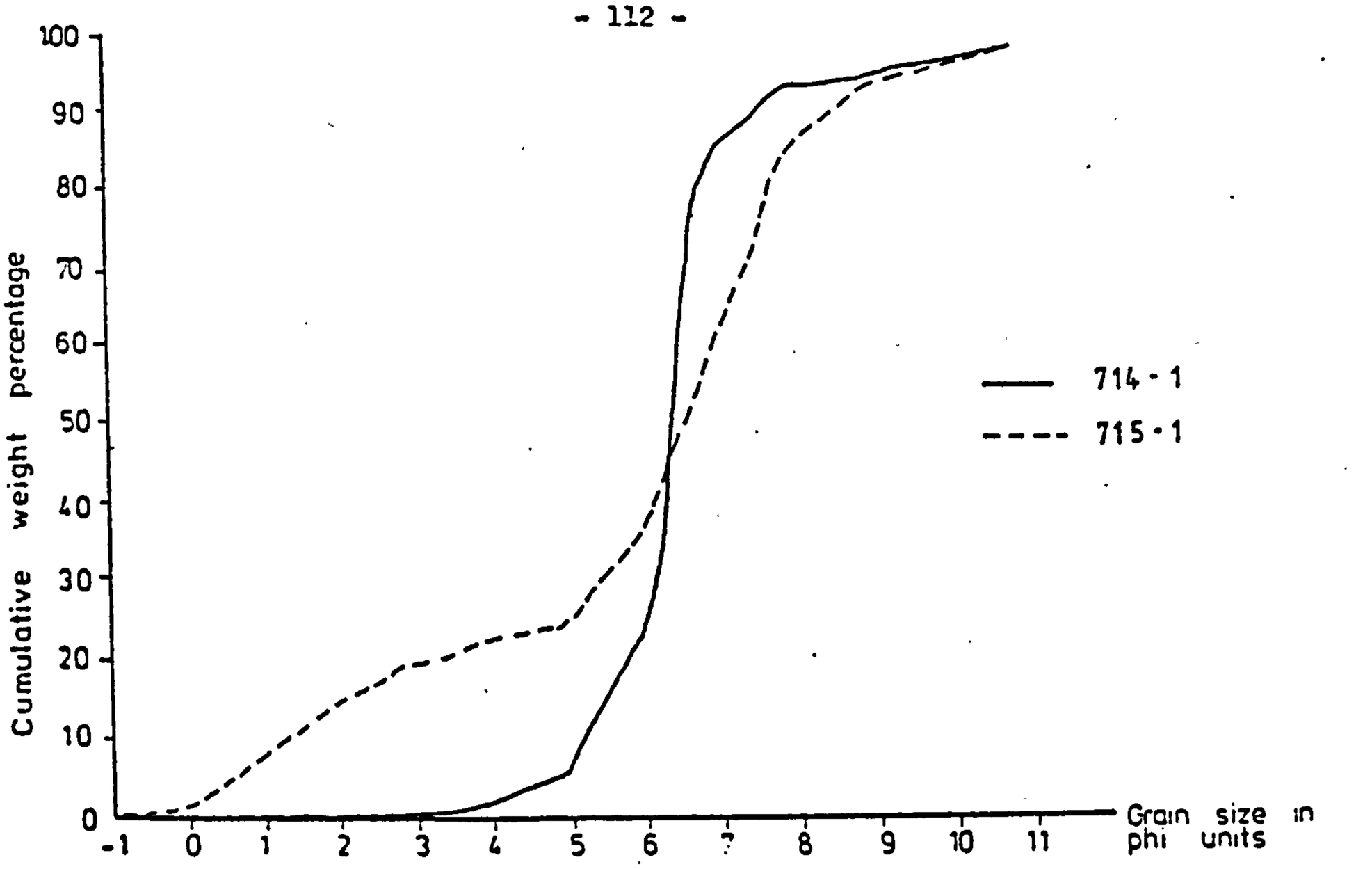
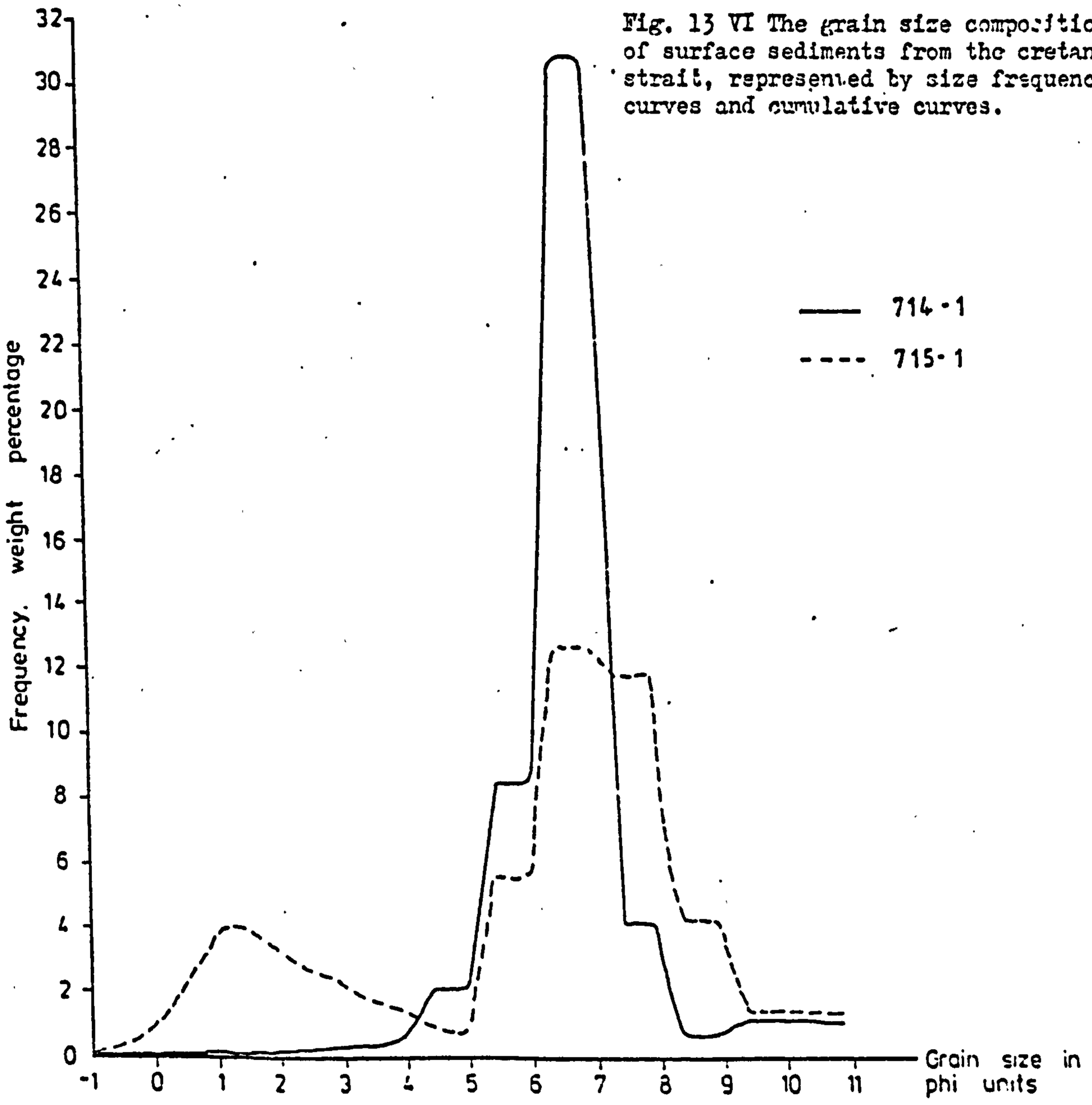


Fig. 13 VI The grain size composition of surface sediments from the cretan strait, represented by size frequency curves and cumulative curves.



the interpretation of a mixed grain size population, there is no substitute for constructing a frequency curve. Such curves, reveal all the properties of a complex distribution.

5.3a Measure of the average grain size: (Table 4)

The median; (The intercept of the 50th percentile with the cumulative curve). The northern Aegean sediments show a median size in the clay or very fine silt size range. The average median size is 8.37 phi units. The middle Aegean sediments show a median size in the fine silt range with an average size of 7.02 phi. The southern Aegean sediments have a median size in the medium silt range, with an average of 6.58 phi. The volcanic arc sediments have a medium size in the coarse silt to fine sand range. Close to the volcanic islands the median size is coarse (4.65) while away from the islands it is finer (5.25). South of Crete the shelf sediments have a median in the medium to fine silt range, with an average of 7.57 . Further to the south, sediments from the deeps have a coarser median size but still in the silt range. The surficial sediments examined from the Levantine Sea southeast of Crete and east of Karpathos and Rhodes generally have a median size in the silt range. Curves drawn for the median size (in phi units) against the depth Fig. (14 a - g), show that the median size increases generally as the depth increases. This relationship is seen south of Crete (Fig. 14 e, f and g) as well as between the islands of Milos and Thera (Fig. 14a), but does not exist in all places, especially on continental shelves or when the physiography is irregular (Fig. 15).

Table 4: The Average Size Parameters and the Average Sand, Silt and Clay Contents in the Surface Sediments in the Different Parts of the Study Area

	Median	Mean	Sorting	Skew.	Kur.	Sand	Silt	Clay
Northern Aegean	8.373	8.058	1.841	-0.279	1.449	3.375	42.053	54.572
Middle Aegean	7.020	6.994	1.392	0.0097	2.023	2.769	86.575	10.640
Santorini-Milos area	4.647	4.252	3.379	-0.202	1.579	34.205	55.723	6.61
a) Close to the islands	5.245	5.023	1.616	-0.177	2.361	14.615	78.936	5.955
b) Away from the islands	7.568		2.934	-0.039	0.926			
Southern Aegean	6.579		1.512	0.227	2.098	2.58	79.327	18.092

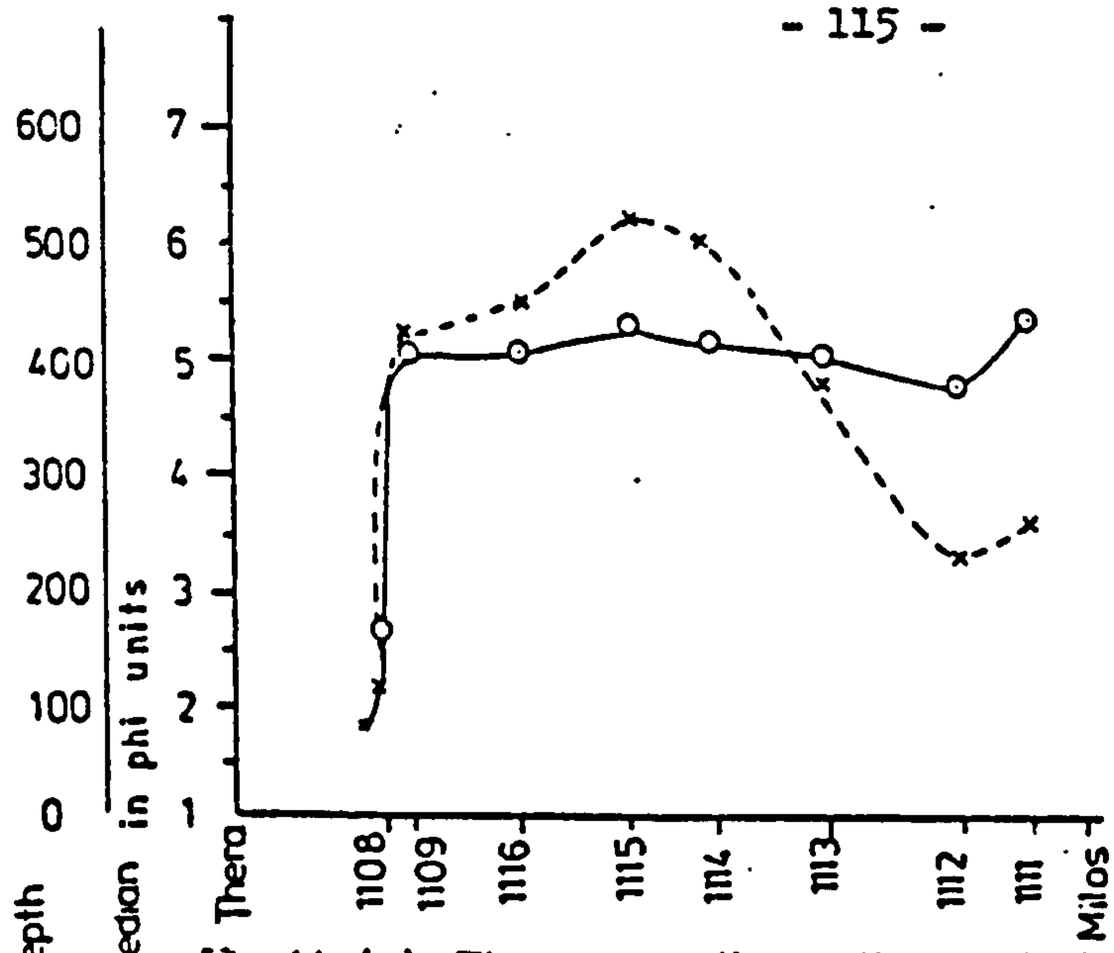


Fig.14:(a) to (g) The Median size in phi units plotted against the depth of the sea floor along the main sampling lines in areas studied in the Eastern Mediterranean and Aegean Seas.

x - - - - depth

⊙——— Median

Fig.14: (a) The sampling line between Milos and Thera

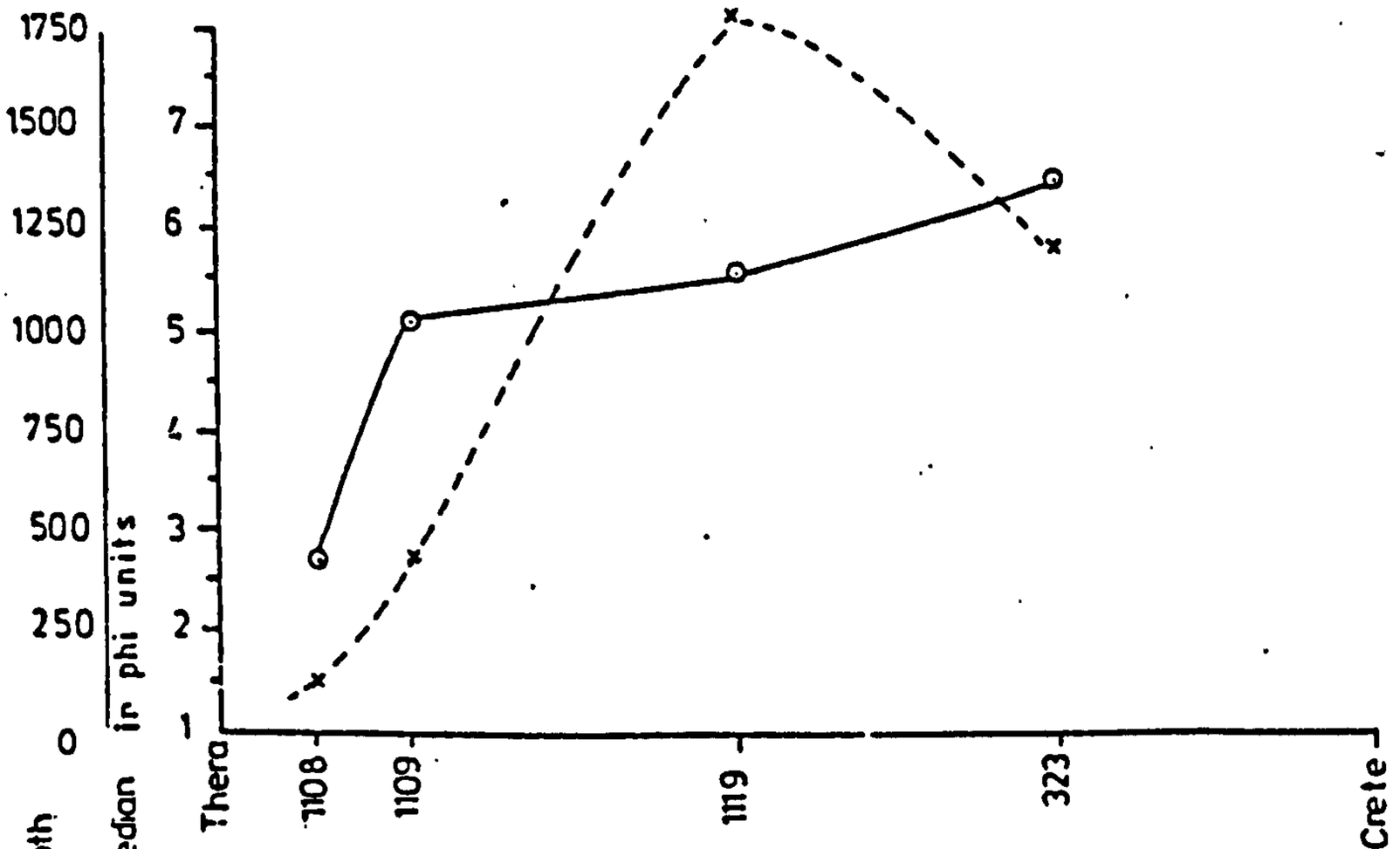


Fig.14: (b) The sampling line between Thera and Crete

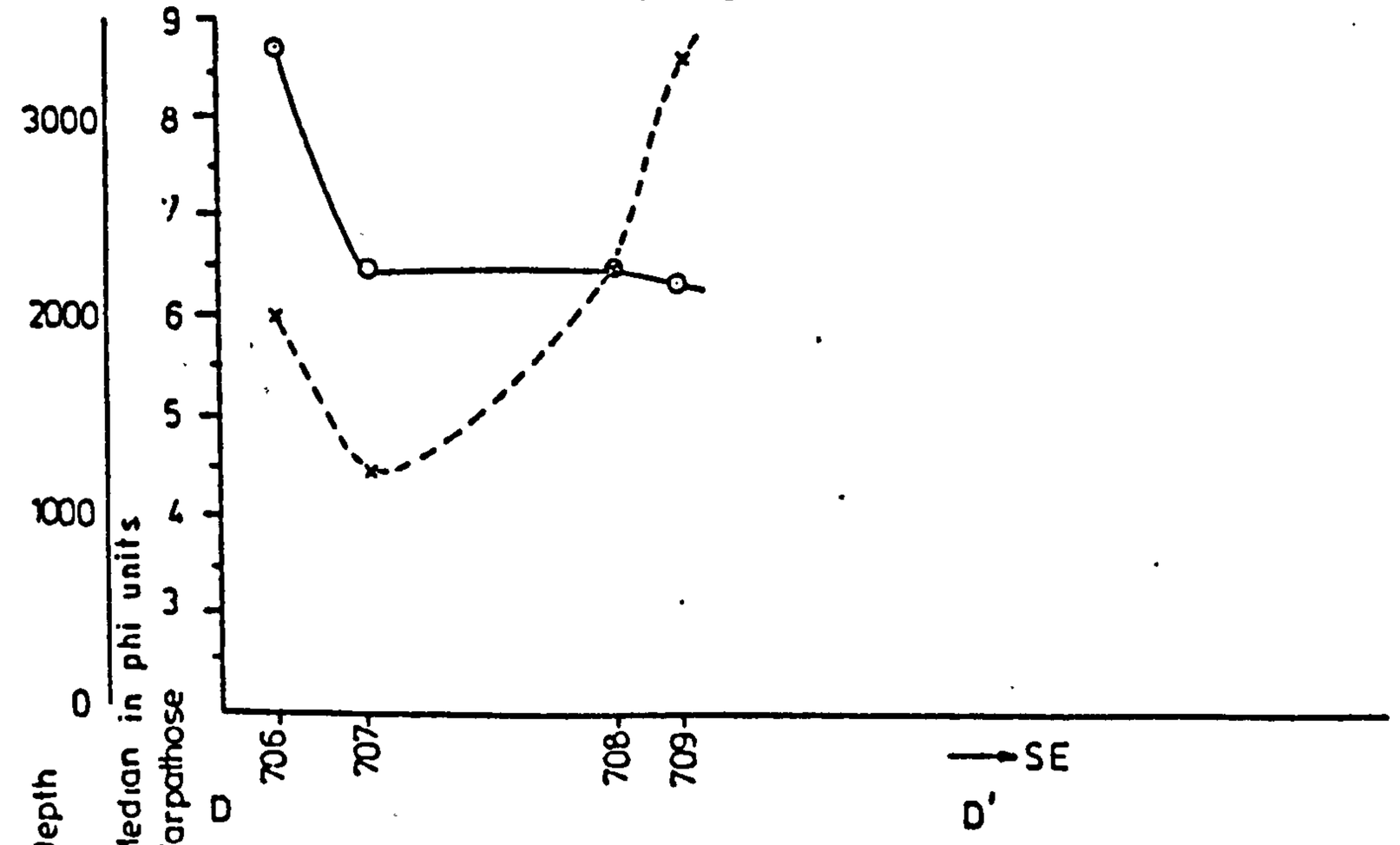


Fig.14:(c) The sampling line south east of Karpathos

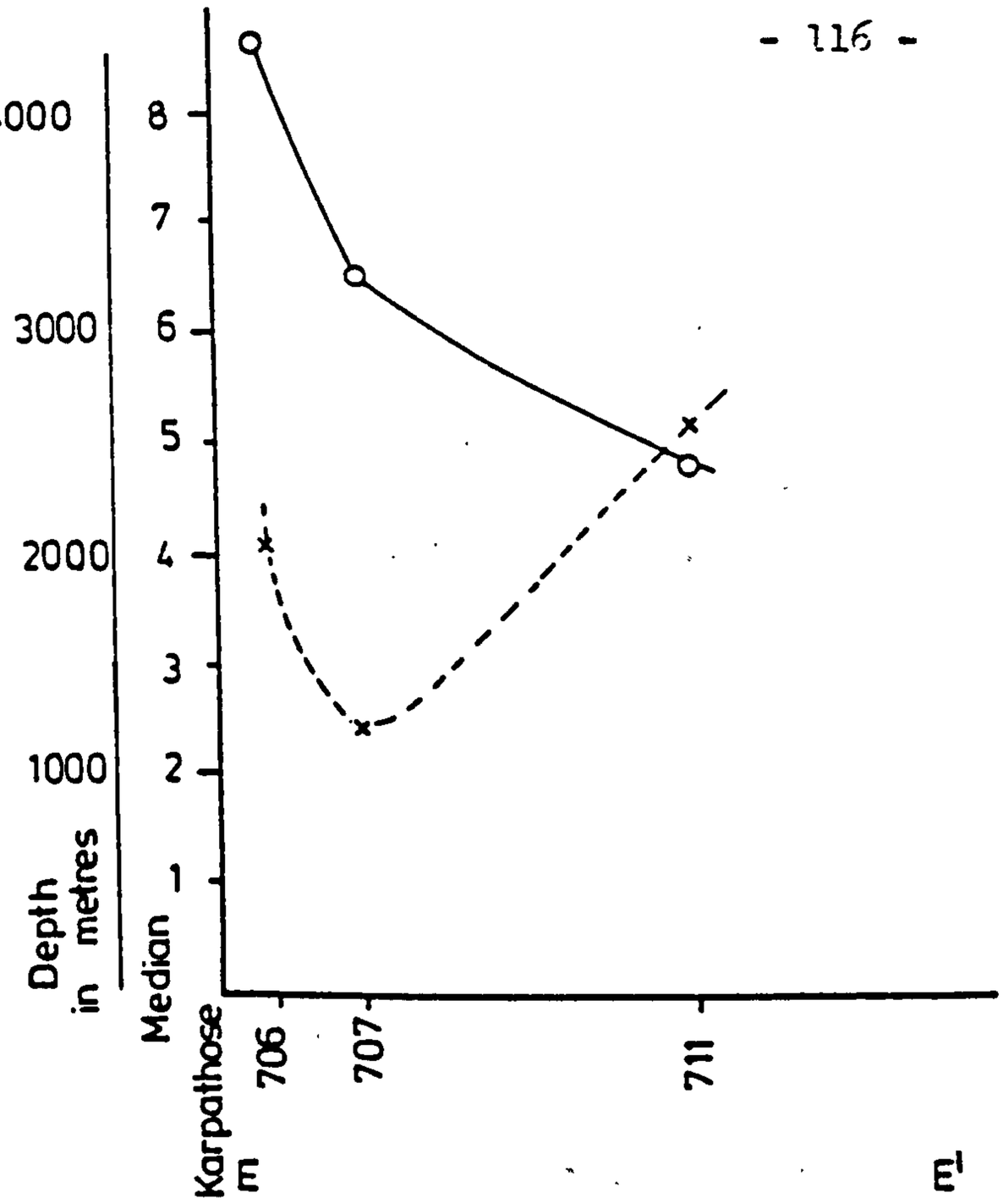


Fig.1 4 : (cont.)

Fig.14. (d) The sampling line from Karpathos to the south-east

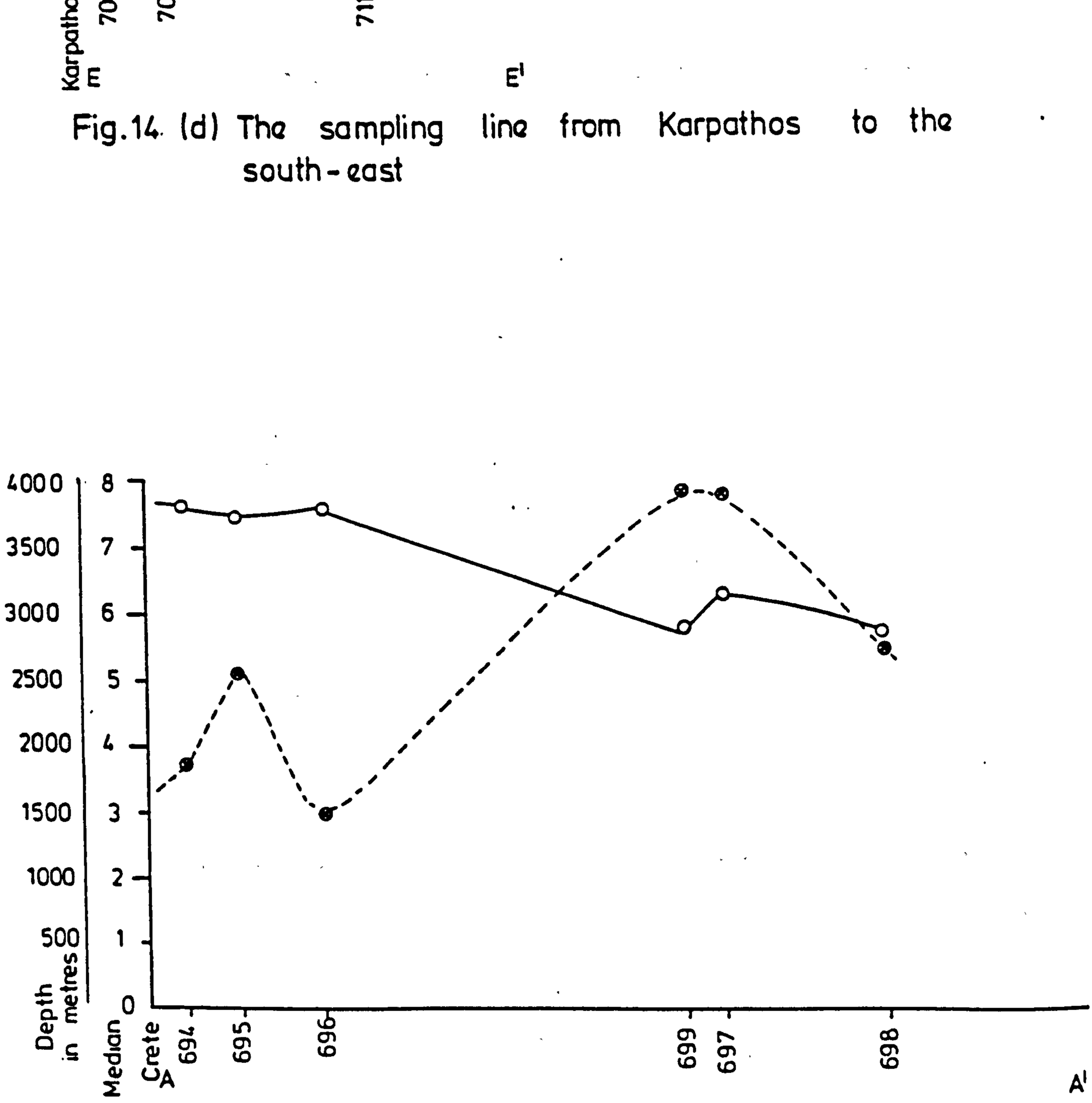


Fig.14 : (e) The sampling line A - A' south of Crete

Fig.14 : (cont.)

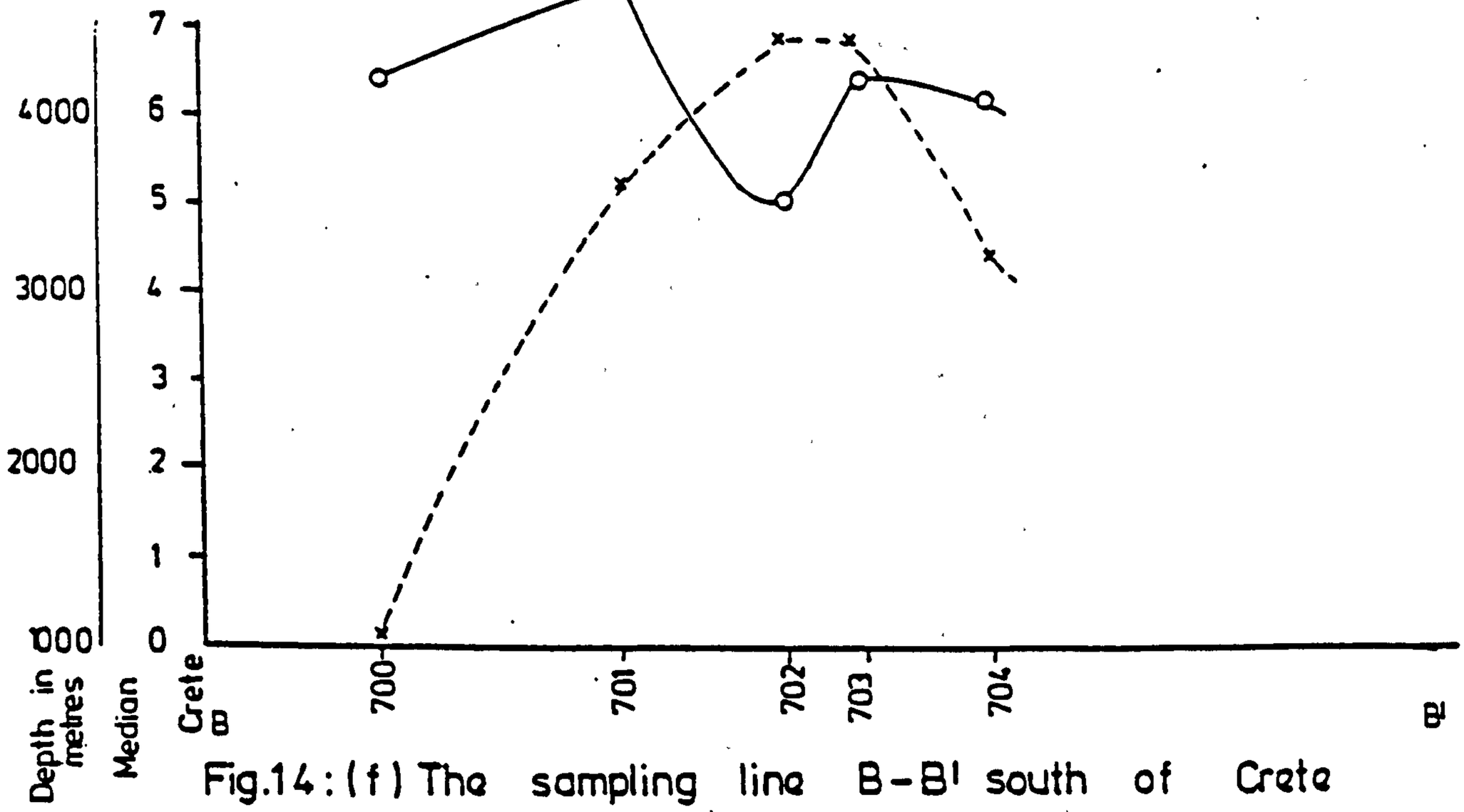


Fig.14 : (f) The sampling line B - B' south of Crete

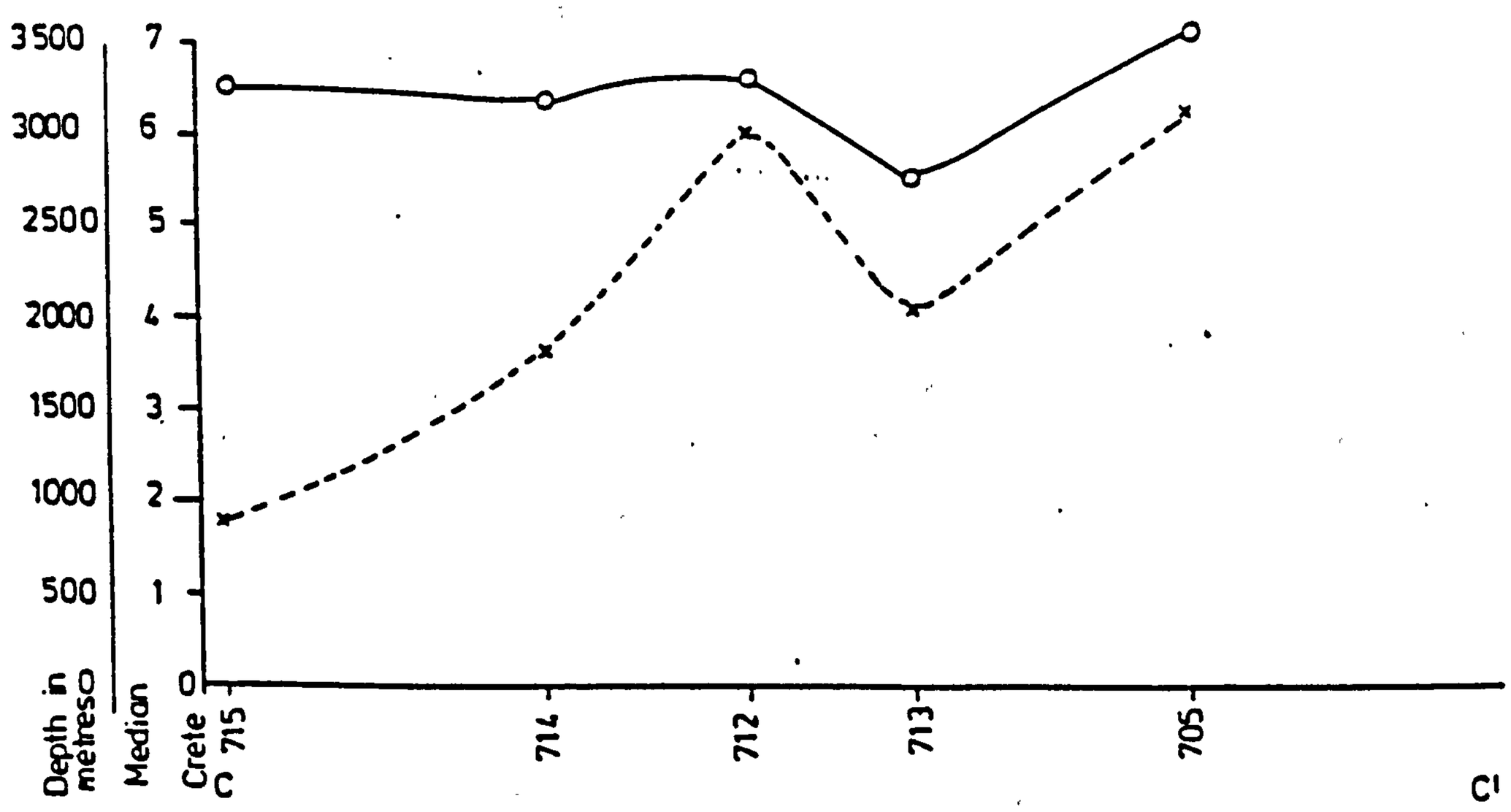


Fig.14 : (g) The sampling line C - C' from the Cretan strait to the south - east toward the trench area

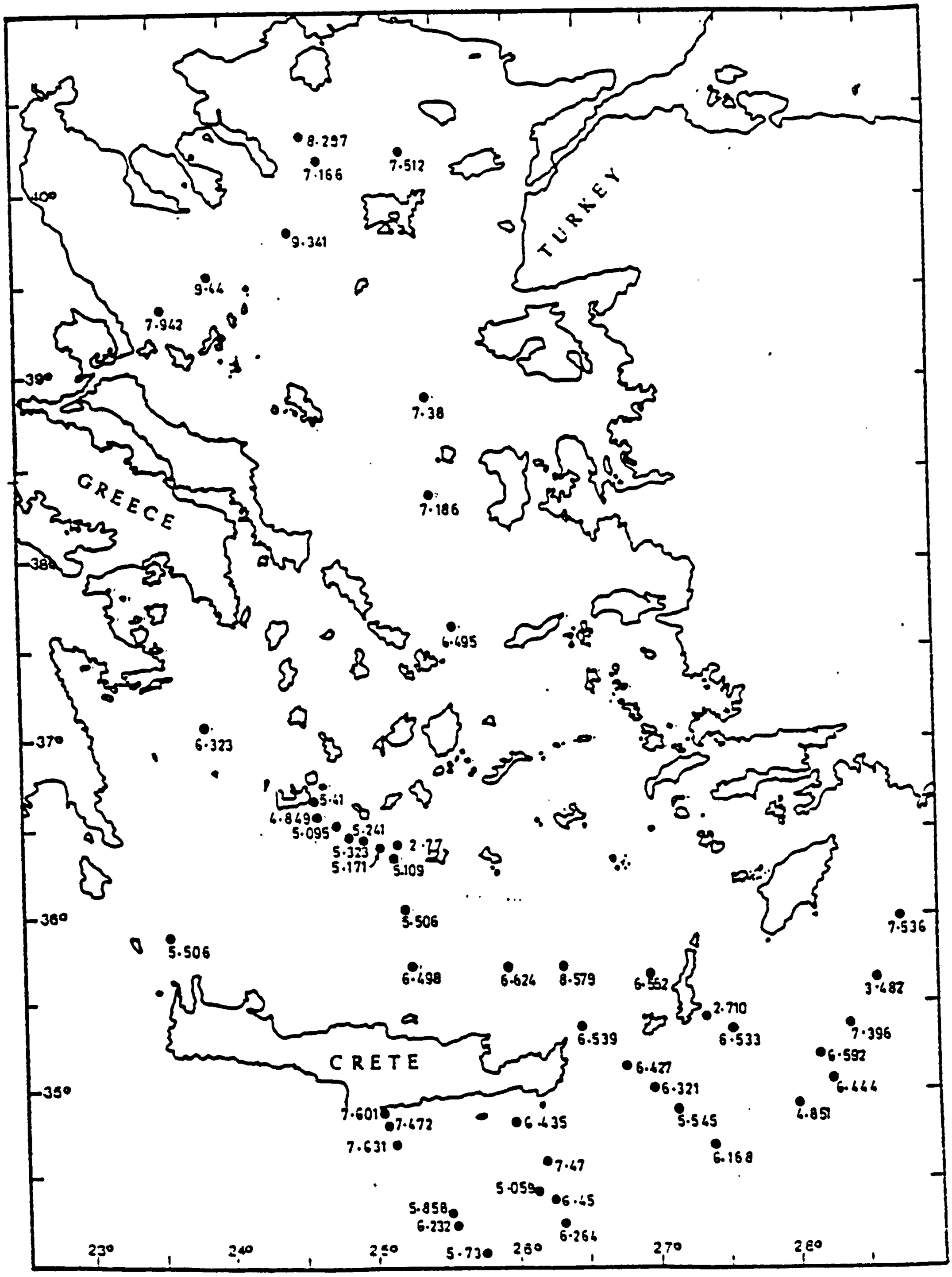


Fig.15: The Median Diameter of the surface sediments of the Eastern Mediterranean and Aegean Seas

(in phi units)

5.3b The mode: In the northern Aegean the sediments are unimodal (Fig. 13, IV). The mode falls in the fine silt or in the clay range. In the middle Aegean the mode has shifted towards the medium silt to coarse silt range. Between Santorini and Milos, sediments close to the volcanic islands consist of a mixed population of sand, silt and clay with a bimodal or polymodal distribution. The strongest mode is in the medium silt range and another one in the coarse sand range. Weaker modes are found in the sand and clay ranges. Away from the islands, sediments are simply bi-modal, with a strong mode in the coarse silt range and a weaker one in the coarse sand. The southern Aegean sediments have a different bi-modal nature with the strongest mode again in the medium silt range but the weaker one in the clay range. South of Crete the main mode has shifted towards the clay size range. Sediments off the continental shelf show a mode in the fine silt to clay range or are bi-modal (Fig. 13, 1A). Near the trenches the strongest mode is again in the medium silt range with a weaker mode in the clay range. In the Strabo Trench a mode is noticed in the sand range (sample No. 705-1) together with the usual mode in the medium silt. The figure here, and in sample No. 629-1 (two modes a strong one in the sand, and another in clay range), represents a turbidite sample from the trench. Off the continental shelves of Crete, Karpathos and Rhodes a very strong mode occursin the medium silt range, (Fig. 13, 1A and 1C).

5.3c Sorting: The sorting coefficient (as defined by Trask, 1932, the square root of the ratio of the larger quartile, Q_1 to the smaller quartile, Q_3) calculated for the sediments in the region show that the northern Aegean sediments are moderately well sorted. Sediments from the shelf have an average coefficient

of 1.84 . Sediments from the middle and southern Aegean have similar values of the sorting coefficient (Table 4), and are also mostly moderately well sorted. In the Cyclades arc, sediments from localities close to the volcanic islands are slightly more poorly sorted with an average coefficeint value of 3.38. Away from the volcanic islands the sediments have lower sorting coefficients and are generally well sorted. It is noticed that the larger the distance from the islands, the better sorted is the sediment (Fig. 16). Away from the islands the average sorting coefficient is 1.62. South of Crete sediments are generally well sorted except off the shelf and in the trench zone.

5.3d Skewness: Skewness measures the asymmetry of the frequency distribution, the coefficient is $SK = Q_1 Q_3/(Md)^2$ where Q_1 and Q_3 are the particle diameters respectively at the 25% and 75% intersections on the cumulative frequency distribution and Md is the median particle diameter.

In the northern Aegean the sediments have negative values in the range up to -0.53 and an average value of -0.28 . They are fine in nature, with a tail in the coarse fraction. The middle Aegean sediments have slightly positive to slightly negative values, showing a relatively symmetrical distribution. The average value in the middle Aegean is +0.1 . In the Cyclades arc, sediments have a very wide range of values , between -0.42 - 0.24 & 0.51 (see appendix No.1)The latter two values are single samples, one is close to Thera and the other is further south. The rest of the sediment samples from the Cyclades arc have negative skewness values. The sediments have a larger fine fraction with a tail in the coarse. The southern Aegean sediments have an average value of +0.23 . South of Crete the sediments have skewness values generally low (positive or

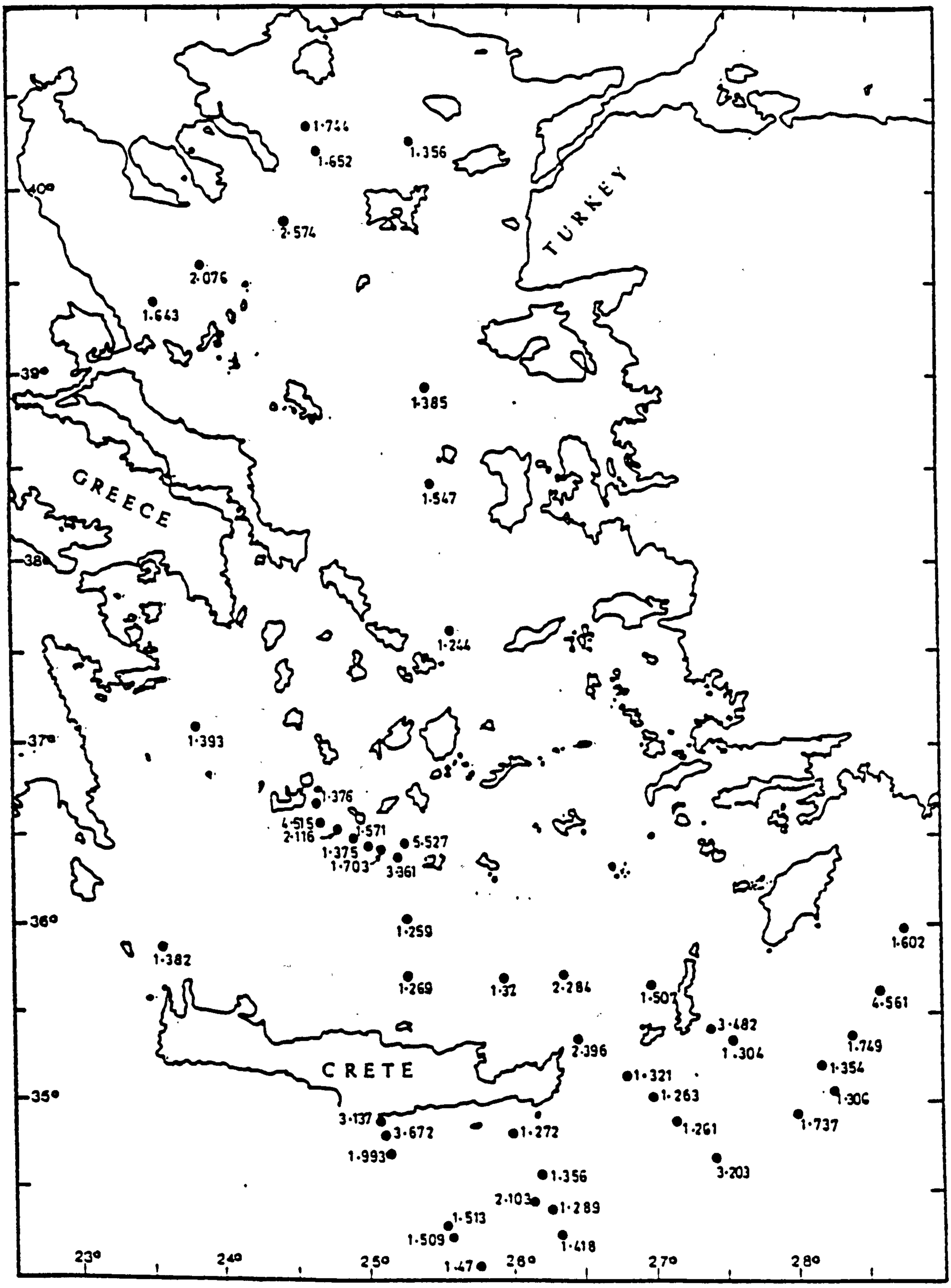


Fig 16 The sorting coefficient of the surface sediments of the Eastern Mediterranean and Aegean Seas.

negative), except those near the axes of deeps (Fig. 17). The continental shelf sediments south and southeast of Crete show symmetrical curves with skewness values around zero. Further to the south samples analysed from the subduction zone show very irregular skewness values, suggesting that this zone contains displaced sediments. High positive skewness values are found near the axes of deeps reflecting the coarse nature of the turbidite present there. Sample number 705-1 from the Strabo trench has a high negative skewness value and a weak mode in the sand range, and a stronger mode in the medium silt with tails on both the sand and clay sides. The clay content in this sample is very low (3.95%). Such a figure represents an unusual sediment which may be a mixture of displaced deposits. Such a deposit would be expected in this area of subduction.

5.3e Kurtosis: (Table 4)

Kurtosis measures the peakedness of the frequency distribution; i.e. the concentration of sediment particles about the median diameter: The coefficient is $k = (Q_3 - Q_1)/2(P_{90} - P_{10})$, where Q_3 and Q_1 are the particle diameters at 75% and 25% intersections on the cumulative frequency distribution respectively, P_{90} and P_{10} are the particle diameter such that 90% or 10% of the particles are larger respectively.

The northern Aegean sediments have a platykurtic distribution with an average kurtosis value of 1.45 . Such a value is not very low but still reflects the unimodal distribution of the sediments, and its peakedness. The middle Aegean sediments have higher kurtosis values with an average value of 2.02 , reflecting their leptokurtic distribution of sharp peaks and long tails. In the Cyclades Arc, sediments generally show a leptokurtic distribution. Close to the

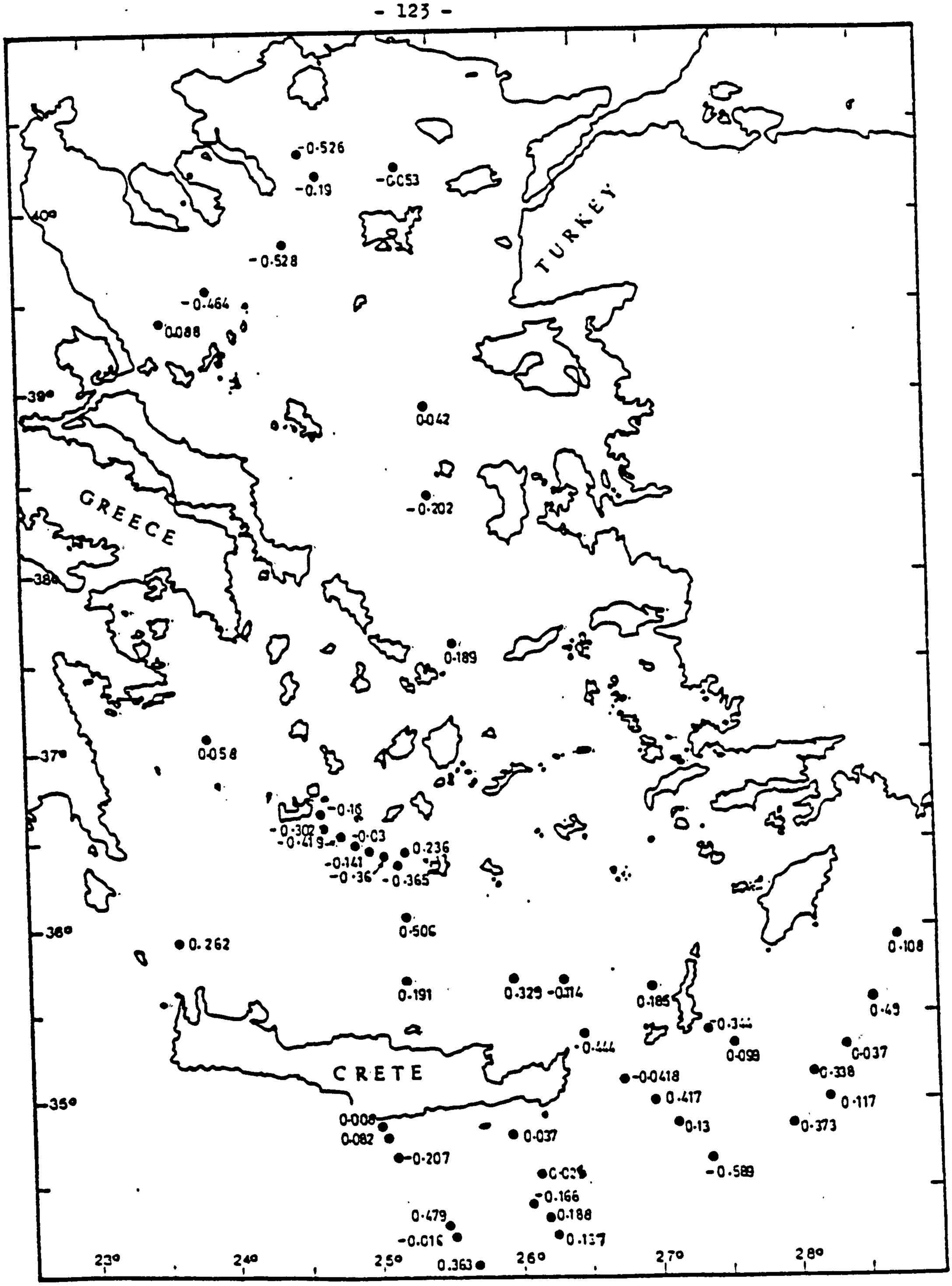


Fig 17 Skewness (Folk 1954) in the surface sediments of the Eastern Mediterranean and Aegean Sea

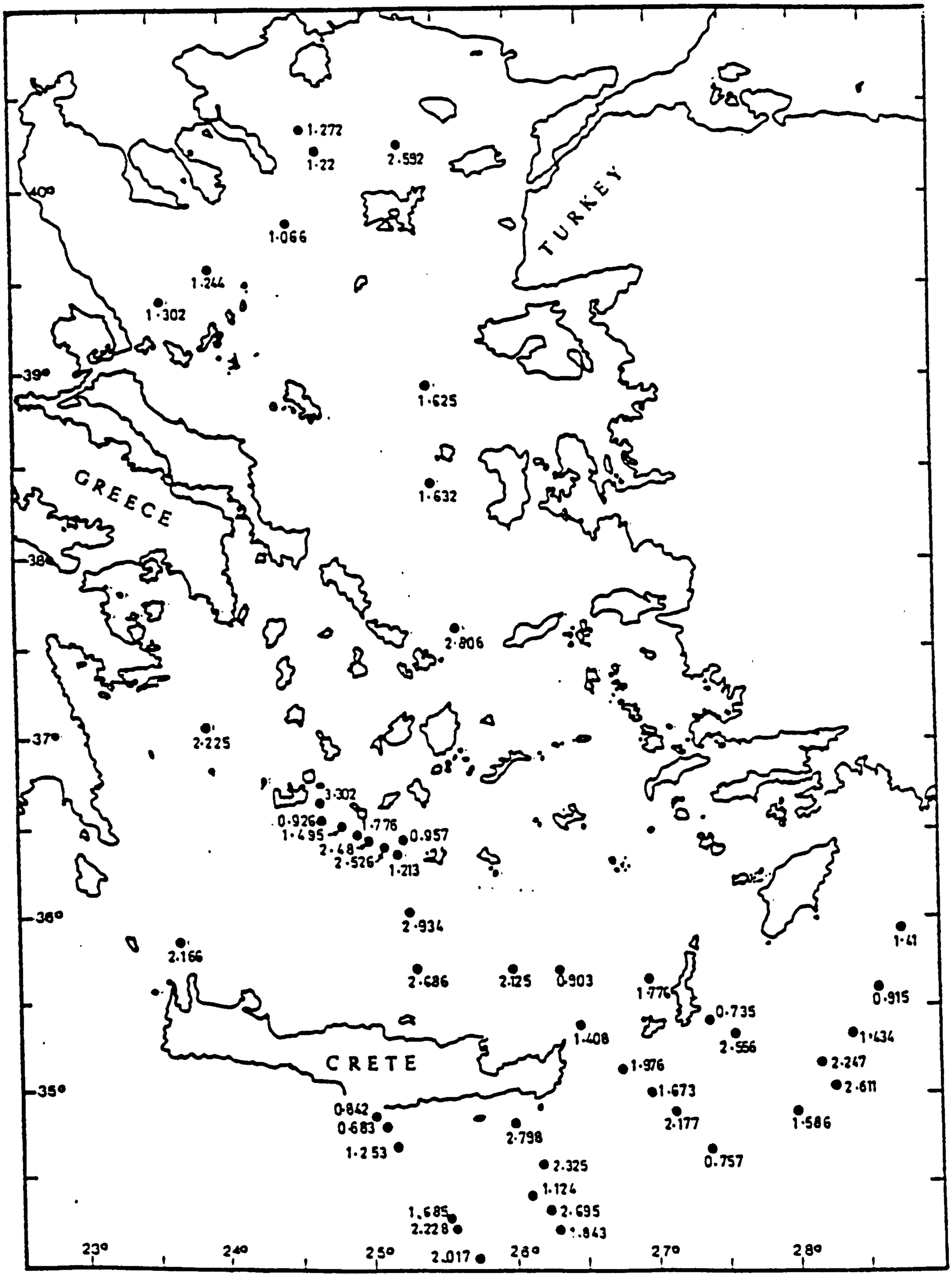


Fig 18 Kurtosis (Folk 1954) in the surface sediments of the Eastern Mediterranean and Aegean Sea

volcanic islands the average value (1.58) is lower than the average value away from the islands (2.36). This reflects the fact that the grain size distribution of sediments away from the islands have stronger peakedness than those close to the islands. In the southern Aegean the sediments are lept-okurtic with an average kurtosis of 2.1 . South of Crete the kurtosis value start increasing from the shelf outward, but near to and in the trench zones, kurtosis values are very irregular suggesting sediment mixing, (fig. 18).

5.6 Inter-relations of the different size parameters:

In order to understand the geological significance of the size analysis data, the different size parameters have been plotted against each other. In this way the inter-relations between the mean size, standard deviation, skewness and kurtosis are revealed, (fig. 19 A, B and C).

5.6a Mean size versus standard deviation:

The grain size range present is relatively small, including all the silt range with small amounts of coarser and finer fractions. A V shaped trend is noticed in general.(Fig.19A). Some sub-areas show only one limb of the V shape due to the small size range present or because of few data being available. Sediments are moderately sorted in the deep waters, poorly sorted in the straits and continental shelves and very poorly sorted in the Cyclades Arc particularly those close to the volcanic islands. Sediments from the trench zone are similarly poorly sorted. Both the trench zone sediments and the volcanic sediments form the left hand side of the V shape, (Fig. 19, A), within the mean size range of 3 to 5.5 phi. The rest of the Aegean Sea sediments and the eastern Mediterranean Sea south of

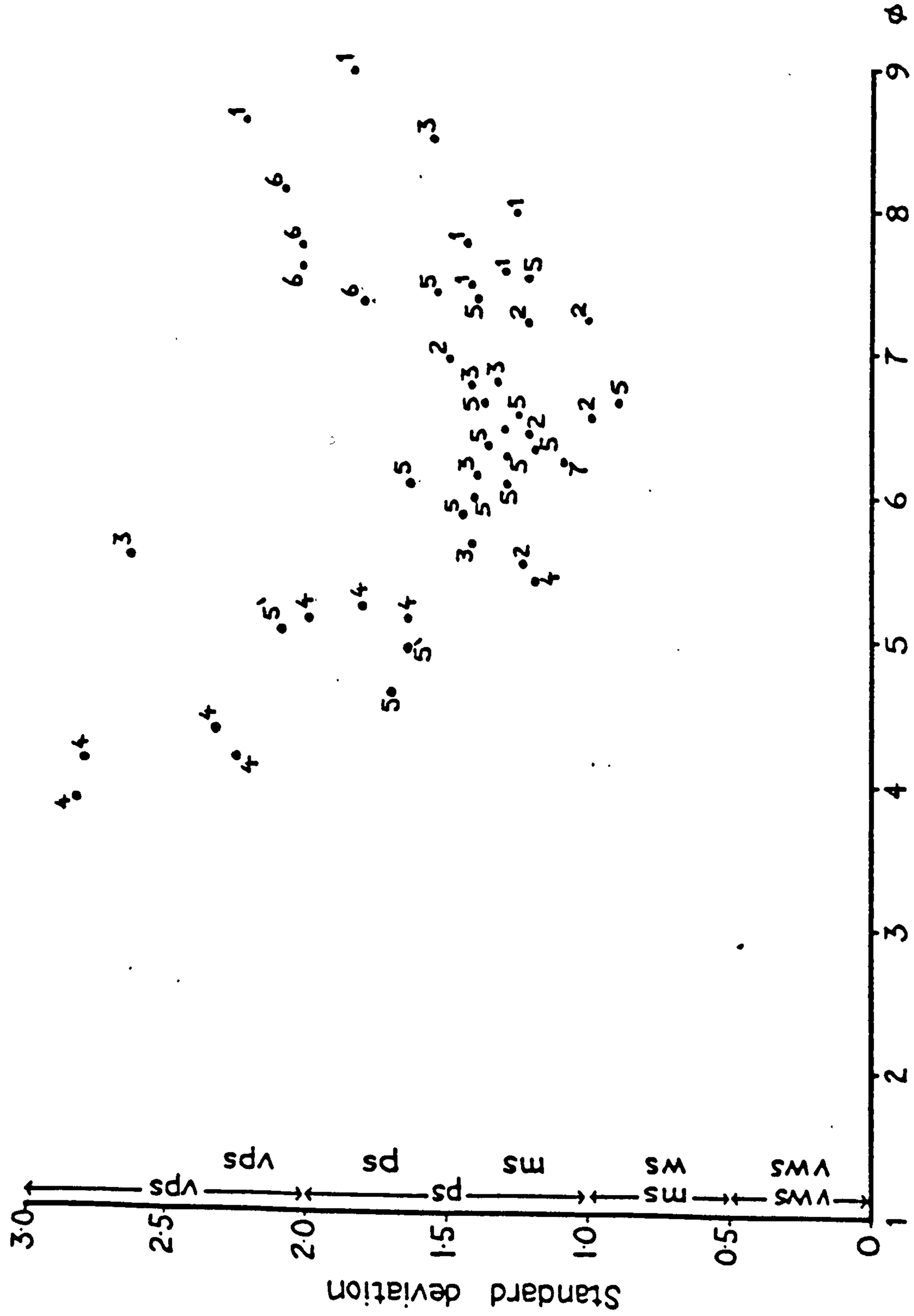


Fig 19A : Plots of mean size versus standard deviation

the island arc zone are less poorly sorted. Those from deeper waters show better sorting, and form the most clustered part of the curve in the medium silt range between 6 to 7 phi. The shelf sediments form the right side of the V shape within the mean size range of 7 to 9 phi. The dominant silt mode seems to be better sorted than sand or clay modes. The bulk of the samples occur in the medium silt range between 5.5 and 7.5 phi. The longer limb on the left hand side of the curve in the fine sand range is composed of samples from the Cyclades Arc. They contain sand sized volcanic deposits.

5.6b Mean size versus skewness:

The curve produced is nearly symmetrical and, tends to have positive values in the medium silt range. The trend is generally sinusoidal (Fig. 19 B). Pure silt mode is clearly dominant. There is a clear positive skewness maximum in the middle of the silt range. As the mean size becomes either coarser or finer than medium silt the skewness falls through zero and becomes negative. The most extreme negative values being reached at the limits of the silt range (4-8 phi units). The mixing of two different populations in a sediment could give rise to negative skewness values. Although the pure silt range is nearly symmetrical, equal quantities of two modes one coarser and the other finer could result in the same symmetrical curve.

5.6c Mean size versus kurtosis:

Most sediments fall in the leptokurtic region (Fig. 19 C). All sediments with dominant silt mode are leptokurtic particularly those in the medium silt range. With the addition

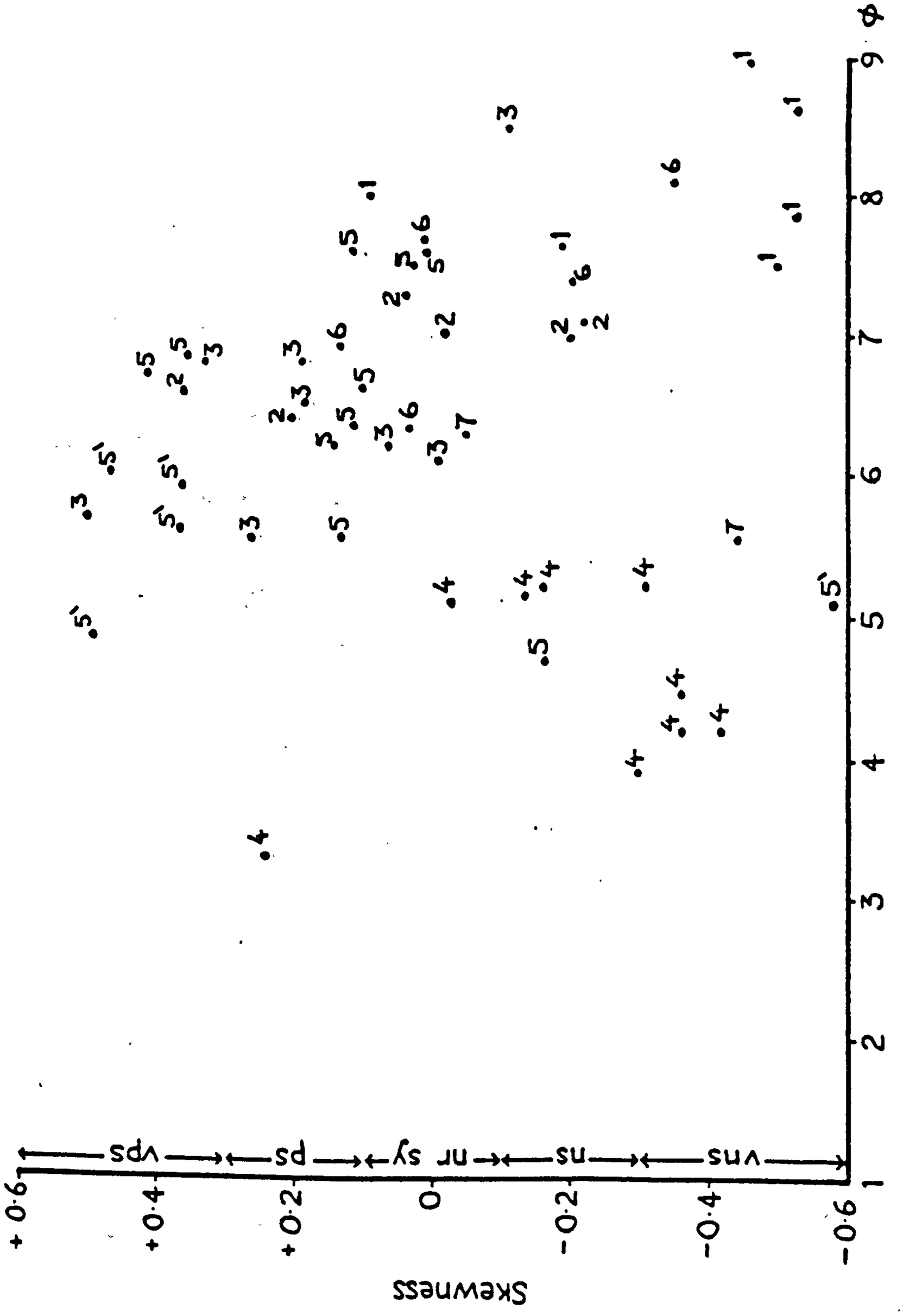


Fig 19B : Plots of mean size versus skewness

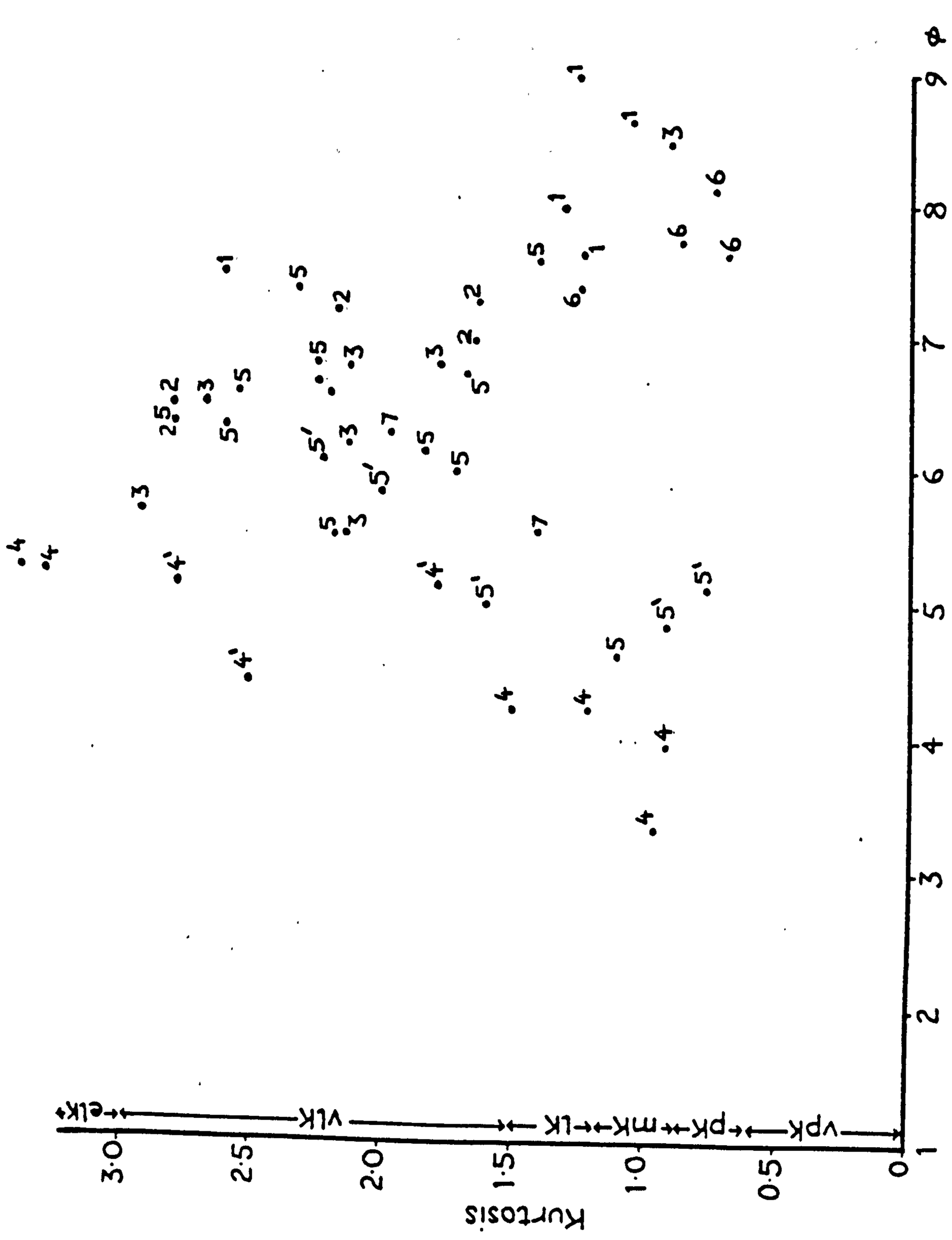


Fig 19c : Plots of mean size versus Kurtosis

of a finer or coarser mode the sediment becomes mesokurtic or platykurtic. In other words the bimodal sediments with sub-equal mode give rise to platykurtic curves. On the other hand if one of the two modes in a bimodal sediment attains a very high percent the curve becomes again leptokurtic. An example of the latter case is found in the sediments of the northern Aegean Sea and the Cyclades Arc (Fig. 13, V). The largest clustering of the curve is in the leptokurtic zone corresponding mainly to the medium silt range and the bimodal case mentioned before. Other mixtures of finer or coarser sediments fall in the platykurtic region of the curve.

5.7 Granulometric Study of the eastern Mediterranean Sediments

(B) Buried Sediments

Texture:

5.7a Sands

The sand percent in the buried sediments is generally similar to the surface layer except locally in certain layers or patches. These have high sand percentages up to 71-87% in the southern Aegean (Fig. 20). Other parts of the eastern Mediterranean are uniform in their sand content. The study of cores east of Rhodes and Karpathos shows that the sand content is uniform.

South of Crete a sandy layer is found on the shelf close to the shore at less than one meter depth(80 cm). In the trench area the presence of a sandy layer has been recorded in different cores at different depths. This is a proof of the presence of turbidites in this area, as has been noticed in the surface layer. In core no. 697 a turbidite layer is found at 35 cm from top, in core no. 704 one is found at 100 cm and in core no. 713 one occurs at 75 cm from top. Apart from the high sand contents in the trench area, the sand percentages are a little higher than average near to and on the continental shelf. This is due to the proximity of land and fluvial sediments, as has been mentioned in case of surface sediments.

5.7b Silts

The silt content in the buried sediments is generally less than that of the surface sediments except in the trench zone and the inner shelf south of Crete, where some core samples

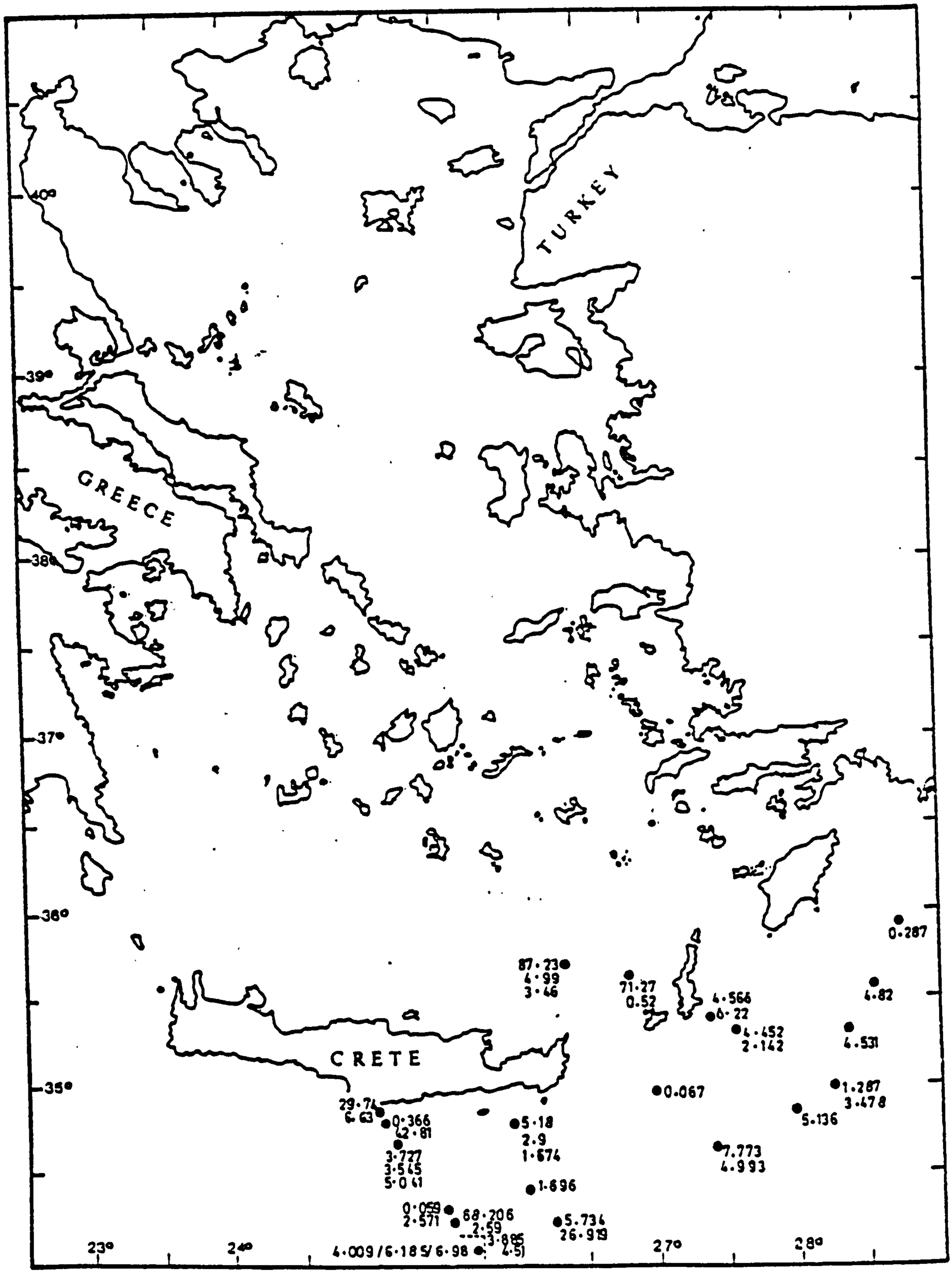


Fig 20 Distribution of sand in the buried sediments of the Eastern Mediterranean Sea
(in percent)

show higher values than in the surface sample. Sometimes within the same core, the silt content decreases down the core from the top and then it increases again. The distribution of the silt fraction in the buried sediments seems to be similar to that noticed in the study of the surface layer. Low silt percentages are noticed on the continental shelf south of Crete, while abyssal sediments are generally higher in their silt content (Fig. 21). South of Crete the silt percentages increase slightly from the shelf outward, but this is not typical of the trench area nor of east of Karpathose and Rhodes.

5.7c Clays

The clay content of the buried sediments is generally higher than that of the surface sediments except in cores on the continental shelves south of Crete and west of Karpathose. It is noticed that the clay content shows two changes from top to bottom within these latter cores. First it shows a slight decrease and then a big increase (Fig. 22).

5.7d Sand: Silt: Clay Ratios

The buried sediments have been described and classified on the basis of their sand, silt and clay ratios (Folk, 1954) (Figs. 23, 24). Generally they are similar to those at the surface with slight differences in some places. The sandy silt layer present at the surface in the Cretan strait (Fig. 11) seems to spread towards the north as a subsurface layer (Fig. 24). South of Crete the mud layer found on the shelf as a surface layer is also present in the subsurface. The silt covers most of the rest in this area, south of the island but does not extend to the east of Karpathose. The sandy silt layer that covers the trench zone as a surface layer is found buried in only a small area south of Crete, and does not have the same lateral extent as it has on the surface.

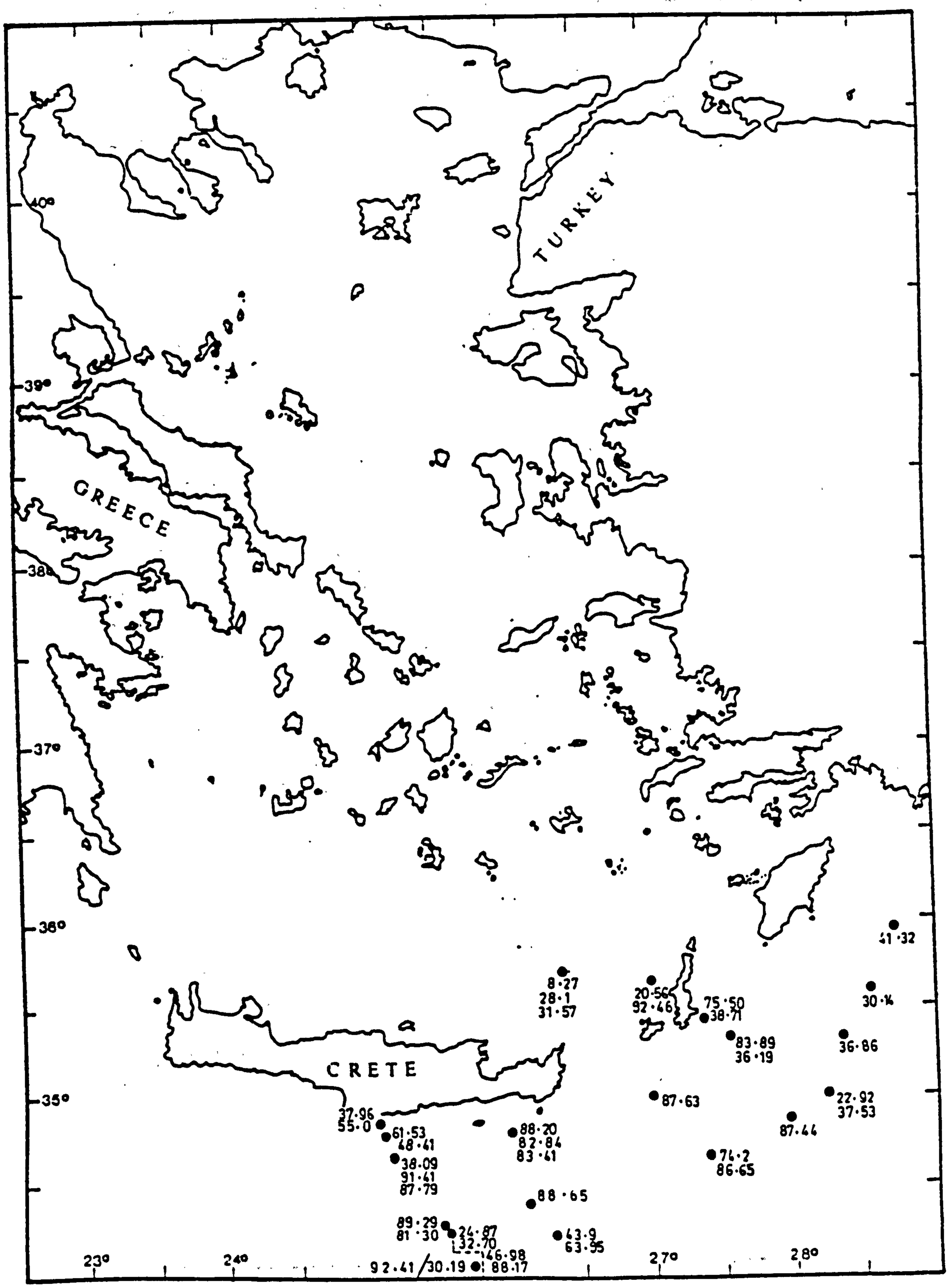


Fig 21 Distribution of silt in the buried sediments in the Eastern Mediterranean Sea
(in percent)

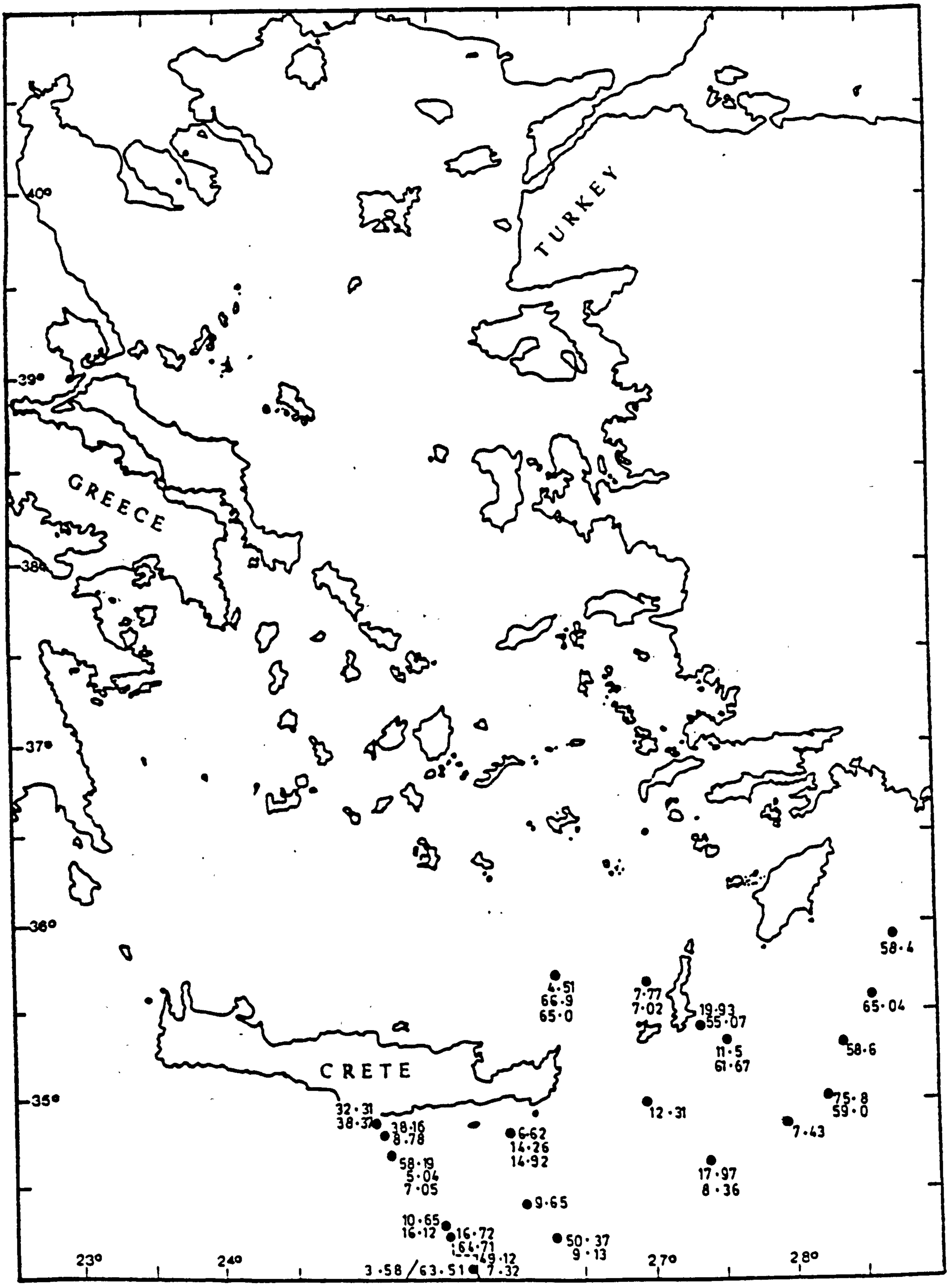


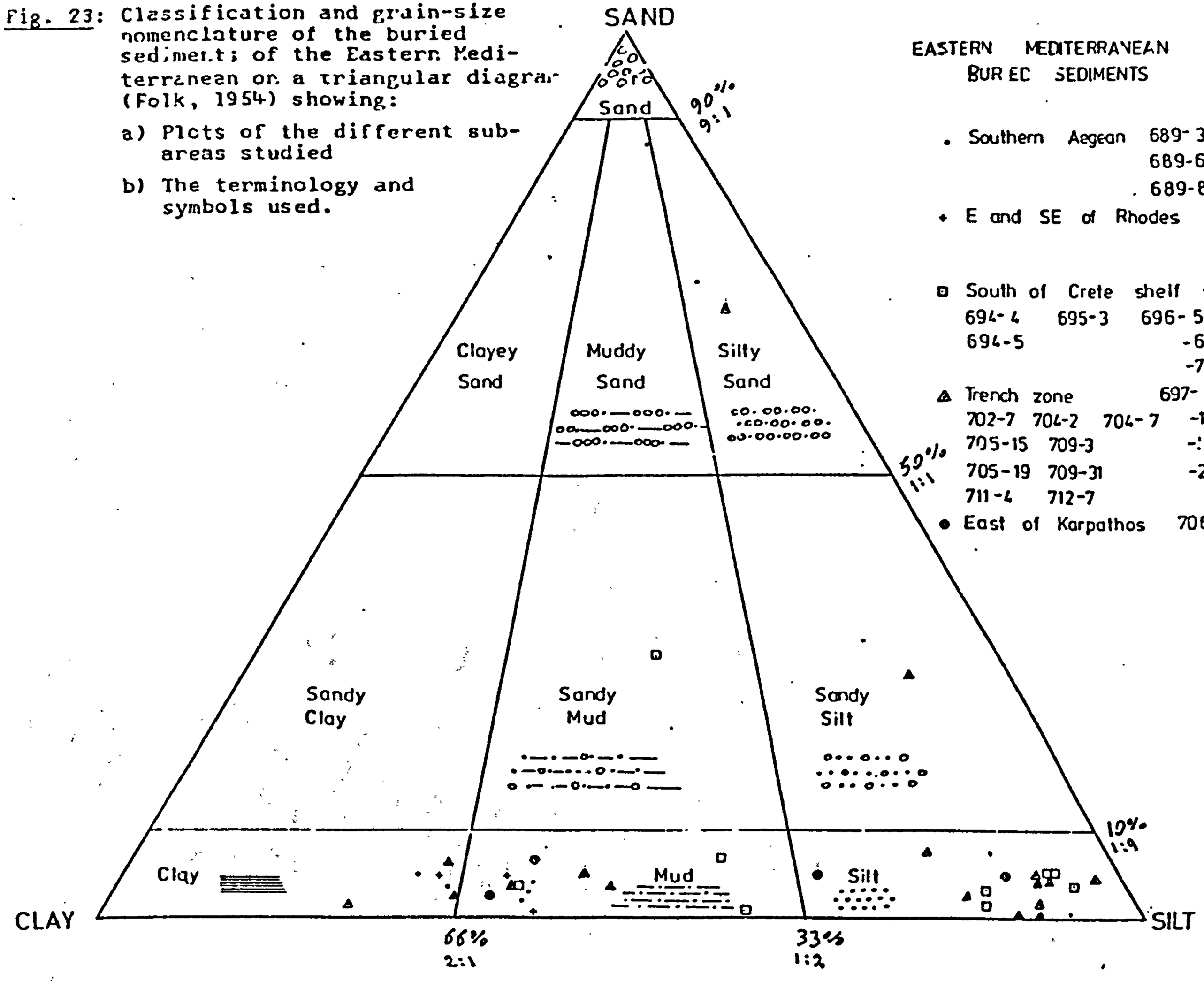
Fig 22 Distribution of clay in the buried sediments of the Eastern Mediterranean Sea

(in percent)

Fig. 23: Classification and grain-size nomenclature of the buried sediments of the Eastern Mediterranean on a triangular diagram (Folk, 1954) showing:

a) Plots of the different sub-areas studied

b) The terminology and symbols used.



EASTERN MEDITERRANEAN
BUR ED SEDIMENTS

- Southern Aegean 689-3 690-7 689-6 690-9 689-8
- E and SE of Rhodes 691-5 692-3 693-6
- South of Crete shelf sediments 694-4 695-3 696-5 700-2 694-5 -6 -5 -7 -10
- Trench zone 697-5 698-3 699-12 702-7 704-2 704-7 -10 -11 -56 705-15 709-3 -17 705-19 709-31 -24 711-4 712-7
- East of Karpathos 706-10 707-3 -14 -13

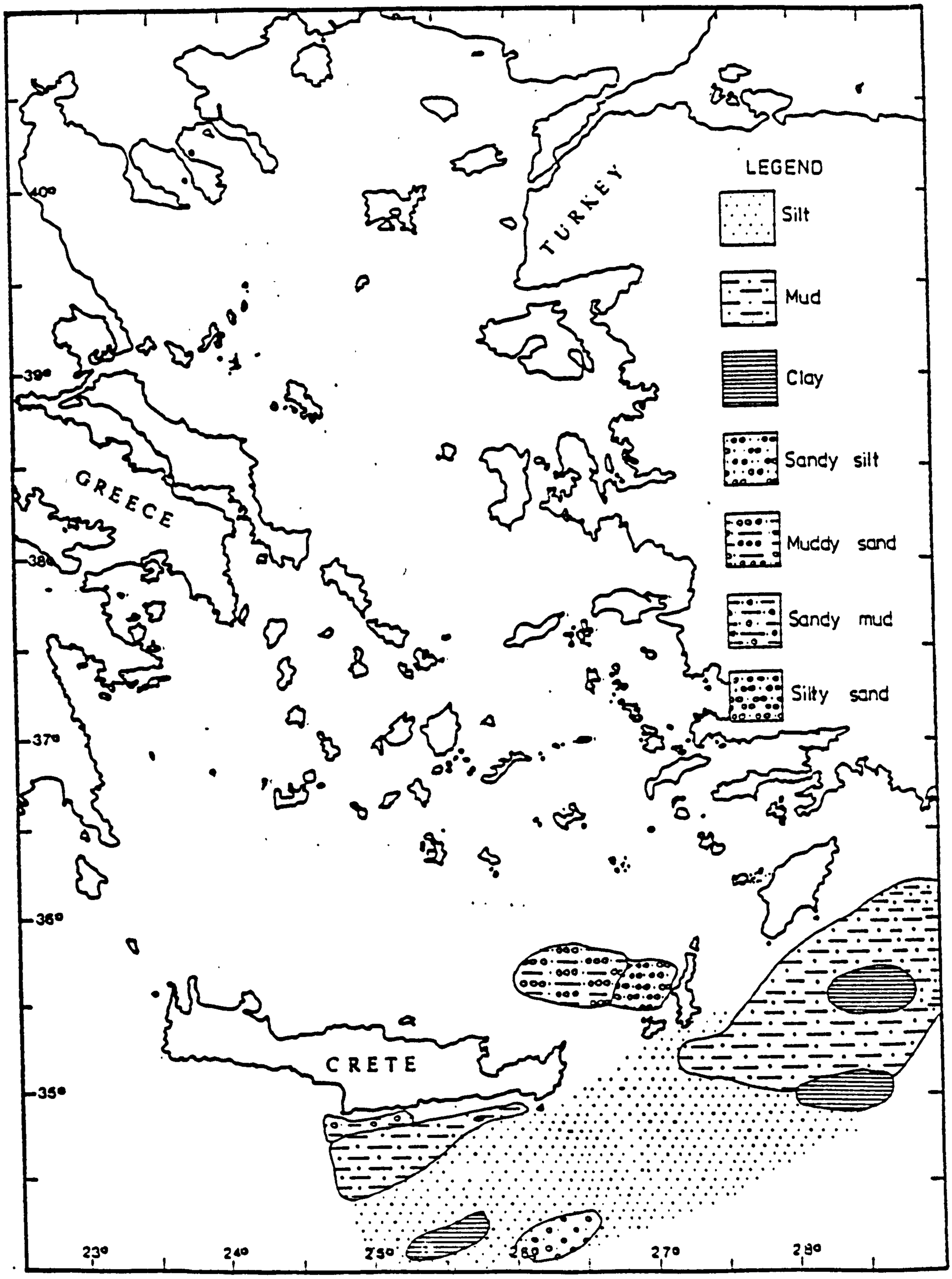


Fig. 24: A sediment distribution map of the buried sediments studied in the eastern Mediterranean.
The grain size distribution is after Folk (1954)

The buried sediments are generally less silty in their nature than the surface layer as seen from Fig. 24. It is clear that the southern Aegean buried sediments have higher sand and clay content than those of the surface layer in the same area (Fig. 12). East and southeast of Rhodes the sediments are richer in their clay content and likewise east of Karpathos. South and southeast of Crete silts predominate, and sediments are either pure silt or silty in nature. A remarkable difference between the surface layer and the buried sediments, is noticed to the east of Rhodes and Karpathos , where the silt present at the top grades into clay or mud. The sandy silt layer found in the trench area at the surface is recordcd over a smaller area in the subsurface sediments.

Fig. 25 Examples of the size frequency curves of the buried sediments studied from the eastern Mediterranean and Aegean Seas and their size composition represented by cumulative curves.

The complete set of the size analysis data and the calculated size parameters are given in appendix no. 1. The types of size frequency distribution present are:

1A South of Crete shelf sediments

(i) The sediments close to the shore on the inner shelf are poly-modal with one common mode in the clay range, another in the silt range and sometimes a third in the sand range.

(ii) The sediments further to the south and away from the inner shelf tend to have a very strong mode in the silt range. Sometimes they are unimodal and if they are bi- or polymodal the silt mode still is a principal one.

1B South of Crete trench sediments

Sediments in this area have a diverse nature. Generally they are similar to the normal silty lutites or ooze present in the surrounding areas.

IC East of Rhodes and Karpathos & Southeast of Crete

(i) The buried sediments here are quite similar to the surface sediments. They are generally clayey in nature,having a mode in the clay range or on the limit between the silt and clay fractions. Some samples are found to have bimodal or polymodal distribution, but they still have a clay mode.

(ii) One sample close to the island of Karpathos (707-1 & 707-3) is found to be unimodal with a very sharp peak in the medium silt range.

II The Southern Aegean Sediments

The buried sediments analysed from this area are found to be different from those of the surface layer. Two different layers are found:

a) A sandy layer between the top and 68 cm from top. This is coarse grained sediment with a bimodal distribution having both modes in the sand range. (No. 698-8 and 690-7).

b) A lower clayey layer (No. 689-6 and 689-8).

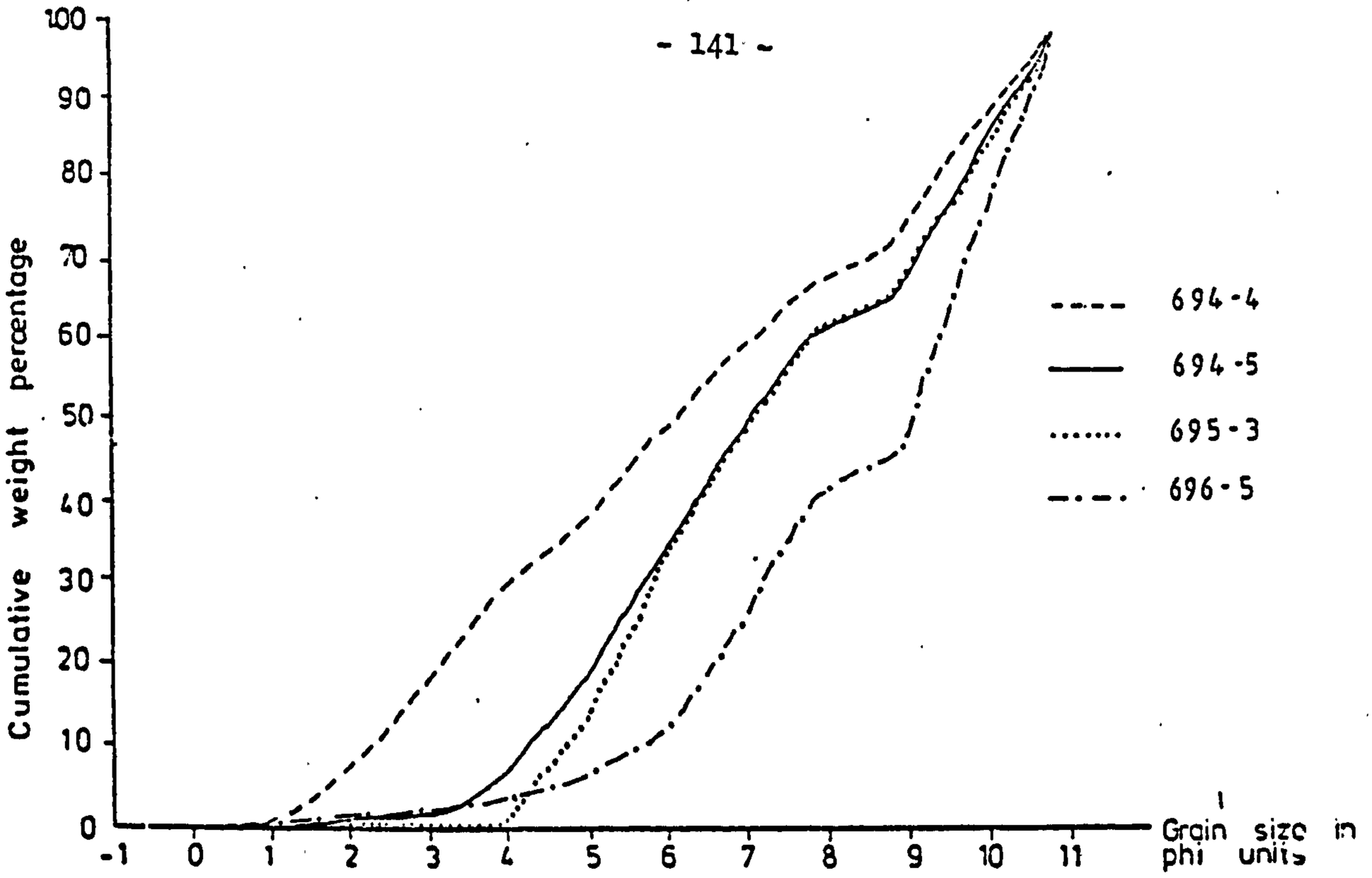
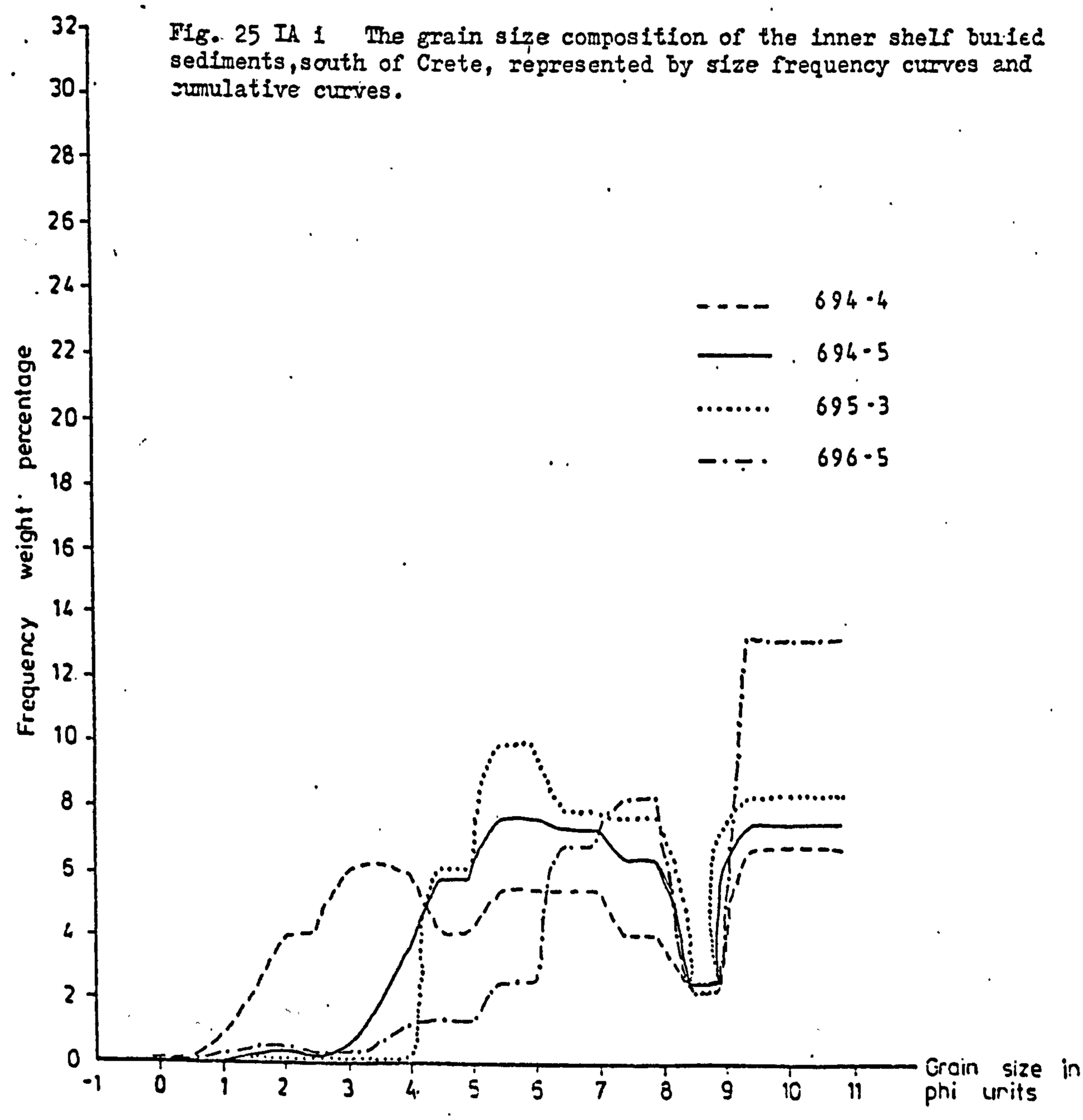


Fig. 25 IA i The grain size composition of the inner shelf buried sediments, south of Crete, represented by size frequency curves and cumulative curves.



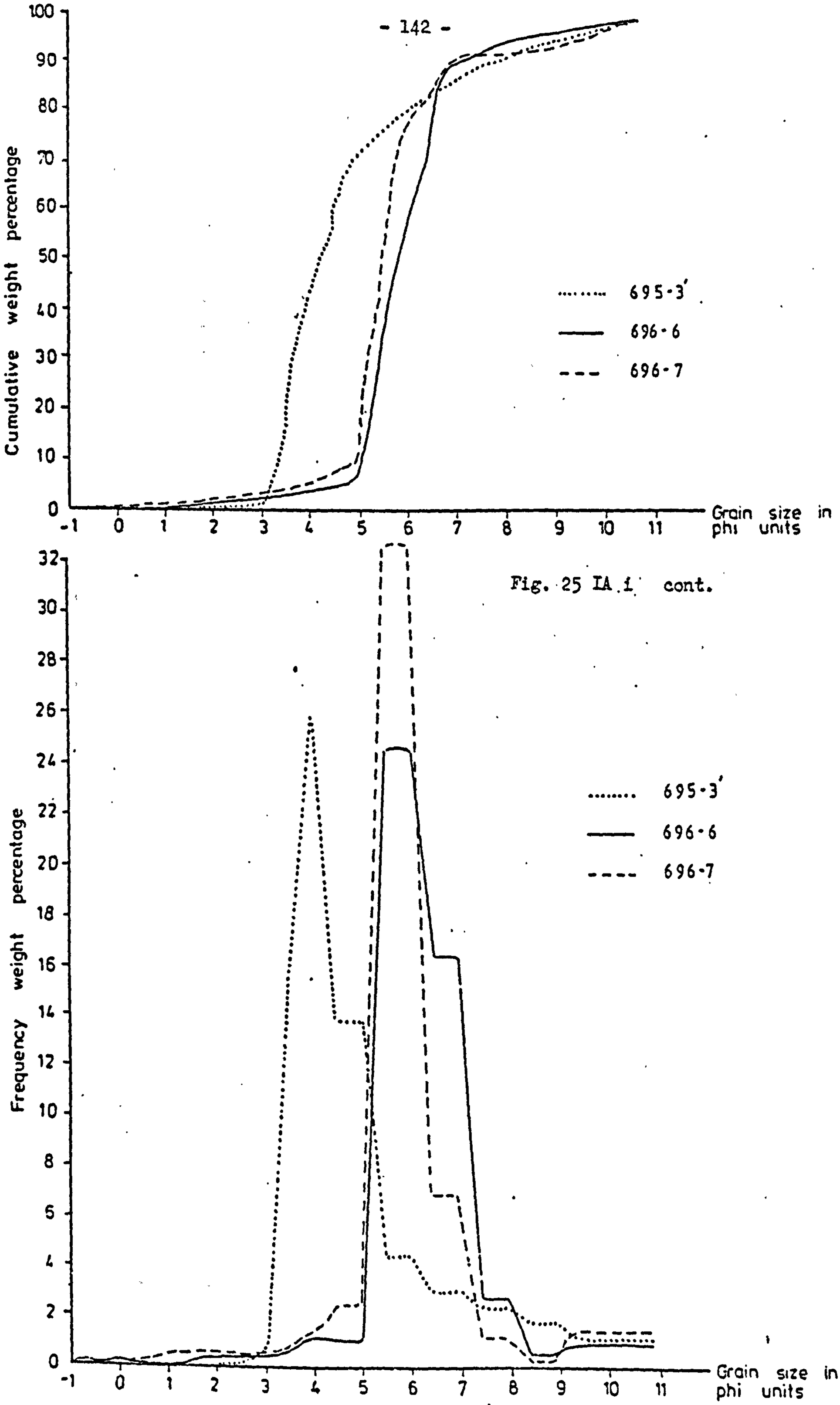


Fig. 25 IA.1 cont.

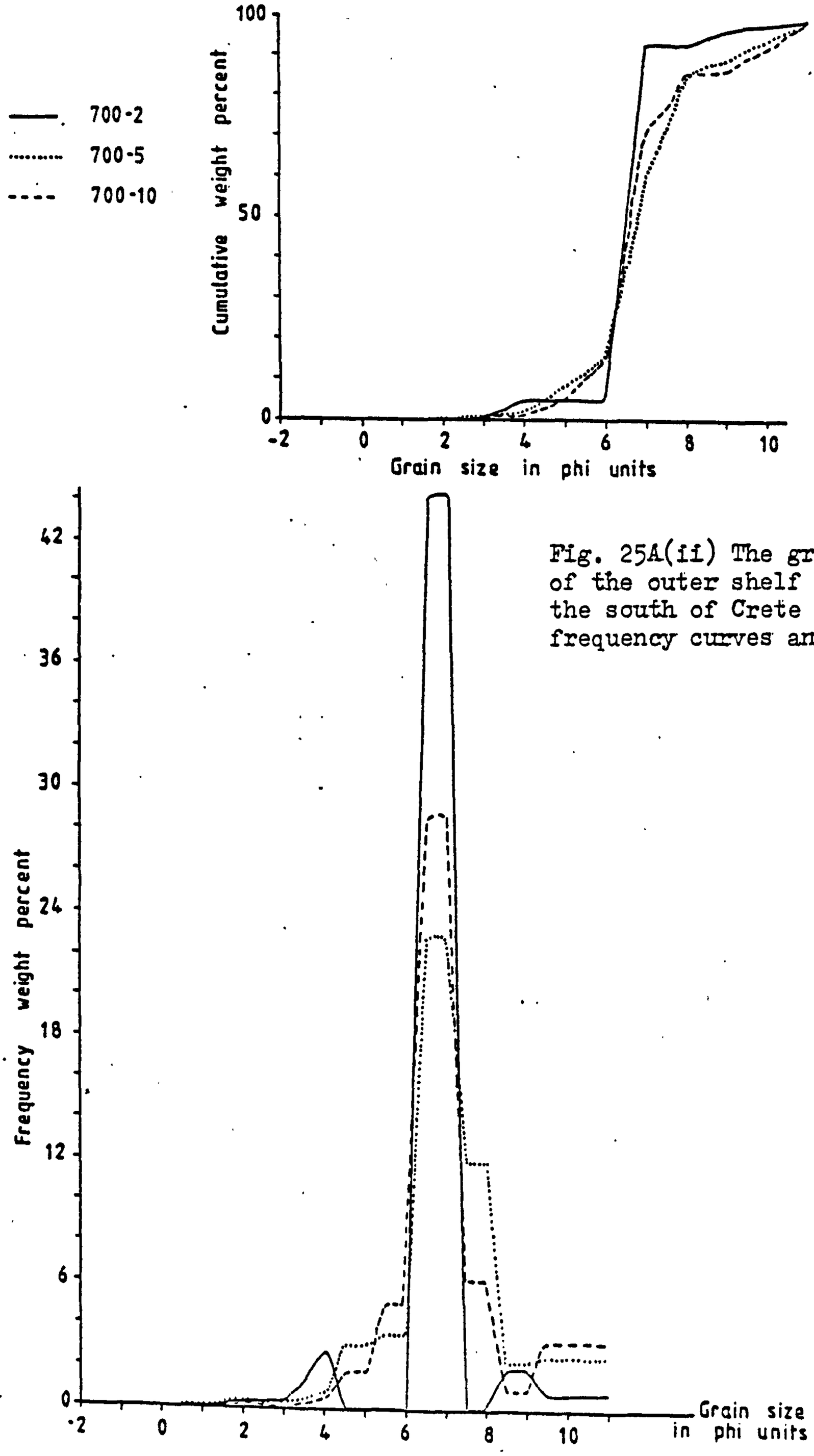


Fig. 25A(ii) The grain size composition of the outer shelf buried sediments of the south of Crete represented by size frequency curves and cumulative curves

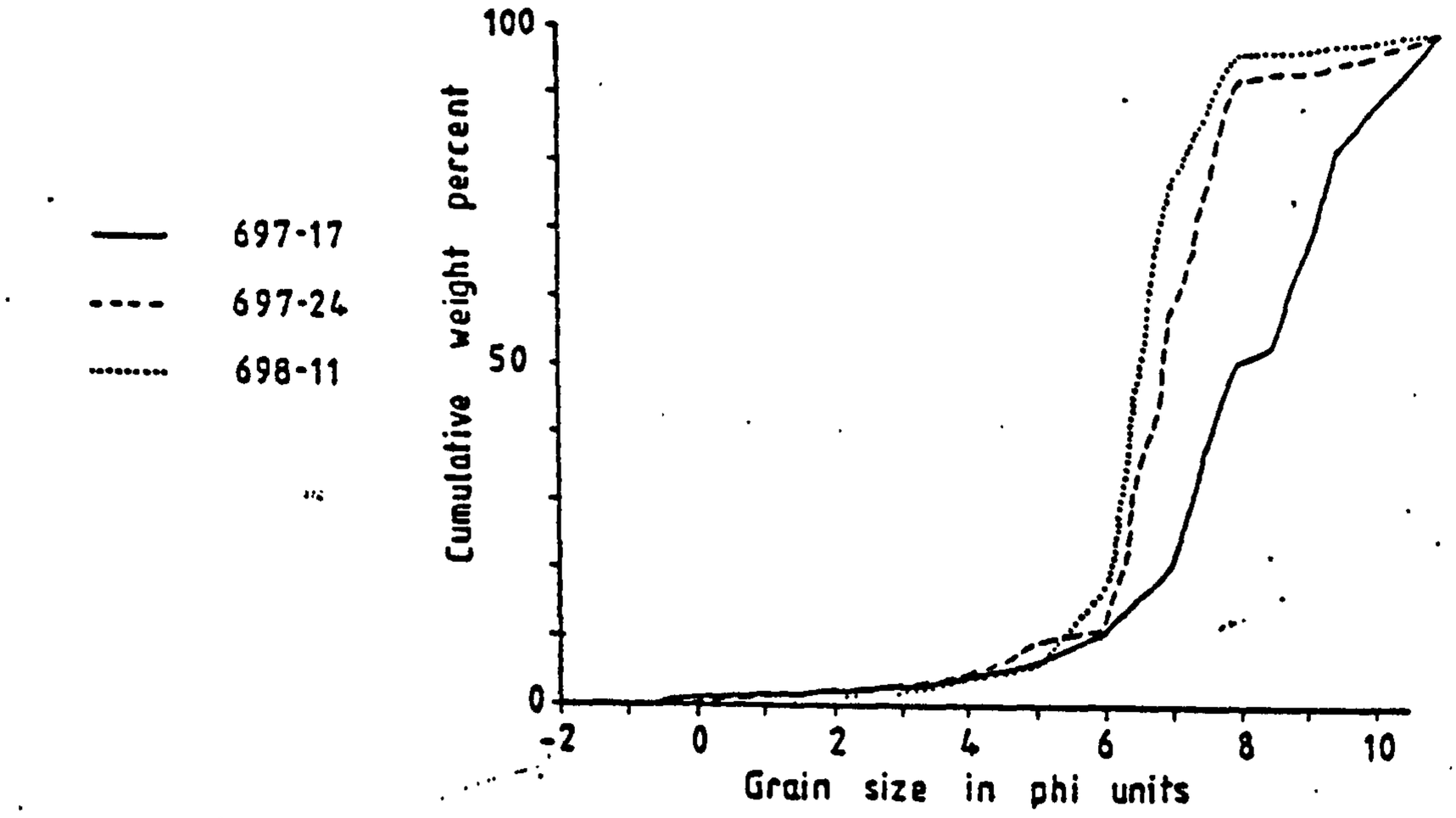
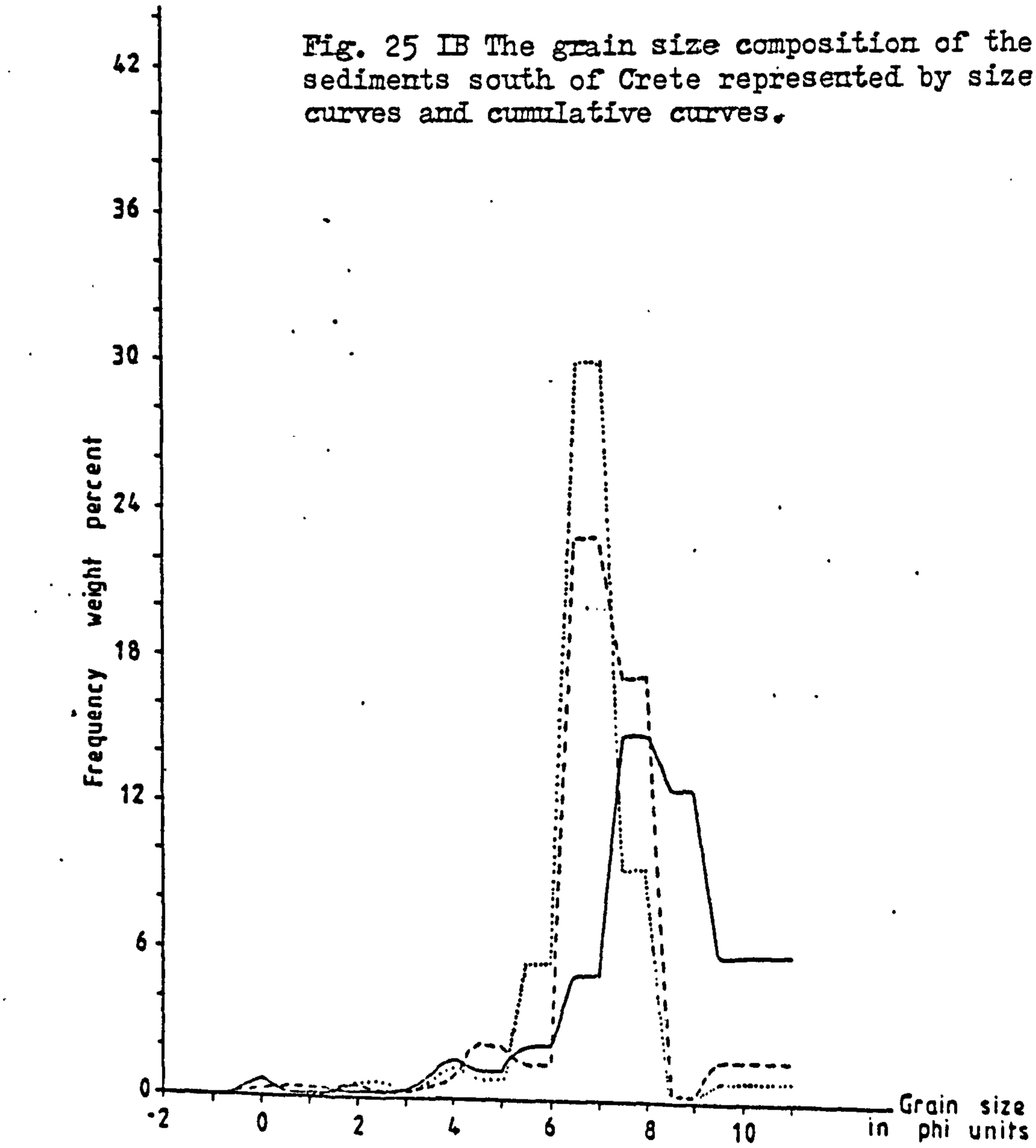


Fig. 25 IB The grain size composition of the trench burie sediments south of Crete represented by size frequency curves and cumulative curves.



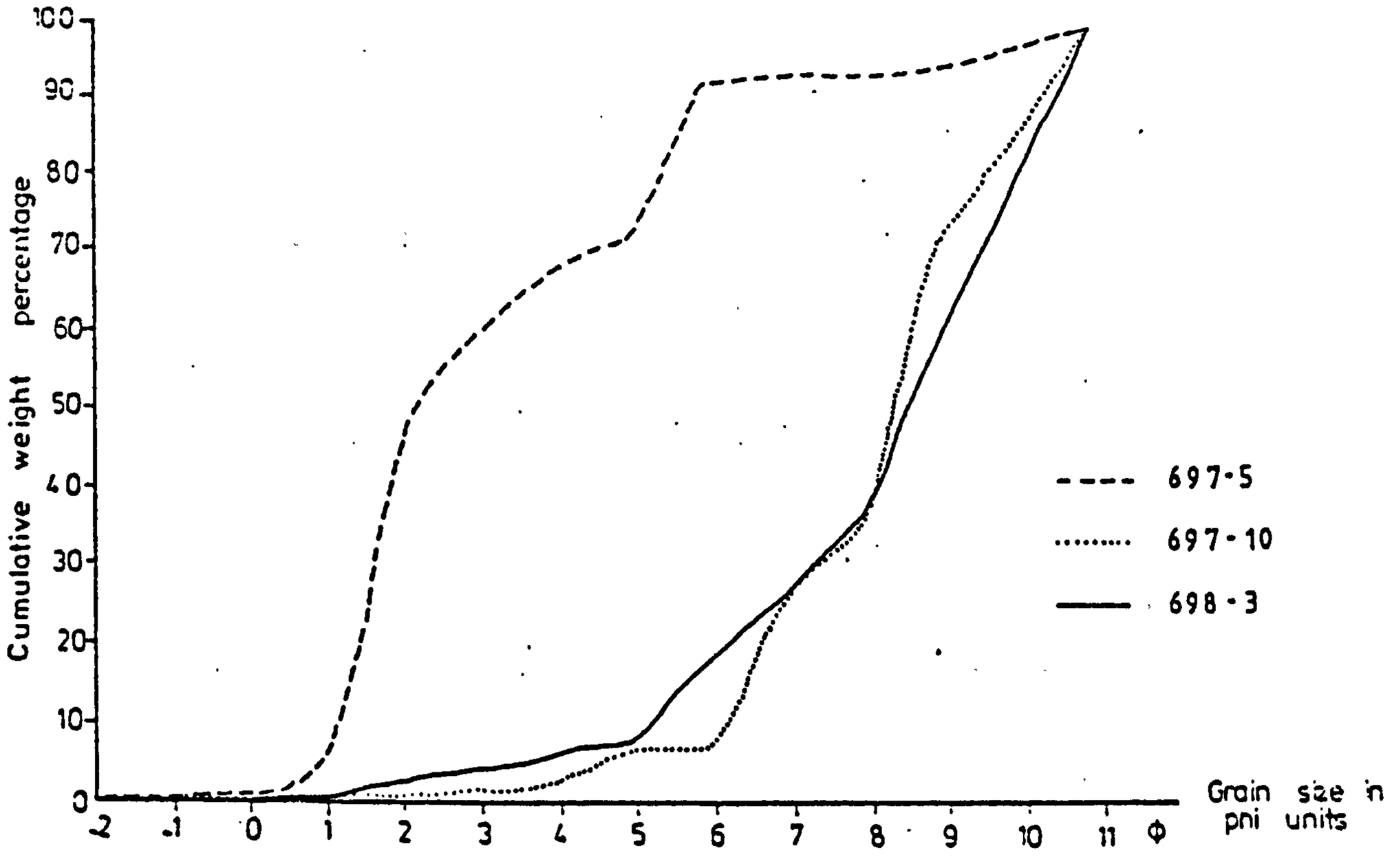
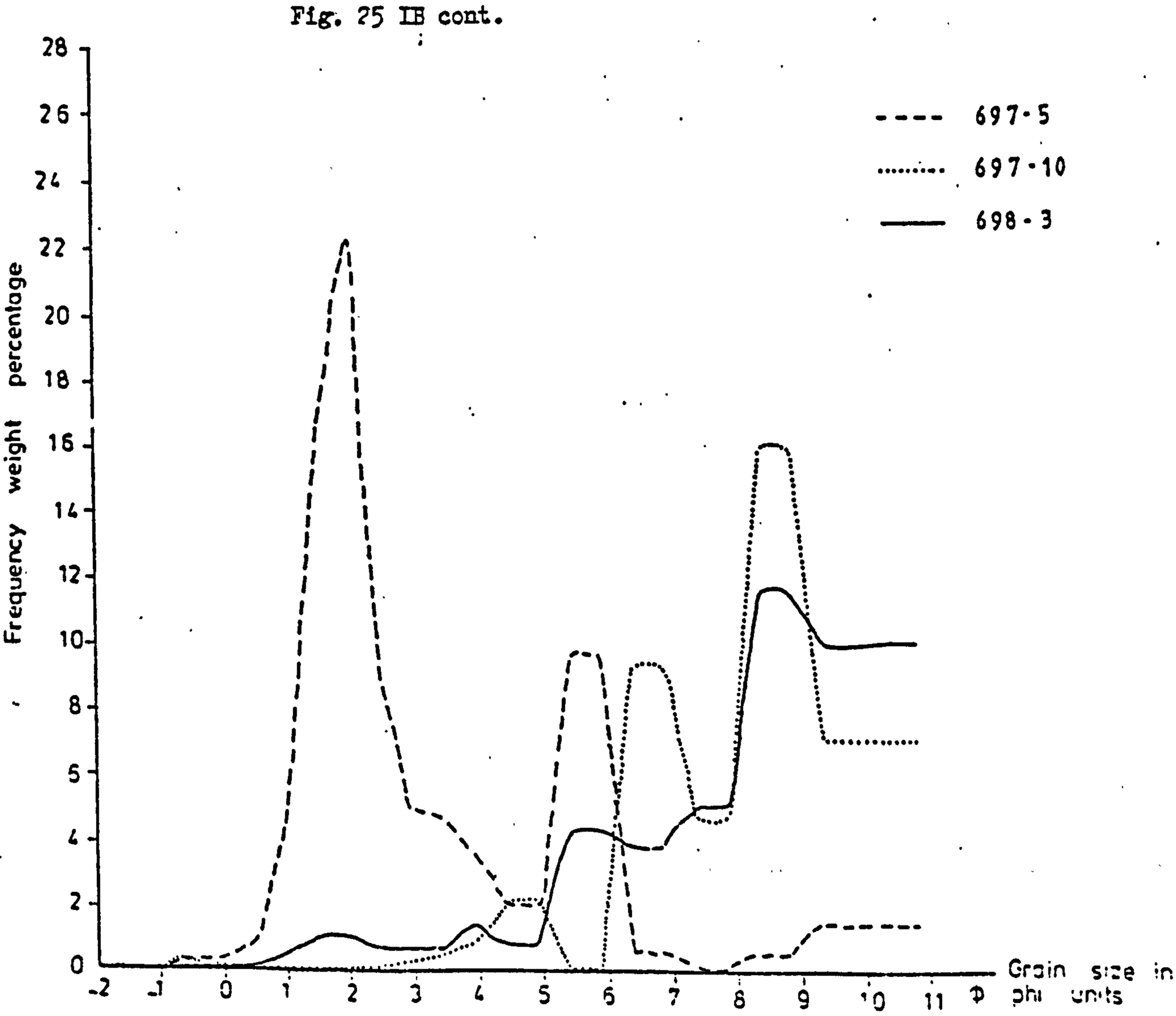


Fig. 25 IB cont.



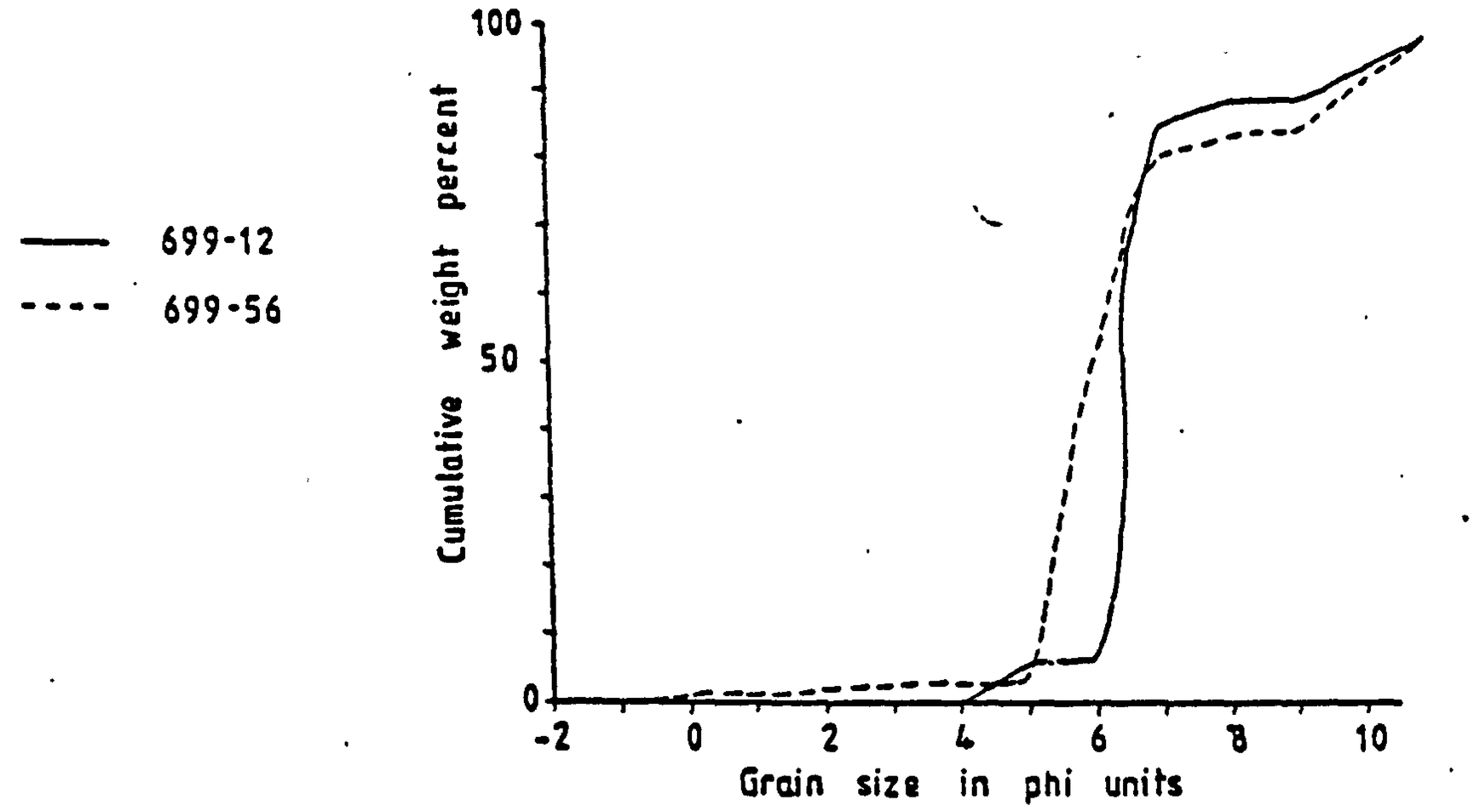
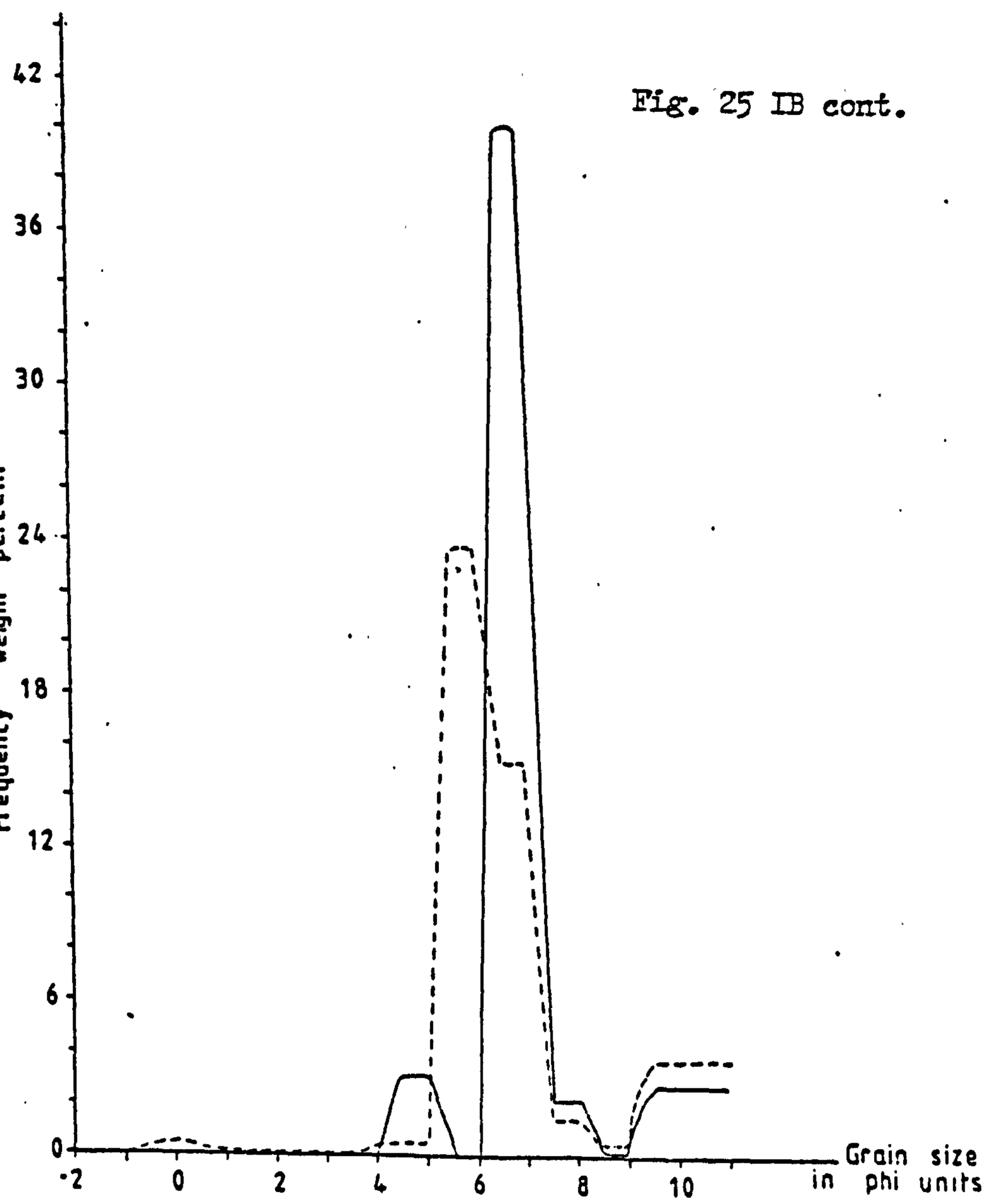


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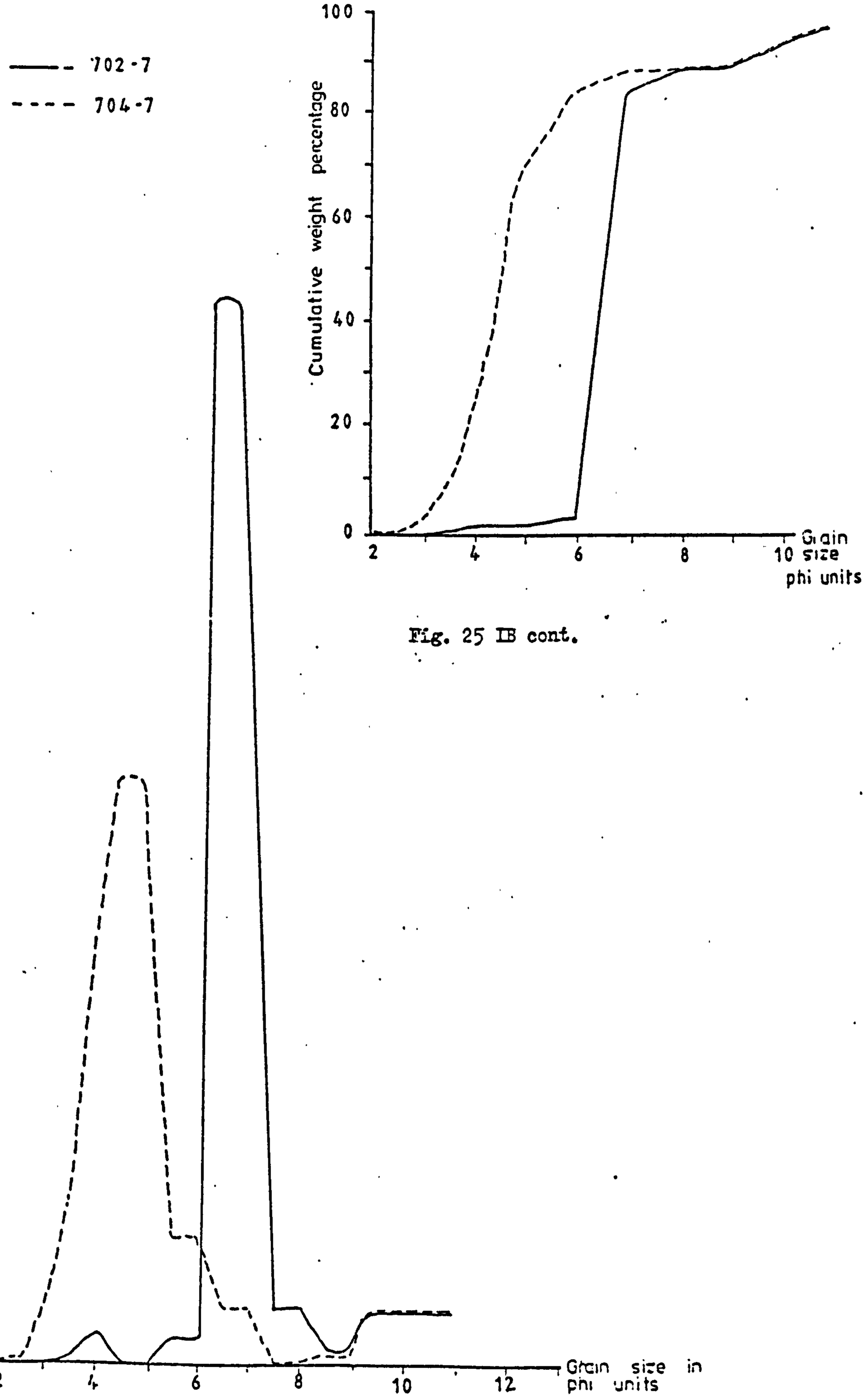


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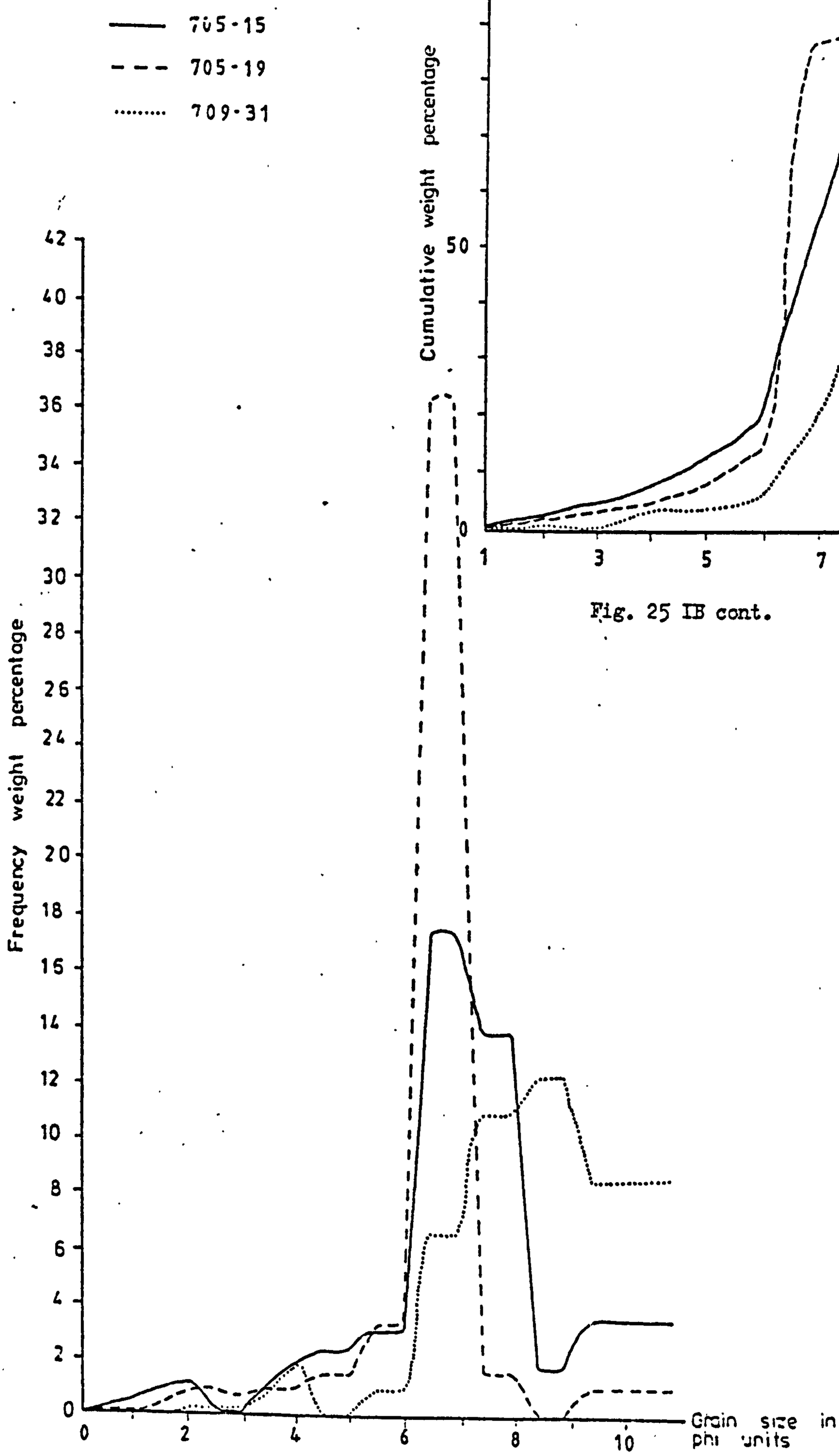
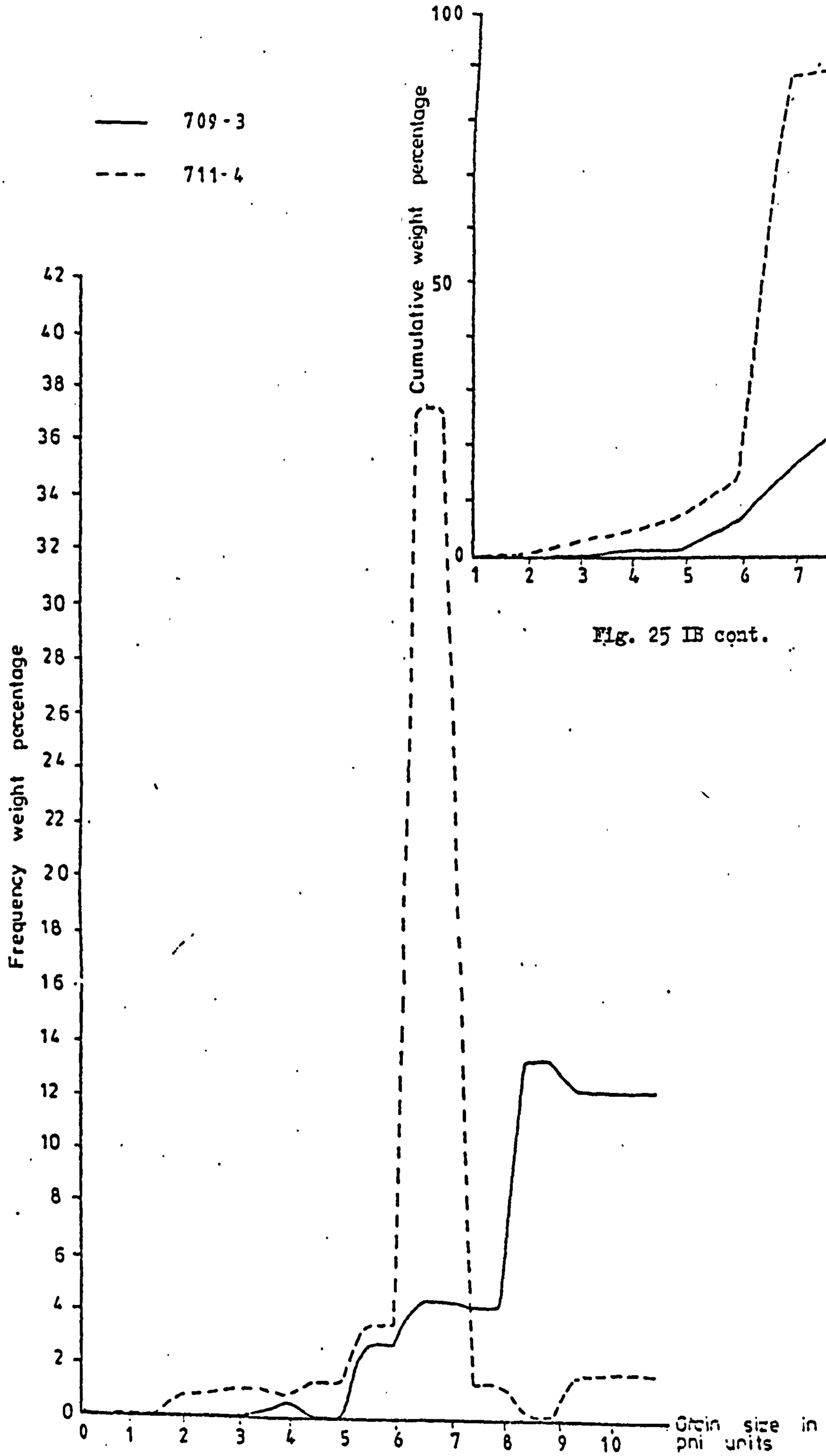


Fig. 25 IB cont.



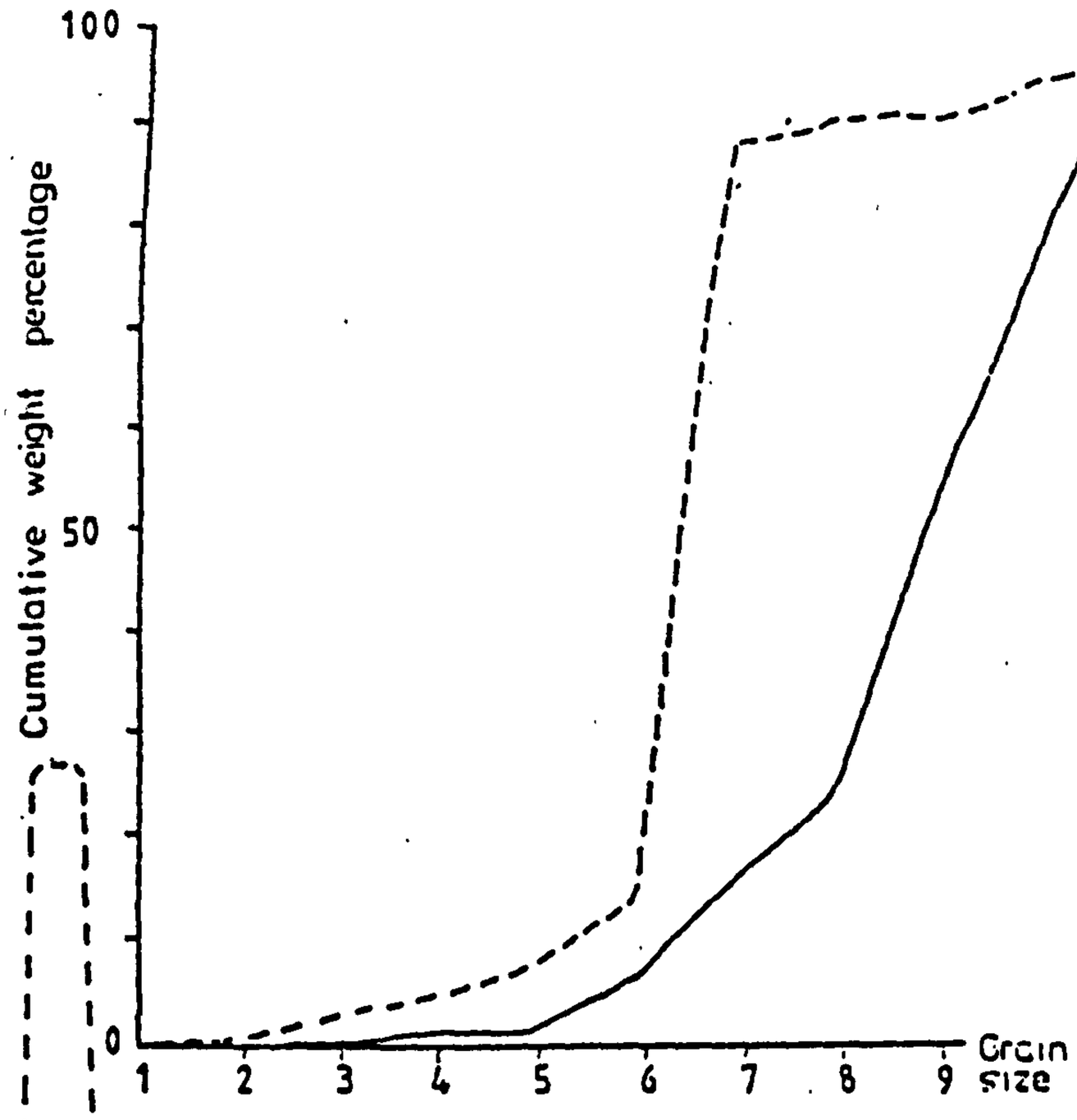


Fig. 25 IB cont.

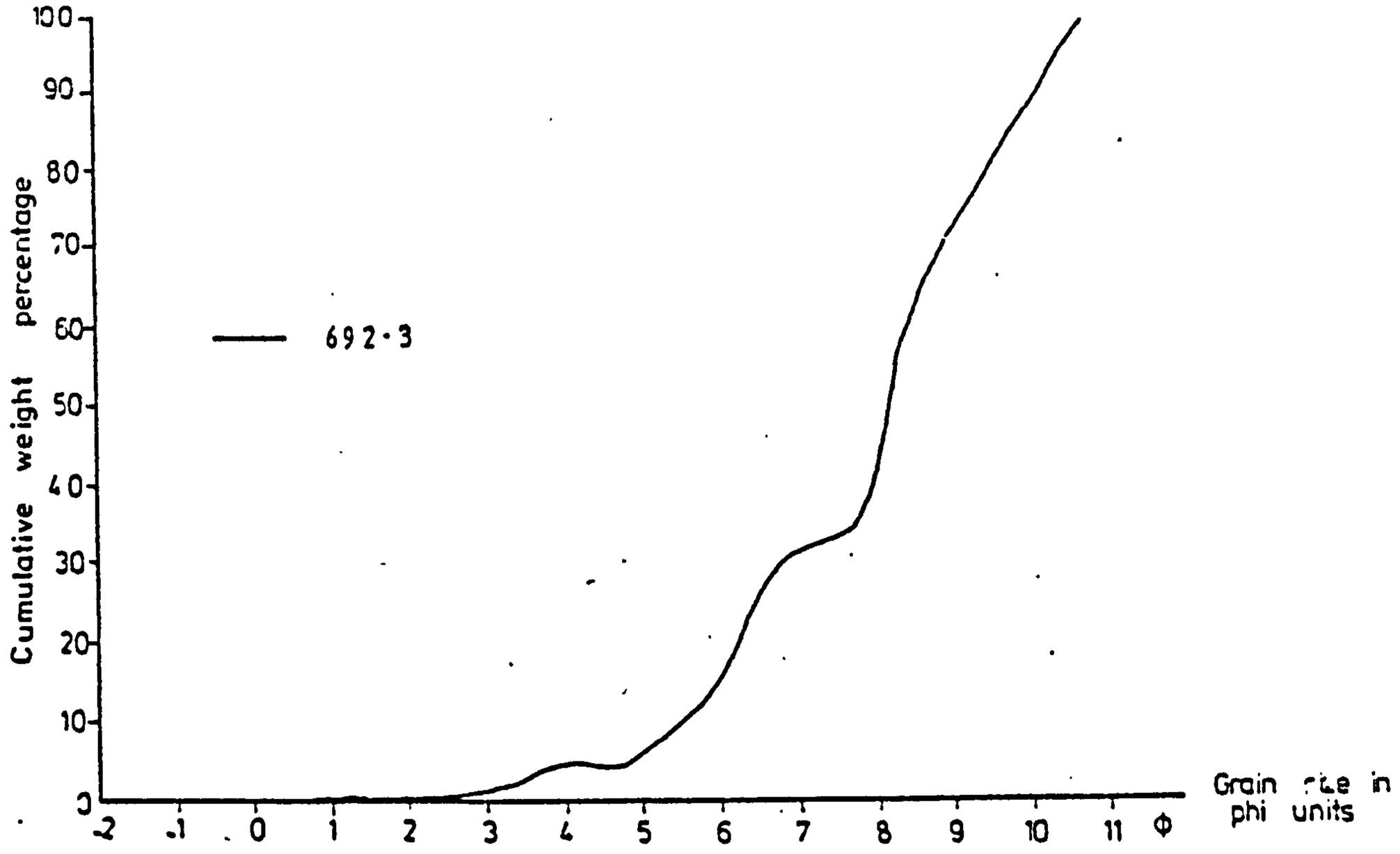
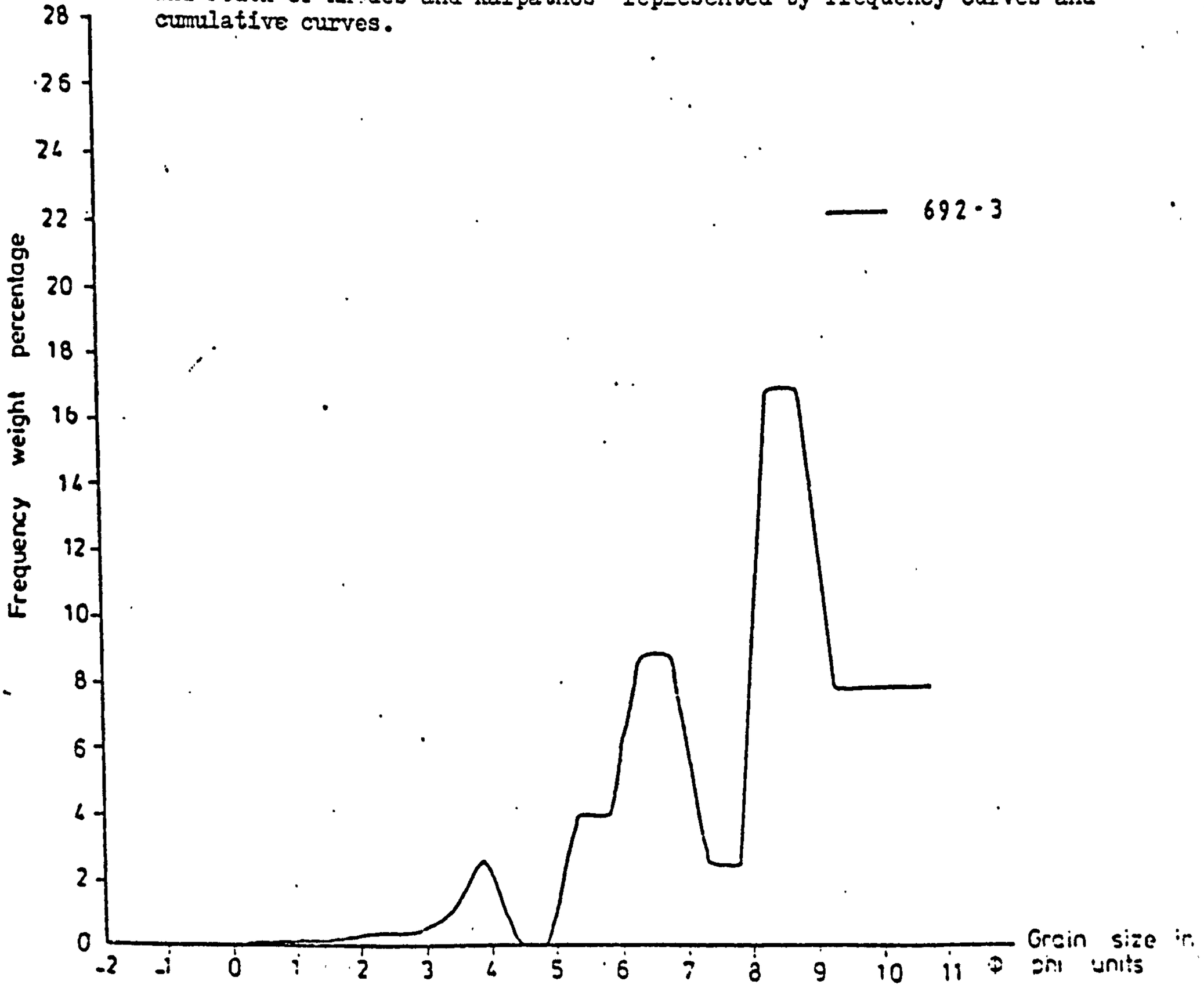


Fig.25IC(i)The grain size composition of the buried sediments east and south of Rhodes and Karpathos represented by frequency curves and cumulative curves.



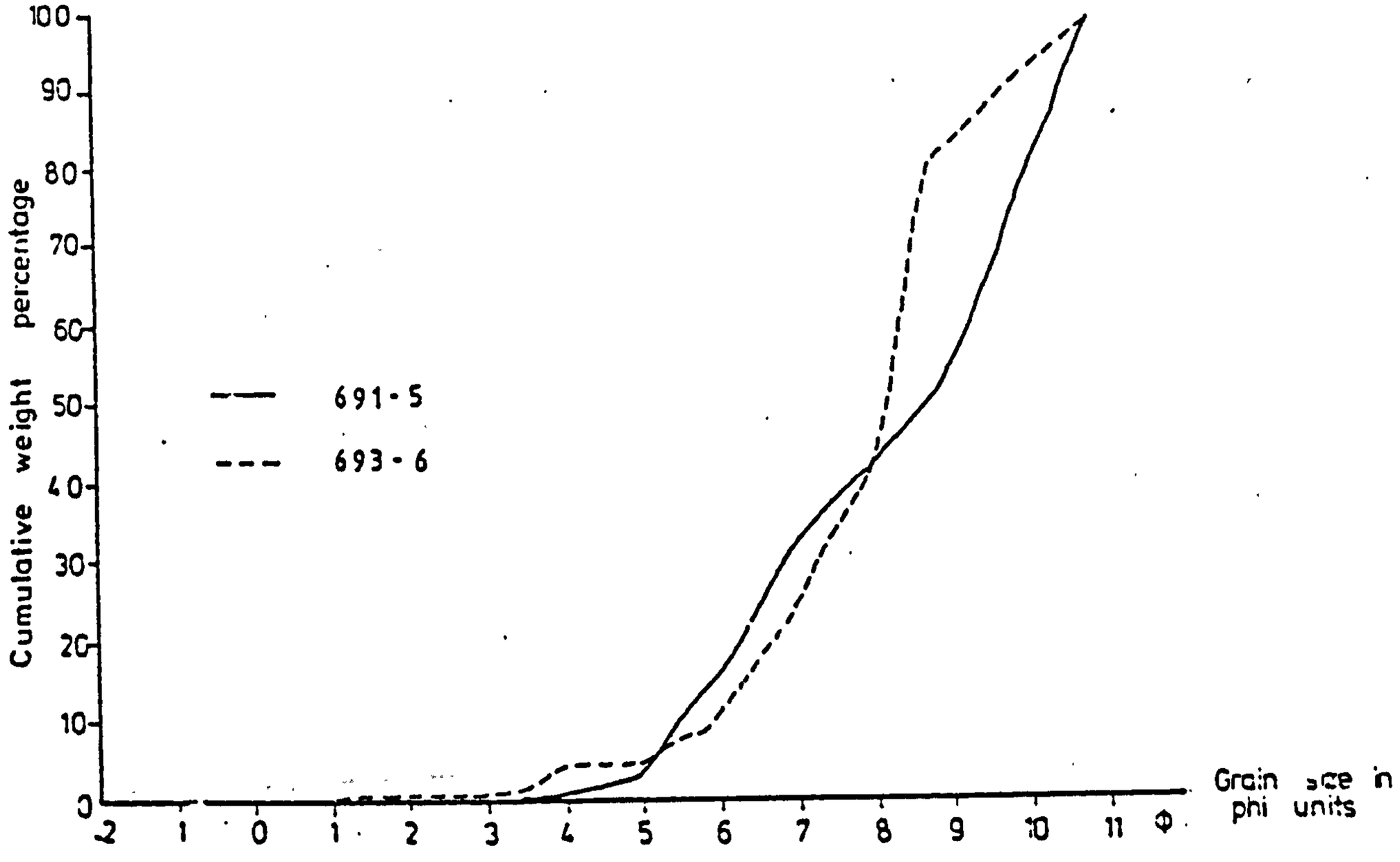
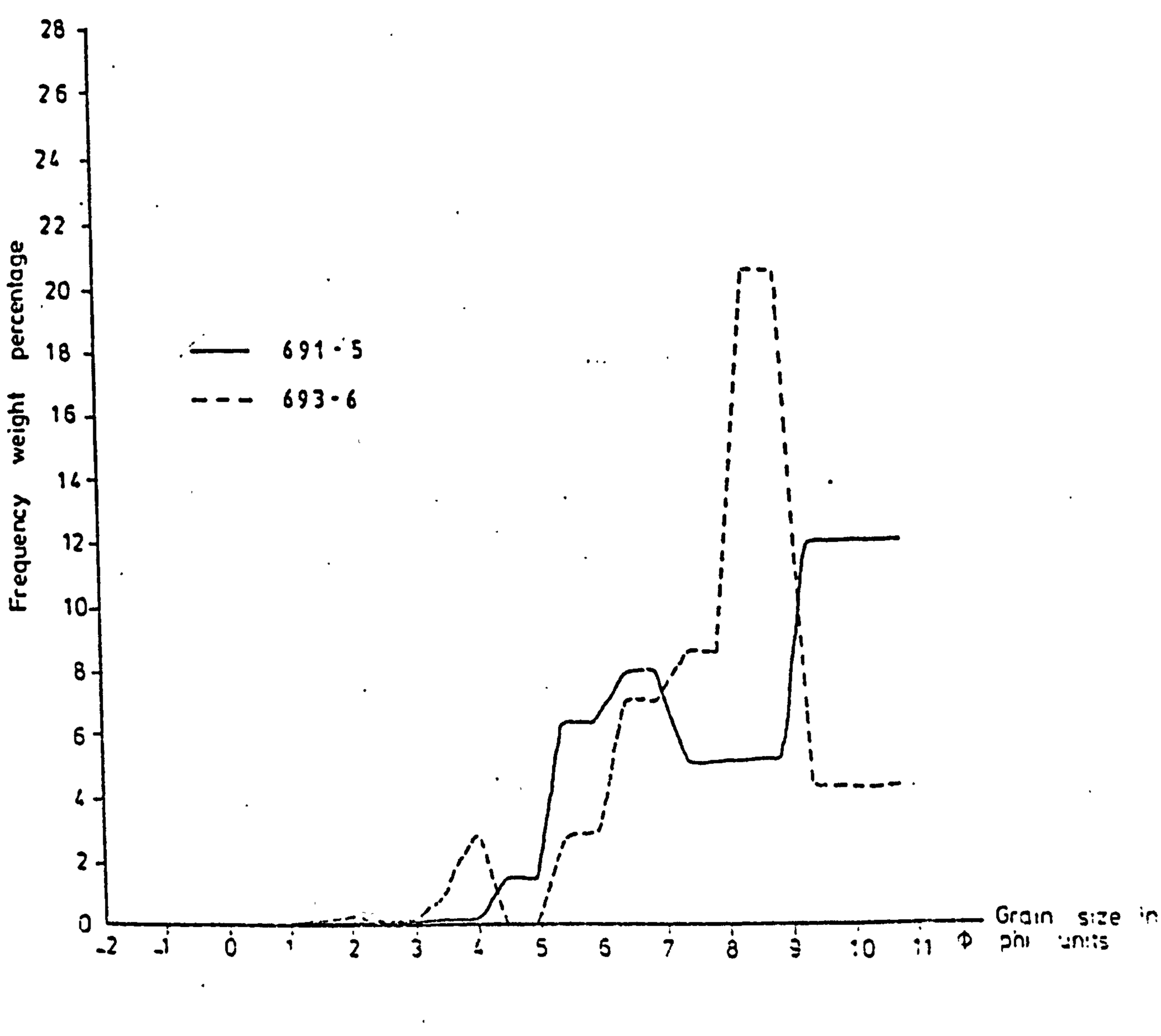


Fig. 25IC(i) cont.



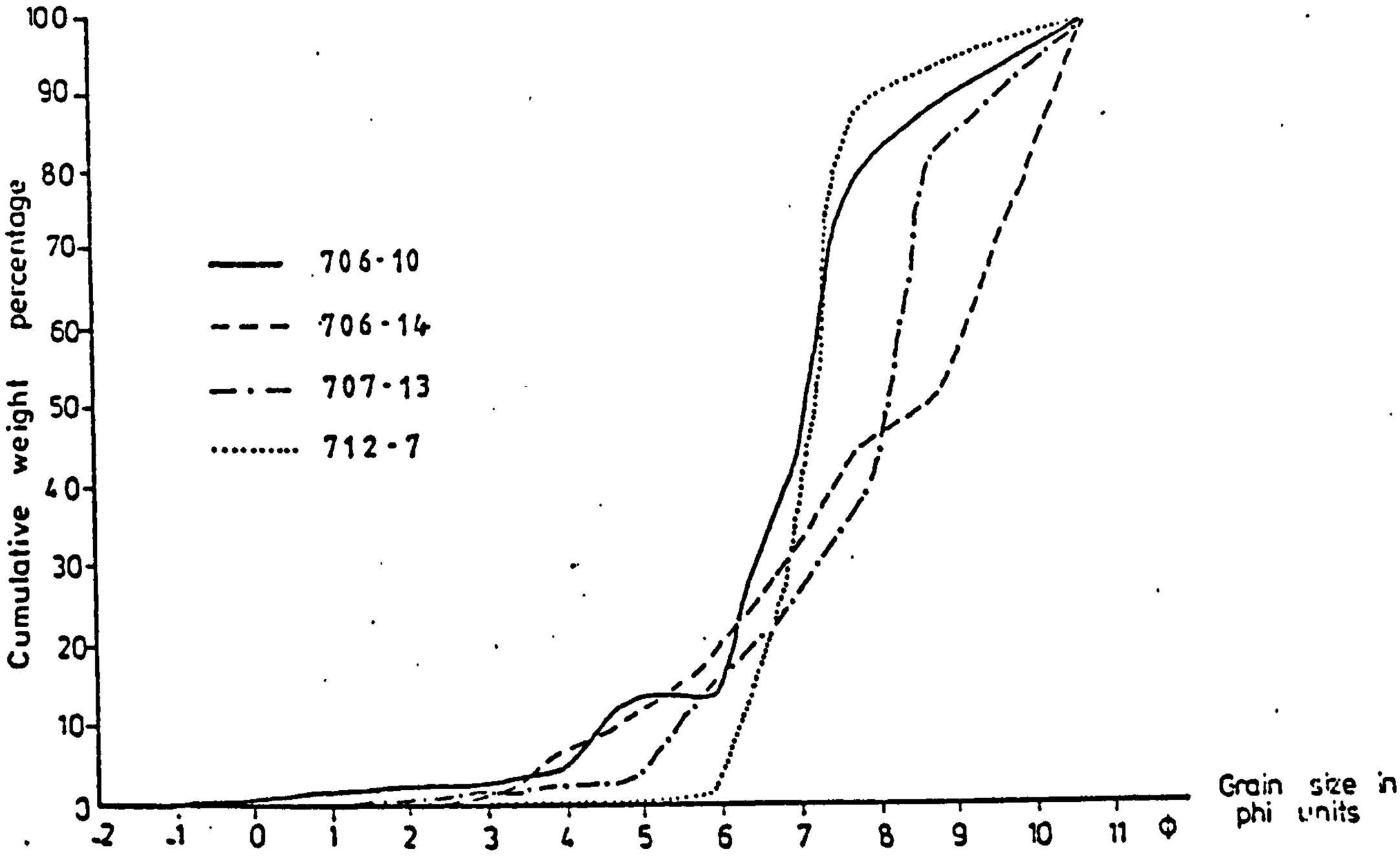
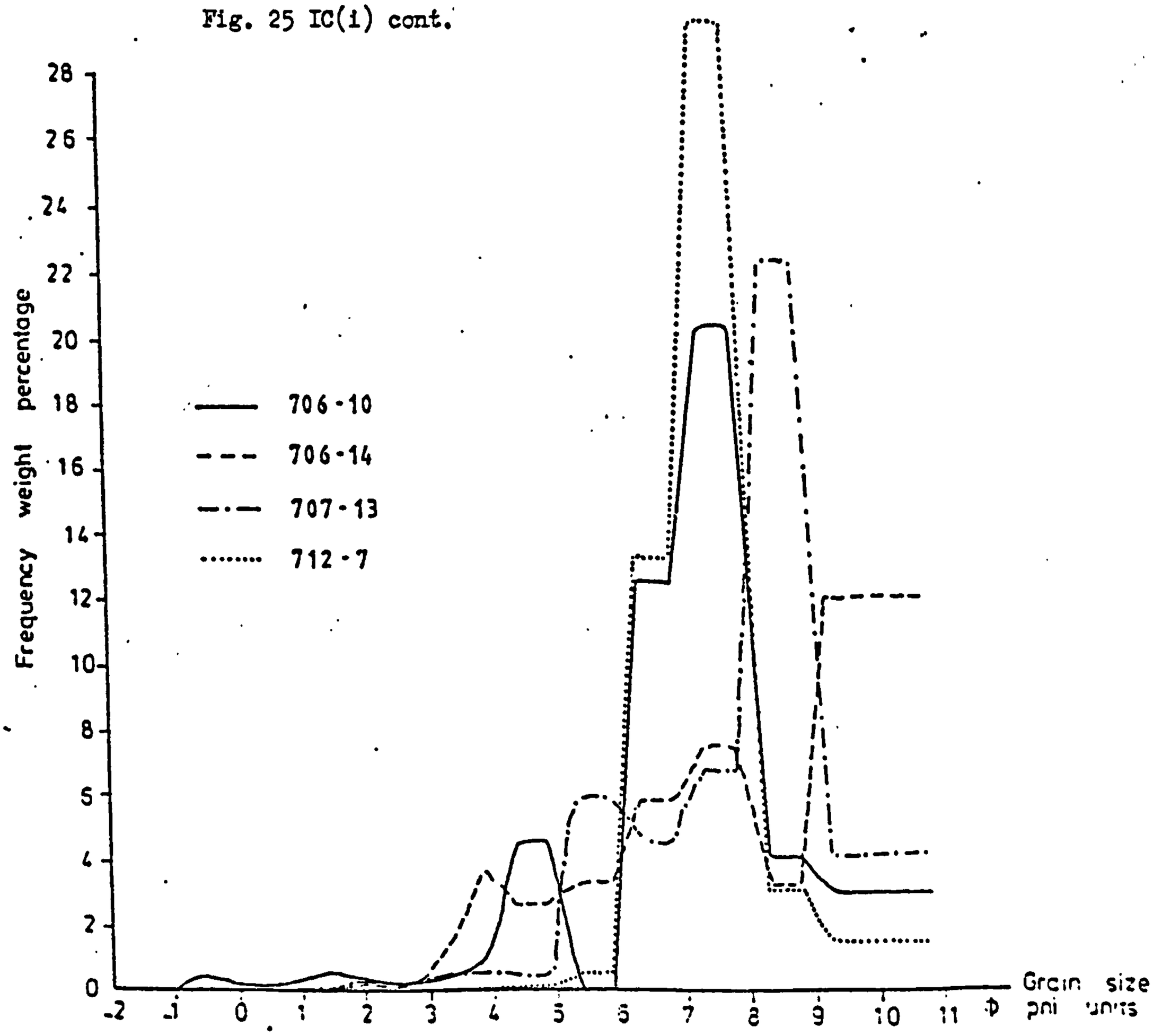


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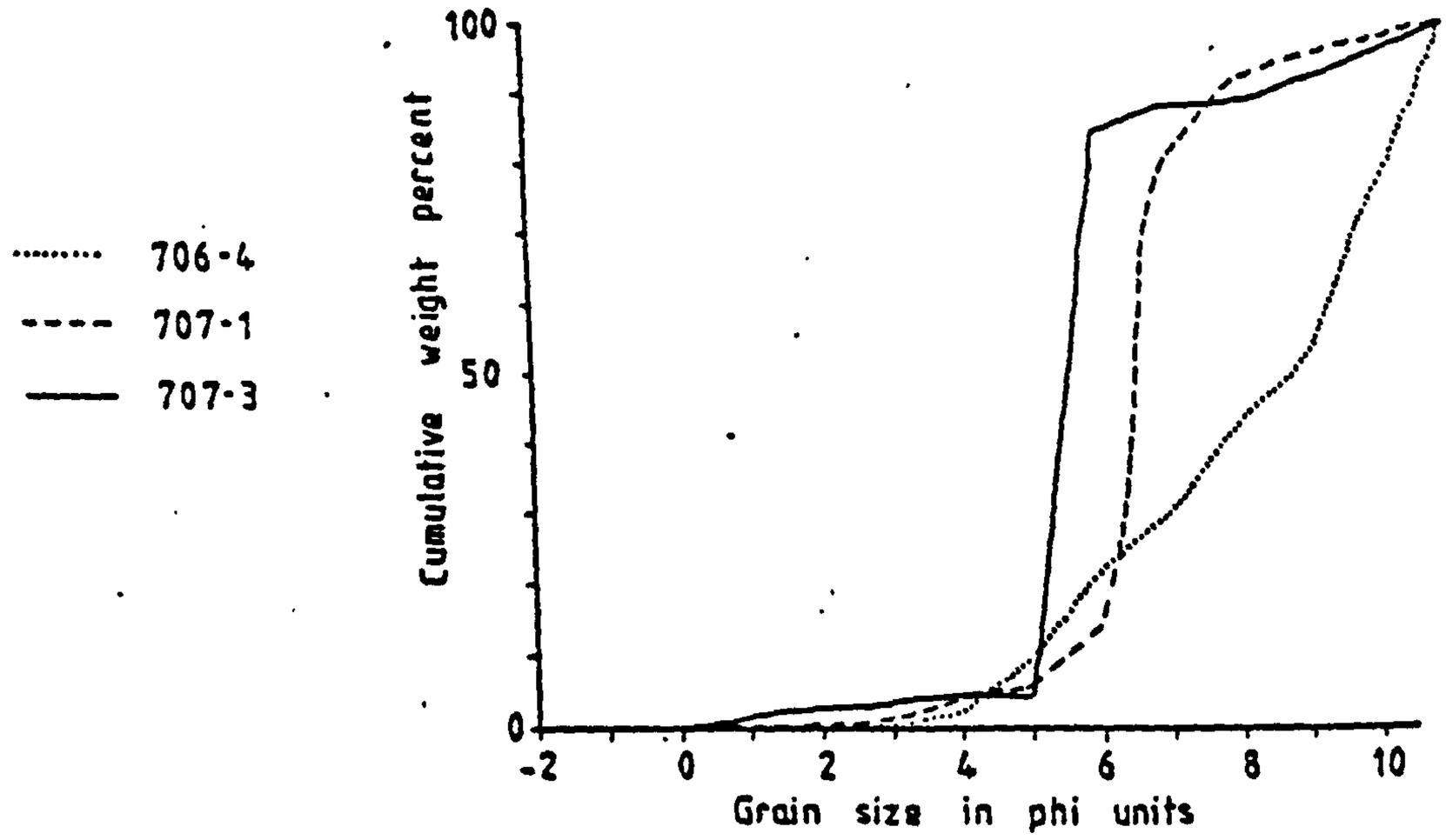
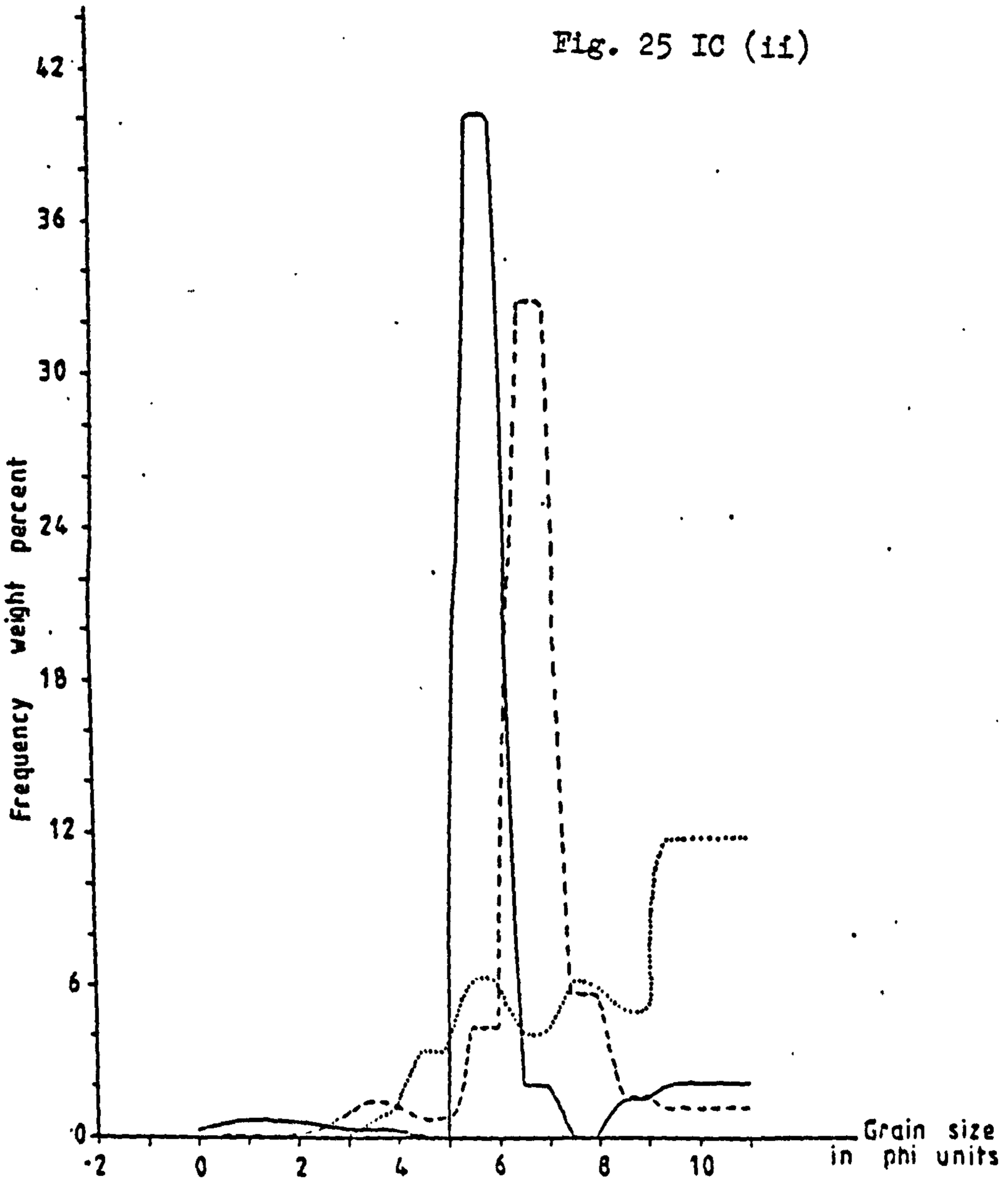

706-4
707-1
707-3
Cumulative weight percent
100
50
0
-2
0
2
4
6
8
10
Grain size in phi units

Fig. 25 IC (ii)


Frequency weight percent
42
36
30
24
18
12
6
0
-2
0
2
4
6
8
10
Grain size in phi units

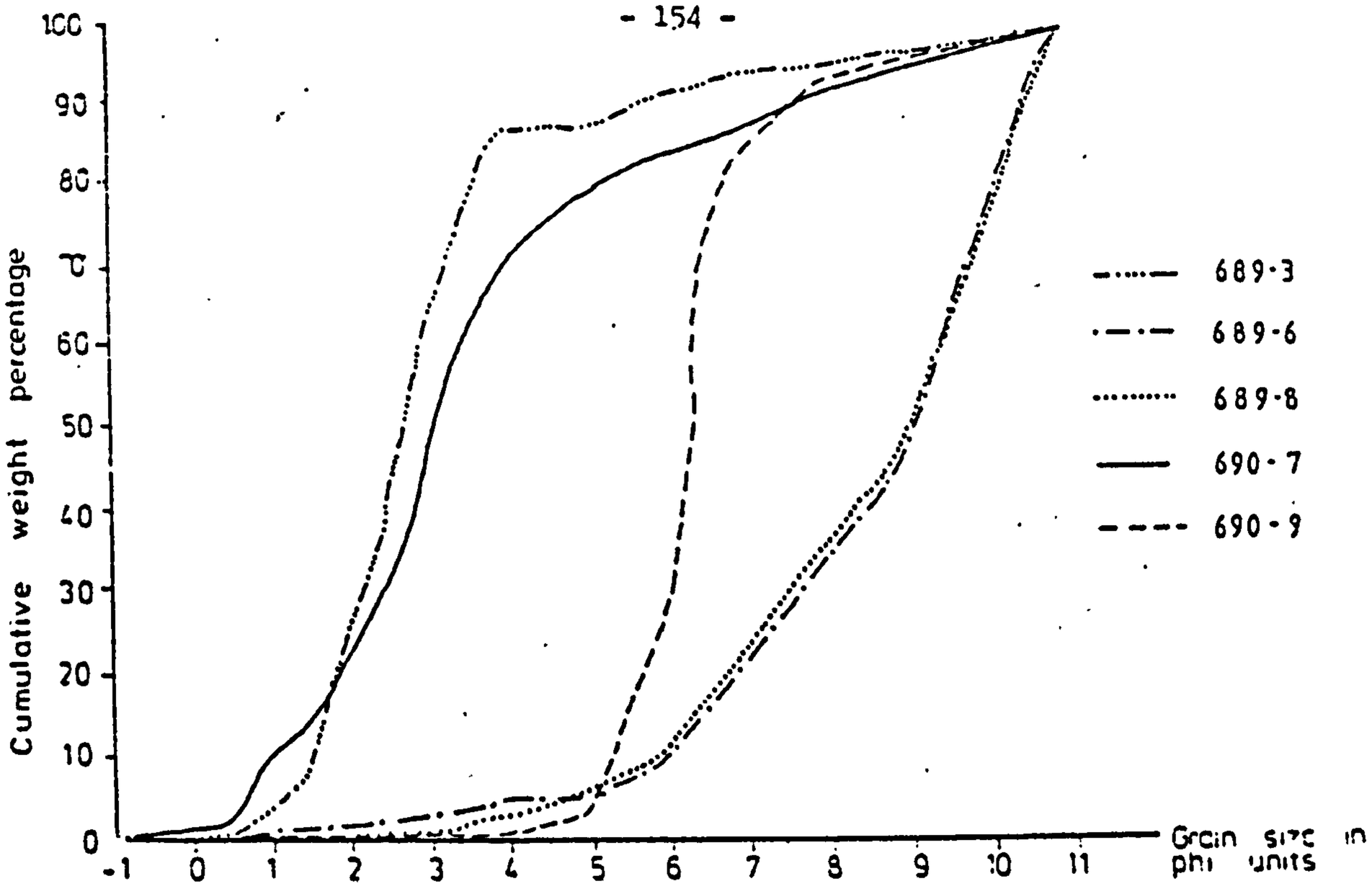
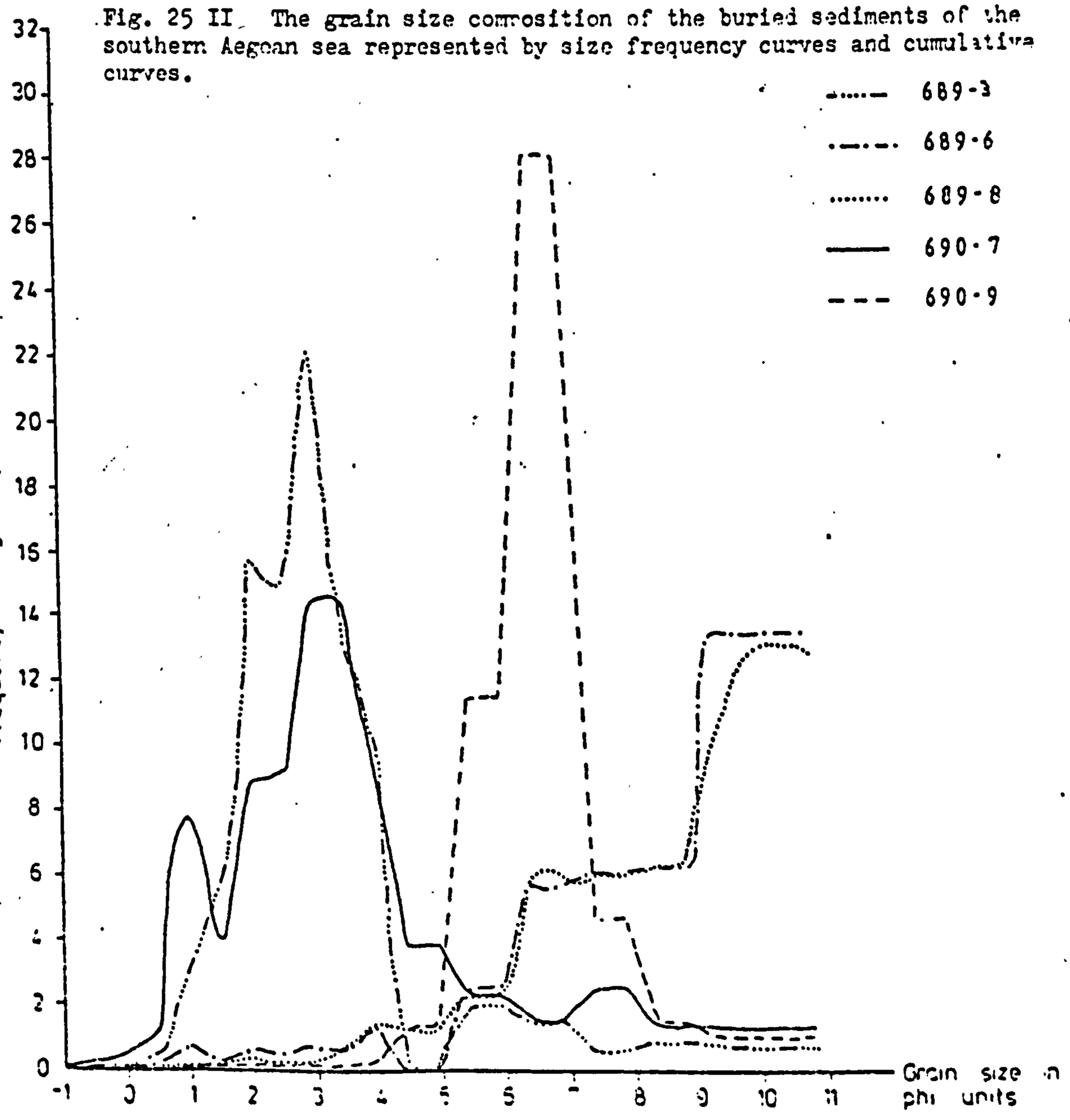


Fig. 25 II The grain size comrosition of the buried sediments of the southern Aegean sea represented by size frequency curves and cumulative curves.



CHAPTER VI

GEOCHEMISTRY OF THE EASTERN MEDITERRANEAN AND AEGEAN SEA SEDIMENTS

PART ONE: THE CHEMICAL COMPOSITION OF THE SURFACE SEDIMENTS

6.1 Calcium carbonate: Throughout the eastern Mediterranean the sediments are moderately carbonate-rich with the majority of the samples containing 30-50% $CaCO_3$. There is a larger variation in the calcium carbonate content of the surface sediments of the Aegean Sea (Fig. 26 & table 3, see also appendix II).

For all the surface samples shown in Fig. 2 the carbonate content has been determined by two different ways, acetic acid attack, and LECO system, to attack the sediment sample with HCL and absorb the CO_2 in a weighing tower (see procedure in chapter 3). The carbonate was also calculated by a computer program from the percent of calcium determined by atomic absorption after the HF digestive attack. Comparison between the three values shows that the value calculated from the calcium content is always lower than the other two values. Values determined on the basis of carbon dioxide analyses are the highest, and those determined by acetic acid attack have an intermediate range. The carbonate values determined by the acetic acid leach are sometimes similar to those calculated from the calcium or slightly higher. On the other hand the difference between them and those determined by the LECO system ranges up to 5%. This means that the carbonate fraction in the sediments is not only calcium carbonate and that another form of carbonate is present in the surface sediments in the eastern Mediterranean

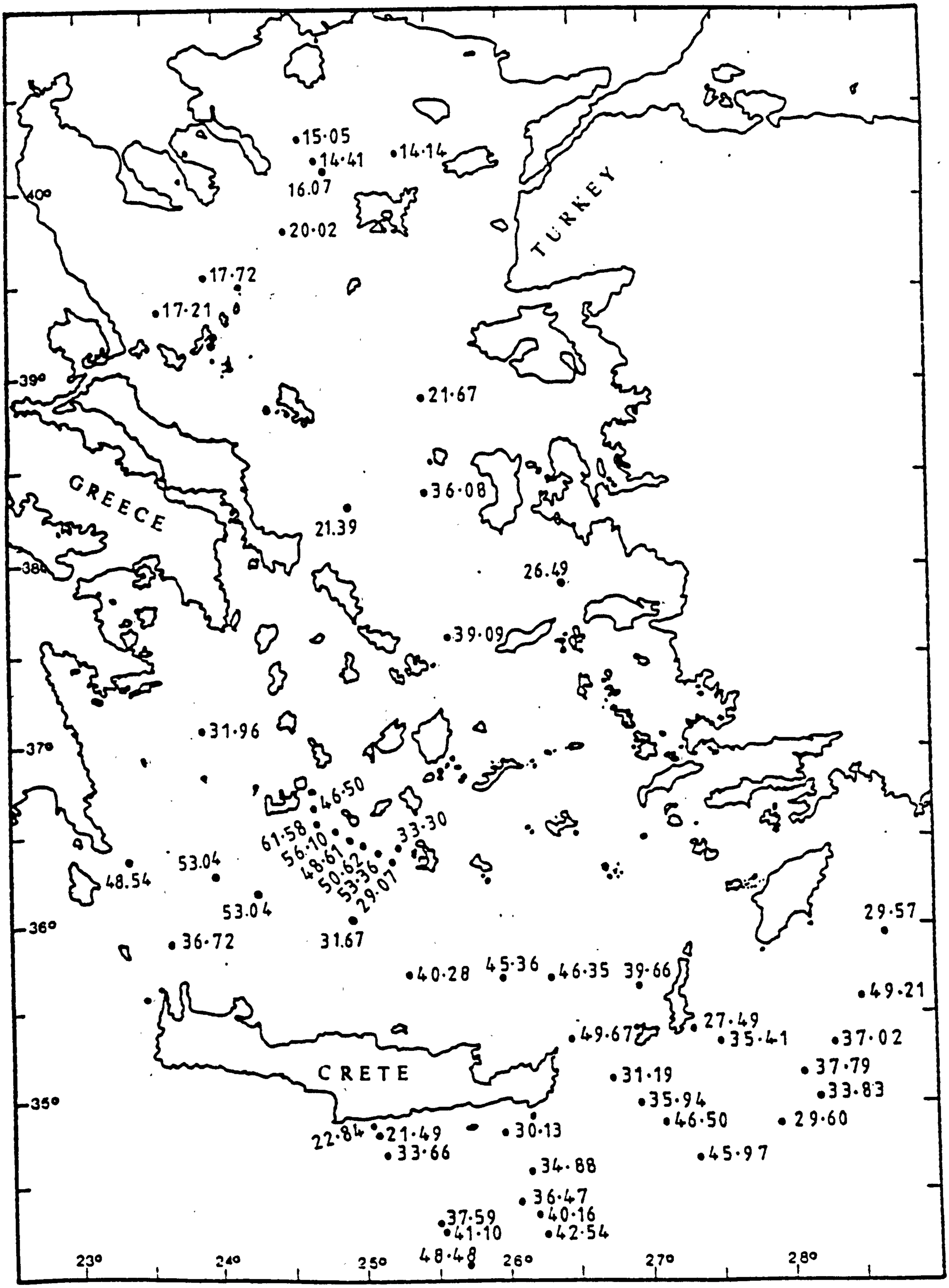


FIG. 26. Distribution of the $CaCO_3$ (in percent) in the surface sediments of the Eastern Mediterranean and Aegean Seas.

Sea. This form of carbonate is less soluble in acetic acid than in hydrochloric acid. Milliman and Muller (1973) stated that magnesian calcite is an important sedimentary component in the deep sediments of the eastern Mediterranean Sea. The magnesium carbonate content in the sediments was calculated, and found to have values up to 3% in the surface layer (5% in the sub-surface layers). This means that the non-calcium part of the carbonate fraction is most probably in the form of magnesium carbonate (magnesium calcite has 5.5 - 7.5 mol.% $MgCO_3$). (See Table 5)

The $CaCO_3$ distribution patterns illustrated in figure 26 are similar to those given by Venkatarathnam, Biscay and Ryan (1972) and McCoy (1974) but differ from those suggested by Emelyanov (1965) based on fewer samples. The northern Aegean shelf sediments have low carbonate content in the range between 14% and 20% with an average of 16.43%. All other parts of the Aegean Sea and eastern Mediterranean Sea have higher ranges and average values (table 3). The middle Aegean sediments have an average carbonate content of 32.28%. Such a value is twice that of the northern Aegean, but the depth is not very much different from the northern Aegean. A wider range and higher average is noticed in the Cyclades Arc and southern Aegean. Between Milos and Santorini the average carbonate content in the surface sediment layer is 45.31% close to the islands and 50.86% away from the islands. In the area between the island of Crete and the Cyclades Arc and Karpathos to the east, the average is 42.22%. East of Karpathose, sediments from the shelf have an average of 31.45%. South and southeast of Crete the carbonate content increases steadily outward from the shelf towards the deeps (Fig. 27). Further

Table 5: The Average Mg Content in the Different Parts of the Study Area, and the Calculated $MgCO_3$ Equivalent and Ca/Mg Ratios

Area	Mg %	$MgCO_3$ Equivalent %	Ca/Mg Ratio
Northern Aegean Sea	2.03	7.04	4.0
Middle Aegean Sea	2.50	8.67	5.7
Southern Aegean Sea	2.33	8.08	7.91
South of Crete (shelf sediments)	2.69	9.33	4.43

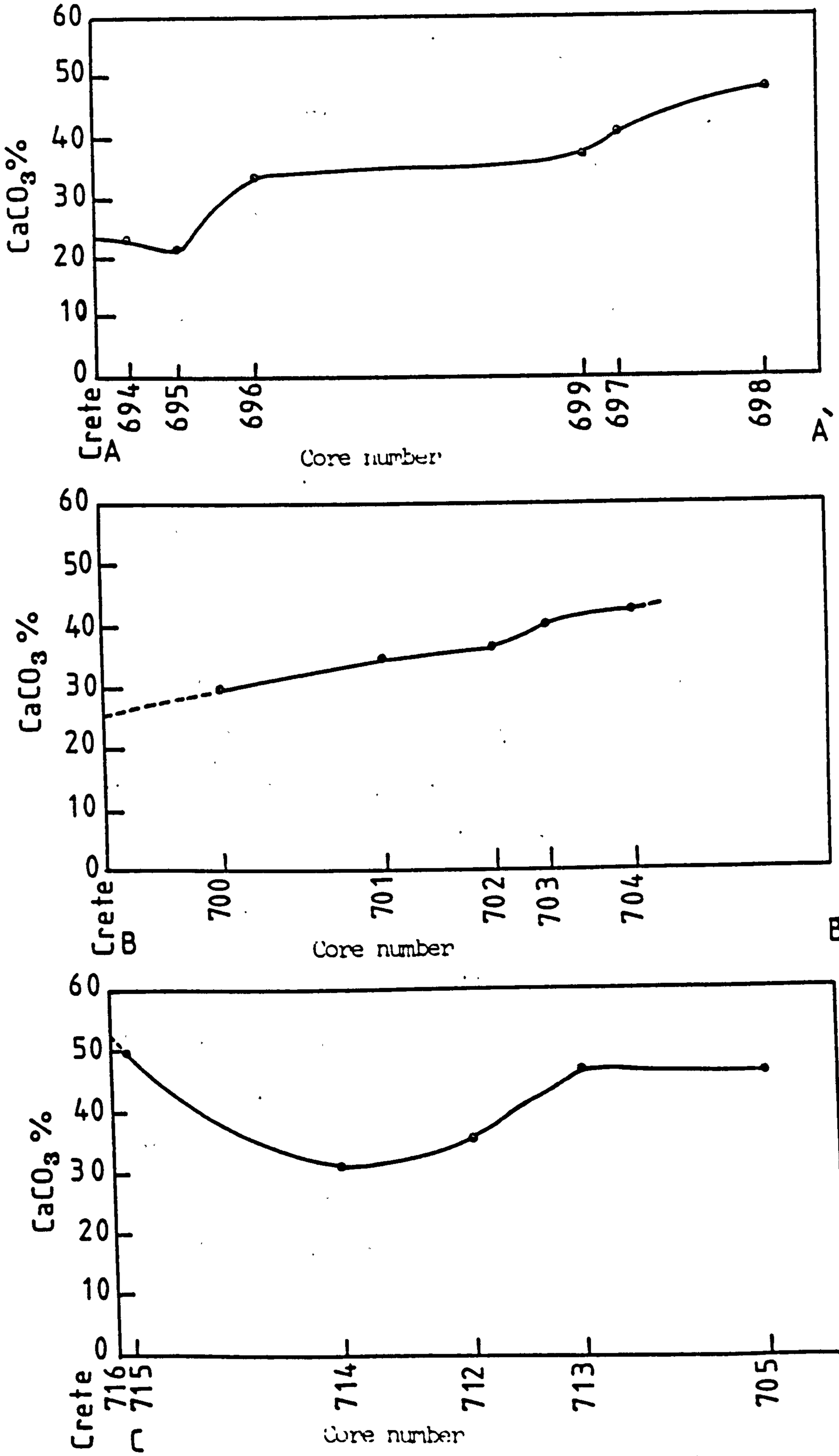


Fig.27 Variations in the $CaCO_3$ along the main sampling lines to the South of Crete. (See Figure 2)

east of Crete and Karpathos the values are non uniform, and the carbonate contents vary, particularly in the trench zones.

The relationship between the carbonate content and depth in the Aegean Sea shows that the carbonate percent generally decreases as the water depth increases. The value changes from over 60% in the shallow zone, other than to the south of Crete (less than 250 m), to just under 15% when the depth reaches 1,500 m. However this figure does not apply further south and southeast of the island of Crete in the deeps and the trench zones where the range is confined to between 30% and 50% (Fig. 28), in spite of the large change in depth from 2,500 m to 4,500 m. It is noticed that low calcium carbonate values distinguish areas that are proximal to large fluvial sediment sources, as might be expected, such as those in the northern Aegean (average 16.4%), southern Turkey and south of Crete on the inner shelf. This is apparently because of a low input of calcium carbonate detritus and dilution by alluvial and terrigenous input. In the Levantine Sea high carbonate values are noticed south of Crete and similar values were recorded by McCoy (1974) near the ridge, far from the continental shelf off north Africa, probably due to lack of dilution by non-biogenic or terrigenous material where fluvial detritus is at a minimum.

The carbonate components of all the samples analysed from the continental margin, as well as from the deeps, are mainly fine-sized foraminifera tests with other marine shells. Limestone fragments are rare. Just a few samples studied from the shelf sediments off the island arc contain small amounts of carbonate rock fragments. This would support the idea that there is a low input of allogenic carbonate detritus into the shallow and

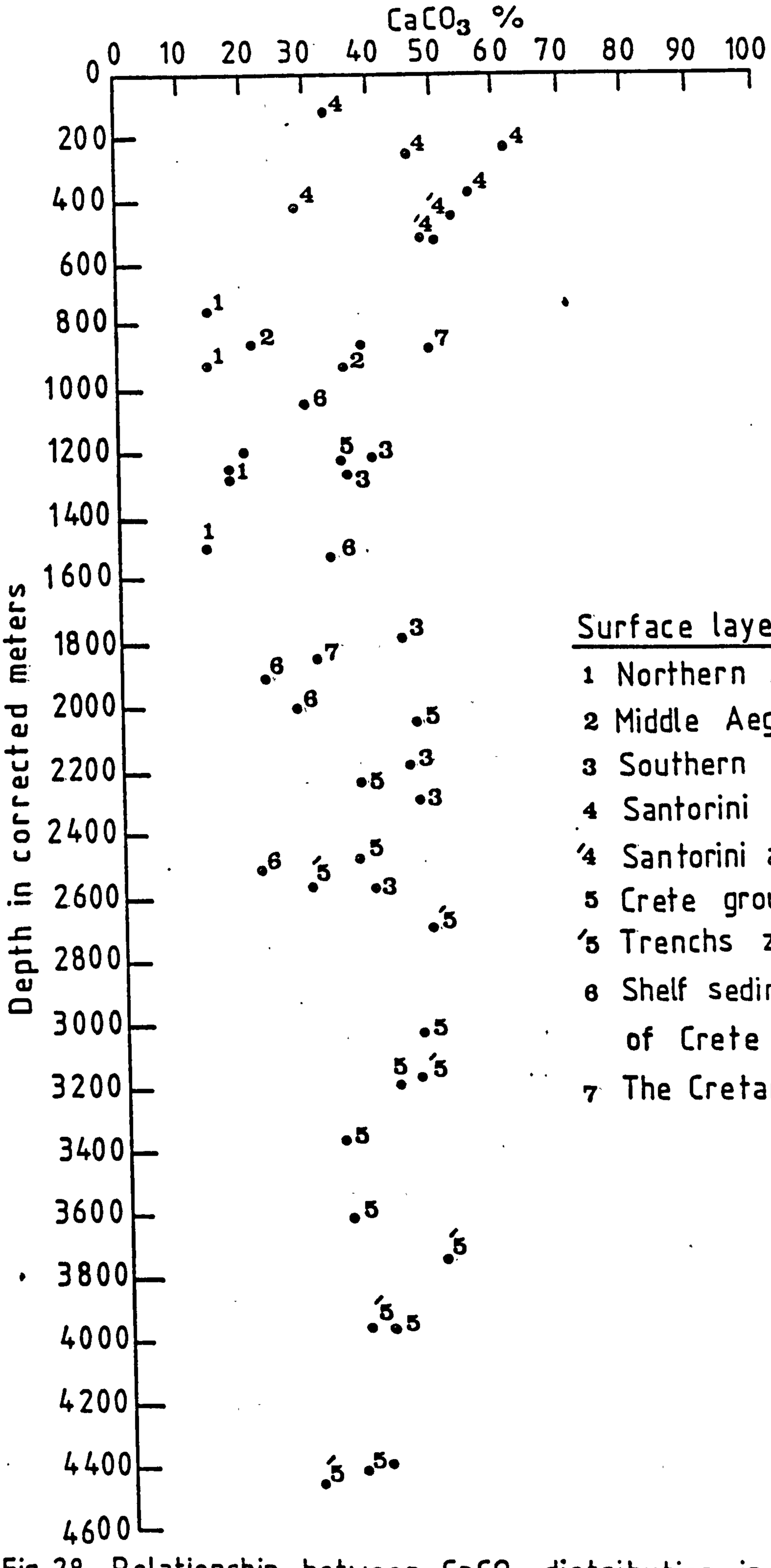


Fig. 28 Relationship between $CaCO_3$ distribution in surface sediments and depth of water in the Eastern Mediterranean and Aegean Seas.

nearshore marine environments. Similar cases were recorded by McCoy (1974) and Milliman and Muller (1973), but they differ between themselves in identifying the variety of the carbonate; McCoy (1974) described it as "allogenic calcium carbonate detritus", while Milliman and Muller recorded detritial dolomite crystals. McCoy (1974) stated that the amount of the detritial limestone fragments is less than 5% while Milliman and Muller (1973) recorded layers of very high dolomitic concentrations. However the latter case was not from the surface layer.

The surface sediments studied from the shelves off the Hellenic island arc, south of Turkey, Rhodes, Karpathos and Crete all contain calcium carbonate less than 36%. Not all of this amount is biogenic, apparently there is a low input of allogenic carbonate detritus (limestone rock or carbonate rock fragments) especially in nearshore, shallow marine environment.

On the continental margin south and southeast of the islands of Karpathos ,there is a general trend of increase in the calcium carbonate content from the continental shelf outward on the continental slope towards the trench zone (Fig. 27). Extrapolation of these curves using data published by previous workers shows that the calcium carbonate value continues increasing until it reaches its maximum in the Outer Ridge area.

Between Milos and Thera the calcium carbonate content is high in the surface layer, with a general trend of increase towards Milos. Other than this general trend, the samples close to the volcanic islands have lower values than those away from the islands. This is quite expected because of the ash

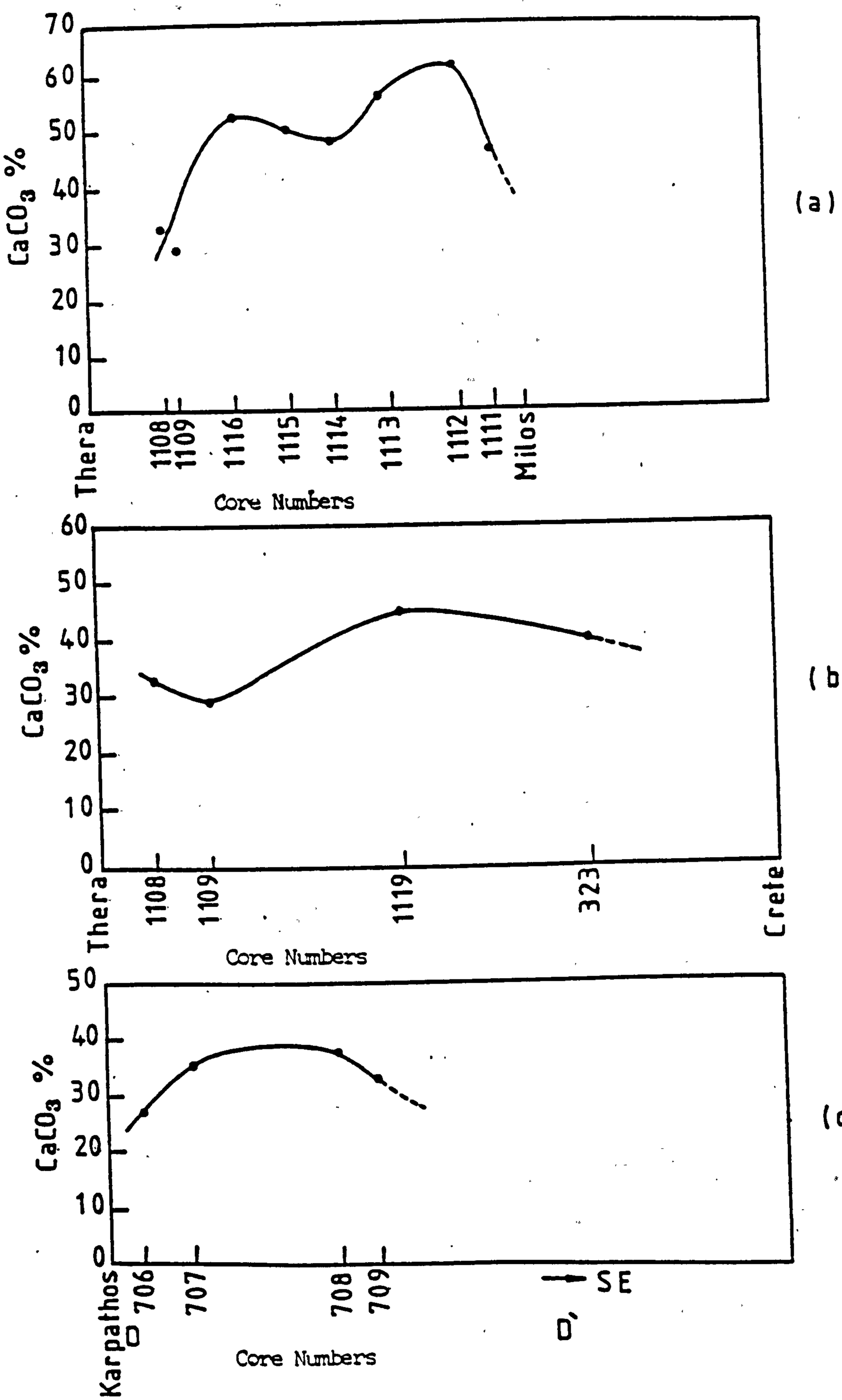


Fig.29 Variations in the $CaCO_3$ content in the surface sediments along three sampling lines :

(a) Between the island of Thera and Milos.

(b) Between Thera and Crete.

(c) From the shelf of Karpathos to the south-east.

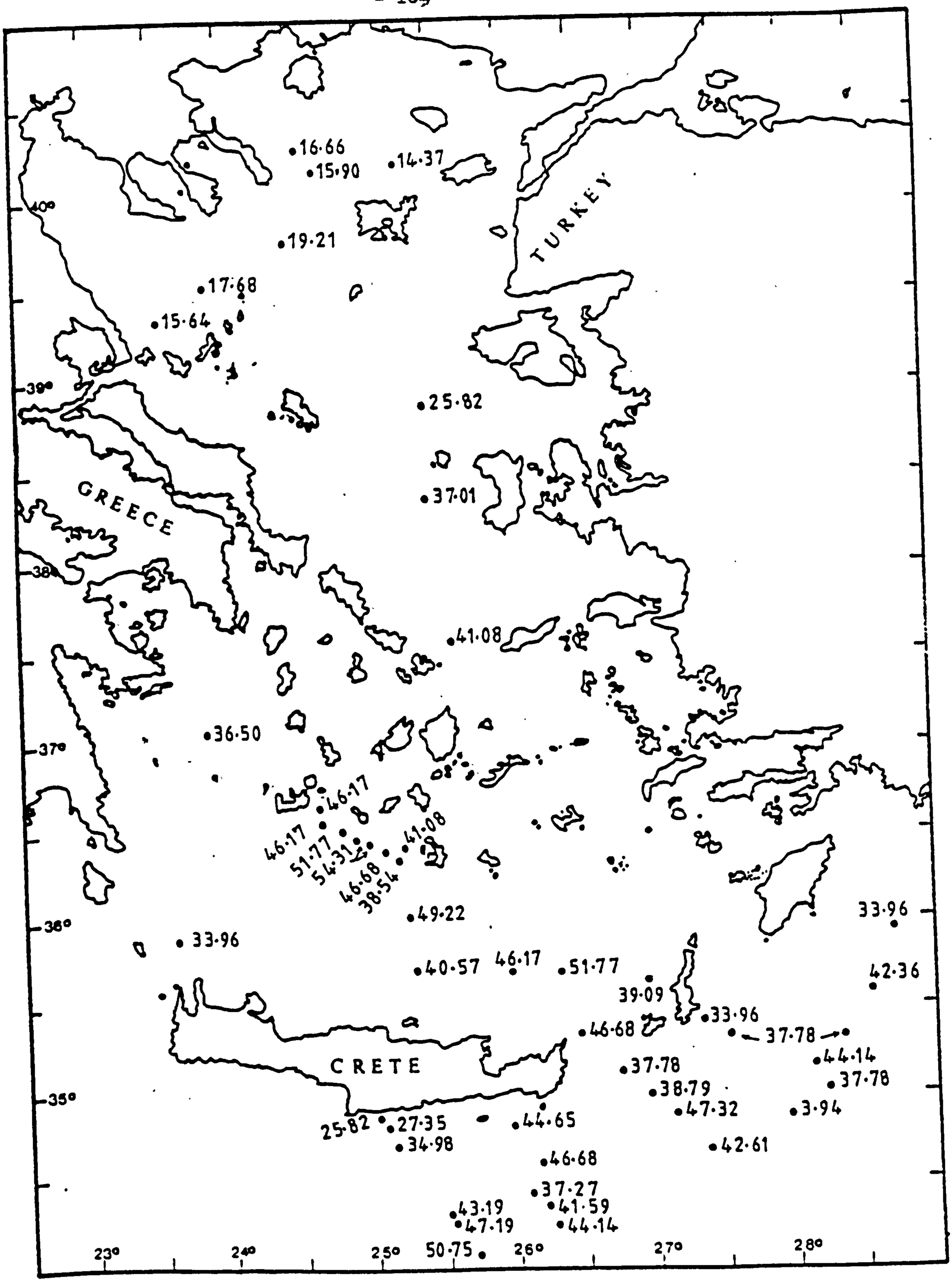


FIG. 30. Distribution map of the $CaCO_3$ content in the fraction less than 63 microns in the surface sediments of the Eastern Mediterranean and Aegean Seas. (CONCENTRATIONS IN PERCENT)

Table (6) Comparison between the $CaCO_s$ content in the bulk sample and that found in the fraction less than 63 microns

Sample No.	$CaCO_3$ in total sample	$CaCO_3$ in less than 63μ	Percent of fraction less than 63μ in sample
689-1	46.35	51.77	98.73
690-1	39.66	39.09	96.28
691-1	29.57	33.69	99.9
692-1	49.21	42.36	41.84
693-1	37.02	37.78	96.69
694-1	22.84	25.82	94.44
695-1	21.49	27.35	98.36
696-1	33.66	34.98	95.13
697-1	41.1	47.19	92.19
698-1	48.48	50.75	95.9
699-1	37.59	43.19	98.43
700-1	30.13	44.65	97.59
701-1	34.88	46.62	98.55
702-1	36.47	37.27	66.48
703-1	40.16	41.59	96.9
704-1	42.54	44.14	96.55
705-1	45.97	42.61	70.96
706-4	27.49	33.96	97.34
707-1	35.41	37.78	95.25
708-1	37.79	44.14	98.25
709-1	33.83	37.78	95.8
710-1	-	-	-

Table 6 (continued)

711-1	29.6	3.94	82.86
712-1	35.94	38.79	99.77
713-1	46.5	47.32	96.19
714-1	31.19	37.78	98.24
715-1	49.67	46.68	76.84
1108-1	33.3	41.08	36.87
1109-1	29.07	38.54	60.61
1110-1	46.77	48.72	87.14
1111-1	46.5	46.17	88.62
1112-1	61.58	46.17	54.91
1113-1	56.1	51.77	70.63
1114-1	48.61	54.31	89.75
1115-1	50.62	54.31	85.40
1116-1	53.3	46.68	79.51
1119-1	44.92	49.22	97.41
306-1	20.02	19.21	93.49
307-1	17.72	17.68	95.85
308-1	17.21	15.64	99.48
309-1	14.14	14.37	96.79
310-1	16.07	-	-
311-1	14.41	15.9	98.47
312-1	15.05	16.66	95.64
313-1	21.67	25.82	99.37
314-1	21.39	36.50	98.95
315-1	36.08	37.01	95.58
316-1	26.49	26.33	97.31
317-1	39.09	41.08	96.72
318-1	31.96	36.5	96.36
319-1	48.54	-	-

Table 6 (continued)

320-1	36.72	33.96	98.88
323-1	40.28	40.57	96.16
324-1	45.36	46.17	96.93

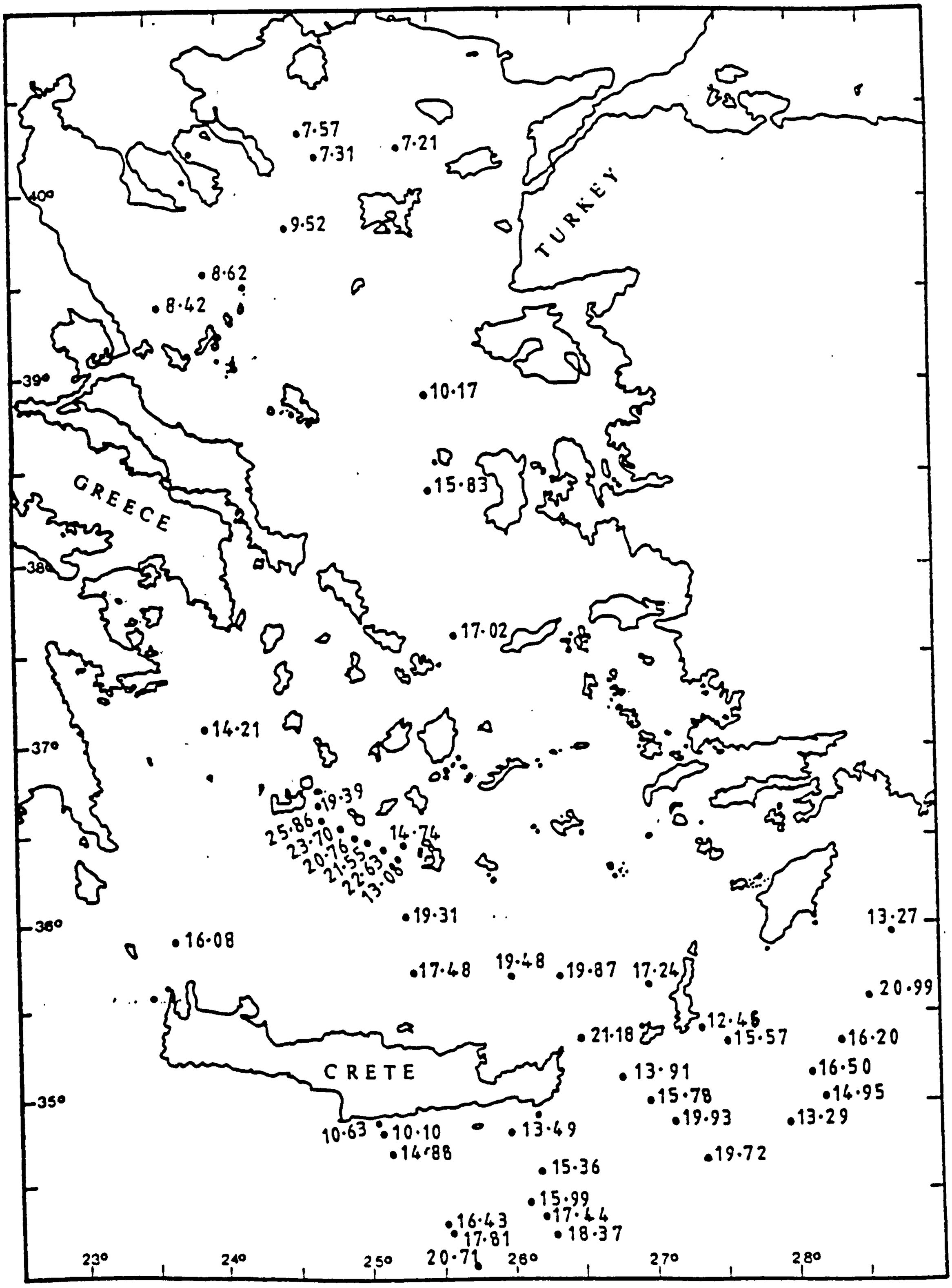


FIG. 31. Distribution of Ca in the surface sediments in the study area. (In percent)

layer and pumice deposits found near the volcanic islands. The $CaCO_3$ distribution curves drawn for the calcium carbonate around Thera, show the values to generally increase away from the island in all directions (Fig. 29 a, b and c).

6.1a The relationship between $CaCO_3$ and the grain size:

It is noticed that the carbonate content of the sediment increases as the grain size increases and that the fine sediments are low in $CaCO_3$ content. Figure 49b*, (the relation between the carbonate percentage in the samples and the median diameter of the grains), shows that the carbonate poor sediments of the northern Aegean are very fine silt and clay, on the other hand, carbonate rich sediments between Santorini and Milos are coarser sediments. Most of the moderately $CaCO_3$ rich sediments from other parts of the study area are medium silt.

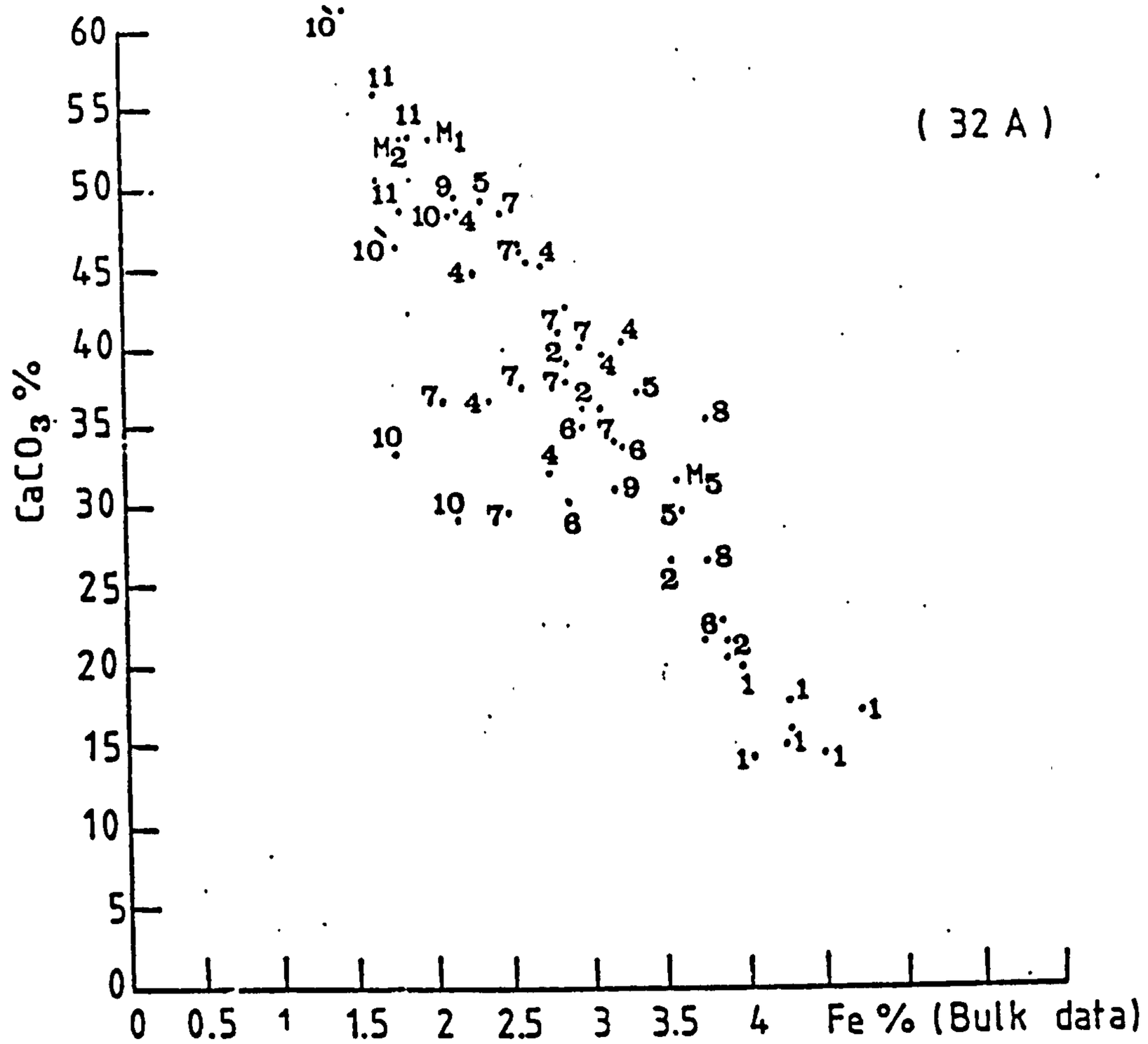
From Fig. 30 and Table 6 it can be seen that calcium carbonate in the fine sediments is slightly concentrated in the fraction less than 63 microns. More careful comparison between the carbonate content in the total sample and that found in the fraction less than 63 micron, shows that the carbonate is concentrated in the fraction between 2 and 63 microns. A group of samples were found to have higher $CaCO_3$ in the bulk sample than in the fraction less than 63 microns. This means that in these samples the coarse fraction is more carbonate rich than the general level in the surrounding area.

6.1b <u>Correlation of elements with calcium carbonate</u>:

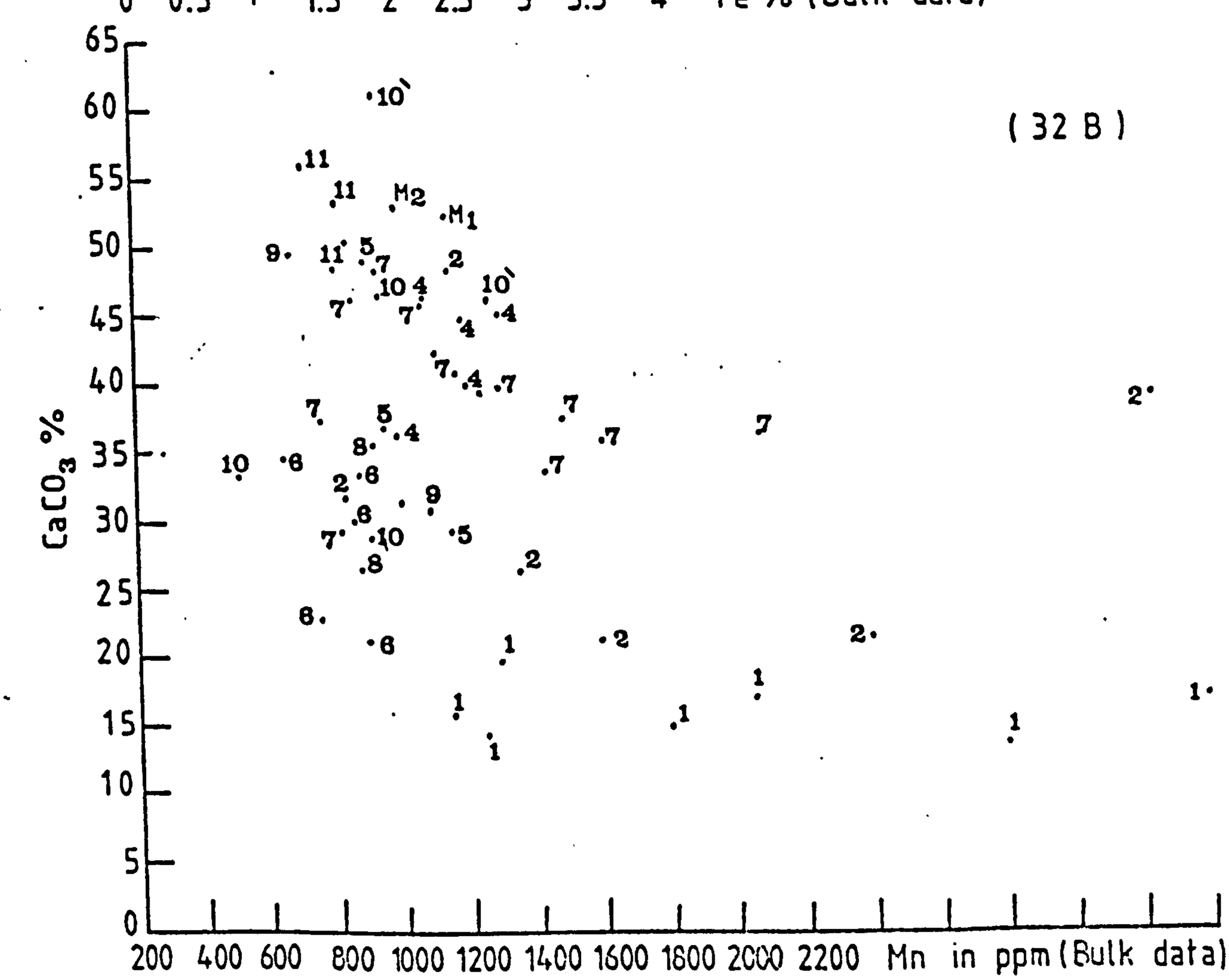
For the purpose of correlation, all elements were plotted against the carbonate content in the surface samples (figures 32a to 32 m). Three different trends were found.

1. Elements negatively correlated with $CaCO_3$: This group includes iron, aluminium, zinc, chromium and titanium.

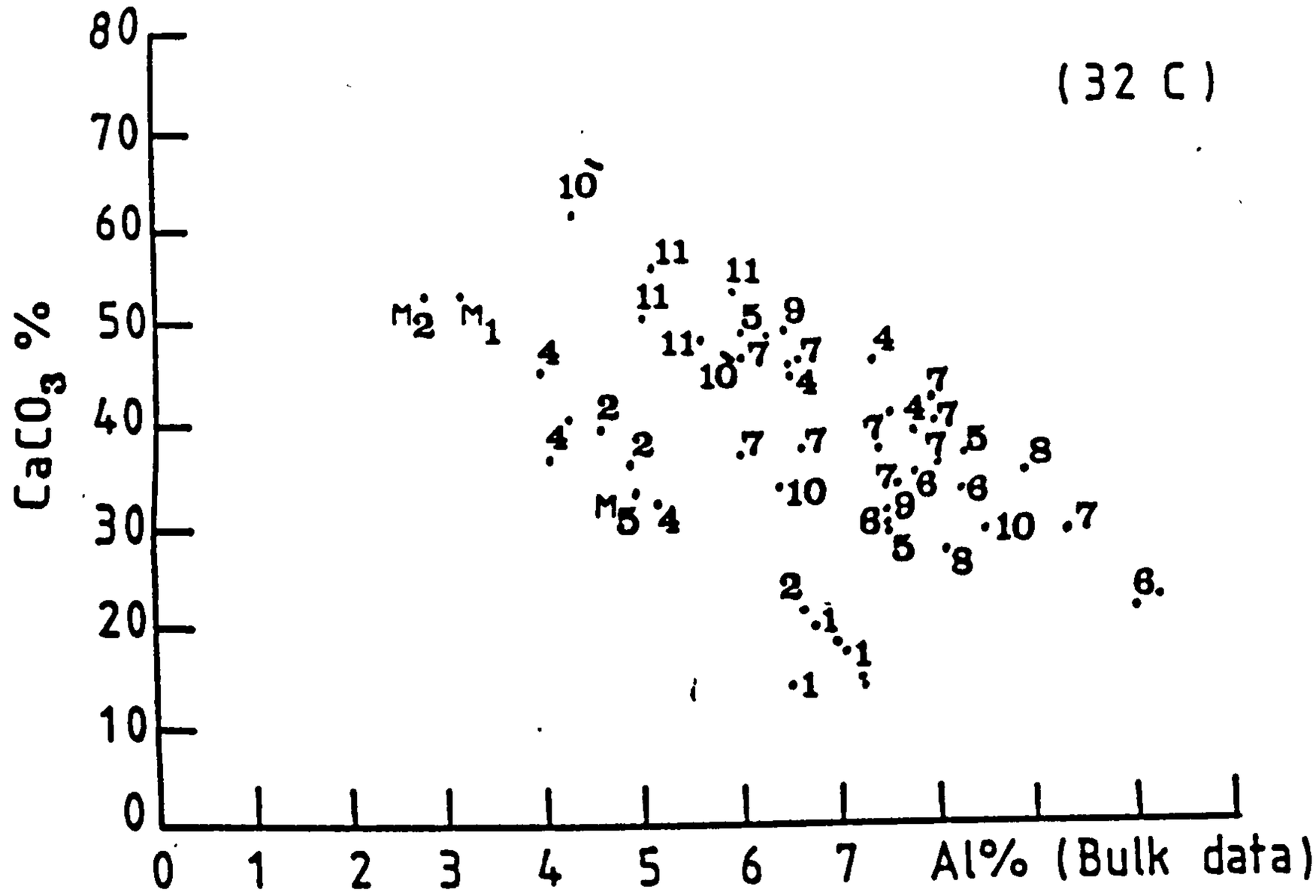
* See page 222

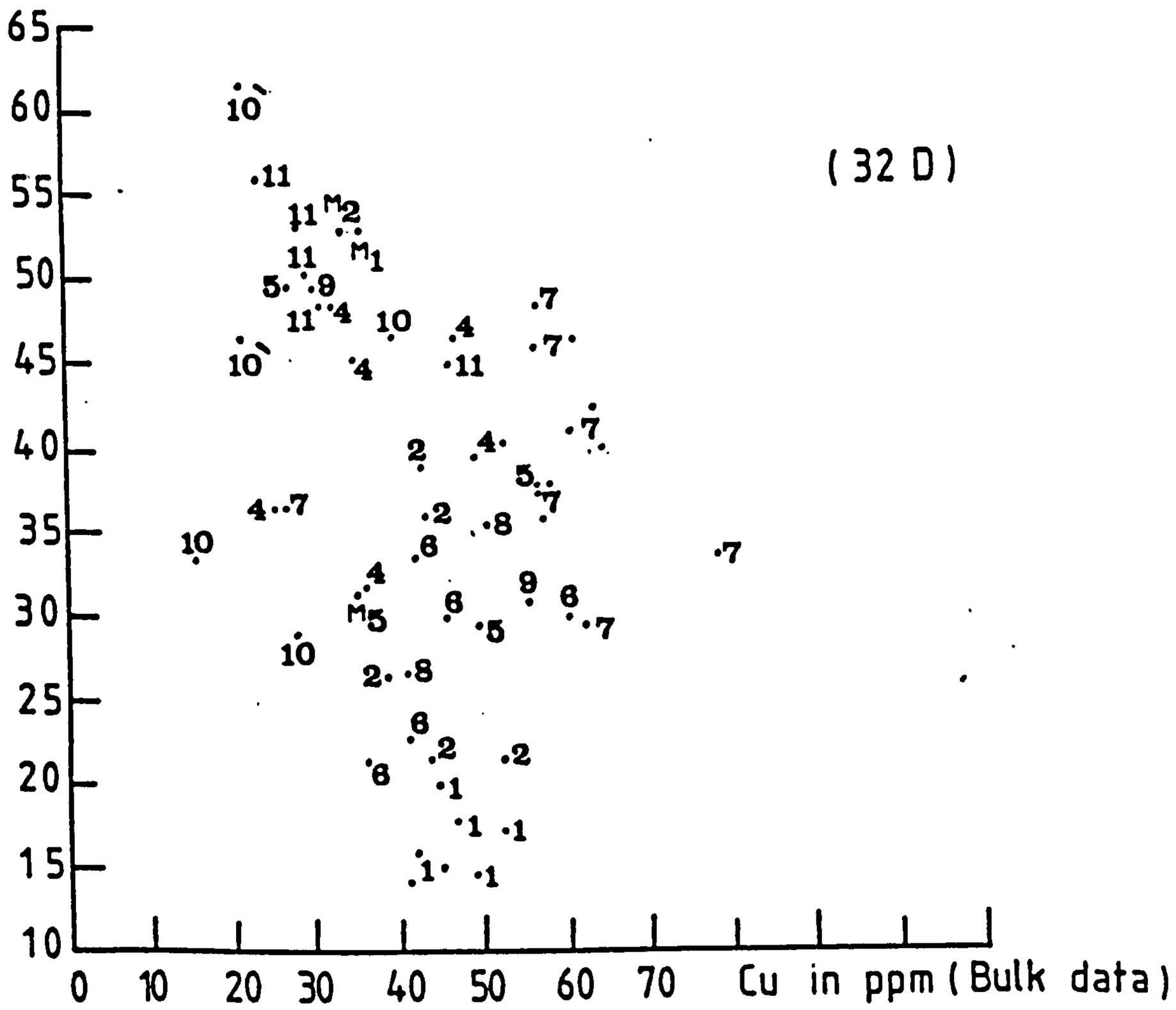

60
55
50
45
40
35
30
25
20
15
10
5
0
$CaCO_3$ %
0 0.5 1 1.5 2 2.5 3 3.5 4 Fe % (Bulk data)

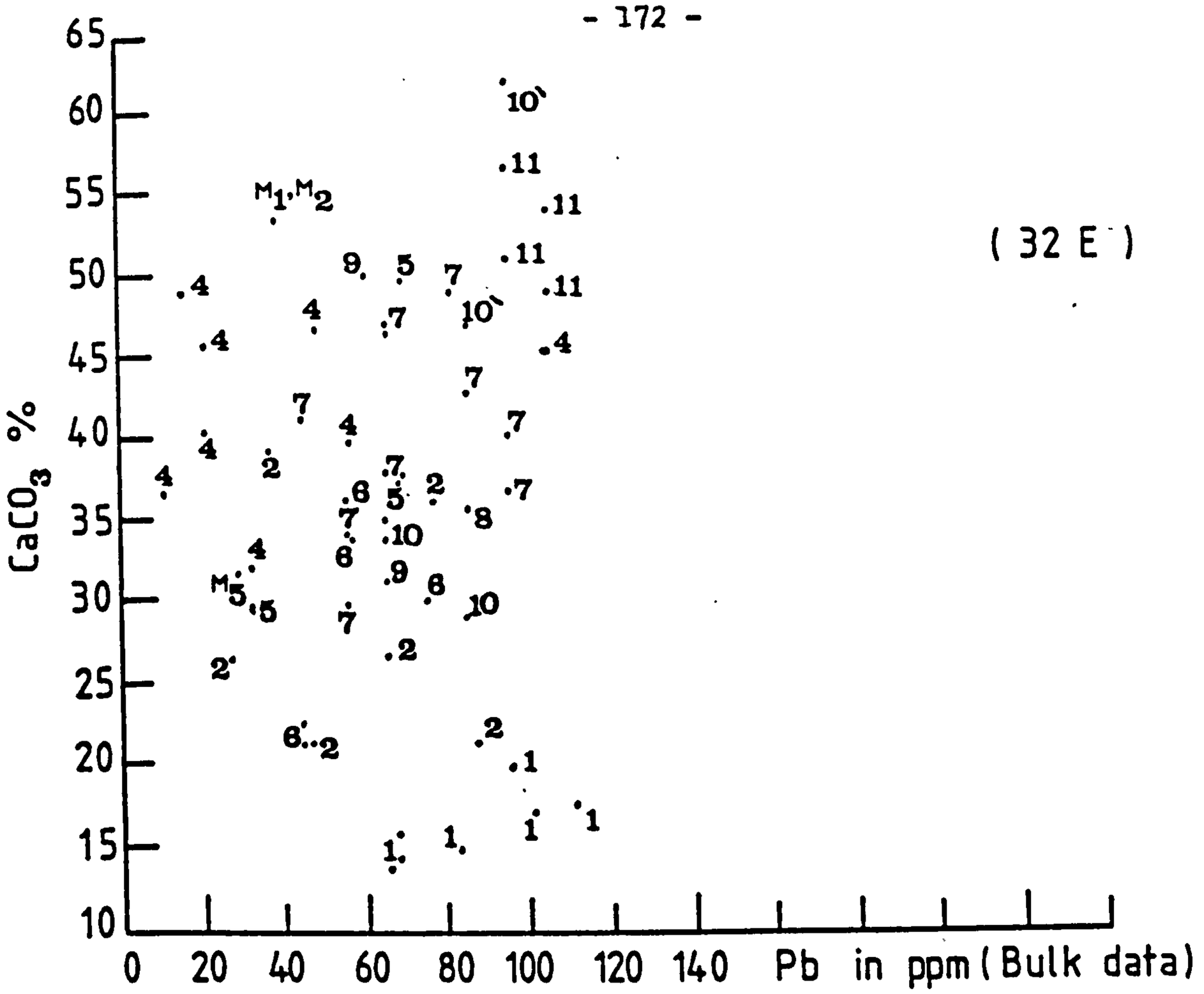
(32 A)


65
60
55
50
45
40
35
30
25
20
15
10
5
0
$CaCO_3$ %
200 400 600 800 1000 1200 1400 1600 1800 2000 2200 Mn in ppm (Bulk data)

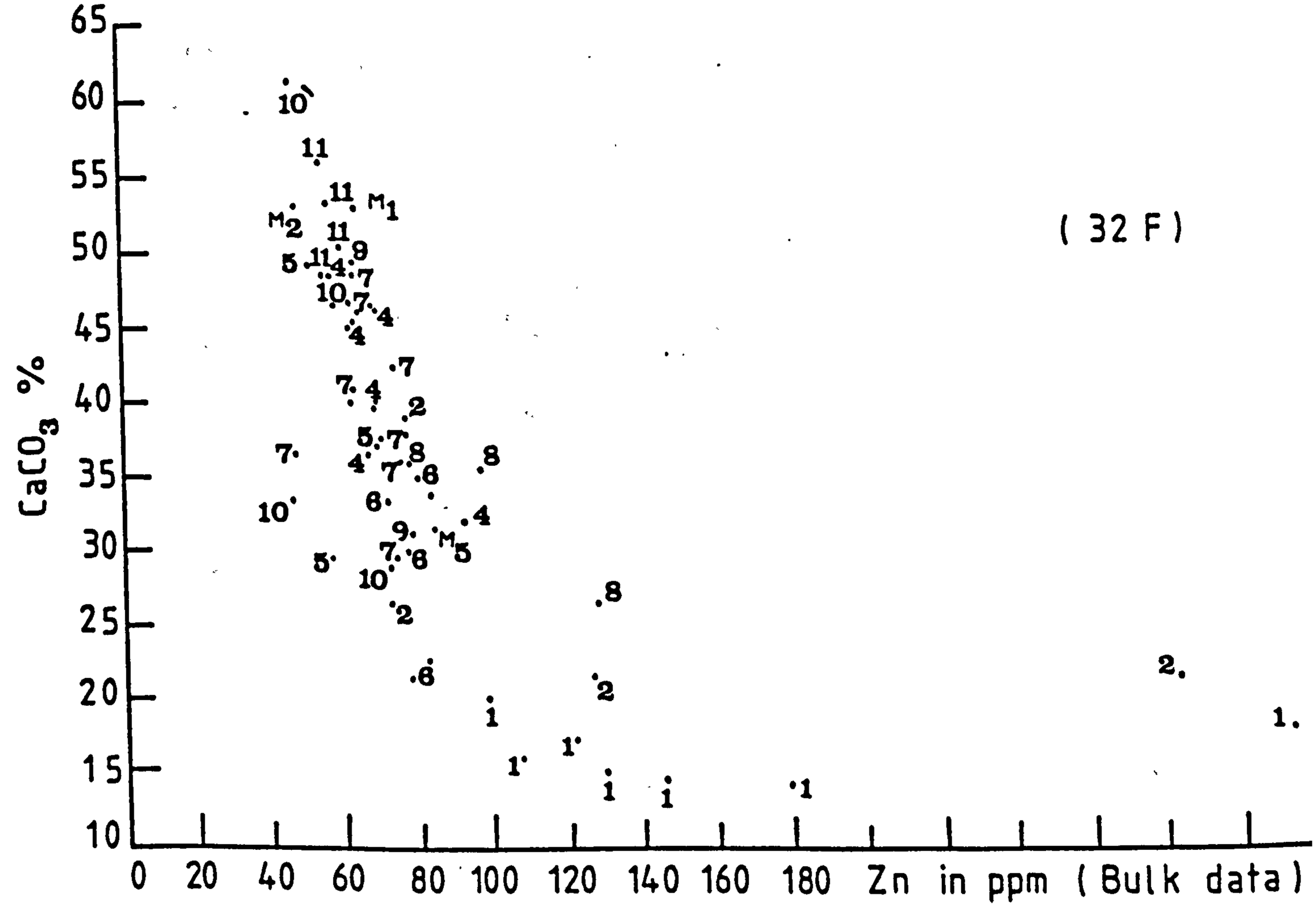
(32 B)


(32 C)
CaCO3 %
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 Al% (Bulk data)

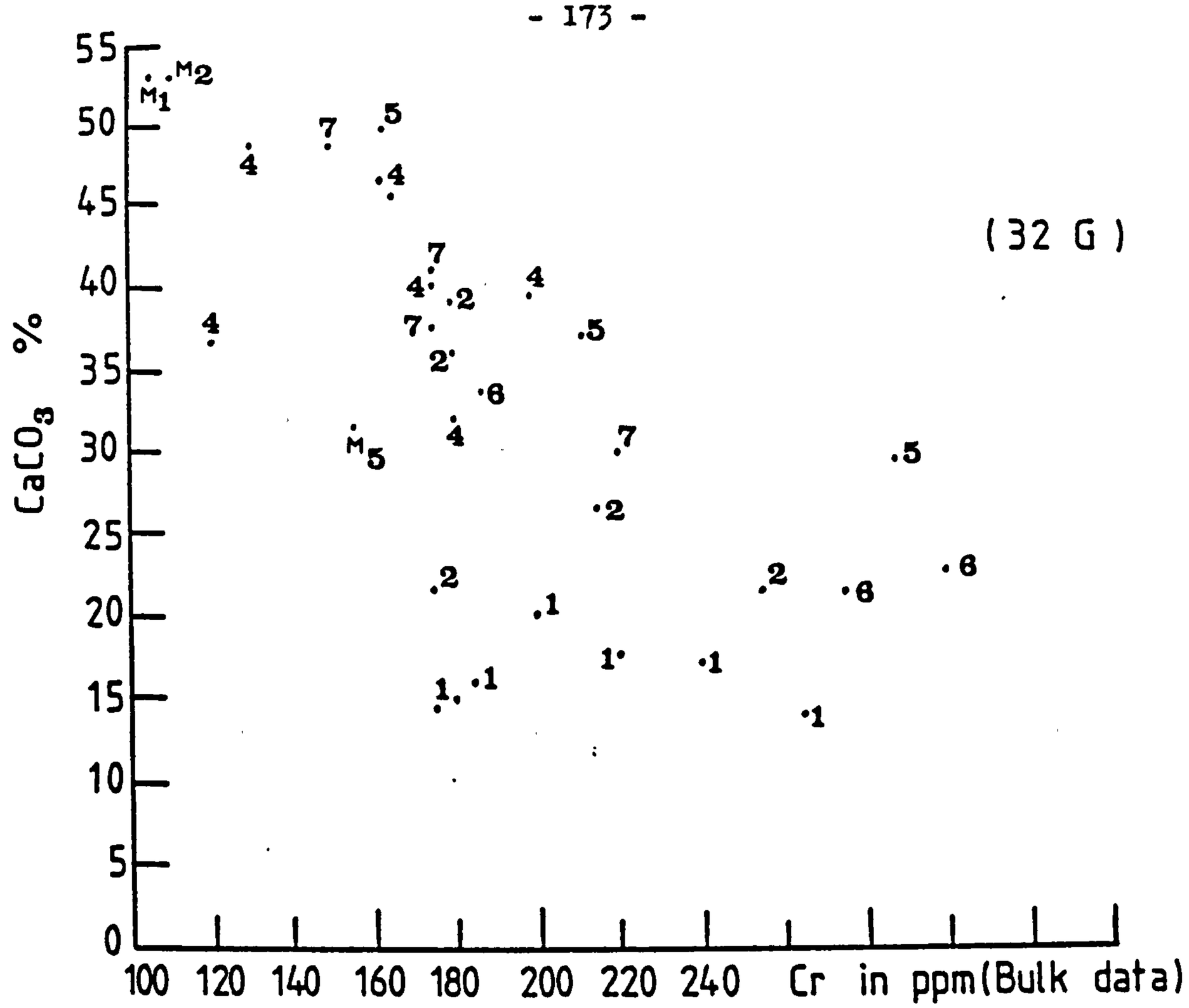

(32 D)
CaCO3 %
65
60
55
50
45
40
35
30
25
20
15
10
0 10 20 30 40 50 60 70 Cu in ppm (Bulk data)


65
60
55
50
45
40
35
30
25
20
15
10
CaCO3 %
0 20 40 60 80 100 120 140
Pb in ppm (Bulk data)

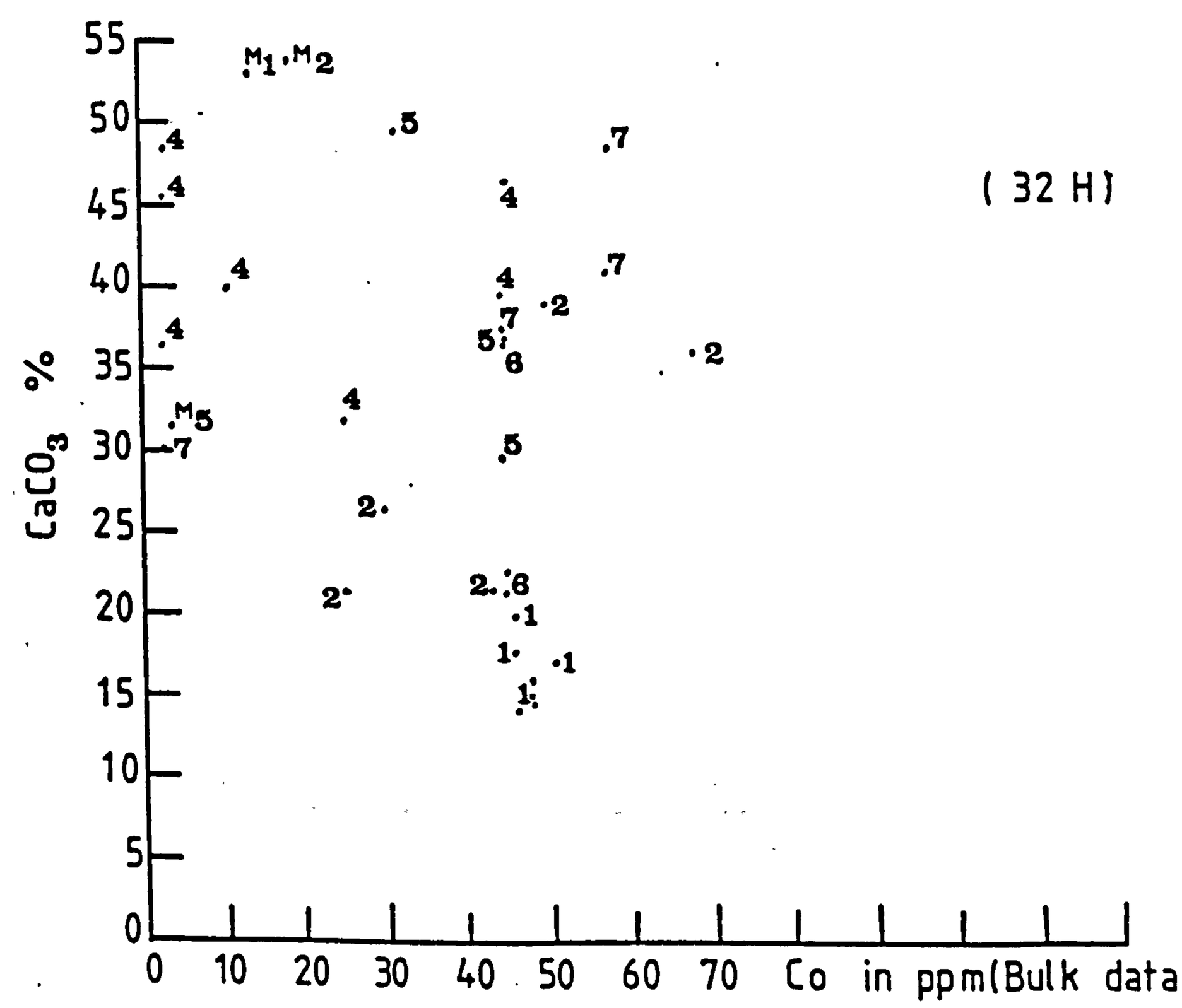
(32 E)


65
60
55
50
45
40
35
30
25
20
15
10
CaCO3 %
0 20 40 60 80 100 120 140 160 180
Zn in ppm (Bulk data)

(32 F)

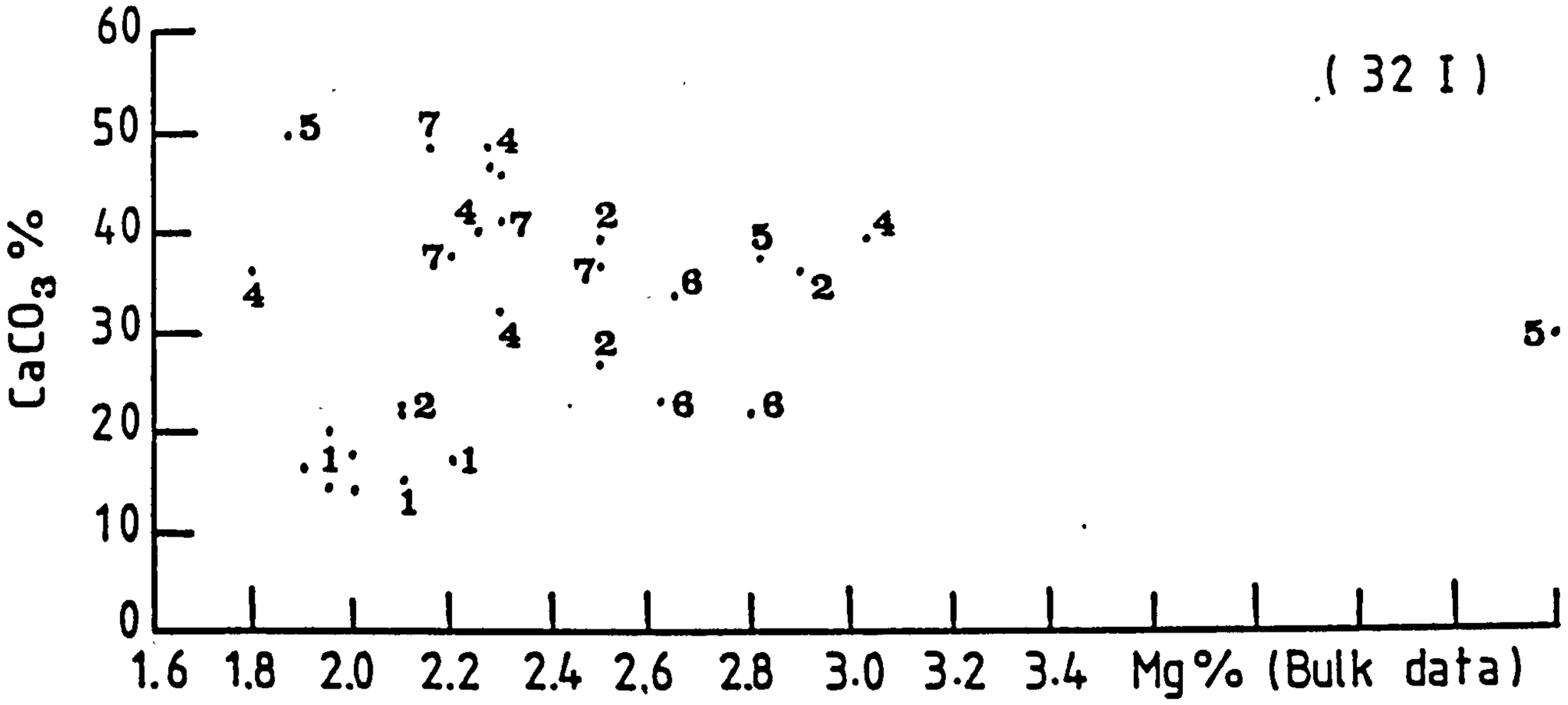

55
50
45
40
35
30
25
20
15
10
5
0
CaCO3 %
M1
M2
M5
100 120 140 160 180 200 220 240
Cr in ppm(Bulk data)

(32 G)

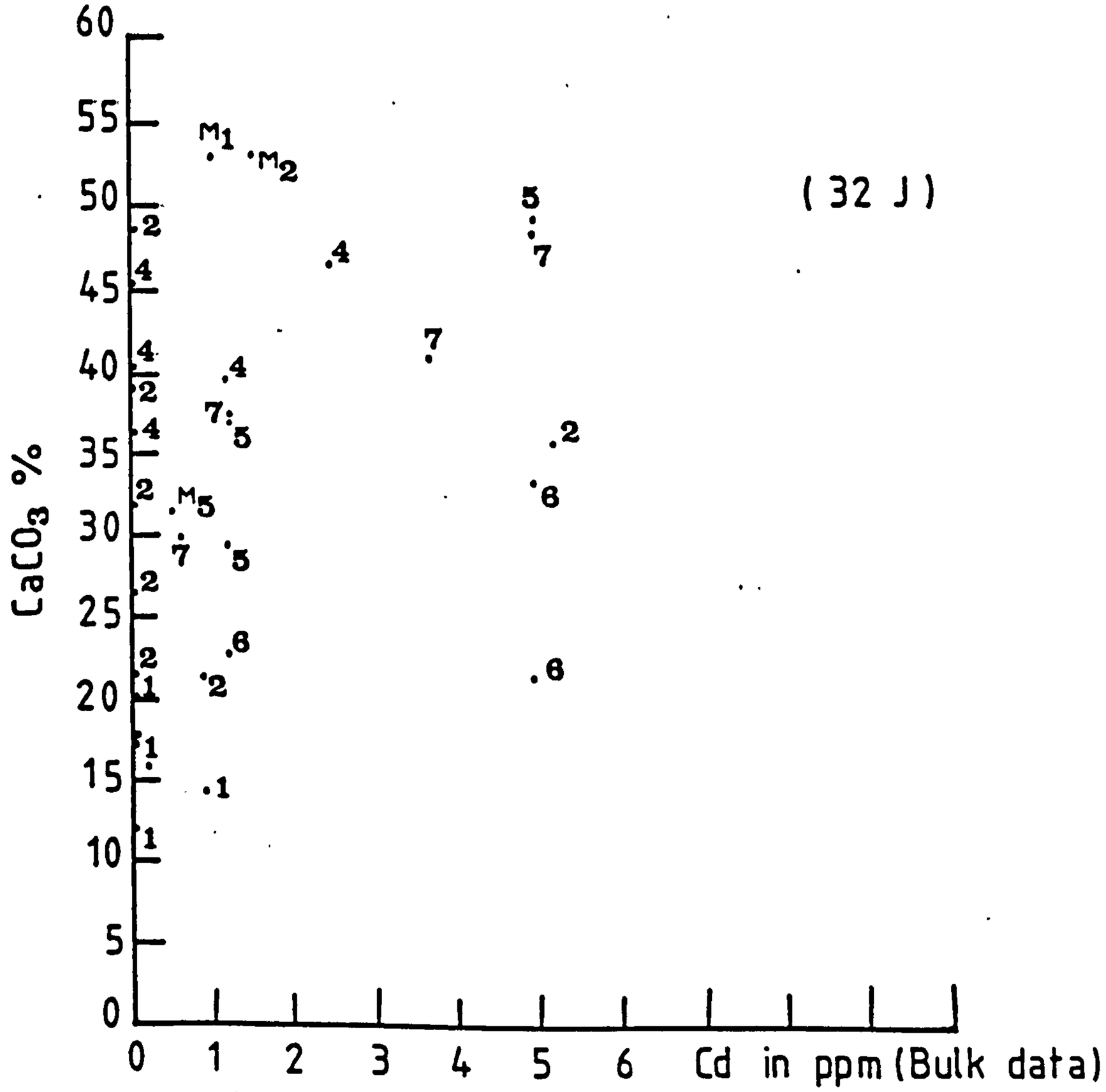

55
50
45
40
35
30
25
20
15
10
5
0
CaCO3 %
M1
M2
M5
0 10 20 30 40 50 60 70
Co in ppm(Bulk data)

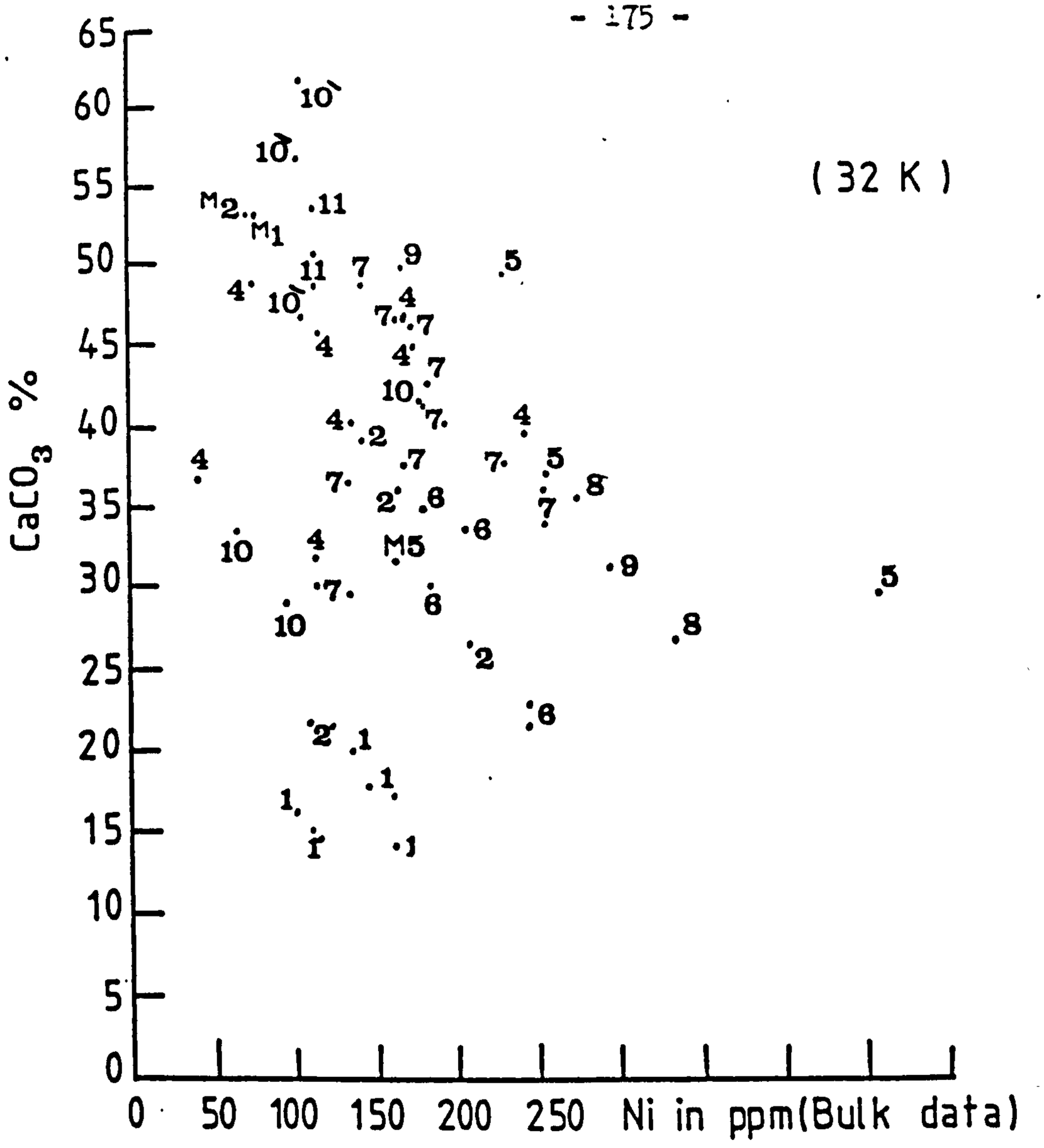
(32 H)

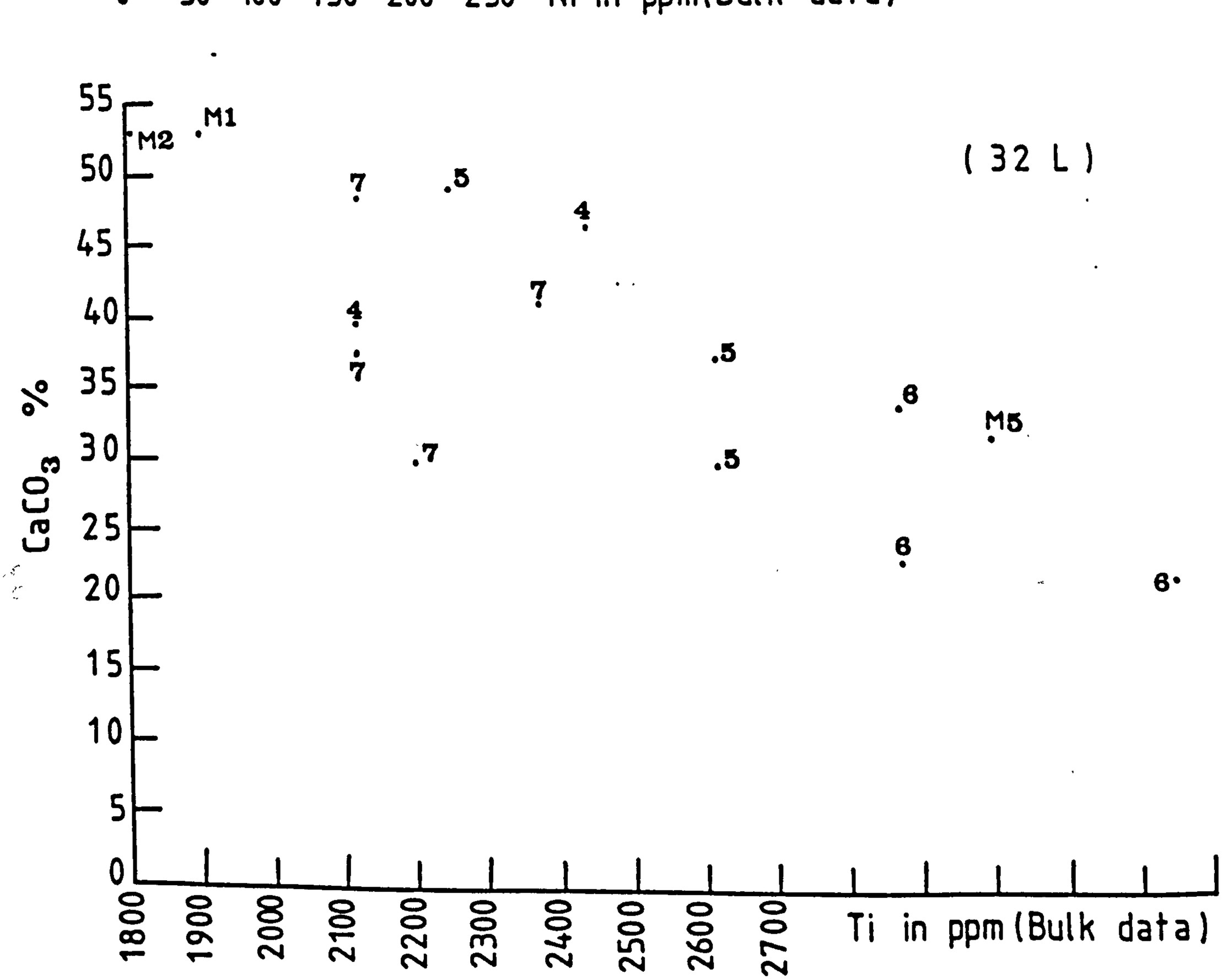
(32 I)


60
50
40
30
20
10
0
CaCO3 %
1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 Mg% (Bulk data)

(32 J)


60
55
50
45
40
35
30
25
20
15
10
5
0
CaCO3 %
0 1 2 3 4 5 6 Cd in ppm (Bulk data)


(32 K)
CaCO3 %
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 50 100 150 200 250 Ni in ppm(Bulk data)
M1
M2
M5


(32 L)
CaCO3 %
55
50
45
40
35
30
25
20
15
10
5
0
1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 Ti in ppm (Bulk data)
M1
M2
M5

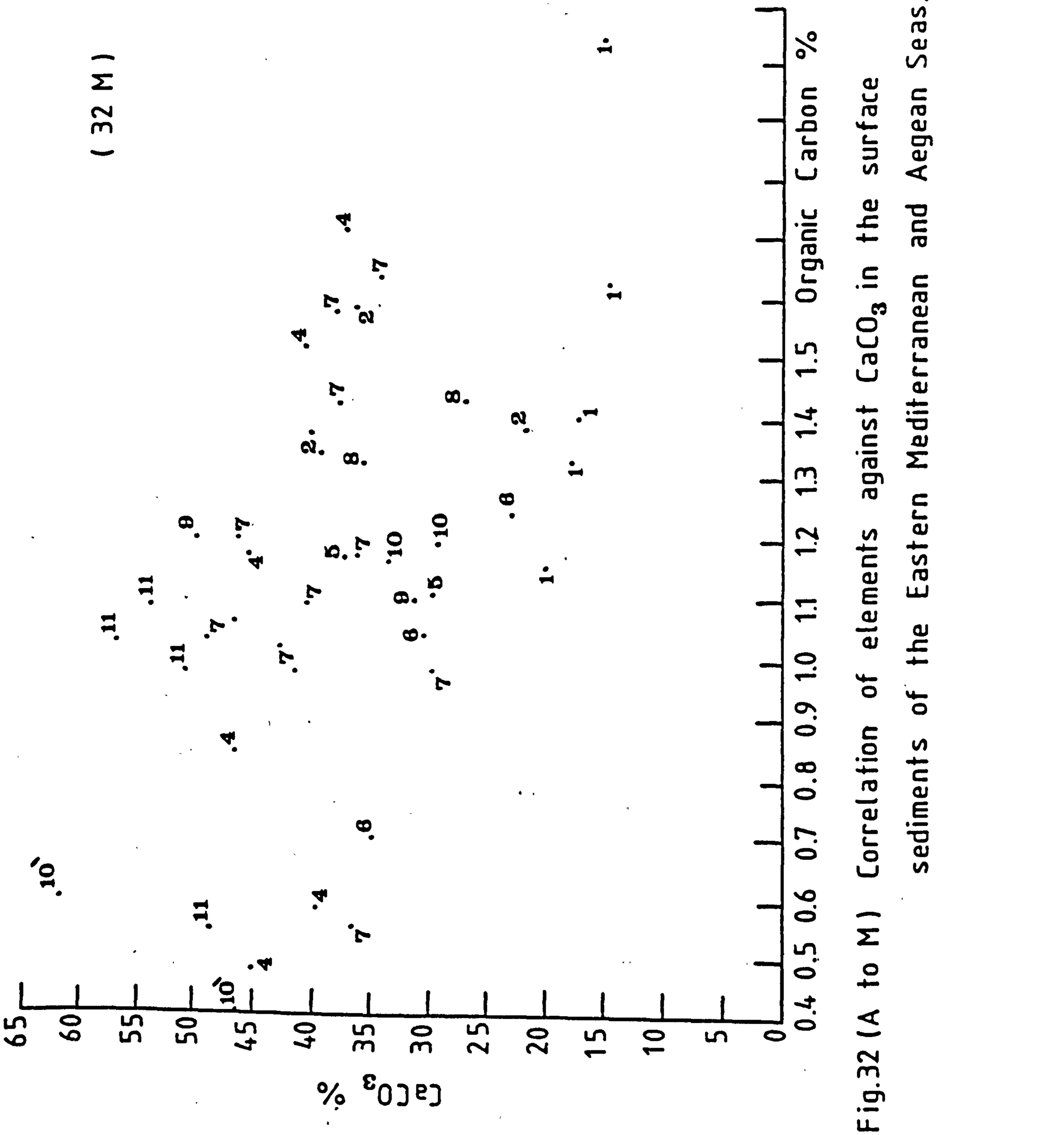


Fig.32 (A to M) Correlation of elements against $CaCO_3$ in the surface sediments of the Eastern Mediterranean and Aegean Seas.

The organic carbon was also found to have negative correlation with calcium carbonate.

2. Elements positively correlated with $CaCO_3$ lead, cobalt and magnesium have a positive correlation with $CaCO_3$, especially in the Aegean sediments. However this trend is not clear in the case of the sediments to the north and south of the island of Crete where the correlation is weak.

3. Elements with a slightly negative correlation with carbonate:

This group includes manganese, copper, cadmium and nickel.

6.2 Magnesium: Magnesium has a range from 1.8% to 4.4% in the samples analysed. The northern Aegean sediments have an average value of 2.03, equivalent to 7.04% $MgCO_3$ if all of it is present in the form of carbonate. The middle Aegean has a higher average value of 2.5%. In the southern Aegean the average is 2.33%. Higher values are noticed south of the island of Crete showing an average Mg content of 2.69%, (Fig. 33) (Table 7).

6.2a Ca/Mg Ratio:

The Ca/Mg ratio (Fig. 34) shows that Mg is high "relative to total carbonate" in the northern Aegean, low in the middle Aegean and lower in the southern Aegean, i.e. the Mg content in the Aegean Sea decreases from the northern Aegean to the southern Aegean, with the highest relative values (lowest Ca/Mg ratios) close to the northern Aegean shelf. In the eastern Mediterranean, south of Crete, the Mg content relative to calcium decreases from the shelf of Crete outward towards the trench. The Ca/Mg ratio supports this trend, increasing outward from the shelf. Sample No. 692-1 to the east of Karpathos in the trench area, has a very low Mg content and high

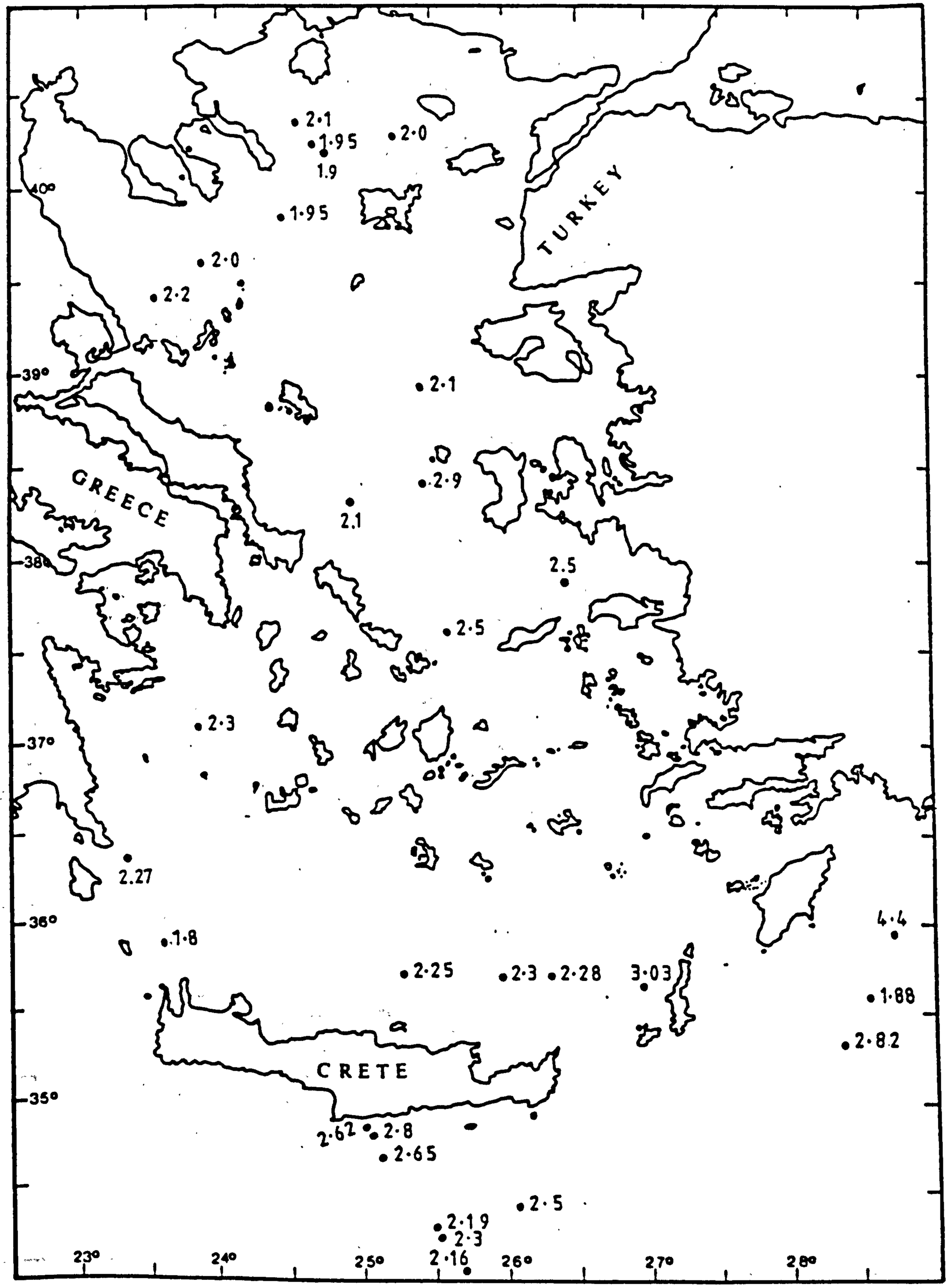


FIG. 33. Distribution of Mg (in percent) in the surface sediments in the study area.

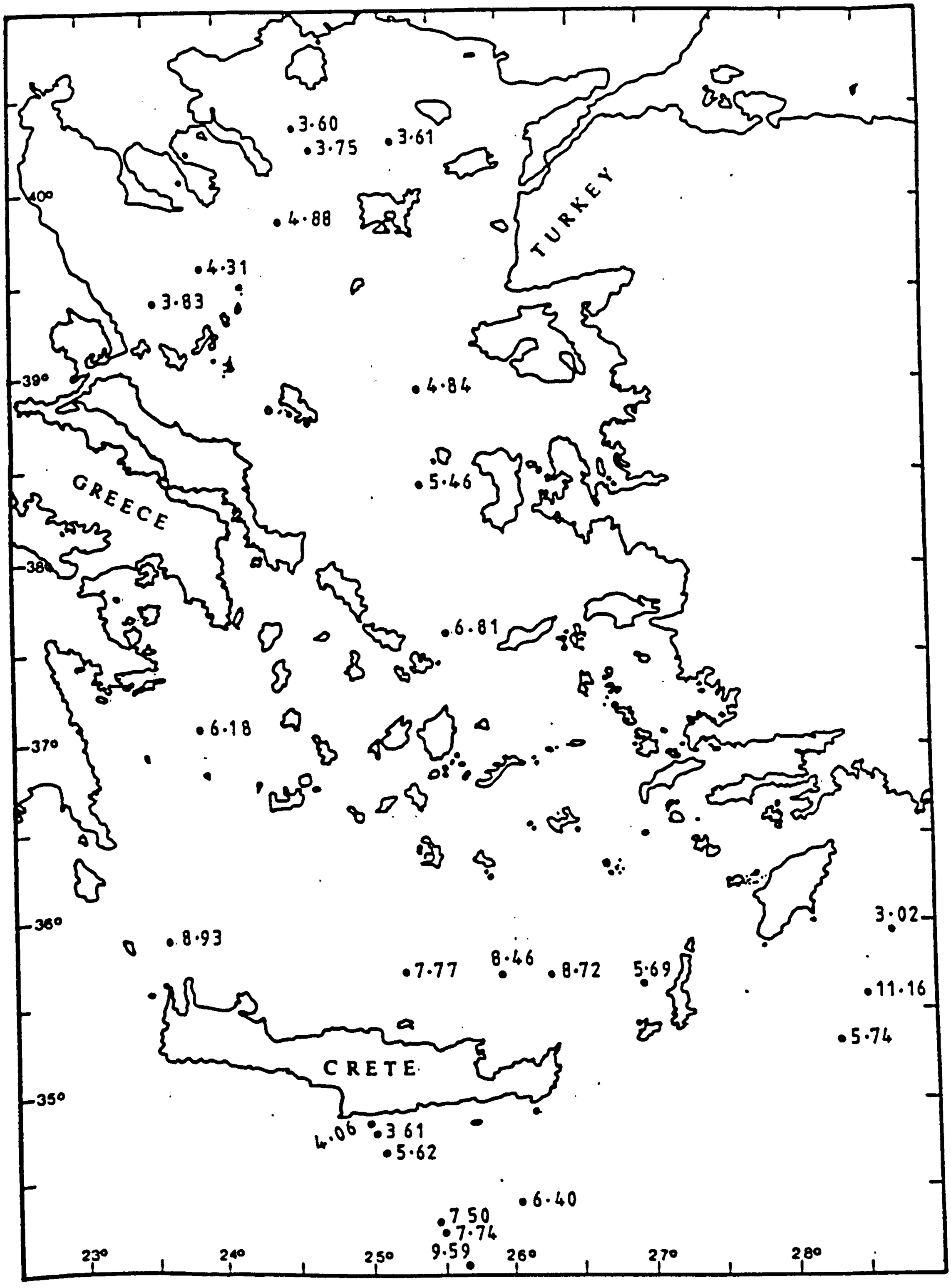


FIG. 34. Ca/Mg ratio in the surface sediments in the study area.

Table 7 The Average Element Concentrations in the Eastern Mediterranean and Aegean Sea Surface Sediments

Area	Fe %	Al %	Mn (ppm)	Cu (ppm)	pb (ppm)	Zn (ppm)	Ni (ppm)	Cr (ppm)	Co (in ppm)	Cd	Ti	Organic Carbon
Northern Aegean	5.16	8.34	2205	56	105	197	167	225	57	0.2		1.49
Middle Aegean	4.81	7.85	4781	65	98	137	214	267	81	27		1.44
Santorini-Milos Close to the islands	3.36	11.12	1702	42	170	105	196					0.87
Santorini-Milos Away from the islands	3.70	11.23	1685	60	209	116	238					0.87
South of Crete shelf sediments	4.90	12.82	1156	54	68	105	315	341	61	5	4067	1.24
North East of Crete	4.37	12.82	1351	60	121	125	341					1.20
East of Karpathos	5.15	12.48	1429	78	119	135	454					1.38
East of Rhodes	5.14	10.64	1631	70	46	81	650	443	64	1.7	3723	1.11
The Trenches zone	4.35	12.35	1639	82	113	107	327	320	63	10	4430	1.12
Southern Aegean	4.75	9.85	2033	74	59	115	260	284	37	1.3	3849	1.05

Ca/Mg ratio, thus the Mg is not likely to be associated with carbonate phases. (Table 3).

6.3 Aluminium: Aluminium has negative correlation to $CaCO_3$ (Fig. 32c). Aluminium concentrations in the sediments were thus plotted both on a non C.F.B. and on a C.F.B (Figs. 35 and 36). In both cases high values are found south and southeast of Crete. In the Aegean Sea the highest Al value is found in the northern Aegean and the lowest is in the Santorini area. The C.F.B. recalculation reverses the figure in Santorini, and the average values change to be the highest in the Aegean on a C.F.B. This is quite understandable because of the high carbonate content in this area.

Table 8 Comparison between the average Al content in the different parts of the eastern Mediterranean and Aegean Seas both non C.F.B. and on C.F.B.

AREA	Al% non C.F.B.	Al% on C.F.B.
Northern Aegean	6.97	8.34
Middle Aegean	5.35	7.85
Santorini Area (close to the Islands)	6.06	11.12
Santorini Area (away from the Islands)	5.5	11.23
Southern Aegean	5.64	9.85
South of Crete shelf sediments	9.5	12.82
East of Karpathos	8.5	12.48
Trenches zone South of Crete	7.27	12.35

6.3a Ca/Al Ratio: The Ca/Al ratio could be regarded as a criterion of the ratio of carbonate to non-carbonate fractions of the

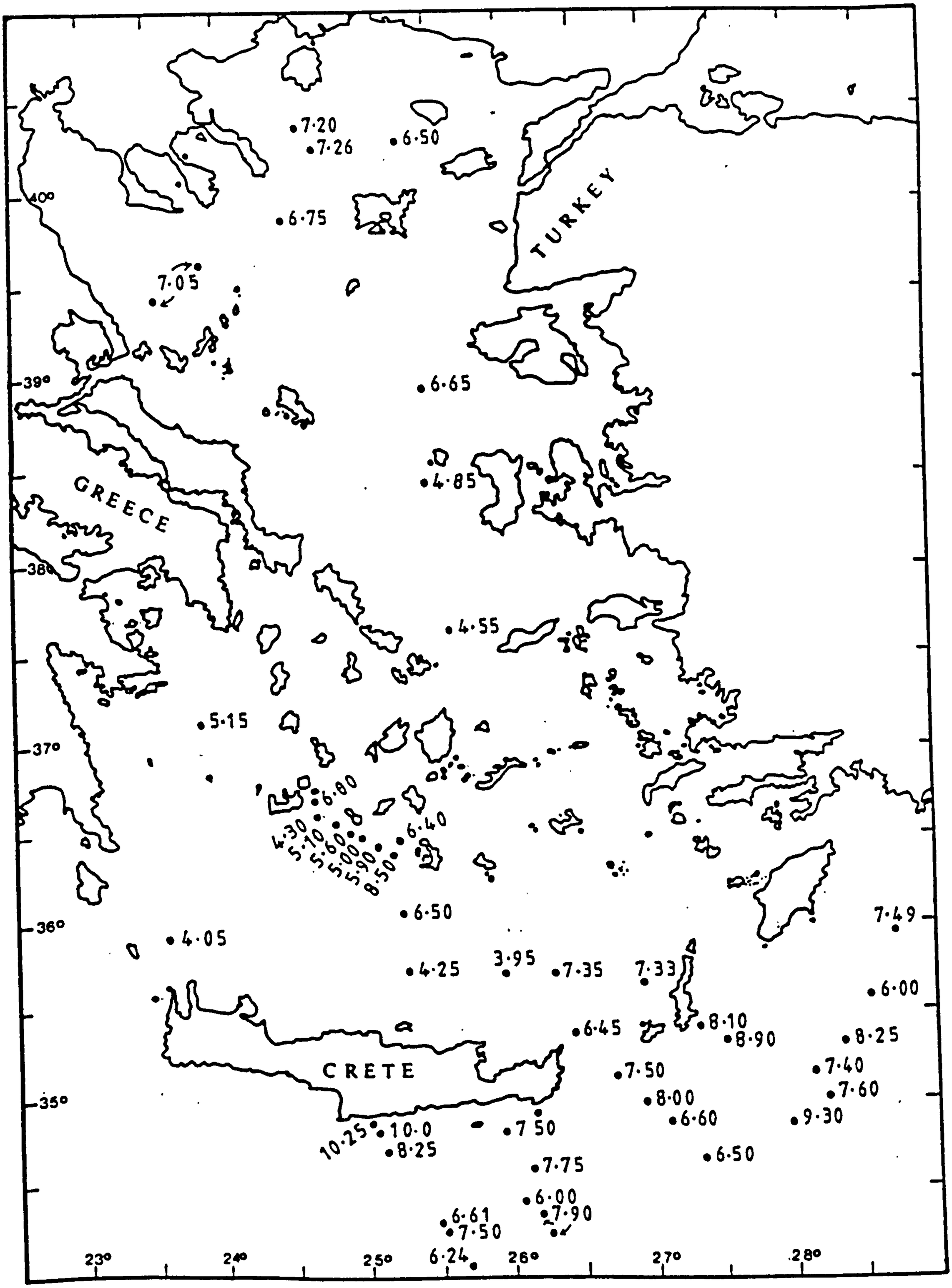


FIG. 35. Distribution of Al on non C.F.B.(in percent) in the surface sediments in the study area.

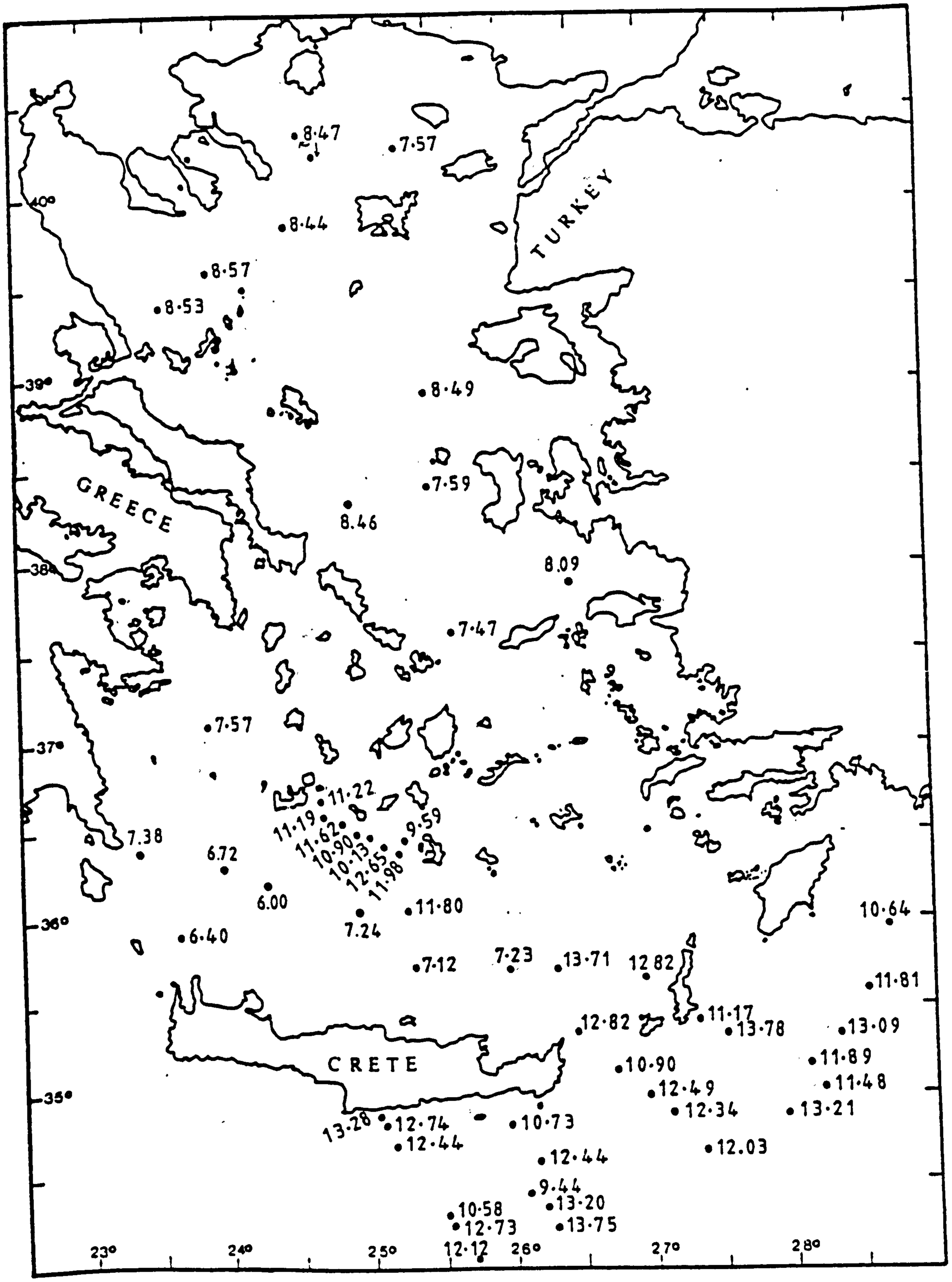


FIG. 36. Distribution of Al on a C.F.B. (in percent) in the surface sediments in the study area.

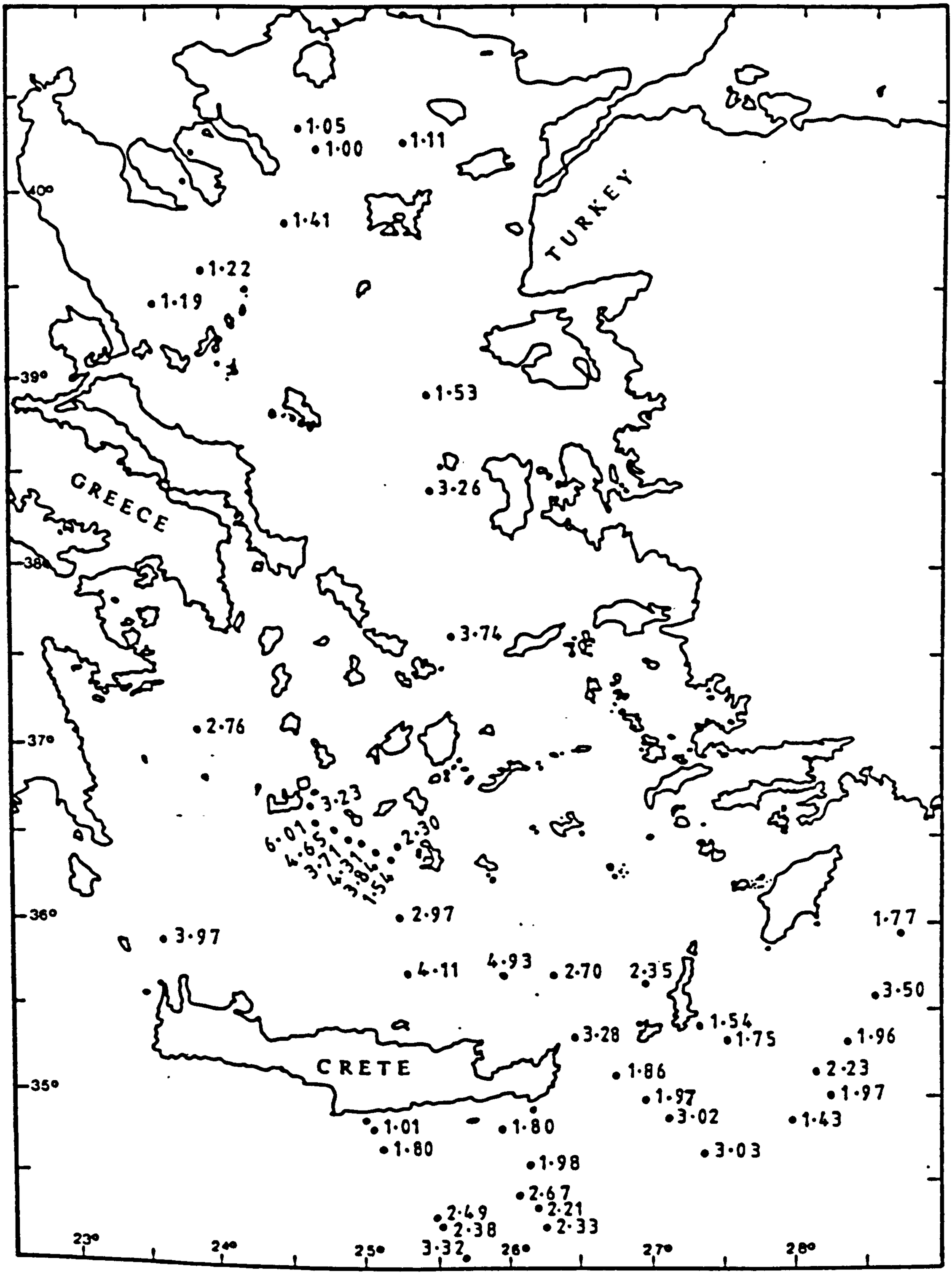


FIG. 37. Ca/Al ratio in the surface sediments of the Eastern Mediterranean and Aegean Seas.

sediment. From figure 37 the variation in the Ca/Al ratio is found to coincide with that of the carbonate distribution in the study area.

6.4 Iron: Iron is found to have a negative correlation with Ca CO_3. The carbonate poor sediments in the northern Aegean Sea are found to be the richest in iron content. The carbonate rich sediments near the volcanic island of Milos are found to be the poorest in their iron, having values less than 2% Fe on a non C.F.B. The northern Aegean sediment has values of more than 4% Fe on a non C.F.B. (Fig. 32a). When plottted on C.F.B. a similar distribution is noticed (Fig. 38).

The iron content of the surface sediments from throughout the area has averages in the range from 3.36 to 5.16 on a C.F.B. The highest value (5.16%) is found in the northern and southern Aegean Sea, and the lowest average value is found in the area between Santorini and Milos, where it is 3.36% close to the islands and 3.7% away from them. The rest of the study has an average Fe content in the range between 4 and 5% on C.F.B. (table 7).

6.5 Manganese: The manganese content in the surface sediments is higher in the Aegean Sea sediments than other parts of the study area. The highest average value is found in the Middle Aegean sediments. They have an average of 4,781 ppm on a C.F.B. and range up to 6,964 ppm, Fig. 39a, table 7. It is noticed that the high Mn values are associated with low Al values. This is found in all parts of the Aegean Sea. It is also noticed that a low content of Mn is associated with high content of Al, in the Santorini area and south of the island of Crete and east of Karpathos. South, southeast and east of the island arc the Mn content generally increases from the

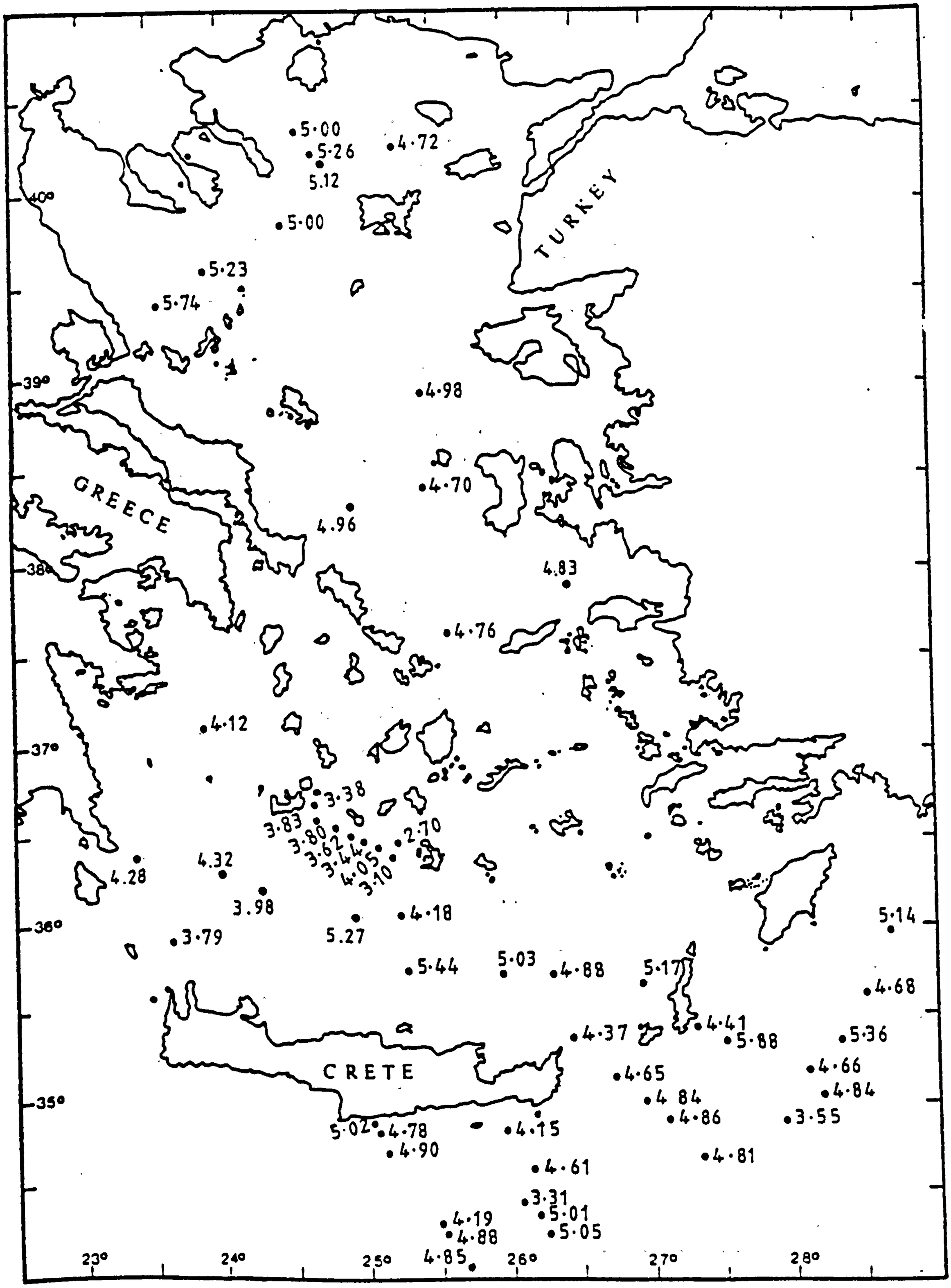


FIG. 38. Distribution of Fe in percent on a C.F.B. in the surface sediments in the study area.

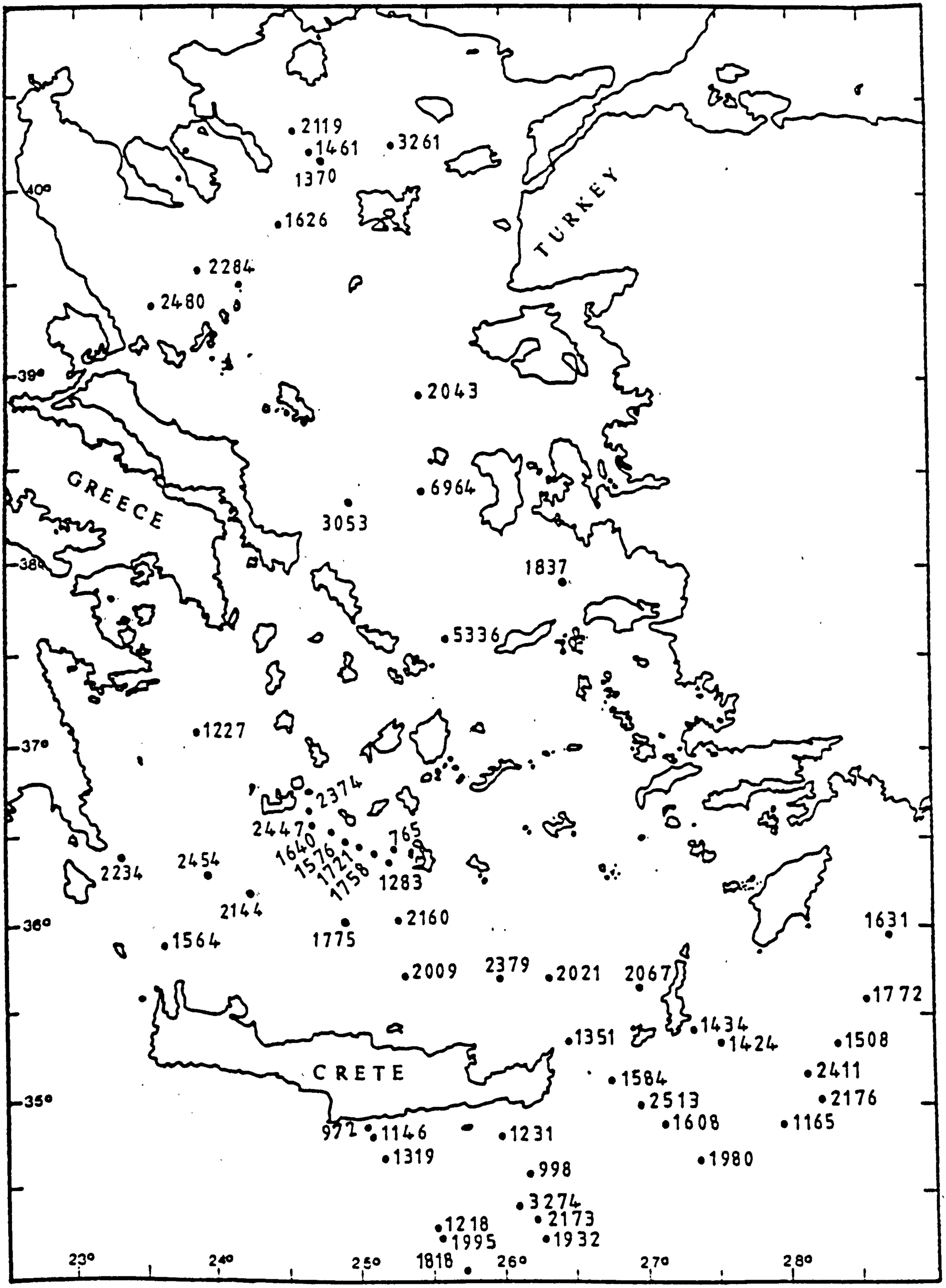


FIG. 39a. Distribution of Mn on a C.F.B. in the surface sediments in the study area. (Concentrations are given in ppm)

shelf outward towards the trench area. One surface sample south of Crete (sample No. 702-1) was found to have higher Mn than the surrounding sediments. When Mn is plotted against calcium carbonate, it is found that areas characterized by high Mn content are generally not carbonate rich but mainly poor or moderate in their carbonate content. It is also noticed that areas poor in Mn are carbonate rich. This negative correlation between Mn and $CaCO_3$ is only noticed in cases of very high or very low content of both of them. In the case of moderate content of the two variables, the trend is not so clear (Fig. 32b). However consideration of the Mn content on both a C.F.B. and a non C.F.B. gives similar trends.

6.6 Copper: When copper is plotted against carbonate (Fig. 32d) a similar case to Mn is noticed. Again a weak negative correlation is found. The non carbonate free data shows that the copper has a lower range in the Aegean Sea than in the Levantine Sea sediments and that most sediments have a copper content between 30-60 ppm. The Santorini area is found to have lower values, less than 30 ppm, and only one area is found to be copper rich, having values mostly more than 70 ppm on a non C.F.B. This area is the trench zone south and southeast of Crete. On the basis of C.F.B. data (Fig. 39b)Cu has an average of 56 and 64.7 in the northern and middle Aegean respectively. The average is slightly lower in the Santorini area. Close to the islands of Thera and Milos it is 42.7 and 60.3 ppm away from the islands. South of Crete shelf sediments have an average of 54 ppm on a C.F.B. Higher values are recorded further to the south. The highest values are found near and in the trench area. An average of 82.3 ppm Cu on a C.F.B. is found for the sediments in this area, and

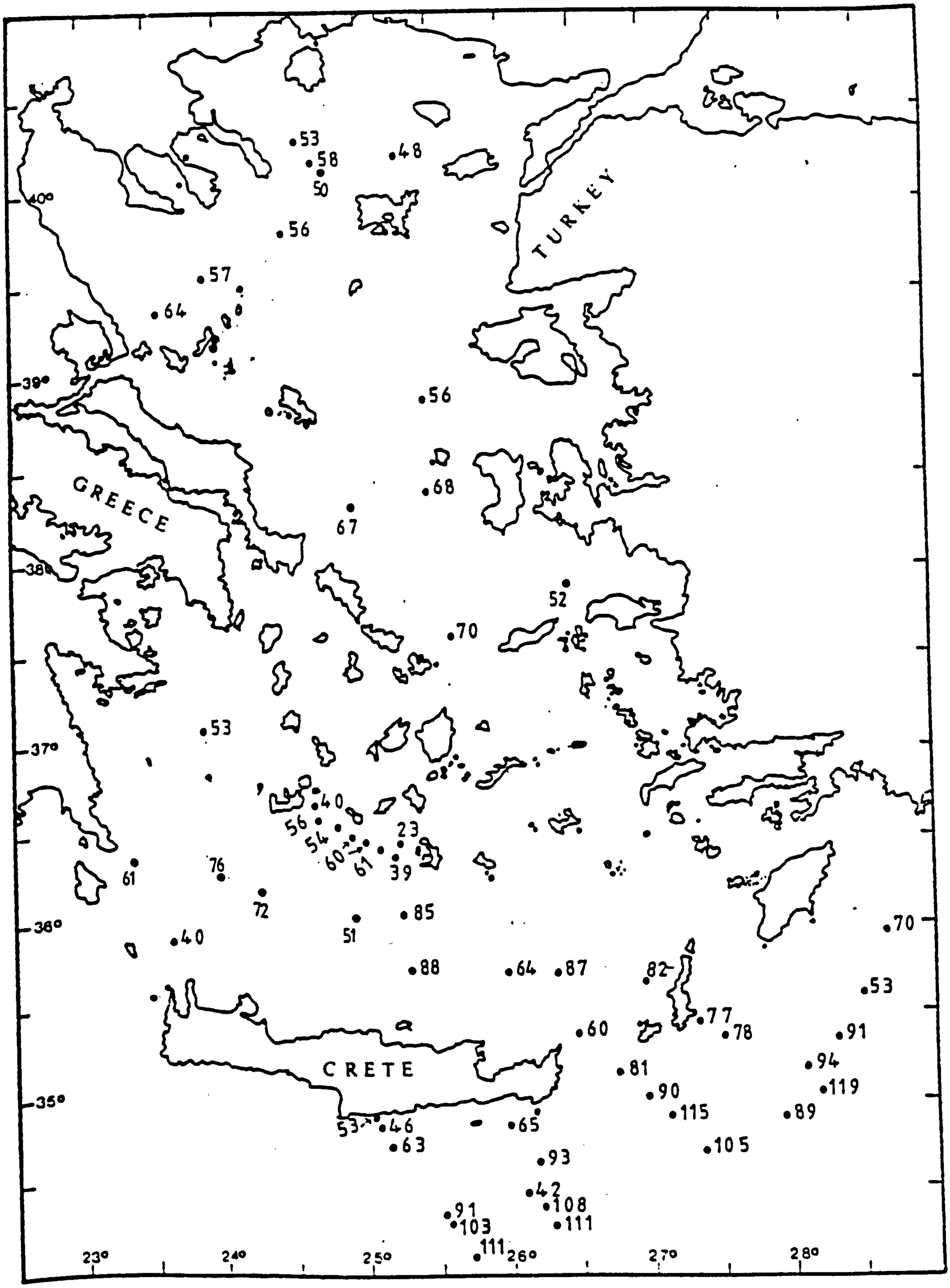


FIG. 39b. Copper distribution on a C.F.B. in the surface sediments in the study area. (Concentrations are given in ppm)

the range goes up to 119 ppm. A trend of increase in Cu is noticed from the shelf off Crete towards the trenches, to the south and southeast of Crete and Karpathos. It can be concluded that copper is higher in deeper zones than on the continental shelf in this area.

6.7 Lead: Pb seems to be independent of $CaCO_3$. From figure 32e it bears no clear relation to $CaCO_3$. It has a range between 10 and 110 ppm on a non C.F.B. The highest values are found in some of the northern Aegean sediments and between the islands of Thera and Milos. The lowest values are found in the southern Aegean where they are usually less than 50 ppm on a C.F.B. and sometimes as low as 10-20 ppm. South and southeast of Crete and Karpathos the range is between 50-100 ppm on a non C.F.B. The highest values are found in some of the trench area sediments. It is also noticed in this area that the lead content increases from the shelf off Crete to the south towards the trench area. When plotted on a C.F.B. the high lead values are again found in the area between Thera and Milos with average values of 170 and 209 ppm close to the islands and away from the islands respectively. Lead values increase from the island of Thera outward. A low average of 59 ppm on a C.F.B. is recorded in the southern Aegean, where a few samples have remarkably low lead values (Fig. 40). A similar low value is noticed east of Rhodes and south of Crete on the shelf. Again, it is noticed that the lead content of the sediments south of the island of Crete, increases from the shelf outwards towards the trench area, and a zone of slightly high lead is found with that noticed in the case of copper. The average values are 67.7 ppm on the shelf south of Crete and 113 ppm on C.F.B. in the

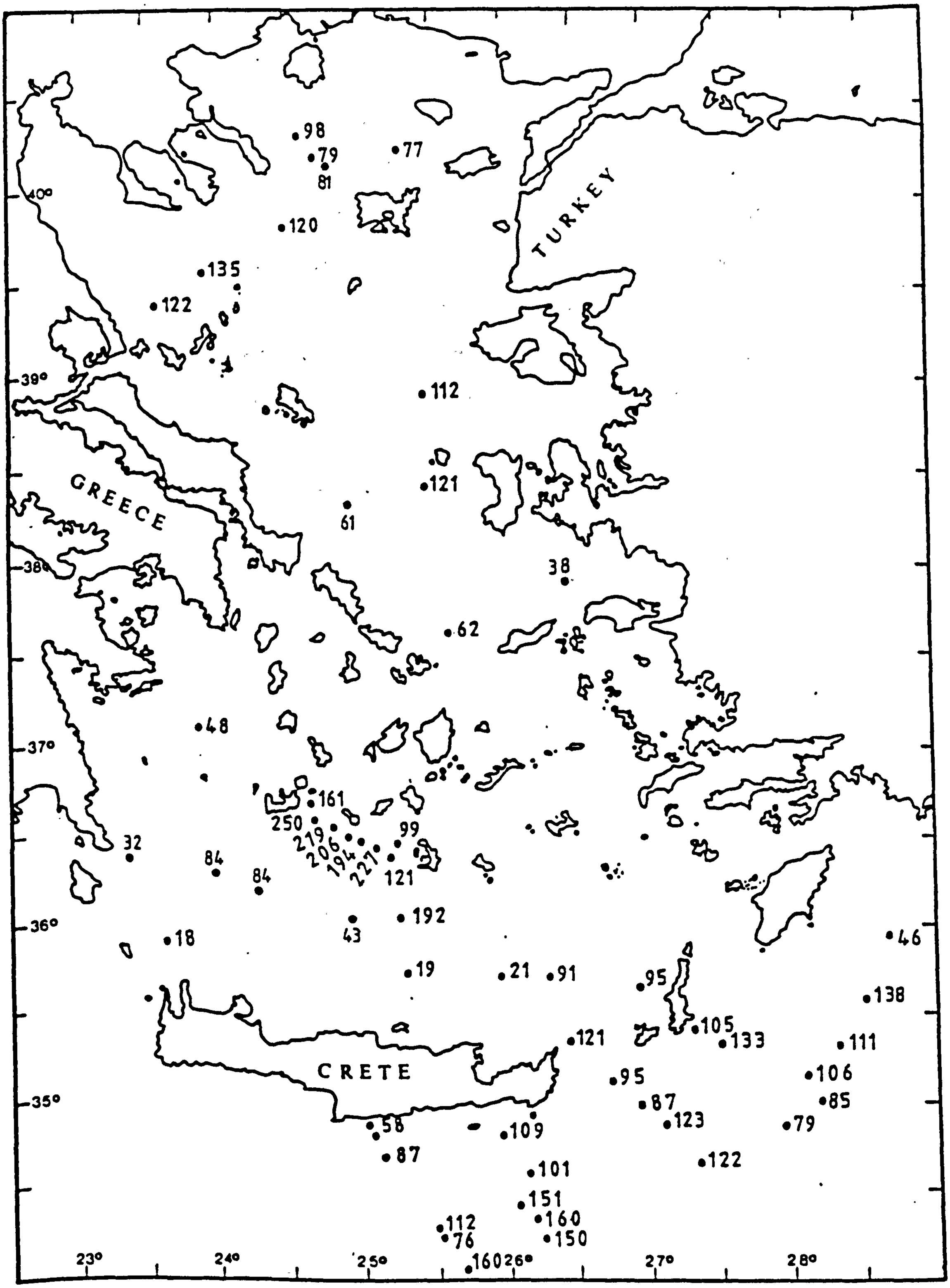


FIG. 40. Distribution of Lead in ppm on a C.F.B. in the surface sediments of the study area.

trench area.

6.8 Zinc: Zinc shows a clear trend of negative correlation with $CaCO_3$ (Fig. 32f), similar to that noticed in the case of iron. Low Zn occurs with high Ca CO_3 and vice versa. The highest zinc values are recorded in the northern and middle Aegean. The lowest values are found between the islands of Thera and Milos. The rest of the study area has a moderate range mostly confined to between 60 and 80 ppm on a non C.F.B. When considered on a C.F.B. again high Zn values are found in the northern Aegean and east of Karpathos. Low values are found between Milos and Thera. It is noticed that in the Santorini area between these two volcanic islands The low zinc values are, in most cases, associated with high Pb. South of the island of Crete the C.F. data show a very slight increase in Zn outward from the shelf to the south towards the deeps, (Fig. 41). However this increase is not as clear as in the case of copper and lead.

6.9 Nickel: When nickel is plotted against $CaCO_3$ no clear correlation is observed, and it appears in general that nickel is independent of $CaCO_3$ (Fig. 32k). Nickel has a range of 100 to 300 ppm on a non C.F.B. The lowest values are found in the northern and middle Aegean and in the area between Milos and Thera, areas that differ considerably in their $CaCO_3$ content in keeping with the independence of Ni and $CaCO_3$. These areas generally exhibit less than 150 ppm Ni on a non C.F.B. The sediments in other parts of the study area are found mostly to have moderate content of nickel, in the range of between 150-250 ppm on a non C.F.B. Few samples are found to have higher nickel content. The C.F.B. data (Fig. 42) show a similar distribution, namely

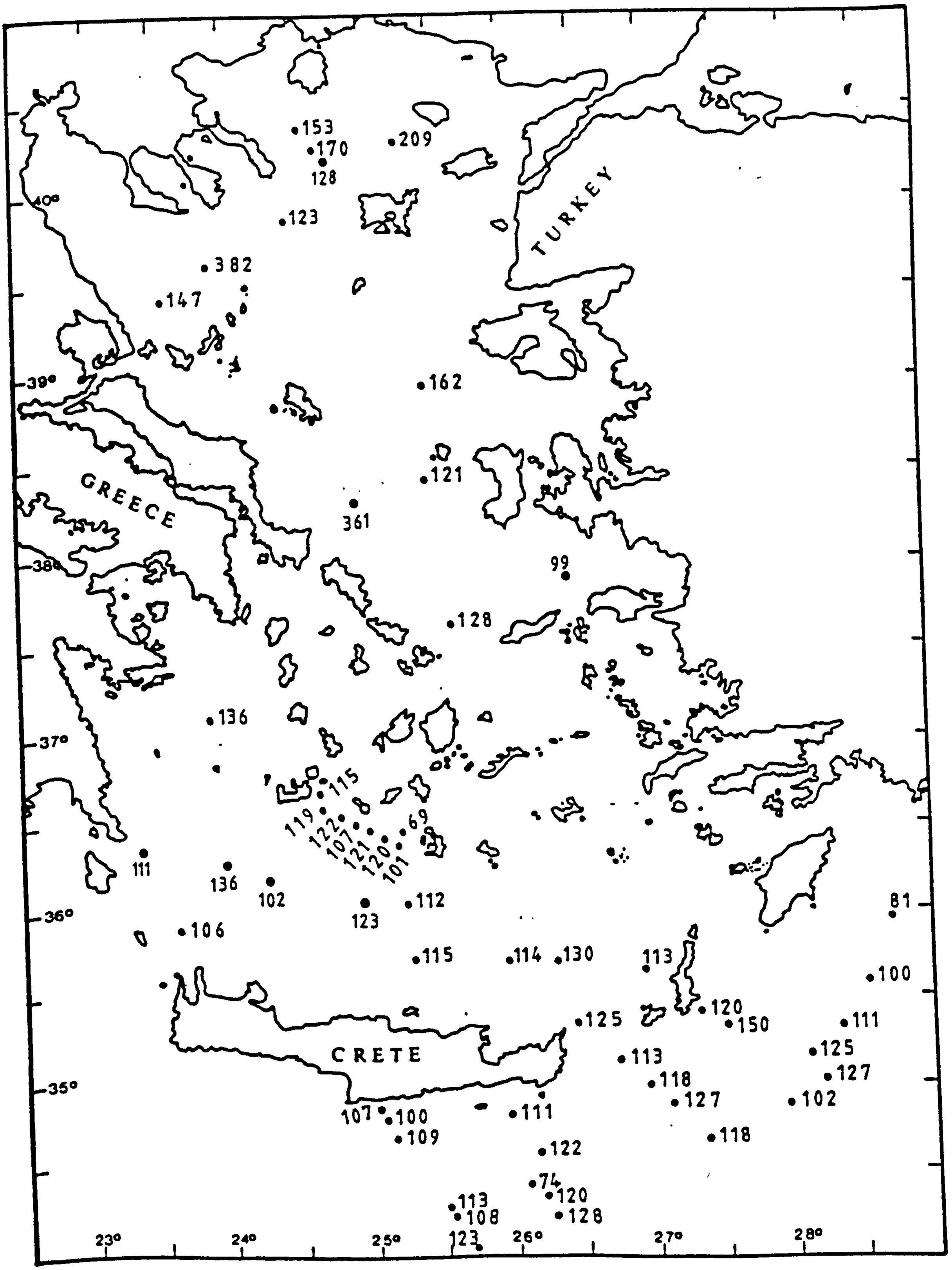


FIG. 41. Distribution of Zinc in ppm on a C.F.B. in the surface sediments in the study area.

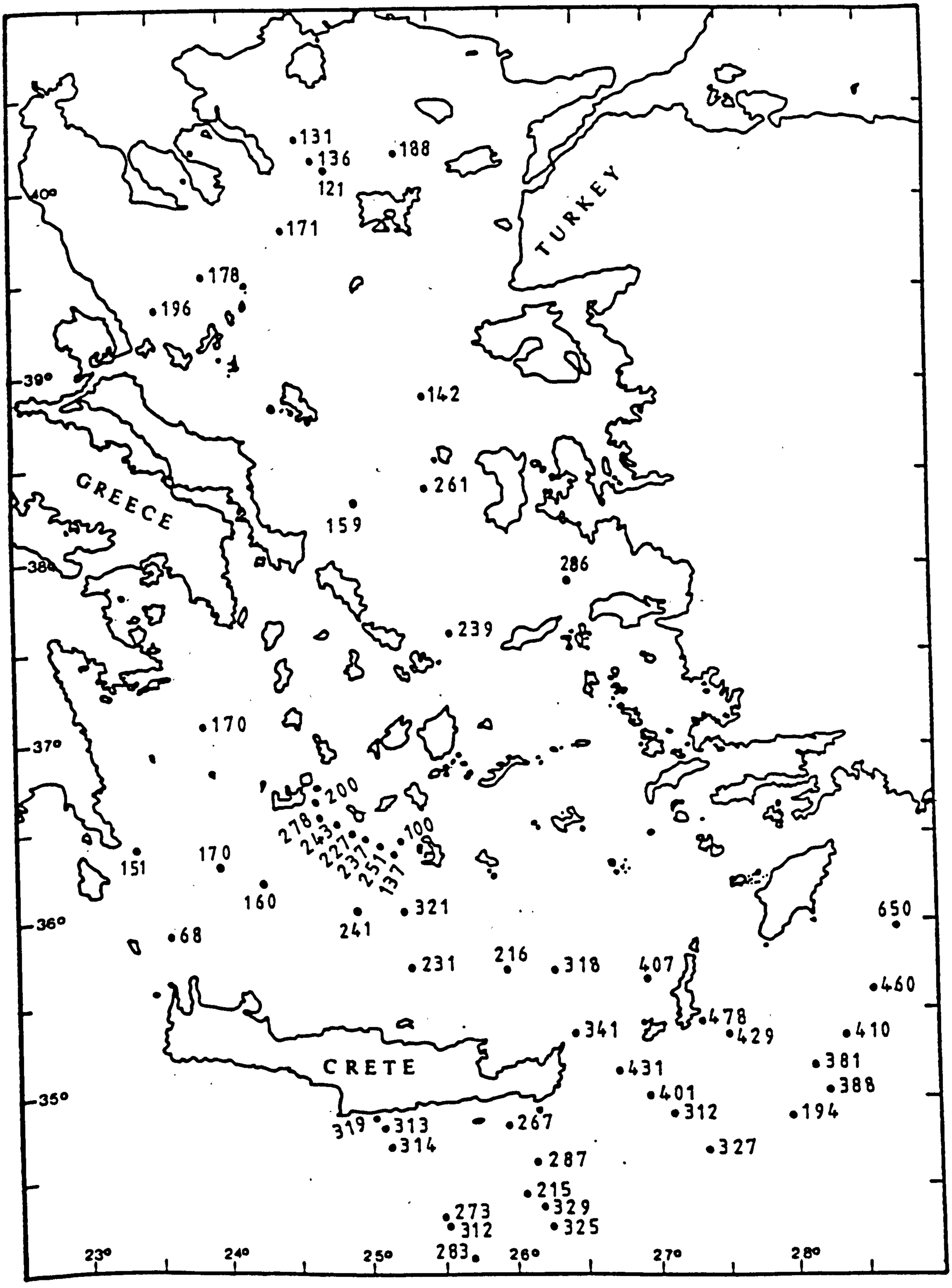


FIG. 42. Distribution of Ni in ppm on a C.F.B. in the surface sediments in the study area.

that Ni has very low concentrations in the northern Aegean and in the Santorini area. Other parts of the Aegean Sea have slightly higher values. South, southeast and east of Crete the Ni content of the surface sediments is very much higher. Very high Ni average values are recorded south of Turkey and east of Rhodes and Karpathos. A value of 650 ppm on a C.F.B. is recorded east of the island of Rhodes close to the southern shelf of Turkey. East of Karpathos the average Ni content of the sediments is 453.5 ppm on a C.F.B.

6.10 Chromium: Chromium shows a negative correlation with $CaCO_3$ (Fig. 32). It has a wide range, from 100-300 ppm on a non C.F.B. The northern Aegean sediments have slightly higher contents than elsewhere. The middle Aegean sediments are moderate in their Cr content. The southern Aegean has the lowest values. The rest of the study area has moderate values. The C.F.B. recalculation changes the figure completely, and the northern Aegean sediment turns out to be relatively poor in Cr, so are the middle and southern Aegean sediments. The averages are 255, 267 and 284 ppm on C.F.B. respectively. The highest value is recorded east of the island of Rhodes where a sample was found to contain 443 ppm Cr on a C.F.B. The south of Crete shelf sediments have an average value of 340 ppm on a C.F.B. (Table 7). It is noticed that Cr has higher values on the Cretan shelf than in the trench area. Unlike other elements, the chromium content of the sediments is found to decrease from the shelf outward to the south of Crete (Fig. 43).

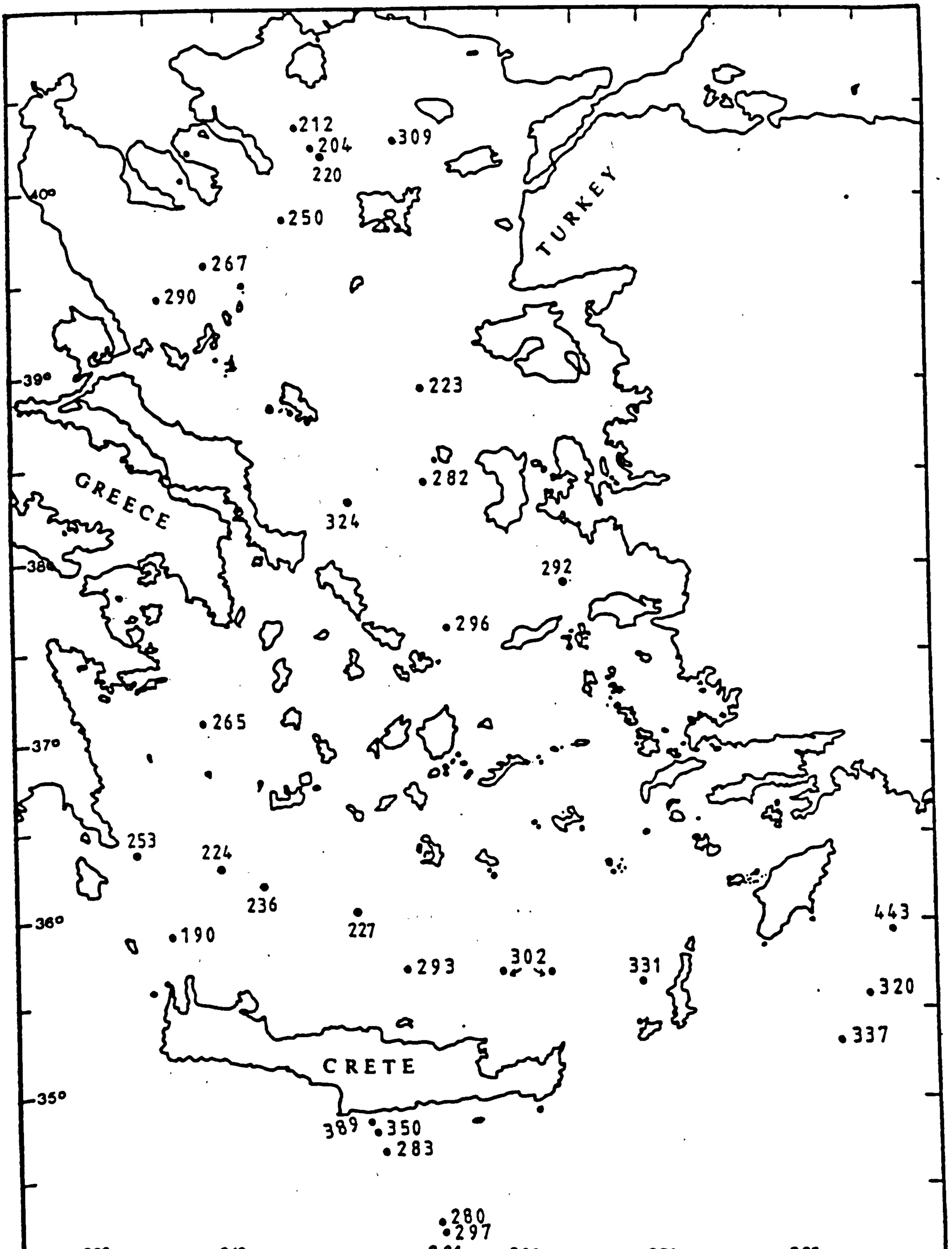


FIG. 43. Distribution of Cr in ppm on a C.F.B. in the surface sediments in the study area.

6.11 Cobalt: Correlation of cobalt with $CaCO_3$ shows that the element is independent of $CaCO_3$. The distribution of Co in the Aegean is similar to that noticed in the case of chromium. A relatively high content is found in the northern Aegean. The middle Aegean contains generally moderate values, and the lowest values are those of the southern Aegean. Some of the trench area sediments show high cobalt content (Fig. 32h). The C.F.B. recalculation of the data shows a similar trend for the northern and southern Aegean, but the middle now has the highest Co values with an average of 81 ppm. The south of Crete shelf sediments have an average of 61 ppm on a C.F.B. The values increase steadily from the shelf to the south towards the trench area, (Fig. 44).

6.12 Cadmium: Cd is independent of $CaCO_3$ (Fig. 32j). Most of the Aegean Sea sediments have very low Cd values under the detection limit of the method which is about 2 ppm. Only one sample from the middle Aegean was found to contain a high Cd content, slightly over 5 ppm. Other parts of the study area have a range between 2 and 5 ppm. On a C.F.B. the distribution of Cd shows that the middle Aegean has the highest average value of 27 ppm. The northern and southern Aegean have much lower values of Cd, near to the detection limit. Shelf sediments south of Crete have an average of 5 ppm on a C.F.B. This value increases to 9.7 ppm on a C.F.B. in the trench area. Again the trend of increase in element concentration is noticed south of Crete from the shelf outwards. One sample in the middle Aegean was found to have high Cd content, although other parts of the area do not show similar high values, (Fig. 45).

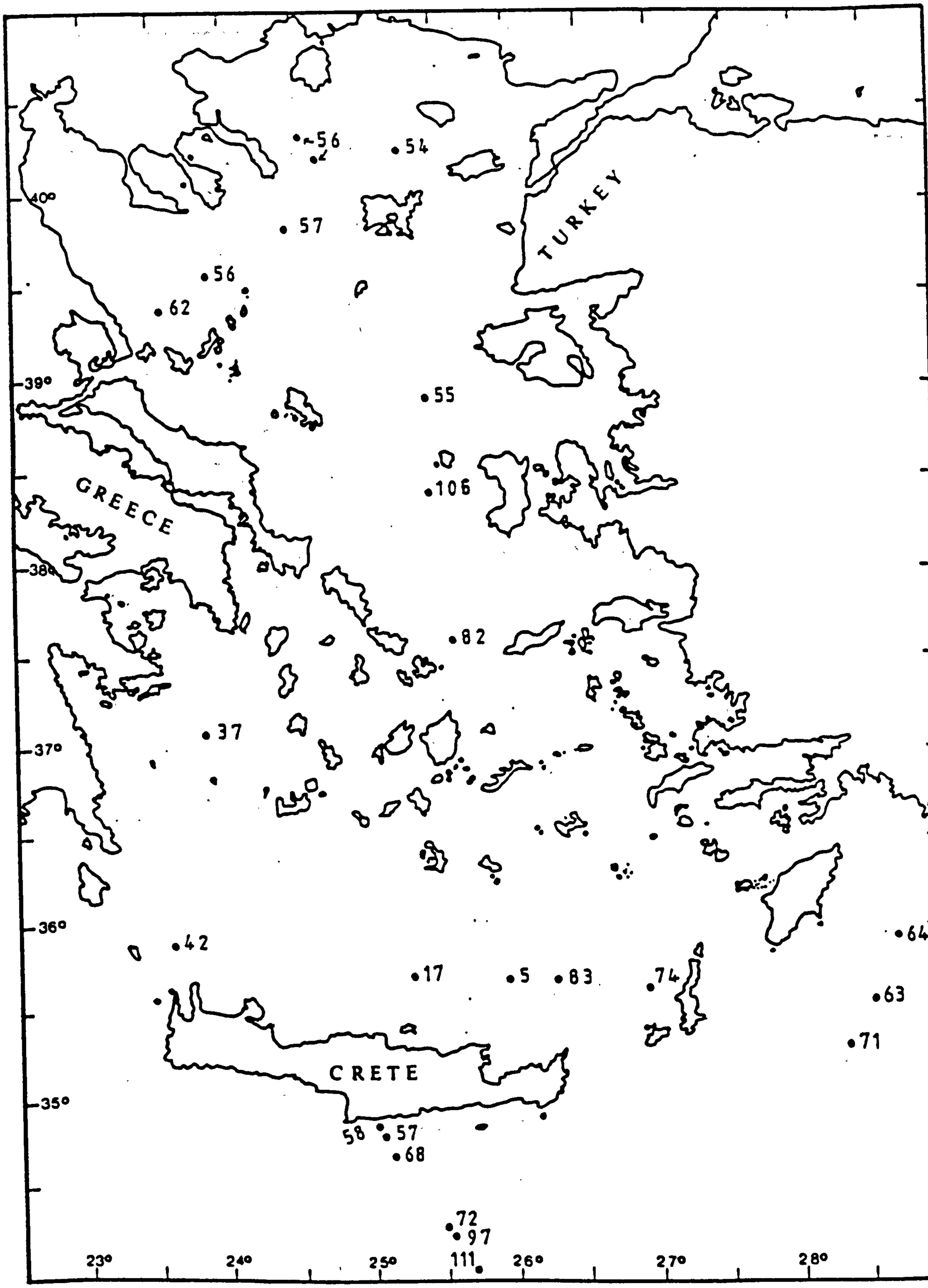


FIG. 44. Distribution of Co in ppm on a C.F.B. in the surface sediments in the study area.

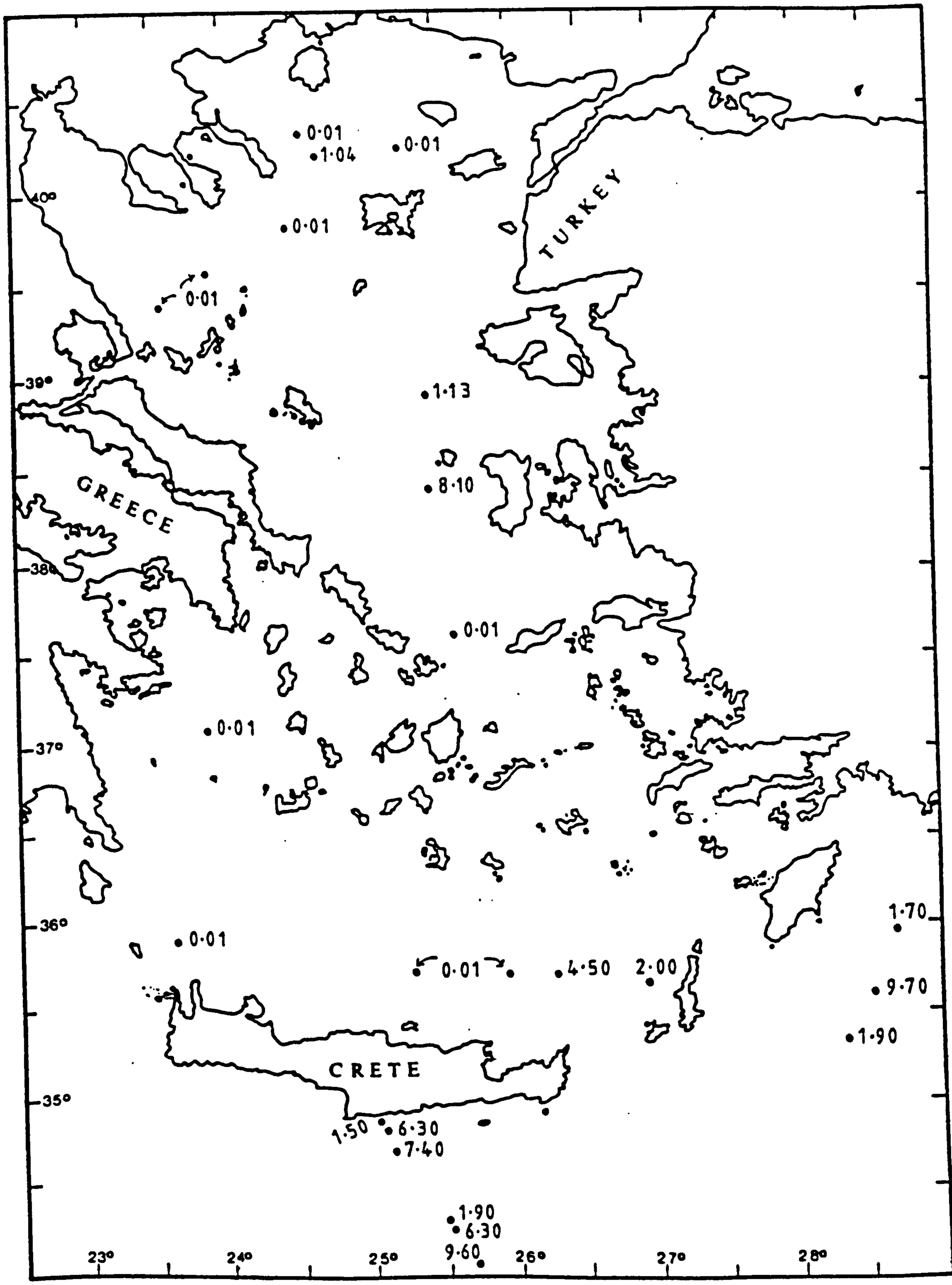


FIG. 45. Distribution of Cd in ppm on a C.F.B. in the surface sediments in the study area.

6.13 Titanium: Titanium has a negative correlation with $CaCO_3$, (Fig. 32L). It has a wide range, from 1,800 to 3,250 ppm on a non C.F.B. Sediments on the continental shelf off Crete seem to have higher values than sediments from the deeps. The shelf sediments south of Crete have Ti in the range between 2,850 and 3,250 ppm on a non C.F.B. The C.F.B. recalculation reverses the trend and the trench area sediments turn out to be the highest in Ti. It has an average of 4,067 ppm on a C.F.B. on the shelf south of Crete and a higher average of 4,430 ppm on a C.F.B. in the trench zone, but it does not have steady gradual increase from the shelf outward towards the trench area, (Fig. 46 and Table 7).

6.14 Organic Carbon: The relation between organic carbon and carbonate, as seen from figure 32M, shows that the organic carbon has a negative correlation with calcium carbonate. The carbonate rich sediments tend to be poor in organic carbon and vice versa. The organic carbon values vary from 0.55% to 1.64%. The highest values are recorded in the northern and middle Aegean while the lowest values are found in the area between the islands of Thera and Milos.

Figure 47 is a map of the distribution of organic carbon in the surface sediments. In the northern Aegean Sea the range is 1.15 to 2.06%. A sample south to the island of Nisos Thasos has the highest organic carbon content of 2.06%. The average organic carbon content in the northern Aegean is 1.49%. A similar average is recorded for the middle Aegean surface sediments where the range is 1.34 to 1.58% and the average is 1.45%. The southern Aegean has a range from 0.49 to 1.71% and an average of 1.05%. The sediments between the volcanic islands of Thera and Milos have lower organic carbon content in the range from 0.41%

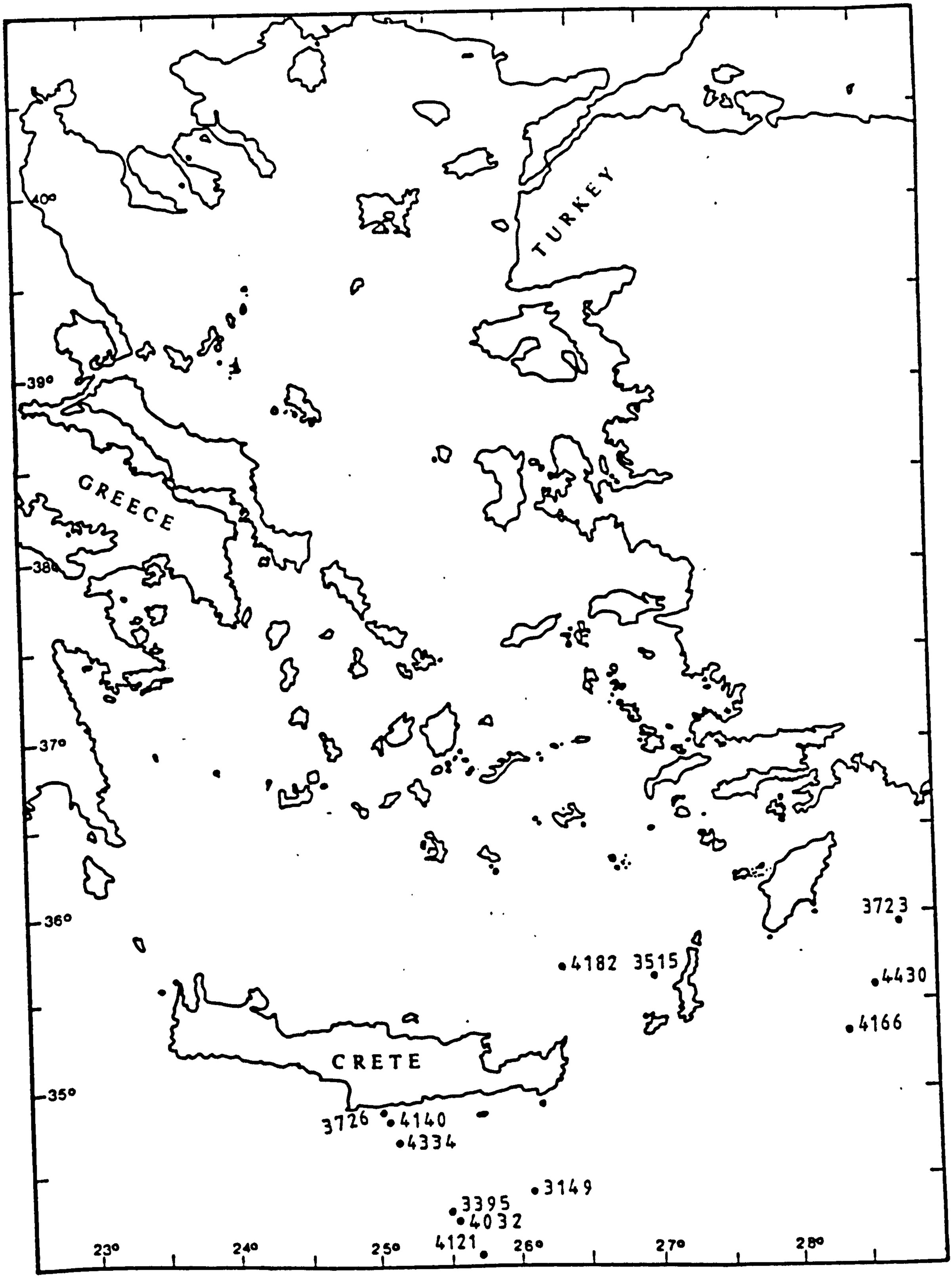


FIG. 46. Distribution of Ti in ppm on a C.F.B. in the surface sediments in the study area.

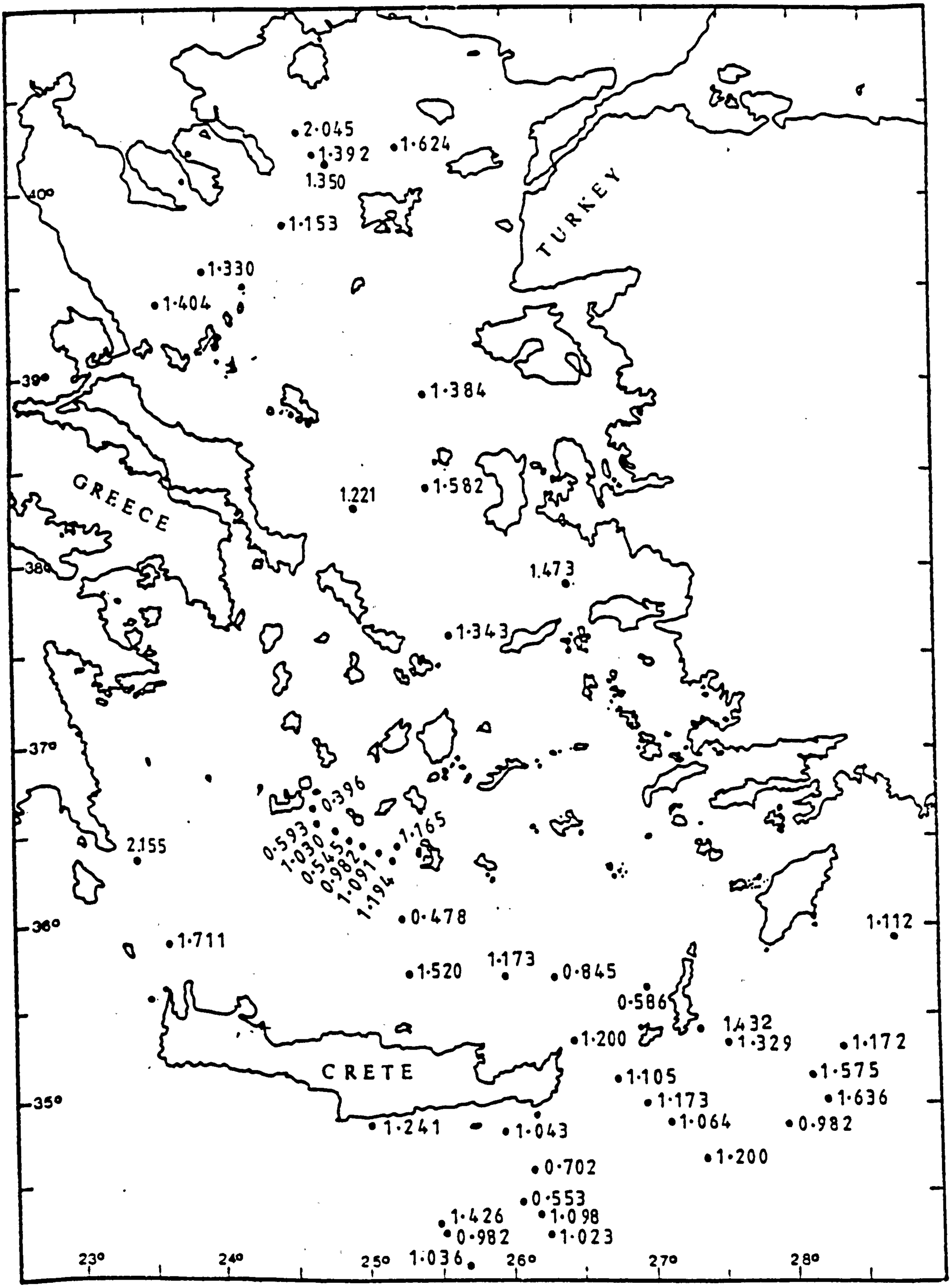


FIG. 47. Distribution of Organic Carbon in percent in the surface sediments in the study area.

to 1.19%. The average in this area is the lowest average value in the entire Aegean Sea. It is 0.88%. To the south of Crete the values are 1.04% and 1.2% organic carbon. Similar average values are recorded for the shelf sediments east of the islands of Karpathos and Rhodes. The averages are 1.38% and 1.11% on the shelves east of Karpathos and Rhodes respectively. Further to the south of the island arc the sediments in the trench area have organic carbon in the range from 0.55% to 1.65%. The average calculated for a few sediment samples in this area is 1.13%. For further data see tables 9 & 10 and fig. 47. It is noticed that in and around the deeps the organic carbon content fluctuates from low values of 0.55% to high values, as high as 1.65%. The following are examples of relatively low and high values recorded:-

Sample No.	Low Organic Carbon	Sample No.	High Organic Carbon
697-1	0.98%	709-1	1.65%
702-1	0.55%	708-1	1.59%

6.14a Correlation of elements with organic carbon:

Figures 48a to 48l show the variation of element concentrations with the organic carbon content, in the surface sediments studied in both the Eastern Mediterranean and Aegean Seas. The elements can be divided into three groups:

A) Elements positively correlated to organic carbon:

This group includes iron, titanium and cadmium. The northern and middle Aegean surface sediments have the highest values of both organic carbon and iron. The southern Aegean sediments and the eastern Mediterranean sediments have lower contents of both variables. The lowest values are recorded in the area between the two volcanic islands, Thera and Milos.

Table 9 Concentration of Organic Carbon in the Surface Sediments of the Eastern Mediterranean and Aegean Seas.

Sample No.	C org. %	Sample No.	C org. %
689-1	0.845	1110-1	1.227
690-1	0.586	1111-1	0.396
691-1	1.112	1112-1	0.593
693-1	1.172	1113-1	1.030
694-1	1.241	1114-1	0.545
697-1	0.982	1115-1	0.982
698-1	1.036	1116-1	1.091
699-1	1.426	1119-1	0.478
700-1	1.043	306-1	1.153
701-1	0.702	307-1	1.330
702-1	0.553	308-1	1.404
703-1	1.098	309-1	1.624
704-1	1.023	310-1	1.350
705-1	1.200	311-1	1.392
706-1	1.432	312-1	2,045
707-1	1.329	313-1	1.384
708-1	1.575	314-1	1.221
709-1	1.636	315-1	1.582
711-1	0.982	316-1	1.473
712-1	1.173	317-1	1.343
713-1	1.064	318-1	3.375
714-1	1.105	319-1	2.155
715-1	1.200	320-1	1.711
1108-1	1.165	323-1	1.520
1109-1	1.194	324-1	1.173

Table 10 The Average Organic Carbon Content in the Surface Sediments in the Different Parts of the Eastern Mediterranean and Aegean Seas

Area	C.org.%
N. Aegean	1.491
M. Aegean	1.436
S. Aegean	1.052
Santorini area	
a) Close to the islands	0.876
b) Away from the islands	0.873
South of Crete shelf sediments	1.241
Trench zone	0.55 - 1.64
East of Crete and the Cretan Strait	1.200
East of Rhodes	1.112
East of Karpathos	1.381

B) Elements indépendent of the organic carbon:

This group indicates manganese, aluminium, copper, nickel, chromium, zinc and cobalt.

C) Elements with a slight negative correlation with organic carbon:

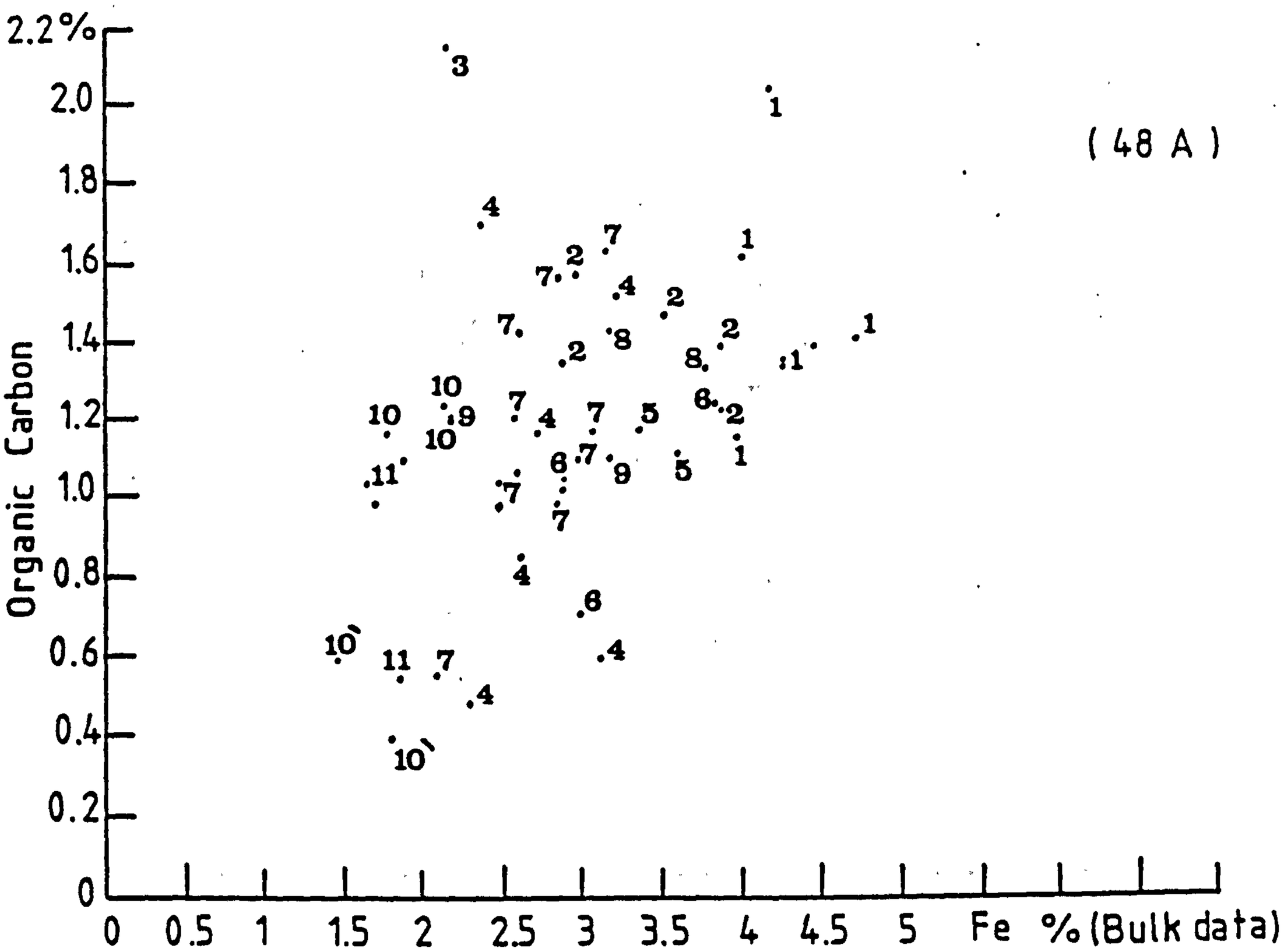
This group includes magnesium and lead. Magnesium shows a similarity to the case of carbonate.

It is noticed that the northern Aegean carbonate poor sediments are rich in the organic carbon.

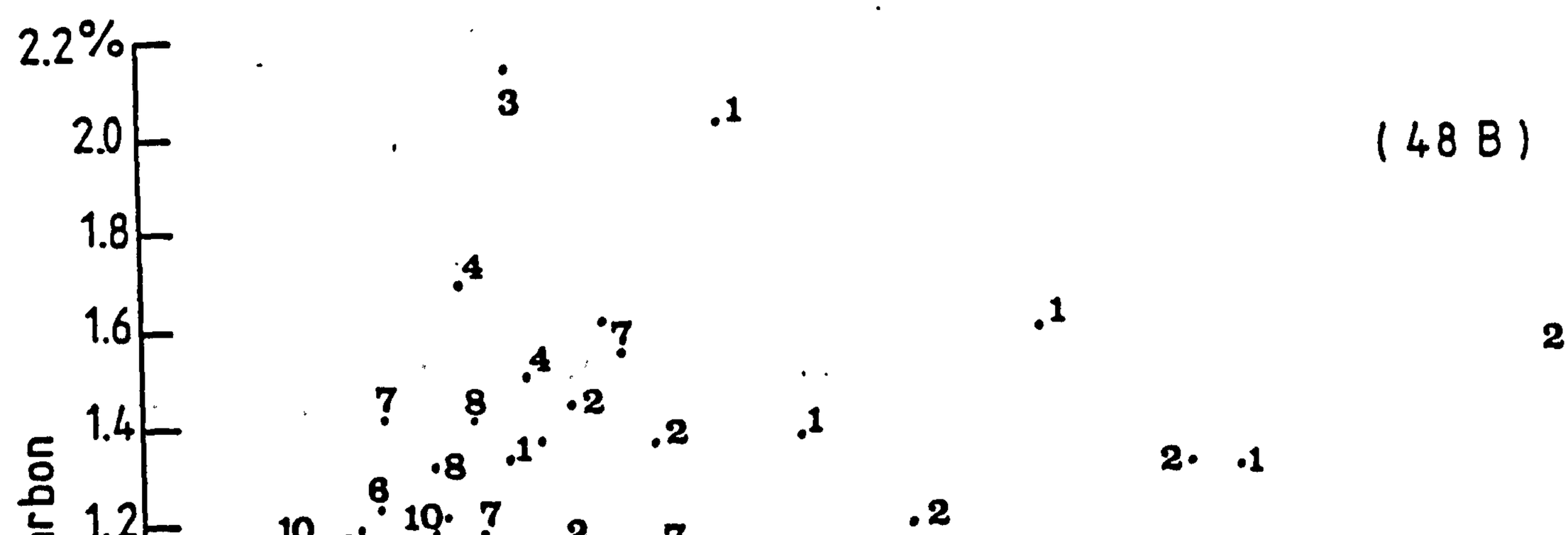
6.15 Chemistry of the size fractions in the surface layer sediments

For all the surface sediments in the study area the fraction less than 63 microns was separated by wet sieving and then dried and analysed for the same group of elements as the total sample. For a few selected samples the analyses were carried out on fractions larger than 950 microns and larger than 63 microns. Further analyses were made on the fraction less than 2 microns and the fraction between 63 and 2 microns. All fractions were dried and attacked by the HF, nitric, perchloric attack,and the elements concentrations were determined by atomic absorption using a Perkin Elmer 403 as described in Chapter Two. The elements determined include iron, manganese, aluminium, lead, zinc calcium, magnesium, chromium, cobalt, cadmium, nickel and titanium. The carbonate content was calculated from the calcium values using a computer program,in the same way it is calculated for the total sediment sample. Table 11 summarizes the analytical data and compares the content of each element in the fraction less than 63 microns to that found in the total sediment sample. The following is a summary of the result of the study of the size fractions chemistry.

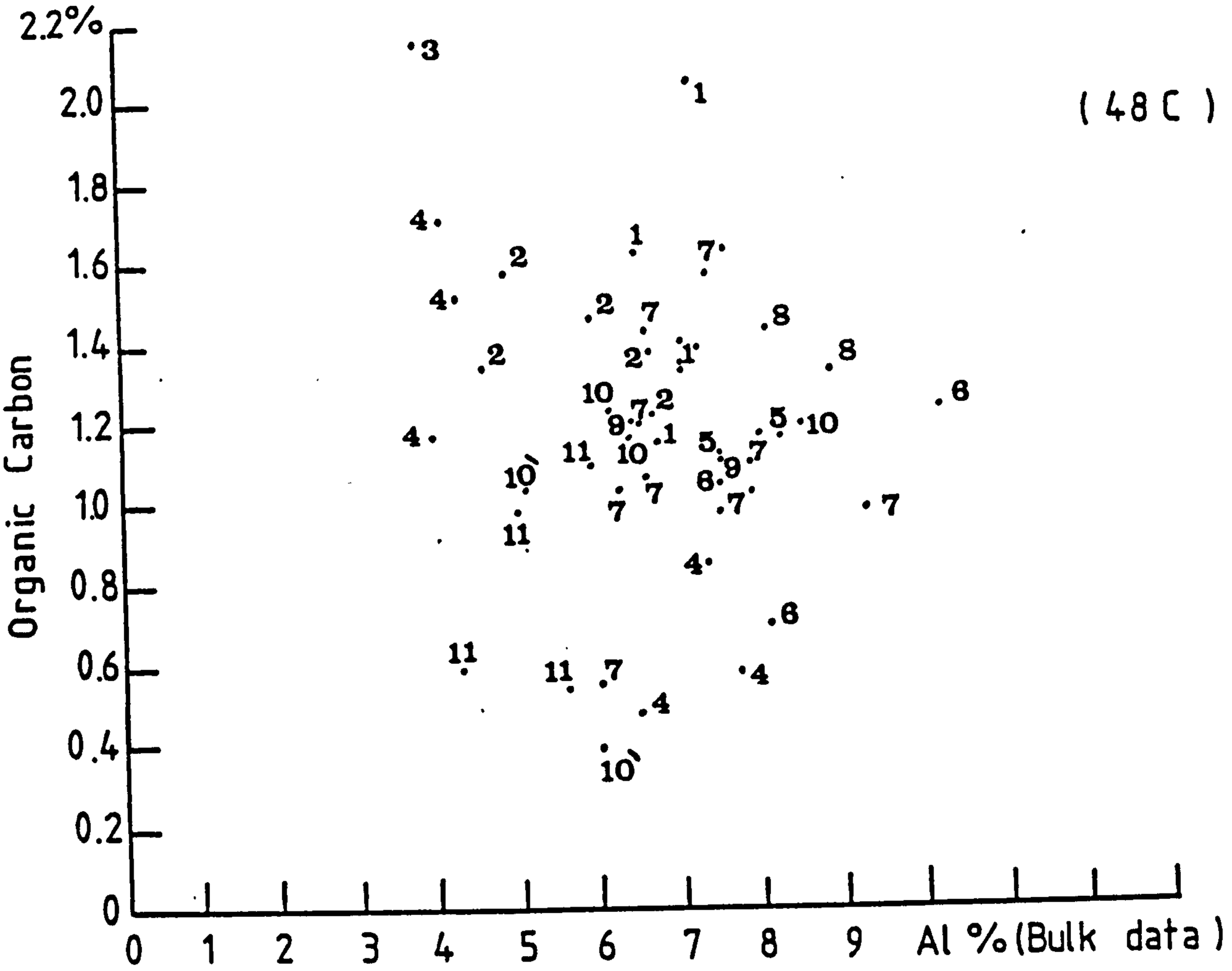
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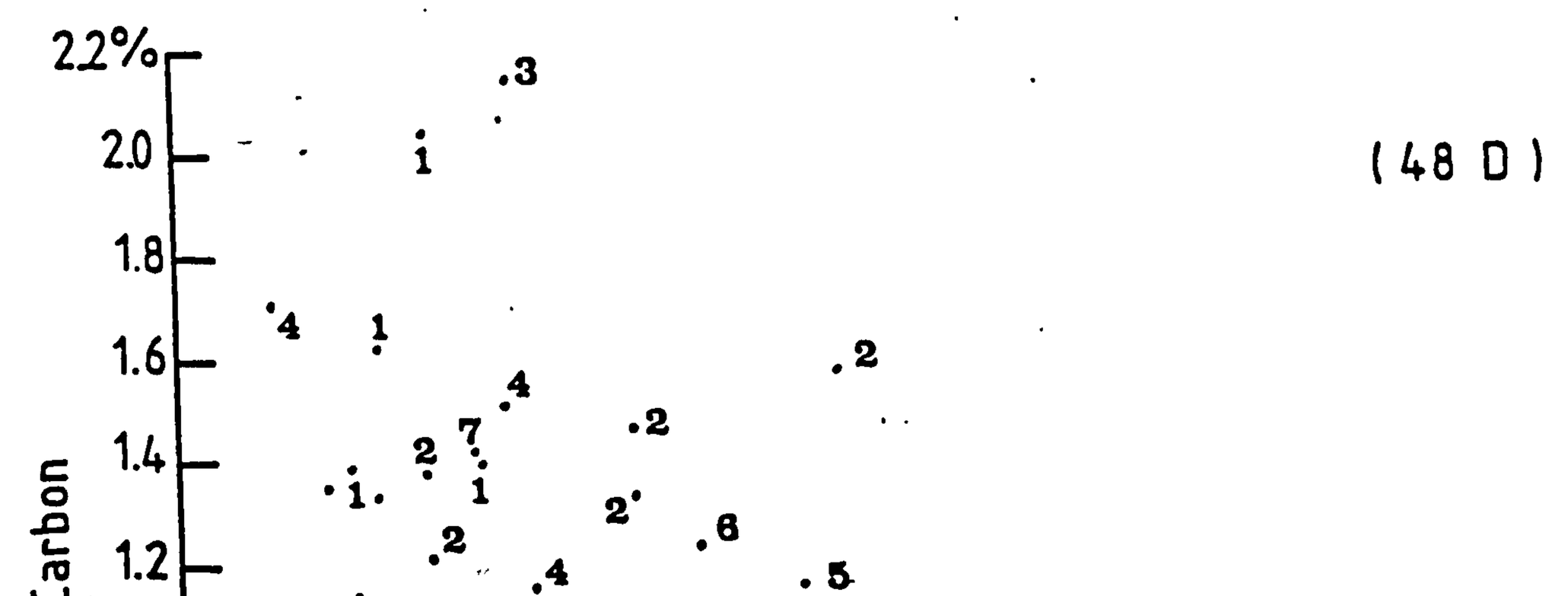

2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Organic Carbon
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 Fe % (Bulk data)

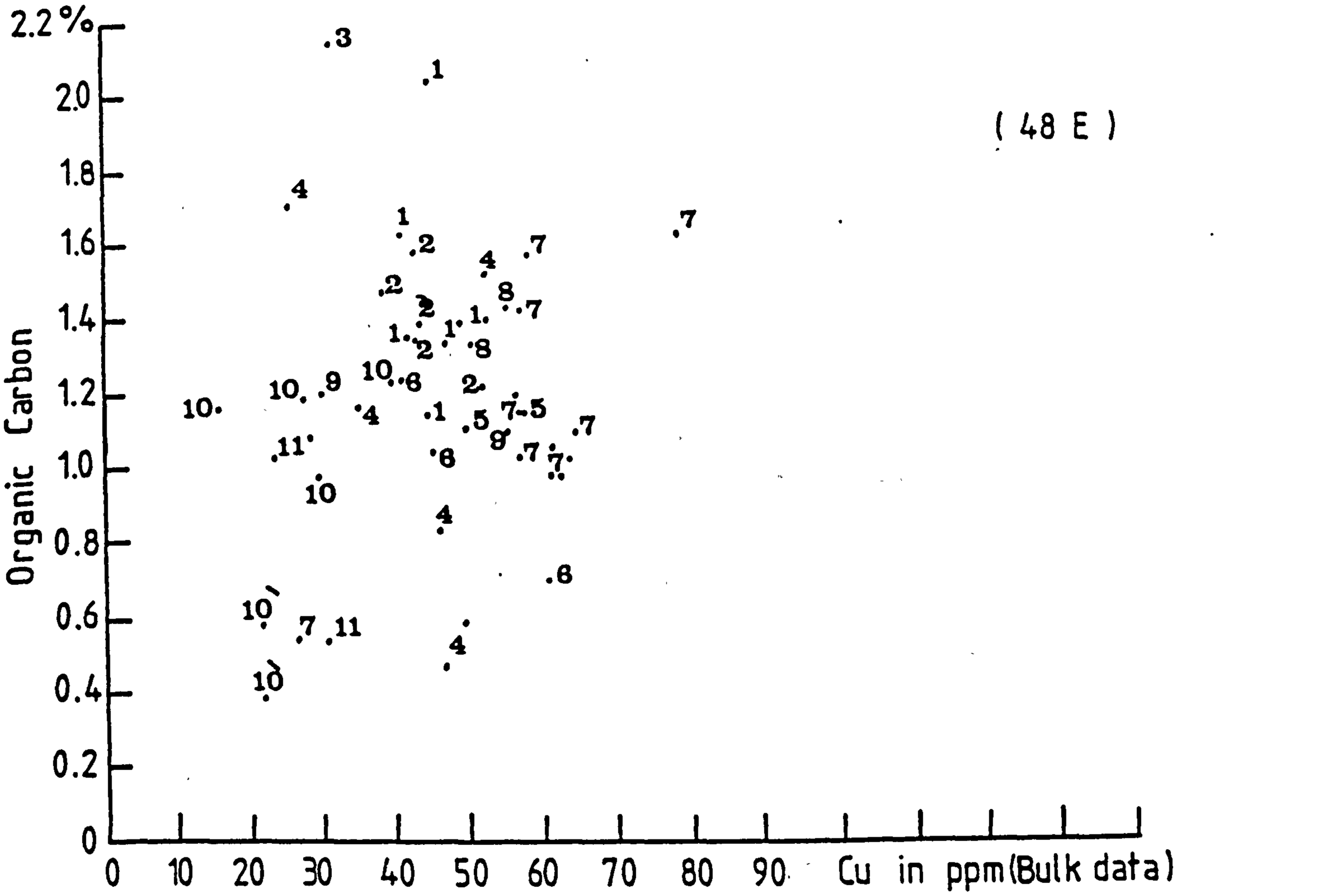
(48 A)

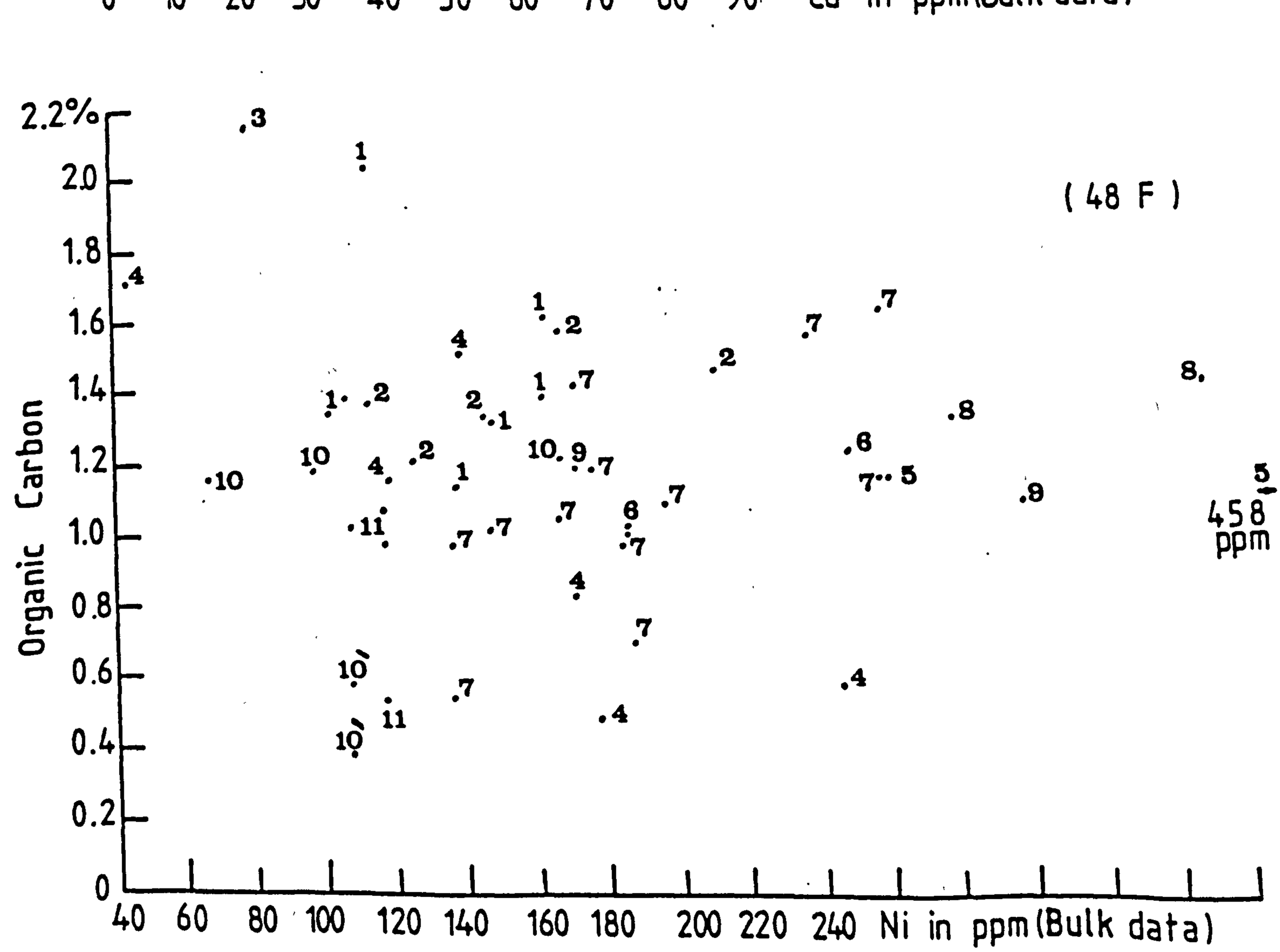

2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Organic Carbon
0 300 600 900 1200 1500 1800 2100 2400 2700 Mn in ppm (Bulk data)

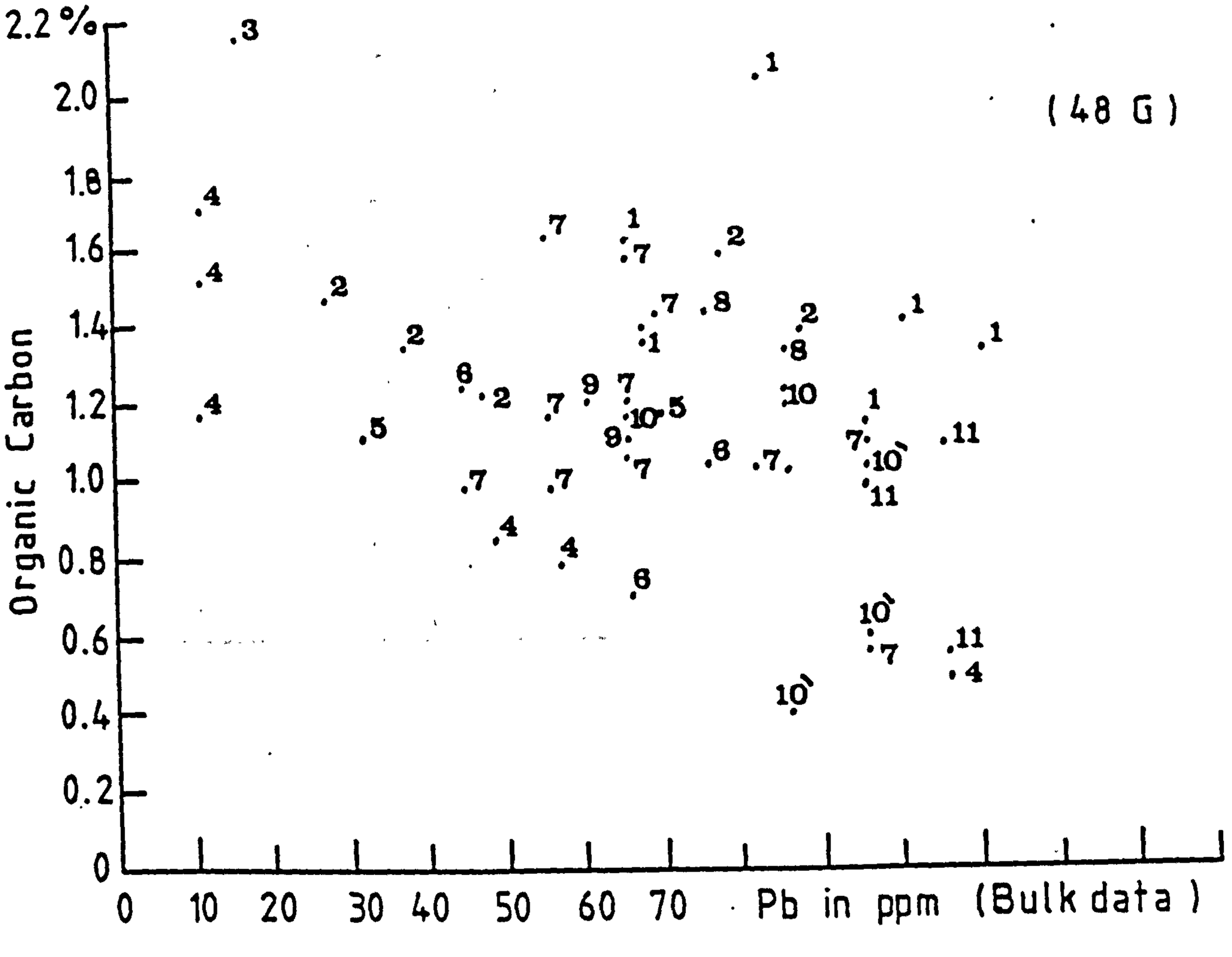
(48 B)

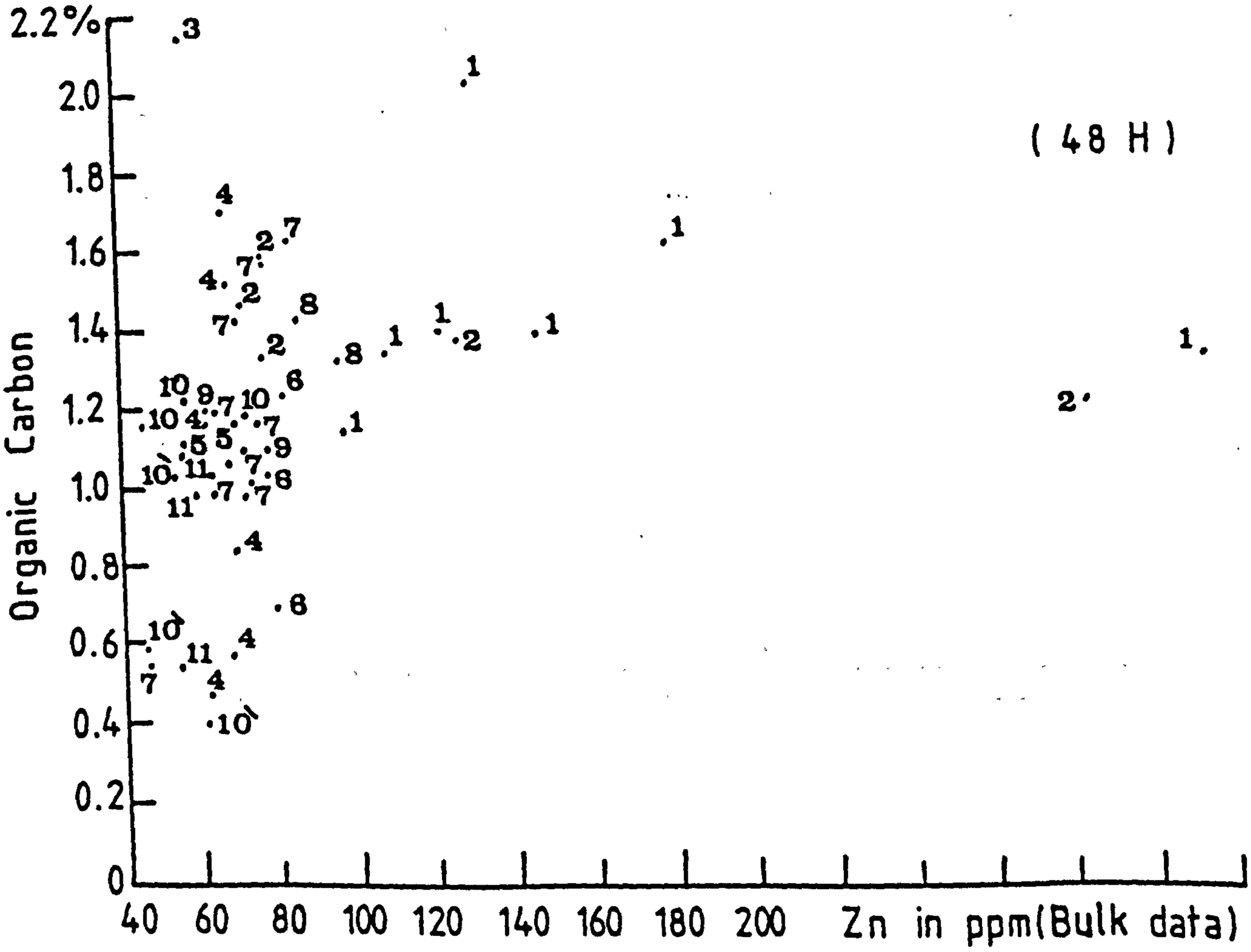

(48 C)
Organic Carbon
2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 Al % (Bulk data)


(48 D)
Organic Carbon
2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 Mg% (Bulk data)

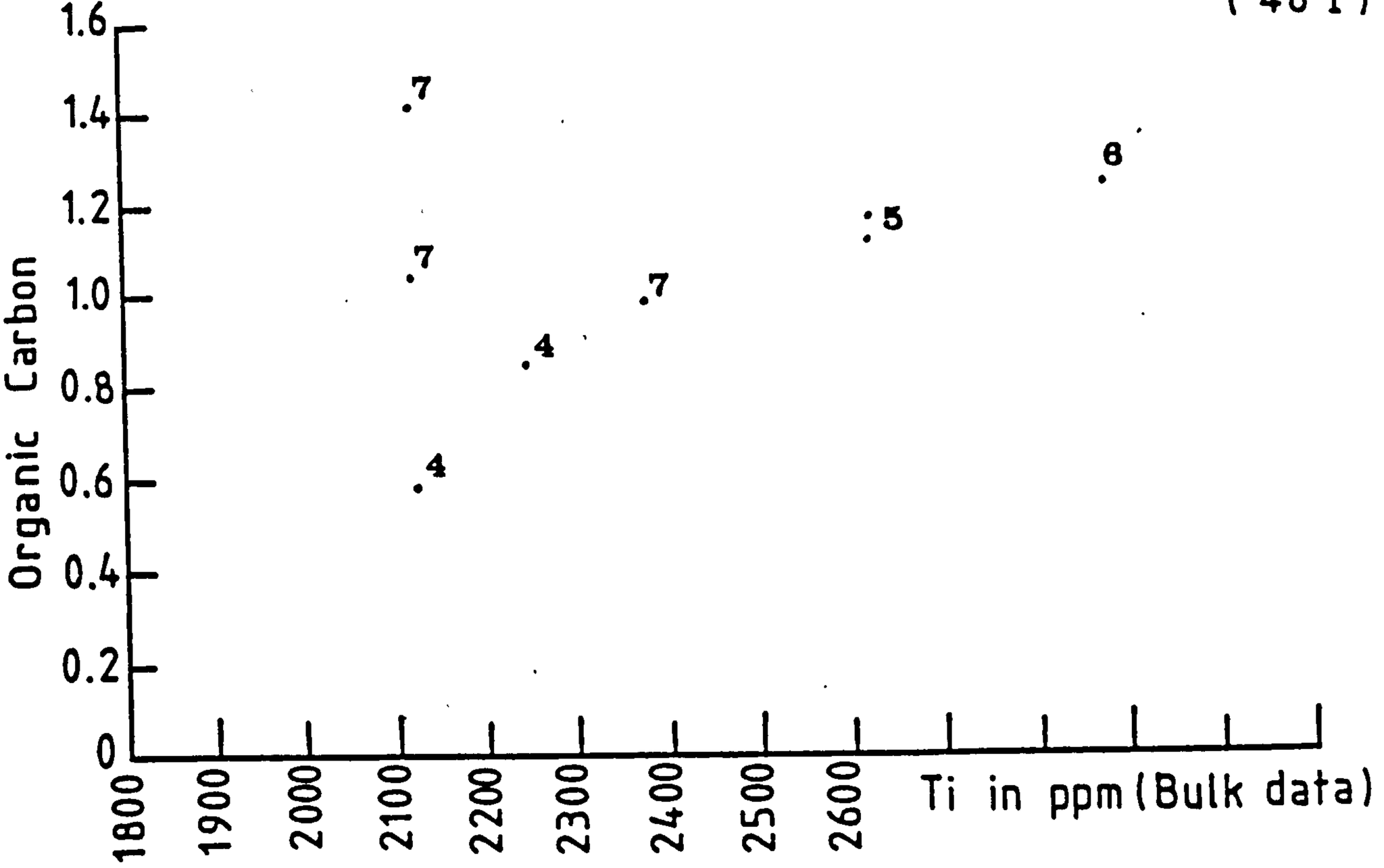

(48 E)
Organic Carbon
2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0 10 20 30 40 50 60 70 80 90
Cu in ppm (Bulk data)


(48 F)
Organic Carbon
2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
40 60 80 100 120 140 160 180 200 220 240
Ni in ppm (Bulk data)

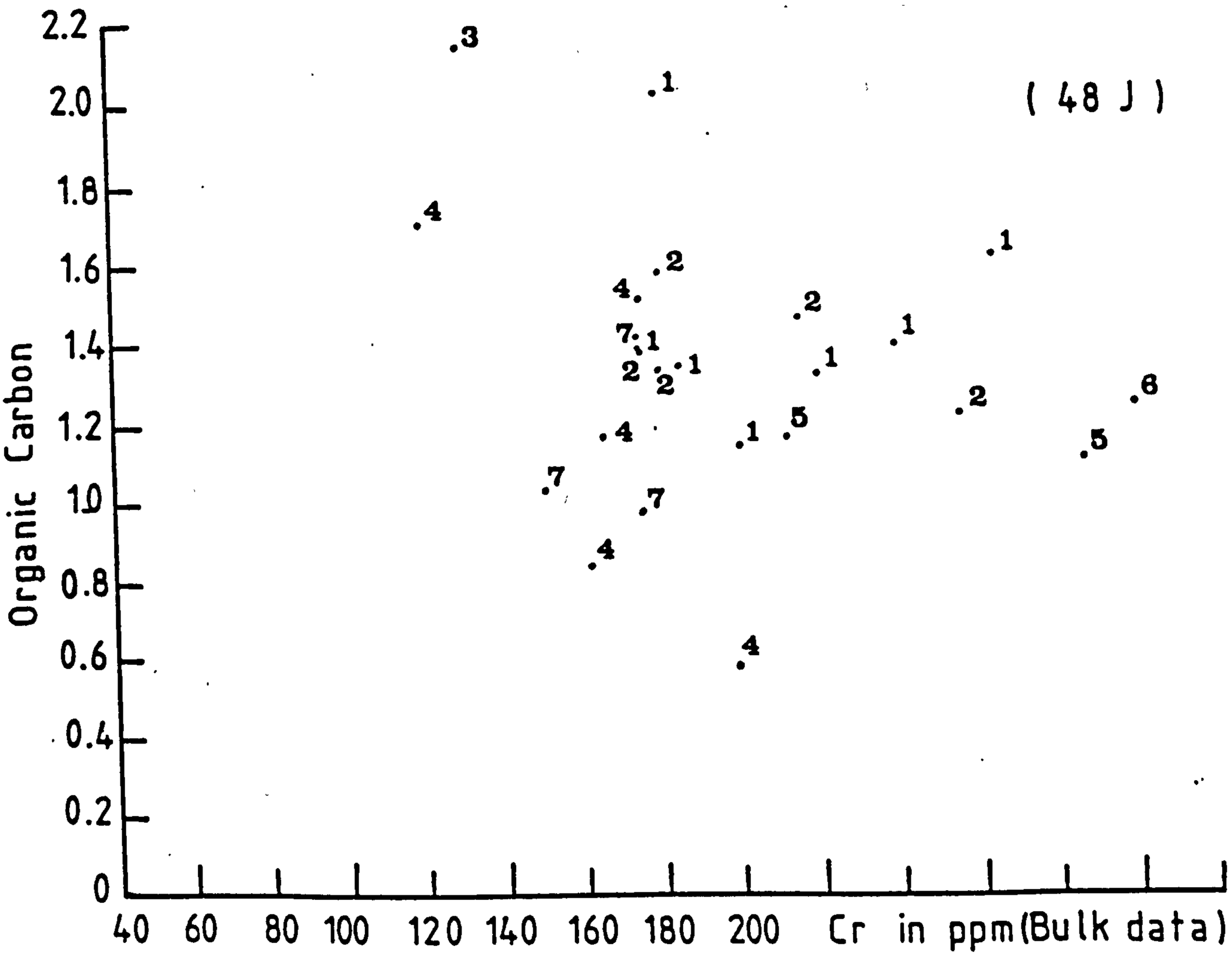

(48 G)
Organic Carbon
2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
0 10 20 30 40 50 60 70
Pb in ppm (Bulk data)

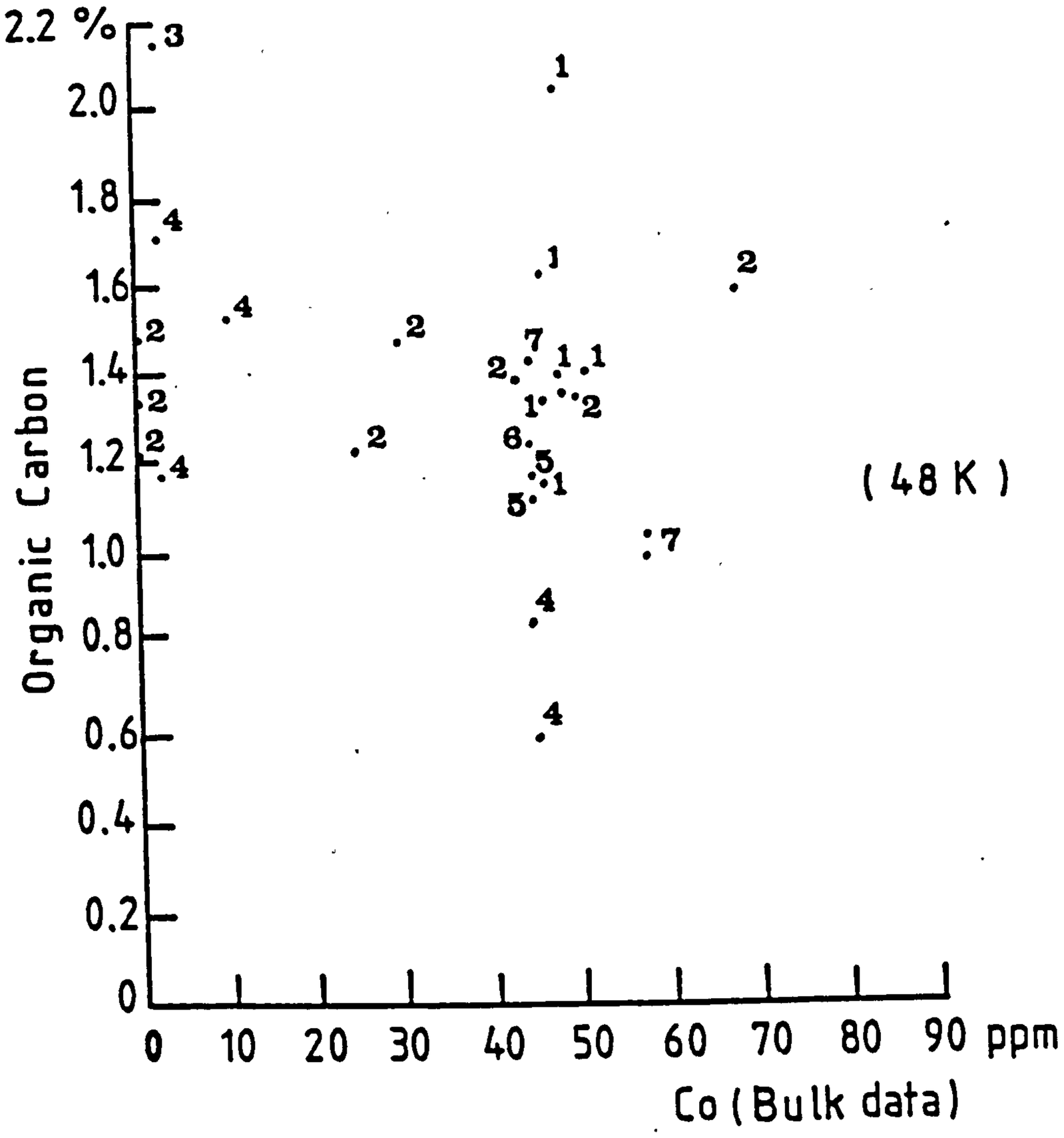

(48 H)
Organic Carbon
2.2%
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
40 60 80 100 120 140 160 180 200
Zn in ppm(Bulk data)

(48 I)


Organic Carbon
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1800
1900
2000
2100
2200
2300
2400
2500
2600
Ti in ppm (Bulk data)

(48 J)


Organic Carbon
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
40
60
80
100
120
140
160
180
200
Cr in ppm (Bulk data)



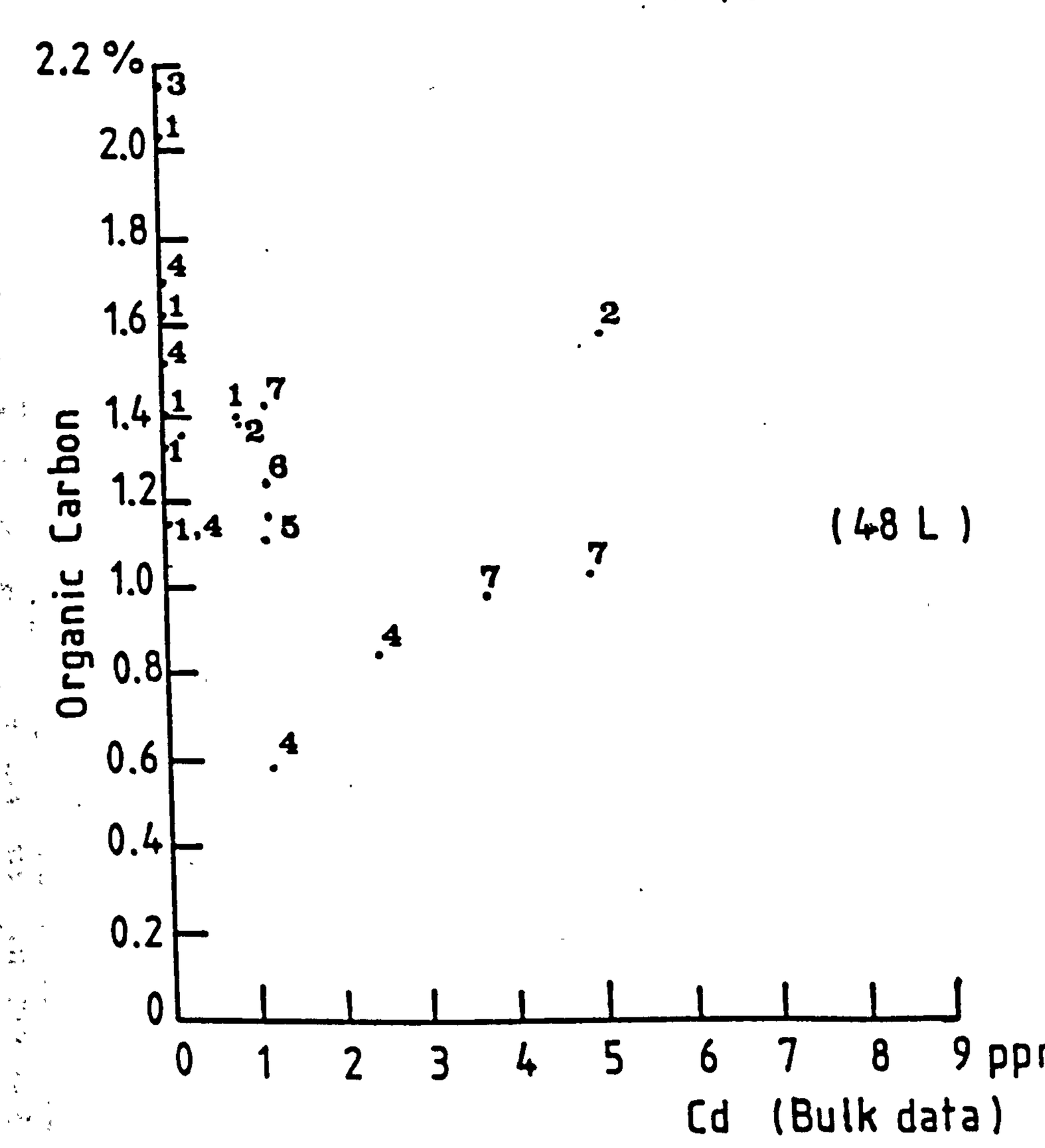


Fig.48(A to L) Correlation of elements with Organic Carbon.

Table 11 Comparison between the chemical analysis data of the size fraction less than 63 micron and those of the total sample in the surface sediments of the Eastern Mediterranean and Aegean Seas (Ion carbonate free basis data)

Sample No	$CaCO_3$ %		FE %		Mn ppm		Al %		PB ppm		ZN ppm		NI %		CR ppm		CO ppm		CD ppm		NI ppm		TI ppm	
	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M
306-1	20.02	19.21	4.00	4.10	1300	1500	6.75	7.20	100	59	98	134	1.95		200	160	46	3.6	n.d.	n.d.	137	125		3500
307-1	17.72	17.68	4.30	4.40	1870	4200	7.05	7.00	111	59	314	106	2.00		220	170	46	13.6	n.d.	n.d.	147	135		3600
308-1	17.21	15.64	4.75	4.50	2050	2200	7.05	7.40	101	49	122	274	2.20		240	190	51	13.6	n.d.	n.d.	162	155		3500
309-1	14.14	14.37	4.05	4.30	2800	4700	6.50	7.30	66	49	179	192	2.00		265	160	46	13.6	n.d.	n.d.	162	95		3500
311-1	14.41	15.90	4.50	4.40	1250	1800	7.25	6.90	68	49	146	474	1.95		175	190	48	13.6	n.d.	n.d.	117	105		3300
312-1	15.05	16.66	4.25	3.95	1800	1450	7.20	7.15	83	59	130	158	2.1		180	135	48	6.8	0.9	0.5	112	90		3750
N. Aegean Average	16.43	16.50	4.31	4.275	1845	2642	6.97	7.16	88.2	54	164.8	236.3	2.03		213.3	167.5	47.5	10.77	0.157	0.09	139.5	117.5		3525
315-1	36.08	37.01	3.00	3.10	4450	2350	4.85	4.85	78	59	77	105	2.90		180	150	68	13.6	5.1	1.50	167	155		2600
313-1	21.67	25.82	3.90	3.80	1600	1900	6.65	6.40	88	39	127	142	2.10		175	150	43	13.6	0.9	n.d.	112	105		3000
314-1	21.39	36.50	3.90	3.10	2400	5400	6.65	5.00	48	39	284	142	2.10		255	140	25	23.6	n.d.	n.d.	125	125		2500
316-1	26.49	26.33	3.55	4.10	1350	1800	5.95	5.90	28	29	73	90	2.50		215	190	30	3.6	n.d.	n.d.	210	215		3000
317-1	39.09	41.08	2.90	3.10	3250	1500	4.55	4.50	38	39	77	102	2.50		180	160	50	3.6	n.d.	1.5	145	145		2400
M. Aegean Average	28.94	33.35	3.45	3.44	2610	2590	5.73	5.33	56	41	127.6	117.8	2.42		201	158	43.2	11.59	1.21	0.61	151.8	148.7		2700
318-1	31.96	36.50	2.80	2.90	835	1100	5.15	4.90	33	49	92	114	2.30		180	150	25	3.6	n.d.	n.d.	115	125		2700
320-1	36.72	33.96	2.40	2.00	990	660	4.05	3.00	11	29	67	64	1.80		120	90	3	3.6	n.d.	0.5	43	55		2400
323-1	40.28	40.57	3.25	3.00	1200	1300	4.25	4.30	11	49	68	82	2.25		175	160	10	13.6	n.d.	1.5	137	165		2600
324-1	45.36	46.17	2.75	2.60	1300	1500	3.95	3.90	11	39	62	94	2.30		165	150	3	13.6	n.d.	2.5	117	145		2600
689-1	46.35	51.77	2.62	2.10	1084	1100	7.35	3.30	50	52	69	150	2.28	2.33	162	140	45	45.0	2.4	6.6	171	110	2243	2500
690-1	39.66	39.06	3.12	3.10	1248	1400	7.73	4.60	57	52	68	182	3.03	3.15	200	200	45	55.0	1.2	4.6	246	199	2121	2800
1119-1	44.92	49.22	2.3	2.50	1190	1300	6.50	3.80	106	39	62	74				120		13 6		4.5	177	125		2200
S. Aegean Average	40.75	42.46	2.75	2.6	1121	1194	5.57	3.97	40	44	70	109	2.33	2.74	167	144	21.73	21.14	0.61	2.89	143.7	133	2102	2543
691-1	29.57	33.96	3.62	3.7	1149	1400	7.49	4.00	32	32	57	200	4.40	4.8	207	250	45	55	1.2	3.6	450	409	2622	2900
692-1	49.21	42.36	2.37	2.8	900	1300	6.00	3.0	70	42	51	160	1.80	4.10	163	270	32	55	4.9	5.6	234	329	2250	2400
693-1	37.02	37.78	3.37	3.60	950	1100	8.25	4.90	70	42	70	212	2.82	3.40	212	200	45	55	1.2	6.6	258	229	2624	3200
East of Rhodes	38.6	38.03	3.12	3.37	1000	1267	7.25	3.97	57.5	38.7	59.3	191	3.03	4.1	221	240	40.7	55	2.43	5.3	317	322	2499	2833
694-1	22.84	25.82	3.88	3.6	750	830	10.3	5.3	45	32	82	179	2.62	2.70	300	220	45	35	1.2	4.6	246	179	2875	800
695-1	21.49	27.35	3.75	3.1	900	800	10.0	4.8	45	32	78	106	2.80	2.63	275	200	45	45	4.9	7.6	246	149	3250	3500
696-1	33.66	34.98	3.25	2.4	875	820	8.3	4.0	57	32	72	86	2.65	2.70	188	180	45	45	4.9	4.6	209	119	2875	3000
700-1	30.13	44.65	2.90	2.7	860	830	7.5	3.9	76	32	78	78		2.70		160		35		3.6	187	159		2600
701-1	34.88	46.68	3.00	2.4	650	1000	8.1	3.5	66	52	80	78		2.65		110		45		4.6	187	129		3000
South of Crete (Average)	28.60	35.9	3.36	2.84	807	856	8.82	4.3	57.8	36	78	105.4	2.69	2.676	254.3	174	45	41	3.68	5.03	215	147	3000	2580

Table 11 Cont.

Sample No.	Ca CO_3 %		FE %		Mn ppm		AL %		PB ppm		ZN ppm		MG %		CR ppm		CO ppm		CD ppm		NI ppm		TI ppm	
	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M	Total	<63M
697-1	41.10	47.19	2.87	2.9	1175	1500	7.5	4.3	45	42	63.4	162	2.30	2.50	175	150	57	55	3.7	12	104	149	2375	2800
698-1	48.48	50.75	2.5	2.5	937	1000	6.2	3.7	82	32	63	118	2.16	2.40	150	140	57	45	4.9	17	146	109	2122	2500
699-1	37.59	43.12	2.62	2.9	760	930	6.6	4.4	70	42	71	106	2.19	2.55	175	160	45	45	1.9	4.6	171	129	2119	2700
702-1	36.47	37.27	2.10	2.8	2080	2500	6.0	4.0	96	42	47	134		2.90		260		45		19	137	159		3000
703-1	40.16	41.59	3.00	2.7	1300	1400	7.9	4.0	96	32	72	92		2.70		190		45		2.6	197	149		3000
704-1	42.54	44.14	2.90	2.7	1110	1300	7.9	4.4	86	42	74	85		2.45		150		45		3.6	187	149		3000
705-1	45.97	42.61	2.60	2.9	1070	1100	6.5	4.4	66	52	64	159		2.65		170		45		6.6	177	149		3100
708-1	37.79	44.14	2.90	2.8	1500	1700	7.4	4.1	66	42	78	103		3.30		180		55		10.6	237	189		3100
709-1	33.83	37.78	3.20	3.3	1440	1800	7.6	4.9	56	42	84	108		3.20		200		55		6.6	257	229		3400
711-1	29.60	3.94	2.50	2.3	820	740	9.3	7.4	56	32	72	118		0.70		40		25		n.d.	137	19		2500
712-1	35 94	30.79	3.10	3.2	1610	1700	8.0	4.4	56	39	76	130				160		14		5.5	257	185		2700
713-1	46.5	47.32	2.60	2.6	860	850	6.6	3.8	66	44	68	90				140		9		3.0	167	140		2400
Trench Zone (Average)	42.39	47.02	2.66	2.77	957	1143	6.78	4.13	66	30.7	65.8	128.7	2.22	2.51	166.7	150	53	48.3	3.26	11.21	167	129	2205	2667
706-4	26.70	33.96	3.80	2.9	880	920	8.7	4.0	66	42	129	98		4.0		260		45		1.6	337	269		3400
707-1	35.41	37.78	3.80	3.0	920	960	8.9	4.6	86	32	97	81		3.5		210		45		4.6	277	239		3100
East of Karpothos	31.06	35.07	3.8	2.95	900	940	8.8	4.3	76	37	113	89.5		3.75		235		45		3.13	307	254		3250
714-1	31.19	37.78	3.20	3.2	1090	1100	7.5	4.2	66	39	78	92				190		14		1.5	297	245		2900
715-1	49.67	46.68	2.20	2.7	680	820	6.5	3.9	61	29	63	86				140		14		6.5	172	135		2400
Cretian Strait	40.43	42.23	2.7	2.95	885	960	6.98	4.05	63.5	34	70.5	89				165		14		4	234.5	190		2650
1108-1	33.30	41.08	1.80	2.2	510	600	6.4	3.7	66	59	46	180				80		3.6		11	67	55		1900
1109-1	29.07	38.54	2.2	2.5	910	1000	8.5	4.3	86	49	72	103				90		3.59		1.5	97	85		2400
Close to Thera	31.185	39.81	2.0	2.35	710	800	7.45	4 0	76	54	59	141.5				85		3.595		6.0	82	70		2150
1110-1	46.77	48.72	2.15	2.5	945	1000	6.2	3.6	86	49	57	109				130		14		3.5	167	135		2200
1111-1	46.50	46.17	1.81	2.0	1270	1600	6.0	3.6	86	49	62	84				110		4		1.5	107	85		2100
1112-1	61.58	46.17	1.47	2.3	940	1300	4.3	3.7	96	39	46	94				110		14		6.5	107	85		2000
Close to Milos	51.62	47.02	1.81	2.27	1052	1300	5.48	3.63	89.3	45.7	55	95.7				116.7		10.3		3.83	127	101.7		2100
1113-1	56.10	51.77	1.67	2.3	720	860	5.1	3.3	95	49	54	73				100		4		4.5	107	85		2000
1114-1	48.61	54.31	1.86	2.1	810	900	5.6	3.3	106	49	55	82				100		4		4.5	117	95		1900
1115-1	50.62	54.31	1.70	1.9	850	920	5.0	3.1	96	39	60	74				100		14		4.5	117	85		1800
1116-1	53.36	46.68	1.89	2.1	820	980	5.9	3.5	106	39	56	74				100		14		3.5	117	85		2000
Away from the Islands	52.17	51.77	1.78	2.1	800	915	5.4	3.3	100.8	44	56.3	75.8				100		9		4.25	114.5	87.5		1925

6.15a The calcium carbonate:

In general, the $CaCO_3$ content of the fraction less than 63 microns is usually slightly higher than that found in the whole sediment sample. Sometimes it is similar or lower than the $CaCO_3$ content in the whole sediment sample, particularly when the sediment is rich in shell fragments. Shell fragments are carbonate rich as noticed in samples number 711-1, 705-1, 692-1 and 690-1 south and south east of the island arc. This has also been recorded in some sediments between the volcanic islands of Milos and Thera and in some parts of the northern and southern Aegean Sea. Generally, in the Aegean Sea alone, the carbonate content in the fraction less than 63 microns is similar to that of the total sediment sample; if different, it is only slightly higher or lower. In the trench area south of Crete, a few samples are found to have very low $CaCO_3$ in the silt and clay fraction in comparison to that found in the whole sediment sample. In sample number 711-1 the carbonate content in the fraction less than 63 microns is only 13.3% of the amount of carbonate found in the whole sediment sample.

Further analyses on some fine fractions show that in some samples the carbonate is concentrated in the fraction between 63 and 2 microns, (the silt fraction). It is noticed that the amount of carbonate is higher in the silt fraction and lower in the clay fraction compared to that found in the total sediment sample (Table 12).

Table 12 Comparison of the carbonate content in the silt and clay fractions of some samples to that of the total sediment sample.

Sample No.	$CaCO_3$ in total sample	$CaCO_3$ in the fraction between 63-2 microns	$CaCO_3$ in the fraction less than 2 microns
713-1	46.5	54.3	40.3
312-1	15.1	18.2	15.1
315-1	36.1	40.1	34.0

Fig. 30 is a map of the distribution of $CaCO_3$ in the size fraction less than 63 microns in the surface sediment. Table 6 represents the $CaCO_3$ analyses for this fraction, as well as in the whole sediment, together with the percent that the fraction is of the whole sediment.

6.15b Iron:

The iron content in the fraction less than 63 microns is similar to its content in the total sediment sample. It is noticed that the sediments south of Crete and east of Karpathos have lower values of iron in the silt and clay fractions than in the total sample. Sediments from the area between the volcanic islands of Thera and Milos and between Crete and Karpathos, have a slightly higher iron content in the fraction less than 63 microns compared to that found in the whole sediment sample (Table 11).

6.15c Manganese:

Manganese is found to be slightly higher in the fraction less than 63 microns than in whole sediment samples. It is only in the middle Aegean that a few samples are found to have lesser manganese in that fraction than in the total sediment sample. It is noticed that these samples are characterised by high manganese.

6.15d Aluminium:

Except in the northern Aegean and some of the middle Aegean samples it is noticed that Al is higher in the total sediment sample than in the fraction less than 63 microns. It is sometimes as high as twice the amount found in the silt and clay fractions. Further analysis of the silt and clay fractions show that Al is concentrated in the clay fraction, where it probably occurs in clay minerals. It is also noticed that the silt fraction is poor in Al compared to the total sample and to the clay fraction.

6.15e Lead:

The lead content of the fine size fraction is found to be less than that of the bulk sediment sample. This is noticed in all parts of the study area except for a few samples in the southern Aegean (Table 11).

6.15f Zinc:

In most cases zinc is found to be higher in the fraction less than 63 microns, compared to its content in the total sample. This is noticed everywhere in the study area, except in the middle Aegean and a few samples east of Karpathos. It is also noticed that zinc is concentrated in the fraction less than 2 microns, (Table 13).

6.15g Magnesium:

The magnesium content in the sediment fraction less than 63 microns is found to be generally similar or slightly higher than its content in the bulk sediment sample. East of the island of Rhodes, a few sediment samples have a higher Mg content in the fraction less than 63 microns than in the total sediment sample. Sample number 692-1 is found to have remarkably high Mg in the silt and clay fractions compared to that found in the total sample, (Table 11).

Table 13 Intercomparison of the Chemical Analysis of the Different size fractions and comparison with the chemical composition of the total sample (Non carbonate free basis data)

Sample No.	Ca CO_3 %		Fe %		Th ppm		Al %		Pb ppm		Zn ppm		Mg %		Cr ppm		Co ppm		Cu ppm		Ni ppm		Ti ppm	
	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.	Total	Frac.
713-1a	46.5	40.32	2.6	3.40	860	1100	6.6	5.0	66	49	60	121				160		13.6		2.5	167	175		2500
713-1b		54.31		1.80		600		2.5		39		50				120		3.6		3.5		105		2300
312-1a	15.05	15.14	4.25	5.2	1000	1000	7.2	8.0	82	69	129	214	2.1		180	150	48	13.6	n.d	0.5	112	115		3200
312-1b		10.19		2.7		1100		6.3		49		102				120		n.d.		0.5		65		4300
315-1a	36.08	33.96	3.0	4.0	4450	1600	4.85	5.6	70	69	77	129	2.9		100	170	60	13.6	5.1	0.5	167	195		2500
315-1b		40.07		2.2		3100		4.1		49		81				130		13.6		2.5		115		2700
319-3a		67.47		1.02		1000		2.1		11.3		34.4		2.7		80		5.3		0.9		30		
319-3b		40.66		2.4		1300		4.1		21.3		50.4		2.2		130		15.3		n.d.		80		
319-3c		41.55		2.7		1400		4.1		1.3		60.4		2.3		140		15.3		n.d.		90		
319-4a		60.99		1.02		600		1.4		21.3		33.4		2.9		80		5.3		n.d.		18		
319-4b		55.52		1.80		820		3.0		11.3		52.4		2.4		100		5.3		n.d.		30		
323-2a		60.99		1.03		530		1.6		21.3		35.4		2.8		90		5.3		1.9		30		
323-2b		46.12		2.5		720		3.6		1.3		59.4		2.5		140		5.3		n.d		90		
323-2c		50.07		1.72		600		2.6		1.3		46.4		2.4		110		5.3		n.d		60		
323-2d		42.82		2.6		740		3.7		11.3		60.4		2.4		150		5.3		5.9		90		
323-5a		70.77		1.18		1100		1.5		31.3		37.4		2.6		90		5.3		n.d		48		
323-5b		42.82		3.00		1200		4.2		1.3		63.4		2.6		160		5.3		n.d.		120		
323-8a		0.51		6.1		1200		7.8		1.2		105.4		1.7		60		n.d.		n.d.		n.d.		
323-8b		17.40		4.9		1100		6.8		11.25		89.4		1.9		90		n.d.				19		

key to abbreviations
a..... frac. >950 μ
b..... frac. <950 μ ->250 μ
c.....frac. <250 μ
d.....frac. <63 μ

6.15h Chromium:

Chromium is found to be low in the fraction less than 63 microns compared to the total sample, except for the sediments studied east of Rhodes. It is also found to be higher in the fraction less than two microns compared to the fraction between 63 and two microns.

6.15i Cobalt:

Similar to the case of chromium, cobalt is found to be higher in the total sample than in the fraction less than 63 microns. The sediments east of Rhodes are excluded. It is also noticed that cobalt is high in the fraction less than 2 microns compared to both the fraction between 63 and two microns, and the total sample, (Tables 11 and 13).

6.15j Cadmium:

Cadmium is generally higher in the fraction less than 63 microns compared to the total sediment sample, except for a few samples in the northern and middle Aegean.

6.15k Nickel:

Nickel is found to be higher in the total sediment sample compared to the fraction less than 63 microns. This is noticed in sediments studied in all parts of the Eastern Mediterranean and Aegean Seas, except sample number 692-1 east of the island of Rhodes.

6.15l Titanium:

Titanium is generally higher in the fraction less than 63 microns compared to its content in the total sample, except in one sample on the shelf south of the island of Crete (sample no. 694-1).

In conclusion, analysis carried on the fractions less than two microns and between 2 and 63 microns, shows that the $CaCO_3$ is concentrated in the silt fraction (2-63 microns). Iron seems to be concentrated in the clay fraction (less than two microns).

Manganese is normally concentrated in the clay fraction but in case of manganese rich sediments, high concentrations of Mn are found in the silt fraction. Aluminium and lead are concentrated in the sand and clay fractions. Copper and zinc are highly concentrated in the clay fraction. Chromium and cobalt are highest in the sand and clay fractions. Cadmium is high in the sand and silt fractions compared to the clay fraction. Nickel is high in the clay fraction only.

6.16 Relationship between the Median diameter and element concentrations:

To avoid plotting the percentage of sand, silt and clay against the concentrations of elements, it was chosen to plot the median as being representative of the grain size against each element analyses in the surface sediments studied.

To answer the question whether to plot the C.F.B. data or the non C.F.B. data, the median size was first plotted against the $CaCO_3$ values determined for the surface layer, (Fig. 49b). It is noticed from the curve that there is a clear relation between the grain size and the carbonate concentrations. Generally it can be said that the coarser the sediment the higher is the $CaCO_3$ content, and the finer the sediment, the lower is the $CaCO_3$ content. Keeping this relation in mind, plus the fact that most elements are diluted by the carbonate (see Figs. 32a to 32m), it is preferable to plot the non-carbonate free data against the median, because of the fact that the C.F.B. data will be enhanced in the coarser, and depressed in the finer sediments.

Magnesium:

It is clear in the case of Mg that the content of Mg increases as the median size decreases, (Fig. 49c).

Aluminium:

Aluminium seems to be independent of the grain size variation.

It does not bear a clear relation to the median size (Fig. 49a).

Lead and Nickel:

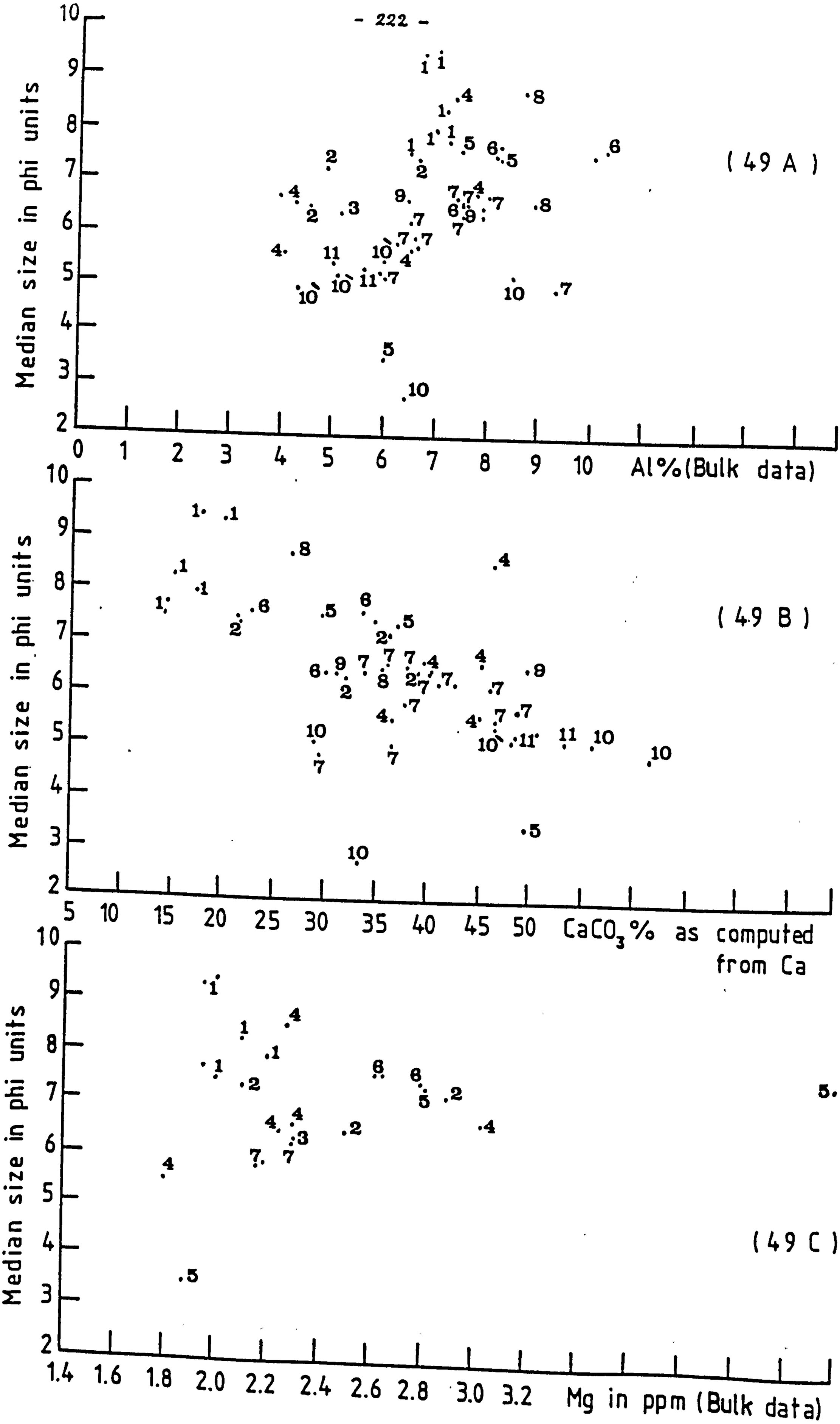
Lead and nickel also seem to be independent of the grain size. From Fig. 49d and 49e neither of them varies with the median grain size.

Zinc, Copper, Iron, Manganese, Cobalt and Chromium:

These elements all have negative correlation to the median grain size. They all have higher concentrations in the finer sediments than in the coarse, (Figs. 49f, g, h, i, j and l).

Cadmium:

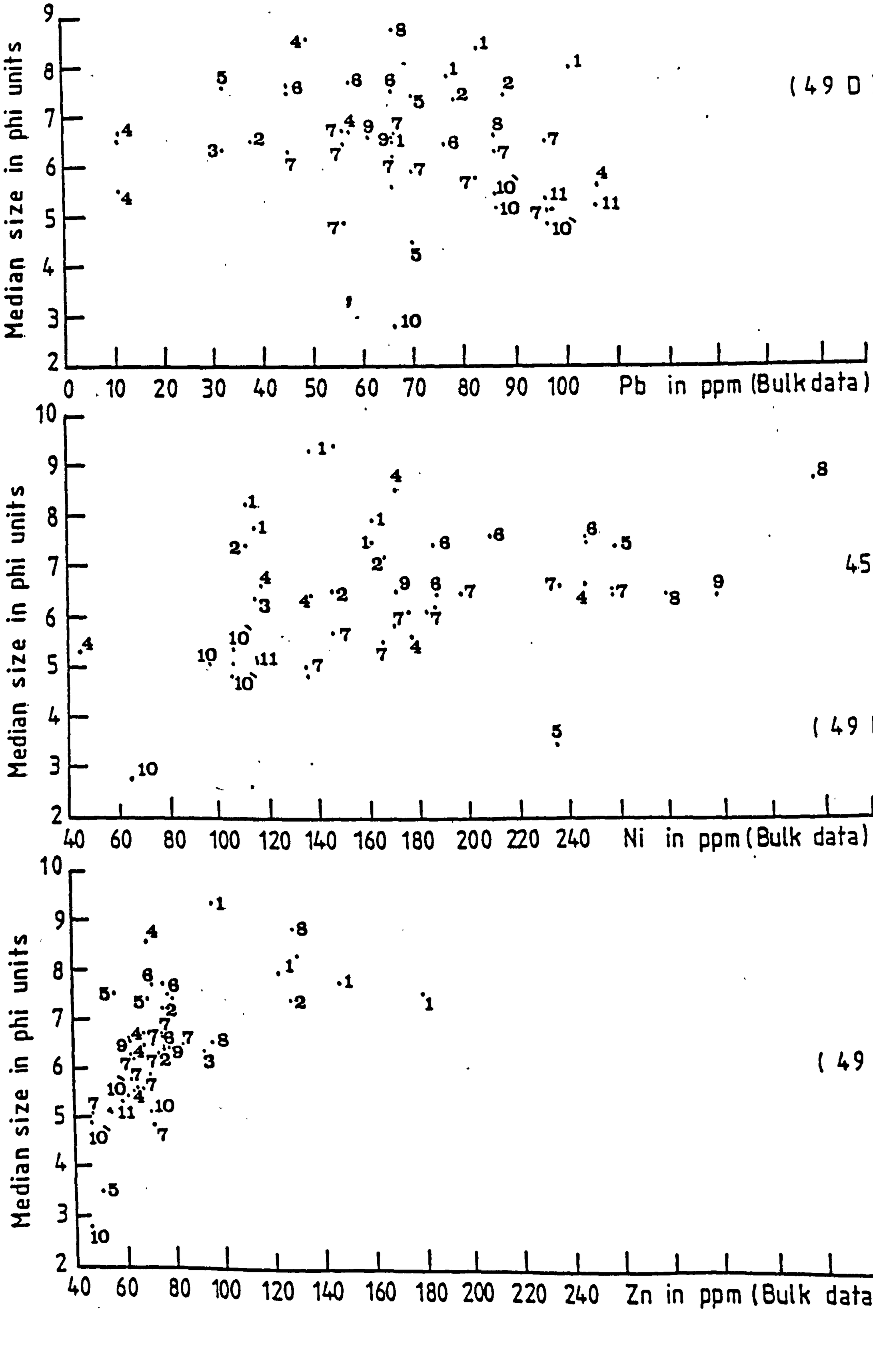
Cadmium is found to have positive correlation to the median grain size. Its content is generally higher in the coarser sediments than in the fine ones, (Fig. 49K).


Median size in phi units
Al%(Bulk data)
Median size in phi units
CaCO3% as computed from Ca
Median size in phi units
Mg in ppm (Bulk data)

(49 A)

(49 B)

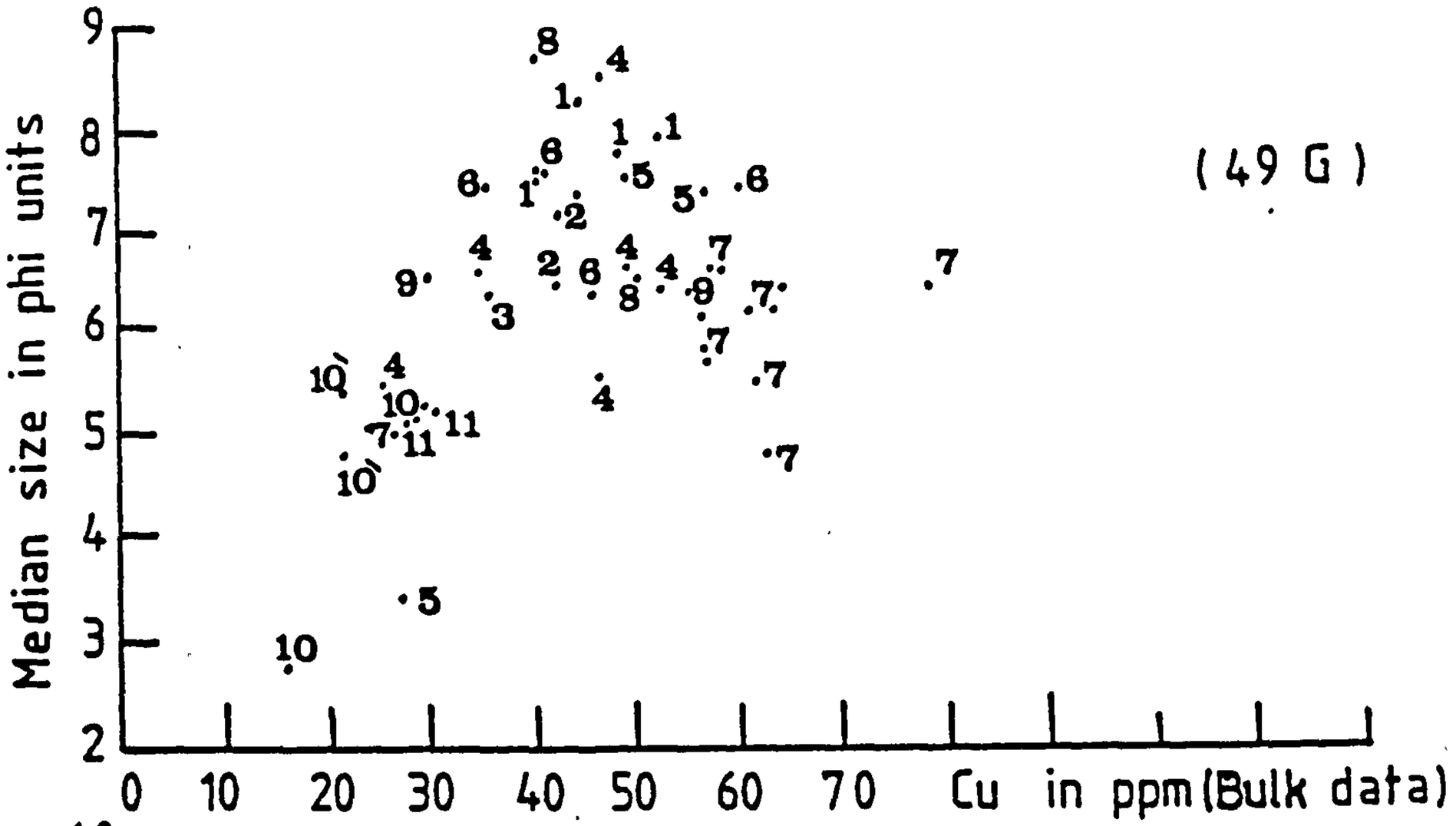
(49 C)


Median size in phi units
Pb in ppm (Bulk data)
458 ppm
Ni in ppm (Bulk data)
Zn in ppm (Bulk data)

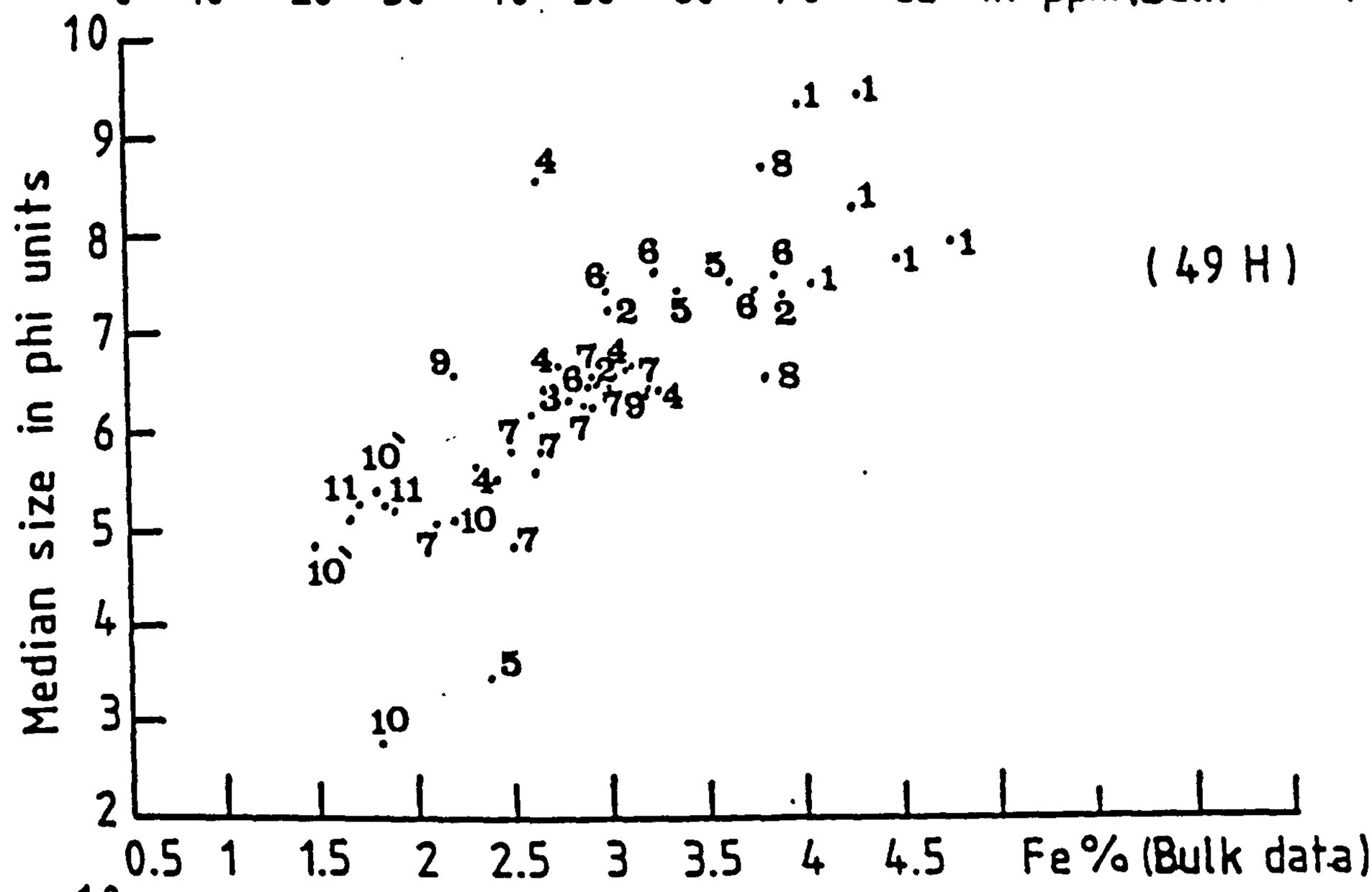
(49 D)

(49 E)

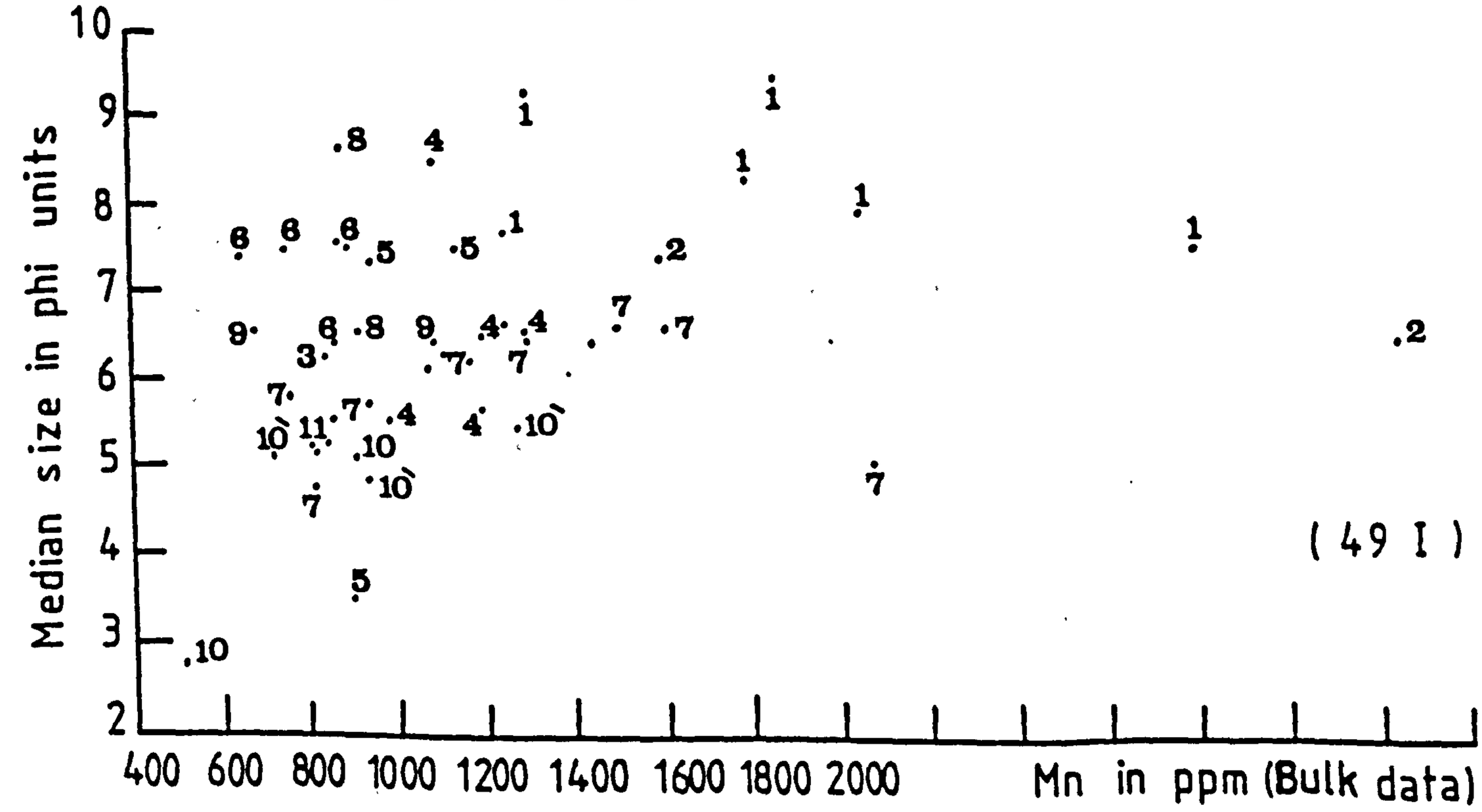
(49 F)


Median size in phi units
9
8
7
6
5
4
3
2
0 10 20 30 40 50 60 70
Cu in ppm (Bulk data)

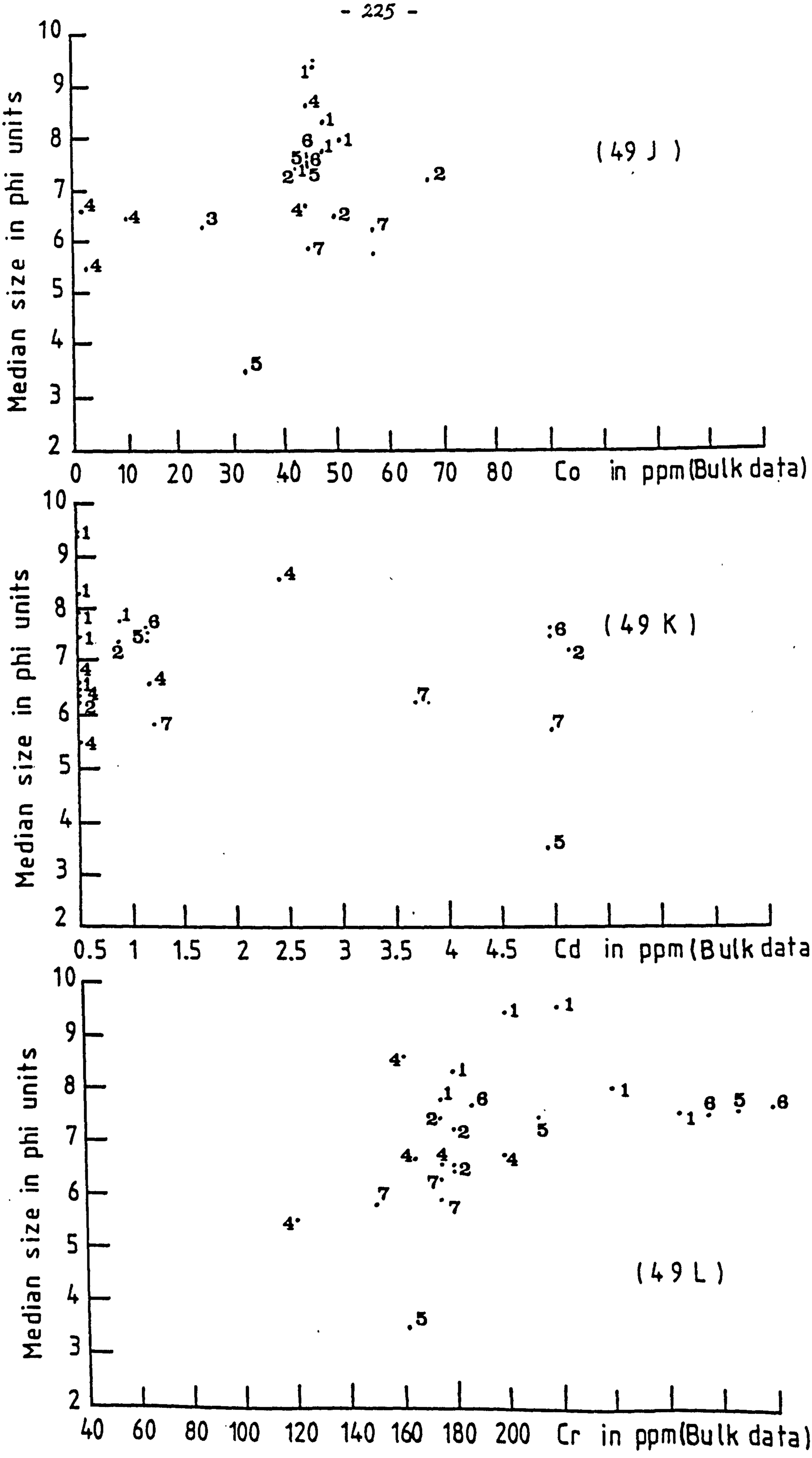
(49 G)


Median size in phi units
10
9
8
7
6
5
4
3
2
0.5 1 1.5 2 2.5 3 3.5 4 4.5
Fe % (Bulk data)

(49 H)


Median size in phi units
10
9
8
7
6
5
4
3
2
400 600 800 1000 1200 1400 1600 1800 2000
Mn in ppm (Bulk data)

(49 I)


Median size in phi units
Co in ppm (Bulk data)
(49 J)
Median size in phi units
Cd in ppm (Bulk data)
(49 K)
Median size in phi units
Cr in ppm (Bulk data)
(49 L)

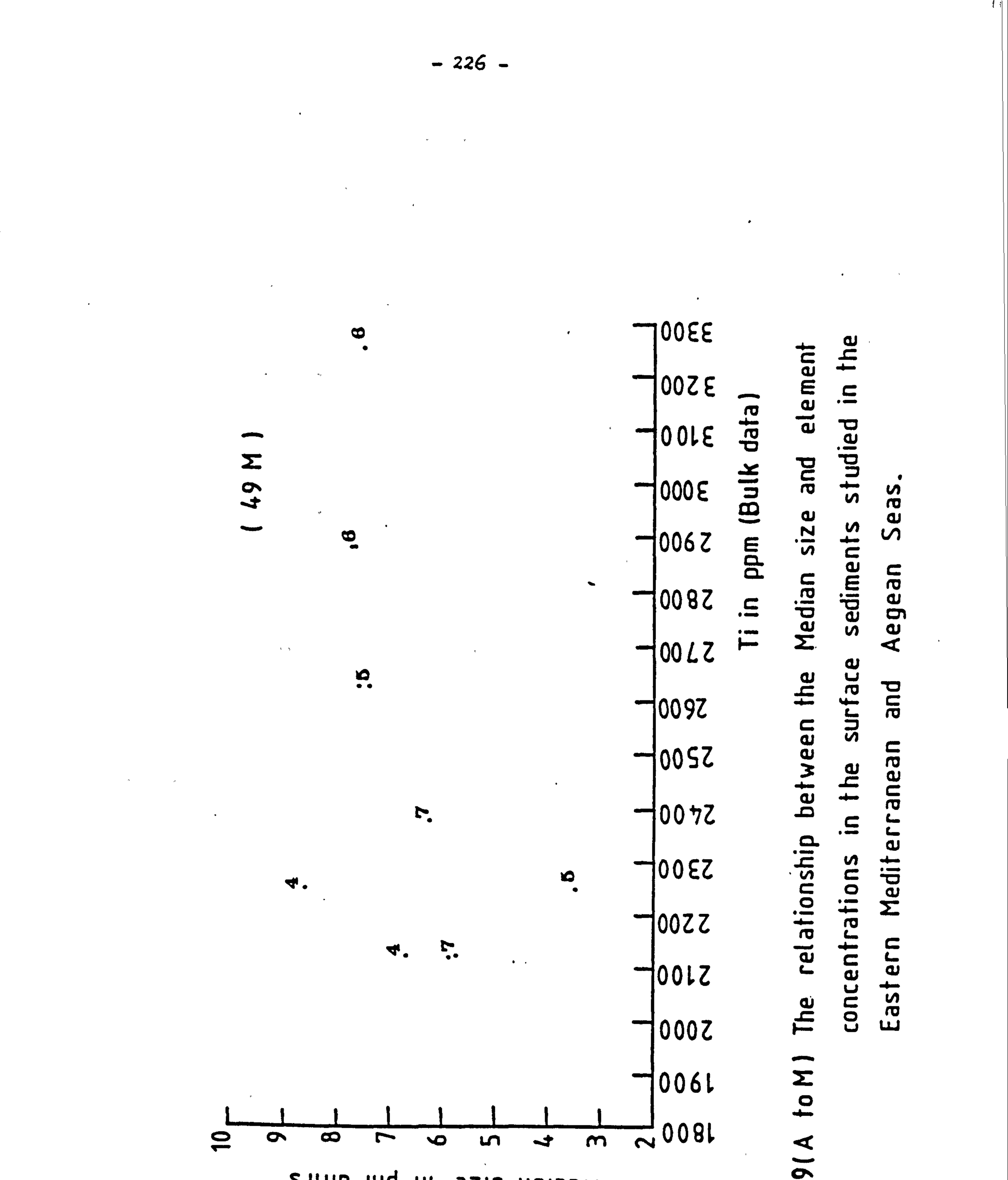


Fig. 49(A to M) The relationship between the Median size and element concentrations in the surface sediments studied in the Eastern Mediterranean and Aegean Seas.

CHAPTER VI

Part Two: The Chemical Composition of the Buried Sediments of the Eastern Mediterranean and Aegean Seas

Thirteen elements were determined in buried sediments in the cores studied in the eastern Mediterranean and Aegean Seas. Samples were taken on a standard interval of 20 cms, and on closer intervals when needed, as mentioned in Chapter III. All samples were prepared in the same way as the surface sediments and attacked by a HF, nitric and perchloric attack. A selected group of the buried sediment samples was treated by chemical partition selective attacks, and some chemical analyses on the size fraction less than 63 microns were done. Among the elements studied were calcium, aluminium, iron, manganese, copper, lead, zinc and nickel in every sediment sample and fraction. A few more elements were studied occasionally; these were magnesium, chromium, cobalt, cadmium and titanium. $CaCO_3$ was calculated from the calcium values using the same computer program as used for the surface sediments.

The $CaCO_3$ and various elements are plotted on a core log chart on the standard sampling interval of 20 cms from top to bottom, (charts 1 to 45). All elements are plotted on a C.F.B. except aluminium. The chemical data are represented both on a non C.F.B. and on a C.F.B. in Appendix II. The chemical partition data are presented in part three of this chapter. The following is a description of the contents of the $CaCO_3$ and the elements studied in the different sub-areas.

6.17 Calcium carbonate in the buried sediments:

In the northern Aegean the $CaCO_3$ content in the upper sediments is similar to that found in the surface layer, in the range between 15 and 22%. These sediments are usually in the range of one metre thickness. Under this the sediments have a lower level

of $CaCO_3$, generally between 10 and 15%. (charts no. 1 to 7). In the middle Aegean the carbonate in the top sediments is higher than the northern Aegean. Usually it is more than 25% and it ranges up to 40% in places. In the uppermost sediments it is slightly higher than in the surface layer. In the underlying sediments it is noticed that the $CaCO_3$ decreases, in general, the same as noticed in the northern Aegean sediments, (charts no. 8 to 12). In the southern Aegean, cores from east to Peloponnesus are similar to those of the middle Aegean and sometimes higher in $CaCO_3$ content. Core no. 319 is found to have a very high $CaCO_3$ content. The $CaCO_3$ in this core is between 35% and 68%, (charts no. 13 and 14). In the rest of the southern Aegean Sea (charts no. 15 to 20), the upper sediments are found to have a high content of $CaCO_3$, in the range of 35 to 40%. The analyses carried out on the size fractions in this area show that the $CaCO_3$ seems to be concentrated in the fractions larger than 950 microns. Near to Thera some samples have very low $CaCO_3$ and high Al% (low Ca/Al ratio). These are mainly ash or samples with high glass content, e.g. sample no. 1108-4 and 1108-5 (chart no. 21). West of the Santorini islands (chart no. 21 and 22) the sediments seem to be rich in their carbonate content, showing high values similar to those noticed in the middle Aegean Sea. To the east and south east of the island of Milos (charts no. 23 and 24) the $CaCO_3$ decreases from the top downwards and then it increases again to high values, sometimes as high as 75%. The slight decrease down from the top is because of the presence of some ash mixed with the sediment. Between the two islands of Thera and Milos the sediments analysed away from the islands are found to have a $CaCO_3$ content similar to that noticed in the uppermost southern Aegean sediments. Generally, the $CaCO_3$ values are similar to those found in the surface layer except sample

number 1115-3 which is found to contain only 6.36% of $CaCO_3$ (chart no. 25).

East of the island of Rhodes the $CaCO_3$ content is uniform. The buried sediments are found to have a similar carbonate content to that of the surface sediments (chart no. 26). An interval of one metre thickness is found to have a uniform content of 30% $CaCO_3$ in core no. 691. The same interval is found to contain from 29 to 36% $CaCO_3$ in other cores. In core no. 692 one interval is found to have high carbonate, up to 46%, similar to that of the surface sample in the same core. This sample is found to contain many shells and shell fragments. South of Rhodes core no. 693 is found to be similar to that east of Rhodes,but core no. 708 is completely different. In the latter case, the buried sediment is very low in $CaCO_3$ in comparison to the surface layer. Values change from more than 40% to less than 10% $CaCO_3$ (chart no. 27).

South of Crete the samples analysed from the upper sediments are found to have a value of $CaCO_3$ similar to that of the surface layer present in this area. The $CaCO_3$ content in these sediments is found to increase from the shelf outward. Cores close to the shelf have 20% to 25% (chart no. 28 and 29). Those away from the shore on the outer shelf have values greater than 40%, (chart no's. 29, 30 and 31). In core no. 701, the $CaCO_3$ content in the slumped zone shows a slight change in value with a drop in the middle from 44% to 30% in sample no. 701-10. Further to the south, near and in the trench zone, sediments are found to have $CaCO_3$ in the range of 40%, more or less. Some thin laminations here are found to contain very high values of $CaCO_3$, up to 70 and 80% (e.g. samples no. 697-2 and 697-5). These two samples represent the highest $CaCO_3$ values found in the study area. A long core (562.4 cms) studied from one of the deeps in this area,

shows that the upper sediments consist of a thick, uniform, moderately carbonate rich bed, (chart no. 37). In core no. 704 a sample is found to have very low $CaCO_3$ and very high Al, (sample no. 704-7, chart no. 34). No similar sample was found in other cores studied in the surrounding area. This core was collected from a structurally faulted and folded area on the northern flank of the Mediterranean Outer Ridge. Another core studied from the same side of the ridge was found to have one similar horizon (sample no. 698-7, chart no. 33). Core sediments studied from the deeps to the south east of Crete and Karpathos do not have the uniform content of carbonate noticed south of Crete. The $CaCO_3$ values in these cores vary from 10% up to 65%. This is because of the displaced sediments and turbidites present in this area, (chart no. 27 and 38 to 40).

East of the island of Karpathos the buried sediments have a similar carbonate content to that found in the surface layer except for sample no. 707-3 which has low $CaCO_3$ (21.4%). The sediments close to the island have $CaCO_3$ contents generally less than 30%, and this value increases locally on the outer shelf and decreases again to the south east between the deeps, (chart no's. 41 and 42). The local increase noticed in core no. 707 is accompanied by a local decrease in depth. South of Karpathos, the buried sediments are generally similar to the surface layer in their $CaCO_3$ content, or slightly lower. Sediments here have generally more than 35% carbonate, except in one sample only (sample no. 712-2), which is found to have only 18% carbonate. In the Cretan Strait "Kasos Strait" the buried sediments are found to be generally similar to the surface layer (chart no. 45). They have 45% $CaCO_3$. East of Crete the shelf sediments are similar to those off Karpathos.

6.18 Aluminium in the buried sediments (non C.F.B. data):

In the northern Aegean, aluminium has a range from 6 to 7.5 on a non C.F.B. Similar values are found in the middle Aegean, or slightly lower values. The southern Aegean buried sediments east of Peloponnesus show lower values, generally less than 5.5% and sometimes as low as 1.5%, (chart no. 13 and 14), as recorded in core number 319. The rest of the southern Aegean sediments studied also have low values except in one core south of Santorini which is found to have a very high Al content ranging up to 13.35%, (chart no. 18). In the area between Thera and Milos, Al has a range slightly higher than that noticed in other parts of the Aegean Sea. Values are in the range of 6 to 12% west of the island of Thera; 1.5 to 10% east of Milos and 5 to 11.5% between the two islands.

East and south of the islands of Rhodes, Al values range from 4 to 13.5%. Values differ, sometimes they are similar to the surface layer (chart no. 27) and sometimes they are not. South of the island of Crete the shelf sediments are characterized by high Al values, particularly those on the inner shelf (chart no's. 28 and 29). Near the shore it is high (nearly 10%), and it decreases seawards. Further to the south in cores studied between the deeps, it is noticed that Al decreases as in the case of the surface sediments south of Crete. In the trench area the Al values are found to fluctuate up and down in a wide range from less than 3% to more than 9%. It is generally similar to the surface layer except in certain horizons that have very low values. Sediments on the northern flank of the Outer Ridge are generally similar to the surface layer there, having values generally less than 10%, except in one sample that has a very high Al content (15 to 19%). This

is the same sample that has a very low $CaCO_3$ content. East of Karpathos the shelf sediments are found to have a similar Al content to that of the surface layer. Values are generally less than 10% on the inner shelf decreasing outwards in reverse to that of the $CaCO_3$ (chart no's. 41 and 42). South of the island of Karpathos the cores studied from the deeps are found to have a similar Al content to that of the surface layer, and so do the sediments in the Cretan strait. It is noticed south and south east of the island of Crete that Al values vary greatly. The following are examples of very high and very low values recorded in this area.

Sample No.	Example of high Al values non C.F.B.	Sample No.	Example of low Al values non C.F.B.
698-7	15.2%	697-2	3%
704-7	18%	697-5	2.6%
708-4	13.4%	705-3	2.9%

It is noticed that the sediments with low Al content have very high $CaCO_3$ and a high content of some metals such as Pb and Zn.

6.19 Iron in the buried sediments:

In the northern Aegean, iron concentrations are generally similar to those in the surface layer sediments. The range is mostly 4 to 6%. The Fe content is uniform in the cores examined in both the northern and middle Aegean, except in core number 316 where values are found to vary. East of Peloponnesus the iron concentrations are uniform and slightly lower than in other parts of the Aegean Sea. The general level in the cores here is about 4%, and generally less than 5%. The southern Aegean sediments have iron concentrations similar to the general level noticed in the northern and middle Aegean sediments, but the

iron content is not uniform throughout the cores studied. It is noticed that the concentrations vary in different layers and that the values fluctuate from 2.6 to 6%.

Sediments from the Cyclades Arc in the area between Thera and Milos have a wide range of iron concentration from 1.7 to 5.6% on a C.F.B. High values are recorded close to Thera (chart no. 21), while low values are found near Milos. The general Fe level in this area is 4% on a C.F.B. The buried sediments have generally similar iron concentrations to the surface layer except in one core near the island of Thera.

East of the island of Rhodes the sediments have similar iron concentrations to the surface layer, in the general level of 5% on a C.F.B. One sample in this area was found to have 7% Fe on a C.F.B. (sample no. 692-2). South of Crete the shelf, sediments are uniform in their Fe content. They have concentrations around the general level of 5% on a C.F.B. Sample no. 701-10 from a slumped layer in core no. 701 is found to have 6.6% of Fe on a C.F.B. In and around the deeps, south and south-east of Crete, the iron concentration in the buried sediments is uniform throughout the cores studied. It is generally similar to the surface layer with slight differences in some cores. The general level is between 4 and 6% on a C.F.B. On the northern flank of the Hellenic Outer Ridge high concentrations of Fe (more than 6%) are recorded at a few centimetres from the surface. In this area, Fe is found to have concentrations in the general level of 5% on a C.F.B. East of the island of Karpathos, the iron concentration in the buried sediments is uniform having a general level of 5%. It is similar to the surface layer on the inner shelf. East of Crete and in the Cretan Strait, the iron concentration in the buried sediments is uniform and more or

less similar to that recorded for the surface layer. Its general level is 5% on a C.F.B.

6.20 Manganese in the buried sediments:

Manganese concentrations in the buried northern Aegean sediments are found to be lower than those of the surface layer. However a few samples are found to have very high concentrations of manganese, (Table 14). The general level of Mn concentration is less than 2000 ppm on a C.F.B. in both the northern and middle Aegean sea sediments. Manganese in the southern Aegean has the same general level as noticed in other parts of the sea.

Table 14 Examples of high concentrations of Mn recorded in the Aegean Sea

In the Northern Aegean

Sample No.	Mn in ppm on C.F.B.	Sample No.	Mn in ppm on C.F.B.
306-4	3282	307-7	3793
307-1	4133	309-1	3261
307-2	3112	311-5	5459

In the Middle Aegean

Sample No.	Mn in ppm on C.F.B.	Sample No.	Mn in ppm on C.F.B.
313-5	4908	315-1	6964
313-5	3594	315-3	8559
313-7	3627	317-1	5336
314-5	6196	317-5	4617

In the Southern Aegean

Sample No.	Mn concentration in ppm on C.F.B.
319-3A	3074
320-3	5434
323-5A	3764
324-5	2833

Between the two volcanic islands of Thera and Milos, the manganese concentration in the buried sediments is found to be less than that of the surface layer, except in one core close to Thera (core no. 1108) which is found to have a similar or higher Mn concentration to that of the surface layer. It is noticed that in some cores, the Mn values decrease gradually from top to bottom (chart no. 23) and that another two layers are present, an upper layer with high Mn concentrations and a lower one with low Mn concentrations. East of the island of Rhodes the general level of Mn is less than 2000 ppm on a C.F.B. It is similar or slightly less than in the surface layer. Two samples are found to have high Mn concentrations. Sample no. 693-6 has 2729 ppm and sample no. 708+2 has 5916 ppm, both on a C.F.B. Shelf sediments south of Crete are found to have a similar Mn concentration to that of the surface layer sediment, or slightly lower. They have a general level of about 1000 ppm Mn on a C.F.B. except in core no. 701 which has a higher level. In this core it is noticed that the buried sediments have a higher Mn concentration than the surface layer sediments. A few samples are found to have high Mn concentration in this area (e.g. sample no. 696-6 has 4329 ppm and sample no. 700-2 has 3777 ppm, both on C.F.B.).

Further to the south and south east of the Island Arc Mn concentrations are found to vary. A general level of one to two thousand ppm on a C.F.B. occurs, but higher concentrations are frequently recorded in this area. Table 15 summarizes examples of the high manganese concentrations recorded in the trench area. Core no.709, a long core between the deeps in this area, is found to have a lower general level of Mn than recorded for the surface layer. Its general

level of Mn concentration is less than 1000 ppm on a C.F.B., (chart no. 40).

Table 15 Examples of the high concentrations of Manganese recorded in and between the deeps south of the island of Crete, and on the northern flank of the Hellenic Outer Ridge.

Sample No.	Mn concentration in ppm on a C.F.B.	Sample No.	Mn concentration in ppm on a C.F.B.
696-6	4329	700-2	3777
697-9	3216	704-8	6657
697-10	10311	707-2	17518
697-22	3971	707-3	18.2%
697-24	4246	708-2	5916
698-2	6909	713-2	7019
698-9	15534	713-7	2774
698-11	3813	713-9	2994
714-2	15.7%	702-1	3777

The group of samples recorded in table 15 represents a zone of high Mn concentration that is noticed south and south east of the island of Crete. Cores studied from the northern flank of the Hellenic Outer Ridge are found to vary in their Mn content.

East of the island of Karpathos, the Mn concentrations in the buried shelf sediments are similar to that recorded for the surface layer. It is uniform and generally in the range of 1500 ppm on a C.F.B. or less. East of the island of Crete and in the Cretan Strait, Mn concentrations in buried sediments are found to be similar or slightly lower than those of the surface layer. High concentrations of Mn are recorded in this area. in a few samples (Table 15).

6.21 Copper in the buried sediments:

In the northern Aegean the copper concentration in the buried sediments is similar to that of the surface layer. It is uniform and has the general level of 50 ppm on a C.F.B. in the upper sections of the cores studied. In the lower part of the sections studied, values are recorded in the range between 18 and 71 ppm on a C.F.B. Concentrations in the lower section are generally less than in the upper section of the cores studied, except in a few samples mentioned below. These concentrations seem to be higher than the general level of copper noticed in the surrounding area. They are all from a layer in the middle of the section studied. In the middle Aegean the general content of copper is similar to that of the northern Aegean, and again some samples are found to have high concentrations in comparison to the general level.

Samples from the Northern Aegean	Copper concentration in ppm on a C.F.B.	Samples from the middle Aegean	Copper concentration in ppm on a C.F.B.
306-4	64	314-2	73
307-4	61	314-5	103
308-6	59	315-3	68
308-7	71	315-4	69
311-5	58	317-4	79
		317-5	93
		317-6	77

They all correspond to the same layer as noticed in the northern Aegean. In the southern Aegean the copper concentrations vary greatly. They have a range from 18 to 125 ppm on a C.F.B. The copper concentrations of the buried sediments in this area are different from the surface layer. The following is a list of sporadic, relatively high or low concentrations of copper re-

Sample No.	High concentration of Cu in ppm on C.F.B.	Sample No.	Low concentration of Cu in ppm on C.F.B.
689-5	123	689-2	28
689-6	125	689-3	18
320-4	102	690-6	33
320-5	94	320-9	8
320-6	81	320-11	37
320-12	112	323-8A	26
323-5A	106	324-6	27
324-2	211	1119-5	27
324-3	94	318-9	27
319-8	97		

East of Peloponnesus the concentrations of copper are generally similar to the surface layer except in one sample which is included in the above list.

In the Santorini area, the buried sediments near to the island of Thera have copper concentrations similar to or slightly higher than the surface layer. The general level is from 40 to 60 ppm on a C.F.B. except in core number 1110-1 which is found to have higher concentrations of copper in the range of 70 to 110 ppm on a C.F.B. Close to the island of Milos, the copper has lower concentrations, generally less than 40 ppm on a C.F.B. This value is found to increase slightly away from the island; the concentration is similar or slightly less than that found in the surface layer. Between Thera and Milos it is noticed that the copper concentrations gradually decrease from top to bottom in the cores studied.

East of the island of Rhodes the copper has slightly high concentrations. The general level noticed here is 70 ppm on a C.F.B., more or less. Concentrations are similar to or less than in the surface layer. South of the island of Crete the

shelf sediments have copper concentrations similar to the surface layer, in the general level of 50 ppm. Values are found to increase slightly away from the island to the south. The outer shelf sediments have a slightly higher general level of nearly 70 ppm on a C.F.B. (chart no's. 28 and 29). In cores numbers700 and 701 from this area, high concentrations of copper, in the range between 62 and 114 ppm on a C.F.B., are found. Such concentrations are considered to be high in comparison to the general level noticed in the area. Further to the south, between the deeps, copper concentrations are found to vary considerably between cores collected from nearby locations. Some samples are found to have high concentrations of copper. Table 17 is a list of the relatively high concentrations of copper recorded south and south east of the island of Crete,in and around the trench area. East of the island of Karpathos,the shelf sediments have a general level of copper concentration similar to the surface layer on the inner shelf. Sediments on the outer shelf are found to be slightly different, having higher copper concentrations in the upper layer of the cores studied,and a lower concentration in its lower part (chart no. 42). The general level in this area is 70 to 100 ppm on a C.F.B. East of Crete and south of Kasos, the Cu concentrations are slightly high in the general level of 60 to 116 ppm and low in Kasos Strait (chart no. 45).

Table 16 A summary of the general level of concentration of copper in the cores studied along the four sampling lines south and south east of the island of Crete

1) Line A-A`

Core No.	The general level of copper concentration in ppm	
	a) on C.F.B.	b) non C.F.B.
694	42 - 62	33 - 47
695	46 - 52	37 - 41
696	57 - 102	35 - 61
699	20 & 90 - 117	16 & 57 - 71
697	56 - 335	32 - 184
698	85 - 215	45 - 120

2) Line B-B`

700	61 - 111	41 - 61
701	42*- 108	27 - 65
702	42 108	27 - 65
703	97 - 121	59 - 70
704	61 - 130	59 - 112

3) Line C-C`

715	56 - 60	30 - 31
714	55 - 116	38 - 82
712	77 - 106	58 - 69
713	73 - 150	45 - 96
705	74 - 118	34 - 86

4) Line D-D`

706	53 - 83	41 - 58
707	51 - 133	41 - 86
708	29 - 108	26 - 59

4) Line D-D (Continued)

709	69 - 119*	50 - 79*
711	67 - 144	42 - 95

* surface layer sample

Table 17 List of the high concentrations of copper noticed south and south east of the island of Crete

Core and Sample No.	Concentrations of copper in ppm on a C.F.B.	Core and Sample No.	Concentrations of copper in ppm on a C.F.B.
704-5*	183	714-5	116
700- 4	111	712- 5 & 6	106
700- 5	107	712- 7	105
700-10	111	713- 2	103
701- 2	104	713- 3	138
701- 3	114	713- 4	127
701-10	110	713- 5	109
697- 2	176	713- 7	125
697- 5	168	713- 9	150
697-22	210	705- 2	118
697-24	335	705-15	131
698- 9	215	705-16	124
698-11	107	707- 4	133
699- 3	104	707- 5	119
699- 6	101	711- 3	144
699-19	117	711- 4	113
699-36	115	709- 3	111
704- 4*	140		

* All core no. 704 has a high general level greater than 100 ppm.

From tables 16 and 17 and from figure 39 it is clear that there is a general trend of increase in concentrations of copper, from the island arc to the south and south east of the islands of Crete and Karpathos. This is noticed along the three coring lines A-A, B-B and C-C from the continental shelves off the islands towards the Hellenic Outer Ridge. The highest concentrations are found between the deeps and on the northern flank of the Outer Ridge.

6.22 Lead in the buried sediments:

In the northern Aegean the buried sediments are found to contain similar or lower lead concentrations than the surface layer. Two major units are noticed (chart no.'s 1 to 7). The top unit, about one metre thick or less, has higher lead concentrations than the lower unit. The level of the concentration of lead in the upper unit is in the range of 70 to 120 ppm on a C.F.B. (60 to 95 non C.F.B.). In the lower unit the range is 40 to 90 ppm on a C.F.B. (33 to 76 non C.F.B.); core number 311 is excluded here. In the middle Aegean the lead concentration in one of the cores studied close to the northern part of the sea,is found to have a similar trend to that noticed in the northern Aegean sediments, (chart no. 8). The rest of the middle Aegean is found to contain lower lead concentrations than in the surface layer. Concentrations are in the region of 50 ppm on a C.F.B., or less. A general trend of decrease in lead concentration is noticed between the northern and middle Aegean sediments.. In the middle Aegean the lead concentrations decrease from the north to the south (chart no's. 8 to 12). A thin bed is noticed in the middle of the studied section. It contains high lead concentration (sample no. 314-6). Core no. 316 contains a very low concentration of lead. It contains many ash layers.

Sediments east of Peloponnesus are found to be similar to the middle Aegean sediments in their lead content. In the southern Aegean, lead concentrations are found to vary greatly. In cores west of Karpathos, Pb concentrations vary from 47 to 144 ppm on a C.F.B.(44 to 82 non C.F.B.). A smaller range is noticed in the other parts of the southern Aegean. Lead concentrations decrease to less than 50 ppm on a C.F.B. east and south east of Peloponnesus. A trend of decrease is noticed in the southern Aegean from the east to the west between the islands of Karpathos and Peloponnesus. Between the two volcanic islands of Thera and Milos, the lead concentration in the buried sediments is generally less than the surface layer. High concentrations are recorded near Thera and Milos. Away from the islands concentrations are even higher. Close to Thera the general level is less than 75 ppm on a non C.F.B. (nearly 100 to 150 ppm on C.F.B.). Near Milos it is 55 to 95 ppm on a non C.F.B. and 120 to 250 on C.F.B. South of the island of Paros a similar range is noticed (chart no's. 21 to 25).

East of Rhodes, lead concentration in the buried sediments is similar to or less than that of the surface layer. The general level of concentration is 50 ppm on a non C.F.B. Values range from 32 to 70 ppm on a non C.F.B. (45 to 138 ppm on a non C.F.B.).

South of the island of Crete the buried shelf sediments are more or less similar in their lead content to the surface layer. Lead concentrations on the outer shelf are higher than on the inner shelf. Lead concentrations are found to increase from near Crete towards the south, (chart no's. 28 and 29). The general level of lead concentration is 45 to 57 ppm in the inner shelf sediments. It increases to nearly 45 - 82 ppm on a non C.F.B. in the outer shelf sediments. On a C.F.B. it is 32 - 78 ppm on the inner shelf

and 47 - 137 ppm on the outer shelf. Further to the south and south east, sediments between the deeps and on the outer ridge have higher concentrations of Pb. It is noticed in this area that the carbonate rich sediments have high concentrations of lead. Buried sediments in the Cretan Strait are found to have similar lead concentration to the surface layer.

6.23 Zinc in the buried sediments:

In most of the Aegean Sea the zinc concentrations in the buried sediments are less than those of the surface layer. In the northern Aegean the general level is nearly 100 to 130 ppm on a C.F.B. while it is 200 ppm in the surface layer, (chart no's. 1 to 7). In the middle of the Aegean the level of concentration in the buried sediments is 100 ppm or less on a C.F.B., while it is 137 ppm in the surface layer, (chart no's. 8 to 12). A similar case is noticed east of Peloponnesus, (chart no's. 13 and 14). In the southern Aegean,Zn concentrations higher than those of the surface layer are frequently present. A wide range of concentration is found in this area, between 60 and 140 ppm on a C.F.B. (chart no's. 15 to 20). The surface sediments have an average of 115 ppm Zn. Between the islands of Thera and Milos,zinc concentrations vary greatly (chart no's. 21 to 25). Values range between 70 to 177 ppm on a C.F.B. Near Thera the buried sediments have higher concentrations than the surface layer. Away from Thera near Sikinos, Folegandros and Milos the sediments have similar or lower concentrations than the surface layer. Sample number 1108-4 is found to contain 177 ppm Zn on a C.F.B. It is noticed that this sample is poor in its carbonate content and has high iron and aluminium concentrations. East of the island of Rhodes zinc concentrations of the buried sediments are similar to those of the surface layer, except in core no. 708. Sediments in this

area have a general level of zinc concentration of 100 ppm more or less on a C.F.B. South of the island of Crete, sediments on the inner shelf have a zinc concentration typical of that of the surface layer, in the level of 100 ppm to 125 ppm on a C.F.B. Sediments from the outer shelf area are found to have a wider range, sometimes higher than the concentration found in the surface layer. Further to the south and south east of Crete and Karpathos, the sediments between the deeps are found to contain similar or higher zinc concentrations in comparison to the surface layer, except core no. 709 which is found to have a reverse case. The following are examples of high concentrations of zinc found in this area.

Sample No.	Zinc in ppm on a C.F.B.	Sample No.	Zinc in ppm on a C.F.B.
697-2	177	704-5	147
697-5	149	705-2	157
from			
699-18*	146	705-3	221
699-25	147	705-4	209
to			
699-50*	142	705-6	158
698-2	174	705-15	160
698-3	132	711-4	140
* Between these two samples similar high concentrations are found (see chart no. 37).		712-7	155

The general level of concentration is between 100 and 150 ppm on a C.F.B. East of the island of Crete and Karpathos the sediments have a similar range of zinc concentrations.

6.24 Nickel in the buried sediments:

In the northern Aegean the buried sediments are found to contain nickel concentrations similar to or less than in the

surface layer. The general level of concentration is between 100 and 200 ppm on a C.F.B., (chart no.'s 1 to 7). It is noticed that all the northern Aegean sediments are poor in their nickel content in comparison to other parts of the sea and the eastern Mediterranean in general. In the middle Aegean, the general level of nickel concentration is higher. Values are in the range between 175 and 200 ppm up to 300 ppm on a C.F.B. (chart no. 8 to 12). Concentrations are generally similar to those of the surface layer except in cores that contain ash layers, (e.g. core no. 316). East of Peloponnesus, concentrations are similar to the northern Aegean. The range is 100 to 150 ppm on a C.F.B. (chart no's. 13 and 14). In the southern Aegean, nickel concentration varies widely. It has a range from less than 100 ppm to more than 300 ppm on a C.F.B. It is generally less than in the surface layer, except in core number 320 south east of Peloponnesus. It is noticed that cores west of Karpathos contain higher concentrations of nickel, than those south of Santorini or south and south east of Peloponnesus (chart no's. 13 to 20). Between the two volcanic islands of Thera and Milos, Ni values range from 100 to 300 ppm on a C.F.B. It is noticed that higher concentrations are recorded near Milos than elsewhere between the two islands. High concentrations are also recorded in core number 1110.

East of the island of Rhodes, nickel concentrations are very high, in the range from 450 to 700 ppm on a C.F.B. (chart no.'s 26 and 27). South of the island of Crete the inner shelf sediments are found to contain Ni concentrations typical to those of the surface layer, (chart no's. 28 and 29). On the outer part of the shelf the sediments are found to have slightly higher concentrations than in the surface layer. It is noticed that the outer shelf sediments have generally higher nickel concentrations

than the inner shelf sediments. On the inner shelf the general level of concentration is about 300 ppm while it it up to 400 ppm on a C.F.B. on the outer part of the shelf, (chart no. 28 to 31). In cores number 700 and 701 south of the eastern part of Crete, two samples are found to contain very high concentrations of nickel. 700-5 at 50 - 52 cms from top contains 997 ppm on a C.F.B. and 701-10 at 26.5 - 27.5 cms from top contains 693 ppm on a C.F.B. It is noticed that high values are recorded in the same cores above and below these samples where a dark layer is found in both cores at this depth. In and around the trench area nickel concentrations vary in the range between 200 and 300 up to 400 ppm on a C.F.B. The general level of concentration here is 300 to 400 ppm. Only one core, a short core, is found to contain very low concentrations of nickel (chart no. 27). In this core, core no. 708, concentrations in the level of 100 ppm are found in the upper part of the buried sediments. It is noticed that these very low nickel values are associated with low concentrations of $CaCO_3$ and high concentrations of Al. The following are examples:

Sample No.	Ni concentration in ppm on C.F.B.	$CaCO_3$%	Al% on C.F.B.
708 - 3	98	11.7	8.9
- 4	41	10	14.9
- 5	62	8.2	8
698 - 7	59	0.52	15.3
704 - 7	143	4.3	18.8
712 - 2	299	17.5	9.6

East of Karpathos, the nickel concentration is found to be similar to that in the surface layer. It has a general level between 400 and 500 ppm on a C.F.B. East of the island of Crete and in the Cretan Strait the level of concentration is between 300 and 450 ppm on a C.F.B. Values are more or less similar to the surface layer.

It is noticed that the samples containing high concentrations of nickel are from or close to a dark layer in cores no. 713 and 714 at a similar depth from the top as noticed in cores no. 700 and 701.

Sample No. 713-4 at 14-17 cms from top contains 411 ppm Ni)
Sample No. 714-3 at 19-23 cms from top contains 493 ppm Ni) all on C.F.B.
Sample No. 714-4 at 32-35 cms from top contains 481 ppm Ni)

6.25 Chromium in the buried sediments:

In the northern Aegean the sediments are found to contain chromium in the range between less than 200 ppm to more than 300 ppm on a C.F.B. Similar to nickel, it is noticed that the sediments south of Akra Kassandras and Akra Pinnes contain higher concentrations of chromium than those south of Nisos Thasos and south west of Samothraki, (chart no's. 1 to 7). Cores numbers 306 to 308 have a level of chromium concentration of about 300 ppm, while cores no's 309 to 312 have a lower level of about 200 ppm of Cr on a C.F.B. In the middle Aegean a slightly higher range of chromium concentration is found,and sediments are found to be similar in their chromium content to the surface layer, having a level of concentration between 200 and 300 ppm on a C.F.B. Sample no. 317-4 is found to contain a high concentration of chromium. Sediments east of Peloponnesus are similar to the middle Aegean sediments in their content of chromium. In the southern Aegean chromium has a wide range of concentration. Concentrations vary from 60 up to 400 ppm on C.F.B. (chart no's. 15 to 20).

East of the island of Rhodes,chromium concentrations are similar to those of the surface layer. Concentrations are high, in the level of 400 to 520 ppm on a C.F.B. South of Crete shelf sediments have a range from 300 to 400 ppm on C.F.B. Chromium concentrations are generally similar here to the surface layer.

Further south of the island, concentrations decrease to less than 300 ppm on a C.F.B. in sediments between the deeps.

6.26 Cobalt in the buried sediments:

In the northern and middle Aegean, cobalt has a general level of concentration between 40 to 60 ppm on a C.F.B. Core number 316 is found to have a lower level of cobalt concentration. This core contains many ash layers. Some samples are found to contain higher concentrations of Cobalt.

The following are examples

Sample No.	Co in ppm on C.F.B.	Sample No.	Co in ppm on C.F.B.
312-3	67	315-2	89
312-4	72	315-7	72
310-2	70	317-6	62
314-6	103	318-4	59
		318-5	75

Apart from those samples mentioned above, it is noticed that the cobalt concentration in the surface layer is generally higher than in the buried sediments. East of Peloponnesus, sediments are found to be similar to the middle and northern Aegean. Core number 319 is found to have low concentrations of cobalt (chart no. 14). In the southern Aegean the range of cobalt concentration is wider. Values vary from 10 to 90 ppm on C.F.B. Higher values are noticed in cores west of Karpathos than those east of Peloponnesus and south of Santorini, (charts no. 15 to 20). In cores no. 689 and 690 high values between 50 and 90 ppm are very frequent.

East of Rhodes, buried sediments have cobalt concentrations similar to those of the surface layer. Concentrations are in the range from 60 to 85 ppm on a C.F.B. South of the island

of Crete the shelf sediments have concentrations of cobalt similar to the surface layer. The range is from 40 to 85 ppm on a C.F.B. It is noticed that the general level of concentration is higher in cores on the outer shelf than in those on the inner shelf, (charts no. 28 and 29). Further towards the south, the sediments in and around the deeps have higher concentrations of cobalt, in the range from less than 50 to greater than 100 ppm. Values vary greatly but 75 ppm could be estimated as a general level of concentration in the cores studied in this area. Some unusual high Co concentrations are found in this area; the following are examples:

Sample No.	Concentration of Cobalt in ppm on a C.F.B.
697-2	247
697-5	169
697-24	104
698-2	106
698-3	102
698-9	171

6.27 Cadmium in the buried sediments:

Cadmium seems to have a very low range of concentrations, sometimes under the detection limit of the method used. Some high concentrations are recorded in the northern Aegean area. Although most of the sediment samples do not record readings over the detection limit, concentrations less than 2 ppm on a C.F.B. are found (charts 1 to 7). It is noticed that the sediments south of eastern Greece, (charts no. 4 to 7) have higher concentrations than those close to western Greece, (charts no. 1 to 4). A range of higher concentration is found in the middle Aegean sediments. Values have a range from 3 to 10 ppm on C.F.B. (charts 8 to 12). In the southern

Aegean higher concentrations up to 12 ppm on a C.F.B. are found (charts no. 13 to 20).

East of the island of Rhodes some sediments have cadmium concentrations in the range between 1 to 10 ppm on a C.F.B. South of the island of Crete, the shelf sediments have cadmium concentrations in the range between 2 and 12 ppm on a C.F.B.

It is noticed that sediments on the outer shelf contain more cadmium than sediments on the inner shelf. Further to the south the sediments in and around the deeps are found to contain higher concentrations of cadmium and the range is larger. Values as high as 28 ppm on a C.F.B. are recorded in this area.

6.28 Titanium in the buried sediments:

Titanium was determined in a few cores in the southern Aegean Sea and in the eastern Mediterranean Sea. In the southern Aegean the concentrations are in the range between 2660 - 4513 ppm on a C.F.B. East of Rhodes, titanium concentrations are similar to its concentration in the surface layer. Values are recorded in the range between 3723 and 4900 ppm on a C.F.B. South of the island of Crete the shelf sediments have a titanium content typical of that of the surface layer. Concentrations are in the range between 3726 to 4458 ppm on a C.F.B. Further south of the island higher concentrations are found, and values differ from those of the surface layer. Concentrations are recorded in a wide range from 2506 - 6880 ppm on a C.F.B. Such a range includes much higher and lower values than the range noticed in the surface layer.

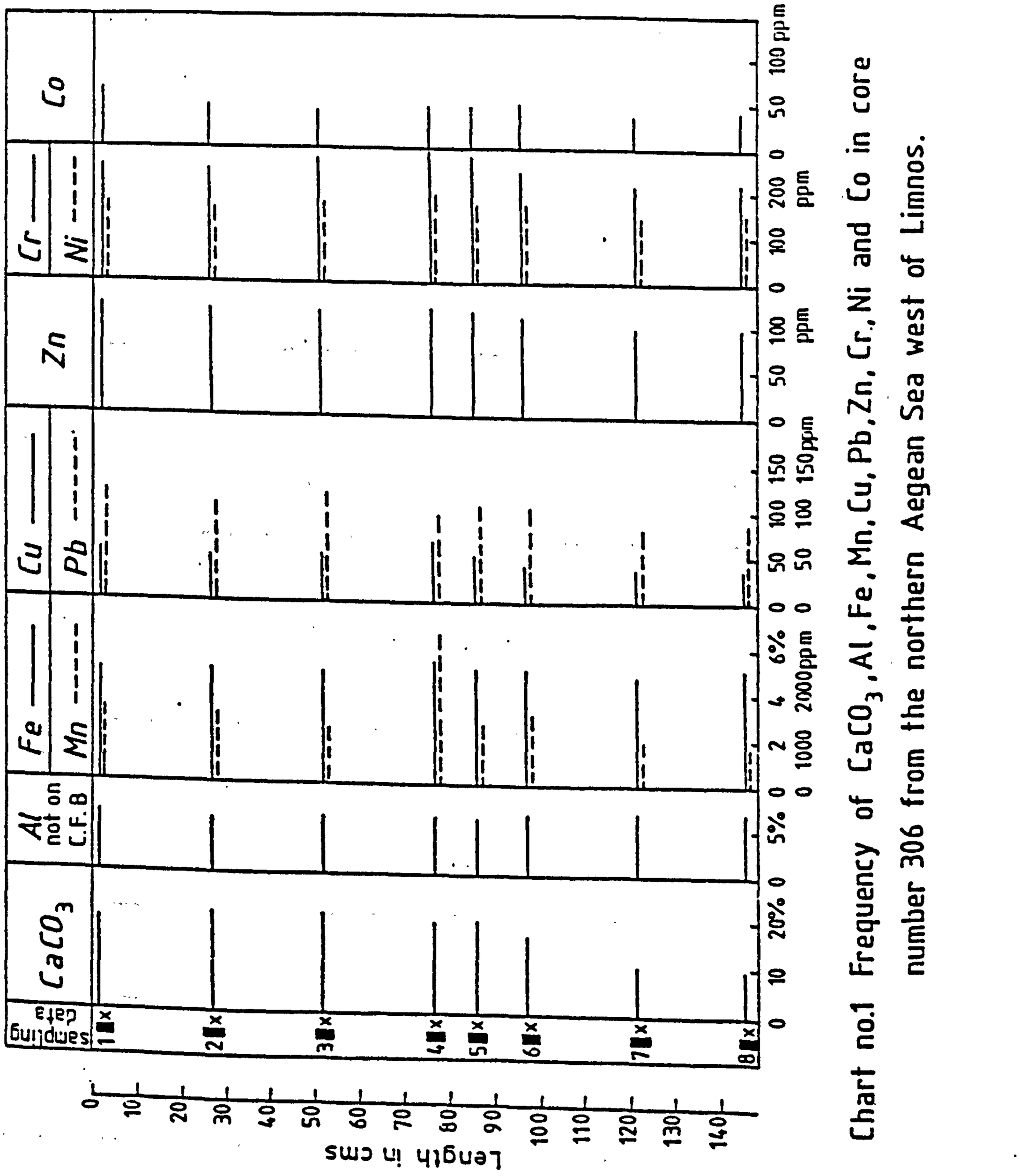


Chart no.1 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr., Ni and Co in core number 306 from the northern Aegean Sea west of Limnos.

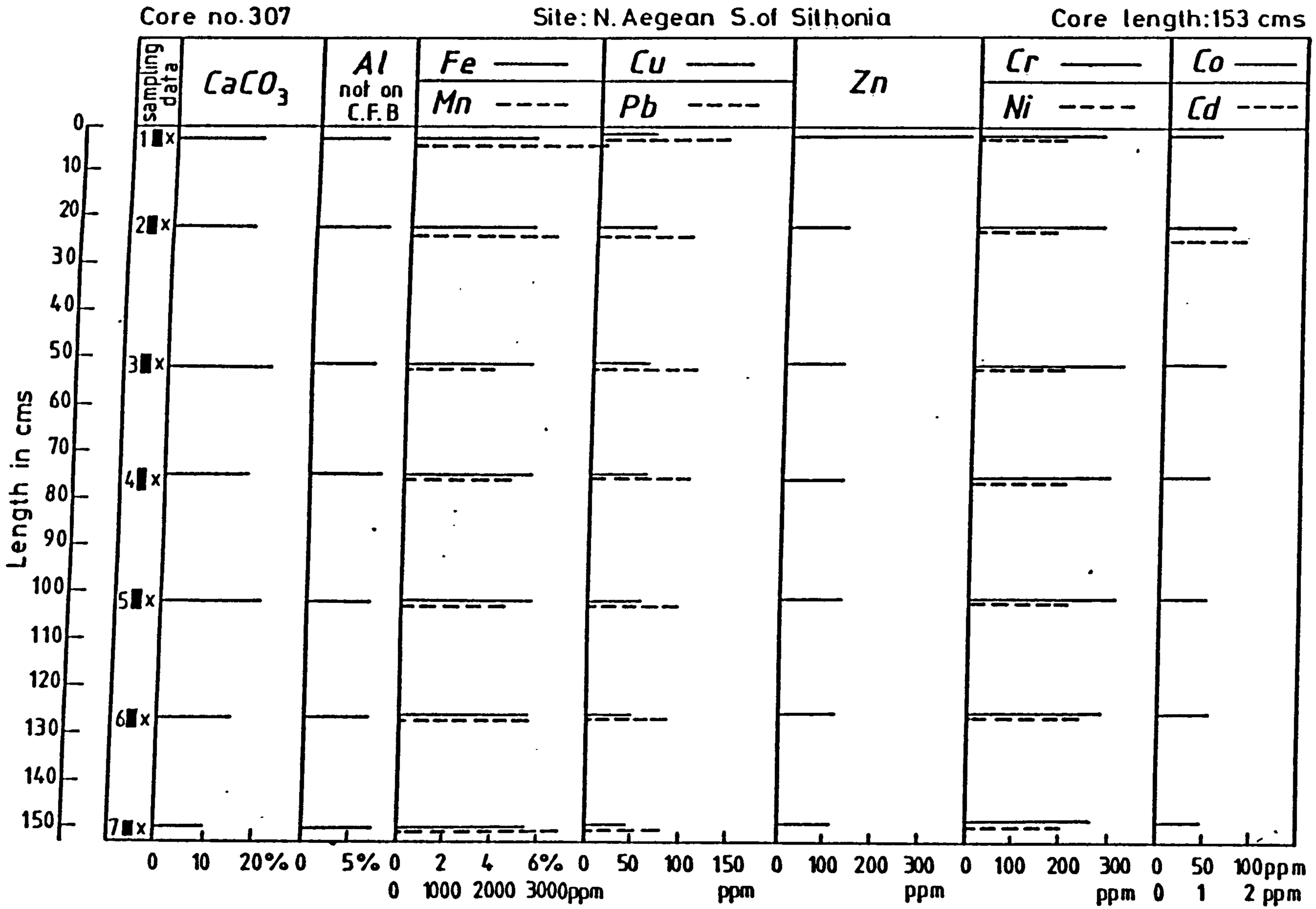


Chart no.2 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 307 from the northern Aegean Sea south of Khersenises Sithonia.

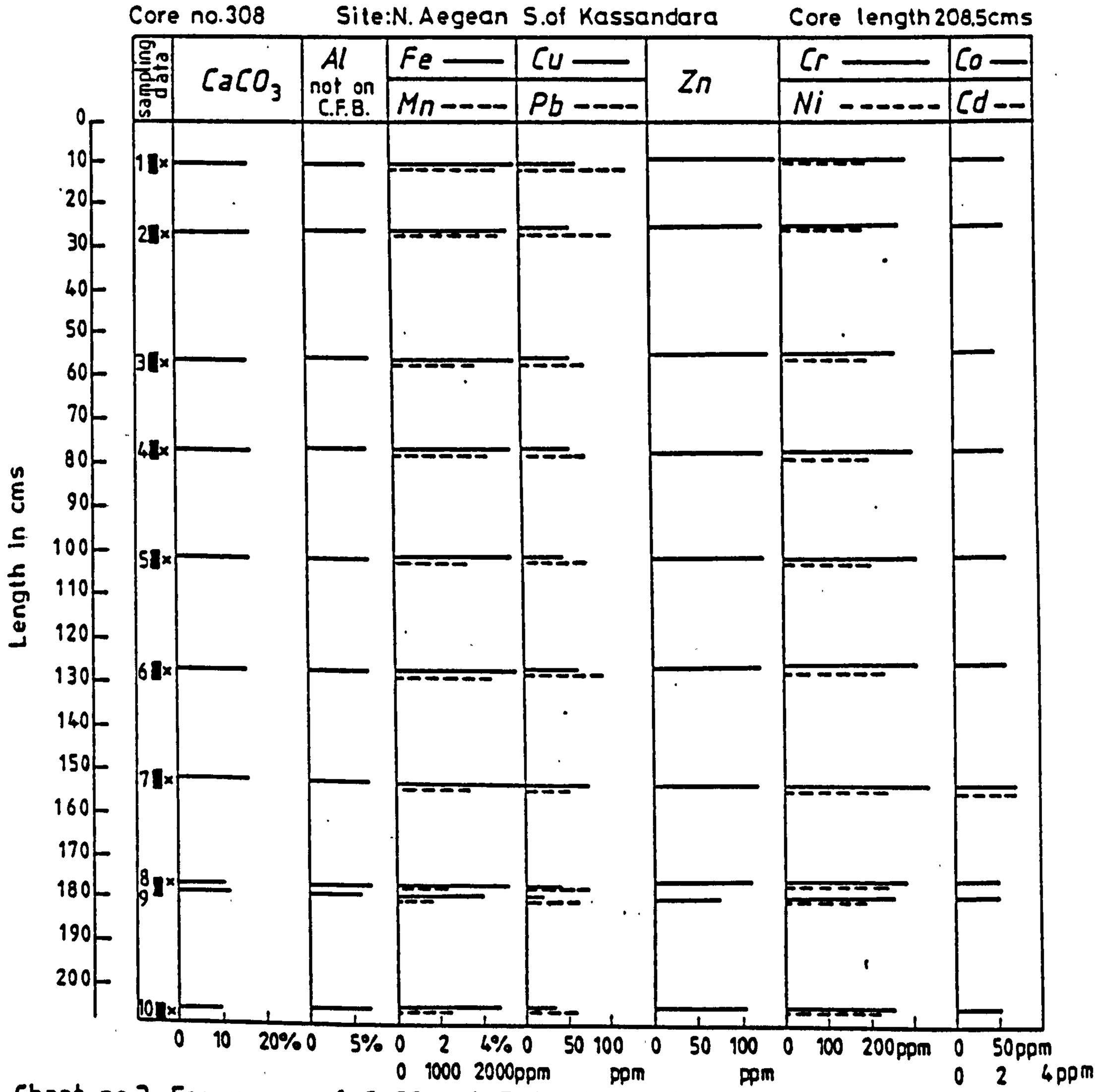


Chart no.3 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Co, Ni, Co and Cd in core number 308 from the northern Aegean Sea, south of Akra Kassandara.

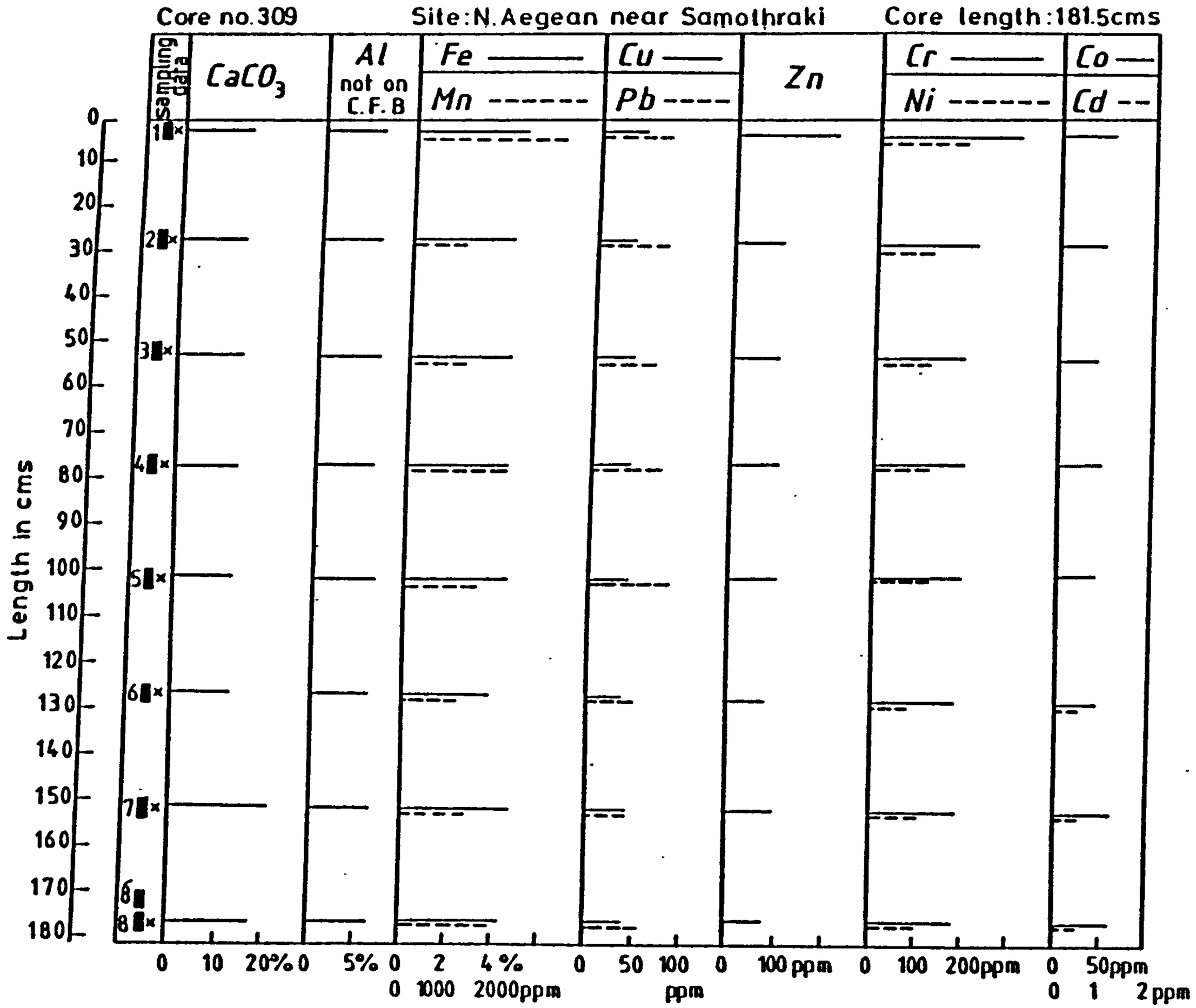


Chart no.4 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 309 from the northern Aegean Sea, south west of Samothraki.

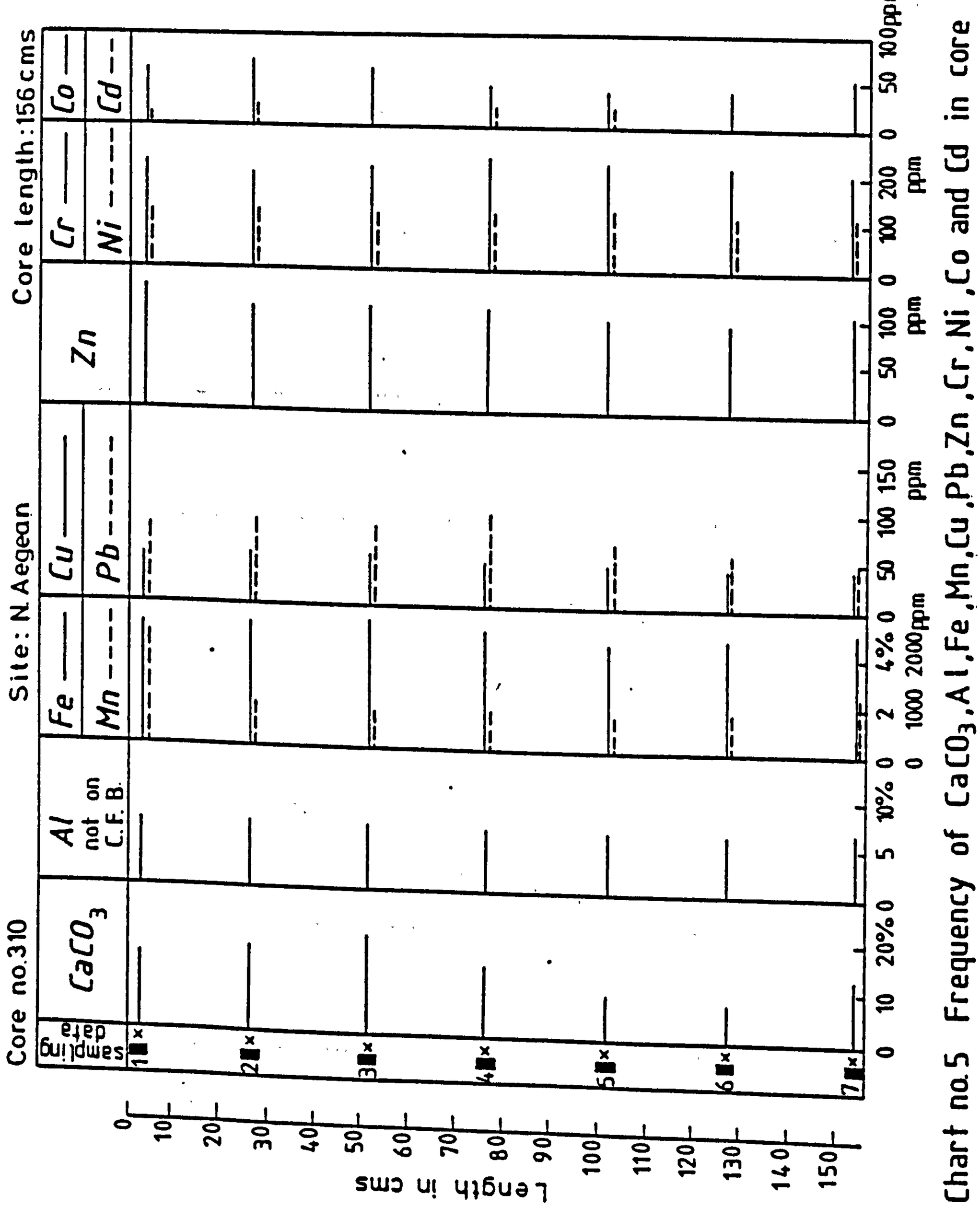


Chart no.5 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd number 310 from the northern Aegean Sea, south of Nisos Thasos.

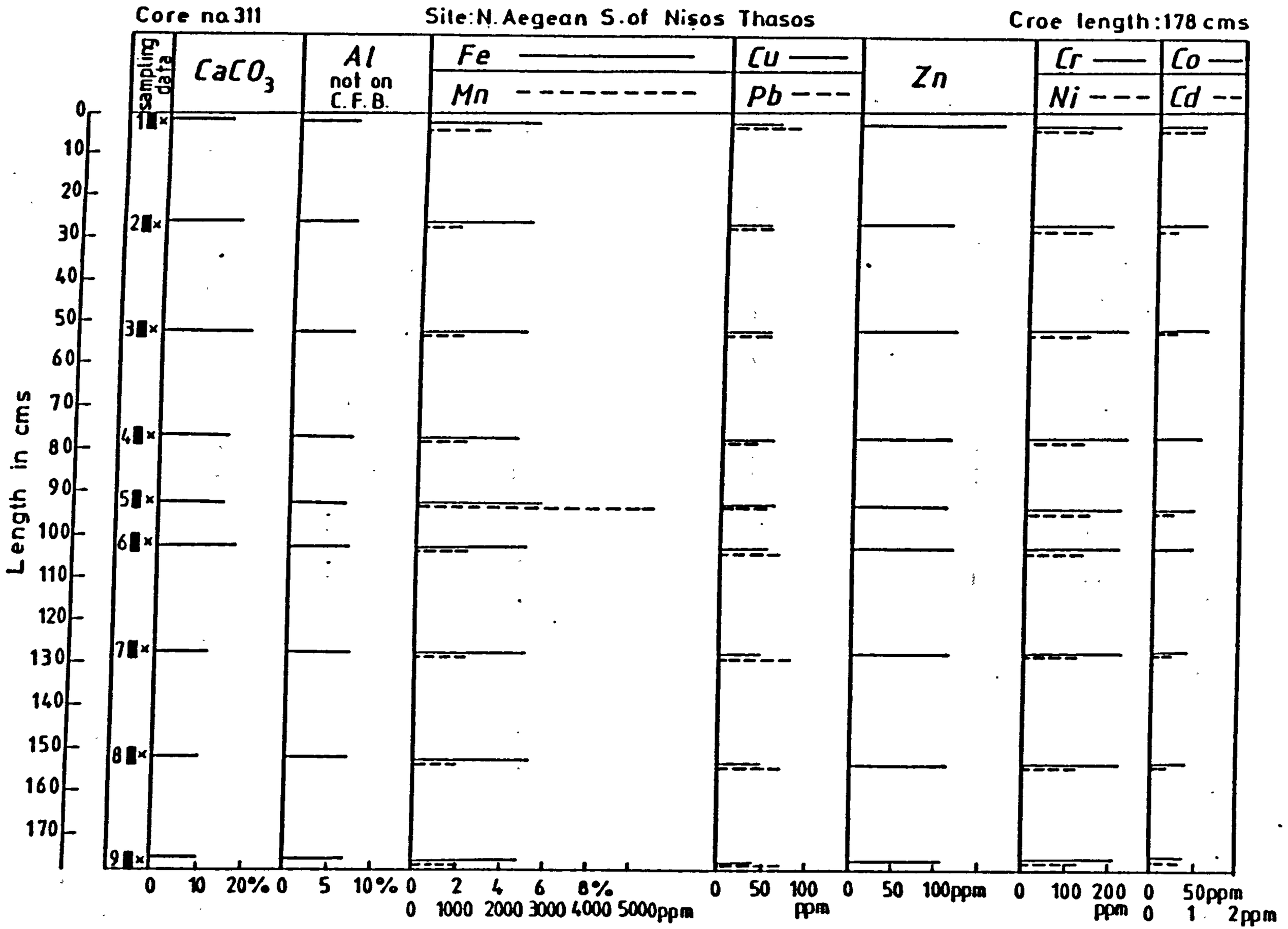


Chart no.6 Frquency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 311 from the northern Aegean Sea, south of Nisos Thasos.

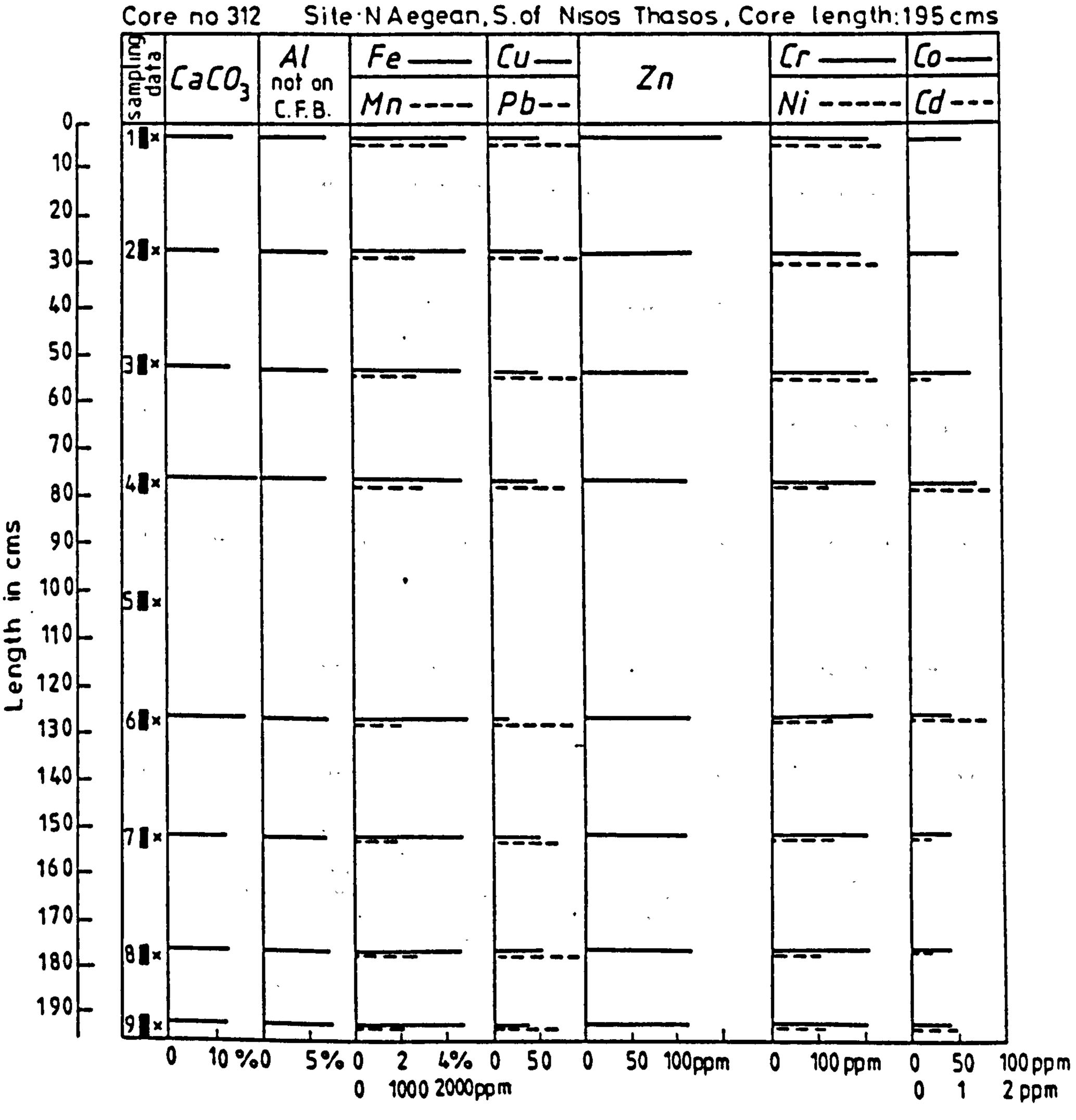


Chart no.7 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core no.312 from the northern Aegean Sea, south of Nisos Thasos.

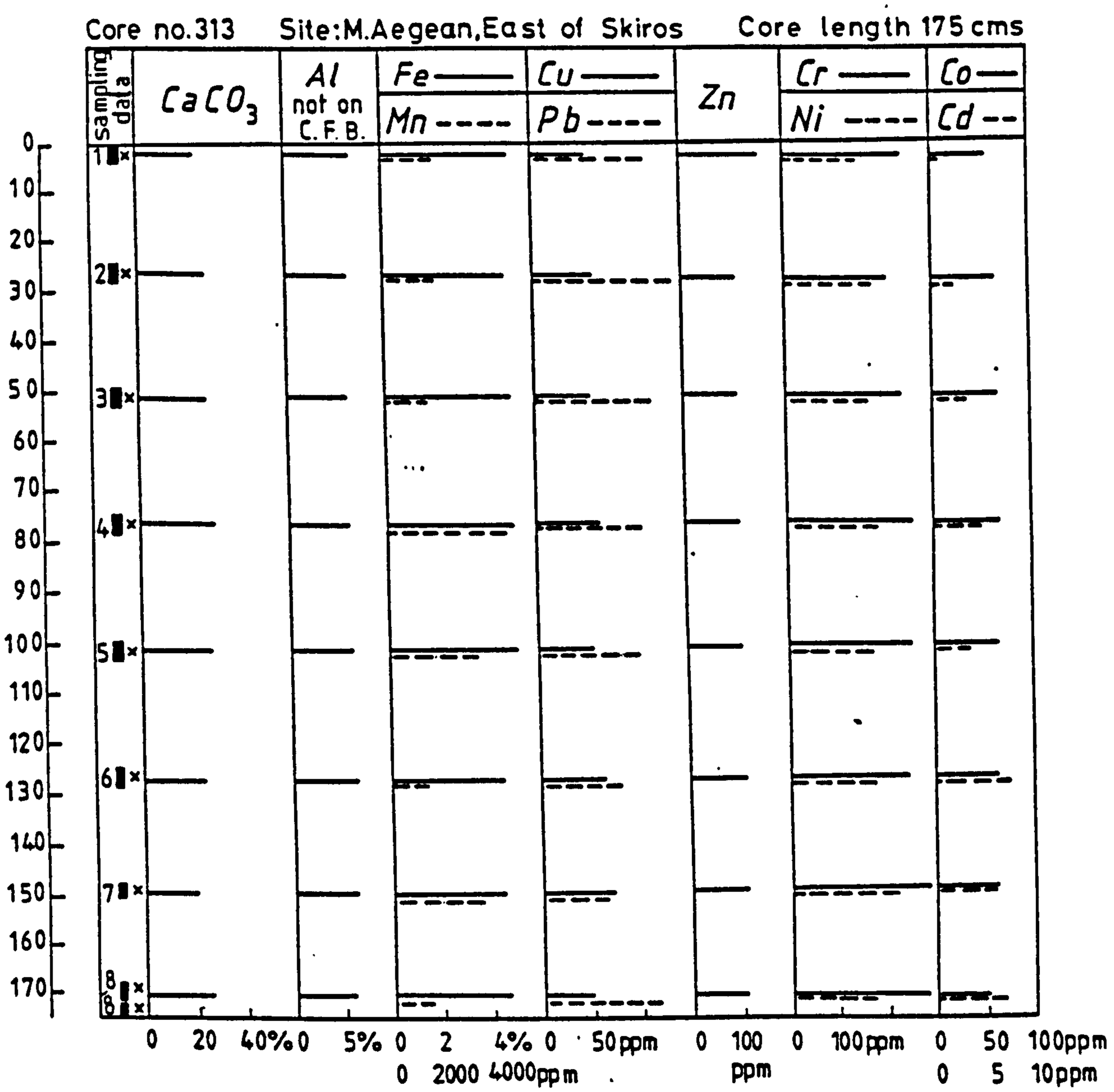


Chart no.8 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 313 from the Middle Aegean Sea, east of Skiros.

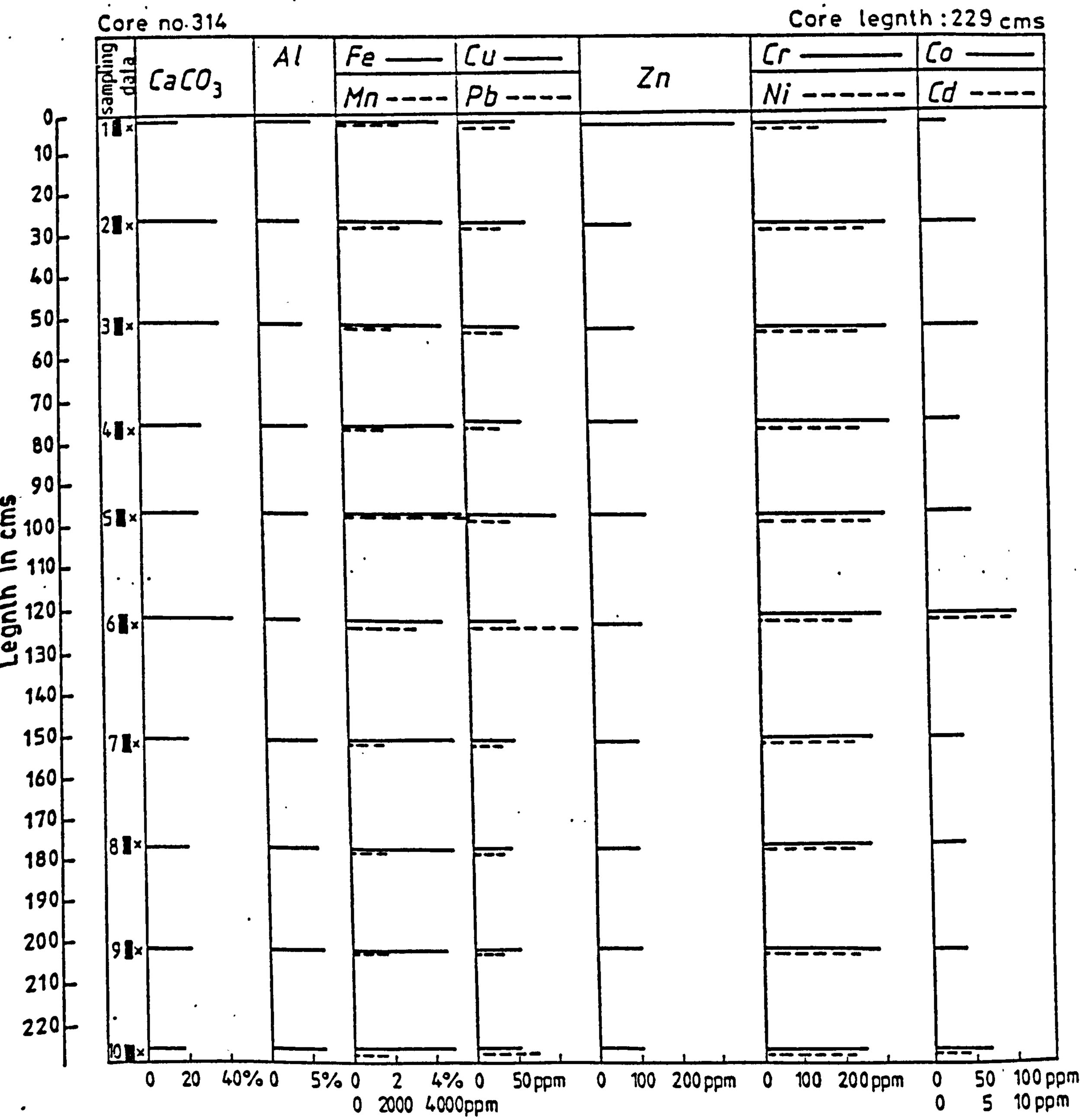


Chart no.9 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 314 from the middle Aegean Sea, east of Evvola.

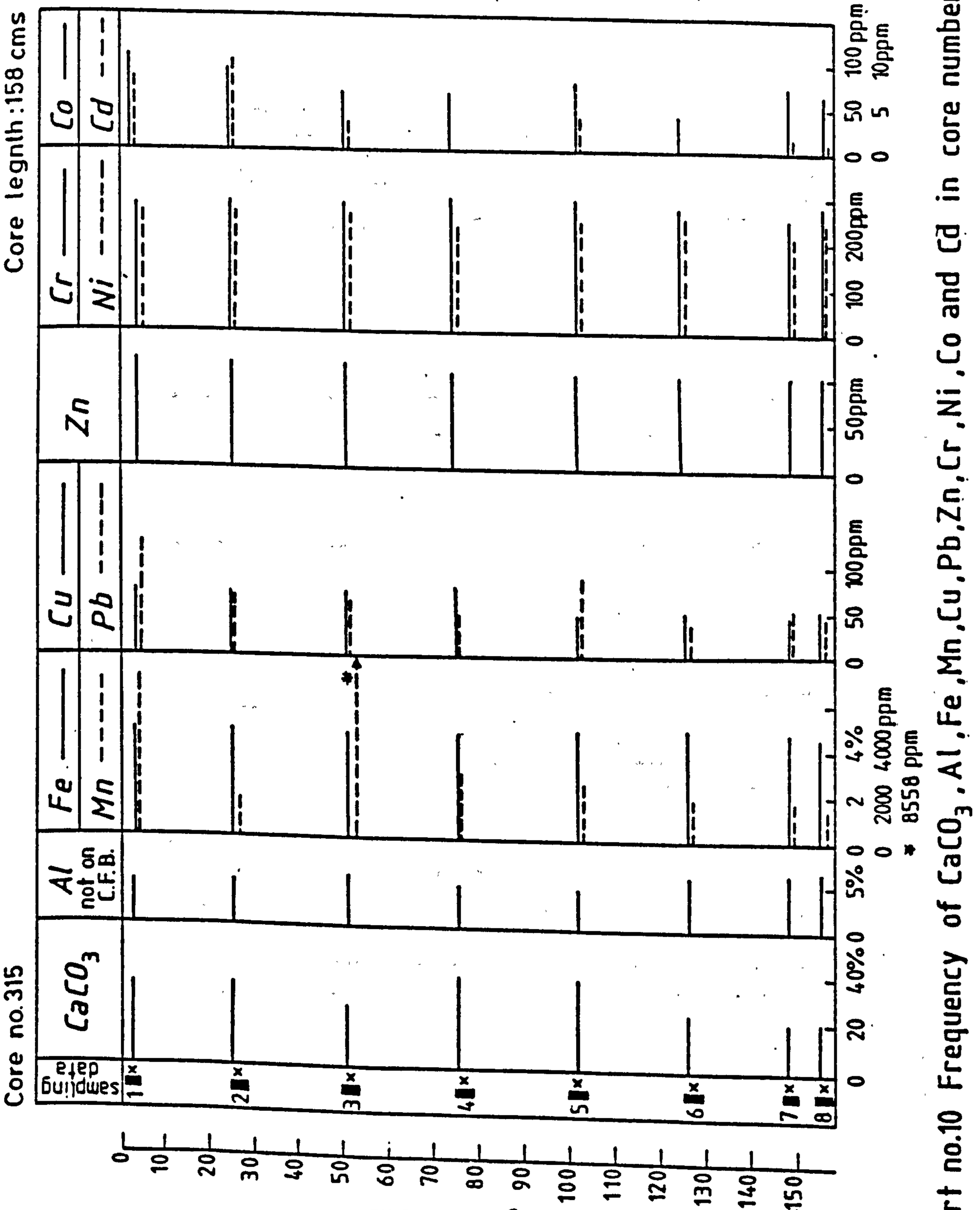


Chart no.10 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 315 from the middle Aegean Sea, south of Psara.

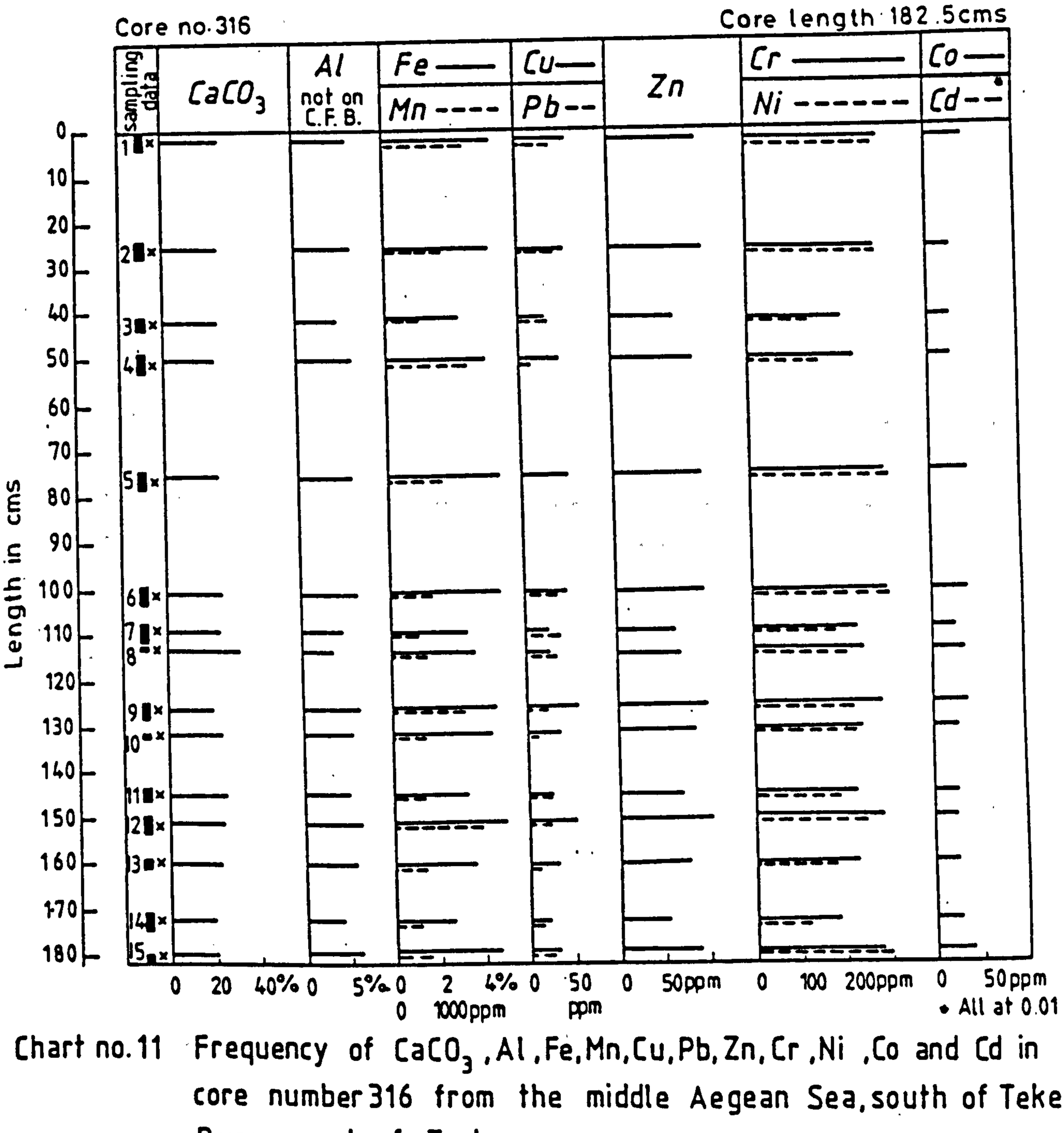


Chart no.11 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 316 from the middle Aegean Sea, south of Teke Burnu, west of Turkey.

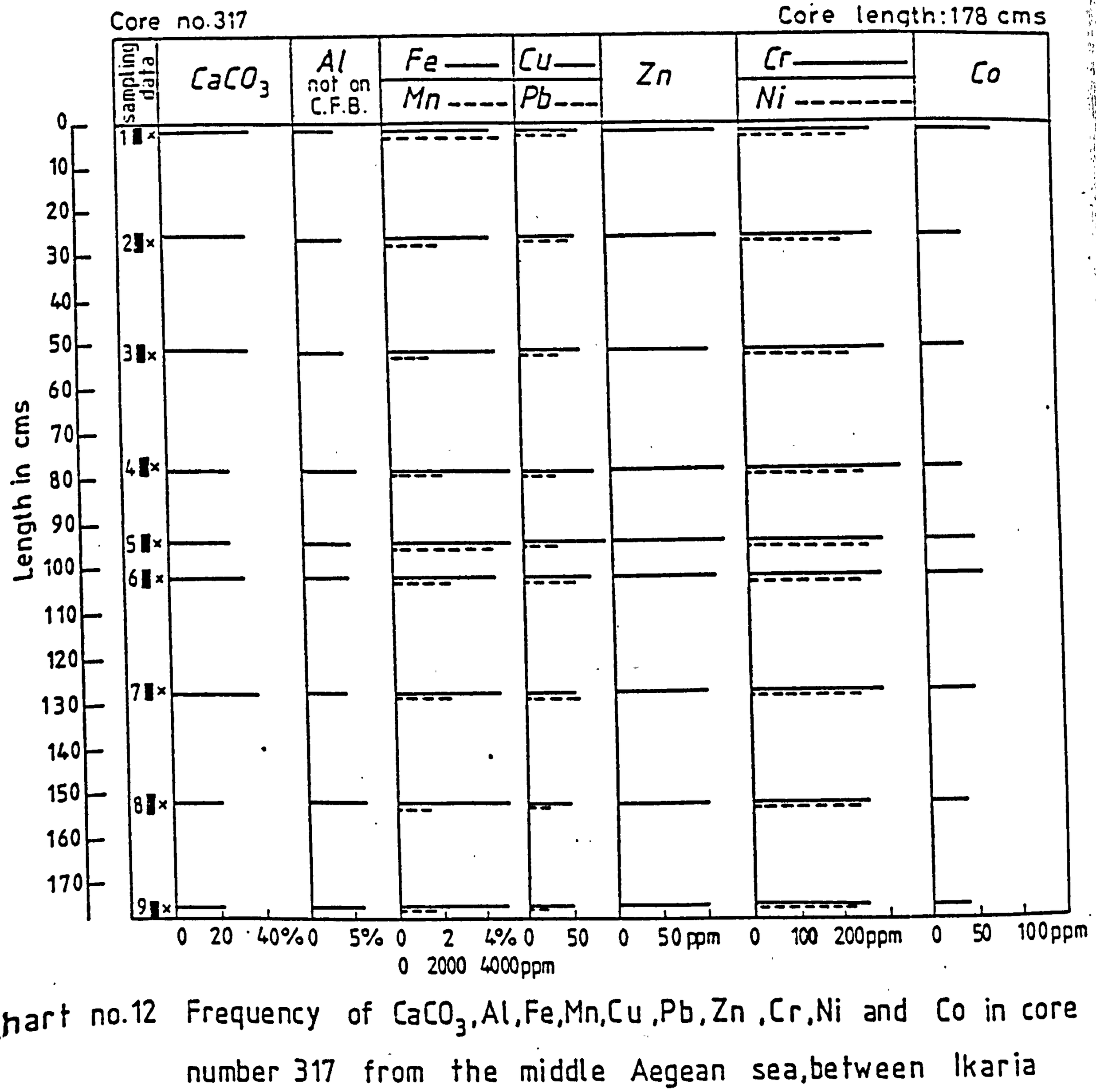


Chart no.12 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni and Co in core number 317 from the middle Aegean sea, between Ikaria and Tinos.

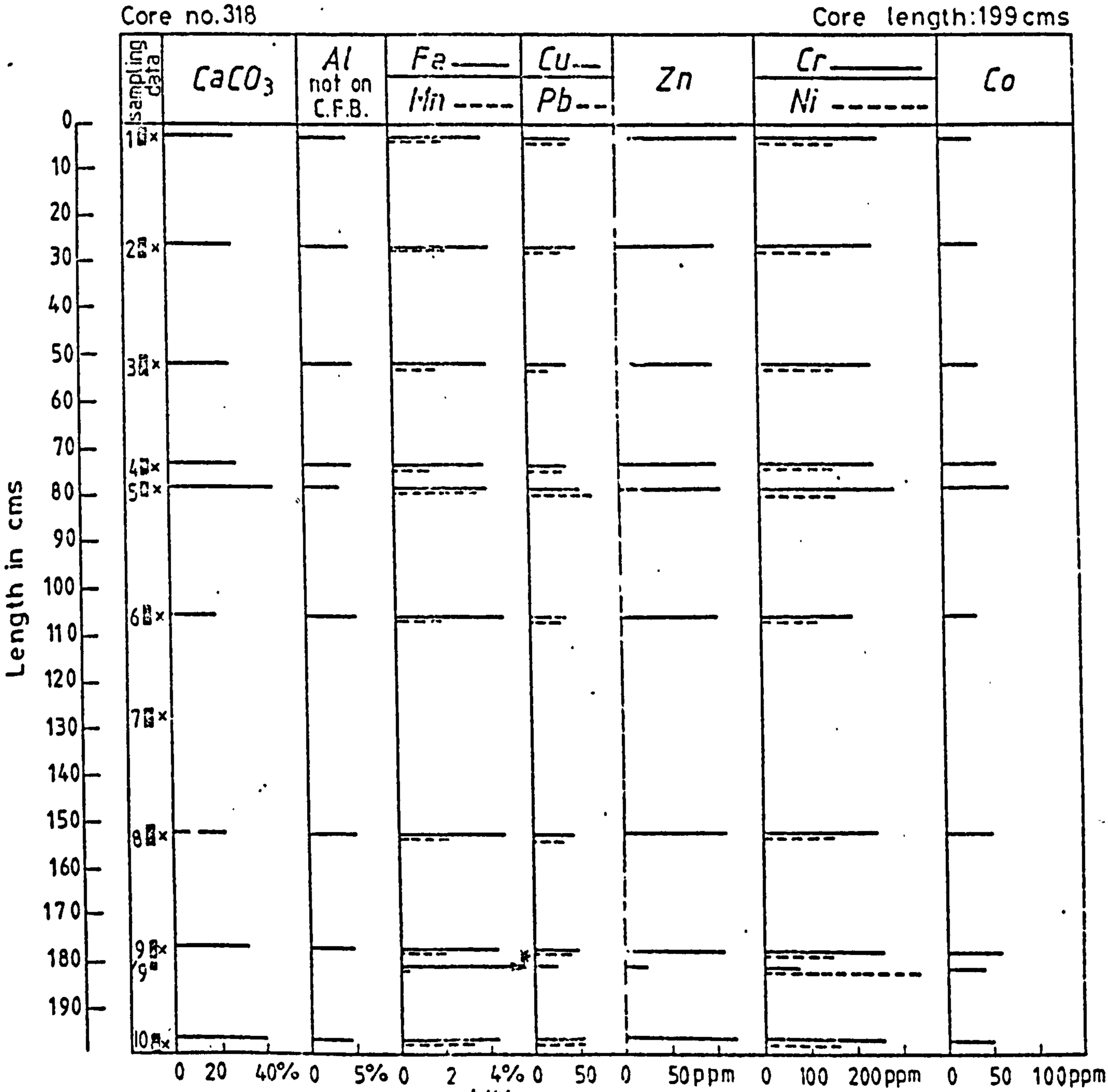


Chart no.13 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni and Co in core number 318 from the Aegean Sea, east of Peloponnesus.

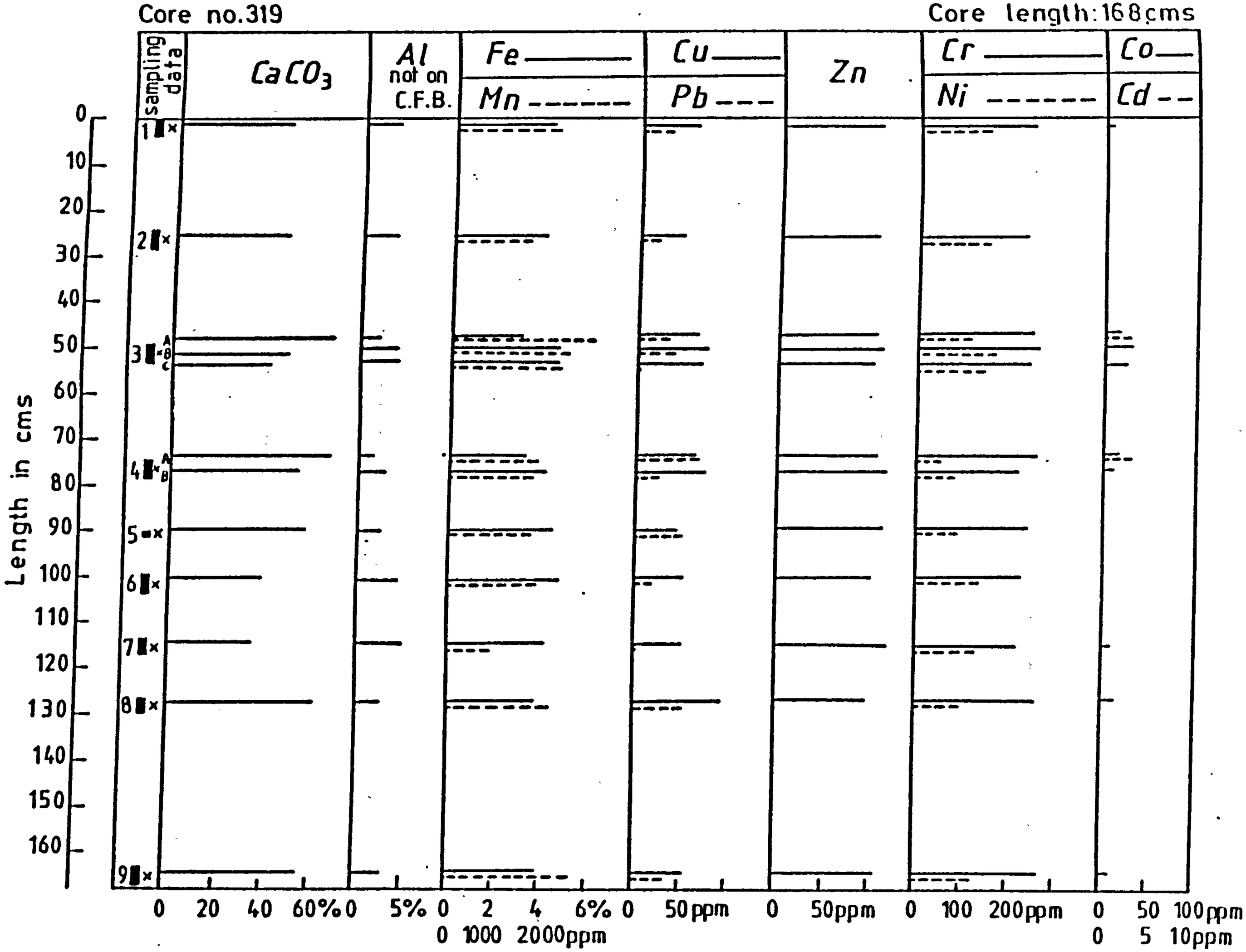


Chart no.14 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 319 from the southern Aegean, east of Kithira.

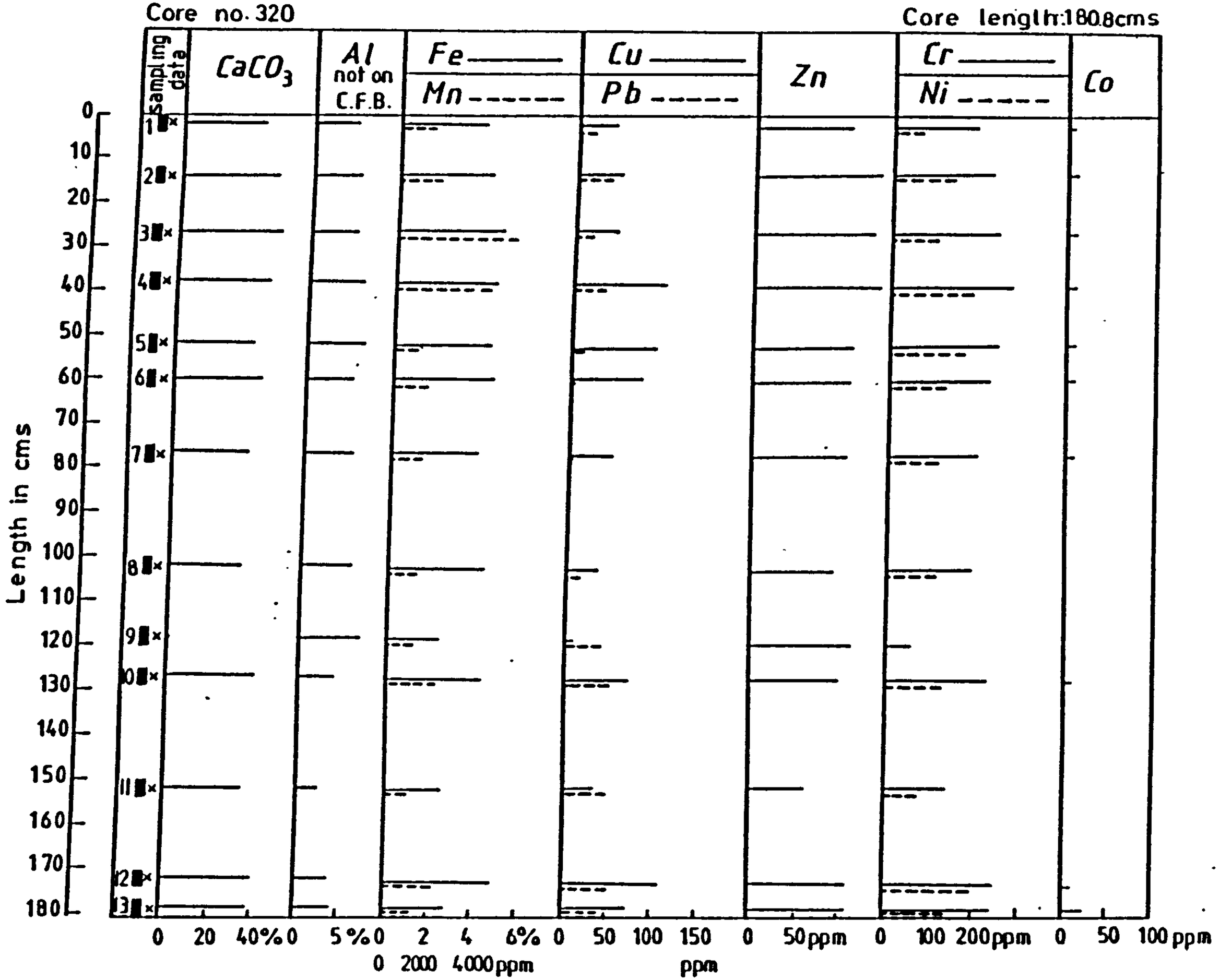


Chart no.15 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni and Co in core number 320 from the southern Aegean, east of Andikithira.

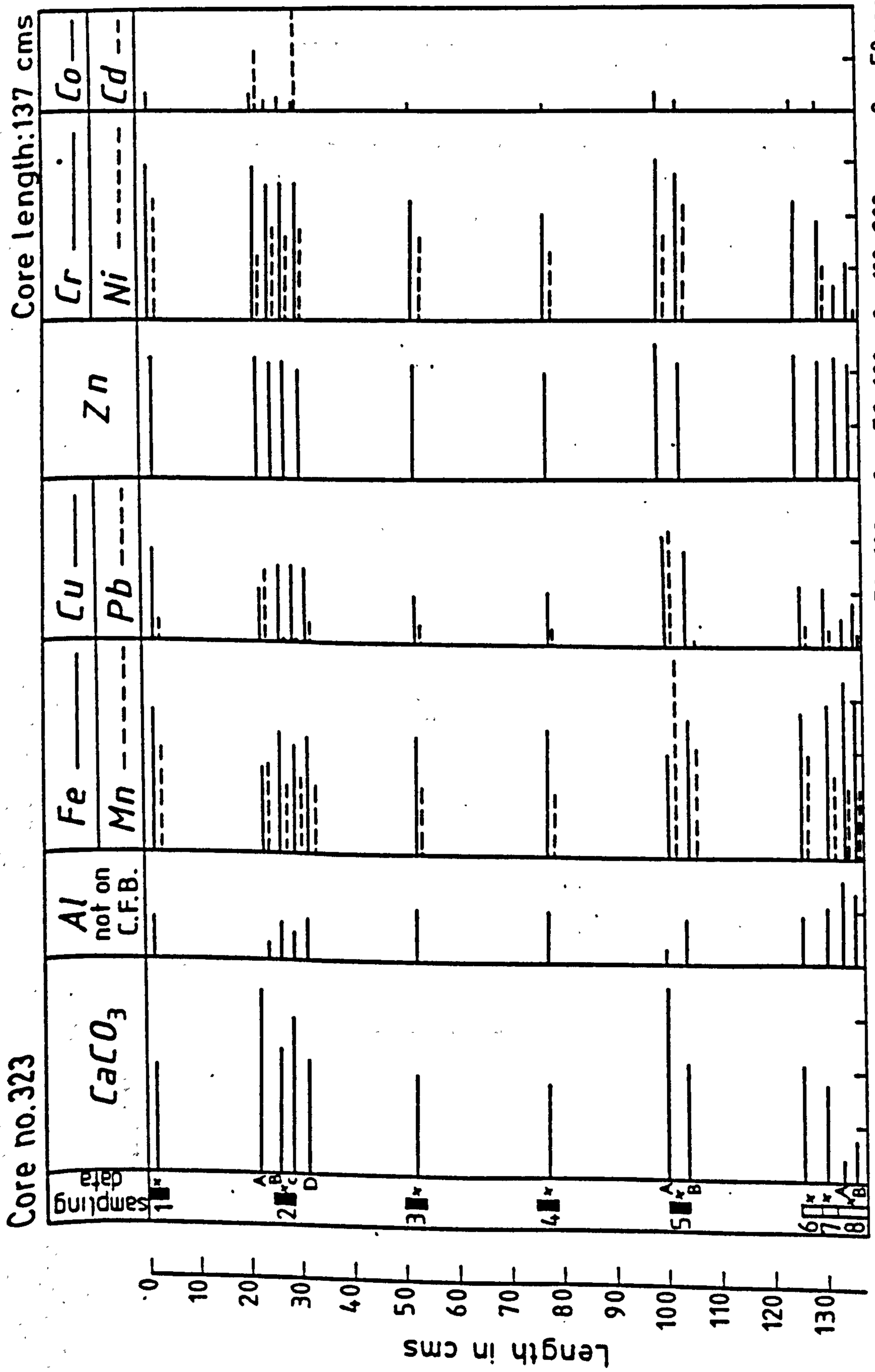


Chart no.16 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 323 from the Southern Aegean, North of Crete.

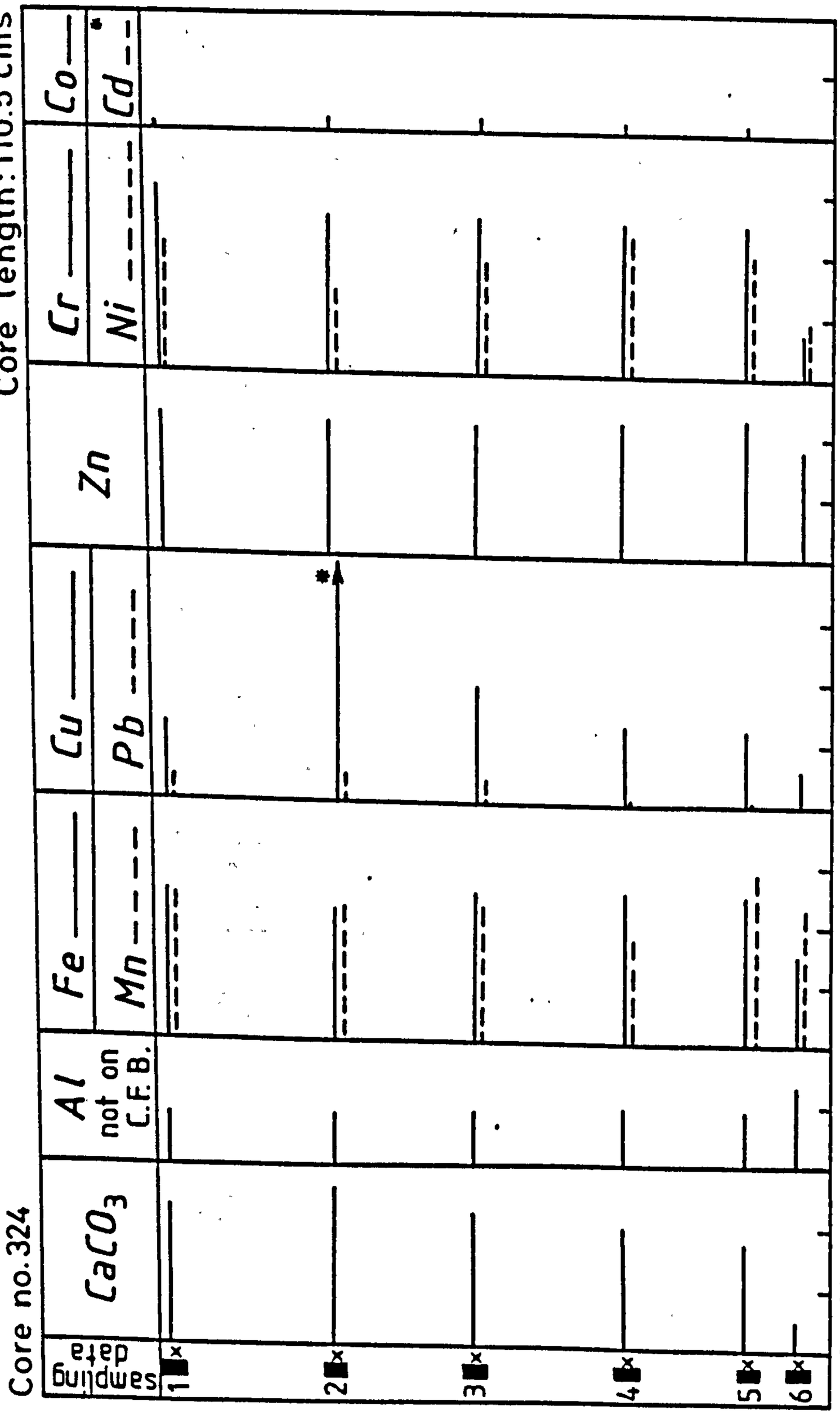


Chart no.17 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co and Cd in core number 324 from the southern Aegean, North of Crete.

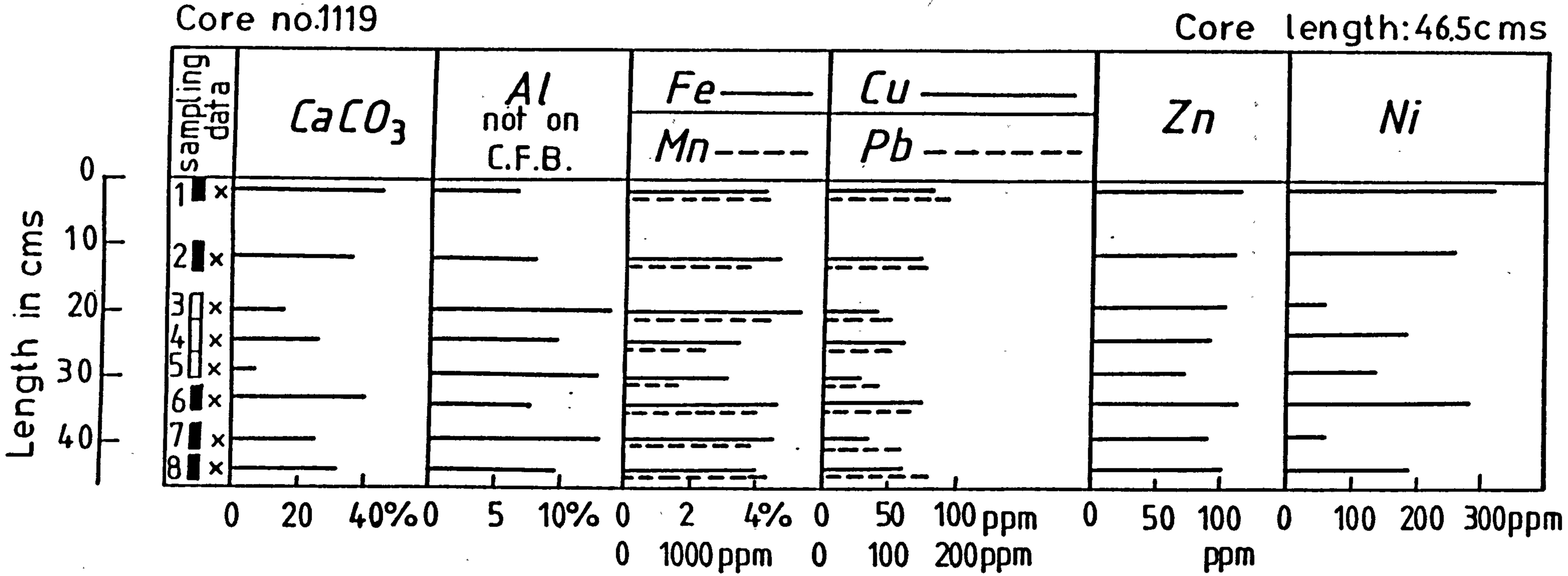


Chart no.18 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn an Ni in core number 1119 from the southern Aegean, between Thera and Crete.

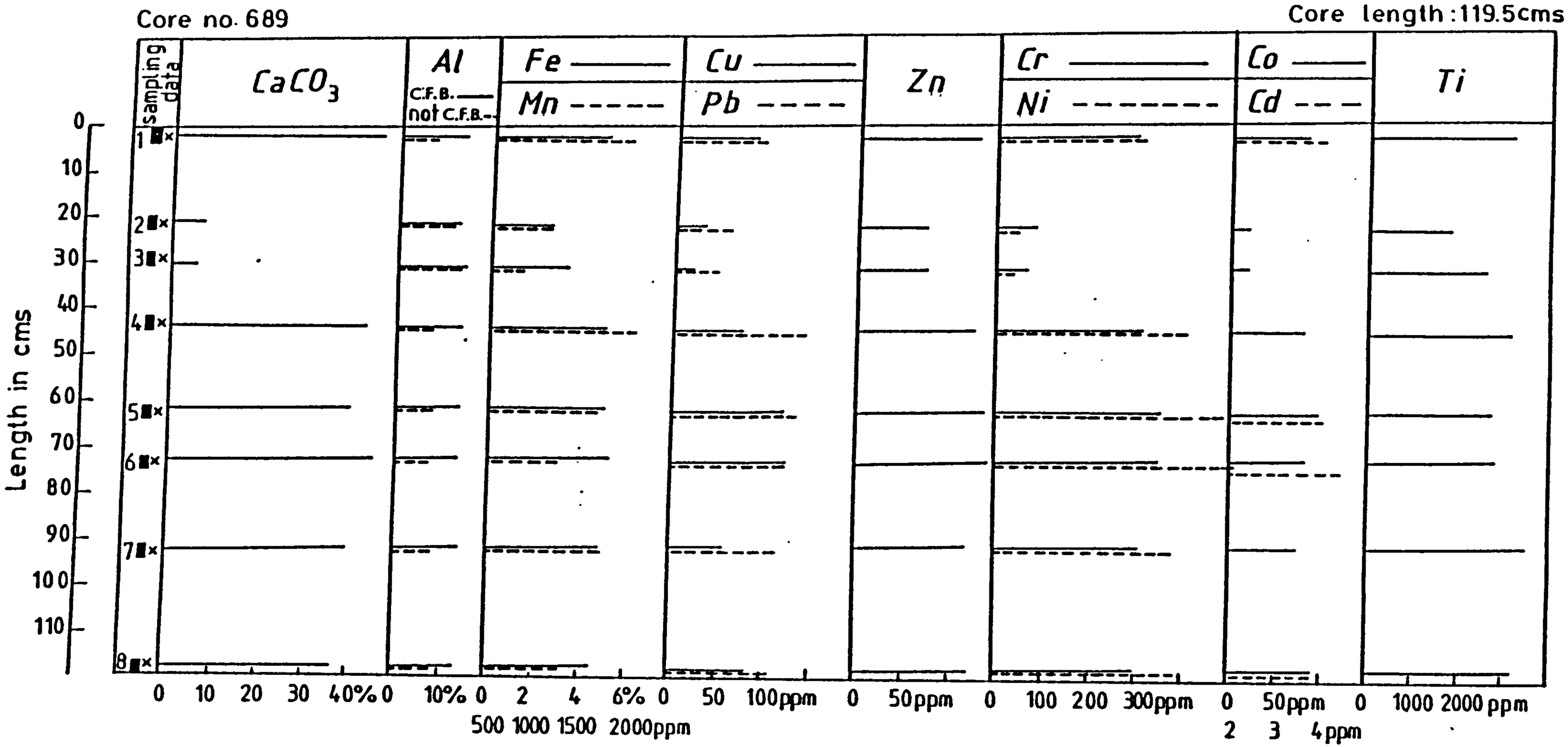


Chart no.19 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in core noumber 689 from the Southern Aegean, west of Karpathos.

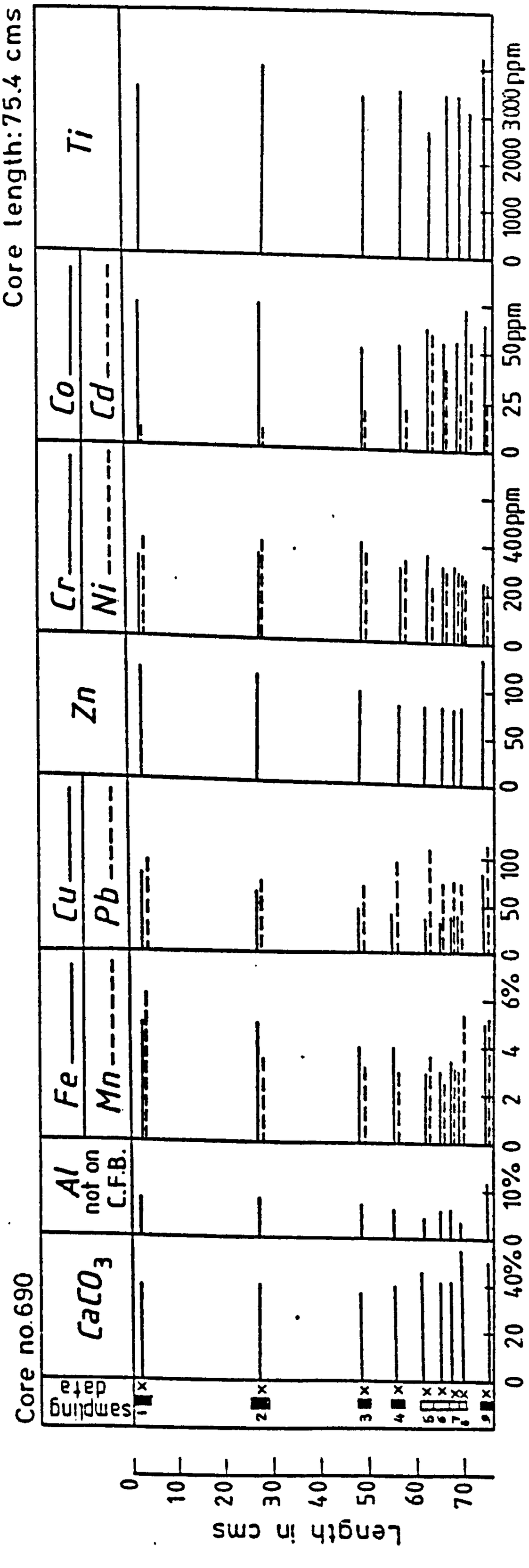
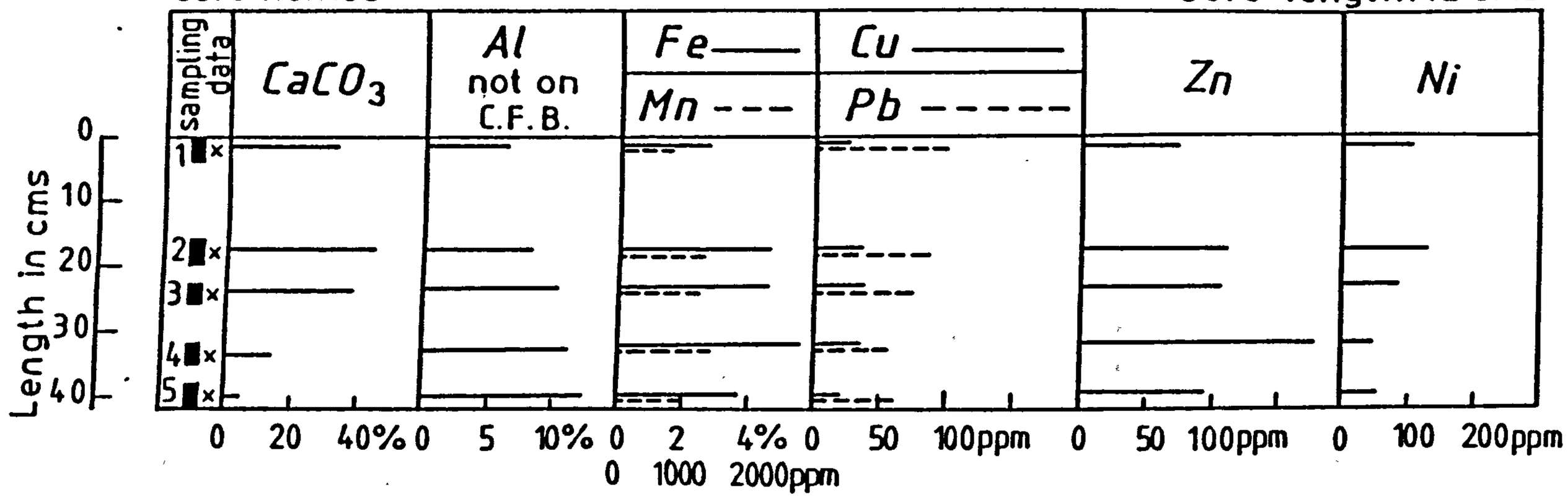


Chart no.20 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in core number 690 from the southern Aegean, west of Karpathos.



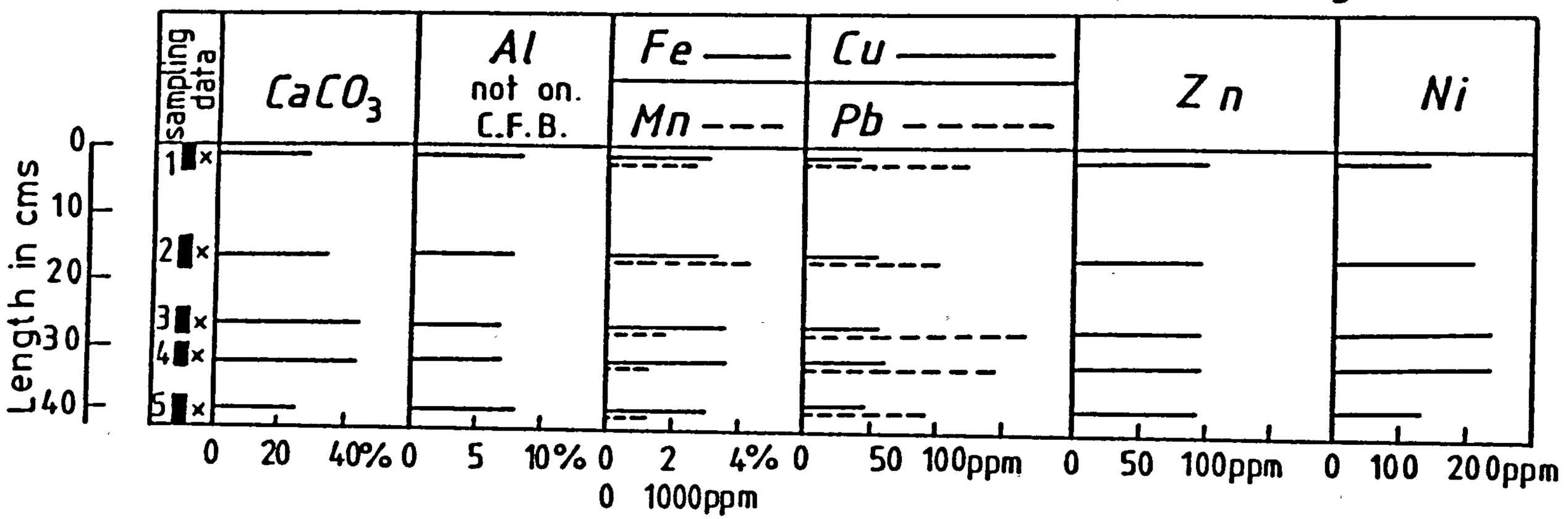
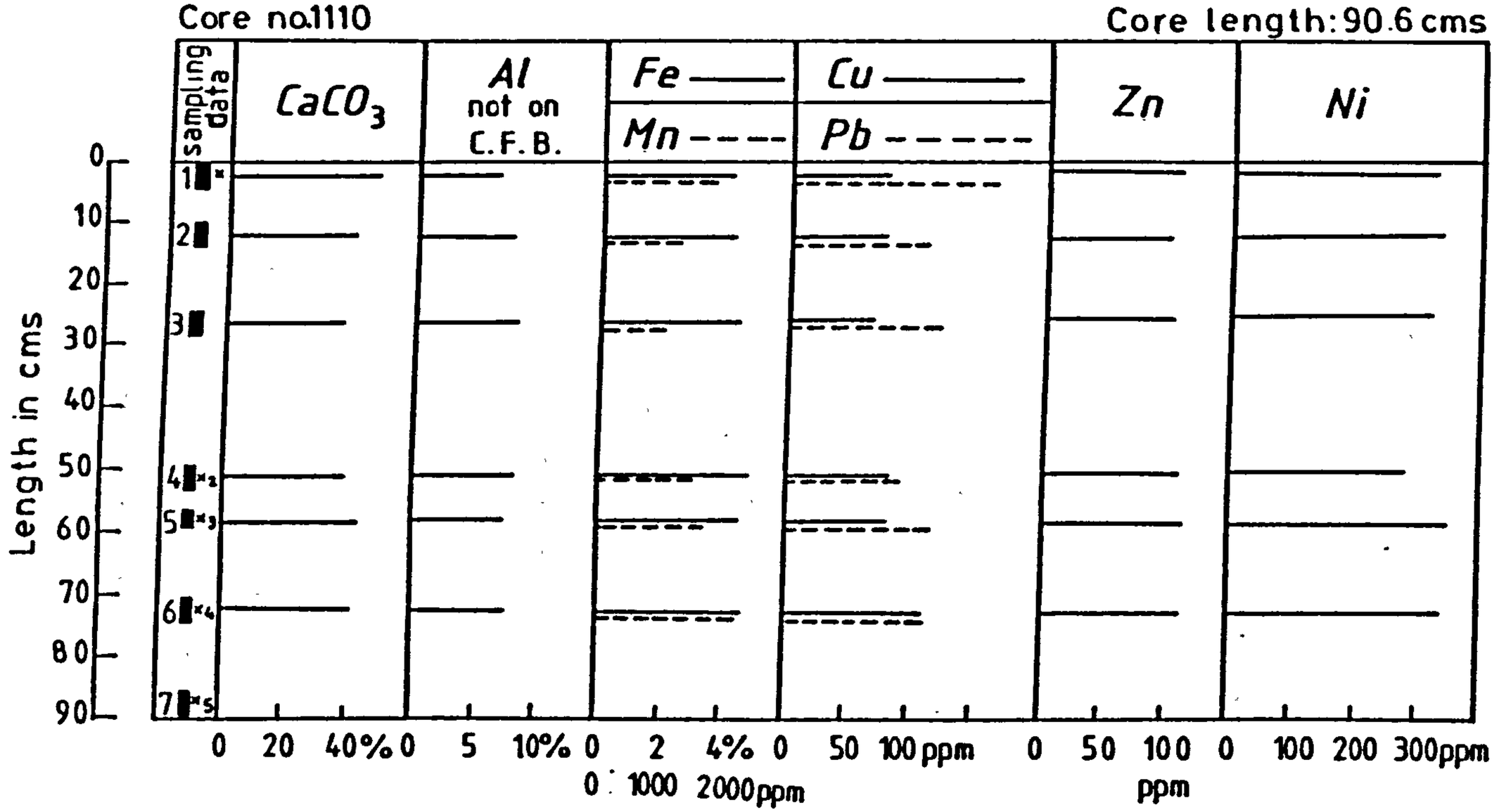


Chart no.21 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in cores numbers 1108 & 1109 from Santorini area, west of Thera.



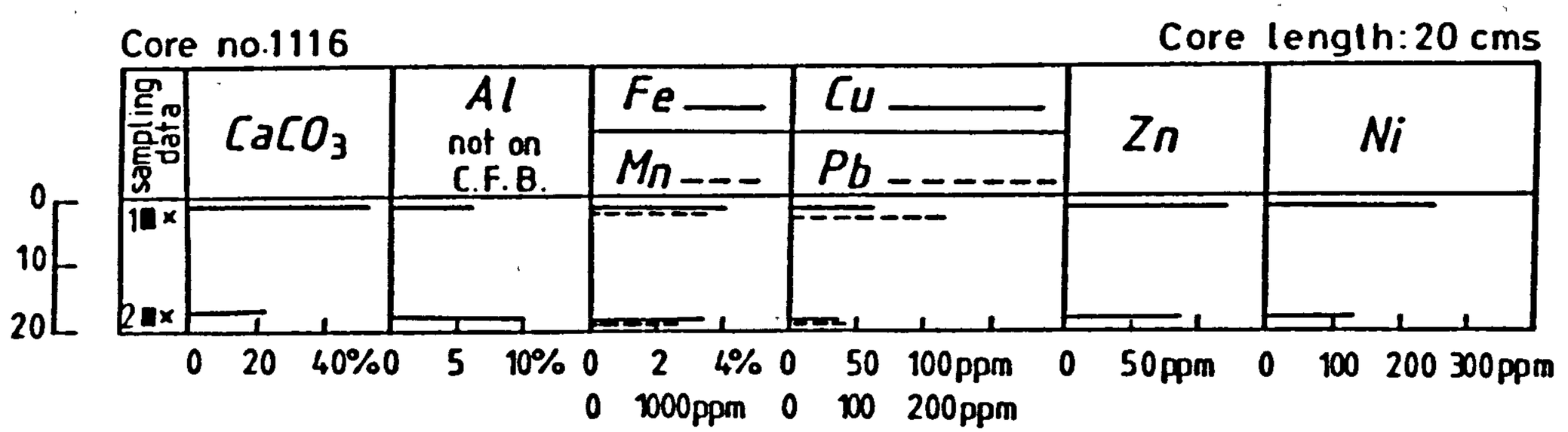


Chart no.22 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in cores numbers 1110 & 1116 from Santorini area, between Milos and Thera.

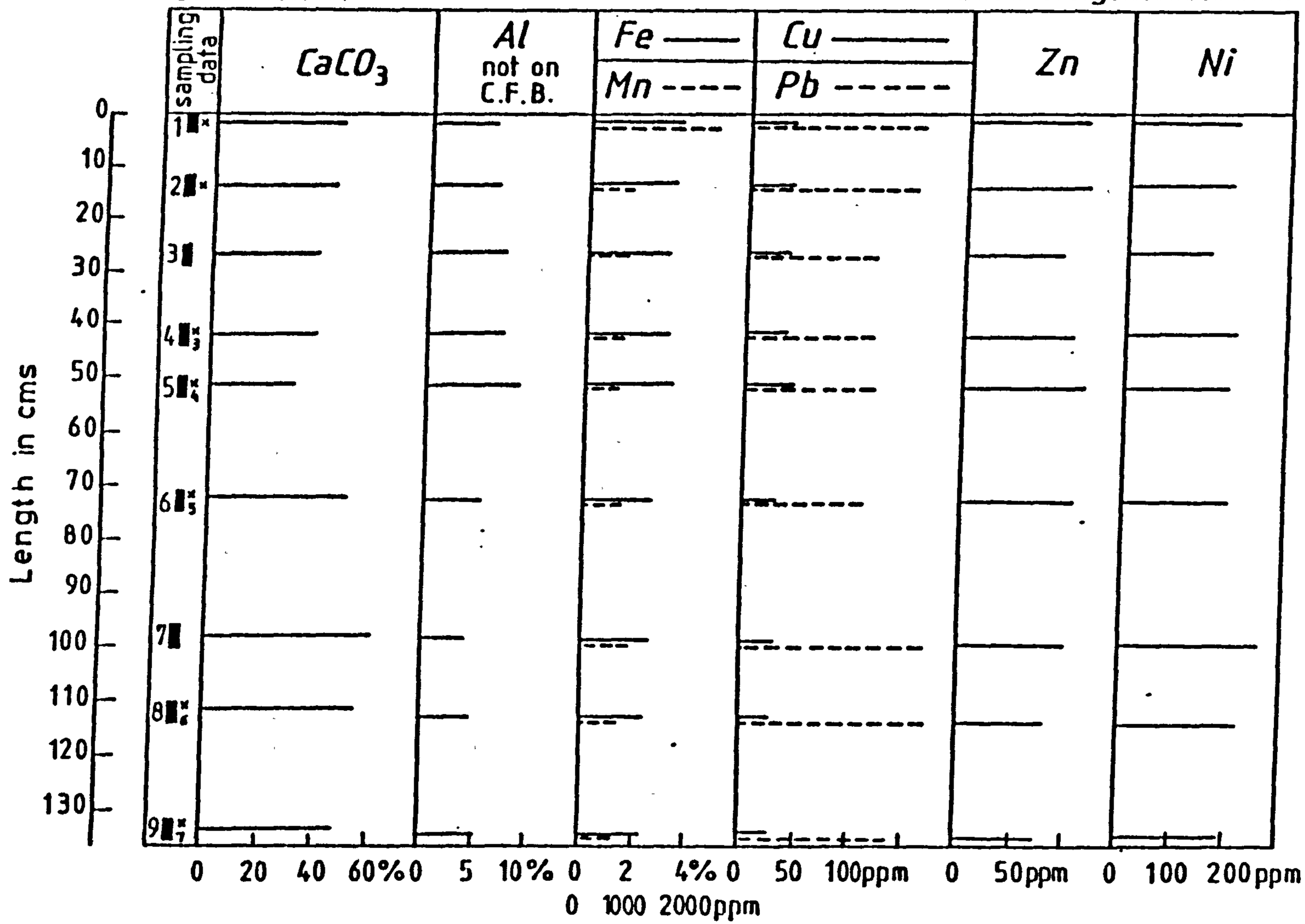
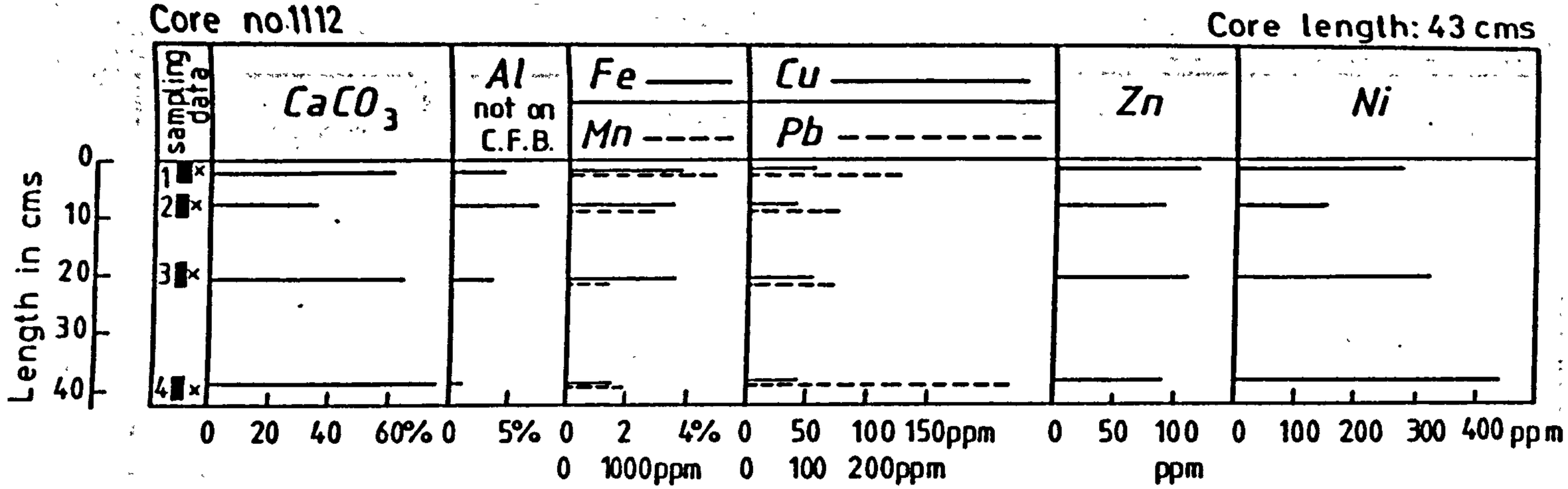


Chart no.23 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 1111 from Santorini area, east of Milos.



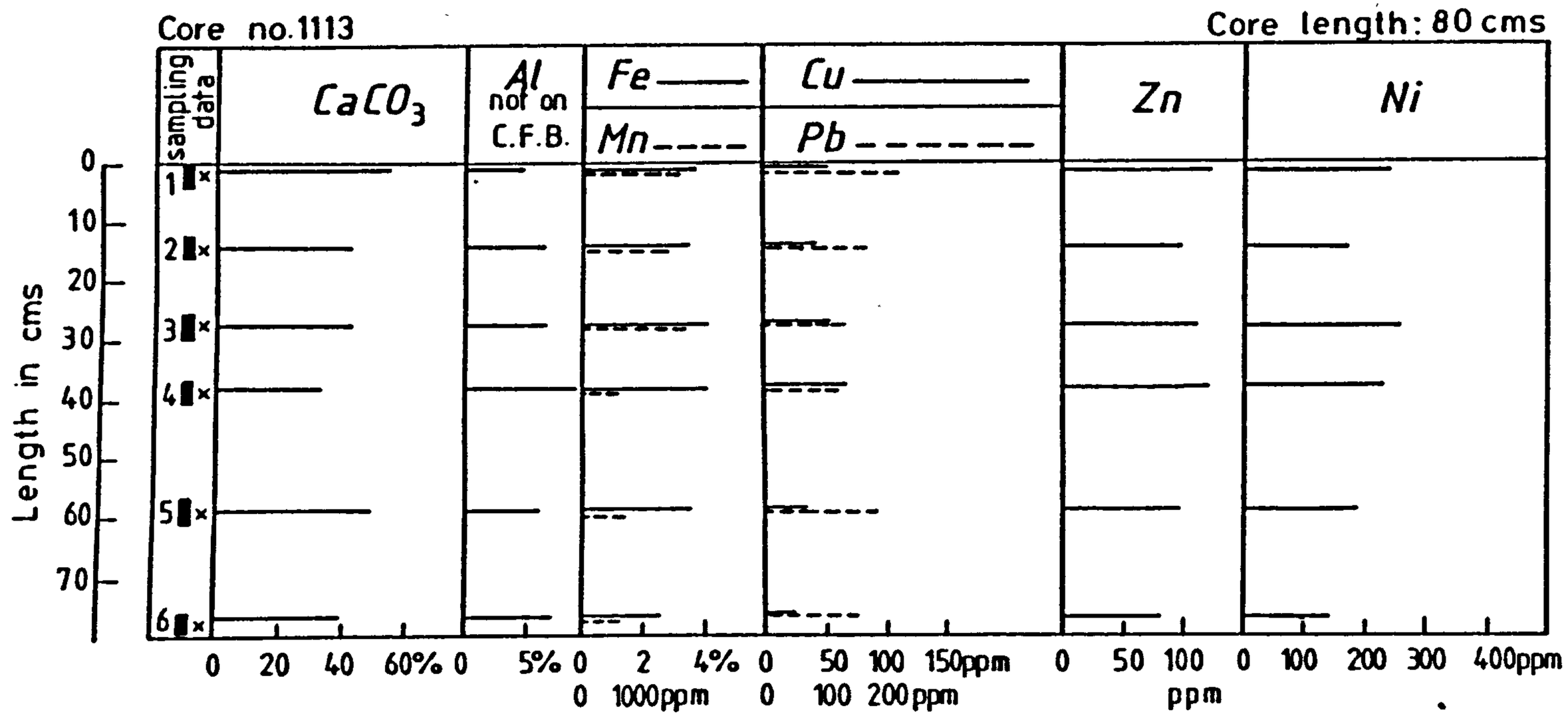
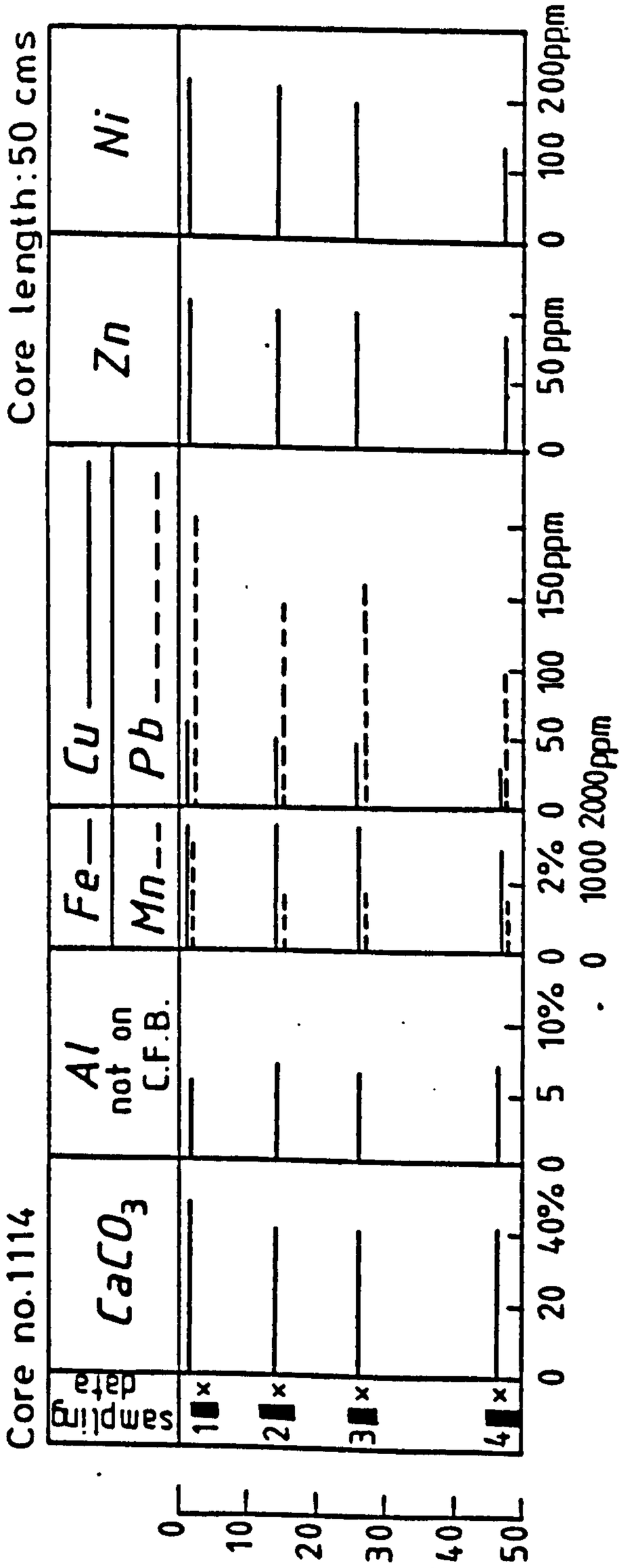


Chart no.24 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in cores numbers 1112 & 1113 from Santorini area, south-east of Milos.



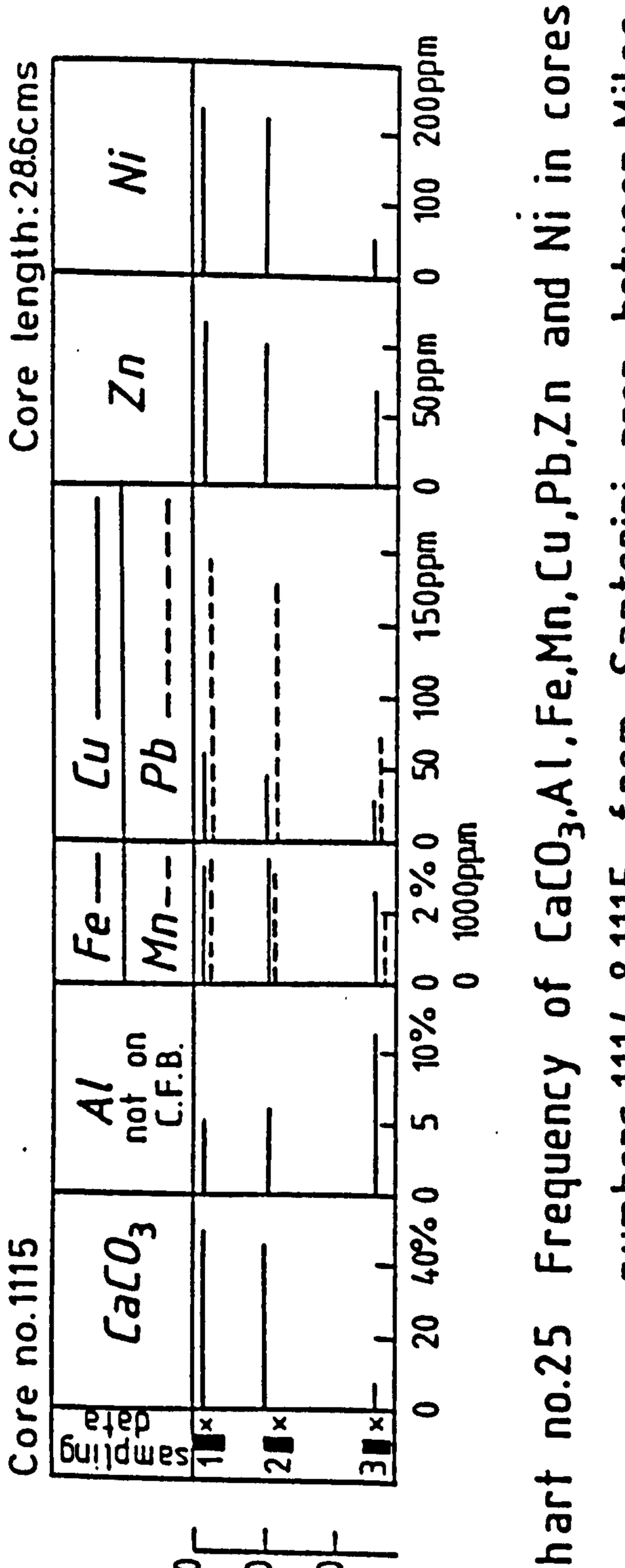
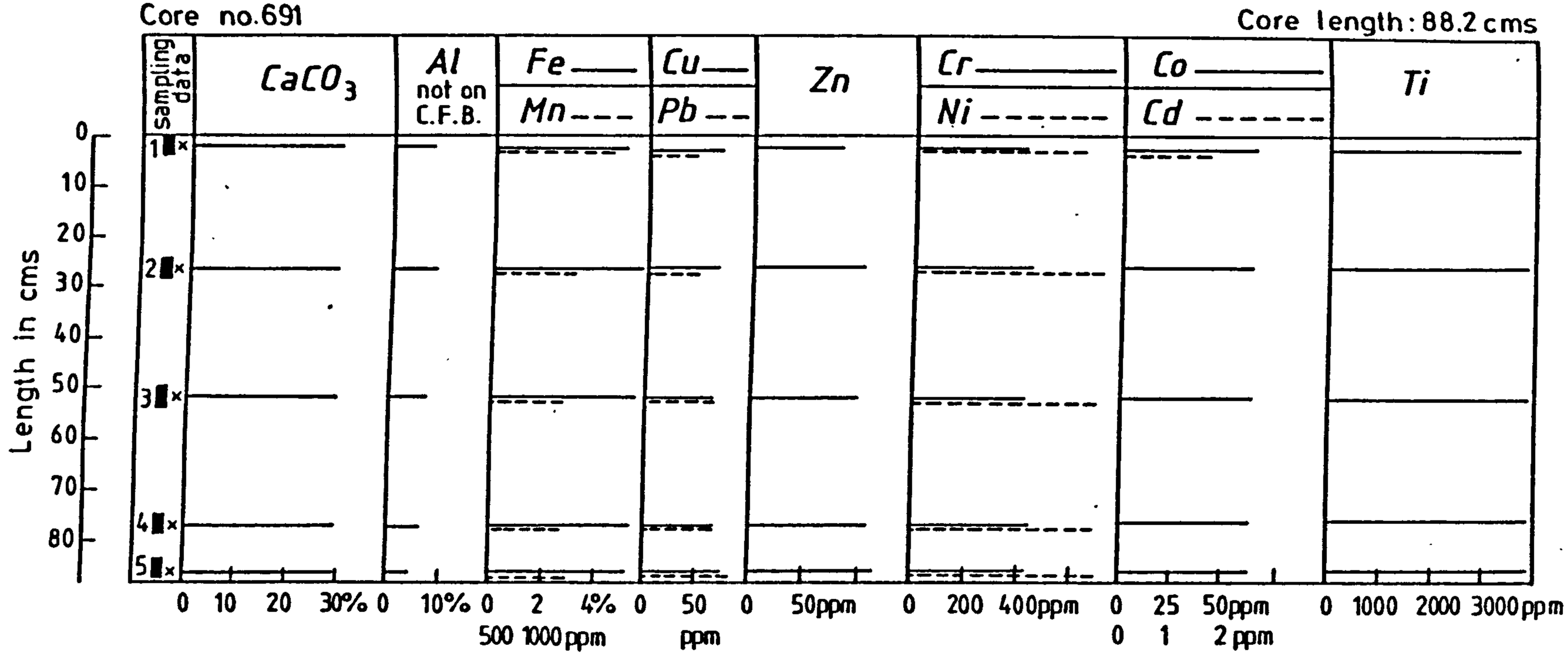


Chart no.25 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in cores numbers 1114 & 1115 from Santorini area, between Milos and Thera.



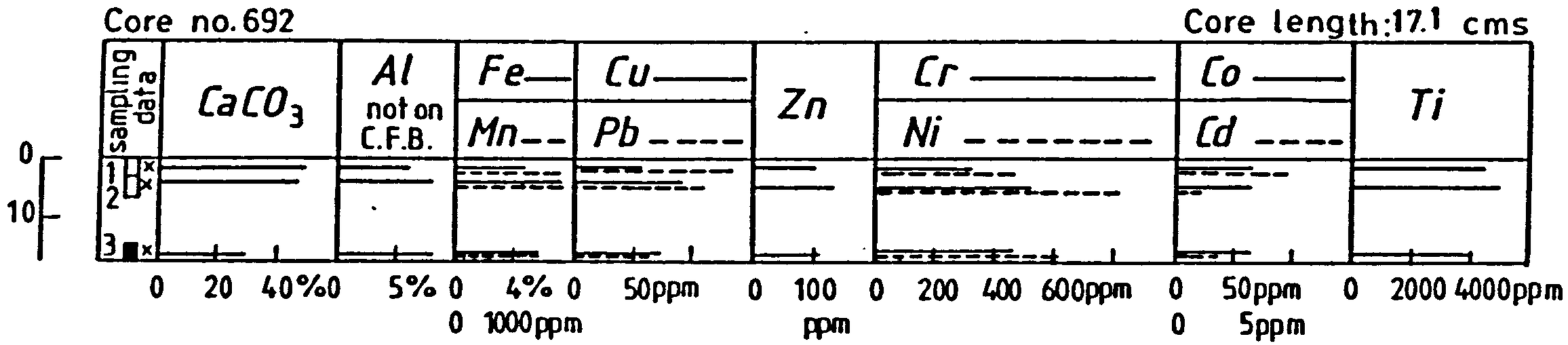
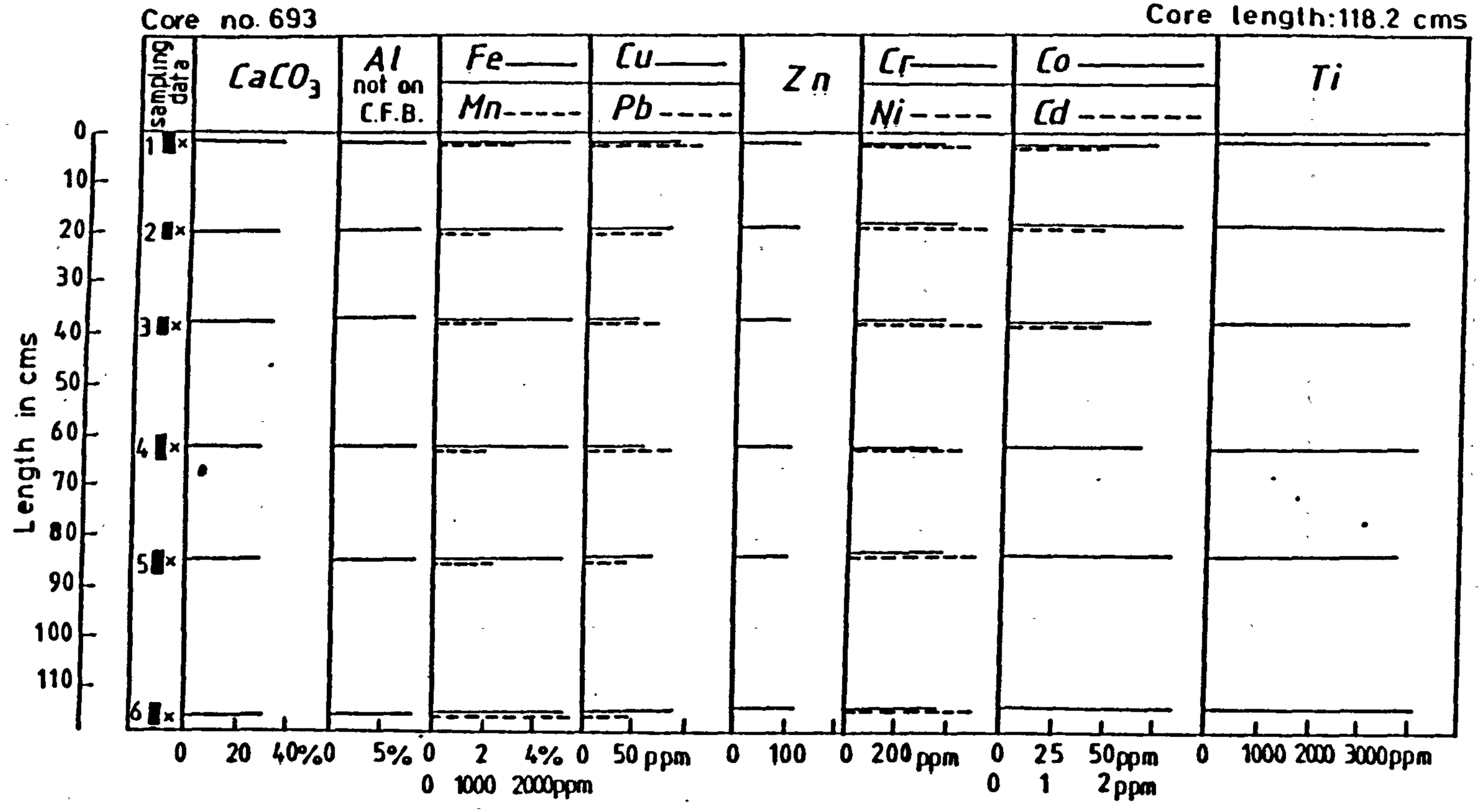


Chart no.26 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in cores numbers 691 & 692 from east of Rhodes and Karpathos.



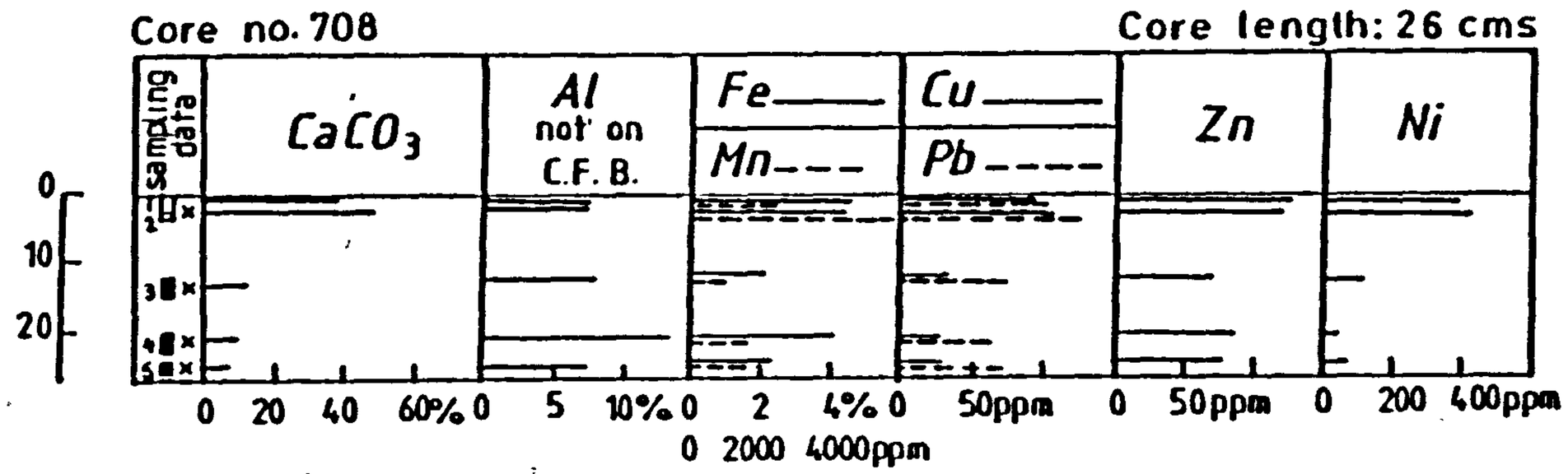


Chart no.27 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in core number 693 and $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 708 from the south of Rhodes.

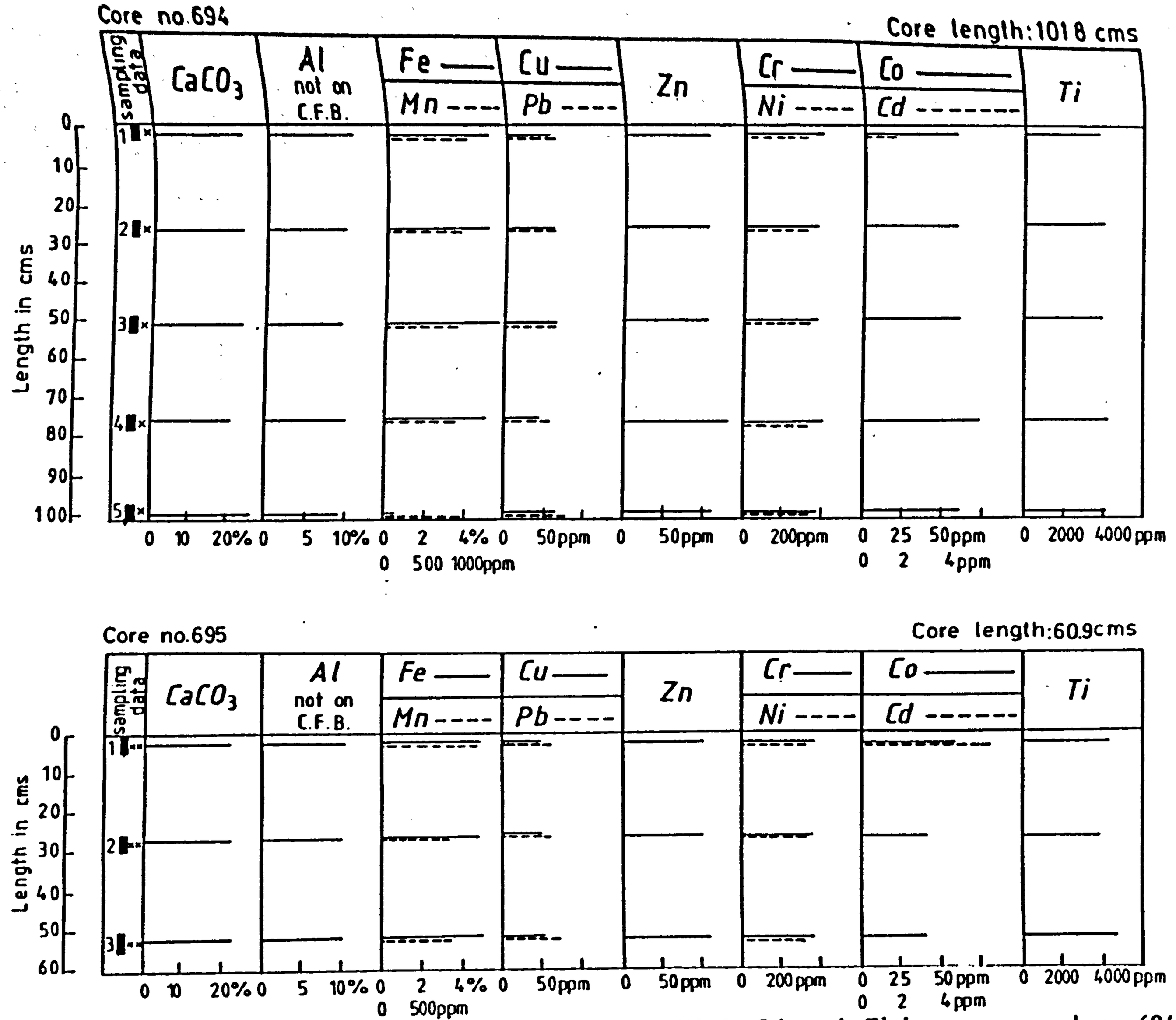


Chart no.28 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in cores numbers 694 &695 from the continent shelf south of the island of Crete.

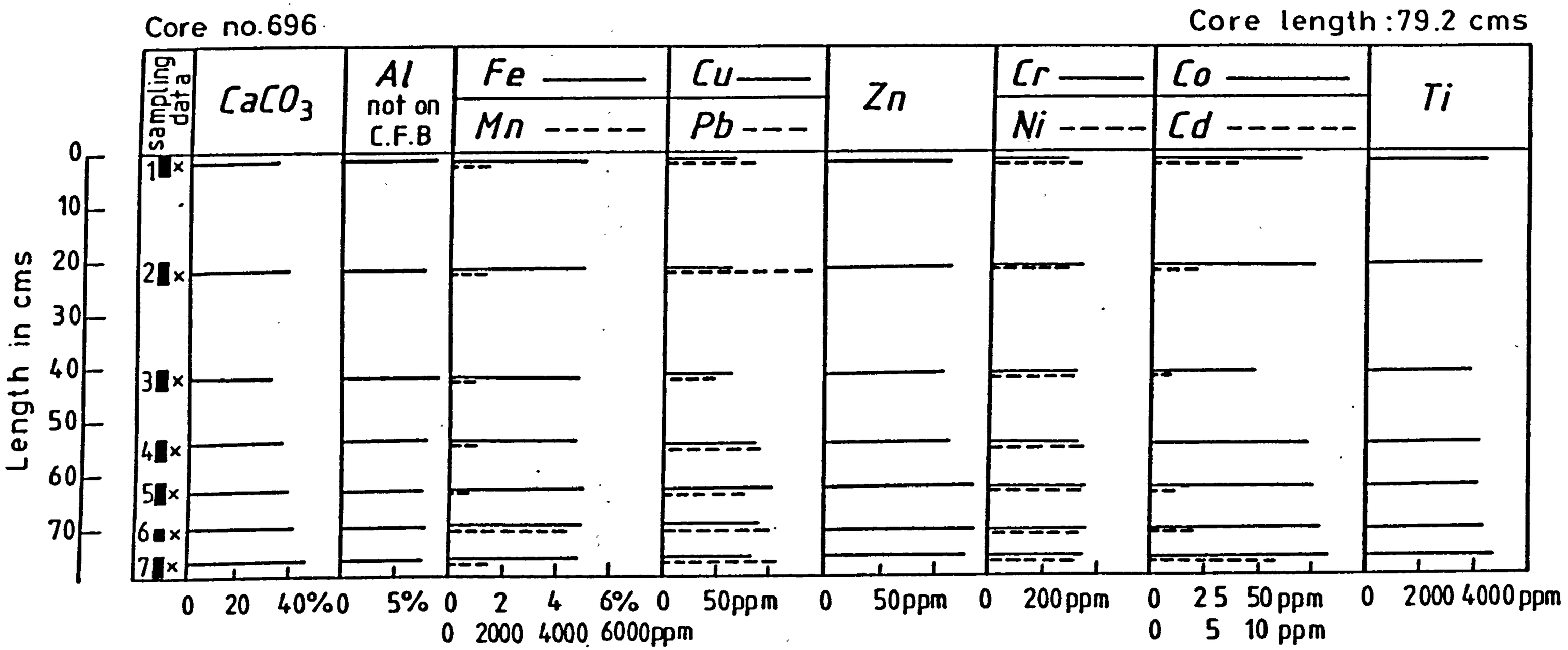
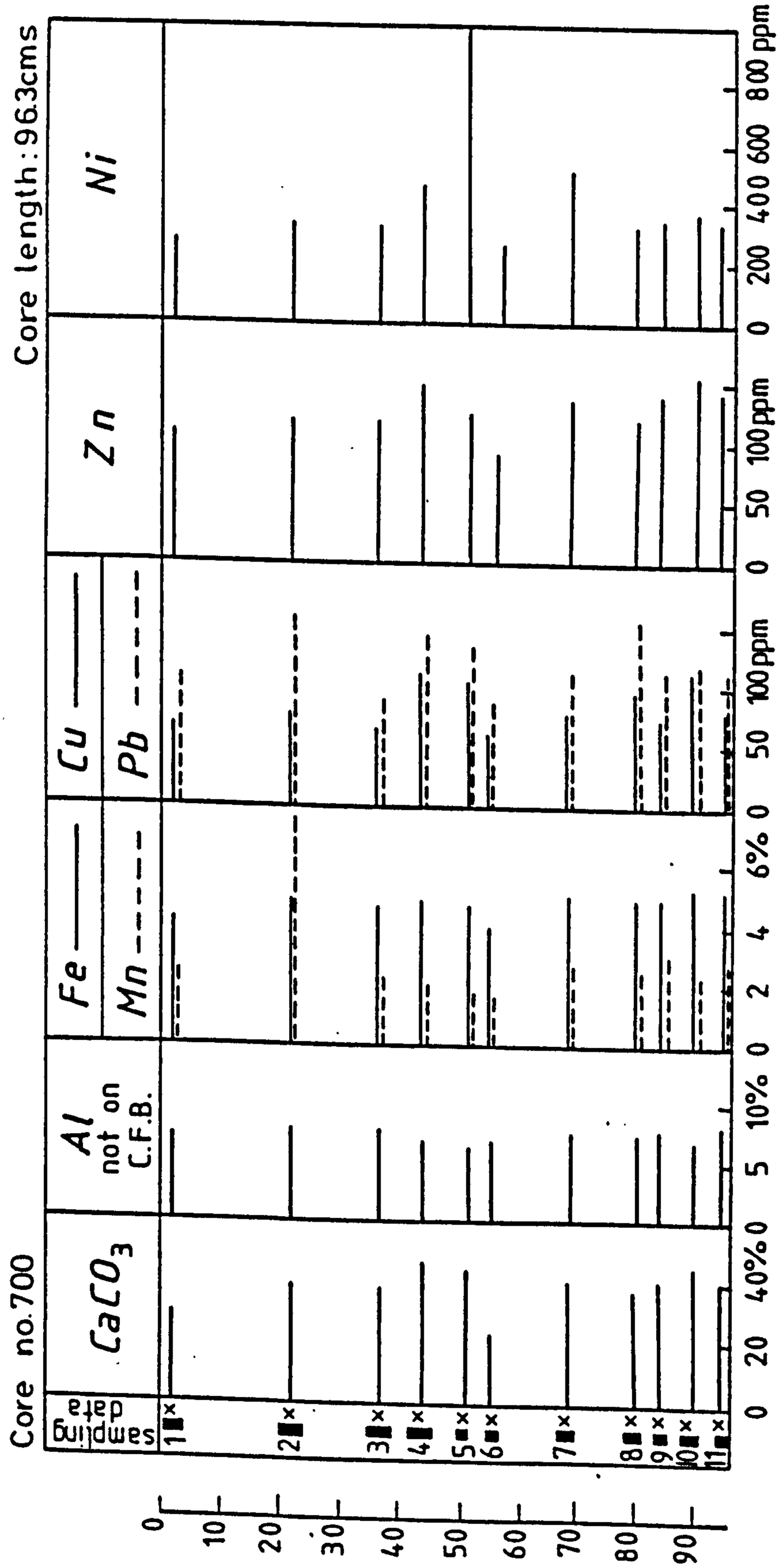


Chart no.29 Frequency of $CaCO_3$, Al, Fe, Cu, Mn, Pb, Zn, Cr, Ni, Co, Cd and Ti in core number 696 from the Shelf area South of Crete.



Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 700 from the Shelf area south of the island of Crete.

Chart no.30

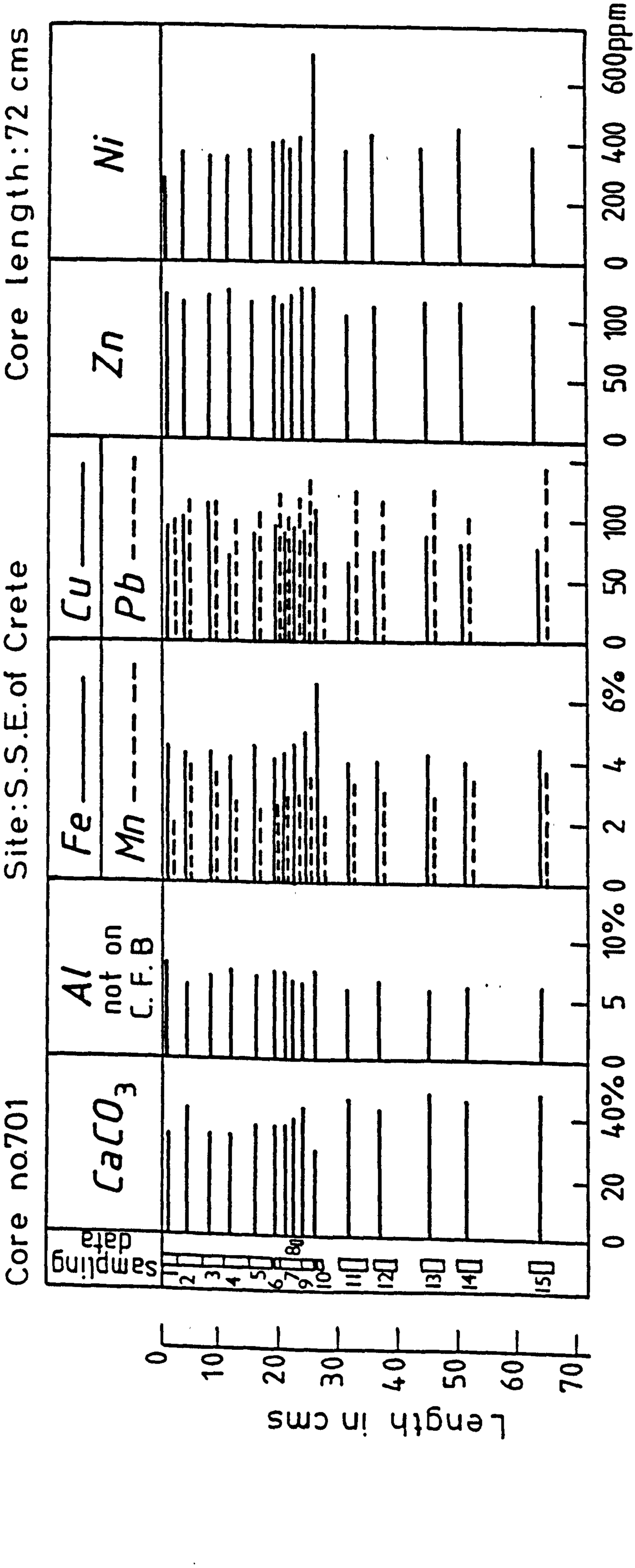


Chart no.31 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 701 from the area between the deeps, South of the eastern half of Crete.

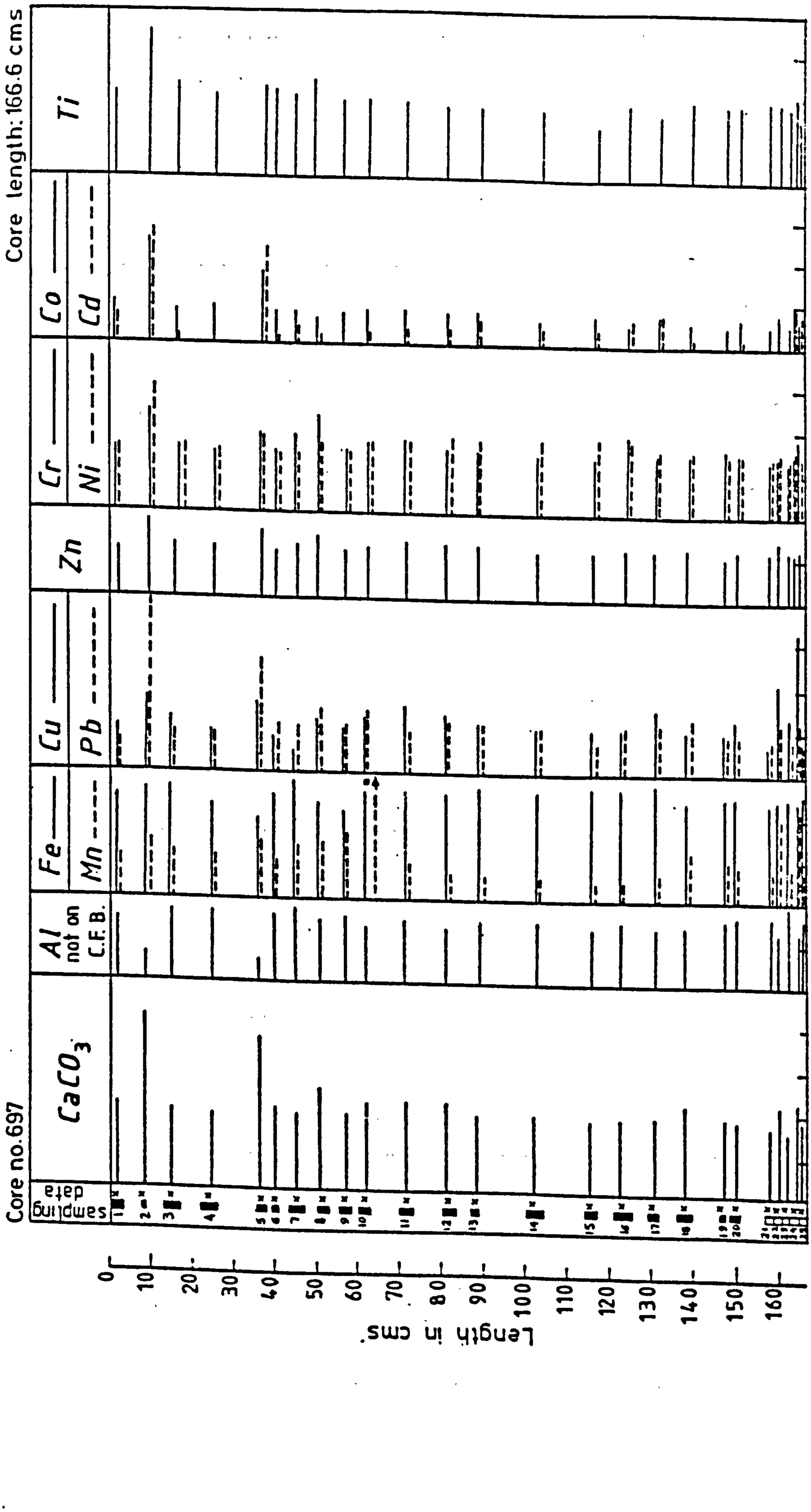


Chart no.32 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in core number 697 from the deeps south of Crete.

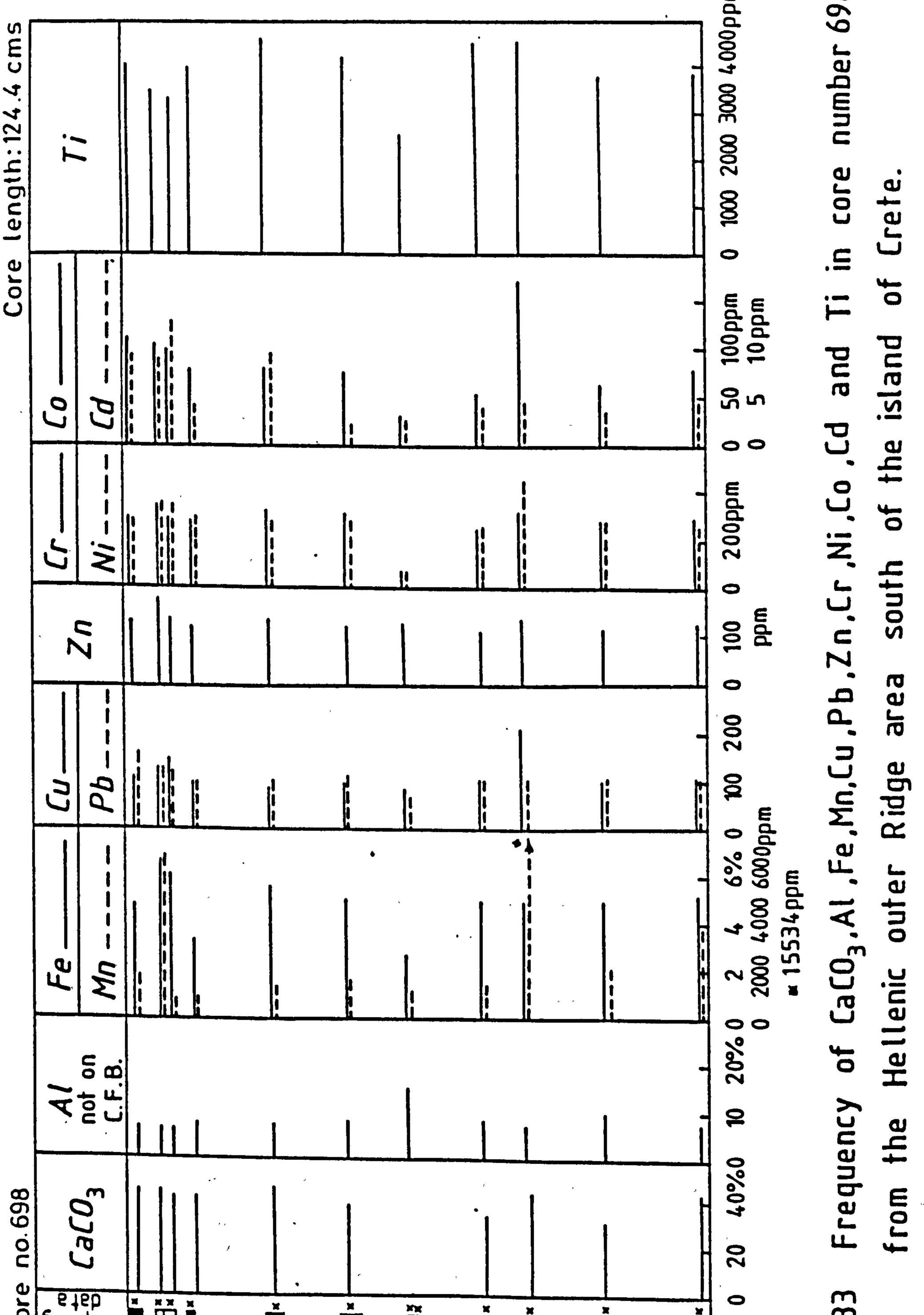


Chart no.33 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in core number 698 from the Hellenic outer Ridge area south of the island of Crete.

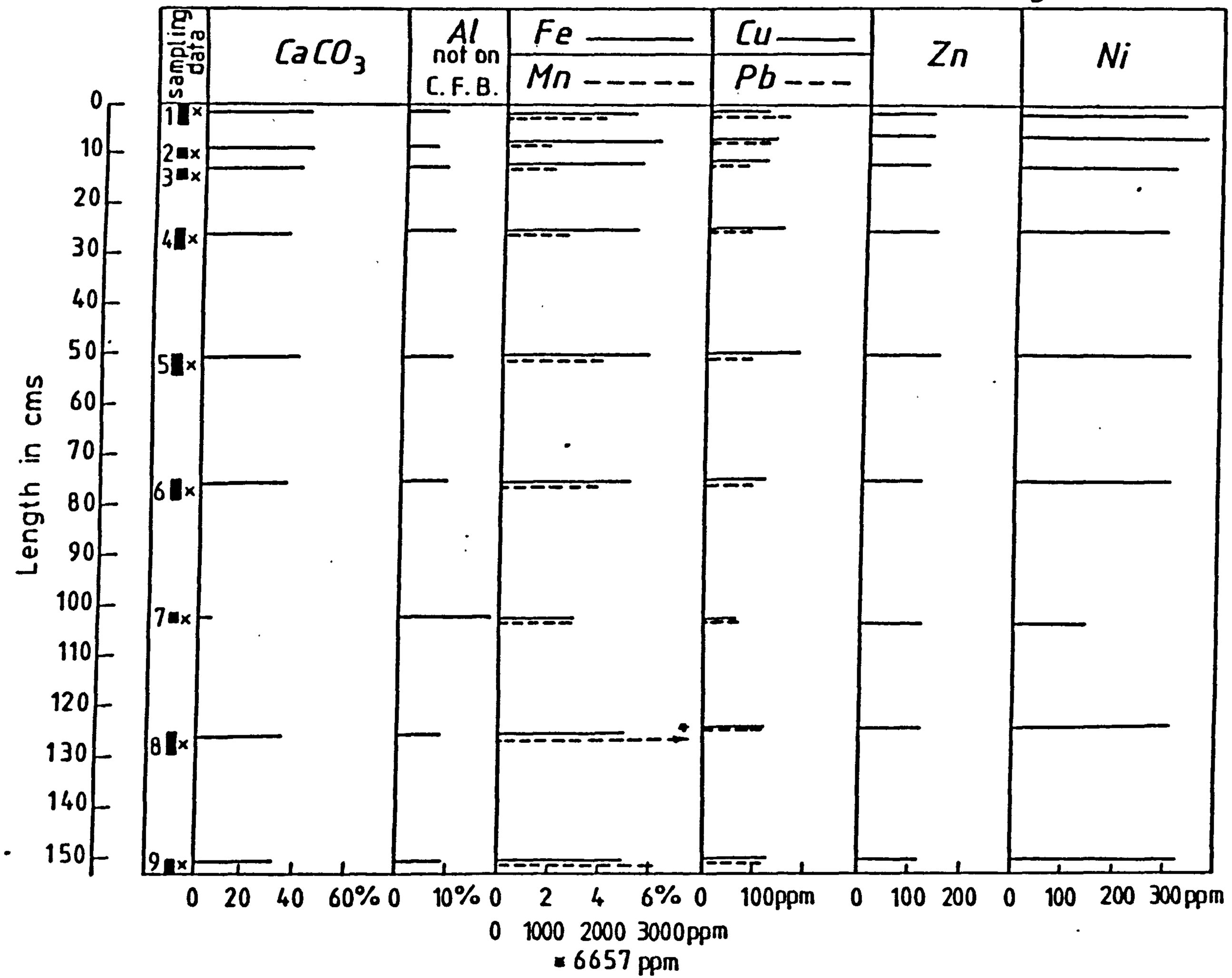


Chart no.34 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 704, close to the outer ridge area south of Crete.

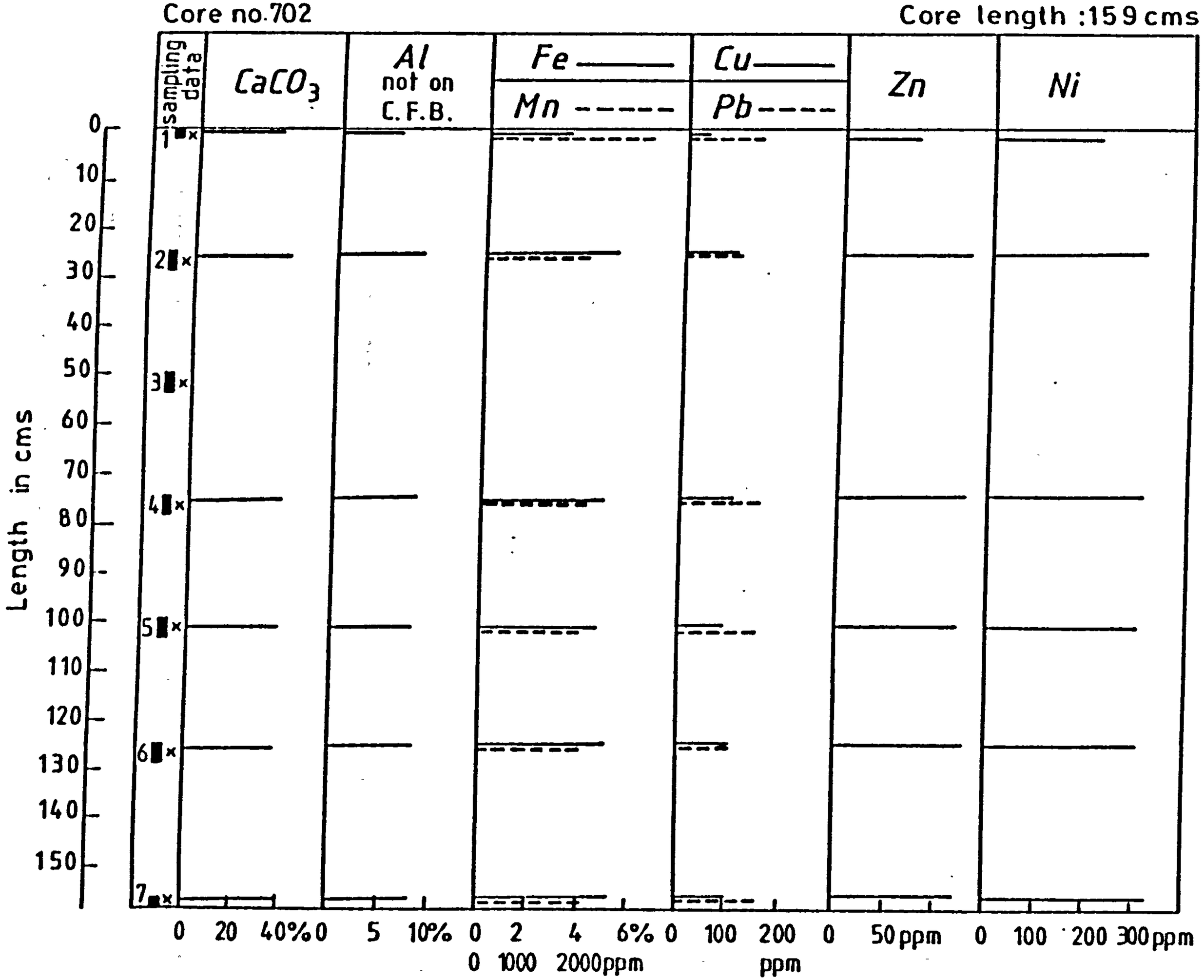


Chart no.35 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 702 from the deeps, south of Crete.

Core no:703, S.of Crete near the trenohs zone Core length:102.4 cms

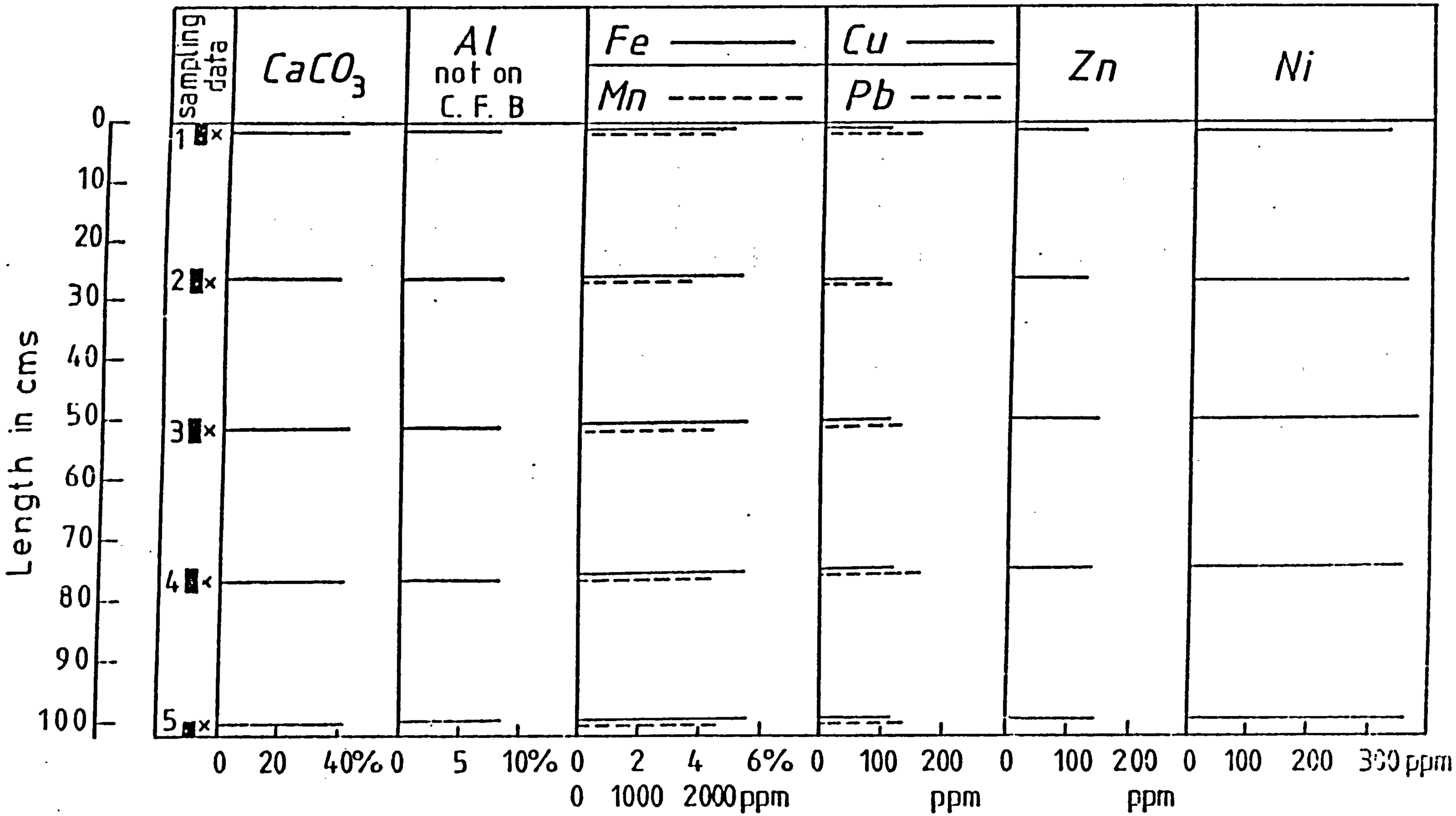


Chart no.36 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 703, between the deeps South of Crete.

Core no 699 Core length 562.4 cms

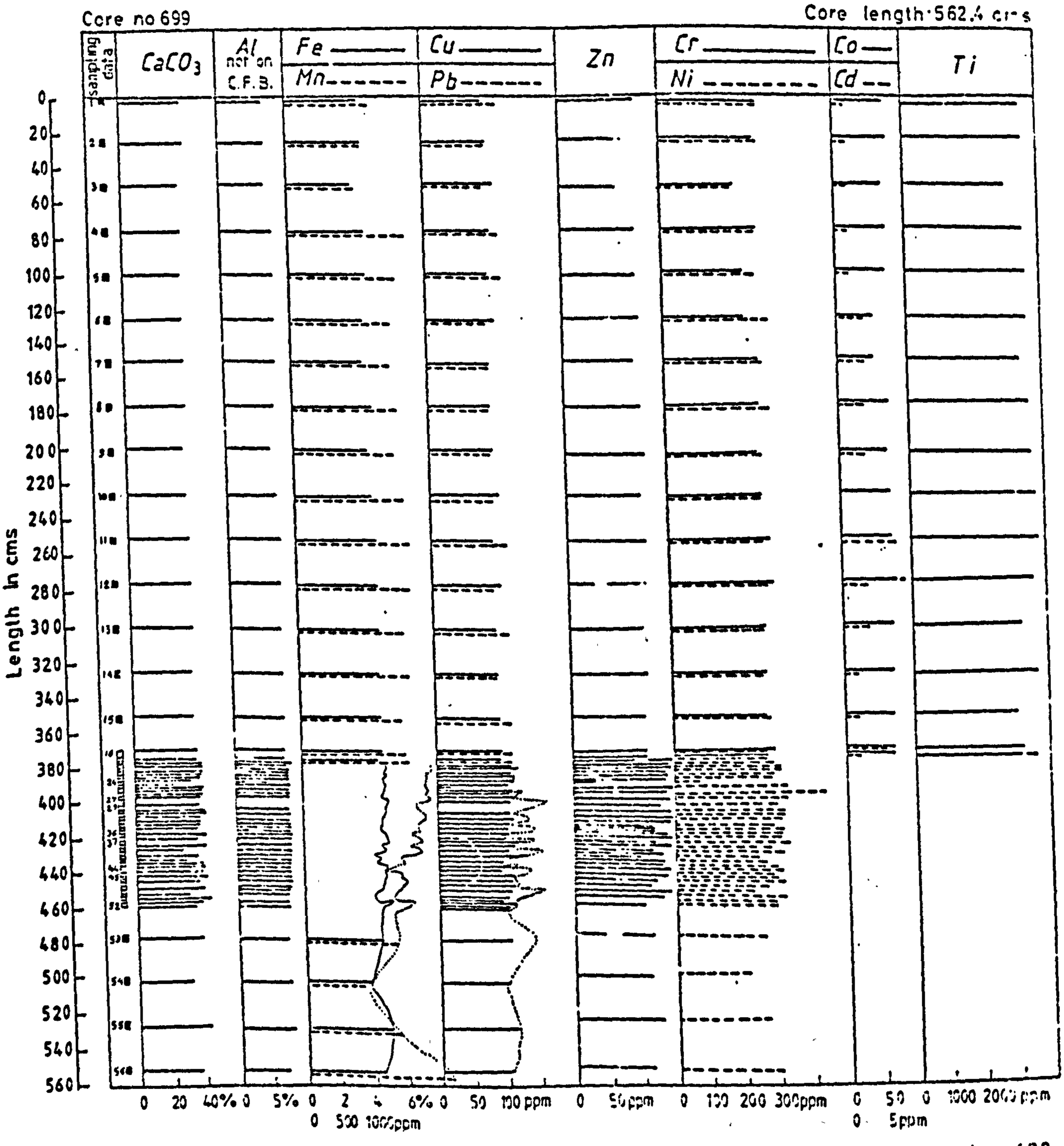


Chart no. 37 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn, Cr, Ni, Co, Cd and Ti in core number 699, a long core taken between the deeps south of Crete.

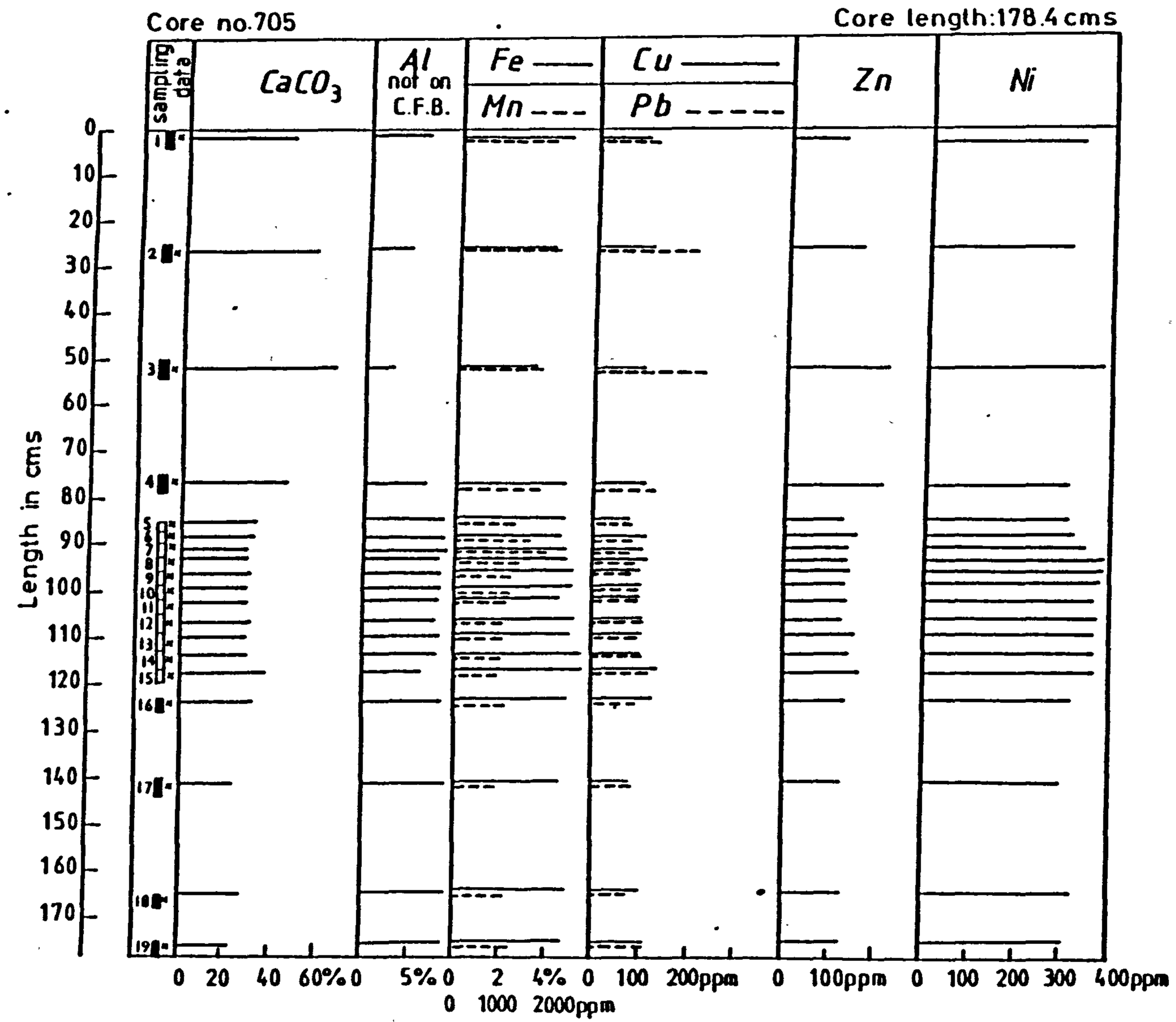


Chart no.38 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 705, between the deeps to the south-east of the island of Crete.

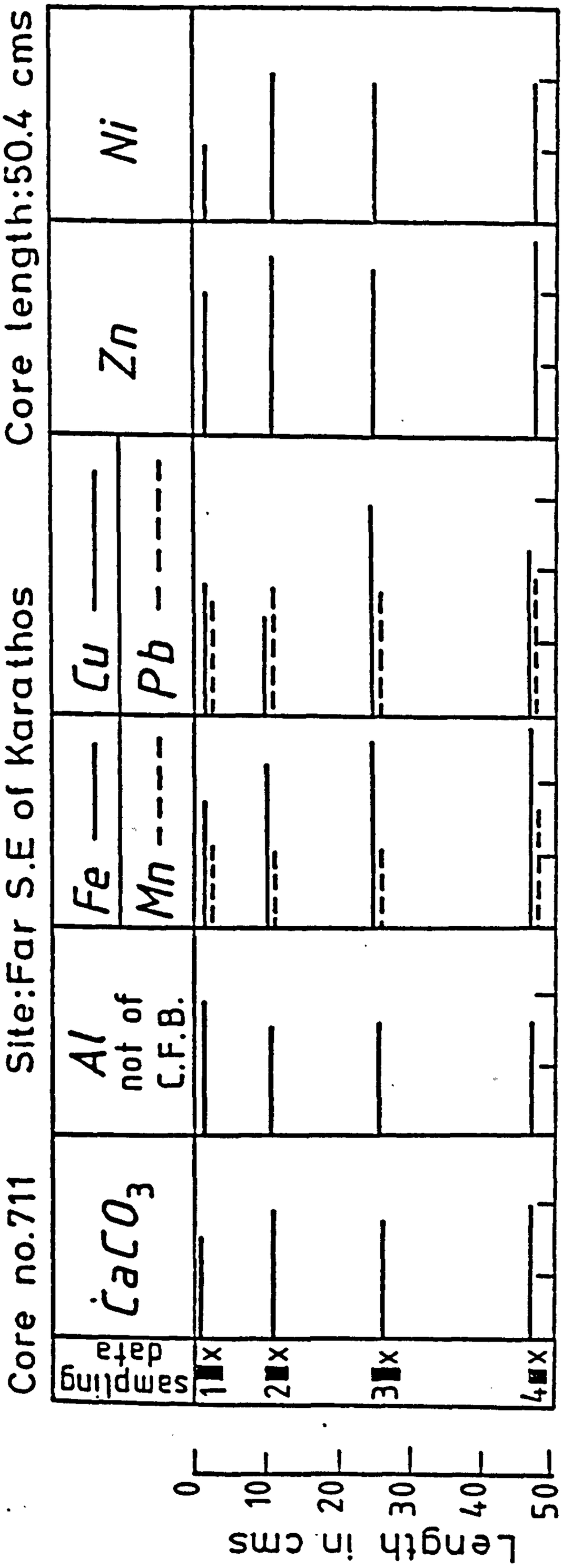


Chart no.39 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 711 in the deeps South-east of Karpathos.

Core no.709 Core length: 262.9cms

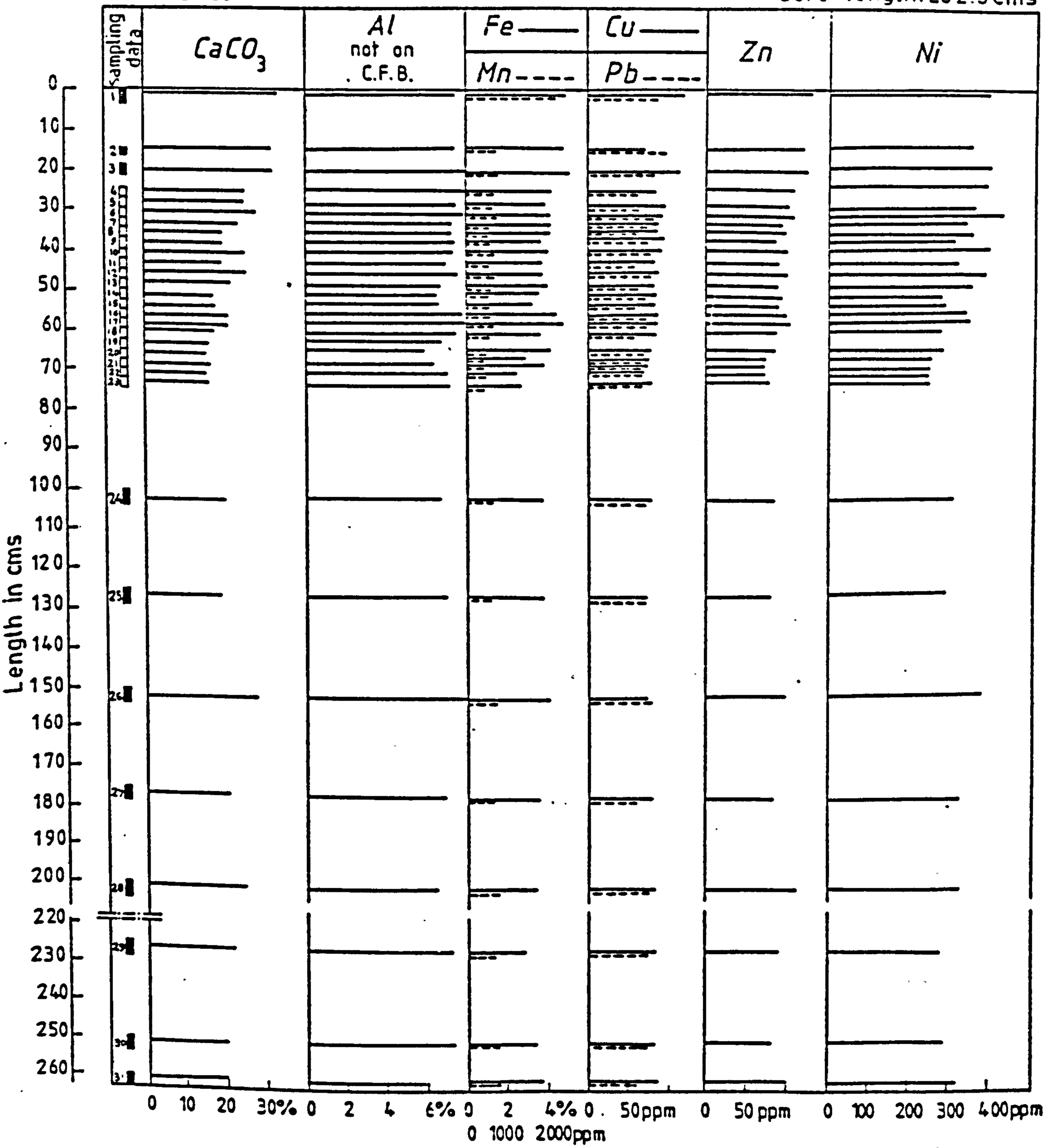


Chart no.40 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 709 in the deeps south-east of Karpathos.

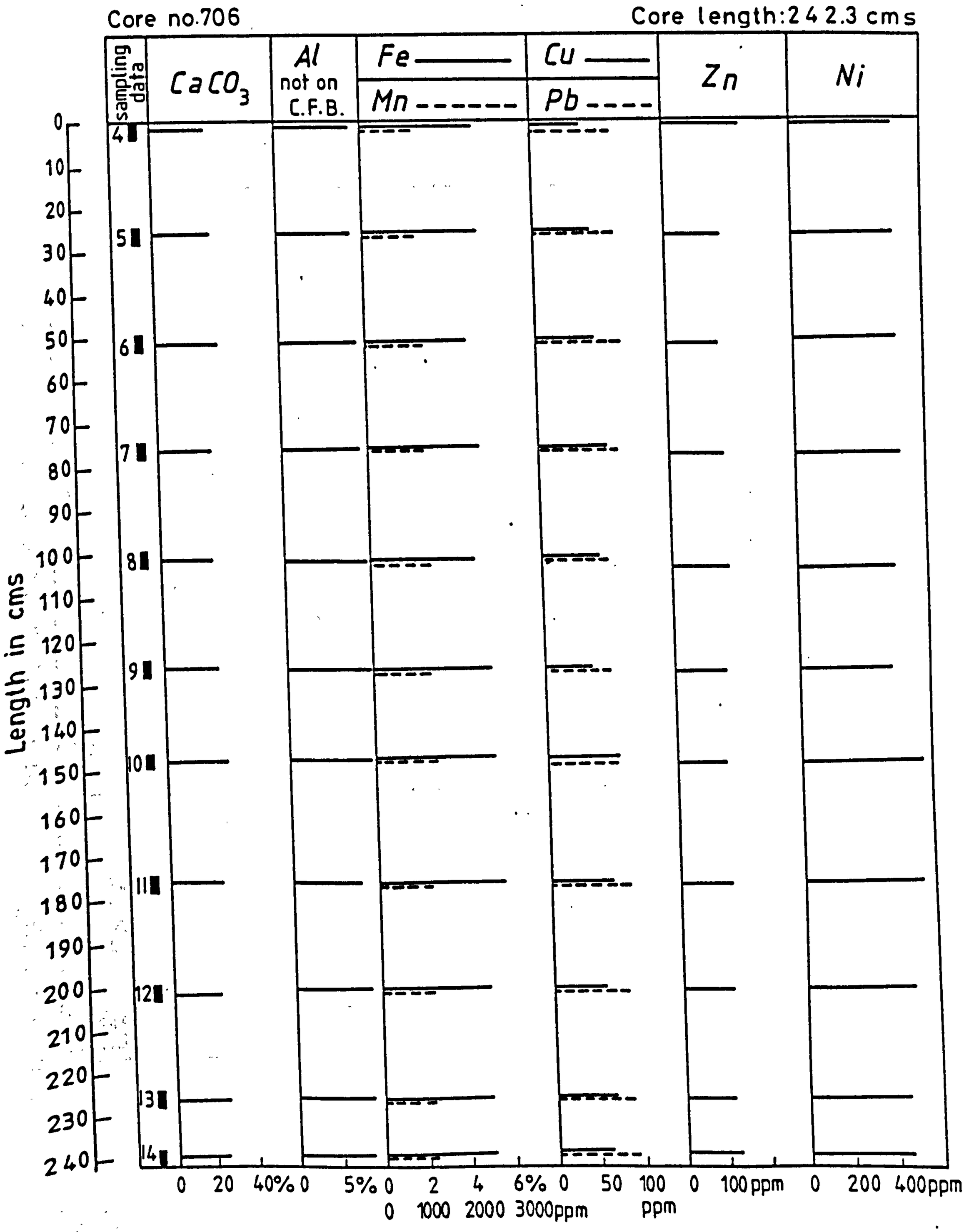


Chart no.41 Frequency of CaCO ,Al,Fe,Mn,Cu ,Pb,Zn and Ni in core number706 east of Karpathos.

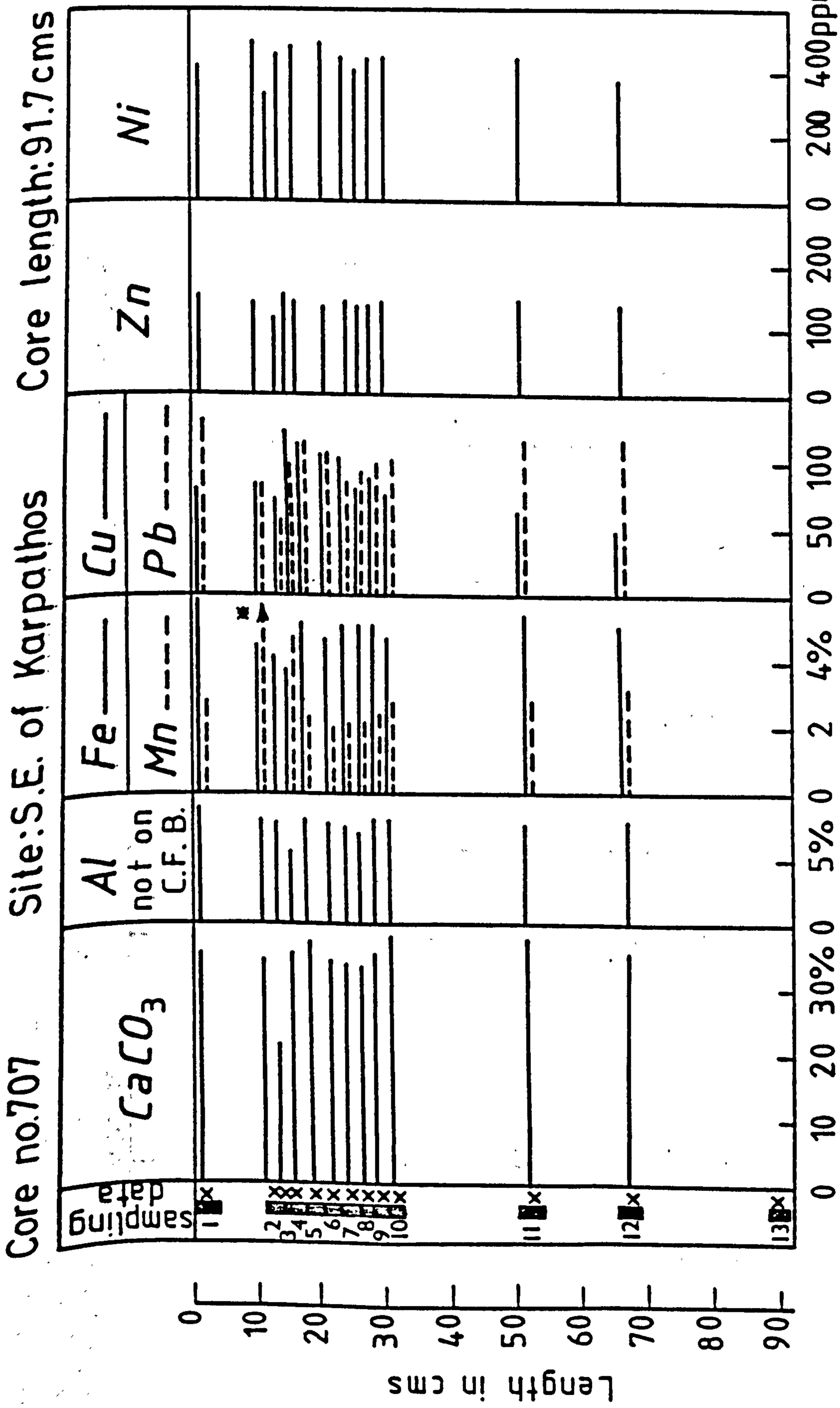


Chart no 42 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in Core number 707 E. of Karpathos.

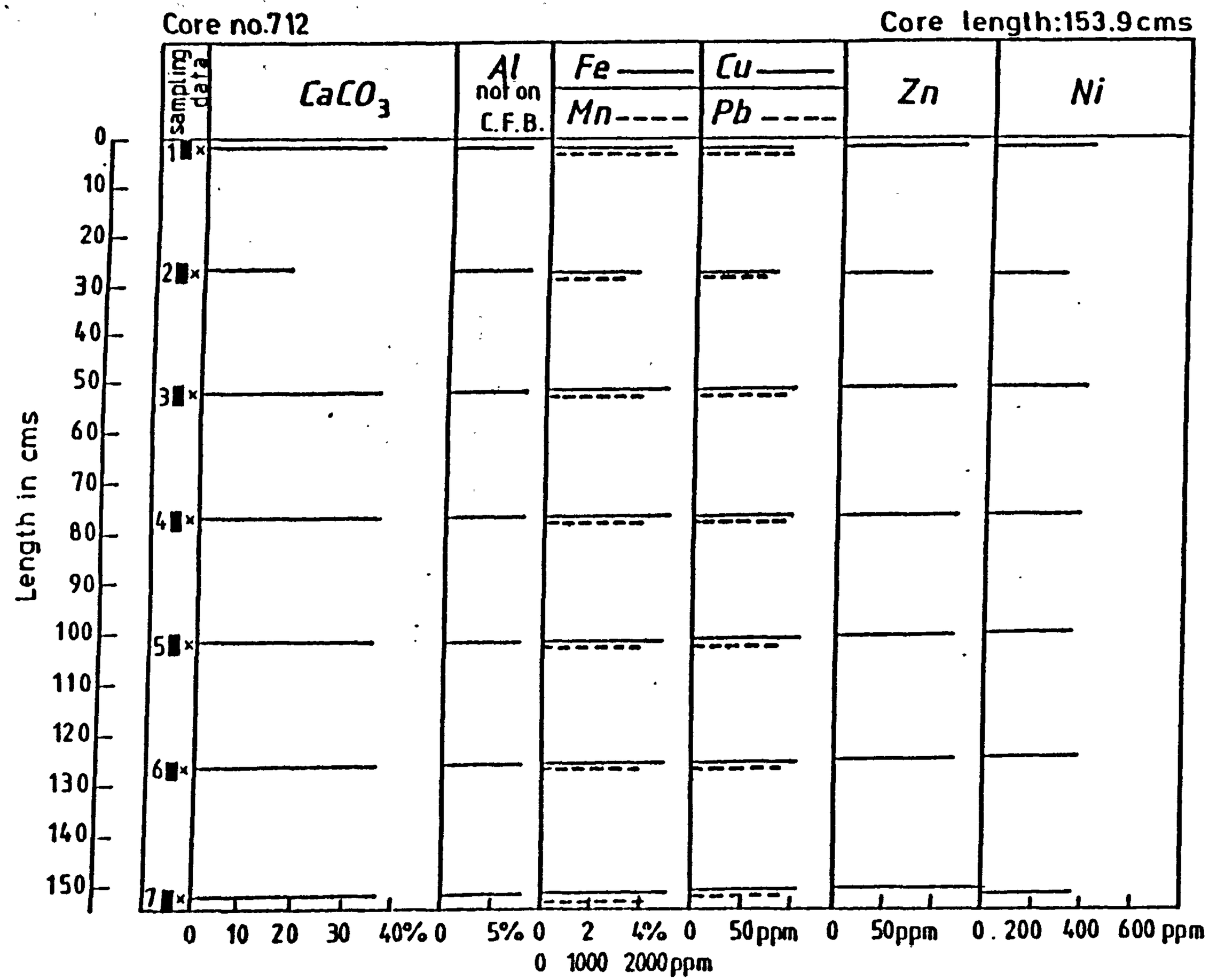


Chart no 43 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 712, between the deeps east of Crete, south of Kasos.

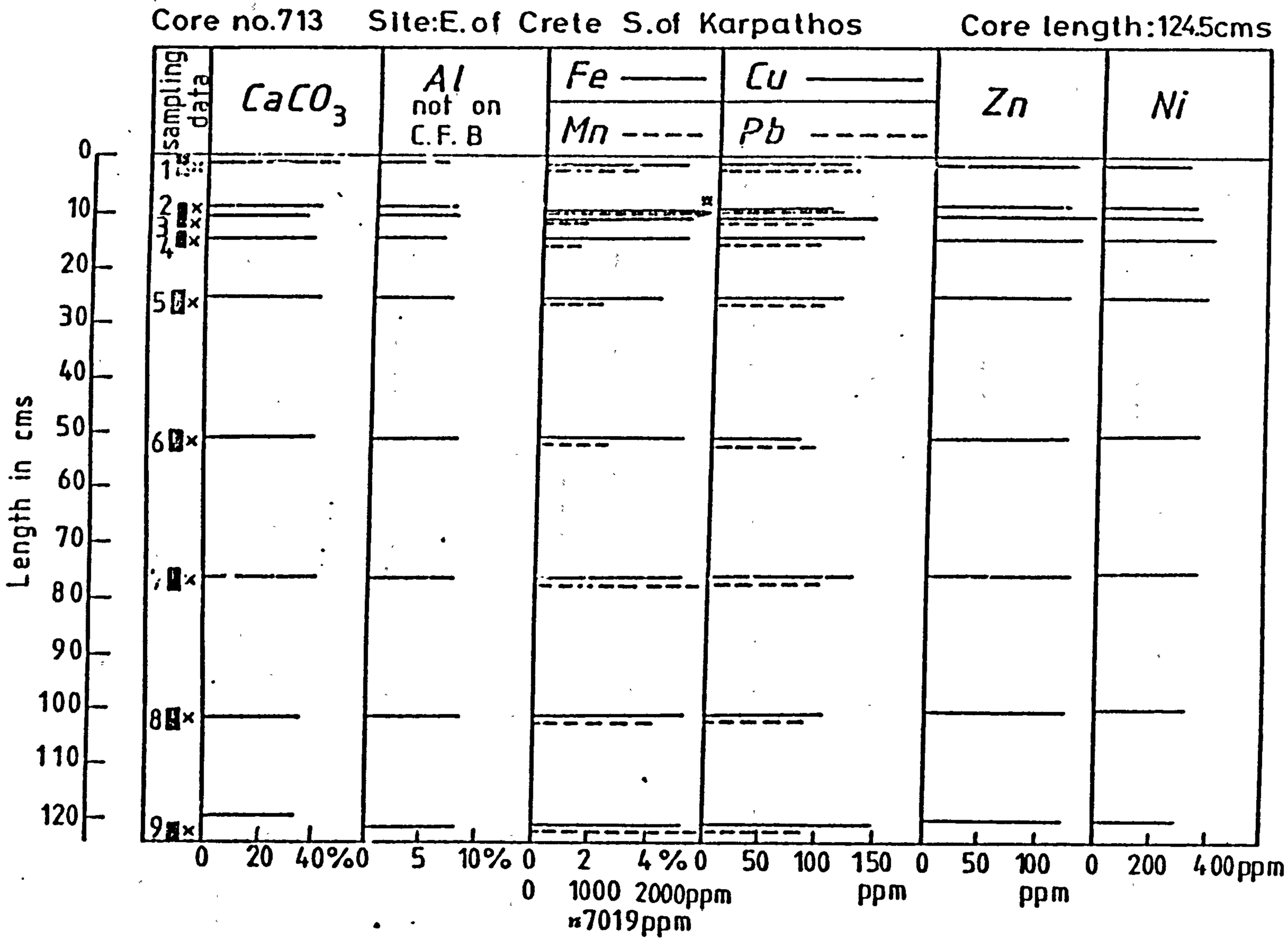
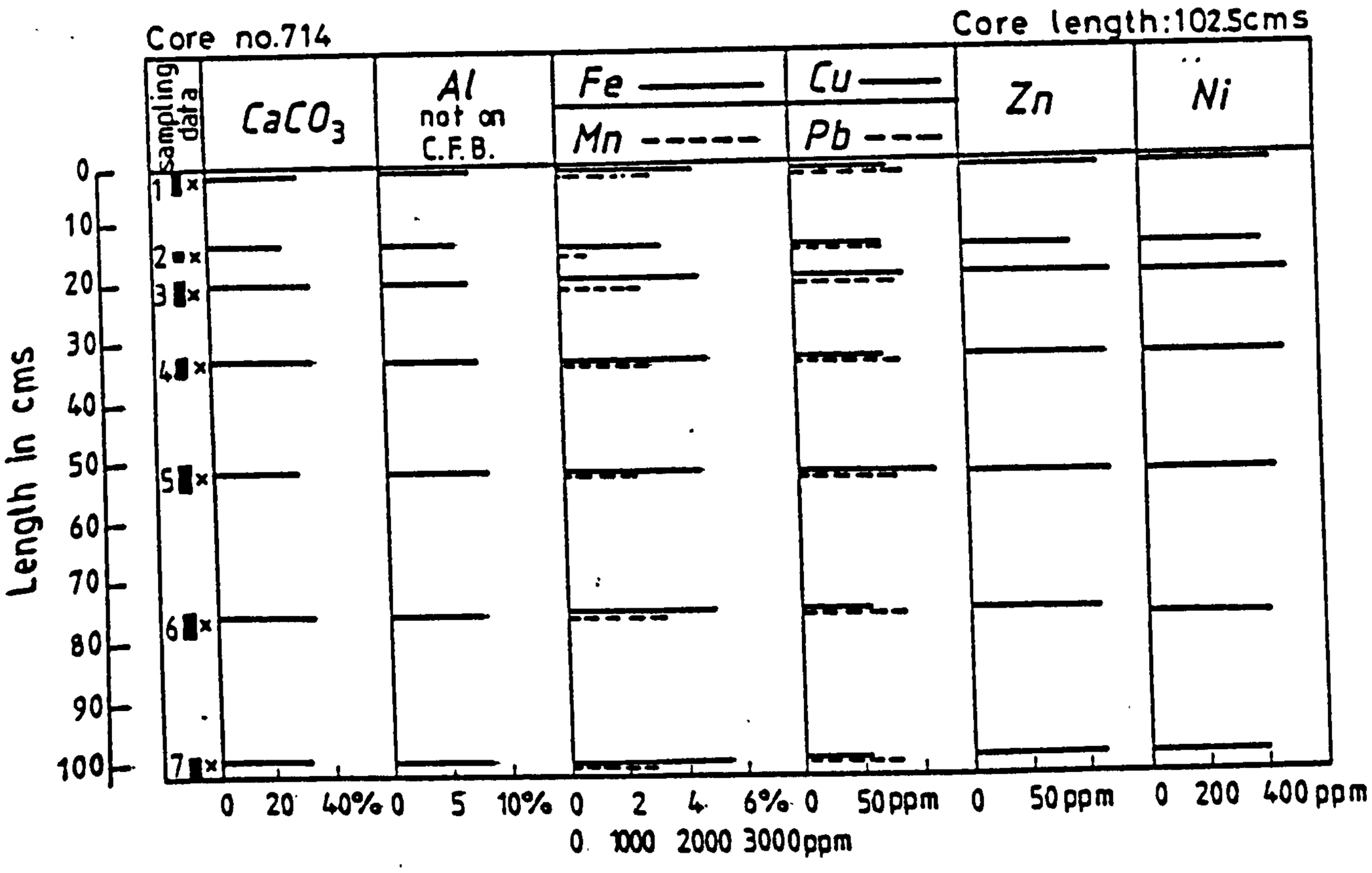


Chart no. 44 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in core number 713 taken between the deeps east of Crete south of Karpathos.



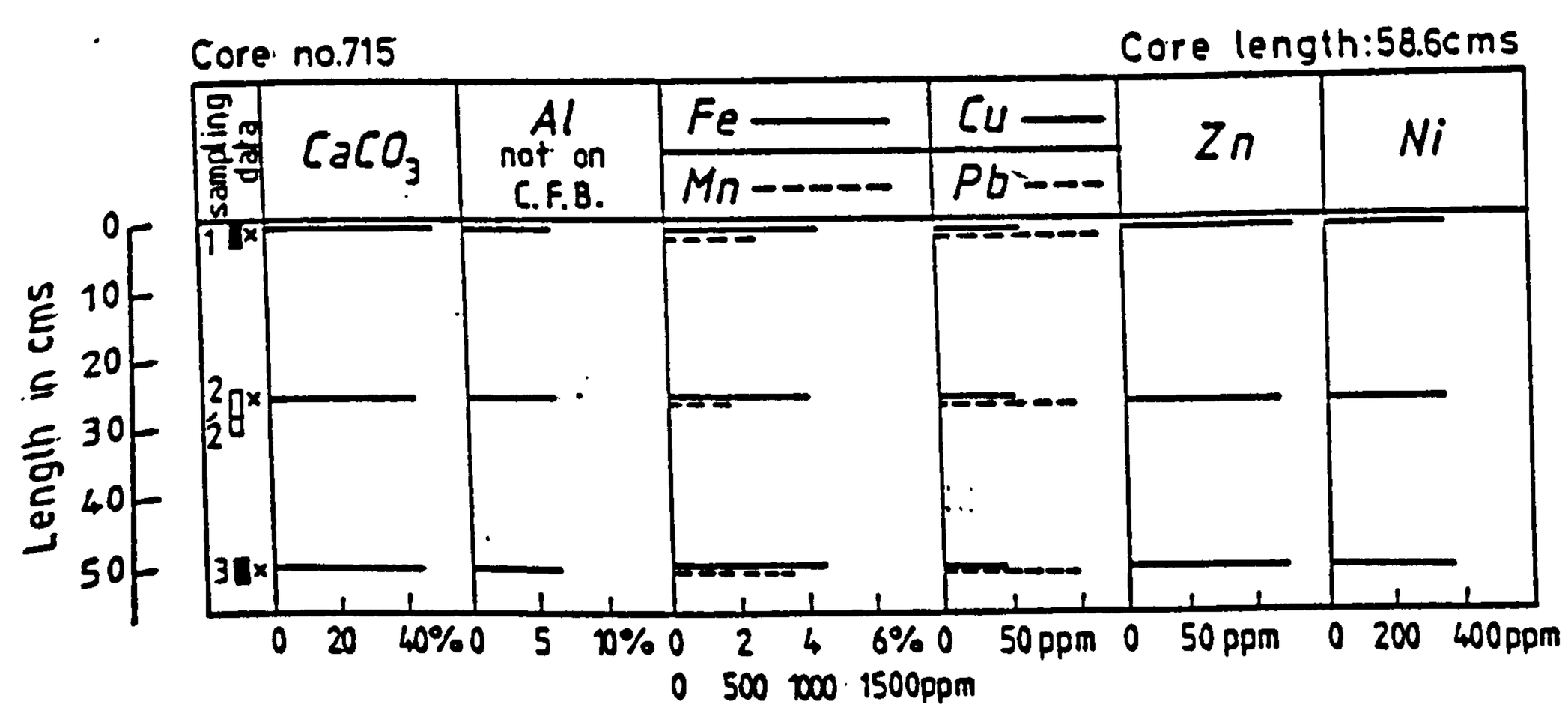


Chart no.45 Frequency of $CaCO_3$, Al, Fe, Mn, Cu, Pb, Zn and Ni in cores numbers 714&715 east of Crete, in the Kasos Strait.

6.29 Chemistry of the size fraction in the buried sediments

6.29a Calcium carbonate:

Similar to the surface sediments, it is noticed that the carbonate concentration in the fraction less than 63 microns is slightly higher than in the total sample. Few samples are found to have less $CaCO_3$ in the fraction than in the total samples. Examples are found west of Karpathos and south of Crete, (table 18).

Table 18 Examples of buried sediments containing more $CaCO_3$ in the whole sediments sample than in the fraction less than 63 microns

Sample No.	$CaCO_3$ in the total sediment sample	$CaCO_3$ in the fraction less than 63 micron	% of the fraction less than 63 micron	Mean size in phi units
690-7	41.1%	29.9%	28.32	3.64
690-9	49.8%	19.7%	99.48	6.49
697-5	73.5%	46.7%	31.6	3.27
697-24	45.1%	39.6%	95.49	6.77
704-7	4.3%	0.9%	73.1	4.94
711-4	40.2%	35%	94.9	6.45

Some of these samples are found to be coarse-grained, others are lighter in colour than the rest of the core. For more information see charts no. 20, 32, 34 and 39. It is noticed that the coarser the sediment, the less is the $CaCO_3$ in the fraction less than 63 microns in comparison to the whole sediment sample. Generally, there is a decrease in $CaCO_3$ with decrease in size, except in the fraction between 63 and 2 microns where a slight increase in $CaCO_3$ is noticed, (Tables 13 and 19).

Table 19 Comparison between the chemical analysis data of the size fraction less than 63 micron to those of the total sample in the buried sediments studied in the Eastern Mediterranean and Aegean Seas (non C.F.B. data)

Sample No.	Ca CO_3 %		FE %		Mn ppm		AL %		PB ppm		Zn ppm		HG %		CR ppm		CO ppm		CD ppm		NI ppm		TI ppm	
	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ	Total	<63µ
689-3	5.25	7.0	3.12	3.4	786	1300	13.50	7.5	45	52	68	414	0.87	1.10	62	60	20	45	n.d.	3.64	33.5	18.6	3368	3000
-6	44.48	44.65	2.87	2.9	700	750	7.25	3.4	70	42	81	178	2.32	2.40	188	180	45	55	2.4	5.63	204	179	2125	2300
-8	36.34	39.56	2.87	2.4	837	880	8.25	4.1	70	42	77	188	2.67	2.80	187	180	57	55	2.43	6.63	246	159	2624	2800
690-7	41.10	29.89	2.00	2.7	725	880	6.00	4.3	45	22	47	182	2.0'	2.75	188	250	32	45	3.68	8.63	171	179	2000	2900
-9	49.80	19.72	2.62	3.0	811	890	11.11	6.2	57	42	66	150	1.54	1.90	125	130	32	45	2.43	5.64	121	99	2122	2700
691-5	29.57	34.47	3.75	3.2	887	1000	7.62	3.5	57	32	77	200	4.93	5.30	312	350	45	55	n.d.	3.63	496	449	2747	2900
692-3	29.60	34.47	3.75	3.5	1025	1100	8.13	4.5	45	32	77	163	3.85	4.00	325	310	45	55	2.43	5.63	434	319	2750	3000
693-6	32.98	37.01	3.63	3.3	1875	2200	8.00	4.2	32	32	77	180	3.17	3.80	238	230	57	55	n.d.	2.63	334	279	2750	3200
694-4	21.14	22.26	4.00	3.0	687	630	10.00	5.0	45	22	102	122	2.66	2.70	312	210	57	35	n.d.	1.63	258	149	3248	3500
-5	26.22	28.36	0.35	2.9	725	750	9.25	4.5	57	32	81	105	2.67	2.75	275	210	45	35	n.d.	1.63	246	149	3000	3500
695-3	21.49	23.79	3.88	3.1	675	690	9.87	4.8	57	32	86	106	2.99	2.61	288	220	32	40	n.d.	6.63	246	154	3500	3700
696-5	40.38	41.59	3.00	2.7	437	550	7.24	3.7	45	22	80	82	2.32	2.40	212	170	45	45	1.18	3.63	196	139	2373	2900
-6	41.73	42.1	2.87	3.0	2522	3700	7.62	4.3	57	32	77	123	2.32	2.50	212	190	45	45	2.43	6.63	196	179	2498	3000
-7	45.80	48.21	2.62	2.6	800	830	7.25	3.8	57	32	70	102	2.36	2.60	187	150	45	45	6.18	6.62	171	129	2499	2507
697-5	73.47	46.68	1.04	2.8	737	2000	2.62	4.0	70	32	40	269	0.86	2.30	100	150	45	45	6.18	3.62	96	129	1124	2600
-10	43.00	46.17	2.87	2.8	5869	7200	6.62	3.8	82	32	68	121	2.10	2.35	187	170	45	55	1.18	3.62	196	159	2123	2600
-17	37.67	39.05	3.5	4.4	712	1100	6.74	4.1	70	32	72	123	2.00	2.30	175	170	45	55	4.93	4.63	196	179	1873	2600
-24	45.05	39.56	2.62	3.0	2333	1700	6.74	4.8	70	32	63	148	1.93	2.55	162	170	57	55	4.92	3.63	171	139	2121	3000
698-3	43.71	41.59	3.37	3.3	449	430	6.11	3.5	70	32	76	110	1.81	2.00	162	170	57	55	7.42	18.63	196	149	1871	2500
-11	44.38	43.12	2.87	2.7	2121	2200	7.24	4.0	57	32	68	75	2.12	2.20	162	140	45	45	2.43	4.63	146	109	2121	2900
699-12	36.32	42.10	3.00	3.0	1061	1100	7.62	4.8	57	52	72	94	2.34	2.60	187	170	57	45	2.43	4.63	183	139	2248	2900
-56	37.52	39.05	2.80	3.1	1350	1500	7.00	4.8	66	42	71	111	-	2.40	-	170	-	45	-	4.63	187	159	-	2800
700-2	39.64	39.56	2.90	2.9	2280	2000	7.80	4.4	96	22	73	82	-	2.70	-	140	-	35	-	3.63	197	159	-	2800
-10	45.44	43.63	2.90	2.7	640	600	7.20	3.5	66	32	85	66	-	2.40	-	170	-	45	-	3.63	197	159	-	2800
702-7	40.16	41.34	3.20	2.8	1270	1300	8.30	4.2	96	32	74	144	-	2.80	-	170	-	45	-	5.63	197	149	-	3000
704-2	42.80	42.86	3.50	3.7	480	600	6.20	3.7	66	42	75	131	-	2.25	-	160	-	45	-	5.63	207	199	-	2800
-7	4.25	00.89	2.90	2.6	1390	1300	18.00	10.0	66	62	123	194	-	0.65	-	30	-	45	-	n.d.	137	39	-	3200
705-15	37.52	36.00	3.60	3.7	610	750	6.30	4.7	76	32	100	114	-	3.00	-	200	-	55	-	6.63	227	239	-	3100
-19	32.77	32.43	3.15	3.2	820	880	8.40	5.0	76	32	86	101	-	3.00	-	180	-	45	-	4.63	207	159	-	3500
706-10	30.13	31.42	3.80	4.2	1000	960	8.90	3.8	56	32	84	132	-	4.00	-	310	-	45	-	2.63	307	349	-	3000
-14	26.17	33.96	3.70	3.0	870	910	8.20	4.2	66	32	100	111	-	4.15	-	300	-	45	-	3.63	337	299	-	3900
707-13	-	39.05	-	2.6	-	950	-	3.7	-	32	-	101	-	3.75	-	220	-	45	-	4.63		239	-	3200
709-3	31.71	36.50	3.4	3.2	530	590	8.00	4.6	56	32	82	96	-	3.50	-	220	-	55	-	4.63	267	249	-	3400
-31	19.83	27.35	3.0	3.9	650	740	6.90	4.2	46	22	81	117	-	3.60	-	210	-	45	-	2.63	257	259	-	3100
711-4	40.16	34.98	3.3	3.3	1030	1000	8.00	4.6	56	32	84	85	-	3.20	-	160	-	45	-	4.63	237	199	-	3400
712-7	37.52	30.54	3.2	3.1	1300	1300	8.10	4.4	56	39	97	122	-	-	-	160	-	13.6	-	2.5	227	195	-	2800

6.29b Iron:

Sediments with high $CaCO_3$ concentration in the whole sample are found to contain higher concentration of iron in the fraction less than 63 microns in comparison to the iron concentration found in the whole sediment sample, (Table 19). Analysis carried out on some of the Aegean Sea sediments shows that the iron content of the fine fraction is higher than the coarse fraction. From tables 13 and 19 it is seen that the iron concentration in the fraction less than 63 microns and between 63 and 950 microns is higher than its concentration in the coarser fraction larger than 950 microns. It is also noticed that the fraction between 63 and 2 microns contains more iron than the fraction larger than 63 microns, i.e. the iron content increases as the grain size decreases.

6.29c Manganese:

It is found that manganese concentrations in the silt and clay fraction are higher than its concentrations in whole sediment samples. Similar to iron it is noticed that some of the carbonate rich sediments have much higher manganese in the fraction less than 63 microns in comparison to the total sediment sample. Also similar to iron it is noticed that the finer fractions contain more Mn than the coarser ones, (table 19).

6.29d Aluminium:

Aluminium is found to have higher concentrations in the whole sediment sample than in the fraction less than 63 microns except in one sample that has a very high Ca CO_3 content. More detailed study on some size fractions from the Aegean Sea show that the fraction larger than 950 microns is very poor in aluminium concentration, (tables 13 and 19).

6.29e Lead:

Lead concentrations are found to be higher in the total sample than in the fraction less than 63 microns. Analysis carried out on some fractions of the Aegean Sea sediments shows that lead is slightly concentrated in the coarser fraction of the sediment. The fraction larger than 950 microns for example is found to be richer in lead than finer fractions in some samples, (table 13). It is also noticed that the carbonate rich coarse grained sediments contain more lead in the total sample than in the silt and clay fraction.

6.29f Zinc:

Zinc concentrations are found to be very much higher, in the fraction less than 63 microns, than in the total sediment sample. More detailed analysis on the size fraction shows that zinc is concentrated in the fine fraction and that its concentration decreases in the coarser fraction, (tables 13 and 19).

6.29g Magnesium:

Magnesium concentration is slightly higher, in the fraction less than 63 microns, than in the total sediment sample. It is also noticed that Mg has slightly high concentrations in the fraction larger than 950 microns in comparison to finer fractions.

6.29h Chromium:

Chromium concentration in the fraction less than 63 microns is usually found to be similar to or less than its concentration in the whole sediment sample except in the samples that have high $CaCO_3$ concentrations. It is noticed that the chromium concentration in the fraction greater than 950 microns is less than its concentration in the finer fraction, (tables 13 and 19).

6.29i Cobalt:

Cobalt concentrations in the fraction less than 63 microns are generally similarto or higher than in the whole sediment sample, (table 19).

6.29j Cadmium:

Cadmium concentrations are found to be very much higher in the fraction less than 63 microns, than in the total sediment sample, except in the sample that have high $CaCO_3$ contents. It is also noticed that the fraction greater than 950 microns has higher concentration of cadmium than other fractions.

6.29k Nickel:

The concentrations of nickel in the fraction less than 63 microns are less than its concentrations in the whole sediment sample,except in one sample that has very much higher $CaCO_3$ in the total sediment sample than in the fraction less than 63 microns. The fraction greater than 950 microns is found to have less Ni than the smaller fractions.

6.29L Titanium:

Titanium concentrations in the fraction less than 63 microns are found to be greater than its concentration in the whole sediment sample except in one sample west of Karpathose that is found to have high Ti content and very low $CaCO_3$, (Table 19).

CHAPTER VI PART THREE

Chemical Partition Analysis of Eastern Mediterranean and Aegean Sea Sediments

6.30 Introduction:

Following the bulk analysis selective chemical attacks were carried on the samples in order to investigate the partion of the major and trace elements in the eastern Mediterranean and Aegean Sea Sediments. Three different chemical attacks were used to separate chemically the elements incorporated into the carbonate fraction from those found in the non-carbonate or detrital fraction of the sediment. Such analysis helps to understand the relationships between the trace elements and the major elements in the sediments.

Several authors have attempted to study the trace element partition in the marine sediments by attacking the total sediment using selective chemical attacks. Of them are, Hirst and Nicholś (1958); Goldberg and Arrhenius (1958); Arrhenius and Korkish (1959) Lynn and Bonatti (1965); Chester (1965a); Chester and Hughes (1967) Cronan and Garrett (1973) and others. Of all these techniques,the technique introduced by Chester and Hughes (1967) is the most commonly used for the investigation of the partitioning of trace elements in marine sediments. This technique is ideal for the separation of trace elements in marine sediments. It makes it possible to distinguish between those elements incorporated into the sediment from sea water and those occuring in pre-existing mineral lattice.

A selected group of samples from the south of Crete and between Thera and Milos were analysed using an adaption of the leach procedure evolved by Chester and Hughes (1967, 1969).

Three accurately weighed representative sub-samples, one gram each, were obtained from each of the sediment samples. The first sub-sample was leached with ten percent acetic acid added slowly until reaction ceased, stirred for four hours and then filtered. The second sub-sample was leached with an excess of mixed acid-reducing reagent consisting of acetic acid and hydroxylamine hydrochoride; this was also stirred for four hours and filtered. The third was leached with hot fifty percent hydrochloric acid and kept hot for four hours prior to filtration. The dissolved materials were always filtered through previously weighed filter papers and the residues were weighed. The leach solutions were analysed by atomic absorption spectrophotometry for the same elements as the bulk samples.

The aim of the chemical partition work was to analyse the carbonate mineral constituents soluble in the acetic acid; the ferromanganese oxide phases reducible by hydroxylamine HCl; and everything, including iron oxide minerals, except the more resistent silicates and aluminosilocates, soluble in hydrochloric acid. The comparison between the various leach solutions from the three selective chemical attacks shows the partition of elements between the various constituent phases of the sediment. During the following discussion the term "acetic acid soluble fraction" will refer to that part of the sample soluble in ten percent acetic acid; the hydroxylamine HCl soluble fraction will refer to that part soluble in the acid-reducing reagent but not in acetic acid alone and the "HCl soluble fraction" to that part soluble in hot fifty percent HCl but not in acid-reducing reagent. The term "detrital fraction" will be used here to describe the HCl-insoluble residues of the samples.

No previous partition analysis has been reported on the sediments in the study area. In this work samples from both the surface and buried sediments were subjected to chemical partition studies in order to investigate the trace element partition patterns in them. A clear picture of the partition of elements in the sediments is important in understanding the complex geochemistry of the eastern Mediterranean and Aegean Seas sediment. Such a picture would not be easily obtained by physical separation of the various mineralogical componenets of the sediments which is extremely time consuming and may not be successful in case of very fine grained sediments.

6.31 Partition of Elements Between Phases:

6.31a Partition of Calcium:

Calcium is found to be concentrated in the carbonate fraction, mostly soluble in the acetic acid. A small percent of Ca is found in the acetic acid residue and is regarded as non-carbonate calcium. The average non-carbonate calcium is 1.038%. Table 20a shows the concentration of Ca found in the various fractions of sediments analyses south of the island of Crete. Table 20b shows the concentration of the same element in the sediments analysed from the area between the two islands Thera and Milos. A few samples are found to contain a high concentration of Ca in the residue (samples no. 689-2, 648-3, 690-8 and 692-1 from south of Crete and samples no. 1108-1, 2, 3, 4 and 5 and 1119-3 and 7 near to the island of Thera). It is noticed that most of these samples are carbonate poor sediments, dark coloured or black (sapropels). Higher percentages

of their Ca are found to be soluble in HCl than in acetic acid or in the combined acid-reducing reagent attacks. The HCl soluble Ca values are generally, apart from analytical error, found to be similar to those soluble HF except sample no. 689-3 which has a very high calcium in the HCl insoluble residue.

Table 20a Partition of Ca in Sediments from the Eastern Mediterranean Sea, South of the Island of Crete

(Calcium concentrations in percent)

Sample	Acetic Acid Soluble Frac.	Acid Reducing Reag. Soluble Frac.	HCl Soluble Frac.	Residue
689-2	2.95	nd	1.82	1.07
-3	1.63	nd	1.00	1.76
-5	14.45	1.42	nd	2.23
690-1	15.49	0.38	nd	1.55
-2	15.48	0.39	nd	5.58
690-3	13.94	1.93	nd	2.79
-4	15.48	nd	nd	2.88
-5	18.06	nd	3.61	1.21
-6	16.77	nd	1.68	1.21
-7	16.52	1.84	1.20	1.25
-8	20.90	nd	2.18	1.34
691-2	11.1	0.8	nd	1.58
-4	12.14	nd	1.44	1.97
-5	11.61	0.29	nd	2.16
692-2	17.81	nd	nd	6.86
-3	12.39	nd	nd	1.75
693-1	15.48	nd	0.03	1.29
-2	14.45	nd	1.23	1.80
-3	13.68	nd	4.43	1.77
-4	12.90	nd	4.62	0.51
694-1	9.81	nd	2.08	1.28
-2	9.55	nd	4.72	1.27
-3	10.06	nd	nd	1.80
-4	9.29	0.54	0.21	0.12
-5	10.58	0.83	nd	1.44
695-1	9.29	nd	0.25	0.84
-2	8.52	0.54	nd	1.43
-3	8.52	0.44	nd	1.24
696-1	12.90	1.48	nd	1.24
-2	15.23	1.63	nd	2.17
-3	13.16	nd	0.65	1.15
-4	15.23	nd	0.32	2.03
-5	15.23	0.15	nd	2.32
-6	16.26	2.59	nd	2.46
-7	18.07	nd	nd	2.51

Table 20b partition of (Ca) in sediments from the area between the volcanic islands Thera and Milos of the Aegean Sea. (Concentration in percent)

Sample No.	Acetic Acid Soluble	Acid Reducing Reagent Soluble	Hcl Soluble	HF Attack of the Final Residue
1108-1	19.84	0.32	0.65	2.2
-2	14.88	0.26	0.72	2.8
-3	5.95	0.19	0.70	2.4
-4	0.75	0.10	0.48	2.8
-5	0.50	0.08	0.56	2.76
1109-1	12.40	0.21	0.42	1.44
-5	11.16	0.31	0.40	1.28
1101-1	21.33	1.00	0.24	0.52
-7	23.56	1.15	0.26	0.28
1111-1	19.84	0.85	0.30	0.48
-9	19.84	0.48	0.30	1.00
1112-1	21.82	0.75	0.38	0.92
-2	17.86	0.60	0.35	0.88
-3	27.28	0.75	0.63	0.80
-4	32.24	1.10	0.45	0.62
1113-1	22.82	0.65	0.36	0.84
-6	15.62	0.43	0.20	1.04
1114-1	21.33	0.60	0.30	0.76
-2	17.36	0.38	0.32	0.76
-3	17.36	0.70	0.32	0.76
-4	17.11	0.55	0.40	1.22
1115-1	23.31	0.75	0.25	0.68
-2	20.83	0.55	0.28	0.72
-3	2.74	0.11	0.24	1.12
1116-1	21.82	0.60	0.34	0.88
-2	9.92	0.19	0.38	1.08
1119-1	19.84	0.60	0.20	0.36
-3	3.81	0.13	0.96	3.48
-7	4.96	0.15	0.86	2.68
-8	13.89	0.46	0.27	0.76

6.31b Partition of Magnesium:

Less than half of the Mg is found to be soluble in the acetic acid and most of the rest is soluble in the HCl with small amounts soluble in the acid reducing reagent (table 21). A smaller amount of Mg is found in the more resistant part of the sediment and is only soluble in HF. This indicates that some of it occurs in the more resistant silicate minerals. The occurence of some Mg soluble in HCl may be due to its being leached from clays by the HCl attack (Cronan, 1976). It is noticed that greater concentrations of Mg are extracted by the acetic acid from the surface sediments than in the case of the buried sediments.

6.31c Partition of Iron:

Iron is found to be concentrated in the HCl soluble fraction of the sediment. A small part is found in the more resistant detrital fraction as silicate or aluminosilicate insoluble in hydrochloric acid. It only occurs in minor amounts in the acid-reducible fraction containing the ferromanganese oxide minerals. These results are in agreement with the supposed mineralogic associations of iron in marine sediments (Dymond and others, 1976). The iron present in the HCl insoluble fraction of the sediment points to the presence of some detrital iron-bearing minerals. Iron also does not occur to any significant concentration in the carbonate fraction soluble in acetic acid, (tables 22a and 22b). This indicates that part of the iron is introduced to the basin either by fluvial or aeolian transport. Iron stained grains of the desert type were reported in different parts of the Levantine Sea.

Table 21 Partition of (Mg) in Sediments from the Area Between the Volcanic Islands Thera and Milos of the Aegean Sea. Concentration in Percent.

Sample No.	Acetic Acid Soluble	Acid Reducing Agent Soluble	Hcl Soluble	HF Attack of the Final Residue
1108-1	1.07	0.14	0.55	0.84
-2	0.88	0.13	0.41	1.12
-3	0.37	0.07	0.33	0.84
-4	0.13	0.02	0.14	1.26
-5	0.09	0.01	0.14	0.98
1109-1	0.95	0.13	0.88	0.46
-5	0.70	0.15	1.00	0.44
1101-1	1.30	0.49	2.20	0.54
-7	1.50	0.50	2.20	0.38
1111-1	1.30	0.37	1.40	0.38
-9	0.88	0.26	0.60	0.28
1112-1	0.90	0.37	1.40	0.50
-2	1.00	0.29	1.30	0.38
-3	1.55	0.34	1.30	0.34
-4	2.65	0.59	1.88	0.36
1113-1	1.67	0.33	1.50	0.42
-6	0.70	0.23	0.65	0.24
1114-1	1.40	0.32	1.70	0.40
-2	1.00	0.21	1.80	0.36
-3	0.95	0.30	1.60	0.38
-4	0.80	0.27	0.70	0.42
1115-1	1.75	0.33	1.70	0.46
-2	1.50	0.25	1.40	0.36
-3	0.27	0.05	0.29	0.26
1116-1	1.62	0.29	1.50	0.42
-2	0.09	0.11	0.52	0.34
1119-1	1.35	0.35	2.10	0.44
-3	0.31	0.03	0.23	1.44
-7	0.37	0.04	0.31	1.00
-8	0.85	0.19	1.60	0.46

Table 22a Partition of (Fe) in Sediments South of the Island of Crete
(Concentrations in wt. percent)

Sample No.	Acetic Acid Soluble Frac. in %	Acid Reducing Agent Soluble Frac. in %	Hcl Soluble Frac. in %	Residue
689-1	0.02	0.11	2.14	0.52
-2	0.05	0.06	1.14	1.41
-3	0.11	0.06	1.33	1.82
-4	0.03	0.10	2.42	0.51
-5	0.14	0.16	2.00	0.89
-6	0.10	0.19	1.71	1.06
-7	0.11	0.01	2.70	0.26
-8	0.11	0.06	2.43	0.44
690-1	0.06	0.28	2.56	0.46
-2	0.07	0.18	2.05	1.05
-3	0.07	0.19	2.14	0.43
-4	0.07	0.19	1.64	0.65
-5	0.06	0.10	1.04	0.41
-6	0.09	0.70	1.04	0.11
-7	0.07	0.83	0.90	0.36
-8	0.05	0.46	0.59	0.36
-9	0.05	0.52	1.23	0.97
691-1	0.13	0.65	2.77	0.30
-2	0.07	1.23	2.50	0.63
-3	0.10	0.53	3.27	0.27
-4	0.09	0.96	2.75	0.50
-5	0.09	1.36	2.15	0.44
692-1	0.06	0.24	1.55	0.70
-2	0.07	1.48	2.05	0.44
-3	0.06	1.49	2.15	0.34
693-1	0.08	1.47	1.70	0.34
-2	0.09	0.71	2.13	0.37
-3	0.07	0.60	2.63	0.42
-4	0.05	0.39	2.91	0.50
-5	0.06	0.80	2.49	0.50
-6	0.07	0.75	2.53	0.50
694-1	0.09	0.86	2.38	0.77
-2	0.08	1.07	2.60	0.37
-3	0.15	2.10	1.85	0.42
-4	0.23	0.54	3.03	0.45
-5	0.21	1.44	1.70	n.d.
695-1	0.17	1.13	2.30	0.39
-2	0.25	1.10	2.20	0.30
-3	0.31	0.79	2.60	0.42
696-1	0.04	0.71	2.25	0.45
-2	0.05	0.65	2.10	0.38
-3	0.07	0.73	2.35	0.30
-4	0.07	0.47	2.01	0.50
-5	0.09	0.34	1.77	0.99
-6	0.04	0.59	2.12	0.30
-7	0.04	0.54	1.87	0.34

Table 22b Partition of (Fe) in Sediments from the Area Between the Volcanic Islands Thera and Milos, of the Aegean Sea. Concentration in Percent

Sample No.	Acetic Acid Soluble	Acid Reducing Reagent Soluble	Hcl Soluble	HF Attack of the Final Residue
1108-1	0.03	0.13	2.3	2.02
-2	0.03	0.11	2.5	2.6
-3	0.04	0.09	2.0	2.28
-4	0.05	0.04	2.3	2.94
-5	0.04	0.04	1.52	2.50
1109-1	0.04	0.15	2.40	1.58
-5	0.02	0.09	2.60	1.46
1101-1	0.03	0.25	4.80	0.82
-7	0.02	0.13	4.90	0.54
1111-1	0.03	0.22	3.50	0.68
-9	0.02	0.09	1.37	0.98
1112-1	0.03	0.29	3.70	1.14
-2	0.02	0.17	3.50	1.06
-3	0.25	0.26	3.50	0.68
-4	0.03	0.19	3.75	0.76
1113-1	0.04	0.31	3.50	1.18
-6	0.02	0.06	1.76	0.88
1114-1	0.03	0.27	3.7	1.02
-2	0.03	0.09	3.4	1.22
-3	0.03	0.13	3.2	1.34
-4	0.03	0.09	1.7	1.74
1115-1	0.04	0.33	3.9	1.10
-2	0.03	0.23	3.3	1.12
-3	0.05	0.10	0.9	1.58
1116-1	0.05	0.32	3.4	1.26
-2	0.03	0.19	1.75	1.40
1119-1	0.04	0.36	4.80	0.78
-3	0.07	0.09	1.57	3.44
-7	0.07	0.14	1.64	2.90
-8	0.03	0.15	3.70	1.20

It is noticed that the amount of iron extracted by the acetic acid attack is very small. This is in agreement with Cronan's (1976) statement that the acetic acid attack does not dissolve the iron oxides and associated trace elements to the extent as originally suggested by Chester and Hughes (1967). In the sediments south of the island of Crete, iron occurs mainly in the HCl soluble fraction (table 22a), whilst in the sediment studied between the two volcanic islands Thera and Milos, iron is found to be partially present in the HCl soluble fraction and partially in the HCl insoluble phase. This suggests the presence of some iron bearing detrital minerals in the latter group of samples (table 22b).

6.31d Partition of Manganese:

Manganese behaves quite differently to iron in its partition between phases. It is partly soluble in the acetic acid. It occurs in higher concentrations in the fractions soluble in all other reagents used, but occurs mainly in the reducible hydroxylamine HCL-soluble fraction. There appears to be little manganese in the HCl-insoluble detrital fraction. The data indicate that most of the manganese in the sediments is in phases different from those containing most of the iron. Manganese is most likely present as ferromanganese oxide minerals. It is noticed that the amount of manganese soluble in the acetic acid increases when there is a high content of manganese in the sample. (Table 23a and 23b).

The partition of Mn in the buried sediment is broadly different from the surface sediments. In both cases a small proportion is extracted by acetic acid, reflecting its leaching from oxides or clay minerals and the Mn coating on some

Table 23a Partition of (Mn) in Sediments South of the Island of Crete. All Concentrations are given in ppm

Sample No	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Fraction	Hcl Soluble Fraction	Residue
689-1	120	330	530	104
-2	220	130	440	258
-3	120	10	170	486
-4	530	170	480	n.d.
-5	640	210	100	61
-6	270	230	170	30
-7	760	n.d.	330	n.d.
-8	530	n.d.	290	17
690-1	430	620	170	28
-2	510	190	n.d.	190
-3	550	150	150	n.d.
-4	500	150	80	33
-5	490	10	240	n.d
-6	420	130	110	14
-7	450	200	60	15
-8	520	130	100	n.d.
-9	350	n.d.	230	231
691-1	730	n.d.	420	n.d.
-2	500	250	120	4
-3	480	n.d.	400	n.d.
-4	480	120	270	n.d.
-5	490	260	110	27
692-1	320	n.d.	430	150
-2	440	410	80	44
-3	520	330	130	45
693-1	380	470	80	20
-2	370	80	190	n.d.
-3	470	n.d.	320	n.d.
-4	410	n.d.	340	n.d.
-5	500	50	360	n.d.
-6	1000	n.d.	1074	n.d.
694-1	400	n.d.	390	n.d.
-2	340	10	380	n.d.
-3	360	140	160	13
-4	370	n.d.	290	27
-5	410	190	90	35
695-1	500	150	200	50
-2	300	200	150	n.d.
-3	300	150	230	n.d.
696-1	460	240	150	25
-2	370	230	100	n.d.
-3	310	140	160	2
-4	310	140	180	n.d.
-5	150	85	155	47
-6	390	1810	604	n.d.
-7	250	450	70	30

Table 23b partition of (Mn) in sediment from the area between the volcanic islands Thera and Milos of the Aegean Sea. All concentrations are given in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble frac.	Hcl Soluble frac.	HF attack of the final residue
1108-1	160	30	180	700
-2	137.5	35	220	840
-3	145	35	200	680
-4	75	15	210	960
-5	60	15	150	820
1109-1	130	475	180	500
-5	113	35	190	440
1101-1	250	1250	300	120
-7	325	70	280	40
1111-1	325	1550	280	160
-9	125	35	110	320
1112-1	165	180	280	320
-2	203	900	240	300
-3	137	40	220	160
-4	160	60	250	140
1113-1	128	1000	270	340
-6	78	20	140	360
1114-1	193	1000	250	280
-2	203	25	230	280
-3	198	40	220	300
-4	135	30	140	440
1115-1	148	1450	270	280
-2	135	950	230	300
-3	113	250	90	500
1116-1	155	1050	250	380
-2	525	40	140	440
1119-1	230	1750	310	140
-3	250	800	150	940
-7	238	900	150	780
-8	325	1350	230	300

carbonate organisms.The high proportion of Mn present in the HCl soluble fraction suggests that Mn is held in the lattices of clay minerals in the sediments south of the island of Crete (table 23a). The presence of Mn in HCl insoluble phases in the sediments between Thera and Milos suggests the presence of HCl insoluble detrital material in this area (table 23b).

6.31e Partition of Aluminium

Aluminium is not present to any significant extent in the fractions soluble in either acetic acid or the acid-reducing reagent. A large part of it occurs in the HCl soluble fraction, sometimes as high as 50% or more. The rest of the aluminium occurs in the detrital fraction insoluble in HCl. The very small amount of Al extracted by acetic acid and/or by the acid reducing reagent from the sediments is probably removed from the surfaces of authigenic clay minerals present.

The majority of the Al is found to be partitioned between the HCl soluble and insoluble phases. This partition is seen in most of the sediments and it shows that Al, like iron, occurs in authigenic and detrital clay minerals and/or other detrital components of the sediments. It is noticed that more Al is extracted by HCl from the sediments south of Crete than from those between the two volcanic islands Thera and Milos and that more Al is found in the final residue in case of the sediments between Thera and Milos, (Tables 24a and 24b).

6.31f Partition of Copper

The partition of copper in the sediments south of Crete is different from that found in the sediments between the two islands Thera and Milos. The amount of copper removed by the

Table 24a Partition of (Al) in Sediment South of the Island of Crete in the Eastern Mediterranean Sea. Al_2O_3 Concentration in Percent

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Fraction	Hcl Soluble Fraction	Residue
689-1	0.05	0.02	3.43	3.85
-2	0.12	n.d.	1.72	10.30
-3	0.70	n.d.	1.73	11.67
-4	0.04	0.03	3.73	3.94
-5	0.06	0.04	4.10	3.78
-6	0.04	0.05	3.41	3.75
-7	0.07	n.d.	4.56	3.53
-8	0.07	n.d.	3.98	4.20
690-1	0.09	0.05	4.36	3.23
-2	0.07	0.06	3.52	4.35
-3	0.05	0.06	3.39	3.63
-4	0.05	0.06	2.69	3.57
-5	0.04	0.03	1.63	2.54
-6	0.05	0.39	1.79	3.29
-7	0.05	0.43	2.17	3.35
-8	0.04	0.21	1.35	1.65
-9	0.13	0.16	2.66	8.16
691-1	0.09	0.14	4.97	2.29
-2	0.07	0.38	5.20	2.71
-3	0.09	0.11	5.80	1.74
-4	0.07	0.27	5.41	1.86
-5	0.08	0.40	4.32	2.82
692-1	0.08	0.03	2.64	3.25
-2	0.09	0.46	5.43	1.82
-3	0.07	0.51	5.72	1.83
693-1	0.11	0.45	5.64	2.05
-2	0.10	0.30	5.80	1.79
-3	0.07	0.12	4.86	2.70
-4	0.07	0.06	5.62	2.37
-5	0.07	0.21	5.49	2.49
-6	0.07	0.21	5.54	2.20
694-1	0.08	0.29	4.18	5.70
-2	0.06	0.36	5.68	3.64
-3	0.06	0.61	5.21	3.47
-4	0.08	0.19	5.68	4.05
-5	0.08	0.59	5.38	3.20
695-1	0.08	0.36	5.16	4.40
-2	0.09	0.42	5.54	3.45
-3	0.09	0.29	5.72	3.77
696-1	0.06	0.22	4.97	3.00
-2	0.07	0.20	4.88	2.47
-3	0.08	0.22	5.35	3.09
-4	0.07	0.22	4 91	2.55
-5	0.07	0.18	4.70	2.29
-6	0.06	0.20	4.89	2.47
-7	0.11	0.16	4.63	2.35

Table 24b partition of (Al) in Sediment from the Area Between the Volcanic Island Thera and Milos of the Aegean Sea.
AL_2O_3 Concentration in percent.

Sample No.	Acetic Acid Soluble frac.	Acid Reducing Reagent Soluble frac.	Hcl soluble frac.	HF attack of the Final Residue
1108-1	0.02	0.06	1.5	6.2
-2	0.02	0.05	1.3	7.4
-3	0.03	0.04	1.3	6.4
-4	0.02	0.02	0.8	8.0
-5	0.02	0.02	0.9	8.4
1109-1	0.05	0.07	1.8	7.0
-5	0.04	0.09	2.0	6.6
1101-1	0.03	0.13	3.5	5.2
-7	0.02	0.11	4.6	5.0
1111-1	0.03	0.11	3.0	5.0
-9	0.02	0.05	1.3	5.2
1112-1	0.03	0.14	3.0	5.2
-2	0.03	0.11	2.8	5.6
-3	0.12	0.36	3.7	4.2
-4	0.02	0.16	3.8	4.2
1113-1	0.04	0.16	3.0	6.0
-6	0.03	0.05	1.2	4.8
1114-1	0.04	0.16	3.0	4.8
-2	0.04	0.09	2.9	4.6
-3	0.03	0.11	2.7	4.6
-4	0.02	0.05	1.4	5.6
1115-1	0.04	0.17	3.0	5.2
-2	0.04	0.14	2.6	5.0
-3	0.04	0.05	0.7	6.0
1116-1	0.05	0.16	2.7	5.8
-2	0.25	0.21	1.7	5.8
1119-1	0.05	0 17	3.7	6.0
-3	0.04	0.04	1.4	7.4
-7	0.04	0.06	1.4	7.4
-8	0.04	0.14	2.8	6.2

acetic acid leach from the sediments between these two islands is under the detection limit of the method used (2. ppm), whilst up to 35% of the total is removed by the same reagent from the sediments south of Crete (table 25a) which reflects its incorporation into biogenic carbonate material in this area. In the sediments south of Crete the majority of copper is partitioned between the ferromanganese oxides in the hydroxylamine HCl soluble fraction and the HCl soluble fraction. Amounts leached by the different reagents vary greatly. Up to 54% is found in the acid reducing reagent soluble fraction indicating its incorporation into iron and Mn oxide minerals. In the sediments between the two islands Thera and Milos the majority of copper is found in the fraction soluble in HCl indicating its associating with the iron oxides and authigenic clay minerals, (tables 25a and 25b).

6.31g Partition of Zinc:

Minor amounts of Zn are leached by the acetic acid. Usually amounts less than 10% of the element is removed by this leach. The amounts of Zn soluble in the acid reducing reagent differ broadly between sediments (tables 26a and 26b). The majority of Zn in most sediments is concentrated in the HCl soluble and/or HCl insoluble phases. The zinc in the acetic acid soluble fraction may be incorporated into biogenic material or removed from absorbed sites on the surface of other minerals. A negative correlation between the amount of Zn found in the acetic acid leach and the carbonate content of the sediment is noticed (table 26a, e.g. core number 689), particularly in the sediments south of the island of Crete. This means that zinc basically occurs in the non-carbonate part of the sediments and eliminates the possibility of it being

Table 25a Partition of (Cu) in Sediments South of the Island of Crete. All Concentrations are given in ppm.

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Fraction	Hcl Soluble Fraction	Residue
689-1	10.2	1.6	38.2	3
-2	4.9	n.d.	22.1	4
-3	2.4	n.d.	7.6	13
-4	7.4	8.4	24.2	9
-5	2.7	14.1	30.2	33
-6	1.4	17.4	23.2	33
-7	11.4	n.d.	22.6	7
-8	20.4	1.4	28.2	9
690-1	13.9	17.9	15.2	8
-2	11.4	14.4	5.2	14
-3	11.4	8.4	9.2	6
-4	9.9	8.9	5.2	13
-5	9.4	1.4	8.2	6
-6	9.2	5.6	7.2	3
-7	10.4	10.4	2.2	3
-8	8.9	3.9	3.2	4
-9	10.4	0.4	26.2	11
691-1	9.1	11.7	26.2	8
-2	9.4	20.4	13.2	9
-3	8.9	5.9	31.2	4
-4	7.7	16.1	18.2	8
-5	8.4	24.4	7.2	16
692-1	9.9	n.d.	18.1	5
-2	8.7	29.1	10.2	6
-3	8.9	31.9	13.2	2
693-1	12.9	30.9	11.2	8
-2	17.7	30.1	0.2	8
-3	4.7	8.1	19.2	7
-4	4.7	2.1	31.2	7
-5	6.2	15.6	26.2	6
-6	11.2	11.6	34.2	8
694-1	7.2	9.2	27.2	2
-2	8.7	11.1	27.2	3
-3	13.9	24.9	9.2	5
-4	10.4	0.4	24.2	4
-5	16.2	22.6	8.2	4
695-1	8.9	15.9	11.2	5
-2	10.7	16.1	6.2	10
-3	12.9	10.9	12.2	10
696-1	7.2	17.5	16.2	7
-2	7.7	14.1	10.2	8
-3	11.4	14.4	14.2	8
-4	20.7	14.1	14.2	10
-5	3.2	3.6	33.2	26
-6	12.7	23.1	14.2	8
-7	12.7	21.1	10.2	6

Table 25b Partition of (Cu) in Sediments from the Area Between the Volcanic Islands Thera and Milos in the Aegean Sea. All Concentrations are given in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	HF Attack of the Final Residue
1108-1	n.d.	2.3	24.7	7.3
-2	n.d.	0.8	8.7	5.3
-3	n.d.	1.3	7.7	5.3
-4	n.d.	0.3	7.7	3.3
-5	n.d.	1.8	1.7	3.3
1109-1	n.d.	4.8	15.7	5.3
-5	n.d.	5.3	17.7	3.3
1101-1	n.d.	13.3	45.7	1.3
-7	n.d.	10.3	54.7	1.3
1111-1	n.d.	5.8	23.7	n.d.
-9	n.d.	1.3	4.7	3.3
1112-1	n.d.	8.3	27.7	1.3
-2	n.d.	5.3	27.7	3.3
-3	n.d.	4.8	28.7	11.3
-4	n.d.	7.7	32.1	11.3
1113-1	n.d.	8.3	28.7	1.3
-6	n.d.	2.8	5.7	1.3
1114-1	n.d.	9.3	28.7	1.3
-2	n.d.	4.3	26.7	11.3
-3	n.d.	6.8	25.7	9.3
-4	n.d.	1.8	12.7	3.3
1115-1	n.d.	10.8	32.7	1.3
-2	n.d.	9.8	27.7	n.d.
-3	n.d.	3.8	3.7	1.3
1116-1	n.d.	9.3	34.7	n.d.
-2	n.d.	5.8	12.7	1.3
1119-1	1.98	19.3	47.7	1.3
-3	0.01	2.8	3.65	13.3
-7	0.01	7.8	5.7	9.3
-8	0.01	16.3	34.7	3.3

Table 26a Partition of (Zn) in Sediments from the South of Crete. Concentrations are given in ppm.

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Fraction	Residue
689-1	6	9	44	19
-2	41	n.d.	n.d.	43
-3	14	n.d.	12	50
-4	4	9	50	17
-5	6	21	61	5
-6	4	32	59	n.d.
-7	8	n.d.	77	n.d.
-8	8	32	31	14
690-1	6	12	64	n.d.
-2	8	24	50	n.d.
-3	5	9	108	n.d.
-4	5	118	n.d.	n.d.
-5	6	5	21	17
-6	11	22	9	14
-7	6	36	1	12
-8	8	17	4	15
-9	5	12	26	31
691-1	4	17	41	3
-2	4	25	40	10
-3	4	13	52	6
-4	3	24	42	12
-5	5	37	47	16
692-1	4	4	38	13
-2	3	33	35	7
-3	3	54	15	13
693-1	5	35	30	8
-2	8	30	49	n.d.
-3	5	14	49	3
-4	5	6	60	9
-5	7	18	48	5
-6	5	16	58	6
694-1	4	20	59	7
-2	3	21	58	8
-3	4	47	24	13
-4	3	14	58	35
-5	5	37	30	17
695-1	3	26	48	9
-2	3	30	39	16
-3	5	18	71	n.d.
696-1	5	23	65	n.d.
-2	5	22	41	7
-3	5	21	49	4
-4	7	18	38	12
-5	5	18	42	23
-6	5	20	42	18
-7	9	23	29	17

Table 26b Partition of (Zn) in Sediments from the Area Between The Volcanic Islands Thera and Milos of the Aegean Sea. Concentrations are in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	HF Attack of the Final Residue
1108-1	7	16	52	37
-2	6	10	41	43
-3	4	32	32	43
-4	5	16	53	47
-5	4	38	25	39
1109-1	10	17	43	31
-5	7	10	51	27
1101-1	7	13	86	11
-7	8	16	94	4
1111-1	11	14	75	8
-9	5	7	27	21
1112-1	9	13	69	23
-2	5	10	71	19
-3	13	13	63	2
-4	8	19	75	-12
1113-1	12	14	67	17
-6	4	6	35	19
1114-1	7	13	70	15
-2	6	48	74	19
-3	5	109	64	23
-4	7	7	33	31
1115-1	14	18	74	19
-2	8	10	63	23
-3	4	5	12	33
1116-1	10	17	75	21
-2	12	13	30	23
1119-1	8	14	94	12
-3	5	5	30	51
-7	4	54	29	41
-8	5	12	68	19

incorporated in the biogenic fraction of the sediments. In the sediments between the two islands Thera and Milos, the majority of zinc is associated with the HCl soluble fraction showing its association with iron oxides and iron silicates minerals.

6.31h Partition of Lead

A large proportion of lead is removed by the acetic leach (tables 27a and 27b). A positive correlation is noticed between the amount of Pb removed by the acetic acid leach and the total carbonate content of the sediment. The association of lead with the calcarous biogenic components of marine sediments has been reported by Greenslate et al (1973): Cronan and Garrett, (1976) and Bostrom et al (1974). Minor proportions of Pb are soluble in the acid reducing reagent. This represents the association of Pb with reducible ferromanganes oxides. Lead is virtually absent in the HCl leach of some sediments and present in small amounts in others. Larger amounts of lead are found in the HCl insoluble detrital fraction, in most sediments south of the island of Crete. In the sediments between the two islands Thera and Milos, greater amounts of Pb are found in the HCl soluble and/or the HCl insoluble fraction.

6.31i Partition of Nickel

Minor amounts of nickel occur in the HCl insoluble detrital fraction and the acetic acid soluble fraction. In the sediments between Thera and Milos amounts between 5% and 21% were removed by the acetic acid leach, whilst greater amounts were removed from the sediments south of Crete using the same reagent. Generally similar amounts occur in the detrital fraction insoluble in HCl. Greater percentages are found in the acid reducing reagent

Table 27a Partition of (pb) in Sediments from the South of Crete. All Concentrations are given in ppm.

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hol Soluble Frac.	Residue
689-1	21	2	35	42
-2	11	12	n.d.	40
-3	6	17	n.d.	27
-4	26	12	30	20
-5	34	19	n.d.	35
-6	24	24	n.d.	27
-7	34	n.d.	14	27
-8	29	n.d.	24	22
690-1	29	18	10	5
-2	34	14	n.d.	12
-3	26	22	n.d.	2
-4	29	19	n.d.	15
-5	36	1	15	11
-6	31	17	n.d.	2
-7	31	12	n.d.	5
-8	46	2	5	n.d.
-9	16	7	10	30
691-1	26	n.d.	22	n.d.
-2	24	24	n.d.	n.d.
-3	24	n.d.	24	2
-4	24	14	10	2
-5	26	17	n.d.	20
692-1	36	n.d.	25	27
-2	26	21	1	15
-3	24	23	n.d.	7
693-1	26	21	1	27
-2	31	12	5	2
-3	24	9	20	n.d.
-4	24	n.d.	25	15
-5	24	4	20	n.d.
-6	24	n.d.	24	n.d.
694-1	24	n.d.	24	2
-2	21	2	25	2
-3	21	17	10	2
-4	24	n.d.	14	12
-5	24	19	5	15
695-1	24	14	n.d.	12
-2	24	14	5	7
-3	24	9	10	20
696-1	26	17	5	15
-2	26	22	n.d.	40
-3	24	14	10	n.d.
-4	36	7	5	15
-5	24	24	n.d.	2
-6	24	24	n.d.	15
-7	36	17	n.d.	15

Table 27b Partition of (Pb) in Sediment from the Area Between the Two Volcanic Islands Thera and Milos of the Aegean Sea. All Concentrations are in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	HF Attack of the Final Residue
1108-1	37	23	46	92
-2	24	23	n.d.	92
-3	14	23	n.d.	92
-4	12	23	n.d.	92
-5	12	23	n.d.	92
1109-1	19	23	n.d.	92
-5	19	23	n.d.	92
1101-1	29	23	46	92
-7	37	23	46	92
1111-1	29	23	46	92
-9	32	23	46	92
1112-1	32	23	46	92
-2	27	23	46	92
-3	31	23	n.d.	92
-4	46	46	57	92
1113-1	29	23	n.d.	92
-6	22	23	n.d.	92
1114-1	24	23	46	92
-2	27	23	46	92
-3	24	23	46	92
-4	32	23	46	92
1115-1	27	23	46	92
-2	9	23	46	92
-3	29	23	n.d.	92
1116-1	19	23	46	92
-2	29	23	46	92
1119-1	9	23	46	92
-3	9	23	46	92
-7	22	23	46	92
-8	22	23	46	92

soluble fraction. The majority of nickel occurs in the HCl soluble fraction and/or the acid reducing reagent soluble fraction, (tables 28a and 28b). It is noticed that the sediments with high nickel content have the greater part of their nickel in the HCl soluble fraction. This is always the case in the sediments between Thera and Milos (table 28b), whilst some of the Ni rich sediments outh of Crete are found to have their high nickel in the acid reducing reagent soluble fraction (table 28a) The concentration. of Ni in the HCl soluble fraction suggests that it has been removed from the lattice of clay minerals or iron oxide minerals. Horowitz (1974a)

Table 28a Partition of (Ni) in Sediment from the South of the Island of Crete. All Concentrations are given in ppm.

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	Residue
689-1	25	5	125	20
-2	30	n.d.	30	n.d.
-3	13	n.d.	12	13
-4	25	25	140	48
-5	70	35	145	50
-6	45	80	95	68
-7	43	n.d.	152	43
-8	50	5	160	35
690-1	35	35	145	35
-2	50	30	95	75
-3	28	37	135	38
-4	28	47	100	38
-5	30	10	95	n.d.
-6	38	62	65	10
-7	40	70	70	n.d.
-8	38	42	45	n.d.
-9	15	25	60	25
691-1	70	90	260	43
-2	60	220	180	53
-3	50	95	335	20
-4	50	185	260	5
-5	50	250	165	35
692-1	35	15	130	58
-2	50	210	125	53
-3	43	197	140	53
693-1	45	145	65	8
-2	58	162	85	20
-3	48	82	180	15
-4	48	32	215	5
-5	75	75	180	20
-6	64	66	190	18
694-1	28	57	145	20
-2	25	65	150	10
-3	28	122	65	35
-4	25	50	150	38
-5	25	125	50	50
695-1	25	90	95	40
-2	30	105	100	15
-3	25	85	120	20
696-1	30	80	80	23
-2	33	77	65	n.d.
-3	35	70	95	13
-4	45	65	90	13
-5	53	47	100	n.d.
-6	23	77	90	10
-7	33	62	55	25

Table 28b Partition of (Ni) in Sediments from the Area Between the Volcanic Islands Thera and Milos of the Aegean Sea. All Concentrations are in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	HF Attack of the Final Residue
1108-1	14	3	37	14
-2	12	3	27	14
-3	10	8	7	14
-4	2	8	7	14
-5	2	3	7	14
1109-1	10	8	67	14
-5	10	8	77	14
1101-1	17	33	197	14
-7	14	23	217	14
1111-1	17	23	97	14
-9	14	8	37	14
1112-1	14	38	107	14
-2	12	13	97	14
-3	27	23	97	14
-4	22	37	159	14
1113-1	14	18	117	14
-6	12	8	47	14
1114-1	14	23	137	14
-2	14	8	137	14
-3	14	13	117	14
-4	12	8	47	14
1115-1	14	23	147	14
-2	14	18	127	14
-3	5	3	17	n.d.
1116-1	14	13	137	14
-2	27	8	37	n.d.
1119-1	17	28	197	n.d.
-3	7	3	7	n.d.
-7	7	3	7	n.d.
-8	12	13	157	n.d.

reported the association of nickel with HCl soluble phases in sediments from near Iceland.

6.31j Partition of Chromium

Small proportions of Cr are associated with the acetic acid soluble fraction (1% to 5%). This reflects the removal of small amounts of Cr from biogenic carbonate material or from absorbed sites on other minerals. Greater amounts are removed by the acid reducing reagent (up to 49.6%), reflecting its removal from ferromanganese oxides material or its association with amorphous Fe oxide. The amounts of Cr extracted by HCl leach differ largely between sediments (table 29). However the majority of Cr is found in the HCl insoluble residue (up to 72.7%) in the sediment between the volcanic islands of Thera and Milos. This suggests that Cr may be incorporated in these sediments by inclusion in them of some volcanic fragments, which would be insoluble in hydrochloric acid. Many authors attributed the presence of Cr, in the HCl insoluble phases of some oceanic sediments, to the inclusion of basaltic detrital debris (Chester and Messiha-Hanna, 1970; Horowitz, 1974a; Chester et al, 1976).

6.31k Partition of Cobalt

A large proportion of cobalt is removed by the acetic acid leach (up to 47%) reflecting its incorporation with biogenic carbonate material, and/or its removal from adsorbed sites on the surfaces of clay minerals. Up to 32% of Co is found in the acid reducing reagent soluble fraction. This reflects its association with ferromanganese oxides minerals.

The amounts of Co removed by the HCl leach vary broadly

Table 29 Partition of (Cr) in Sediments from the Area Between the Volcanic Islands Thera and Milos of the Aegean Sea. All Concentration are given in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	HF Attack of the Final Residue
1108-1	5	60	20	120
-2	5	55	10	120
-3	3	45	10	120
-4	n.d.	45	n.d.	120
-5	3	140	n.d.	140
1109-1	4	65	40	120
-5	3	85	50	140
1101-1	5	50	140	200
-7	5	65	140	180
1111-1	5	55	90	200
-9	7	55	30	140
1112-1	5	60	90	160
-2	5	100	80	160
-3	20	75	120	260
-4	8	120	113	160
1113-1	5	45	90	160
-6	5	40	30	120
1114-1	5	100	100	160
-2	8	135	100	160
-3	5	130	90	140
-4	5	60	40	140
1115-1	5	70	110	120
-2	5	55	90	140
-3	n.d.	60	n.d.	120
1116-1	5	85	90	160
-2	15	80	40	160
1119-1	5	60	140	180
-3	3	50	10	140
-7	3	110	10	120
-8	3	85	100	160

Table 30 Partition of (Co) in Sediments from the area between the Volcanic Islands Thera and Milos of the Aegean Sea. All Concentrations are in ppm

Sample No.	Acetic Acid Soluble Frac.	Acid Reducing Reagent Soluble Frac.	Hcl Soluble Frac.	HF Attack of the Final Residue
1108-1	16	n.d.	6	12
-2	14	n.d.	6	12
-3	9	n.d.	n.d.	12
-4	4	n.d.	6	32
-5	4	n.d.	n.d.	12
1109-1	9	8	6	n.d.
-5	9	3	16	12
1101-1	11	23	26	12
-7	16	8	36	n.d.
1111-1	11	8	16	n.d.
-9	14	n.d.	6	12
1112-1	11	23	26	12
-2	11	18	16	12
-3	19	n.d.	16	12
-4	24	6	32	12
1113-1	14	8	16	n.d.
-6	11	n.d.	6	12
1114-1	14	13	26	12
-2	14	3	16	12
-3	14	3	6	12
-4	14	n.d.	6	12
1115-1	16	18	16	12
-2	14	13	16	12
-3	6	n.d.	16	32
1116-1	16	13	16	12
-2	16	n.d.	6	12
1119-1	11	23	26	12
-3	6	3	n.d.	12
-7	6	3	6	12
-8	11	13	16	12

in the sediments between the two islands Thera and Milos (17.6% to 60%). This suggests its removal from Fe oxides and silicate minerals soluble in HCl or from the lattices of clay minerals. Chester (1965a) suggested that Co, if present in the sea water in its monovalent state as ($Co\ Cl^+$ or $Co(OH)^+$), it can substitute for H_2 in the OH groups in the lattice of clay minerals. This lattice held cobalt could be removed by the HCl leach and would account for the high proportions of cobalt in the HCl soluble fraction (table 30). An association of cobalt with the HCl soluble fraction was recorded by Chester et al (1976) in some oceanic sediments. The amounts of Co present in the HCl insoluble residue vary from almost under the detection limit up to greater than 70%. Normally it is in the level between 16 and 41%. The fluctuation in values reflects the variable incorporation into the sediments of cobalt rich detrital fragments in this volcanic provence.

6.31 1 Partition of Cadmium

Cadmium is found to be concentrated in the acetic acid soluble fraction, (up to 97%) of the sediments, (Table 31). Due to very low levels of Cadmium it was not possible to determine this element in any other leach. In the acid reducing reagent and the HCl soluble or insoluble fractions, the values were under the detection limit of the atomic absorption method used (less than 1 ppm). Therefore there is no further discussion of this element.

Table 31 Cd Concentration in the acetic acid soluble fraction in Sediments from the area between the Volcanic Islands Thera and Milos of the Aegean Sea. All Concentrations are given in ppm.

Sample No.	Acetic Acid Soluble Frac.
1108-1	5.2
-2	25.2
-3	37.2
-4	33.5
-5	99.8
1109-1	3.5
-5	6.7
1101-1	4.0
-7	11.5
1111-1	3.2
-9	9.7
1112-1	4.5
-2	7.2
-3	10.2
-4	9.0
1113-1	3.2
-6	14.0
1114-1	2.7
-2	3.5
-3	2.7
-4	8.0
1115-1	3.0
-2	2.7
-3	2.5
1116-1	3.5
-2	3.7
1119-1	4.5
-3	11.7
-7	13.0
-8	11.0

CHAPTER VII

SUMMARY

The previous sections have outlined the general geology, sedimentology and geochemistry of both the surface and buried sediments of the eastern Mediterranean and Aegean Seas. Detailed sedimentological and geochemical data are presented for deep sea cores collected from the different sub-areas shown in figure 1. The environments studied includes continental shelves and slopes , abyssal plains, a median ridge, a trench island arc structure and small isolated basins.

As a sedimentary basin the eastern Mediterranean could be described as transitional between a true basin and an open ocean. Because of the fact that the basin is a semi-closed basin,the sediments display features of both an open ocean situated in analogous climatic zone (calcareous oozes, calcareous lutites) and those of a closed basin (stagnation deposits). The basin is characterized by its high rate of sediment input from the surrounding borderlands, from the drainage network in the high relief areas and the river systems and from the fluvial inputs from the large islands within the basin,as well as from aeolian sources such as the north African desert.

The sedimentological data demonstrate the great variability in composition and distribution of the bottom sediments in the eastern Mediterranean Sea. The formation of the different sediment types seems to be controlled by the influence of several factors. These factors are reflected in the granulometric and the chemical composition

of the sediments. Abyssal regions are characterized by sediments which are particularly silty in nature, while shelf sediments exhibit more textural and compositional differences.

Volcanic influences, despite the presence of active volcanoes in the region, seems to have a minor importance in the recent sedimentation. Volcanic sediments are found in and around the Santorini area. Ash, pumice and glass shards were noticed in a wide circle, but in very low concentrations.

Sediments in cores from the different parts of the study area are as mentioned, formed predominantly of fine grained material (silt), but some layers of sandy sediments are observed. Most of the coarse grained fraction is volcanic (pumice), or organic (shells) in origin. Only a few cores have layers of these sand sized sediments; mostly from the area close to the volcanic islands. However, thin layers of sandy sediments were found in the area south and south-east of Crete and Karpathos. Some of the cores from deep areas were found to contain a mixture of terrigenous sand and silt sized components as well as shell fragments.

Sediments appear to be transported to the abyssal plains via submarine channels and trenches. The submarine topography throughout the eastern Mediterranean provides major conduits of sediment transport downslopes to basins and plains. It offers the key for interpreting the dispersal patterns in the region.

Sapropelic layers occur throughout the eastern Mediterranean. They are sometimes discernible by a slight grey colour. They do not always exist as easily recognizable dark black layers.

However, sapropels are easily recognized by a strong H_2S smell when freshly collected. The sapropelic layers are very poor in faunal content reflecting the disappearance of fauna during the stagnant stages, due to oxygen depletion of the deep water masses.

Calcareous lutites and oozes and hemipalagic silty lutites cover the floor of the deep basins.

The surface layer shows great similarity in sediment type throughout the study area, apart from the northern Aegean area where terrigenous clays and muds predominate on the continental margin. A sandy, silt layer occurs on the surface to the southeast of Crete. The latter is an area that is highly faulted and folded. Displaced sediments are noticed in this area where slumped sediments have been recorded as well as turbidites.

In regard to the sedimentary provenance, there is a wide variability of source areas which contribute to the eastern Mediterranean sediments. The exposed rocks and sediments in these areas are available for mechanical erosion under the predominantly arid and semi-arid Mediterranean conditions. Because of the high relief in the northern drainage areas of the eastern Mediterranean all the old geological terrains surrounding the Aegean sea and on the islands are potential contributors to the sediments of the Aegean Sea; and they can then be flushed out of the Aegean into the eastern Mediterranean. Sediments could also be

supplied from north Africa to the south, from Turkey, Israel, Lebanon and Syria to the east, from Greece to the north and west of the area and from the Aegean islands and the islands of Crete, Cyprus and Rhodes.

The north African aeolian sands form a widespread sediment component. The presence of fine sand-sized quartz with frosted grain surface or iron-oxide staining in the sediments of the Levantine basin, south of the island of Crete, is diagnostic of supply from the aeolian desert sands of north Africa.

Clastic sedimentary rocks occur in large area of southern Turkey, Cyprus, Greece and the Peloponnesus. These include greywakes, sub-greywakes and conglomerates. Large areas of mafic igneous rocks are exposed in southern Turkey and in Cyprus. Basaltic and andesitic volcanoes occur in the Levant to the east and southern Turkey as well as in the Cyclades Islands in the southern Aegean Sea and in portions of Greece. Metamorphic rocks also form exposures such as along the eastern side of Antalya Bay in southern Turkey. Sandstones, mudstones, siltstones and conglomerates occur in the Tertiary basins of the Hellenides and Taurus Mountains. These multiple source areas contribute different types of terrigenous material to the basin. The relative importance of the different source areas as contributors to the sediments depends on the transport paths and mechanism as well as the circulation patterns in the region.

There are two main mechanisms for the dispersal of sediments in the study area, these are wind and marine currents.

Turbidites and mid-water suspended-sediment plumes are a major transporting mechanism in the southern and eastern Mediterranean. In the northern part of the basin, small river systems drain a high relief semi-arid region. Fluvial material is dominant source for the sediments in this area.

The Hellenic trench area serves as a trap for sediment movement; furthermore, the Mediterranean Outer Ridge is also an effective barrier to sediment transport southward towards Africa. The irregular submarine topography within the trench system south of the islands of Crete and Rhodes suggests a very limited lateral dispersal of detritus in this area. Sediments may be locally disturbed within the trench area by slumping.

In the southern part of the basin, which is characterized by a high rate of sediment input and highly smoothed physiography, the sediment transport path is evidently a long one. By contrast path with no doubt would be relatively short in areas characterized by irregular physiography such as in the trench area and in the northern part of the study area.

The areas complex stratigraphic nature has led to a certain difficulty in correlation between cores. Cores contain calcareous oozes, pelagic lutites, sapropels, volcanic ash and turbidites. The correlation between sediments in the study area is generally based upon volcanic ash and sapropels. Olausson (1961) and Ryan (1969, 1978) based their correlation on the uppermost sapropelic layer. However, sequences of sapropels cannot be used as correlative seq-

ences without additional criteria Individual sapropelic layers are not usually distinctive throughout the area. Sometimes they occur as individual dark grey-black horizons in cores, while in other cases two or three layers may be present together.

The work by Mellis (1954), Ninkovitch and Heezen (1965, 1967) and others on volcanic ash layers has provided the foundation for defining a sequence of correlative time stratigraphic horizons in the eastern Mediterranean. The deep-sea stratigraphic section samples in the present work from both the eastern Mediterranean and Aegean Seas contains several volcanic ash layers. All ashes are vitric with a low percentage of rock fragments. Pumice fragments are also found.

Regarding the chemical composition of the surface sediments, it can generally be said that the sediments of the eastern Mediterranean are moderately carbonate rich except in the northern Aegean because of a high dilution by detrital sediments in that area. Most of the carbonate rich fraction of the sediments is biogenic. However, a small fraction of the carbonate is possibly aeolian, transported by wind from the carbonate formations in the surrounding areas.

The fact that the carbonate values determined in the present work by CO_2 absorption are high compared to those determined by the acetic acid leach or those calculated from calcium concentrations, indicates the existence of a form of carbonate other than $CaCO_3$ in the sediments. This is likely to be magnesium carbonate which is less soluble in

the acetic acid than in HCl. The magnesium carbonate equivalent calculated for the magnesium values estimated in the area ranges up to 7%.

The chemical analyses of the bulk sediments are presented on a c.f.b. to remove the diluting effect caused by the presence of carbonate material in their concentrations. The correlation of elements against Ca CO_3 shows that iron, aluminium, zinc, chromium and titanium, all have negative correlations with carbonate. Organic carbon was also found to have negative correlation with carbonate. Lead, cobalt and magnesium are found to have a slightly positive correlation with carbonate, noticable in the Aegean sea sediments, but not in those surrounding the island of Crete. Manganese, copper, cadmium and nickle show no correlation with the calcium carbonate. The correlation of the same elements with the organic carbon shows that, iron,titanium and cadmium have positive correlation with the organic carbon in the surface sediments. Calcium, magnesium and lead are found to have negative correlation, while the rest of the elements studied are found to vary independently of organic carbon.

As would be expected, the elements that have a positive correlation with Ca CO_3, have a negative correlation with the organic carbon and vice versa. This is in correspondence with the fact that the organic carbon itself has a negative correlation with the calcium carbonate. The negative correlation between the carbonate and iron, aluminum, titanium and other elements corresponds with the observation that concentrations of these elements are related to several sources of

aluminosilicate detritus with the carbonate acting only as a diluent. By contrast, it is not possible to distinguish between biogenic and detrital controls on the distribution of those elements independent of the carbonate.

The geochemical study of the area reveals that with the exception of manganese the variations in the elemental abundances within the region can generally be explained by the differences in the depositional environments and the nature of the sediment types, except in the trench area south of Crete and near the Hellenic Outer Ridge, where a trend of increase in certain elements is noticed (Mn, Cu, Pb, Co and Cd) which cannot be accounted for by provenance or the environment of deposition. Further work will be needed to the south of the present study area to explain these trends.

Patches of manganese rich sediments occur in places in the study region and manganese values higher than the average were also frequently recorded elsewhere. From the size fraction chemistry the high concentrations of manganese seem to be concentrated in the coarse fraction of the sediments and may represent diagenetically remobilised manganese.

BIBLIOGRAPHY

Alexanderson., T., 1969. Recent littoral and sublittoral high-Mg calcite lithification in the Meditterranean; Sediment, 12 47-61.

Allan, T.D. and C. Morelli, 1971. A geophysical study of the Mediterranean Sea; Bull. Geol. Teor. App., 13: 142.

Allan, T.D., Charnock, H., and Morelli, C., 1964. Magnetic gravity and depth surveys in the Meditterranean and Red Sea; Nature, 204: 1245-1248.

Almagor, G., 1967. Interpretation of strength and consolidation data from some bottom cores off Tel-Aviv-Palmakhim coast, Israel; in Marine Geotechnique, A. Richards (Ed.), U. Ill. Press: 131-153.

Almagor, G., 1964. Studies of sediments in core samples collected from the shelf and slope off Tel-Aviv Palmakhim coast; Rept. No. QGR/2/64. Geol. Surv. Israel, 80p.

Anastopoulos, L., 1963. Geological Study of Antiparos Island Group (In Greek with English summary) Institute for Geological and Subsurface Research, 8, No. 5.

Anwar, Y.M. and M. A.M. Mohamed, 1970. The distribution of calcium carbonate in continental shelf sediments of Mediterranean Sea north of the Nile Delta in the United Arab Republic; Bull. Inst. Ocean and Fisheries, 1: 451-460.

Arrhenius, G.A.S. and Korkish, J., 1959. Uranium and thorium in marine minerals. Intern. Oceanog. Congr. 1st. Am. Assoc. Advan. Sci., preprinit, 497 pp.

D'Arrigo, A., 1936. Recherce sur regime dei litorali del Mediterraneo; Recherche sulle variazioni delle Spiagge Italiane, Consiglio Nazionalle delle Recherche.

Aubouin, J., 1965. Geosynclines; Elsevier, Amsterdam.

Bass, G.F., 1961. The Cape Gelidonya wreck: preliminary report; Am. Jour. Arch., 65: 267-276.

Belderson, R.H., Kenyon, N.H., and Stride, A.H., 1972. Comparison between narrow-beam and conventional echo-surroundings from the Mediterranean Ridge; Mar. Geol., 12: M11-M15.

Berger, W.H., 1971. Pleistocene deep-sea stratigraphy: statistical study of correlation by faunal variation; Jour. Foram. Res., 1: 178-186.

Bernard, F., 1959. Donnees sur l'abondance de sable corrode dans les eaux de la Mediterranee orientale; Rev. Geog. Phys. Géol. Dyn. II (2): 113-119.

Blanc, J.J., 1969. Sedimentary geology of the Mediterranean Sea. Oceanogr. Mar. Biol. 6, 377-453.

Blanc, J.J., 1964. Recherches géologiques et sedimentologiques, campagne de la Calypso en Mediterranee nord-orientale (1960); Ann. Inst. Ocean Monaco, 41: 219-270.

Blanc, J.J., 1958. Recherches géologiques et sedimentologiques campagne de la Calypso (Septembre-Octrobre, 1955); Ann. Inst. Ocean. Monaco, 34: 157-211.

Blanc, J.J. and Froget, C., 1967. Recherches de geologie marine et sedimentologie, campagne de la Calypso en Mediterranee orientale (Quatrieme mission, 1964); Ann. Inst. Ocean. Monaco, 45: 257-292.

Boekschoten, G.V., 1963. Some geological observations on the coast of Crete; Geol. Mijnb., 42: 241-247.

Boggild, O.B., 1912. The deposits of the sea-bottom; Report Danish Oceanographical Expeditions, 1908-1910. Mediterranean and Adjacent Seas; 1: 257-270.

Bostrom, K., et al., 1974. Plankton: Its chemical composition and its significance as a source of pelagic sediments. Chem. Geol., 14, pp. 255-271.

Boulos, J., 1962. Carte de Reconnaissance des Cotes du Liban 1:150,000. Bassile Freres, Beyrouth, 2 sheets, 2nd edition.

Bradley, W.H., 1938. Mediterranean sediments and Pleistocene sea-levels; Sci., 88: 376-379.

Brinkmann, R., 1969. Geologic Evolution of Europe. (Translated from the German by J.E. Sanders). Verlag, Stuttgart.

Butuzova, G., 1966. The composition and genesis of the deposits of iron minerals near the fumeroles of the Santorini Volcano. Dokl. Acad. Sci. U.S.S.R. 168, No. 6, pp. 215-17.

Caputo, M., Panza, G.F. & Postpishl, D., 1970: Deep Structure of the Mediterranean Basin. J. Geophys. Res., 75, No. 26.

Carlisle, D.H., 1962. A continuous seismic profiling survey off the coast of Lebanon; unpublished MScThesis, Mass. Inst. Tech.

Carter, T.G. et. al., 1972. A New Bathymetric Chart and Physiography of the Mediterranean Sea. In the Mediterranean Sea, A Natural Sedimentation Laboratory. D.H. & R. Inc: Stroudsburg, Pennsylvania, pp. 1-23.

Chamley, H., 1972. Sur la sedimentation argileuse profonde en Mediterranee; in Stanley, D.J. (Ed.), The Mediterranean Sea: 387-399.

Chamley, H., 1969a. Quelques modalites de la sedimentation argileuse marine aux environs de L'Ile de Crete; Bull. Anth. Prehist. Monaco, No. 14m 25-48.

Chamley, H., 1969b. Interêt de l'étude chiffrée des mineraux argileaux par diffraction des rayons X, pour la connaissance des paleoclimats exemple des sediments de Mediterranee nord-occidentale; er collogue d'analyse par rayonnements X, Monpellier, 6-9 mai, 1969. Recherche et Industrie, 99-106.

Chamley, H., 1968a. La sedimentation argileuse actuelle en Mediterranee nord-occidentale. Donnees preliminaires sur la diagenese superficiell. Bulletin de la Societe Geologique de France, 7: 75-88.

Chamley, H., 1963. Contribution a l'etude minderalogique et sedimentologique de vases Mediterraneennes; Rec. Trav. Sta. Mar. End., Bull. 29: 91-195.

Charlesworth, J.K., 1957. The Quaternary Era. Edward Arnold (Publ.), London.

Chester, R., 1965d. Elemental geochemistry of marine sediments. In. J.P. Riley and G. Skirrow (Editors), Treatise on Chemical Oceanography, Acad. Press, New York, N.Y., 2: 23-80.

Chester, R. and Huges, M.J., 1967. A chemical technique for the separation of ferromanganese minerals, carbonate minerals, and adsorbed trace elements from pelagic sediments. Chem. Geol., 3: 199-212.

Comninakis, P.E., Papazachos, B.C., 1972. Seismicity of the Eastern Mediterranean and some features of the Mediterranean Ridge. Geol. Soc. Bull., 83, No. 4, 1093-1102.

Cronan, D.S., 1976. Basal metalliferous sediments from the eastern Pacific. Bull. Geol. Soc. Am., 87, pp. 928-930.

Cronan, D.S., and Garrett, D.E. (1973). Distribution of Elements in Metalliferous Pacific sediments collected during the Deep Sea Drilling Project. Nature (Phys. Sci.), 242, pp. 88-89.

Delauze, H., 1966. Resultats d'analysis; Prelevements de la mer Ionienne, de la mer Mediterranee et de la fosse des Kouriles; ubpublished report, Laboratoire du Bathyscape, Centre National de la Recherche Scientifique, Marseille, Feb. 26, 1966, 6 p.

Dewey, J.F., W.C. Pitman III, W.B.F. Ryan and J. Bonnin, 1973. Plate tectonics and the evolution of the Alpine system; Bull. Geol. Soc. Am., 84: 3137-3180.

DeWindt, J. and Berwerth, F., 1904. Ütersuchung von Grund proben der I., II. und IV. Reise von S.M. POLA in den Jahren 1890, 1892 und 1893; Ber Comm Erforschung ostl. Mittelmeeres Denkschr. Akad. Wiss. Wien, Math.-nat. Klasse, 74: 285-294.

Diester-Haass, L., 1973. No current reversal at 10,000 B.P. in the Strait of Gibraltar. Mar. Geol., 15: M1-M9.

Diester-Haass, L., 1974. No current reversal at 10,000 B.P. in the Strait of Gibraltar - a reply. Mar. Geol., 17: M4-M7.

Doeglas, D.J., 1950. Old beaches in the Mediterranean; 18th Intl. Geol. Congr., Lond., Part 8:16-20.

Duplaix, S., 1958. Etude mineralogique des Niveaux sableux des carottes prelevees sur le fond de la mediteranee; Repts. Swedish Deep-Sea Exped., 1947-1948, 8 (2) : 139-166.

Dymond, J., et al., 1976. Chemical composition and metal accumulation rates of metalliferous sediments from sites 319, 320 and 321. Initial reports of D.S.D.P. vol. 34 Washington U.S. Government Printing Office.

Einsele, G., 1967. Sedimentary processes and physical properties of cores from the Red Sea, Gulf of Aden, and off the Nile Delta: in, Richards, A. (Ed.), Marine Geotechnique, U. Ill. Press: 154-169.

Einsele, G. and Werner, F., 1968. Zusammensetzung, Gefunge und mechanishe Eigenschaften rezenter Sediments vom Nildelta, Roten Meer und Golf von Aden; METEOR Forschung., Reihe C, 1: 21-42.

El Hinnawi, 1964. Mineralogical and geochemical studies on Egyptian (U.A.R.) black sands; Beit. Min. Pet., 9: 519-532.

El Wakeel, S.K., 1964. Recent bottom sediments from the neighbourhood of Alexandria, Egypt; Mar. Geol. 2: 137-146.

Emelyanov, E.M., 1972. Principal types of recent bottom sediments in the Mediterranean Sea: their mineralogy and geochemistry; in, Stanley, D.J. (Ed.), The Mediterranean Sea: 355-386.

Emelyanov, E.M., 1965. Granulometric content of recent sediments and some features of their origin in the Mediterranean Sea; in, Fomin, L. (Ed.), Basic Features of the Geological Structure, Hydrologic Regime, and Biology of the Mediterranean Sea, Academy of Science, Moscow: 42-68.

Emelyanov, E.M. and Shimkus, K.M., 1972. Suspended matter in the Mediterranean Sea. In the Mediterranean Sea, A Natural Sedimentation Laboratory, pp. 417. D.H. & Ross, Pennsylvania.

Emery, K.O. and Bentor, Y.K., 1960. The continental shelf of Israel; Israel Geological Survey, Bull. 26: 25-41.

Emery, K.O. Heezen, B.C., Allan T.D., 1966. Bathymetry of the Eastern Mediterranean Sea. Deep Sea Res: 13, No. 2, 173-92.

Emery, K.O. and George, C.J., 1963. The shores of Lebanon; Am. Univ. Beirut, Misc. Paper Natl. Sci., No. 1, 10p.

Emery, K.O. and Neev, 1960. The Mediterranean beaches of Israel; Israel Sea Fisheries Res. Sta. Bull. 28: 1-22.

Emery, K.O., Heezen, B., and Allan, T.D., 1966. Bathymetry of the eastern Mediterranean Sea; Deep-Sea Res., 13: 173-192.

Emiliani, C., 1955. Pleistocene temperature variations in the Mediterranean; Quat. 2: 87-94.

Erickson, A.J., 1970. The measurement and interpretation of heat flow in the Mediterranean and Black Sea; Report 70-5, Mass. Inst. Tech., Dept. Earth and Planetary Sci., 272 p.

Fabricius, F. and Muller, S.T., 1970. A buret cylinder for grain-size analysis of silt and clay (with Algol-program), sedimentology, 14 (1970) 39-50.

Fairbridge, R.W., 1972. Quaternary sedimentation in the Mediterranean region controlled by tectonics, paleoclimates and sea level; in Stanley, D.J. (Ed.). The Mediterranean Sea: 99-113.

Fevret, M. and Sananville, P., 1965. Contribution a l'etude du littoral libanois. Mediterranee, 6: 113.

Fiske, R.S., 1969. Recognition and significance of Pumice in marine pyroclastic rocks. Geol. Soc. Am. Bull. v. 80, p. 1-8, fig. 7 pls, Jan. 1979.

Folk, R.L., 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature: Jour. Geology, v. 62, p. 344-359.

Folk, R.L., 1965. Petrology of Sedimentary Rocks Univ. Texas, Austin, Texas, 159 pp.

Fouque, F., 1979. Santorin et ses Eruptions; Paris, Masson et Cie.

Fomin, L., (Ed.), 1965. The Main Features of the Geological Structure, the Hydrological Regime and the Biology of the Mediterranean Sea; Nauka, Moscow.

Frangato, D., 1951. Paros Manganese Deposits. Geological Reconnaisance Report, 13. Subsurface Research Department, Ministry of Co-ordination, Athens.

Friedman, G.M., 1972. Significance of Red Sea in problem of evaporites and basinal limestones; Bull. Am. Assoc. Pet. Geol., 56: 1072-1086.

Gavish, E., and Friedman, G.M., 1969. Progressive diagenesis in Quaternary to Late Tertiary carbonate sediments: sequence and time scale. Journal of Sedimentary Petrology, 39: 980-1,006.

Georgalas, G.C., 1962. Creece. Catalogue of the Active Volcanoes of the World including solfatara fields. 12, 40 Napoli.

Gierman, G., 1966. Gedankenzur Ostmediterranean Schwelle; Bull. Inst. Ocean. Monaco, 66 (1362A), 16 p.

Goedicke, T.R., 1972. Submarine canyons on the central continental shelf of Lebanon; in Stanley, D.J. (Ed.). The Mediterranean Sea: 655-670.

Goldberg, E.D. and Arrhenius, G., 1958. Chemistry of Pacific pelagic sediments. Geochim. Cosmochim. Acta, 13: 153-212.

Goncharov, V.P. and Mikhaylov, O.V., 1966. Depth corrections for changes in the velocity of sound in water for echo sounding in the Black Sea and Mediterranean: Oceanology, 6: 577-581.

Goncharov, V.P. and Mickhailov, 1964. New data on the bottom relief of the Mediterranean Deep Sea Res., 11: 625-628.

_____, 1963. 2nd-Intl. Oc. Con. Moscow 137.

Goudie, A., 1969. A note on Mediterranean beachrock: its history. Atoll Research Bulletin, 126 : 11-14.

Georgalas, G.C. & Papastamatious, J., 1951. Uber den Ausbruch des Santorinvulcanes von 1939-1941. Der Ktenas-Ausbruch. Bull. volcan. (2), 11, 3-40.

Greenslate, J.L. et al., 1973. Origin and deposition of selected transition elements on the seabed. In: The origin and distribution of Manganese nodules in the Pacific and prospects for Exploration, pp. 45-70, Morgenstein M. (Ed.), Hawaii Inst. Geophys. Honolulu.

Gregory, J.W., 1931. A submarine trough off the coast of Cyprus; Geog. Jour., 78: 357-361.

Harrison, J.C., 1955. An interpretation of gravity anomalies in the Eastern Mediterranean; Phil. Trans. Roy. Soc. London, Ser. A. 248: 283-325.

Heezen, B.C., Ewing, M. and Johnson, G.L., 1966. The Gulf of Corinth floor; Deep-Sea Res., 13: 381-411.

Heinhold, J., and Gaede, K.W., 1964. Mathematische Statistik fur Ingenieure. Oldenbroug, Munchen, 321 pp.

Herman, Y., 1972. Quaternary eastern Mediterranean sediments: micropaleontology and climatic record; in Stanley, D.J. (Ed.). The Mediterranean Sea: 129-148.

Herman, Y., 1971a. Vertical and horizontal distribution of pteropods in Quaternary sequences; in Funnell, B.M. and Riedel, W.R., (Eds.). The Micropalaeontology of Oceans, Univ. Press, Cambridge: 463-492.

Herman Y., 1971b. Quaternary climatic changes in the eastern Mediterranean as recorded by pteropods and planktonic foraminifers; in Farinacci, A., Ed., Proc. 2nd Planktonic Conf., Rome, 1970: 611-647.

Herman Y., 1966. Climatic changes in Quaternary cores from the Mediterranean and Red Sea basins recorded by 1) pteropods, 2) planktonic foraminifera. Second international oceanographic Congress, (abstract): 156-157.

Hermal, Y., et. al., 1969. Micropaleontology, paleotemperatures, and radiocarbon dates of Quaternary Mediterranean deep-sea croes. 8th INQUA Congress proceedings, (abstract): 174.

Hersey, J.B., 1965. Sedimentary basins of the Mediterranean Sea; Proc. 17th Symp. Colston Res. Soc., Univ. of Bristol: 75-91.

Heye, D., 1970. Mangetische untersuchungen an sedimentkernen des Mittelmeeres; Meteor Furschung., Ser. C, 3: 85-88.

Hicke, W.W. Sigl, and Fabricius, F., 1973. Morphological and structural aspects of the Mediterranean Ridge. SW of the Peloponnesus (Ionian Sea): Bull. Geol. Soc. Greece. 10,: 109-126.

Hilmy, M.E., 1951. Beach sands of the Mediterranean coast of Egypt, Jour. Sed. Pet., 21: 109-120.

Hirst, D.M., and Nicholls, G.D., 1958. Techniques in sedimentary geochemistry 1. Separation of the detrital and non-detrital fractions of limestones. J. Sedim. Petrol., 28, pp. 461-468.

Holmes, A., 1965. Principals of physical geology. Ronald Press, M.Y., 1288 pp.

Holeman, J., 1968. The sediment yield of major rivers of the world; Water Resources Res., 4: 737-747.

Horowitz, A., 1974a. Geochemical investigations of sediments associated with the Mid-Atlantic Ridge. Ph.D. thesis, Univ. of London.

Huang, T.C. and Stanley, D.J., 1974. Current reversal at 10,000 B.P. at the Strait of Gibraltar - a discussion. Mar. Geol., 17: M1-M4.

Huang, T.C., Stanley, D.J., and Stuckenrath, R., 1972. Sedimentological evidence for current reversal at the Strait of Gibraltor; Jour. Mar. Tech. Soc., 6: 25-33.

Jerlov, N.G., 1953. Particle distribution in the ocean; Reports Swedish Deep-Sea Expedition 1947-1948, 3 (2): 73-97.

Karnik, V., 1972: A note on the Morphology and Activity of Seismic Zones in the Aegean Sea. Nature Phys. Sci., 239, No. 92.

Keller, J., 1971. The major volcanic events in recent eastern Mediterranean volcanism and their bearing on the problem of Santorini ash layers; Acta Int. Sci. Cong. Volcano Thera, Athens: 152-169.

Keller, J. and Ninkovitch, 1972. Tephra-lagen in der Agais, Zeit. Deutsch. Geol. Ges., 123: 579-587.

Kholief, M.M., El. Hilmy and Shahat, A., 1969. Geological and mineralogical studies of some sand deposits in the Nile Delta, U.A.R., Jour. Sed. Pet., 39: 1520-1529.

Klemme, H.D., 1958. Regional geology of circum-Mediterranean region. Bull. Amer. Assoc. Petrol. Geol., 42, 477-512.

Koczy, F.F., 1956. Echo soundings; Rept. Swedish Deep Sea Exped. 1947-48, 4 (2): 98-158.

Koreneva, E.V., 1971. Spores and pollen in Mediterranean bottom sediments, in, Funnell, B.M. and Riedel, W.R. (Eds.). The Micropalaeontology of Oceans, Univ. Press, Cambridge, 361-371.

Kredezemnoye More, 1966, Karta, 1:4,000,000: Glavnoe Ypravienye Geoleziie Kartografii Miniserstva Geologii, C.C.C.P., Moskva.

Ktenas C.A., 1925. Les phenomenes explosifs de l'eruption du volcan de Santorin. C.r. hebd. Seanc. Acad. Sci., Paris, 181, 563-565.

Ktenas, C.A., 1922. Les plissements de l'age primaire dans la region centrale de la mer Egeé. C.R. Xlle. Congr. Geol. Intern., Liege, 571-83.

Kullenberg, B., 1952. On the salinity of the water contained in marine sediments; Goteb. Akad. Vet. Vitt-Somhalles, Handl. Sjatte Fol., Ser. B., 6: 3-37.

Kummel, B., 1961. History of the Earth, Freeman, W.H., San Francisco, 396pp. Le Pichon X, 1968. Sea floor Spreading and Continental Drift. J. Geophys. Res. 73, 3661.

Le Pichon X., 1968. Sea floor spreading and continental drift; Jour. Geophys. Res., 73: 3661-3697.

Lort, J.M., 1971. The tectonics of the eastern Mediterranean: A geophysical review; Rev. Geophys. and Space Phys., 9: 189-216.

Ludwing, W.J.B., et al. 1965. Sub-bottom reflection measurements in the Tyrrhenian and Ionian seas. Journal of Geophysical Research, 70 (18): 4719-4723.

Lynn, D.C. and Bohatti, E., 1965. Mobility of manganese in Diagenesis of deep-sea sediments; Marine geology, 3 pp. 457-474.

Maley, T.S. and Johnson, 1971. Morphology and structure of the Aegean Sea; Deep Sea Res., 18: 109-122.

Marakis, G., 1968. Data on the Age of the Sulphide Mineralisation in the Cyclades Area. Ann. Geol. Pays Hellen, 19.

Marinos, G., 1948. Ores of Lead and Zinc in Greece. Intern. Geol. Congr. 18 Session, London, 7, 308-313.

Petrascheck, W.E., 1956. Laurium. Institute for Geology and subsurface Research, 4. Athens.

McCoy, F.W., 1974. Late Quaternary sedimentation in the eastern Mediterranean Sea; Ph.D. thesis, Harvard University, Cambridge, Massachusetts, U.S.A.

McGill, D.A., 1961. A preliminary study of the oxygen and phosphate distribution in the Mediterranean Sea. Deep-Sea Res., 8: 259-269.

McKenzie, D.P., 1972. Active tectonics of the Mediterranean region; Geophys. Jour. Roy. Astr. Soc., 30: 109-185.

McKenzie, D.P., 1970. Plate tectonics of the Mediterranean region; Nature, 226: 239-243.

Mekritz, 1963. Distribution of Aegean Sea.

Melguen, M. and Needham, H.D., 1973. Microfacies in sediments of the North Aegean Sea Trough (abs.); 1st Ann. Mtg., European Geophys. Soc. 67.

Mellis, O., 1954. Volcanic ash-horizons in deep-sea sediments from the Eastern Mediterranean: Deep-Sea Res., 2: 89-92.

Menzies, R.J., Imbrie, J. and Heezen, B.C., 1961. Further considerations regarding the antiquity of the abyssal fauna with evidence for a changing abyssal environment; Deep Sea Res., 8: 79-94.

Mikhailov, O.V., 1965. The relief of the Mediterranean Sea bottom; in Fomin, L.M. (Ed.). Basic Features of the Geological Structure, Hydrological Regime and Biology of the Mediterranean Sea; Nauka, Moscow: 10-19.

Milliman, J.D. and Muller, J.W., 1973. Precipitation and lithification of magnesian calcite in the deep-sea sediments of the eastern Mediterranean Sea; Sediment., 20: 29-45.

Mistardis, G., 1963. On the beachrock of southern Greece. Deltion, Ellenikes Geologikes Etairas, Athens.

Mistardis, G., 1964. Shoreline displacements and sea level changes during the Middle - Upper Quaternary. 20th International Geographical Congress, Abstract of Papers Supplement, 21-22.

Moskalenko, V.M., 1966. New data on the structure of the sedimentary strata and basement in the Levant Sea; Oceanology, 6: 828-836.

Moskalenko, V.W., 1963. New data on the structure of the sedimentary layer in the Mediterranean; Doklady Akademii Nauk:SSSR 152: 1457-1460.

Moskalenko, L.V. and Ovchinnikov, I.M., 1967. Water masses of the Mediterranean Sea; in Fomin, L.M. (Ed.), Basic Features of the Geological Structure, Hydrological Regime and Biology of the Mediterranean Sea, Nauka, Moscow: 119-130.

Munsell, 1954. Soil color charts. Munsell Colour Company, Inc., Baltimore, Maryland, 21218, U.S.A.

Murchison, R.R., 1972. Levantine Sea in chart and physiography of the Mediterranean Sea, in the Mediterranean Sea a nature of sedimentation laboratory. p. 19-21.

Nakhla, F.M., 1958. Mineralogy of the Egyptian black sands and its applications; Egypt. Jour. Geol., 2: 1-21.

National Institute of Oceanography 1972. R.R.S. Discovery Cruise 40, June-July, 1971. Geological exploration of the Mediterranean ridge;Cruise Rept. No. 48, 9p.

Nekritz, R., 1963. Bottom sediment distribution in the Mediterranean Sea; inpublished manuscript, U.S. Naval Oceanographic Office (informal report no. 0-55-63), 10 p.

Nesteroff, W.D., et al., 1972. Evolution de la Sedimentation Pendant le Neogene en Mediterranee d'après les Forages, JOIDES - DSDP. In Stanly's Book, "The Mediterranean Sea, A Natural Sedimentation Laboratory" pp. 47.

Nicholls, I.A., 1971. Petrology of Santorini Volcano, Cyclades, Greece; Jour. Pet., 12: 67-120.

Nielsen, J.N., 1912. Hydrography of the Mediterranean and adjacent waters; Repts. Danish Oceanogr. Exped. 1908-1910, 1: 77-191.

Ninkovich, D., and Hays, J.D., 1972. Mediterranean island area and origin of high potash volcanoes; Earth Plant. Sci. Lett., 16: 331-345.

Ninkovich , D. and Hays, J.D., 1971. Tectonic setting of Mediterranean volcanoes; Acta Int. Sci. Cong. Volcano Thera, Athens: 111-135.

Ninkovich, D. and Heezen, B.C., 1967. Physical and chemical properties of volcanic glass shards from Pozzuolana ash, Thera Island, and from upper and lower ash layers in eastern Mediterranean deep sea sediments; Nature, ___: 582-584.

Ninkovich, D. and Heezen, B.C., 1965. Santorini Tephra; Proc. 17th Symp. Colston Res. Soc., Univ. of Bristol: 413-453.

Oekonomidis, G.T., 1932. Die Vulkane der Inseln von Santorini. I. Teil : Tektonik-Vulkanismus. Neues Jb. Miner. Geol. Palaont, 68, 295-304.

Olausson, E., 1971. Tephrochronology and the late Pleistocene of the Aegean Sea; in Strid, A. (Ed.), Evolution in the Aegean, Opera Bot., 30: 29-39.

Olausson, E., 1965. Evidence of climatic changes in North Atlantic deep-sea cores, with remarks on isotopic paleotemperature analysis; in Sears, M. (Ed.), Prog. in Ocean., 3: 221-252.

Olausson, E., 1961. Studies of deep-sea cores. Reports Swedish Deep-Sea Expedition, 1947-48, 8 (6): 337-391.

Olausson, E., 1960. Description of sediment cores from the Mediterranean and the Red Sea; Reports Swedish Deep-Sea Expedition 1947-48, 8 (5): 287-334.

Olson, E.A. and Broecker, W.S., 1961. Lamont natural radiocarbon measurements, VII; Am. Jour. Sci., Radio carbon Supp., 3: 141-175.

Olsson, I.V., 1959. Uppsala natural radiocarbon measurements, I., Am. Jour. Sci., Radiocarbon Supp., 1: 87-102.

Opdyke, N.D., Ninkovich, D., Lowrie, W., and Hays, J.D., 1971. The paleomagnetism of two Aegean deep-sea cores; Earth Planet. Sci., Lett., 14: 145-159.

Ovchinnikov, I.M. and Plakhin, E.A., 1965. The historical observations of the hydrological researches in the Mediterranean Sea (in Russian). In: L. Fomin (Editor), Osnovnye cherty geologicheskogo stroania gidrologicheskogo rezhimai biologii Stredizemnogomaria. Akad. Nauk S.S.S.R., Okeanogr. Kom., Moscow, pp. 84-107.

Papastamatiou, I., 1951. The Emery of Naxos (in Greek). Subsurface Research Dept., Ministry of Coordination, Athens.

Parker, F.L., 1958. Eastern Mediterranean foraminifera; Rept. Swedish Deep-Sea Exped., 1947-48, 8: 217-283.

Parker, F.L., 1955. Distribution of planktonic Foraminifera in some Mediterranean sediments; Papers on Marine Biology and Oceanography, Deep-Sea Res., Supp. to 3: 204-211.

Pastouret, L., 1970a. Etude sedimentologique et paleoclimatique de carottes prelevees en Mediterranee orientale; Tethys, 2: 227-266.

Pastouret, L., 1970b. Distribution des foraminiferes benthiques dans une carotte de Mediterranee orientale; Bull. Musee Anth. Prehist. Monaco, No. 16: 155-171.

Pfannenstiel, M., 1960. Erlauterungen zu den bathymetrischen karten des ostlichen Mittelmeeres; Bull. Inst. Ocean. Monaco, No. 1192 5.

Pfannenstiel, M., 1952. Zur Quartargeschichte des Nildeltas; Geol. Rund., 40: 108-109.

Pichler, H., and Kussmaul, S., 1972: Calc Alkaline Rocks of Santorini Group (Aegean Sea). Neus. Jahrb. Mineral, 116, No. 3, 268-307.

Pollack, M.J., 1951. The sources of the deep water of the eastern Mediterranean Sea; Jour. Marine Res., 10, 128-152.

Puchelt, H., 1971. Recent iron sediments formation at the Kameni Islands, Santorini, Greece. In "Ores and Sediments", Amstutz, G.C., and Bernard, A.J. (Eds.) Springer-Verlag, Heidelberg (227-245).

Rabinowitz, P.D., and Ryan, W.B.F., 1970. Gravity anomalies and crustal shortening in the eastern Mediterranean; Tectonophysics, 10: 585-608.

Kanteev, M.A., Emelyanov, E.M., and Khelrov, M.B., 1966. Conditions for the formation of clay minerals in contemporaneous sediments of the Mediterranean Sea; Lithology and Min. Res., No. 4: 418-431.

Reck, H., 1936. Santorin. Der Werdegang eines Inselvulkans und sein Ausbruch, 1925-28; Berlin.

Reiss, Z., Merling-Reiss, P., and Moshkovitz, S., 1971. Quaternary planktonic foraminiferida and nannoplankton from the Mediterranean continental shelf and slope of Israel; Israel Jour. Earth Sci., 20: 141-177.

Rentz, C., et al., 1954. Geological Map of Greece, 1: 500,000, Athens.

Rossignol, M. and Pastouret, L., 1971. Analyse pollinique de niveaux sapropeliques post-glaciaires dans une carotte en Mediterranee orientale; Rev. Palaeobot. Palynol., 11: 227-238.

Rubin, M., and Suess, H.E., 1955. U.S. Geol. Survey radiocarbon dates, II.; Sci., 121: 481-488.

Rusnak, G.A., & Luft, S.J., 1963. A suggested outline for the megascopic description of marine sedimentary cores. Submitted to the Office of Naval Res. Contact Monr. 4008 (02) 1, Rickenbocker Causeway, Miami 49, Florida, U.S.A.

Ryan, W.B.F., 1972. Stratigraphy of Late Quaternary sediments in the eastern Mediterranean; in Stanley, D.J. (Ed.), The Mediterranean Sea. A Natural Sedimentation Laboratory, pp. 149. D.H. & Ross, Stroudsburg, Pennsylvania.

Ryan, W.B.F., 1970. The floor of the Mediterranean Sea. Ph.D. thesis Columbia University, N.Y., U.S.A.

Ryan, W.B.F., 1970. "The Stratigraphy of the Eastern Mediterranean, Part II", Ph.D. thesis, Columbia University, New York.

Ryan, W.B.F. et al., 1969. The tectonics and geology of the eastern Mediterranean in the sea. Vol. IV. Ch. 12 pp. 387-493. Ed. Maxwell, Wiley, interscience, New York.

Ryan, W.B.F., and Heezen, B.C., 1965- Ionian Sea submarine canyons and the 1908 Messina Turbidity Current. Bull. Geol. Soc. Amer., 76, 915-932.

Ryan, W.B.F., Hsu, K.J., et al., 1973. Initial reports of the Deep Sea Drilling project, Vol. 13: Washington (U.S. Government Printing Office).

Schattner, J., 1967. Geomorphology of the north coast of Israel. Geografiska Annalar (A) 49: 310-320.

Schmalz, R.E., 1969. Deep-water evaporite deposition: a genetic model; Bull. Am. Assoc. Pet. Geol., 53: 798-823.

Shepard, F.P., and Dill, R.F., 1966. Submarine Canyons and Other Sea Valleys; Rand, McNally, Chicago, 381p.

Shukri, N.M. and Philip, G., 1961. The mineralogy of some recent deposits in the Arish-Ghaza area; Bull. Fac. Sci., Cairo, No. 35: 73-86.

Shukri, N.M. and Philip, G., 1956a. The geology of the Mediterranean coast between Rosetta and Bardia. Part I: Recent sediments: Mechanical analysis and mineral composition; Bull. Inst. Egypte, 37: 377-386.

Shukri, N.M. and Philip, G., 1956b. The geology of the Mediterranean coast between Rosetta and Bardia. Part III: Pleistocene sediments: Mineral analysis; Bull. Inst. Egypte, 37: 445-455.

Sigl, W., Hinz, K. and Garde, S., 1973. "Hummocky and rolling landscape" in the Ionian Sea a contribution to the "cobblestone" problem; METEOR Forschung., Ser. C, 14: 51-54.

Smith, A.G., 1971. Alpine deformation and the oceanic areas of the Tethys, Mediterranean and Atlantic; Bull. Geol. Soc. Am., 82: 2039-2070.

Smith, P.A. and Cronan, D.S., 1975. Chemical composition of Aegean Sea sediments. Mar. Geol., 18: M7-M11.

Sonnenfeld, P., 1974. No current reversal at 10,000 B.P. in the Strait of Gibraltar. A Discussion in Marine Geology, 17 (1974): 339-340. Elsevier Scientific Publishing Company, Amsterdam.

Stanley, D.J., (Ed.), 1972. The Mediterranean Sea: A Natural Sedimentation Laboratory; Dowden, Hutchinson and Ross, Stroudsburg, 765 p.

Sugisaki, R., 1972. Tectonic aspects of Andesite Line. Nature Phys. Sci., 240.

Stride, A.H., et al., 1977. Evolving miogeanticlines of the East Mediterranean (Hellenic, Calabrian and Cyprus Outer Ridges) B plates with an appendix by M.L. Somers. Phi. Trans. of R. Soc. Lond. vol. 284 (A) pp. 255-286.

Todd, R., 1958. Foraminifera from Western Mediterranean deep-sea cores. Rep. Swedish Deep-Sea Exped., 1947-1948, 8: 169-215.

Trask, P.D., 1932. Origin and Environment of Source Sediments of Petroleum. Houston, Texas, 323 pp.

Valette, J.N., 1972. Etude mineralogique et geochimique des sediments de mer d'Alboran: resultats preliminaires. C.R. Acad. Sci. France, 275: 2287-2290.

Taillefer, F., 1964. Le gres de plage de Viransehir Revue Geographique de l'est 4: 393-398.

Venkatarathnam, K. and Ryan, W.B.F., 1971. Dispersal patterns of clay minerals in the sediments of the eastern Mediterranean Sea; Mar. Geol., 11: 261-282.

Venkatarathnam, K., Biscaye, P.E., and Ryan, W.B.F., 1972. Origin and dispersal of Holocene sediments in the eastern Mediterranean Sea; in Stanley, D.J. (Ed.). The Mediterranean Sea: 455-470.

Vergnaud-Grazzini, C., and Bartolini, C., 1970. Evolution paleoclimatique des sediments wurmiens et post-wurmiens en mer d'Alboran. Rev. Geogr. Phys. Geol. Dynam., Ser. 2, 12 (4): 325-334.

Vogt, P.R. and Higgs, R.H., 1969. An aeromagnetic survey of the eastern Mediterranean Sea and its interpretation; Earth Planet, Sci. Lett., 5: 439-448.

Washington, H.S., 1926. Santorini eruption of 1925. Bull. geol. Soc. Am. 37, 349-384.

Watson, J.A., and G.L. Johnson, 1969. The marine geophysical survey in the Mediterranean; Intl. Hydrographic Rev., 46: 81-107.

Whitney, J.C., 1972. Physiography of the eastern Mediterranean Sea, the Aegean and Related Seas. In the Mediterranean Sea a natural sedimentation laboratory, Stanley, D.J., Ed. pp. 16-19. D.H. and Ross Stroudsburg, Pennsylvania.

Williams, H., 1941. Calderas and their origin. Univ. Calif. Publs. geol. Sci. 25, 239-346.

Williams, H., 1942. The Geology of Crater Lake National Park, Oregon. Publs. Carnegie Instn., 540, 162 pp.

Windt, J., and Berwerth, F., 1904. Untersuchungen von grund-proben des Ostlichen Mittelmeeres; Denkschriften Kaiserlichen Akad. der Wissenschaften, 74: 285-294.

Wong, H.K. and Zarudzki, E.F.K., 1969. Thickness of unconsolidated sediments in the eastern Mediterranean Sea; Bull. Geol. Soc. Am., 80: 2611-2614.

Wong, H.K., Zarudzki, E.F.K., Phillips, J.D. and Giermann, G.K.F., 1971. Some geophysical profiles in the Eastern Mediterranean; Bull. Geol. Soc. Am., 82, 91-100.

Woodside, J. and Bowen, C., 1970. Gravity anomalies and inferred crustal structure in the Eastern Mediterranean Sea; Bull. Geol. Soc. Am., 81: 1107-1122.

Wust, G., 1961b. On the vertical circulation of the Mediterranean Sea; Jour. Geophys. Res., 66: 3261-3272.

Yemelyanov, Y.M., 1961. New data on Mediterranean sea deposits; Doklady, 137: 1437-1440.

Zachos, K., Maratos, G., 1965. Carte Metallogenique de la Grece 1: 1,000,000. Institute for Geological and Subsurface Research, Athens.

Zaghloul, Z.M., and Kamel, K.E., 1965. The mineralogical and petrographical features of monazite from the black sands of Rosetta; Jour. Geol. U.A.R., 9: 17-31.

Zarudzki, E.F.K. et al., 1969. Structure of the eastern Mediterranean (abstract). Transactions of the American Geophysical Union, 50: 208.

Appendix I The grain-size analysis and different grain-size parameters for the surface (page 359-371), and buried sediments (page 372-381) of the eastern Mediterranean and Aegean seas.

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 689-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 689-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 690-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 690-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000		
2000.000	-1.0	0.000	0.000		
1414.214	-0.5	0.000	0.000		
1000.000	.0.0	0.000	0.000	0.021	0.021
707.107	0.5	0.000	0.000	0.037	0.058
500.000	1.0	0.023	0.023	0.139	0.196
353.553	1.5	0.028	0.051	0.088	0.284
250.000	2.0	0.053	0.104	0.137	0.421
176.777	2.5	0.089	0.193	0.150	0.571
125.000	3.0	0.159	0.351	0.351	0.922
88.388	3.5	0.257	0.608	0.807	1.729
62.500	4.0	0.665	1.273	1.989	3.718
44.194	4.5	0.560	1.833	1.949	5.667
31.250	5.0	0.560	2.393	1.949	7.616
22.097	5.5	2.625	5.018	3.847	11.463
15.625	6.0	2.625	7.644	3.847	15.310
11.049	6.5	5.416	13.060	26.188	41.498
7.813	7.0	5.416	18.476	26.188	67.686
5.524	7.5	8.892	27.368	9.941	77.627
3.906	8.0	8.892	36.260	9.941	87.569
2.762	8.5	11.865	48.125	2.982	90.551
1.953	9.0	11.865	59.989	2.982	93.533
1.381	9.5	10.003	69.992	1.617	95.150
0.977	10.0	10.003	79.995	1.617	96.767
0.691	10.5	10.003	89.997	1.617	98.383
0.488	11.0	10.003	100.000	1.617	100.000

Median	8.579	6.662
Mean	8.436	6.766
Mean size (Folk)	8.517	6.832
Standard Deviation	1.637	1.380
Sorting (Trask).....	2.284	1.507
Skewness (Folk).....	-0.114	0.185
Kurtosis (Folk).....	0.903	1.776
Sand %	1.273	3.718
Silt %	34.987	83.851
Clay %	63.740	12.431

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 691-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 691-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 692-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 692-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.731	0.731
2000.000	-1.0	0.000	0.000	0.545	1.276
1414.214	-0.5	0.000	0.000	0.601	1.877
1000.000	.0.0	0.000	0.000	0.650	2.527
707.107	0.5	0.007	0.007	1.259	3.786
500.000	1.0	0.031	0.039	3.188	6.974
353.553	1.5	0.015	0.053	4.164	11.138
250.000	2.0	0.015	0.068	8.169	19.307
176.777	2.5	0.011	0.079	8.758	28.065
125.000	3.0	0.008	0.088	11.076	39.141
88.388	3.5	0.005	0.093	11.269	50.409
62.500	4.0	0.007	0.100	7.748	58.157
44.194	4.5	0.282	0.382	3.003	61.161
31.250	5.0	0.282	0.664	3.003	64.164
22.097	5.5	3.952	4.617	3.574	67.738
15.625	6.0	3.952	8.569	3.574	71.311
11.049	6.5	8.957	17.526	2.621	73.932
7.813	7.0	8.957	26.483	2.621	76.553
5.524	7.5	21.951	48.434	0.602	77.155
3.906	8.0	21.951	70.384	0.602	77.757
2.762	8.5	8.350	78.734	1.698	79.455
1.953	9.0	8.350	87.084	1.698	81.153
1.381	9.5	3.229	90.313	4.712	85.865
0.977	10.0	3.229	93.542	4.712	90.577
0.691	10.5	3.229	96.771	4.712	95.288
0.488	11.0	3.229	100.000	4.712	100.000

Median	7.536	3.482
Mean	7.630	4.623
Mean size (Folk)	7.589	4.861
Standard Deviation	1.278	3.195
Sorting (Trask).....	1.602	4.561
Skewness (Folk).....	0.108	0.490
Kurtosis (Folk).....	1.410	0.915
Sand %	0.100	56.881
Silt %	70.284	19.599
Clay %	29.616	22.243

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 693-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 693-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 694- FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 694- CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.013	0.013	0.000	0.000
707.107	0.5	0.043	0.056	0.027	0.027
500.000	1.0	0.092	0.148	0.079	0.106
353.553	1.5	0.031	0.179	0.015	0.122
250.000	2.0	0.070	0.249	0.042	0.163
176.777	2.5	0.137	0.386	0.057	0.220
125.000	3.0	0.248	0.634	0.125	0.345
88.388	3.5	0.760	1.394	1.302	1.647
62.500	4.0	1.916	3.311	3.912	5.559
44.194	4.5	1.343	4.654	2.830	8.389
31.250	5.0	1.343	5.997	2.830	11.219
22.097	5.5	3.775	9.771	4.119	15.338
15.625	6.0	3.775	13.546	4.119	19.457
11.049	6.5	10.672	24.218	11.273	30.730
7.813	7.0	10.672	34.890	11.273	42.004
5.524	7.5	19.063	53.953	6.656	48.660
3.906	8.0	19.063	73.016	6.656	55.316
2.762	8.5	6.648	79.664	5.166	60.482
1.953	9.0	6.648	86.311	5.166	65.647
1.381	9.5	3.422	89.734	8.588	74.236
0.977	10.0	3.422	93.156	8.588	82.824
0.691	10.5	3.422	96.578	8.588	91.412
0.488	11.0	3.422	100.000	8.588	100.000

Median	7.396	7.601
Mean	7.391	7.640
Mean size (Folk)	7.446	7.750
Standard Deviation	1.561	2.080
Sorting (Trask).....	1.749	3.137
Skewness (Folk).....	0.037	0.008
Kurtosis (Folk).....	1.434	0.842
Sand %	3.311	5.559
Silt %	69.705	49.757
Clay %	26.984	44.684

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 695-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 695-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 696-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 696-1 CUMULATIVE (wt. percent)
2828.427	-1.5				
2000.000	-1.0	0.000	0.000	0.101	0.101
1414.214	-0.5	0.000	0.000	0.000	0.101
1000.000	0.0	0.000	0.000	0.000	0.101
707.107	0.5	0.017	0.017	0.043	0.144
500.000	1.0	0.057	0.074	0.049	0.192
353.553	1.5	0.027	0.101	0.212	0.404
250.000	2.0	0.036	0.137	1.124	1.528
176.777	2.5	0.077	0.215	0.799	2.327
125.000	3.0	0.213	0.427	0.653	2.981
88.388	3.5	0.388	0.815	0.840	3.820
62.500	4.0	0.822	1.637	1.046	4.866
44.194	4.5	3.554	5.191	3.306	8.172
31.250	5.0	3.554	8.745	3.306	11.479
22.097	5.5	9.122	17.867	3.070	14.548
15.625	6.0	9.122	26.989	3.070	17.618
11.049	6.5	8.351	35.340	7.113	24.731
7.813	7.0	8.351	43.691	7.113	31.843
5.524	7.5	6.679	50.370	14.398	46.241
3.906	8.0	6.679	57.049	14.398	60.639
2.762	8.5	3.041	60.091	14.121	74.760
1.953	9.0	3.041	63.132	14.121	88.881
1.381	9.5	9.217	72.349	2.780	91.660
0.977	10.0	9.217	81.566	2.780	94.440
0.691	10.5	9.217	90.783	2.780	97.220
0.488	11.0	9.217	100.000	2.780	100.000

Median	7.472	7.631
Mean	7.667	7.356
Mean size (Folk)	7.667	7.398
Standard Deviation	2.083	1.808
Sorting (Trask).....	3.672	1.993
Skewness (Folk).....	0.082	-0.207
Kurtosis (Folk).....	0.683	1.253
Sand %	1.637	4.765
Silt %	55.412	55.773
Clay %	42.951	39.361

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 697-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 697-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 698-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 698-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.051	0.051	0.029	0.029
707.107	0.5	0.080	0.131	0.078	0.107
500.000	1.0	0.201	0.332	0.170	0.277
353.553	1.5	0.558	0.889	0.173	0.450
250.000	2.0	1.514	2.403	0.411	0.861
176.777	2.5	1.030	3.434	0.388	1.249
125.000	3.0	0.082	3.516	0.556	1.806
88.388	3.5	1.459	4.975	0.827	2.633
62.500	4.0	2.828	7.803	1.460	4.093
44.194	4.5	0.585	8.388	2.081	6.175
31.250	5.0	0.585	8.972	2.081	8.256
22.097	5.5	14.723	23.695	28.598	36.854
15.625	6.0	14.723	38.417	28.598	65.451
11.049	6.5	25.006	63.424	11.816	77.268
7.813	7.0	25.006	88.430	11.816	89.084
5.524	7.5	0.823	89.253	0.969	90.054
3.906	8.0	0.823	90.076	0.969	91.023
2.762	8.5	0.167	90.244	0.680	91.703
1.953	9.0	0.167	90.411	0.680	92.382
1.381	9.5	2.397	92.808	1.904	94.287
0.977	10.0	2.397	95.205	1.904	96.191
0.691	10.5	2.397	97.603	1.904	98.096
0.488	11.0	2.397	100.000	1.904	100.000

Median	6.232	5.730
Mean	6.248	6.008
Mean size (Folk)	6.127	5.883
Standard Deviation	1.657	1.473
Sorting (Trask).....	1.509	1.470
Skewness (Folk).....	-0.116	0.363
Kurtosis (Folk).....	2.228	2.017
Sand %	7.803	4.093
Silt %	82.273	86.930
Clay %	9.924	8.977

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 700-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 700-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 701-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 701-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.004	0.004	0.075	0.075
500.000	1.0	0.024	0.027	0.054	0.128
353.553	1.5	0.039	0.066	0.193	0.321
250.000	2.0	0.095	0.161	0.451	0.772
176.777	2.5	0.172	0.334	0.240	1.012
125.000	3.0	0.287	0.621	0.111	1.123
88.388	3.5	0.554	1.175	0.117	1.240
62.500	4.0	1.226	2.401	0.200	1.440
44.194	4.5	2.069	4.489	0.138	1.578
31.250	5.0	2.089	6.578	0.138	1.716
22.097	5.5	6.027	12.605	6.251	7.967
15.625	6.0	6.027	18.632	6.251	14.218
11.049	6.5	36.033	54.666	4.516	18.734
7.813	7.0	36.033	90.699	4.516	23.250
5.524	7.5	1.231	91.931	28.433	51.682
3.906	8.0	1.231	93.162	28.433	80.115
2.762	8.5	0.371	93.533	3.270	83.385
1.953	9.0	0.371	93.904	3.270	86.655
1.381	9.5	1.524	95.428	3.336	89.991
0.977	10.0	1.524	96.952	3.336	93.328
0.691	10.5	1.524	98.476	3.336	96.664
0.488	11.0	1.524	100.000	3.336	100.000

Median	6.435	7.470
Mean	6.471	7.473
Mean size (Folk)	6.375	7.421
Standard Deviation	1.195	1.427
Sorting (Trask).....	1.272	1.356
Skewness (Folk).....	0.037	0.026
Kurtosis (Folk).....	2.798	2.325
Sand %	2.401	1.440
Silt %	90.761	78.675
Clay %	6.838	19.885

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 702-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 702-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 703-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 703-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.099	0.099
1414.214	-0.5	0.000	0.000	0.015	0.114
1000.000	0.0	0.000	0.000	0.020	0.134
707.107	0.5	0.000	0.000	0.043	0.177
500.000	1.0	0.085	0.085	0.136	0.314
353.553	1.5	0.485	0.570	0.098	0.411
250.000	2.0	1.026	1.596	0.193	0.605
176.777	2.5	3.592	5.188	0.347	0.951
125.000	3.0	9.168	14.356	0.438	1.389
88.388	3.5	11.086	25.442	0.638	2.027
62.500	4.0	8.074	33.517	0.985	3.012
44.194	4.5	6.701	40.218	0.978	3.990
31.250	5.0	6.701	46.919	0.978	4.967
22.097	5.5	22.442	69.361	6.875	11.842
15.625	6.0	22.442	91.803	6.875	18.718
11.049	6.5	1.297	93.100	34.179	52.897
7.813	7.0	1.297	94.397	34.179	87.076
5.524	7.5	0.234	94.631	1.385	88.462
3.906	8.0	0.234	94.865	1.385	89.847
2.762	8.5	0.189	95.053	0.866	90.713
1.953	9.0	0.189	95.242	0.866	91.580
1.381	9.5	1.190	96.431	2.105	93.685
0.977	10.0	1.190	97.621	2.105	95.790
0.691	10.5	1.190	98.810	2.105	97.895
0.488	11.0	1.190	100.000	2.105	100.000

	SAMPLE NUMBER ZW 702-1	SAMPLE NUMBER ZW 703-1
Median	5.069	6.458
Mean	4.804	6.567
Mean size (Folk)	4.656	6.405
Standard Deviation	1.696	1.377
Sorting (Trask).....	2.103	1.289
Skewness (Folk).....	-0.166	0.129
kurtosis (Folk).....	1.124	2.695
Sand %	33.517	2.913
Silt %	61.348	86.836
Clay %	5.135	10.153

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 704-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 704-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 705-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 705-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.137	0.137
1414.214	-0.5	0.000	0.000	0.219	0.355
1000.000	0.0	0.010	0.010	0.165	0.520
707.107	0.5	0.052	0.062	0.308	0.828
500.000	1.0	0.102	0.164	0.791	1.619
353.553	1.5	0.170	0.335	2.419	4.038
250.000	2.0	0.245	0.580	7.091	11.129
176.777	2.5	0.327	0.907	6.272	17.401
125.000	3.0	0.398	1.306	5.157	22.559
88.388	3.5	0.714	2.020	3.926	26.485
62.500	4.0	1.420	3.440	2.554	29.039
44.194	4.5	0.000	3.440	1.782	30.821
31.250	5.0	0.000	3.440	1.782	32.603
22.097	5.5	15.644	19.083	4.516	37.119
15.625	6.0	15.644	34.727	4.516	41.635
11.049	6.5	28.935	63.662	24.912	66.547
7.813	7.0	28.935	92.597	24.912	91.460
5.524	7.5	0.000	92.597	2.295	93.754
3.906	8.0	0.000	92.597	2.295	96.049
2.762	8.5	0.186	92.783	0.575	96.624
1.953	9.0	0.186	92.969	0.575	97.199
1.381	9.5	1.758	94.727	0.700	97.899
0.977	10.0	1.758	96.485	0.700	98.599
0.691	10.5	1.758	98.242	0.700	99.300
0.488	11.0	1.758	100.000	0.700	100.000

	SAMPLE NUMBER ZW 704-1	SAMPLE NUMBER ZW 705-1
Median	6.264	6.168
Mean	6.319	5.281
Mean size (Folk)	6.172	5.135
Standard Deviation	1.301	2.150
Sorting (Trask).....	1.418	3.203
Skewness (Folk).....	0.137	-0.589
kurtosis (Folk).....	1.843	0.757
Sand %	3.440	28.902
Silt %	89.157	67.010
Clay %	7.403	3.951

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER 706-4 FREQUENCY (wt. percent)	SAMPLE NUMBER 706-4 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 707-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 707-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.000	0.000	0.047	0.047
500.000	1.0	0.021	0.021	0.078	0.125
353.553	1.5	0.044	0.065	0.090	0.215
250.000	2.0	0.199	0.264	0.196	0.411
176.777	2.5	0.142	0.405	0.430	0.840
125.000	3.0	0.186	0.591	1.074	1.915
88.388	3.5	0.768	1.359	1.490	3.405
62.500	4.0	1.298	2.657	1.344	4.749
44.194	4.5	3.532	6.188	0.830	5.579
31.250	5.0	3.532	9.720	0.830	6.410
22.097	5.5	6.199	15.919	4.373	10.783
15.625	6.0	6.199	22.118	4.373	15.156
11.049	6.5	4.269	26.387	32.665	47.821
7.813	7.0	4.269	30.656	32.665	80.486
5.524	7.5	6.047	36.703	5.735	86.221
3.906	8.0	6.047	42.751	5.735	91.956
2.762	8.5	5.103	47.854	1.645	93.601
1.953	9.0	5.103	52.957	1.645	95.246
1.381	9.5	11.761	64.717	1.188	96.435
0.977	10.0	11.761	76.478	1.188	97.623
0.691	10.5	11.761	88.239	1.188	98.812
0.488	11.0	11.761	100.000	1.188	100.000

Median	8.710	6.533
Mean	8.120	6.561
Mean size (Folk)	8.179	6.618
Standard Deviation	2.133	1.285
Sorting (Trask)	3.482	1.304
Skewness (Folk)	-0.344	0.099
Kurtosis (Folk)	0.735	2.556
Sand %	2.657	4.749
Silt %	40.094	87.208
Clay %	57.249	8.044

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 708-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 708-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 709-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 709-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.126	0.126	0.044	0.044
1000.000	0.0	0.031	0.158	0.010	0.054
707.107	0.5	0.028	0.186	0.035	0.089
500.000	1.0	0.093	0.279	0.087	0.176
353.553	1.5	0.133	0.412	0.047	0.222
250.000	2.0	0.197	0.609	0.090	0.313
176.777	2.5	0.221	0.830	0.146	0.459
125.000	3.0	0.227	1.057	0.215	0.674
88.388	3.5	0.265	1.322	0.945	1.618
62.500	4.0	0.424	1.745	2.573	4.191
44.194	4.5	1.576	3.321	0.270	4.461
31.250	5.0	1.576	4.897	0.270	4.731
22.097	5.5	4.845	9.743	8.208	12.940
15.625	6.0	4.845	14.588	8.208	21.148
11.049	6.5	29.888	44.476	32.471	53.619
7.813	7.0	29.888	74.364	32.471	86.090
5.524	7.5	6.524	80.888	2.078	88.168
3.906	8.0	6.524	87.411	2.078	90.246
2.762	8.5	2.107	89.518	0.241	90.487
1.953	9.0	2.107	91.624	0.241	90.728
1.381	9.5	2.094	93.718	2.318	93.046
0.977	10.0	2.094	95.812	2.318	95.364
0.691	10.5	2.094	97.906	2.318	97.682
0.488	11.0	2.094	100.000	2.318	100.000

Median	6.592	6.444
Mean	6.775	6.567
Mean size (Folk)	6.785	6.366
Standard Deviation	1.375	1.384
Sorting (Trask)	1.354	1.306
Skewness (Folk)	0.338	0.117
Kurtosis (Folk)	2.247	2.611
Sand %	1.745	4.191
Silt %	85.666	86.055
Clay %	12.589	9.754

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 711-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 711-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 712-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 712-1 CUMULATIVE (wt. percent)
2828.427	+1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.024	0.024	0.000	0.000
1000.000	0.0	0.009	0.032	0.019	0.019
707.107	0.5	0.015	0.047	0.019	0.037
500.000	1.0	0.057	0.104	0.017	0.054
353.553	1.5	0.044	0.147	0.025	0.079
250.000	2.0	0.081	0.229	0.018	0.097
176.777	2.5	0.244	0.473	0.017	0.114
125.000	3.0	1.257	1.730	0.027	0.141
88.388	3.5	5.963	7.692	0.030	0.170
62.500	4.0	9.439	17.131	0.050	0.220
44.194	4.5	19.301	36.432	0.000	0.220
31.250	5.0	19.301	55.733	0.000	0.220
22.097	5.5	12.095	67.828	1.832	2.052
15.625	6.0	12.095	79.924	1.932	3.984
11.049	6.5	5.135	85.059	37.113	40.997
7.813	7.0	5.135	90.193	37.113	78.110
5.524	7.5	1.518	91.711	6.900	85.010
3.906	8.0	1.518	93.229	6.900	91.909
2.762	8.5	0.188	93.417	2.021	93.931
1.953	9.0	0.188	93.605	2.021	95.952
1.381	9.5	1.599	95.204	1.012	96.964
0.977	10.0	1.599	96.803	1.012	97.976
0.691	10.5	1.599	98.401	1.012	98.988
0.488	11.0	1.599	100.000	1.012	100.000

Median	4.851	6.621
Mean	5.224	6.814
Mean size (Folk)	5.063	6.737
Standard Deviation	1.640	0.923
Sorting (Trask).....	1.737	1.263
Skewness (Folk).....	0.373	0.417
Kurtosis (Folk).....	1.586	1.673
Sand %	17.131	0.220
Silt %	76.098	91.689
Clay %	6.771	8.091

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 713-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 713-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 714-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 714-1 CUMULATIVE (wt. percent)
2828.427	+1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	.0.0	0.068	0.068	0.021	0.021
707.107	0.5	0.129	0.197	0.042	0.063
500.000	1.0	0.297	0.494	0.049	0.112
353.553	1.5	0.270	0.764	0.066	0.178
250.000	2.0	0.345	1.109	0.117	0.295
176.777	2.5	0.465	1.574	0.183	0.478
125.000	3.0	0.506	2.080	0.239	0.717
88.388	3.5	0.628	2.708	0.315	1.033
62.500	4.0	1.101	3.809	0.724	1.757
44.194	4.5	2.756	6.565	2.209	3.966
31.250	5.0	2.756	9.321	2.209	6.174
22.097	5.5	37.306	46.627	8.634	14.809
15.625	6.0	37.306	83.933	8.634	23.443
11.049	6.5	4.512	88.445	31.122	54.565
7.813	7.0	4.512	92.957	31.122	85.686
5.524	7.5	1.316	94.273	4.199	89.885
3.906	8.0	1.316	95.589	4.199	94.084
2.762	8.5	0.011	95.599	0.755	94.839
1.953	9.0	0.011	95.610	0.755	95.595
1.381	9.5	1.098	96.707	1.101	96.696
0.977	10.0	1.098	97.805	1.101	97.797
0.691	10.5	1.098	98.902	1.101	98.899
0.488	11.0	1.098	100.000	1.101	100.000

Median	5.545	6.427
Mean	5.674	6.445
Mean size (Folk)	5.547	6.323
Standard Deviation	1.248	1.159
Sorting (Trask).....	1.261	1.321
Skewness (Folk).....	0.130	-0.048
Kurtosis (Folk).....	2.177	1.976
Sand %	3.809	1.757
Silt %	91.780	92.327
Clay %	4.411	5.916

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 715-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 715-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 306-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 306-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.216	0.216	0.000	0.000
1414.214	-0.5	0.456	0.672	0.000	0.000
1000.000	0.0	1.007	1.679	0.000	0.000
707.107	0.5	2.503	4.182	0.118	0.118
500.000	1.0	3.956	8.138	0.218	0.336
353.553	1.5	3.596	11.734	0.474	0.811
250.000	2.0	3.320	15.054	0.414	1.225
176.777	2.5	2.634	17.688	0.432	1.657
125.000	3.0	2.348	20.035	0.599	2.256
88.388	3.5	1.669	21.704	1.402	3.658
62.500	4.0	1.457	23.162	2.849	6.507
44.194	4.5	0.768	23.929	1.276	7.783
31.250	5.0	0.768	24.697	1.276	9.059
22.097	5.5	5.726	30.423	2.968	12.027
15.625	6.0	5.726	36.149	2.968	14.995
11.049	6.5	12.860	49.009	3.326	18.321
7.813	7.0	12.860	61.869	3.326	21.647
5.524	7.5	11.993	73.862	3.788	25.435
3.906	8.0	11.993	85.854	3.788	29.223
2.762	8.5	4.195	90.049	5.245	34.468
1.953	9.0	4.195	94.243	5.245	39.713
1.381	9.5	1.439	95.683	15.072	54.785
0.977	10.0	1.439	97.122	15.072	69.857
0.691	10.5	1.439	98.561	15.072	84.928
0.488	11.0	1.439	100.000	15.072	100.000

Median	6.539	9.341
Mean	5.821	8.556
Mean size (Folk)	5.547	8.654
Standard Deviation	2.647	2.212
Sorting (Trask).....	2.396	2.574
Skewness (Folk).....	-0.444	-0.528
Kurtosis (Folk).....	1.408	1.066
Sand %	22.946	6.507
Silt %	62.692	22.716
Clay %	14.146	70.777

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 307-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 307-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 308-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 308-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.000	0.000	0.018	0.018
500.000	1.0	0.015	0.015	0.021	0.039
353.553	1.5	0.045	0.061	0.030	0.069
250.000	2.0	0.045	0.106	0.043	0.112
176.777	2.5	0.052	0.158	0.042	0.153
125.000	3.0	0.063	0.221	0.058	0.211
88.388	3.5	1.014	1.235	0.126	0.337
62.500	4.0	2.909	4.144	0.176	0.513
44.194	4.5	0.958	5.103	0.000	0.513
31.250	5.0	0.958	6.061	0.000	0.513
22.097	5.5	1.418	7.479	2.685	3.198
15.625	6.0	1.418	8.896	2.685	5.882
11.049	6.5	2.864	11.761	3.989	9.871
7.813	7.0	2.864	14.625	3.989	13.860
5.524	7.5	4.499	19.124	19.190	33.050
3.906	8.0	4.499	23.622	19.190	52.240
2.762	8.5	6.145	29.767	15.756	67.996
1.953	9.0	6.145	35.911	15.756	83.752
1.381	9.5	16.022	51.934	4.062	87.814
0.977	10.0	16.022	67.956	4.062	91.876
0.691	10.5	16.022	83.978	4.062	95.938
0.488	11.0	16.022	100.000	4.062	100.000

Median	9.440	7.942
Mean	8.889	8.010
Mean size (Folk)	9.031	8.009
Standard Deviation	1.850	1.259
Sorting (Trask).....	2.076	1.643
Skewness (Folk).....	-0.464	0.088
Kurtosis (Folk).....	1.244	1.302
Sand %	4.144	0.513
Silt %	19.478	51.726
Clay %	76.378	47.760

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 309-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 309-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 311-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 311-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	.0.0	0.000	0.000	0.047	0.047
707.107	0.5	0.015	0.015	0.010	0.057
500.000	1.0	0.019	0.034	0.070	0.127
353.553	1.5	0.038	0.072	0.099	0.226
250.000	2.0	0.056	0.129	0.084	0.310
176.777	2.5	0.102	0.230	0.087	0.396
125.000	3.0	0.477	0.707	0.152	0.548
88.388	3.5	1.167	1.875	0.325	0.873
62.500	4.0	1.331	3.205	0.654	1.527
44.194	4.5	1.830	5.035	1.368	2.895
31.250	5.0	1.830	6.864	1.368	4.263
22.097	5.5	2.561	9.426	2.787	7.050
15.625	6.0	2.561	11.987	2.787	9.837
11.049	6.5	4.429	16.416	7.064	16.901
7.813	7.0	4.429	20.845	7.064	23.965
5.524	7.5	28.448	49.293	17.003	40.968
3.906	8.0	28.448	77.742	17.003	57.971
2.762	8.5	5.870	83.612	17.803	75.775
1.953	9.0	5.870	89.482	17.803	93.578
1.381	9.5	2.629	92.112	1.606	95.183
0.977	10.0	2.629	94.741	1.606	96.789
0.691	10.5	2.629	97.371	1.606	98.394
0.488	11.0	2.629	100.000	1.606	100.000

Median	7.512	7.766
Mean	7.444	7.612
Mean size (Folk)	7.499	7.644
Standard Deviation	1.437	1.332
Sorting (Trask)	1.356	1.652
Skewness (Folk)	-0.053	-0.190
kurtosis (Folk)	2.592	1.220
Sand %	3.205	1.527
Silt %	74.536	56.444
Clay %	22.258	42.029

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 312-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 312-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 313-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 313-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	.0.0	0.000	0.000	0.041	0.041
707.107	0.5	0.027	0.027	0.029	0.070
500.000	1.0	0.015	0.041	0.020	0.089
353.553	1.5	0.027	0.069	0.058	0.147
250.000	2.0	0.027	0.096	0.053	0.201
176.777	2.5	0.016	0.112	0.053	0.254
125.000	3.0	0.027	0.140	0.087	0.341
88.388	3.5	1.060	1.200	0.093	0.434
62.500	4.0	3.156	4.356	0.187	0.621
44.194	4.5	0.584	4.940	0.117	0.738
31.250	5.0	0.584	5.524	0.117	0.856
22.097	5.5	2.540	8.064	1.568	2.424
15.625	6.0	2.540	10.604	1.568	3.992
11.049	6.5	6.828	17.432	12.036	16.028
7.813	7.0	6.828	24.260	12.036	28.064
5.524	7.5	3.757	28.017	28.873	56.937
3.906	8.0	3.757	31.774	28.873	85.810
2.762	8.5	30.705	62.479	3.032	88.842
1.953	9.0	30.705	93.184	3.032	91.874
1.381	9.5	1.704	94.888	2.032	93.905
0.977	10.0	1.704	96.592	2.032	95.937
0.691	10.5	1.704	98.296	2.032	97.968
0.488	11.0	1.704	100.000	2.032	100.000

Median	8.297	7.380
Mean	7.840	7.422
Mean size (Folk)	7.847	7.282
Standard Deviation	1.460	1.095
Sorting (Trask)	1.744	1.385
Skewness (Folk)	-0.526	0.042
kurtosis (Folk)	1.272	1.625
Sand %	4.356	0.621
Silt %	27.418	85.189
Clay %	68.226	14.190

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 314-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 314-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 315-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 315-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.056	0.056	0.156	0.156
1000.000	.0.0	0.026	0.082	0.146	0.302
707.107	0.5	0.040	0.122	0.403	0.705
500.000	1.0	0.071	0.193	0.525	1.230
353.553	1.5	0.072	0.264	0.341	1.571
250.000	2.0	0.073	0.338	0.271	1.842
176.777	2.5	0.080	0.418	0.257	2.100
125.000	3.0	0.122	0.540	0.392	2.492
88.388	3.5	0.167	0.707	0.662	3.154
62.500	4.0	0.328	1.035	1.292	4.416
44.194	4.5	0.449	1.485	1.271	5.687
31.250	5.0	0.449	1.934	1.271	6.958
22.097	5.5	1.790	3.724	3.169	10.127
15.625	6.0	1.790	5.515	3.169	13.296
11.049	6.5	38.442	43.956	13.710	27.006
7.813	7.0	38.442	82.398	13.710	40.717
5.524	7.5	5.173	87.571	24.976	65.692
3.906	8.0	5.173	92.743	24.976	90.668
2.762	8.5	0.563	93.307	1.790	92.458
1.953	9.0	0.563	93.870	1.790	94.247
1.381	9.5	1.533	95.402	1.438	95.685
0.977	10.0	1.533	96.935	1.438	97.124
0.691	10.5	1.533	98.467	1.438	98.562
0.488	11.0	1.533	100.000	1.438	100.000

Median	6.579	7.186
Mean	6.745	6.969
Mean size (Folk)	6.623	7.050
Standard Deviation	1.086	1.506
Sorting (Trask).....	1.253	1.547
Skewness (Folk).....	0.360	-0.202
Kurtosis (Folk).....	2.214	1.637
Sand %	1.035	4.416
Silt %	91.708	86.252
Clay %	7.257	9.332

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 316-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 316-1 CUMULUTIVE (wt. percent)	SAMPLE NUMBER ZW 317-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 317-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	.0.0	0.000	0.000	0.079	0.079
707.107	0.5	0.005	0.005	0.056	0.131
500.000	1.0	0.024	0.029	0.077	0.208
353.553	1.5	0.028	0.058	0.090	0.298
250.000	2.0	0.038	0.095	0.104	0.403
176.777	2.5	0.055	0.150	0.121	0.524
125.000	3.0	0.110	0.260	0.199	0.723
88.388	3.5	0.599	0.859	0.710	1.433
62.500	4.0	1.822	2.681	1.837	3.270
44.194	4.5	1.023	3.704	0.345	3.615
31.250	5.0	1.023	4.728	0.345	3.960
22.097	5.5	3.739	8.467	3.323	7.283
15.625	6.0	3.739	12.206	3.323	10.606
11.049	6.5	6.386	18.592	39.757	50.363
7.813	7.0	6.386	24.978	39.757	90.120
5.524	7.5	30.414	55.392	0.716	90.837
3.906	8.0	30.414	85.806	0.716	91.553
2.762	8.5	4.036	89.842	0.974	92.528
1.953	9.0	4.036	93.817	0.974	93.500
1.381	9.5	1.546	95.363	1.625	95.125
0.977	10.0	1.546	96.909	1.625	96.750
0.691	10.5	1.546	98.454	1.625	98.375
0.488	11.0	1.546	100.000	1.625	100.000

Median	7.411	6.495
Mean	7.288	6.592
Mean size (Folk)	7.226	6.495
Standard Deviation	1.245	1.202
Sorting (Trask).....	1.330	1.244
Skewness (Folk).....	-0.212	0.189
Kurtosis (Folk).....	2.167	2.806
Sand %	2.681	3.270
Silt %	83.125	88.283
Clay %	14.194	8.447

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 318-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 318-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 320-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 320-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.072	0.072	0.000	0.000
500.000	1.0	0.121	0.193	0.011	0.011
353.553	1.5	0.174	0.367	0.012	0.023
250.000	2.0	0.302	0.668	0.016	0.039
176.777	2.5	0.357	1.025	0.019	0.058
125.000	3.0	0.460	1.486	0.030	0.087
88.388	3.5	0.840	2.325	0.066	0.153
62.500	4.0	1.312	3.638	0.859	1.012
44.194	4.5	1.063	4.700	10.927	11.938
31.250	5.0	1.063	5.763	10.927	22.865
22.097	5.5	12.336	18.098	26.793	49.658
15.625	6.0	12.336	30.434	26.793	76.450
11.049	6.5	30.262	60.696	8.685	85.135
7.813	7.0	30.262	90.958	8.685	93.819
5.524	7.5	0.000	90.958	0.240	94.059
3.906	8.0	0.000	90.958	0.240	94.300
2.762	8.5	0.227	91.186	0.198	94.498
1.953	9.0	0.227	91.413	0.198	94.696
1.381	9.5	2.147	93.560	1.326	96.022
0.977	10.0	2.147	95.706	1.326	97.348
0.691	10.5	2.147	97.853	1.326	98.674
0.488	11.0	2.147	100.000	1.326	100.000

Median	6.323	5.506
Mean	6.390	5.696
Mean size (Folk)	6.208	5.542
Standard Deviation	1.404	1.264
Sorting (Trask)	1.393	1.382
Skewness (Folk)	0.058	0.262
Kurtosis (Folk)	2.225	2.166
Sand %	3.638	1.012
Silt %	87.321	93.288
Clay %	9.042	5.700

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 323-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 323-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 324-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 324-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.075	0.075	0.000	0.000
1000.000	0.0	0.077	0.151	0.000	0.000
707.107	0.5	0.065	0.216	0.067	0.067
500.000	1.0	0.128	0.344	0.071	0.138
353.553	1.5	0.220	0.564	0.168	0.307
250.000	2.0	0.295	0.859	0.406	0.713
176.777	2.5	0.271	1.130	0.385	1.097
125.000	3.0	0.288	1.418	0.300	1.397
88.388	3.5	0.653	2.071	0.578	1.976
62.500	4.0	1.763	3.834	1.094	3.069
44.194	4.5	0.051	3.885	0.656	3.726
31.250	5.0	0.051	3.937	0.656	4.382
22.097	5.5	4.888	8.825	3.705	8.088
15.625	6.0	4.888	13.714	3.705	11.793
11.049	6.5	36.426	50.140	30.597	42.390
7.813	7.0	36.426	86.565	30.597	72.986
5.524	7.5	3.020	89.585	8.045	81.031
3.906	8.0	3.020	92.605	8.045	89.076
2.762	8.5	0.109	92.715	1.299	90.375
1.953	9.0	0.109	92.824	1.299	91.674
1.381	9.5	1.794	94.618	2.081	93.756
0.977	10.0	1.794	96.412	2.081	95.837
0.691	10.5	1.794	98.206	2.081	97.919
0.488	11.0	1.794	100.000	2.081	100.000

Median	6.498	6.624
Mean	6.577	6.791
Mean size (Folk)	6.498	6.793
Standard Deviation	1.297	1.361
Sorting (Trask)	1.269	1.370
Skewness (Folk)	0.191	0.329
Kurtosis (Folk)	2.686	2.125
Sand %	3.834	3.069
Silt %	88.772	86.007
Clay %	7.395	10.924

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 1119-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1119-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 1108-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1108-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	6.188	6.188
2000.000	-1.0	0.000	0.000	1.943	8.131
1414.214	-0.5	0.143	0.143	3.392	11.523
1000.000	.0.0	0.134	0.277	4.243	15.766
707.107	0.5	0.214	0.490	6.784	22.549
500.000	1.0	0.173	0.663	8.657	31.206
353.553	1.5	0.111	0.774	6.646	37.852
250.000	2.0	0.117	0.891	5.493	43.345
176.777	2.5	0.149	1.040	4.341	47.686
125.000	3.0	0.177	1.218	4.293	51.979
88.388	3.5	0.523	1.741	5.586	57.565
62.500	4.0	0.842	2.583	5.556	63.121
44.194	4.5	0.918	3.501	3.641	66.761
31.250	5.0	0.918	4.418	3.641	70.402
22.097	5.5	37.601	42.020	4.000	74.402
15.625	6.0	37.601	79.621	4.000	78.403
11.049	6.5	5.713	85.334	2.121	80.523
7.813	7.0	5.713	91.047	2.121	82.644
5.524	7.5	0.295	91.342	3.391	86.035
3.906	8.0	0.295	91.637	3.391	89.425
2.762	8.5	0.126	91.763	0.668	90.094
1.953	9.0	0.126	91.888	0.668	90.762
1.381	9.5	2.028	93.916	2.309	93.072
0.977	10.0	2.028	95.944	2.309	95.381
0.691	10.5	2.028	97.972	2.309	97.691
0.488	11.0	2.028	100.000	2.309	100.000
Median		5.606		2.770	
Mean		5.899		3.287	
Mean size (Folk)		5.714		3.329	
Standard Deviation		1.435		3.380	
Sorting (Trask).....		1.259		5.527	
Skewness (Folk).....		0.506		0.238	
Kurtosis (Folk).....		2.934		0.957	
Sand %		2.583		54.989	
Silt %		89.054		26.305	
Clay %		8.363		10.575	

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 1109-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1109-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 1110-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1110-1 CUMULATIVE (wt. percent)
2828.427	-1.5	3.677	3.677	0.000	0.000
2000.000	-1.0	2.654	6.331	0.293	0.293
1414.214	-0.5	3.103	9.434	0.348	0.691
1000.000	.0.0	1.773	11.207	0.777	1.467
707.107	0.5	1.784	12.991	1.206	2.674
500.000	1.0	2.056	15.047	1.541	4.215
353.553	1.5	2.894	17.941	1.722	5.938
250.000	2.0	3.907	21.847	1.981	7.918
176.777	2.5	4.100	25.946	1.481	9.400
125.000	3.0	5.131	31.079	1.169	10.569
88.388	3.5	5.062	36.141	1.065	11.634
62.500	4.0	3.244	39.384	1.217	12.851
44.194	4.5	3.540	42.925	4.782	17.633
31.250	5.0	3.540	46.465	4.782	22.414
22.097	5.5	16.170	62.635	31.432	53.846
15.625	6.0	16.170	78.804	31.432	85.278
11.049	6.5	6.229	85.033	3.389	89.167
7.813	7.0	6.228	91.261	3.889	93.056
5.524	7.5	1.459	92.719	1.182	94.238
3.906	8.0	1.459	94.178	1.182	95.420
2.762	8.5	0.274	94.452	0.000	95.420
1.953	9.0	0.274	94.726	0.000	95.420
1.381	9.5	1.319	96.044	1.145	96.565
0.977	10.0	1.319	97.363	1.145	97.710
0.691	10.5	1.319	98.681	1.145	98.855
0.488	11.0	1.319	100.000	1.145	100.000
Median		5.109		5.439	
Mean		4.218		5.237	
Mean size (Folk)		4.230		5.249	
Standard Deviation		2.825		1.829	
Sorting (Trask).....		3.361		1.317	
Skewness (Folk).....		-0.365		-0.311	
Kurtosis (Folk).....		1.213		3.398	
Sand %		33.053		12.558	
Silt %		54.794		82.569	
Clay %		5.822		4.580	

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 1111-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1111-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 1112-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1112-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.787	0.787
2000.000	-1.0	0.000	0.000	1.681	2.468
1414.214	-0.5	0.168	0.168	2.874	5.342
1000.000	0.0	0.416	0.584	2.900	8.242
707.107	0.5	0.986	1.569	4.203	12.445
500.000	1.0	1.491	3.060	6.885	19.330
353.553	1.5	1.550	4.610	6.634	25.963
250.000	2.0	1.419	6.029	5.283	31.246
176.777	2.5	1.051	7.071	4.038	35.284
125.000	3.0	1.111	8.182	3.904	39.187
88.388	3.5	1.288	9.469	3.020	42.207
62.500	4.0	1.907	11.376	2.882	45.089
44.194	4.5	7.412	18.789	2.892	47.981
31.250	5.0	7.412	26.201	2.892	50.873
22.097	5.5	29.040	55.242	15.530	66.403
15.625	6.0	29.040	84.282	15.530	81.933
11.049	6.5	4.138	88.420	5.141	87.074
7.813	7.0	4.138	92.558	5.141	92.215
5.524	7.5	1.020	93.578	0.943	93.158
3.906	8.0	1.020	94.598	0.943	94.102
2.762	8.5	0.122	94.720	0.063	94.165
1.953	9.0	0.122	94.841	0.063	94.228
1.381	9.5	1.290	96.131	1.443	95.671
0.977	10.0	1.290	97.421	1.443	97.114
0.691	10.5	1.290	98.710	1.443	98.557
0.488	11.0	1.290	100.000	1.443	100.000

Median	5.410	4.849
Mean	5.312	3.945
Mean size (Folk)	5.329	3.936
Standard Deviation	1.738	2.815
Sorting (Trask).....	1.376	4.515
Skewness (Folk).....	-0.160	-0.302
Kurtosis (Folk).....	3.302	0.926
Sand %	11.376	42.621
Silt %	83.222	49.013
Clay %	5.402	5.898

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 1113-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1113-1 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 1114-1 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 1114-1 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.379	0.379	0.000	0.000
1414.214	-0.5	1.061	1.440	0.253	0.253
1000.000	0.0	1.664	3.104	0.439	0.692
707.107	0.5	3.629	6.733	0.736	1.428
500.000	1.0	4.485	11.218	1.050	2.479
353.553	1.5	3.597	14.816	0.717	3.196
250.000	2.0	2.832	17.648	0.803	3.999
176.777	2.5	2.248	19.895	0.851	4.850
125.000	3.0	2.150	22.046	1.303	6.153
88.388	3.5	2.687	24.732	1.798	7.951
62.500	4.0	4.633	29.366	2.290	10.241
44.194	4.5	8.314	37.680	14.587	24.828
31.250	5.0	8.314	45.994	14.587	39.414
22.097	5.5	20.965	66.959	22.005	61.420
15.625	6.0	20.965	87.924	22.005	83.425
11.049	6.5	2.600	90.524	3.618	87.043
7.813	7.0	2.600	93.125	3.618	90.662
5.524	7.5	0.761	93.886	2.107	92.769
3.906	8.0	0.761	94.647	2.107	94.876
2.762	8.5	1.158	95.804	0.306	95.183
1.953	9.0	1.158	96.962	0.306	95.489
1.381	9.5	0.760	97.721	1.128	96.617
0.977	10.0	0.760	98.481	1.128	97.744
0.691	10.5	0.760	99.240	1.128	98.872
0.488	11.0	0.760	100.000	1.128	100.000

Median	5.096	5.241
Mean	4.498	5.252
Mean size (Folk)	4.237	5.172
Standard Deviation	2.242	1.668
Sorting (Trask).....	2.116	1.571
Skewness (Folk).....	-0.159	-0.030
Kurtosis (Folk).....	1.495	1.776
Sand %	28.987	10.241
Silt %	65.281	84.635
Clay %	5.353	5.124

SAMPLE NUMBER ZW 609-1

SIZE GRADE (mm)	(CLASS LIMITS) phi units	FREQUENCY (wt. percent)	CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000
2000.000	-1.0	0.000	0.000
1414.214	-0.5	0.000	0.000
1000.000	.0.0	0.035	0.035
707.107	0.5	0.021	0.056
500.000	1.0	0.047	0.103
353.553	1.5	0.015	0.118
250.000	2.0	0.016	0.134
176.777	2.5	0.016	0.149
125.000	3.0	0.011	0.161
88.388	3.5	0.355	0.515
62.500	4.0	1.049	1.564
44.194	4.5	0.000	1.564
31.250	5.0	0.000	1.564
22.097	5.5	28.211	29.775
15.625	6.0	28.211	57.987
11.049	6.5	13.931	71.918
7.813	7.0	13.931	85.850
5.524	7.5	2.054	87.904
3.906	8.0	2.054	89.958
2.762	8.5	0.145	90.102
1.953	9.0	0.145	90.247
1.381	9.5	2.438	92.685
0.977	10.0	2.438	95.124
0.691	10.5	2.438	97.562
0.488	11.0	2.438	100.000

Median	5.858
Mean	6.274
Mean size (Folk)	6.016
Standard Deviation	1.420
Sorting (Trask).....	1.513
Skewness (Folk).....	0.479
Kurtosis (Folk).....	1.685
Sand %	1.564
Silt %	88.394
Clay %	10.042

SAMPLE NUMBER ZQ 1115-1

SIZE GRADE (mm)	(CLASS LIMITS) phi units	FREQUENCY (wt. percent)	CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000
2000.000	-1.0	0.000	0.000
1414.214	-0.5	0.779	0.779
1000.000	.0.0	1.755	2.533
707.107	0.5	2.167	4.700
500.000	1.0	2.003	6.704
353.553	1.5	1.491	8.194
250.000	2.0	1.271	9.465
176.777	2.5	1.061	10.526
125.000	3.0	1.245	11.771
88.388	3.5	1.248	13.019
62.500	4.0	1.579	14.598
44.194	4.5	9.855	24.452
31.250	5.0	9.855	34.307
22.097	5.5	24.256	58.563
15.625	6.0	24.256	82.819
11.049	6.5	4.429	87.247
7.813	7.0	4.429	91.676
5.524	7.5	0.753	92.429
3.906	8.0	0.753	93.182
2.762	8.5	0.147	93.329
1.953	9.0	0.147	93.476
1.381	9.5	1.631	95.107
0.977	10.0	1.631	96.738
0.691	10.5	1.631	98.369
0.488	11.0	1.631	100.000

Median	5.323
Mean	5.130
Mean size (Folk)	5.176
Standard Deviation	2.080
Sorting (Trask).....	1.575
Skewness (Folk).....	-0.141
Kurtosis (Folk).....	2.780
Sand %	14.598
Silt %	78.584
Clay %	6.818

SAMPLE NUMBER ZW 1116-1

FREQUENCY (wt. percent)	CUMULATIVE (wt. percent)
0.328	0.328
1.153	1.482
2.261	3.743
2.063	5.806
3.242	9.048
3.047	12.095
1.943	14.038
1.524	15.563
1.142	16.705
1.131	17.836
1.099	18.935
1.552	20.487
11.005	31.492
11.005	42.497
21.922	64.420
21.922	86.342
3.855	90.196
3.855	94.051
0.013	94.064
0.013	94.077
0.067	94.144
0.067	94.211
1.447	95.658
1.447	97.106
1.447	98.553
1.447	100.000

Median	5.171
Mean	4.686
Mean size (Folk)	4.436
Standard Deviation	2.367
Sorting (Trask).....	1.703
Skewness (Folk).....	-0.360
Kurtosis (Folk).....	2.526
Sand %	19.005
Silt %	73.590
Clay %	5.923

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 689-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 689-3 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 689-6 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 689-6 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.003	0.003	0.000	0.000
1414.214	-0.5	0.062	0.064	0.000	0.000
1000.000	0.0	0.076	0.141	0.015	0.015
707.107	0.5	0.496	0.637	0.183	0.197
500.000	1.0	3.233	3.870	0.703	0.901
353.553	1.5	5.856	9.726	0.224	1.125
250.000	2.0	15.858	25.584	0.616	1.741
176.777	2.5	15.162	40.746	0.497	2.238
125.000	3.0	22.541	63.286	0.753	2.991
88.388	3.5	13.557	76.843	0.678	3.668
62.500	4.0	10.387	87.230	1.318	4.986
44.194	4.5	0.130	87.360	0.000	4.986
31.250	5.0	0.130	87.490	0.000	4.986
22.097	5.5	1.920	89.410	2.249	7.235
15.625	6.0	1.920	91.331	2.249	9.484
11.049	6.5	1.501	92.831	5.664	15.148
7.813	7.0	1.501	94.332	5.664	20.812
5.524	7.5	0.582	94.914	6.120	26.932
3.906	8.0	0.582	95.495	6.120	33.052
2.762	8.5	0.804	96.299	6.259	39.311
1.953	9.0	0.804	97.104	6.259	45.570
1.381	9.5	0.724	97.828	13.607	59.178
0.977	10.0	0.724	98.552	13.607	72.785
0.691	10.5	0.724	99.276	13.607	86.393
0.488	11.0	0.724	100.000	13.607	100.000

	SAMPLE NUMBER ZW 689-3	SAMPLE NUMBER ZW 689-6
Median	2.705	9.163
Mean	3.098	8.531
Mean size (Folk)	2.749	8.717
Standard Deviation	1.890	2.070
Sorting (Trask)	1.653	2.584
Skewness (Folk)	0.282	-0.390
Kurtosis (Folk)	1.830	0.870
Sand %	87.228	4.986
Silt %	8.265	28.066
Clay %	4.505	66.948

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 689-8 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 689-8 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 690-7 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 690-7 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.321	0.321
2000.000	-1.0	0.000	0.000	0.087	0.408
1414.214	-0.5	0.062	0.062	0.212	0.621
1000.000	0.0	0.016	0.079	0.523	1.143
707.107	0.5	0.045	0.124	1.202	2.346
500.000	1.0	0.132	0.256	7.902	10.248
353.553	1.5	0.164	0.420	4.074	14.323
250.000	2.0	0.327	0.747	8.947	23.269
176.777	2.5	0.184	0.931	9.372	32.641
125.000	3.0	0.228	1.159	14.740	47.381
88.388	3.5	0.733	1.892	14.431	61.812
62.500	4.0	1.564	3.457	9.866	71.678
44.194	4.5	1.305	4.762	3.835	75.514
31.250	5.0	1.305	6.067	3.835	79.349
22.097	5.5	2.354	8.421	2.366	81.715
15.625	6.0	2.354	10.775	2.366	84.081
11.049	6.5	6.049	16.825	1.601	85.682
7.813	7.0	6.049	22.874	1.601	87.283
5.524	7.5	6.077	28.951	2.475	89.759
3.906	8.0	6.077	35.028	2.475	92.234
2.762	8.5	6.423	41.452	1.383	93.618
1.953	9.0	6.423	47.875	1.383	95.001
1.381	9.5	13.031	60.906	1.250	96.251
0.977	10.0	13.031	73.937	1.250	97.501
0.691	10.5	13.031	86.969	1.250	98.750
0.488	11.0	13.031	100.000	1.250	100.000

	SAMPLE NUMBER ZW 689-8	SAMPLE NUMBER ZW 690-7
Median	9.082	3.091
Mean	8.480	3.635
Mean size (Folk)	8.633	3.556
Standard Deviation	1.981	2.415
Sorting (Trask)	2.700	2.251
Skewness (Folk)	-0.392	0.368
Kurtosis (Folk)	0.889	1.459
Sand %	3.457	71.270
Silt %	31.572	20.556
Clay %	64.972	7.766

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 690-9 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 690-9 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 691-5 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 691-5 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.000	0.000	0.000	0.000
500.000	1.0	0.023	0.023	0.029	0.029
353.553	1.5	0.014	0.037	0.004	0.034
250.000	2.0	0.037	0.075	0.003	0.037
176.777	2.5	0.040	0.115	0.004	0.041
125.000	3.0	0.082	0.197	0.021	0.062
88.388	3.5	0.108	0.305	0.071	0.133
62.500	4.0	0.215	0.520	0.154	0.287
44.194	4.5	1.304	1.824	1.404	1.692
31.250	5.0	1.304	3.128	1.404	3.096
22.097	5.5	11.714	14.842	6.248	9.344
15.625	6.0	11.714	26.557	6.248	15.593
11.049	6.5	28.479	55.035	7.917	23.510
7.813	7.0	28.479	83.514	7.917	31.427
5.524	7.5	4.734	88.248	5.089	36.516
3.906	8.0	4.734	92.982	5.089	41.605
2.762	8.5	1.454	94.436	5.179	46.783
1.953	9.0	1.454	95.889	5.179	51.962
1.381	9.5	1.028	96.917	12.009	63.972
0.977	10.0	1.028	97.945	12.009	75.981
0.691	10.5	1.028	98.972	12.009	87.991
0.488	11.0	1.028	100.000	12.009	100.000

Median	6.412	8.811
Mean	6.492	8.300
Mean size (Folk)	6.337	8.390
Standard Deviation	1.092	1.902
Sorting (Trask).....	1.374	3.210
Skewness (Folk).....	0.057	-0.295
Kurtosis (Folk).....	1.615	0.687
Sand %	0.520	0.287
Silt %	92.462	41.317
Clay %	7.018	58.395

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 692-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 692-3 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 693-6 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 693-6 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.028	0.028	0.000	0.000
707.107	0.5	0.077	0.104	0.000	0.000
500.000	1.0	0.161	0.265	0.047	0.047
353.553	1.5	0.107	0.372	0.157	0.204
250.000	2.0	0.242	0.614	0.227	0.432
176.777	2.5	0.278	0.892	0.152	0.584
125.000	3.0	0.397	1.289	0.140	0.724
88.388	3.5	1.048	2.337	1.018	1.742
62.500	4.0	2.483	4.820	2.789	4.531
44.194	4.5	0.000	4.820	0.000	4.531
31.250	5.0	0.000	4.820	0.000	4.531
22.097	5.5	3.894	8.714	2.769	7.300
15.625	6.0	3.894	12.609	2.769	10.069
11.049	6.5	8.760	21.369	7.024	17.093
7.813	7.0	8.760	30.129	7.024	24.117
5.524	7.5	2.417	32.546	8.634	32.751
3.906	8.0	2.417	34.962	8.634	41.386
2.762	8.5	16.883	51.845	20.637	62.023
1.953	9.0	16.883	68.727	20.637	82.660
1.381	9.5	7.818	76.546	4.335	86.995
0.977	10.0	7.818	84.364	4.335	91.330
0.691	10.5	7.818	92.182	4.335	95.665
0.488	11.0	7.818	100.000	4.335	100.000

Median	8.445	8.209
Mean	8.078	7.906
Mean size (Folk)	8.205	7.928
Standard Deviation	1.881	1.614
Sorting (Trask).....	2.544	1.842
Skewness (Folk).....	-0.200	-0.239
Kurtosis (Folk).....	0.861	1.241
Sand %	4.820	4.531
Silt %	30.142	36.855
Clay %	65.038	58.614

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 694-4 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 694-4 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 694-5 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 694-5 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.138	0.138	0.032	0.032
500.000	1.0	0.781	0.919	0.046	0.079
353.553	1.5	2.241	3.160	0.134	0.213
250.000	2.0	4.062	7.222	0.244	0.456
176.777	2.5	4.194	11.416	0.194	0.650
125.000	3.0	5.980	17.396	0.489	1.139
88.388	3.5	6.338	23.734	1.801	2.941
62.500	4.0	6.002	29.736	3.690	6.630
44.194	4.5	4.085	33.820	5.818	12.449
31.250	5.0	4.085	37.905	5.818	18.267
22.097	5.5	5.452	43.357	7.727	25.994
15.625	6.0	5.452	48.809	7.727	33.722
11.049	6.5	5.405	54.214	7.492	41.214
7.813	7.0	5.405	59.619	7.492	48.706
5.524	7.5	4.038	63.657	6.462	55.168
3.906	8.0	4.038	67.695	6.462	61.630
2.762	8.5	2.488	70.183	2.100	63.731
1.953	9.0	2.488	72.672	2.100	65.831
1.381	9.5	6.832	79.504	8.542	74.373
0.977	10.0	6.832	86.336	8.542	82.916
0.691	10.5	6.832	93.168	8.542	91.458
0.488	11.0	6.832	100.000	8.542	100.000

Median	6.110	7.100
Mean	6.227	7.312
Mean size (Folk)	6.274	7.323
Standard Deviation	2.944	2.298
Sorting (Trask).....	6.880	4.143
Skewness (Folk).....	0.043	0.084
Kurtosis (Folk).....	0.656	0.692
Sand %	29.736	6.630
Silt %	37.960	55.000
Clay %	32.305	38.370

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 695-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 695-3 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 695-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 695-3 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.000	0.000	0.000	0.000
500.000	1.0	0.004	0.004	0.075	0.075
353.553	1.5	0.003	0.007	0.040	0.114
250.000	2.0	0.011	0.017	0.070	0.184
176.777	2.5	0.019	0.036	0.130	0.314
125.000	3.0	0.021	0.057	0.798	1.112
88.388	3.5	0.052	0.109	15.441	16.554
62.500	4.0	0.197	0.306	26.257	42.811
44.194	4.5	6.156	6.462	14.104	56.914
31.250	5.0	6.156	12.617	14.104	71.018
22.097	5.5	10.037	22.654	4.531	75.549
15.625	6.0	10.037	32.691	4.531	80.079
11.049	6.5	7.907	40.599	3.117	83.196
7.813	7.0	7.907	48.506	3.117	86.313
5.524	7.5	6.666	55.172	2.452	88.766
3.906	8.0	6.666	61.838	2.452	91.218
2.762	8.5	2.205	64.043	1.943	93.161
1.953	9.0	2.205	66.248	1.943	95.104
1.381	9.5	8.438	74.686	1.224	96.328
0.977	10.0	8.438	83.124	1.224	97.552
0.691	10.5	8.438	91.562	1.224	98.776
0.488	11.0	8.438	100.000	1.224	100.000

Median	7.112	4.255
Mean	7.446	4.874
Mean size (Folk)	7.444	4.789
Standard Deviation	2.102	1.798
Sorting (Trask).....	3.866	1.852
Skewness (Folk).....	0.170	0.561
Kurtosis (Folk).....	0.664	1.347
Sand %	0.306	42.811
Silt %	61.532	48.407
Clay %	38.162	8.782

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 696-5 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 696-5 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 696-6 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 696-6 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	.0.0	0.081	0.081	0.070	0.070
707.107	0.5	0.072	0.152	0.060	0.130
500.000	1.0	0.249	0.402	0.119	0.248
353.553	1.5	0.428	0.830	0.213	0.461
250.000	2.0	0.509	1.339	0.494	0.956
176.777	2.5	0.315	1.654	0.464	1.420
125.000	3.0	0.365	2.019	0.390	1.810
88.388	3.5	0.523	2.542	0.522	2.332
62.500	4.0	1.184	3.726	1.213	3.545
44.194	4.5	1.370	5.096	1.174	4.719
31.250	5.0	1.370	6.466	1.174	5.893
22.097	5.5	2.514	8.980	24.981	30.874
15.625	6.0	2.514	11.494	24.981	55.855
11.049	6.5	6.828	18.322	16.745	72.600
7.813	7.0	6.828	25.150	16.745	89.344
5.524	7.5	8.331	33.481	2.806	92.150
3.906	8.0	8.331	41.812	2.806	94.956
2.762	8.5	2.502	44.314	0.498	95.454
1.953	9.0	2.502	46.815	0.498	95.951
1.381	9.5	13.296	60.112	1.012	96.963
0.977	10.0	13.296	73.408	1.012	97.976
0.691	10.5	13.296	86.704	1.012	98.988
0.488	11.0	13.296	100.000	1.012	100.000

Median	9.120	5.833
Mean	8.376	6.037
Mean size (Folk)	8.616	5.975
Standard Deviation	2.086	1.261
Sorting (Trask).....	2.899	1.510
Skewness (Folk).....	-0.419	0.216
Kurtosis (Folk).....	0.847	1.180
Sand %	3.726	3.545
Silt %	38.086	91.411
Clay %	58.188	5.044

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 696-7 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 696-7 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 696-8 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 696-8 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.049	0.049
2000.000	-1.0	0.121	0.121	0.150	0.199
1414.214	-0.5	0.000	0.121	0.221	0.420
1000.000	.0.0	0.269	0.390	0.301	0.722
707.107	0.5	0.337	0.727	0.866	1.587
500.000	1.0	0.475	1.202	4.841	6.428
353.553	1.5	0.455	1.657	17.073	23.501
250.000	2.0	0.479	2.136	22.607	46.108
176.777	2.5	0.468	2.603	8.806	54.914
125.000	3.0	0.589	3.192	5.159	60.074
88.388	3.5	0.712	3.904	4.721	64.795
62.500	4.0	1.257	5.162	3.611	68.406
44.194	4.5	2.613	7.775	2.016	70.420
31.250	5.0	2.613	10.387	2.016	72.436
22.097	5.5	33.040	43.427	9.788	82.223
15.625	6.0	33.040	76.467	9.788	92.011
11.049	6.5	7.048	83.515	0.519	92.530
7.813	7.0	7.048	90.563	0.519	93.048
5.524	7.5	1.193	91.756	0.115	93.163
3.906	8.0	1.193	92.950	0.115	93.279
2.762	8.5	0.365	93.314	0.515	93.793
1.953	9.0	0.365	93.679	0.515	94.307
1.381	9.5	1.580	95.259	1.423	95.731
0.977	10.0	1.580	96.839	1.423	97.154
0.691	10.5	1.580	98.420	1.423	98.577
0.488	11.0	1.580	100.000	1.423	100.000

Median	5.599	2.221
Mean	5.772	3.271
Mean size (Folk)	5.740	3.031
Standard Deviation	1.516	2.432
Sorting (Trask).....	1.300	3.480
Skewness (Folk).....	0.342	0.619
Kurtosis (Folk).....	2.969	0.956
Sand %	5.041	68.206
Silt %	87.788	24.873
Clay %	7.050	6.722

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 697-10 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 697-10 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 697-17 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 697-17 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.017	0.017
1414.214	-0.5	0.264	0.264	0.270	0.287
1000.000	0.0	0.144	0.408	0.783	1.069
707.107	0.5	0.128	0.536	0.410	1.479
500.000	1.0	0.085	0.621	0.254	1.733
353.553	1.5	0.065	0.686	0.250	1.983
250.000	2.0	0.100	0.786	0.321	2.305
176.777	2.5	0.140	0.926	0.275	2.580
125.000	3.0	0.299	1.225	0.268	2.848
88.388	3.5	0.466	1.691	0.881	3.729
62.500	4.0	0.895	2.588	0.173	3.902
44.194	4.5	2.161	4.748	1.206	5.108
31.250	5.0	2.161	6.909	1.206	6.313
22.097	5.5	0.000	6.909	2.238	8.551
15.625	6.0	0.000	6.909	2.238	10.789
11.049	6.5	9.383	16.292	5.173	15.962
7.813	7.0	9.383	25.676	5.173	21.135
5.524	7.5	4.808	30.484	14.872	36.008
3.906	8.0	4.808	35.292	14.872	50.880
2.762	8.5	18.164	53.456	12.672	63.552
1.953	9.0	18.164	71.620	12.672	76.223
1.381	9.5	7.095	78.715	5.944	82.168
0.977	10.0	7.095	85.810	5.944	88.112
0.691	10.5	7.095	92.905	5.944	94.056
0.488	11.0	7.095	100.000	5.944	100.000

Median	8.405	7.970
Mean	8.123	7.846
Mean size (Folk)	8.254	8.043
Standard Deviation	1.790	1.939
Sorting (Trask).....	2.199	1.880
Skewness (Folk).....	-0.199	-0.040
Kurtosis (Folk).....	1.097	1.378
Sand %	2.588	3.885
Silt %	32.704	46.978
Clay %	64.708	49.120

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 697-24 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 697-24 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 697-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 697-3 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.118	0.118
1414.214	-0.5	0.000	0.000	0.043	0.160
1000.000	0.0	0.402	0.402	0.055	0.215
707.107	0.5	0.519	0.921	0.116	0.331
500.000	1.0	0.503	1.424	0.452	0.782
353.553	1.5	0.452	1.876	1.068	1.850
250.000	2.0	0.563	2.439	1.053	2.903
176.777	2.5	0.322	2.761	0.610	3.513
125.000	3.0	0.302	3.063	0.613	4.127
88.388	3.5	0.577	3.640	0.766	4.893
62.500	4.0	0.873	4.512	1.410	6.303
44.194	4.5	2.271	6.783	0.801	7.103
31.250	5.0	2.271	9.054	0.801	7.904
22.097	5.5	1.589	10.643	5.316	13.221
15.625	6.0	1.589	12.232	5.316	18.537
11.049	6.5	23.003	35.235	3.894	22.431
7.813	7.0	23.002	58.237	3.894	26.324
5.524	7.5	17.220	75.457	5.082	31.406
3.906	8.0	17.220	92.678	5.082	36.488
2.762	8.5	0.216	92.894	11.648	48.136
1.953	9.0	0.216	93.110	11.648	59.784
1.381	9.5	1.723	94.832	10.054	69.838
0.977	10.0	1.723	96.555	10.054	79.892
0.691	10.5	1.723	98.277	10.054	89.946
0.488	11.0	1.723	100.000	10.054	100.000

Median	6.821	8.580
Mean	6.765	8.069
Mean size (Folk)	6.884	8.182
Standard Deviation	1.568	2.249
Sorting (Trask).....	1.521	2.758
Skewness (Folk).....	0.058	-0.333
Kurtosis (Folk).....	1.844	1.010
Sand %	4.512	6.185
Silt %	88.165	30.185
Clay %	7.322	63.512

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER 698-11 FREQUENCY (wt. percent)	SAMPLE NUMBER 698-11 CUMULATIVE (wt. percent)	SAMPLE NUMBER 699-12 FREQUENCY (wt. percent)	SAMPLE NUMBER 699-12 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.000	0.000	0.000	0.000
500.000	1.0	0.108	0.108	0.000	0.000
353.553	1.5	0.280	0.388	0.000	0.000
250.000	2.0	0.617	1.005	0.020	0.020
176.777	2.5	0.634	1.639	0.000	0.020
125.000	3.0	0.355	1.994	0.009	0.028
88.388	3.5	0.679	2.673	0.014	0.042
62.500	4.0	1.396	4.009	0.017	0.059
44.194	4.5	0.938	4.946	3.099	3.157
31.250	5.0	0.938	5.884	3.099	6.256
22.097	5.5	5.684	11.567	0.000	6.256
15.625	6.0	5.684	17.251	0.000	6.256
11.049	6.5	30.172	47.423	39.419	45.675
7.813	7.0	30.172	77.595	39.419	85.093
5.524	7.5	9.413	87.008	2.129	87.223
3.906	8.0	9.413	96.420	2.129	89.352
2.762	8.5	0.003	96.423	0.067	89.419
1.953	9.0	0.003	96.425	0.067	89.485
1.381	9.5	0.894	97.319	2.629	92.114
0.977	10.0	0.894	98.213	2.629	94.743
0.691	10.5	0.894	99.106	2.629	97.371
0.488	11.0	0.894	100.000	2.629	100.000

Median	6.543	6.555
Mean	6.513	6.787
Mean size (Folk)	6.591	6.555
Standard Deviation	1.214	1.264
Sorting (Trask)	1.333	1.246
Skewness (Folk)	-0.043	0.165
Kurtosis (Folk)	1.680	3.394
Sand %	4.009	0.059
Silt %	92.412	89.293
Clay %	3.580	10.648

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 699-56 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 699-56 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 700-2 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 700-2 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.357	0.357	0.000	0.000
1000.000	0.0	0.598	0.955	0.000	0.000
707.107	0.5	0.342	1.297	0.040	0.040
500.000	1.0	0.207	1.504	0.040	0.079
353.553	1.5	0.122	1.627	0.164	0.243
250.000	2.0	0.153	1.780	0.283	0.525
176.777	2.5	0.136	1.915	0.264	0.789
125.000	3.0	0.148	2.063	0.350	1.139
88.388	3.5	0.118	2.181	1.225	2.365
62.500	4.0	0.390	2.571	2.814	5.179
44.194	4.5	0.438	3.009	0.000	5.179
31.250	5.0	0.438	3.447	0.000	5.179
22.097	5.5	23.596	27.043	0.000	5.179
15.625	6.0	23.596	50.639	0.000	5.179
11.049	6.5	15.185	65.824	44.101	49.280
7.813	7.0	15.185	81.009	44.101	93.382
5.524	7.5	1.433	82.443	0.000	93.382
3.906	8.0	1.433	83.876	0.000	93.382
2.762	8.5	0.543	84.418	1.883	95.265
1.953	9.0	0.543	84.961	1.883	97.148
1.381	9.5	3.760	88.721	0.713	97.861
0.977	10.0	3.760	92.480	0.713	98.574
0.691	10.5	3.760	96.240	0.713	99.287
0.488	11.0	3.760	100.000	0.713	100.000

Median	5.986	6.508
Mean	6.448	6.507
Mean size (Folk)	6.456	6.508
Standard Deviation	1.826	1.069
Sorting (Trask)	1.594	1.217
Skewness (Folk)	0.567	-0.069
Kurtosis (Folk)	1.615	3.226
Sand %	2.571	5.179
Silt %	81.304	88.203
Clay %	16.124	6.618

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER 700-5 FREQUENCY (wt. percent)	SAMPLE NUMBER 700-5 CUMULATIVE (wt. percent)	SAMPLE NUMBER 700-10 FREQUENCY (wt. percent)	SAMPLE NUMBER 700-10 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	.0.0	0.000	0.000	0.000	0.000
707.107	0.5	0.049	0.049	0.050	0.050
500.000	1.0	0.160	0.209	0.114	0.164
353.553	1.5	0.295	0.504	0.239	0.402
250.000	2.0	0.379	0.883	0.240	0.642
176.777	2.5	0.285	1.167	0.125	0.767
125.000	3.0	0.282	1.450	0.107	0.874
88.388	3.5	0.483	1.932	0.227	1.101
62.500	4.0	0.971	2.903	0.573	1.674
44.194	4.5	3.156	6.059	1.849	3.523
31.250	5.0	3.156	9.214	1.849	5.372
22.097	5.5	3.641	12.855	5.097	10.468
15.625	6.0	3.641	16.497	5.097	15.565
11.049	6.5	22.709	39.205	28.569	44.133
7.813	7.0	22.709	61.914	28.569	72.702
5.524	7.5	11.912	73.826	6.191	78.893
3.906	8.0	11.912	85.738	6.191	85.085
2.762	8.5	2.236	87.975	0.955	86.040
1.953	9.0	2.236	90.211	0.955	86.994
1.381	9.5	2.447	92.658	3.251	90.246
0.977	10.0	2.447	95.105	3.251	93.497
0.691	10.5	2.447	97.553	3.251	96.749
0.488	11.0	2.447	100.000	3.251	100.000

Median	6.738	6.603
Mean	6.860	6.875
Mean size (Folk)	6.866	6.841
Standard Deviation	1.533	1.509
Sorting (Trask).....	1.603	1.424
Skewness (Folk).....	0.170	0.368
Kurtosis (Folk).....	1.699	2.141
Sand %	2.903	1.674
Silt %	82.835	83.411
Clay %	14.262	14.915

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER 702-7 FREQUENCY (wt. percent)	SAMPLE NUMBER 702-7 CUMULATIVE (wt. percent)	SAMPLE NUMBER 704-2 FREQUENCY (wt. percent)	SAMPLE NUMBER 704-2 CUMULATIVE (wt. percent)
2828.427	+1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.081	0.081
1000.000	.0.0	0.000	0.000	0.021	0.102
707.107	0.5	0.000	0.000	0.089	0.191
500.000	1.0	0.000	0.000	0.372	0.562
353.553	1.5	0.000	0.000	0.928	1.491
250.000	2.0	0.000	0.000	0.973	2.463
176.777	2.5	0.000	0.000	0.562	3.025
125.000	3.0	0.000	0.000	0.620	3.646
88.388	3.5	0.424	0.424	0.745	4.391
62.500	4.0	1.272	1.696	1.343	5.734
44.194	4.5	0.000	1.696	0.327	6.061
31.250	5.0	0.000	1.696	0.327	6.389
22.097	5.5	1.078	2.773	2.437	8.826
15.625	6.0	1.078	3.851	2.437	11.263
11.049	6.5	40.999	44.849	7.246	18.509
7.813	7.0	40.999	85.848	7.246	25.756
5.524	7.5	2.249	88.097	11.938	37.694
3.906	8.0	2.249	90.346	11.938	49.632
2.762	8.5	0.698	91.044	8.489	58.121
1.953	9.0	0.698	91.742	8.489	66.611
1.381	9.5	2.064	93.807	8.347	74.958
0.977	10.0	2.064	95.871	8.347	83.305
0.691	10.5	2.064	97.936	8.347	91.653
0.488	11.0	2.064	100.000	8.347	100.000

Median	6.563	8.022
Mean	6.792	7.948
Mean size (Folk)	6.563	8.130
Standard Deviation	1.128	2.045
Sorting (Trask).....	1.235	2.424
Skewness (Folk).....	0.355	-0.072
Kurtosis (Folk).....	2.537	1.119
Sand %	1.696	5.734
Silt %	88.651	43.899
Clay %	9.654	50.368

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 704-7 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 704-7 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 705-15 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 705-15 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.056	0.056
2000.000	-1.0	0.000	0.000	0.000	0.056
1414.214	-0.5	0.000	0.000	0.011	0.066
1000.000	0.0	0.000	0.000	0.062	0.128
707.107	0.5	0.000	0.000	0.153	0.282
500.000	1.0	0.258	0.258	0.496	0.778
353.553	1.5	0.044	0.302	1.029	1.806
250.000	2.0	0.126	0.428	1.154	2.960
176.777	2.5	0.310	0.738	0.910	3.870
125.000	3.0	2.912	3.650	0.906	4.776
88.388	3.5	7.408	11.058	1.064	5.840
62.500	4.0	13.861	20.919	1.989	7.829
44.194	4.5	22.604	43.523	2.432	10.261
31.250	5.0	22.604	72.127	2.432	12.694
22.097	5.5	7.035	79.162	3.169	15.863
15.625	6.0	7.035	86.197	3.169	19.032
11.049	6.5	2.206	88.403	17.572	36.603
7.813	7.0	2.206	90.609	17.572	54.175
5.524	7.5	0.131	90.740	13.927	68.102
3.906	8.0	0.131	90.871	13.927	82.029
2.762	8.5	0.391	91.262	1.902	83.931
1.953	9.0	0.391	91.653	1.902	85.833
1.381	9.5	2.087	93.740	3.542	89.375
0.977	10.0	2.087	95.827	3.542	92.917
0.691	10.5	2.087	97.913	3.542	96.458
0.488	11.0	2.087	100.000	3.542	100.000

Median	4.511	6.881
Mean	4.943	6.871
Mean size (Folk)	4.670	6.974
Standard Deviation	1.795	1.942
Sorting (Trask)	1.550	1.728
Skewness (Folk)	0.398	0.021
Kurtosis (Folk)	2.175	1.867
Sand %	26.919	7.773
Silt %	63.953	74.200
Clay %	9.129	17.971

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER 705-19 FREQUENCY (wt. percent)	SAMPLE NUMBER 705-19 CUMULATIVE (wt. percent)	SAMPLE NUMBER 706-10 FREQUENCY (wt. percent)	SAMPLE NUMBER 706-10 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.539	0.539
1000.000	0.0	0.000	0.000	0.305	0.844
707.107	0.5	0.022	0.022	0.214	1.058
500.000	1.0	0.083	0.106	0.322	1.380
353.553	1.5	0.403	0.508	0.582	1.962
250.000	2.0	0.885	1.393	0.417	2.380
176.777	2.5	0.948	2.342	0.298	2.678
125.000	3.0	0.781	3.122	0.350	3.028
88.388	3.5	0.965	4.087	0.531	3.559
62.500	4.0	0.905	4.993	1.007	4.566
44.194	4.5	1.582	6.575	4.601	9.168
31.250	5.0	1.582	8.158	4.601	13.769
22.097	5.5	3.356	11.513	0.000	13.769
15.625	6.0	3.356	14.869	0.000	13.769
11.049	6.5	36.758	51.626	12.620	26.390
7.813	7.0	36.758	88.384	12.620	39.010
5.524	7.5	1.629	90.013	20.530	59.540
3.906	8.0	1.629	91.641	20.530	80.070
2.762	8.5	0.000	91.641	4.089	84.160
1.953	9.0	0.000	91.641	4.089	88.249
1.381	9.5	2.090	93.731	2.938	91.187
0.977	10.0	2.090	95.821	2.938	94.124
0.691	10.5	2.090	97.910	2.938	97.062
0.488	11.0	2.090	100.000	2.938	100.000

Median	6.478	7.268
Mean	6.500	7.089
Mean size (Folk)	6.478	7.279
Standard Deviation	1.459	1.841
Sorting (Trask)	1.266	1.642
Skewness (Folk)	0.073	-0.021
Kurtosis (Folk)	3.496	1.747
Sand %	4.993	4.566
Silt %	86.649	75.504
Clay %	8.359	19.930

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 706-14 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 706-14 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 707-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 707-3 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.160	0.160
2000.000	-1.0	0.000	0.000	0.000	0.160
1414.214	-0.5	0.000	0.000	0.000	0.160
1000.000	0.0	0.000	0.000	0.393	0.553
707.107	0.5	0.000	0.000	0.553	1.106
500.000	1.0	0.014	0.014	0.758	1.863
353.553	1.5	0.044	0.059	0.708	2.571
250.000	2.0	0.204	0.262	0.611	3.182
176.777	2.5	0.142	0.404	0.430	3.612
125.000	3.0	0.317	0.721	0.348	3.960
88.388	3.5	1.796	2.517	0.304	4.264
62.500	4.0	3.709	6.226	0.348	4.612
44.194	4.5	2.675	8.900	0.000	4.612
31.250	5.0	2.675	11.575	0.000	4.612
22.097	5.5	3.309	14.884	39.903	44.515
15.625	6.0	3.309	18.194	39.903	84.419
11.049	6.5	5.923	24.117	2.041	86.459
7.813	7.0	5.923	30.040	2.041	88.500
5.524	7.5	7.447	37.487	0.000	88.500
3.906	8.0	7.447	44.935	0.000	88.500
2.762	8.5	3.254	48.189	1.471	89.971
1.953	9.0	3.254	51.443	1.471	91.442
1.381	9.5	12.139	63.582	2.139	93.582
0.977	10.0	12.139	75.721	2.139	95.721
0.691	10.5	12.139	87.861	2.139	97.861
0.488	11.0	12.139	100.000	2.139	100.000

Median	8.778	5.569
Mean	8.114	5.862)
Mean size (Folk)	8.263	5.569
Standard Deviation	2.194	1.692
Sorting (Trask).....	3.244	1.243
Skewness (Folk).....	-0.376	0.383
Kurtosis (Folk).....	0.840	3.157
Sand %	6.266	4.452
Silt %	38.709	83.888
Clay %	55.065	11.500

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 707-13 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 707-13 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 709-3 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 709-3 CUMULATIVE (wt. percent)
2828.427	+1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.000	0.000
1000.000	0.0	0.055	0.055	0.038	0.038
707.107	0.5	0.015	0.070	0.000	0.038
500.000	1.0	0.027	0.096	0.020	0.058
353.553	1.5	0.066	0.163	0.048	0.106
250.000	2.0	0.266	0.429	0.116	0.221
176.777	2.5	0.333	0.762	0.099	0.320
125.000	3.0	0.332	1.094	0.116	0.435
88.388	3.5	0.506	1.600	0.192	0.627
62.500	4.0	0.542	2.142	0.659	1.287
44.194	4.5	0.556	2.698	0.000	1.287
31.250	5.0	0.556	3.255	0.000	1.287
22.097	5.5	5.961	9.215	2.833	4.120
15.625	6.0	5.961	15.176	2.833	6.953
11.049	6.5	4.739	19.915	4.434	11.387
7.813	7.0	4.739	24.655	4.434	15.821
5.524	7.5	6.838	31.492	4.192	20.013
3.906	8.0	6.838	38.330	4.192	24.205
2.762	8.5	22.407	60.737	13.415	37.620
1.953	9.0	22.407	83.144	13.415	51.035
1.381	9.5	4.214	87.358	12.241	63.276
0.977	10.0	4.214	91.572	12.241	75.518
0.691	10.5	4.214	95.786	12.241	87.759
0.488	11.0	4.214	100.000	12.241	100.000

Median	8.260	8.961
Mean	7.901	8.733
Mean size (Folk)	7.816	8.776
Standard Deviation	1.618	1.605
Sorting (Trask).....	1.862	1.965
Skewness (Folk).....	-0.313	-0.227
Kurtosis (Folk).....	1.202	1.081
Sand %	2.142	1.287
Silt %	36.188	22.919
Clay %	61.670	75.795

SIZE GRADE (mm)	(CLASS LIMITS) phi units	SAMPLE NUMBER ZW 709-31 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 709-31 CUMULATIVE (wt. percent)	SAMPLE NUMBER ZW 709-4 FREQUENCY (wt. percent)	SAMPLE NUMBER ZW 709-4 CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000	0.000	0.000
2000.000	-1.0	0.000	0.000	0.000	0.000
1414.214	-0.5	0.000	0.000	0.032	0.032
1000.000	0.0	0.000	0.000	0.000	0.032
707.107	0.5	0.000	0.000	0.021	0.053
500.000	1.0	0.037	0.037	0.017	0.070
353.553	1.5	0.032	0.069	0.107	0.177
250.000	2.0	0.203	0.273	0.869	1.045
176.777	2.5	0.216	0.489	0.987	2.032
125.000	3.0	0.242	0.731	1.182	3.214
88.388	3.5	0.851	1.582	1.069	4.283
62.500	4.0	1.896	3.478	0.853	5.136
44.194	4.5	0.000	3.478	1.439	6.575
31.250	5.0	0.000	3.478	1.439	8.013
22.097	5.5	1.063	4.541	3.574	11.588
15.625	6.0	1.063	5.605	3.574	15.162
11.049	6.5	6.676	12.280	37.457	52.619
7.813	7.0	6.676	18.956	37.457	90.076
5.524	7.5	11.024	29.980	1.248	91.323
3.906	8.0	11.024	41.004	1.248	92.571
2.762	8.5	12.293	53.297	0.241	92.811
1.953	9.0	12.293	65.589	0.241	93.052
1.381	9.5	8.603	74.192	1.737	94.789
0.977	10.0	8.603	82.795	1.737	96.526
0.691	10.5	8.603	91.397	1.737	98.263
0.488	11.0	8.603	100.000	1.737	100.000

Median	8.366	6.495
Mean	8.284	6.453
Mean size (Folk)	8.405	6.465
Standard Deviation	1.667	1.391
Sorting (Trask).....	2.198	1.260
Skewness (Folk).....	-0.013	0.049
Kurtosis (Folk).....	0.900	3.464
Sand %	3.478	5.136
Silt %	37.526	87.435
Clay %	58.996	7.429

SAMPLE NUMBER ZW 712-7

SIZE GRADE (mm)	(CLASS LIMITS) phi units	FREQUENCY (wt. percent)	CUMULATIVE (wt. percent)
2828.427	-1.5	0.000	0.000
2000.000	-1.0	0.000	0.000
1414.214	-0.5	0.000	0.000
1000.000	0.0	0.028	0.028
707.107	0.5	0.011	0.038
500.000	1.0	0.011	0.049
353.553	1.5	0.012	0.061
250.000	2.0	0.002	0.063
176.777	2.5	0.000	0.063
125.000	3.0	0.000	0.063
88.388	3.5	0.000	0.063
62.500	4.0	0.004	0.067
44.194	4.5	0.106	0.173
31.250	5.0	0.106	0.279
22.097	5.5	0.576	0.855
15.625	6.0	0.576	1.431
11.049	6.5	13.422	14.853
7.813	7.0	13.422	28.275
5.524	7.5	29.709	57.983
3.906	8.0	29.709	87.692
2.762	8.5	3.203	90.895
1.953	9.0	3.203	94.098
1.381	9.5	1.476	95.573
0.977	10.0	1.476	97.049
0.691	10.5	1.476	98.524
0.488	11.0	1.476	100.000

Median	7.366
Mean	7.409
Mean size (Folk)	7.282
Standard Deviation	0.932
Sorting (Trask).....	1.370
Skewness (Folk).....	0.022
Kurtosis (Folk).....	1.431
Sand %	0.067
Silt %	87.625
Clay %	12.308

Appendix II - Chemical analyses of the eastern Mediterranean and Aegean sea sediments.

The data on the sediments examined from the different parts of the study area are presented both on a non carbonate free basis (page 383-404) and on a carbonate free basis (page 405-426).

In the sample number, the first three numbers from the left hand side represent the core number and the last two numbers indicate the sample number within the core, as shown on the charts (page 253-296).

METAL CONCENTRATIONS,

(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)	TI(PPM)
69001	19.87	2.62	1084.25	7.35	46.92	94.62	69.48	2.28	162.61	44.79	2.43	178.53	2243.27
69002	4.38	2.50	1047.90	12.18	23.76	57.29	68.29	.92	74.85	19.88	.01	45.94	2019.75
69003	3.71	3.12	785.93	13.47	17.33	44.81	68.29	.87	62.38	19.88	.01	33.47	3368.26
69004	18.58	2.87	1173.83	7.74	43.27	82.32	72.11	2.37	174.93	44.87	1.18	233.33	2372.63
69005	17.24	2.99	1010.48	7.98	74.41	82.24	84.51	2.37	212.08	57.31	2.43	295.45	2245.51
69006	19.13	2.87	700.00	7.25	69.56	69.91	80.93	2.32	187.50	44.92	2.43	283.54	2125.00
69007	17.01	2.87	1075.00	8.13	35.81	69.93	72.18	2.50	187.50	44.92	.01	233.54	2750.00
69008	15.94	2.87	837.08	8.25	53.28	69.87	77.14	2.67	187.41	57.39	2.43	245.91	2623.69
69001	17.24	3.12	1247.50	7.73	49.46	57.29	68.30	3.03	199.60	44.83	1.18	245.55	2120.76
69002	17.27	3.12	849.58	8.00	39.54	44.83	67.15	2.95	212.33	44.90	1.18	245.91	2373.81
69003	15.94	2.62	837.50	7.13	29.56	44.90	62.18	2.75	262.50	32.42	2.43	233.54	2.25.00
69004	17.01	2.37	762.50	6.37	24.56	57.40	48.43	2.79	187.50	32.42	2.43	208.54	2125.00
69005	20.69	1.50	723.55	4.24	19.52	57.29	40.85	2.02	187.13	32.36	6.17	120.80	1372.26
69006	17.77	1.75	673.65	5.49	19.52	44.82	48.34	2.17	187.13	32.36	4.92	170.70	1996.71
69007	17.81	2.00	725.00	6.00	20.81	44.90	47.18	2.01	187.50	32.42	3.68	171.04	2200.00
69008	23.36	1.37	736.76	3.25	15.80	32.37	35.97	2.29	124.88	32.39	4.93	120.92	1373.63
69009	21.23	2.62	811.28	11.11	42.08	57.32	65.84	1.54	124.81	32.37	2.43	120.85	2121.82
69101	13.27	3.62	1148.85	7.49	49.51	32.37	57.12	4.40	287.21	44.87	1.18	458.08	2622.39
69102	13.27	4.12	872.69	8.36	46.99	32.36	70.83	4.82	312.03	44.85	.01	507.77	2745.83
69103	13.27	3.87	849.15	7.74	44.52	44.86	67.11	4.62	299.70	44.87	.01	495.54	2747.25
69104	13.27	3.99	848.73	7.61	44.49	44.84	73.32	4.71	312.03	44.85	.01	495.29	2745.65
69105	13.27	3.75	886.61	7.62	51.75	57.35	77.10	4.93	312.19	44.87	.01	495.54	2747.25
69201	20.99	2.37	900.00	6.00	27.96	69.91	50.93	1.88	162.50	32.42	4.93	233.54	2250.00
69202	19.91	3.75	974.03	7.87	48.26	57.35	69.61	3.96	274.73	44.88	1.18	433.10	2822.38
69203	13.29	3.75	1025.00	8.13	50.81	44.90	77.18	3.85	325.00	44.92	2.43	433.54	2750.00
69301	16.20	3.37	949.53	8.25	57.03	69.87	69.65	2.92	212.39	44.90	1.18	253.41	2623.69
69302	15.93	3.12	636.86	7.99	50.75	44.86	72.11	3.21	237.26	57.36	1.18	320.72	2872.13

METAL CONCENTRATIONS.
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)	TI(PPM)
69709	16.21	2.62	2025.00	7.75	54.56	69.99	65.93	2.06	187.50	44.92	.01	183.54	2250.00
69710	16.58	2.87	5869.13	6.62	75.93	82.32	68.37	2.10	187.31	44.87	1.18	195.84	2122.88
69711	13.30	2.87	998.00	6.99	90.03	57.29	74.53	2.13	199.60	44.83	2.43	195.65	2120.76
69712	16.57	2.87	760.98	6.35	75.91	69.77	70.79	2.06	174.65	44.83	2.43	208.12	1871.26
69713	16.73	3.25	749.63	7.25	72.02	69.87	78.39	2.30	187.41	44.93	3.68	220.93	1999.00
69714	16.45	3.25	698.95	7.24	59.45	69.69	68.33	2.25	174.74	32.37	2.43	220.71	1997.00
69715	15.68	3.50	537.50	6.50	53.53	44.90	76.93	2.01	175.00	44.92	2.43	233.54	1625.00
69716	15.94	3.25	624.69	7.62	59.53	69.87	72.15	2.41	237.38	32.40	3.68	220.93	2248.88
69717	16.46	3.50	711.79	6.74	94.47	69.84	72.11	2.00	174.83	44.87	4.93	195.64	1673.13
69718	18.60	2.62	1337.50	6.75	57.06	69.91	70.93	1.68	162.50	32.42	1.18	171.84	2125.00
69719	15.91	3.12	1216.08	7.49	51.94	57.29	62.06	2.33	199.60	32.35	.01	183.17	2245.51
69720	15.94	3.12	1062.50	8.03	79.56	57.40	73.43	2.27	187.50	44.92	1.18	183.54	2250.00
69721	14.87	3.12	924.08	8.24	44.52	57.35	70.86	2.45	174.63	32.39	.01	183.35	2497.50
69722	18.58	2.75	2260.24	6.74	119.44	69.84	79.00	1.97	162.34	44.87	.01	171.87	2122.88
69723	13.94	3.37	1123.88	9.12	84.47	57.35	80.85	2.50	174.83	32.39	.01	195.84	2372.63
69724	19.36	2.62	2332.83	6.74	184.19	69.77	63.31	1.93	162.18	57.31	4.92	170.76	2120.76
69725	15.93	3.25	886.61	8.62	52.01	44.86	75.86	2.51	237.26	44.87	4.93	183.35	2497.50
69801	20.71	2.50	935.56	6.24	57.06	82.32	63.37	2.16	149.85	57.36	4.93	145.89	2122.88
69802	19.65	3.62	3746.25	6.24	59.49	69.84	94.59	1.89	187.31	57.36	4.93	195.64	1873.13
69803	18.83	3.37	449.10	6.11	85.64	69.77	74.53	1.81	162.18	57.31	7.42	195.65	1871.26
69804	18.57	3.00	574.14	7.24	55.98	57.32	65.83	2.25	162.25	44.85	2.43	170.76	2246.63
69805	20.45	2.87	674.66	7.25	44.54	57.38	67.15	2.45	174.91	44.90	4.93	145.96	2373.81
69806	17.26	3.00	999.00	7.87	62.00	69.84	68.36	2.25	187.31	44.87	1.18	171.87	2497.50
69807	1.85	2.52	1134.10	15.20	85.55	69.69	123.06	.67	74.78	32.32	2.42	58.36	2492.52
69808	15.67	3.25	937.03	8.12	67.33	69.87	70.90	2.44	162.42	32.40	2.43	170.95	2573.56
69809	19.13	2.75	8625.00	7.13	119.55	57.41	73.43	2.54	175.00	94.92	2.43	246.84	2500.00
69810	14.87	3.37	1411.09	8.74	55.99	69.83	74.61	2.36	187.31	44.87	2.43	183.35	2497.50

METAL CONCENTRATIONS.
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)	TI(PPM)
69811	19.10	2.87	2120.76	7.24	59.44	57.29	68.30	2.12	162.18	44.83	2.43	145.75	2120.76
69901	16.43	2.62	760.22	6.61	56.89	69.70	76.72	2.19	174.48	44.79	1.18	170.52	2118.64
69902	16.73	2.62	661.84	6.74	57.02	57.35	59.62	2.22	162.34	44.87	1.18	170.87	2122.88
69903	14.62	2.50	662.50	6.25	69.56	57.40	58.43	1.69	137.50	44.92	1.18	133.54	2000.00
69904	15.41	2.87	1100.00	7.63	62.36	69.90	72.18	2.22	175.00	44.92	1.18	171.04	2250.00
69905	15.40	2.87	999.60	7.49	59.50	69.83	70.86	2.20	149.85	44.87	1.18	170.87	2247.75
69906	15.41	2.75	949.05	7.49	65.74	57.35	72.11	2.21	149.85	32.39	2.43	195.84	2247.75
69907	15.38	2.74	923.15	7.36	59.44	57.29	65.80	2.25	174.65	32.35	2.43	183.17	2120.76
69908	15.65	2.87	973.65	7.11	59.44	57.29	72.04	2.26	174.65	44.83	2.43	195.05	2245.51
69909	14.64	2.74	960.13	6.73	61.66	57.26	76.24	2.21	174.55	44.81	2.43	183.08	2369.08
69910	15.66	2.87	1023.46	7.24	63.22	57.32	72.07	2.17	174.74	44.85	.01	170.78	2371.44
69911	15.94	3.00	1049.49	7.50	57.03	69.87	73.40	2.21	187.41	44.96	4.93	176.95	2373.61
69912	15.93	3.00	1061.44	7.62	63.25	57.35	72.11	2.34	187.31	57.36	2.43	183.35	2247.75
69913	15.91	2.99	972.57	7.48	51.91	69.73	69.51	2.22	174.56	44.81	2.43	170.61	2119.70
69914	15.91	2.99	1099.98	7.35	51.91	57.26	72.00	2.24	174.56	44.81	1.18	170.61	2369.08
69915	15.92	3.00	961.06	7.49	60.72	69.80	68.33	2.25	174.74	44.85	1.18	183.26	1997.00
69916	16.16	2.99	959.62	7.35	59.38	69.70	68.23	2.26	186.94	44.79	3.67	170.52	2118.64
69917	15.90	2.87	1009.47	7.23	59.38	69.70	69.47	2.19	174.46	44.79	1.18	170.52	2245.27
69918	16.21	2.87	1037.50	7.50	57.05	82.40	70.93	2.27	175.00	44.92	1.18	183.54	2125.00

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
69918	17.02	3.30	1160.00	8.30	65.65	55.92	88.75	176.83
69919	17.23	3.00	1150.00	8.10	70.65	65.92	83.75	186.83
69920	17.23	2.90	1120.00	8.20	65.65	65.92	83.75	186.83
69921	17.23	3.00	1120.00	8.00	65.65	65.92	81.75	186.83
69922	16.82	2.90	1130.00	8.60	54.65	65.92	86.75	176.83
69923	16.82	2.90	1110.00	8.00	62.65	65.92	82.75	176.83
69924	10.59	1.30	410.00	4.50	15.65	45.92	26.75	56.83
69925	17.23	3.00	1130.00	8.30	67.65	75.92	88.75	196.83
69926	16.82	3.00	1100.00	8.00	65.65	55.92	83.75	266.83
69927	17.23	2.90	1130.00	8.10	65.65	65.92	86.75	196.83
69929	16.50	2.90	1040.00	7.90	65.65	95.92	78.75	186.83
69930	17.65	3.00	1050.00	8.20	61.65	65.92	84.75	186.83
69931	17.65	2.90	1070.00	8.10	63.65	75.92	86.75	186.83
69932	16.87	3.00	1040.00	8.00	63.65	65.92	84.75	186.83
69933	16.61	2.90	1010.00	7.70	62.65	85.92	72.75	176.83
69934	16.56	2.90	1030.00	8.00	52.65	55.92	73.75	196.83
69935	15.99	2.90	1000.00	8.00	61.65	85.92	76.75	196.83
69936	16.82	3.00	1060.00	8.40	70.65	65.92	82.75	186.83
69937	17.65	3.00	1150.00	8.20	65.65	55.92	83.75	196.83
69938	15.78	2.90	1020.00	7.90	64.65	95.92	76.75	176.83
69939	17.65	2.90	1030.00	8.00	65.65	65.92	83.75	186.83
69940	12.25	3.00	1040.00	8.20	59.65	65.92	83.75	176.83
69941	15.99	2.90	950.00	8.00	65.65	65.92	83.75	166.83
69942	12.87	3.00	860.00	7.80	64.65	95.92	72.75	496.83
69943	17.23	3.00	870.00	8.10	55.65	75.92	76.75	186.83
69944	16.71	2.90	870.00	8.00	53.65	65.92	78.75	176.83
69945	17.44	2.90	880.00	7.80	56.65	65.92	83.75	176.83
69947	17.65	2.80	910.00	7.80	63.65	65.92	79.75	186.83
69948	16.40	2.90	870.00	7.50	62.65	95.92	73.75	186.83
69949	13.60	2.90	910.00	7.60	53.65	75.92	77.75	156.83
69950	18.89	2.90	920.00	7.60	55.65	75.92	85.75	186.83
69950	17.65	3.10	920.00	7.60	50.65	75.92	77.75	176.83
AVERAGE	18.27	3.00	920.00	7.60	53.15	75.92	81.75	181.83
PCT DIFF	3.41	3.33	0	0	3.96	.00	4.89	2.75
69951	17.02	3.00	900.00	7.70	62.65	65.92	79.75	176.83
69952	14.74	3.10	870.00	7.70	55.65	60.92	67.75	146.83
69953	16.62	2.80	830.00	7.20	53.65	85.92	69.75	156.83
69954	13.70	2.70	800.00	7.40	59.65	65.92	74.75	146.83
69955	17.65	3.00	820.00	7.80	56.65	75.92	75.75	156.83

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
69956	16.40	2.90	1350.00	7.00	54.65	65.92	70.75	186.83
70301	13.49	2.90	860.00	7.50	45.65	75.92	77.75	186.83
70302	17.23	2.90	2230.00	7.80	46.65	95.92	72.75	196.83
70303	16.82	2.90	730.00	8.00	40.65	55.92	72.75	196.83
70004	20.14	2.60	550.00	6.90	58.65	75.92	77.75	236.83
70005	19.60	2.60	510.00	6.40	39.65	75.92	60.75	556.83
70006	11.21	3.00	630.00	7.20	46.65	65.92	67.75	186.83
70007	17.85	3.00	830.00	8.00	45.65	65.92	70.75	296.83
70008	16.61	3.10	790.00	7.50	59.65	95.92	72.75	196.83
70009	17.96	2.90	910.00	8.30	43.65	65.92	82.75	196.83
70010	19.51	2.90	640.00	7.20	50.65	65.92	84.75	196.83
70011	18.06	3.00	820.00	8.20	47.65	65.92	84.75	196.83
70201	15.99	2.10	2080.00	6.00	25.65	95.92	46.75	136.83
70202	17.33	3.20	1230.00	8.20	53.65	65.92	76.75	186.83
70204	17.62	3.00	1270.00	8.20	55.65	95.92	78.75	186.83
70205	16.61	3.00	1240.00	8.00	51.65	95.92	74.75	186.83
70206	16.82	3.10	1270.00	8.20	54.65	65.92	79.75	186.83
70207	17.44	3.20	1270.00	8.30	53.65	95.92	73.75	196.83
70301	17.44	3.00	1300.00	7.90	54.65	95.92	71.75	196.83
70302	17.23	3.20	1120.00	8.30	58.65	65.92	74.75	216.83
70303	18.48	3.20	1300.00	8.50	54.65	75.92	86.75	216.83
70304	18.06	3.20	1280.00	8.40	70.65	95.92	79.75	206.83
70305	18.89	3.20	1330.00	8.70	53.65	65.92	88.75	246.83
	17.65	3.20	1300.00	8.40	65.65	95.92	81.75	206.83
AVERAGE	18.27	3.20	1315.00	8.55	67.15	80.92	85.25	226.83
PCT DIFF	3.41	0	1.14	1.75	2.23	18.54**	4.12	.00
70401	18.37	2.90	1110.00	7.90	63.65	65.92	73.75	186.83
70402	18.48	3.50	480.00	6.20	74.65	65.92	74.75	206.83
70403	16.61	3.40	600.00	8.00	57.65	45.92	75.75	186.83
70404	15.57	3.40	810.00	9.70	90.65	55.92	89.75	186.83
70405	17.02	3.50	1220.00	9.60	111.65	55.92	89.75	206.83
70406	15.36	3.30	1280.00	9.40	71.65	55.92	77.75	196.83
70407	3.32	2.90	1390.00	18.00	39.65	65.92	122.74	136.83
70408	15.57	3.20	4300.00	8.40	75.65	75.92	75.75	196.83
70409	14.43	3.40	2080.00	9.40	76.65	75.92	79.75	216.83
70501	19.72	2.60	1070.00	6.50	56.65	65.92	63.75	176.83
70502	24.78	1.71	880.00	4.40	49.65	85.92	64.75	126.83
70503	28.01	1.12	600.00	2.90	33.65	75.93	72.75	126.83
70504	19.93	2.50	950.00	6.50	56.65	65.92	111.75	106.83
70505	14.32	3.20	890.00	8.40	50.65	55.92	83.75	206.83
70506	14.32	3.20	1120.00	8.50	75.65	55.92	106.75	226.83
70507	13.08	3.40	1420.00	8.90	73.65	55.92	96.75	246.83
70508	13.70	3.40	960.00	8.20	78.65	65.92	91.75	266.83
70509	14.22	3.50	840.00	8.30	53.65	55.92	93.75	266.83

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
70510	13.29	3.60	850.00	8.50	72.65	65.92	95.75	266.83
70511	13.49	3.20	790.00	8.00	71.65	65.92	91.75	256.83
70512	14.53	3.50	720.00	8.00	71.65	75.92	84.75	246.83
70513	13.49	3.50	720.00	8.30	74.65	65.92	105.75	256.83
70514	13.49	3.80	700.00	7.90	71.65	75.92	99.75	256.83
70515	16.40	3.60	610.00	6.30	81.65	75.92	99.75	226.83
70516	13.91	3.40	770.00	8.60	85.65	65.92	89.75	216.83
70517	11.31	3.40	670.00	9.10	55.65	65.92	85.75	216.83
70518	12.25	3.60	790.00	9.00	67.65	55.92	93.75	236.83
70519	14.53	3.10	820.00	8.30	70.65	75.92	85.75	206.83
70519	14.53	3.20	820.00	8.50	75.65	75.92	85.75	206.83
AVERAGE	14.53	3.15	820.00	8.40	73.15	75.92	85.75	206.83
PCT DIFF	0	1.59	0	1.19	3.42	0	0	0
70601	12.46	3.20	1040.00	8.10	55.65	75.92	86.75	346.83
70602	12.66	3.80	2500.00	8.50	55.65	75.92	90.75	396.83
70603	12.25	3.60	1320.00	8.70	54.65	75.92	93.75	406.83
70604	12.14	3.80	880.00	8.70	40.65	65.92	128.75	336.83
70605	12.77	3.80	870.00	8.70	45.65	65.92	92.75	336.83
70606	13.49	3.30	950.00	8.60	46.65	65.92	82.75	326.83
70607	12.04	3.80	960.00	8.60	55.65	65.92	93.75	346.83
70608	11.73	3.60	1040.00	9.00	47.65	55.92	99.75	326.83
70609	12.04	4.00	1000.00	9.00	39.65	55.92	92.75	306.83
70610	13.49	3.80	1000.00	8.90	37.65	55.92	83.75	306.83
70611	12.04	4.30	920.00	7.70	51.65	65.92	97.75	396.83
70612	11.00	3.80	910.00	8.60	44.65	65.92	92.75	366.83
70613	11.83	3.70	870.00	8.60	49.65	65.92	93.75	336.83
70614	11.94	3.70	870.00	8.20	45.65	65.92	99.75	336.83
70701	15.57	3.80	920.00	8.90	51.65	85.92	96.75	276.83
70702	15.15	3.30	11500.00	8.00	55.65	55.92	90.75	326.83
70703	10.07	3.30*	.1E+06	7.70	59.65	45.92	92.75	256.83
70704	15.57	2.50	1560.00	5.50	95.65	65.92	103.75	296.83
70705	15.99	3.30	770.00	7.90	75.65	55.92	92.75	306.83
70706	15.15	3.10	700.00	7.50	73.65	55.92	90.75	326.83
70707	15.36	3.30	690.00	7.60	71.65	55.92	98.75	306.83
70707	14.74	3.40	690.00	7.20	69.65	55.92	93.75	296.83
AVERAGE	15.05	3.35	690.00	7.50	70.65	55.92	96.25	301.83
PCT DIFF	2.07	1.49	0	4.06	1.42	.00	2.66	1.66
70708	14.74	3.40	700.00	7.00	57.65	65.92	92.75	276.83
70709	15.57	3.30	770.00	8.10	59.65	65.92	90.75	286.83
70710	16.61	3.00	870.00	8.00	51.65	65.92	90.75	276.83
70711	16.40	3.40	910.00	7.60	40.65	75.92	89.75	276.83
70712	15.57	3.30	930.00	7.70	32.65	75.92	89.75	246.83
70713	15.15	3.50	990.00	7.60	39.65	65.92	93.75	266.83

MED.SEA SEDIMENTS AA1 JAN 1975

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
70801	16.50	2.90	1500.00	7.40	58.65	65.92	77.75	236.83
70802	20.76	2.30	3040.00	7.40	55.65	65.92	60.75	216.83
70803	6.23	1.90	900.00	7.90	29.65	65.92	62.74	86.83
70804	5.61	3.70	1440.00	13.40	25.65	55.92	76.74	36.83
70805	4.88	2.10	1340.00	7.40	26.65	65.92	70.74	56.83
70901	14.95	3.20	1440.00	7.60	78.65	55.92	83.75	256.83
70902	14.12	3.20	470.00	7.40	49.65	65.92	78.75	236.83
70903	14.12	3.40	530.00	8.00	75.65	55.92	81.75	266.83
70904	11.42	3.10	490.00	8.00	61.65	45.92	77.75	286.83
70905	11.21	2.90	470.00	7.40	71.65	45.92	74.75	266.83
70906	12.66	2.90	520.00	7.60	65.65	55.92	74.75	306.83
70907	10.80	3.10	450.00	7.20	64.65	55.92	69.75	256.83
70908	9.34	3.20	450.00	7.20	57.65	45.92	76.75	286.83
70909	9.34	2.90	450.00	7.40	75.65	55.92	67.75	246.83
70910	11.42	2.90	500.00	7.30	58.65	55.92	70.75	296.83
70911	9.13	2.90	450.00	6.90	64.65	45.92	68.75	256.83
70912	11.42	2.70	520.00	7.50	62.65	55.92	73.75	286.83
70913	9.86	3.10	470.00	6.70	61.65	45.92	68.75	276.83
70914	8.41	2.90	450.00	6.40	57.65	55.92	73.75	226.83
70915	8.51	2.60	450.00	6.60	67.65	45.92	69.75	236.83
70916	9.65	3.40	470.00	7.80	65.65	55.92	75.75	266.83
70917	9.65	3.70	500.00	8.00	55.65	55.92	80.75	276.83
70918	8.51	3.00	460.00	7.40	65.65	45.92	69.75	226.83
70919	7.89	3.40	400.00	6.70	61.65	55.92	67.74	236.83
70920	7.47	2.30	370.00	5.60	57.65	55.92	57.74	206.83
70920	7.99	2.50	430.00	6.30	64.65	55.92	63.74	216.83
AVERAGE	7.73	2.40	385.00	5.95	61.15	55.92	60.74	211.83
PCT DIFF	3.36	4.17	3.90	5.88	3.72	.00	4.94	2.36
70921	7.89	3.10	380.00	6.30	57.65	55.92	58.74	206.83
70922	7.47	2.00	400.00	7.40	57.65	55.92	58.74	206.83
70923	7.68	2.20	390.00	7.20	52.65	55.92	63.74	206.83
70924	9.34	3.00	500.00	6.60	61.65	55.92	64.75	246.83
70925	8.93	3.00	450.00	7.00	59.65	55.92	62.75	236.83
70926	12.35	2.90	510.00	8.00	52.65	55.92	69.75	276.83
70927	9.76	2.80	500.00	6.90	61.65	45.92	65.75	256.83
70928	11.21	2.60	540.00	6.40	61.65	55.92	83.75	246.83
70929	10.17	2.20	520.00	7.20	65.65	55.92	68.75	216.83
70930	9.45	2.70	640.00	7.30	55.65	55.92	63.75	226.83
70931	9.45	3.00	650.00	6.90	69.65	45.92	80.75	256.83

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
71101	13.29	2.50	820.00	9.30	62.65	55.92	71.75	136.83
71102	16.61	2.80	660.00	7.50	41.65	55.92	75.75	246.83
71103	15.15	3.40	730.00	7.90	94.65	55.92	76.75	246.83
71104	17.44	3.30	1430.00	8.00	57.65	55.92	83.75	236.83
71201	15.78	3.10	1610.00	8.00	57.65	55.92	75.75	256.83
71202	8.51	3.10	1240.00	7.90	63.65	55.92	73.75	246.83
71203	15.99	3.10	1250.00	8.00	61.65	55.92	72.75	246.83
71204	15.99	3.20	1260.00	8.00	62.65	55.92	77.75	236.83
71205	15.57	3.10	1250.00	7.80	68.65	55.92	75.75	226.83
71206	15.99	3.20	1280.00	7.90	67.65	55.92	78.75	236.83
71207	16.40	3.20	1300.00	8.10	65.65	55.92	96.75	226.83
71301	19.93	2.60	860.00	6.60	61.65	65.92	67.75	166.83
71302	17.44	3.10	4200.00	6.90	61.65	65.92	71.75	196.83
71303	15.36	3.40	480.00	7.20	89.65	55.92	93.75	226.83
71304	16.40	3.10	400.00	6.60	79.65	55.92	81.75	256.83
71305	17.65	2.50	600.00	7.00	64.65	55.92	72.75	226.83
71306	17.02	3.00	700.00	7.50	44.65	55.92	75.75	216.83
71307	17.44	2.90	1560.00	7.20	74.65	55.92	76.75	216.83
71308	15.57	3.30	1310.00	7.90	63.65	55.92	78.75	206.83
71309	15.88	3.30	1910.00	8.00	95.65	55.92	75.75	176.83
71401	13.91	3.20	1090.00	7.50	55.65	65.92	77.75	296.83
71402	11.42	2.60*	.1E+05	6.00	55.65	55.92	68.75	296.83
71403	15.67	3.10	900.00	7.00	59.65	55.92	78.75	316.83
71404	15.88	3.10	960.00	7.80	49.65	55.92	75.75	306.83
71405	13.29	3.30	890.00	8.70	31.65	55.92	84.75	306.83
71406	15.15	3.30	1100.00	7.70	39.65	55.92	72.75	266.83
71407	13.91	3.70	1020.00	8.30	37.65	55.92	77.75	276.83
71501	21.18	2.20	680.00	6.00	29.65	65.92	62.75	176.83
71501	21.18	2.20	640.00	6.90	31.65	55.92	62.75	166.83
AVERAGE	21.18	2.20	660.00	6.45	30.15	60.92	62.75	171.83
PCT DIFF	0	0	0	6.98	4.98	8.21	0	2.91
71502	19.31	2.30	520.00	6.60	33.65	55.92	61.75	186.83
71503	19.31	2.50	500.00	6.60	25.65	55.92	64.75	196.83

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CO(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
70101	15.36	3.00	650.00	8.10	60.65	65.92	79.75	186.83
70102	16.89	2.40	1100.00	6.20	58.65	65.92	64.75	206.83
70103	15.57	2.80	1200.00	7.10	73.65	75.92	77.75	226.83
70104	15.57	2.70	880.00	7.60	46.65	65.92	80.75	226.83
70105	16.30	2.80	790.00	7.15	55.65	65.92	73.75	236.83
70106	16.71	2.60	790.00	7.50	59.65	75.92	73.75	240.83
70107	16.19	2.70	680.00	7.20	58.65	55.92	73.75	246.83
70107	16.82	2.70	900.00	7.40	55.65	75.92	71.75	256.83
AVERAGE	16.50	2.70	890.00	7.30	57.15	65.92	72.75	251.83
PCT DIFF	1.89	0	1.12	1.37	2.52	15.17**	1.37	1.99
70108	17.54	2.80	870.00	7.40	54.65	65.92	68.75	216.83
70108	17.54	2.70	890.00	7.00	54.65	75.92	77.75	236.83
AVERAGE	17.54	2.75	880.00	7.00	54.65	70.92	73.25	226.83
PCT DIFF	0	1.82	1.14	0	0	7.45	6.14	4.41
70109	19.00	2.80	990.00	6.70	53.65	75.92	70.75	236.83
70110	13.60	4.70	760.00	7.50	77.65	45.92	86.75	496.83
70110	13.08	4.60	760.00	7.40	76.65	45.92	89.75	476.83
AVERAGE	13.34	4.65	760.00	7.45	77.15	45.92	88.25	486.83
PCT DIFF	1.95	1.08	0	.67	.65	.00	1.70	2.05
70111	19.93	2.10	880.00	5.80	35.65	65.92	55.75	206.83
70112	18.48	2.30	850.00	6.50	43.65	65.92	63.75	246.83
70113	20.34	2.20	750.00	6.00	45.65	65.92	60.75	206.83
70114	19.72	2.20	930.00	6.20	44.65	55.92	61.75	246.83
70115	20.34	2.30	980.00	6.30	39.65	75.92	59.75	206.83
11081	14.74	1.80	510.00	6.40	15.65	65.92	45.75	66.83
11082	19.62	2.50	705.00	8.60	19.65	45.92	58.75	66.83
11083	16.71	2.30	770.00	10.30	23.65	45.92	65.75	56.83
11084	7.27	4.80	1200.00	11.00	28.65	45.92	151.74	36.83
11085	3.74	3.50	930.00	12.00	19.65	55.92	69.74	46.83
11091	13.08	2.20	910.00	6.50	27.65	85.92	71.75	96.83
11092	15.36	2.20	1400.00	7.80	34.65	65.92	61.75	136.83
11093	18.16	2.10	520.00	6.70	32.65	95.92	55.75	136.83
11094	17.96	2.10	360.00	7.10	35.65	85.92	56.75	136.83
11095	11.73	2.20	500.00	8.30	34.65	65.92	69.75	96.83
11101	20.14	2.10	960.00	6.30	37.65	105.92	57.75	166.83
11101	19.93	2.20	930.00	6.00	41.65	65.92	56.75	166.83
AVERAGE	20.03	2.15	945.00	6.15	39.65	85.92	57.25	166.83
PCT DIFF	.52	2.33	1.59	2.44	5.14	23.28**	.87	.00
11102	17.13	2.50	735.00	7.30	45.65	65.92	60.75	196.83
11103	16.30	2.80	620.00	7.90	41.65	75.92	66.75	196.83
11104	16.82	2.90	930.00	7.90	49.65	55.92	67.75	166.83
11105	18.37	2.60	970.00	7.00	46.65	65.92	64.75	196.83
11106	17.96	2.70	1300.00	7.30	62.65	65.92	65.75	196.83
11107	21.59	1.80	500.00	5.30	33.65	65.92	49.75	166.83

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
11111	19.93	1.81	1270.00	6.00	21.65	85.92	61.75	106.83
11112	19.20	1.92	480.00	6.60	22.65	85.92	64.75	106.83
11113	16.61	1.87	490.00	7.20	21.65	75.92	56.75	96.83
11114	16.61	1.95	440.00	7.30	22.65	75.92	63.75	126.83
11115	13.49	2.29	440.00	8.70	33.65	85.92	79.75	136.83
11116	21.55	1.30	390.00	5.30	15.65	55.92	52.75	96.83
11117	25.86	1.00	350.00	4.10	11.65	65.92	37.75	96.83
11118	23.70	1.36	300.00	4.50	11.65	75.92	35.75	96.83
11119	20.76	1.20	330.00	5.30	12.65	85.92	38.75	96.83
11119	20.76	1.21	340.00	5.40	13.65	55.92	39.75	96.83
AVERAGE	20.76	1.20	335.00	5.35	13.15	70.92	39.25	96.83
PCT DIFF	0	.41	1.49	.93	3.80	21.15**	1.27	0
11121	25.86	1.47	940.00	4.30	21.65	95.92	45.75	106.83
11122	15.78	2.22	920.00	7.00	25.65	95.92	56.75	96.83
11123	26.94	1.30	240.00	3.50	18.65	85.92	39.75	116.83
11124	32.32	.38	210.00	1.32	9.65	95.93	19.75	96.83
11131	23.70	1.67	720.00	5.10	23.65	95.92	53.75	106.83
11132	18.58	2.06	840.00	6.90	25.65	95.92	55.75	96.83
11133	18.68	2.36	1000.00	7.00	30.65	75.92	62.75	146.83
11134	14.53	2.84	410.00	9.60	45.65	85.92	79.75	156.83
11135	20.76	1.89	360.00	6.40	19.65	95.92	49.75	96.83
11136	16.40	1.59	386.00	6.90	15.65	95.92	48.75	86.83
11141	20.76	1.86	810.00	5.60	31.65	105.92	54.75	116.83
11142	17.65	2.12	470.00	6.90	30.65	85.92	58.75	126.83
11143	17.65	2.10	500.00	6.60	26.65	95.92	64.75	116.83
11144	18.37	1.65	460.00	7.00	17.65	55.92	47.75	76.83
11151	21.55	1.70	850.00	5.00	29.65	95.92	59.75	116.83
11152	19.93	1.90	830.00	6.00	29.65	95.92	53.75	116.83
11153	4.15	2.49	920.00	11.40	25.65	65.92	66.74	46.83
11161	22.63	1.89	820.00	5.90	28.65	105.92	55.75	116.83
11162	11.00	2.55	1100.00	10.00	25.65	65.92	63.75	96.83
11191	19.31	2.30	1190.00	6.50	46.65	105.92	61.75	176.83
11192	15.99	2.90	1210.00	8.00	43.65	95.92	68.75	166.83
11193	7.27	4.50	1850.00	13.10	33.65	85.92	85.74	46.83
11193	7.47	4.50	1870.00	13.60	32.65	85.92	88.74	46.83
AVERAGE	7.37	4.50	1860.00	13.35	33.15	85.92	87.24	46.83
PCT DIFF	1.41	0	.54	1.87	1.51	.00	2.72	.00
11194	11.94	2.55	890.00	9.40	45.65	75.92	65.75	136.83
11195	4.15	2.79	730.00	12.80	25.65	75.92	67.74	126.83
11196	17.65	2.69	1190.00	7.60	45.65	75.92	65.75	166.83
11197	7.68	3.80	1650.00	13.00	29.65	95.92	73.74	46.83
11198	14.53	2.75	1470.00	9.30	39.65	105.92	67.75	126.83
11094	4.15	5.30	1220.00	14.60	20.65	65.92	120.74	36.83

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	NI(PPM)
33601	10.02	4.00	1230.00	6.03	63.55	95.92	96.75	2.50	220.00	45.94	146.83
	9.12	4.00	1230.00	6.70	45.63	95.32	97.75	1.90	200.00	.01	126.83
AVERAGE	9.57	4.00	1200.00	6.75	44.63	95.92	97.25	1.95	200.00	45.94	135.83
PCT DIFF	5.26	0	0	.74	2.24	.66	.51	2.56	0	0	7.31
33602	10.02	2.90	1200.00	5.83	48.63	85.92	97.75	2.00	190.00	35.94	136.83
	9.62	4.00	1220.00	6.33	34.63	35.92	87.75	2.00	200.00	35.94	116.83
AVERAGE	9.92	3.95	1200.00	6.03	39.63	35.92	92.75	2.00	195.00	35.94	126.83
PCT DIFF	1.01	1.27	0	4.13	2.32	.66	5.39	2.56	2.56	.00	7.88
33603	10.02	3.90	1200.00	6.70	39.63	95.92	93.75	2.00	200.00	35.94	146.63
	10.02	3.90	1200.00	6.30	41.63	95.92	66.75	2.00	230.00	25.94	126.83
AVERAGE	10.02	3.90	1200.00	6.50	40.13	95.92	91.25	2.00	215.00	30.94**	135.83
PCT DIFF	0	0	0	3.08	3.74	0	2.74	0	6.96	16.26**	0
33604	10.02	4.30	2600.00	6.63	51.65	65.92	95.75	2.20	230.00	35.94	166.63
	8.42	4.40	2700.00	6.20	31.63	85.92	97.75	2.10	250.00	.01	146.63
AVERAGE	9.22	4.35	2650.00	6.40	51.65	75.92	96.75	2.25	240.00	35.94	156.83
PCT DIFF	8.70	1.15	1.69	3.13	.00	13.17	1.03	2.33	4.17	0	6.38
33701	9.42	4.20	3400.00	6.93	47.65	105.92	293.75	2.10	220.00	45.94	146.63
	8.62	4.40	3400.00	7.23	46.63	115.92	333.75	2.00	220.00	.01	146.83
AVERAGE	9.02	4.30	3400.00	7.05	47.15	110.92	313.75	2.05	220.03	45.94	146.83
PCT DIFF	2.33	2.33	0	2.13	1.06	4.51	6.37	0	0	0.01	.00

IDENT.	AG(PPM)	AS(PPM)	BA(PPM)	BE(PPM)	CD(PPM)	LA(PPM)	MO(PPM)	SB(PPM)	SN(PPM)	SR(PPM)	V(PPM)	W(PPM)	Y(PPM)
33601	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
AVERAGE	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
PCT DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0
33602	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
AVERAGE	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
PCT DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0
33603	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
AVERAGE	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
PCT DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0
33604	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
AVERAGE	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
PCT DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0
33701	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
AVERAGE	.00	1.00	1.00	.00	.00	1.00	.00	.00	.00	1.00	1.00	.00	1.00
PCT DIFF	0	0	0	0	0	0	0	0	0	0	0	0	0

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	NI(PPM)
32703	10.62	4.20.00	1400.00	7.03	53.65	95.92	99.75	2.20	250.0E	55.94	.L1 146.63
33733	9.42	4.40	1500.0E	6.50	45.63	75.92	96.75	2.20	250.00	45.94	.L1 156.83
AVERAGE	9.72	212.2E	1450.00	6.75	49.15	85.92	97.25	2.20	250.00	50.94	.01 151.63
PCT DIFF	3.09	97.93**	3.45	3.7E	12.64	11.64	2.57	L	0	9.82	0 3.29
33764	8.12	4.50	1800.00	7.10	32.03	75.92	118.75	2.20	240.30	45.94	.01 136.63
33704	8.22	4.60	1900.00	6.70	49.03	95.92	99.75	2.30	250.00	35.94	.01 176.83
AVERAGE	8.17	4.55	1850.00	6.90	31.15	85.92	114.25	2.25	245.03	40.94	.01 156.83
PCT DIFF	.61	1.10	2.70	2.9E	2.33	11.64	4.32	2.22	2.04	12.21	0 5.99
33705	10.02	4.40	1330.00	6.70	46.63	75.92	103.75	2.40	240.00	45.94	.01 166.83
33703	9.22	4.60	1400.00	6.60	41.63	75.92	100.75	2.30	250.00	35.94	.01 166.83
AVERAGE	9.62	4.45	1375.00	6.65	44.15	75.92	102.25	2.35	245.00	40.94	.01 166.83
PCT DIFF	4.17	0	1.49	.75	.00	1.47	2.13	2.13	2.14	12.21	0 .0E
33706	7.21	4.70	2300.00	6.90	37.65	65.92	100.74	2.60	230.00	45.93	.01 206.83
33706	7.21	4.70	2430.E0	5.7L	37.65	75.92	99.74	2.60	250.L3	45.93	.01 196.83

IDENT.	CA(PCT)	FE(PCT)	MN(EFM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	NI(PPM)
30707	5.21	4.80	3400.00	7.20	33.65	65.92	99.74	2.5E	230.00	45.93	.01 176.83
30707	5.21	4.80	3500.00	7.20	33.65	75.92	99.74	2.4E	240.00	35.93	.01 186.83
AVERAGE	5.21	4.8E	3450.00	7.20	39.15	70.92	99.74	2.45	235.03	40.93	.01 181.63
PCT DIFF	0	0	1.45	0	1.26	7.05	0	2.04	2.13	12.21	C 2.75
33801	7.41	4.70	2700.03	7.10	53.63	105.92	127.74	2.20	250.00	45.93	.01 156.83
33801	9.42	4.80	2100.00	7.10	51.63	95.92	115.75	2.20	230.00	55.94	.01 166.63
AVERAGE	8.42	4.75	2050.00	7.05	52.63	100.92	121.75	2.20	240.00	50.94	.01 161.63
PCT DIFF	11.90	1.05	2.44	.71	1.9E	4.95	4.93	0	4.17	9.82	0 3.09
33802	8.02	4.40	2000.00	7.13	49.63	105.92	108.74	2.30	220.00	45.93	.01 156.83
33802	8.12	4.40	2100.00	7.14	43.65	65.92	106.74	2.20	230.00	55.94	.01 156.83
AVERAGE	8.07	4.40	2050.00	7.13	46.15	85.92	107.74	2.25	225.03	50.94	.01 156.83
PCT DIFF	0	0	2.44	.71	5.42	23.28**	.93	2.22	2.22	9.82	0 0
33803	7.82	4.70	1600.00	7.13	45.65	65.92	117.74	2.30	220.00	35.93	.01 166.83
33803	8.12	4.70	1600.00	7.03	43.65	55.92	109.74	2.30	220.00	45.93	.01 166.83
AVERAGE	7.92	4.70	1600.00	7.03	44.65	60.92	113.24	.30	220.00	40.93	.01 166.83
PCT DIFF	1.27	0	0	.71	2.24	9.21	3.52	0	0	12.21	0 .00
33804	8.62	4.50	1800.00	6.50	46.65	65.92	102.75	2.40	250.03	55.94	.01 166.83
33804	8.02	4.54	1800.00	6.80	43.65	55.92	105.74	2.30	250.00	45.93	.01 166.83
AVERAGE	8.32	4.50	1800.00	6.65	45.15	60.92	104.25	2.35	250.03	50.94	.01 166.83
PCT DIFF	3.61	0	0	2.26	3.32	0.21	1.44	2.13	0	9.82	0 .00
33805	8.22	4.60	1800.00	7.10	39.65	75.92	112.75	2.4C	250.00	55.94	.01 176.83
33805	8.10	4.50	1800.00	6.80	39.65	75.92	97.75	2.40	260.00	45.94	.01 186.83
AVERAGE	.72	4.55	1800.00	6.90	39.65	75.92	105.25	2.40	255.00	50.94	.01 181.83
PCT DIFF	0.15	1.12	0	2.90	5.31	24.02**	7.60	0	2.34	9.62	0 2.31

ASEAN SEDIMENTS

METAL CONCENTRATIONS. WITH AVERAGES AND REJECTIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	NI(PPM)
30816	7.41	4.70	1200.00	6.43	53.63	75.92	99.74	2.45	250.00	65.93	196.63
31905	7.62	4.93	1900.00	6.64	52.63	105.92	105.74	2.65	250.03	65.93	206.23
31906	7.62	4.36	1930.00	7.10	49.05	73.92	104.74	2.65	290.30	65.93	196.93
31908	6.22	4.76	1900.00	6.60	45.05	45.92	105.74	2.46	260.00	55.94	196.83
30816	7.67	4.75	1875.00	6.77	49.92	75.92	103.99	2.40	202.54	48.43	199.33
AVERAGE PCT DIFF=	2.29	1.05	2.00	2.77	3.51	19.76**	2.04	0	5.24	7.74	1.38
30816	5.81	4.60	1100.00	6.93	35.63	75.92	103.74	2.80	250.00	45.93	216.83
30810	5.81	4.90	1010.00	7.00	36.65	55.32	97.74	3.00	260.00	45.93	226.63
AVERAGE PCT DIFF=	5.71	4.70	1050.00	6.95	36.15	65.92	200.74	2.90	255.00	45.93	221.03
	1.75	2.13	4.76	.72	1.33	15.17**	2.98	3.45	1.96	.04	2.25
30804	6.11	3.80	1900.00	6.60	34.63	65.92	67.74	1.84	170.00	35.93	96.67
30904	7.41	3.90	1900.00	6.53	37.65	65.92	65.74	1.60	170.00	45.93	116.83
AVERAGE PCT DIFF=	6.76	3.85	1900.00	6.63	35.15	65.92	86.74	1.60	170.00	40.93	106.63
	9.63	1.30	0	2.26	4.15	.01	1.15	0	12.21	9.36	
30905	6.21	4.60	1400.00	6.90	35.65	75.92	66.74	1.40	180.00	35.93	106.63
30915	6.51	4.00	1400.00	7.00	37.45	75.92	89.74	1.30	160.00	35.93	126.63
AVERAGE PCT DIFF=	6.36	4.03	1400.00	6.95	37.15	75.92	88.24	1.65	170.03	35.93	106.63
	2.36	0	0	.72	1.35	.01	1.74	2.74	5.80	.00	.01
31931	7.21	4.10	2600.00	6.50	41.65	65.92	160.74	2.00	330.00	45.93	196.63
31971	7.20	4.30	2900.00	6.50	41.65	65.92	177.74	2.00	200.00	45.93	120.83
AVERAGE PCT DIFF=	7.21	4.35	2800.00	6.50	41.15	65.92	179.24	2.00	265.04**	45.93	151.63**
	.10	1.23	0	0	1.22	0	.84	0	24.53**	0	21.63**
31962	7.21	3.80	1000.00	6.60	37.65	65.92	85.74	1.80	170.00	35.93	.01 106.83
31965	7.21	3.90	1000.00	6.60	31.65	65.92	69.74	1.80	210.10	45.93	.01 106.83
AVERAGE PCT DIFF=	7.21	3.80	1001.00	6.60	34.65	65.92	67.74	1.80	190.00	40.93	.01 106.63
	0	0	0	0	3.66	0	2.28	0	10.53	12.21	0
30913	6.21	3.90	1030.00	6.50	34.65	45.92	83.74	1.80	170.30	35.93	.01 96.83
30933	7.01	3.80	1105.00	6.80	34.65	65.92	82.74	1.80	170.00	35.93	.01 106.63
AVERAGE PCT DIFF=	6.91	3.85	1050.00	6.50	34.65	55.92	83.24	1.80	170.00	35.93	.01 101.63
	4.45	1.33	4.76	.01	.01	17.88**	.66	0	0	0	4.31
30934	6.11	3.80	1900.00	6.60	34.63	65.92	67.74	1.84	170.00	35.93	.01 96.67
30904	7.41	3.90	1900.00	6.53	37.65	65.92	65.74	1.60	170.00	45.93	.01 116.83
AVERAGE PCT DIFF=	6.76	3.85	1900.00	6.63	35.15	65.92	86.74	1.60	170.00	40.93	.01 106.63
	9.63	1.30	0	2.26	4.15	.01	1.15	0	12.21	9.36	
30905	6.21	4.60	1400.00	6.90	35.65	75.92	66.74	1.40	180.00	35.93	106.63
30915	6.51	4.00	1400.00	7.00	37.45	75.92	89.74	1.30	160.00	35.93	.01 126.63
AVERAGE PCT DIFF=	6.36	4.03	1400.00	6.95	37.15	75.92	88.24	1.65	170.03	35.93	.01 106.63
	2.36	0	0	.72	1.35	.01	1.74	2.74	5.80	.00	.01
31931	7.21	4.10	2600.00	6.50	41.65	65.92	160.74	2.00	330.00	45.93	.01 196.63
31971	7.20	4.30	2900.00	6.50	41.65	65.92	177.74	2.00	200.00	45.93	.01 120.83
AVERAGE PCT DIFF=	7.21	4.35	2800.00	6.50	41.15	65.92	179.24	2.00	265.04**	45.93	151.63**
	.10	1.23	0	0	1.22	0	.84	0	24.53**	0	21.63**
31962	7.21	3.80	1000.00	6.60	37.65	65.92	85.74	1.80	170.00	35.93	.01 106.83
31965	7.21	3.90	1000.00	6.60	31.65	65.92	69.74	1.80	210.10	45.93	.01 126.63
AVERAGE PCT DIFF=	7.21	3.80	1001.00	6.60	34.65	65.92	67.74	1.80	190.00	40.93	.01 106.63
	0	0	0	0	3.66	0	2.28	0	10.53	12.21	0
30913	6.21	3.90	1030.00	6.50	34.65	45.92	83.74	1.80	170.30	35.93	.01 96.83
30933	7.01	3.80	1105.00	6.80	34.65	65.92	82.74	1.80	170.00	35.93	.01 106.63
AVERAGE PCT DIFF=	6.91	3.85	1050.00	6.50	34.65	55.92	83.24	1.80	170.00	35.93	.01 101.63
	4.45	1.33	4.76	.01	.01	17.88**	.66	0	0	0	4.31

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES

(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31107	6.21	4.50	1080.00	7.30	48.27	72.89	99.85	2.00	200.00	37.96	.39	111.55
31108	5.31	4.80	920.00	7.00	43.27	62.89	101.85	2.20	200.00	37.96	.39	111.55
31109	5.41	4.30	1000.00	7.30	38.27	62.89	95.85	2.10	190.00	37.96	1.39	111.55
31109	5.21	4.40	900.00	7.10	36.27	62.89	99.85	2.10	190.00	37.96	.41	121.55
AVERAGE	5.31	4.35	950.00	7.15	37.27	62.89	97.85	2.10	190.00	37.96	.70	116.55
PCT DIFF	1.89	1.15	5.26	2.10	*2.68	.00	2.04	0	0	.00	96.57**	4.29
31201	7.51	4.20	1800.00	7.40	45.27	82.89	131.85	2.00	180.00	47.96	.41	121.50
31231	7.62	4.30	1800.00	7.00	45.27	82.89	127.85	2.20	180.00	47.96	.41	111.50
AVERAGE	7.57	4.25	1500.00	7.20	45.27	82.89	129.85	2.10	180.00	47.96	.41	111.50
PCT DIFF	.66	1.18	0	2.78	.00	.00	1.54	4.76	0	.00	0	.00
31202	6.01	4.40	1200.00	7.20	56.27	82.89	107.85	2.10	170.00	47.96	.01	111.55
31203	7.01	4.10	1200.00	7.20	45.27	82.89	100.85	2.00	190.00	57.96	.39	111.50
31204	9.32	3.90	1200.00	6.90	40.27	82.89	90.85	2.10	180.00	57.96	1.39	101.50
31206	8.12	4.10	900.00	7.00	42.27	72.89	95.85	2.20	180.00	37.96	1.39	111.50
31207	6.71	4.10	850.00	7.00	46.27	62.89	97.85	2.20	180.00	37.96	.39	121.55
31208	6.61	4.00	1200.00	7.30	35.27	82.89	100.85	2.10	180.00	37.96	.39	91.56
31208	6.51	4.10	900.00	7.60	34.27	62.89	101.85	2.30	180.00	37.96	1.39	101.56
31209	6.31	4.10	920.00	7.20	37.27	62.89	97.85	2.30	180.00	37.96	.39	101.55
AVERAGE	6.41	4.10	910.00	7.40	35.77	62.89	99.85	2.30	180.00	37.96	.89	101.55
PCT DIFF	1.56	0	1.10	2.70	4.19	.00	2.00	0	0	.00	56.47**	.00
31301	10.22	3.80	1600.00	6.70	45.27	82.89	125.85	2.20	170.00	47.96	.39	111.56
31301	10.12	4.00	1600.00	6.60	42.27	92.89	127.85	2.00	180.00	37.96	1.39	111.56
AVERAGE	10.17	3.90	1600.00	6.65	43.77	87.89	126.85	2.10	175.00	42.96	.89	111.56
PCT DIFF	.49	2.56	0	.75	3.43	5.69	.79	4.76	2.86	11.64	56.43**	.00
31302	11.92	3.50	1500.00	6.30	43.27	102.89	77.85	2.10	150.00	47.96	1.39	131.57
31303	12.12	3.70	1300.00	6.10	41.27	82.89	79.85	2.30	170.00	47.96	2.39	121.57

AEGEAN SEDIMENTS

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CO(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	SC(PPM)	CD(PPM)	NI(PPM)
31401	10.11	3.90	2400.00	6.70	63.33	47.67	283.71	2.10	250.00	20.03	.01	130.29
31401	10.01	3.90	2400.00	6.60	61.33	47.67	283.71	2.10	260.00	30.03	.01	120.29
AVERAGE	10.06	3.90	2400.00	6.65	62.33	47.67	283.71	2.10	255.00	25.03	.01	125.29
PCT DIFF	.50	0	0	.75	1.91	.00	.00	0	1.96	19.98**	0	3.99
31402	17.12	3.00	1800.00	5.10	44.33	27.70	65.71	2.40	190.00	40.04	.01	160.32
31403	17.12	2.90	1400.00	5.00	43.33	27.70	65.71	2.40	190.00	40.04	.01	150.32
31404	13.21	3.80	1400.00	5.60	46.33	27.69	81.71	2.20	220.00	30.04	.01	170.30
31405	12.41	4.10	4500.00	5.40	76.33	37.68	89.71	2.10	220.00	40.03	.01	190.30
31407	10.01	3.90	1400.00	6.00	39.33	27.67	79.71	2.40	210.00	30.03	.01	170.29
31408	9.41	4.00	1400.00	6.00	37.33	27.67	78.71	2.50	200.00	30.03	.01	170.28
31409	9.71	3.60	1400.00	6.40	43.33	27.67	81.71	2.50	210.00	30.03	.01	170.29
31504	16.92	2.80	1600.00	4.70	42.33	27.70	64.71	2.30	180.00	40.04	.01	140.32
31506	10.91	3.70	1400.00	5.90	36.33	27.68	78.71	2.40	210.00	30.03	.01	190.29
31601	12.11	3.60	1400.00	5.90	33.33	27.68	73.71	2.50	220.00	30.03	.01	210.30
31601	12.01	3.50	1300.00	6.00	37.33	27.68	71.71	2.50	210.00	30.03	.01	210.30
AVERAGE	12.06	3.55	1350.00	5.95	35.33	27.68	72.71	2.50	215.00	30.03	.01	210.30
PCT DIFF	.41	1.41	3.70	.84	2.80	.00	1.38	0	2.33	.00	0	.00
31602	11.61	3.40	950.00	5.90	35.33	27.68	76.71	2.30	210.00	20.03	.01	170.29
31603	11.31	2.50	550.00	4.50	21.33	27.68	53.71	1.90	160.00	20.03	.01	130.29
31603	11.31	2.40	560.00	4.60	20.33	17.68	49.71	1.80	150.00	20.03	.01	120.29
AVERAGE	11.31	2.45	555.00	4.55	20.33	22.68	51.71	1.85	155.00	20.03	.01	100.29
PCT DIFF	0	2.04	.90	1.10	0	22.05**	3.87	2.70	3.23	0	0	0
31604	10.11	3.40	1400.00	5.10	33.33	7.67	69.71	2.00	180.00	20.03	.01	120.29
31605	11.21	3.60	900.00	6.00	35.33	.01	73.71	2.80	220.00	30.03	.01	230.29
31606	11.21	3.60	720.00	6.10	35.33	27.68	74.71	2.60	230.00	30.03	.01	230.29
31607	10.81	2.50	450.00	4.40	16.33	27.68	49.71	2.40	180.00	20.03	.01	140.29
31607	11.11	2.60	450.00	4.40	17.33	27.68	51.71	2.40	170.00	20.03	.01	140.29
AVERAGE	10.96	2.55	450.00	4.40	15.83	27.68	50.71	2.40	175.00	20.03	.01	140.29
PCT DIFF	1.37	1.96	0	0	2.96	.00	1.97	0	2.86	.00	0	.00

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES

(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31608	14.41	2.50	560.00	3.60	18.33	17.69	46.71	2.20	160.00	30.04	.01	140.30
31608	14.21	2.50	550.00	3.70	16.33	17.69	49.71	2.30	170.00	20.04	.01	140.30
AVERAGE	14.31	2.50	555.00	3.65	17.33	17.69	48.21	2.25	165.00	25.04	.01	140.30
PCT DIFF	.70	0	.90	1.37	5.75	.00	3.11	2.22	3.03	19.97**	0	.00
31609	9.31	3.70	1300.00	6.10	44.33	17.67	80.71	2.40	230.00	30.03	.01	180.28
31610	10.81	3.30	650.00	5.30	26.33	7.68	63.71	2.40	180.00	20.03	.01	170.29
31611	11.41	2.50	520.00	4.90	15.33	17.66	53.71	2.20	170.00	20.03	.01	140.29
31612	10.91	3.90	1500.00	6.10	37.33	17.69	78.71	2.60	220.00	20.03	.01	190.29
31613	10.21	2.80	560.00	5.70	24.33	17.67	60.71	2.40	180.00	20.03	.01	140.29
31613	9.91	2.80	570.00	5.40	24.33	.72	61.71	2.30	170.00	20.03	.01	150.29
AVERAGE	10.06	2.80	565.00	5.55	24.33	9.69	61.21	2.35	175.00	20.03	.01	145.29
PCT DIFF	1.49	0	.88	2.70	.00	99.09**	.82	2.13	2.86	.00	0	3.44
31614	9.21	2.10	440.00	4.20	16.33	7.67	44.71	1.80	150.00	20.03	.01	100.28
31614	9.31	2.10	440.00	4.10	16.33	17.67	46.71	1.80	150.00	20.03	.01	90.28
AVERAGE	9.26	2.10	440.00	4.15	16.33	12.67	45.71	1.80	150.00	20.03	.01	95.28
PCT DIFF	.54	0	0	1.20	.00	39.46**	2.19	0	0	.00	0	5.25
31615	9.41	3.70	600.00	6.10	25.33	17.67	71.71	3.10	220.00	30.03	.01	230.28
31615	9.41	3.60	600.00	5.90	26.33	27.67	74.71	3.20	230.00	30.03	.01	240.28
AVERAGE	9.41	3.65	600.00	6.00	25.83	22.67	73.21	3.15	225.00	30.03	.01	235.28
PCT DIFF	0	1.37	0	.84	1.93	22.05**	2.05	1.59	2.22	0	0	2.13
31701	17.02	2.90	3200.00	4.50	42.33	37.70	78.71	2.50	180.00	50.04	.01	150.32
31701	17.02	2.90	3300.00	4.60	43.33	37.70	75.71	2.50	180.00	50.04	.01	140.32
AVERAGE	17.02	2.90	3250.00	4.55	42.83	37.70	77.21	2.50	180.00	50.04	.01	145.32
PCT DIFF	0	0	1.54	1.10	1.17	0	1.94	0	0	0	0	3.44
31702	15.62	3.00	1500.00	5.10	42.33	37.69	80.71	1.50	190.00	30.04	.01	140.31
31703	16.12	3.10	1200.00	4.90	43.33	27.70	73.71	2.50	200.00	30.04	.01	150.31
31704	12.51	3.90	1700.00	5.90	57.33	27.68	93.71	2.50	250.00	30.03	.01	190.30
31705	12.41	3.90	3400.00	5.30	68.33	27.68	93.71	2.30	220.00	40.03	.01	200.30

AEGEAN SEDIMENTS

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NA(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31706	15.62	3.30	1700.00	5.00	49.39	37.69	75.71	2.30	190.00	40.04	.01	160.31
31707	17.02	2.90	1600.00	4.60	33.39	37.79	64.71	2.40	180.00	30.04	.01	150.32
31708	10.01	4.00	1200.00	6.30	37.39	17.67	81.71	2.50	210.00	30.03	.01	190.29
31709	15.11	3.90	1300.00	6.00	37.39	7.67	80.71	2.50	200.00	30.03	.01	180.29
31709	9.91	3.80	1300.00	6.10	39.39	27.67	79.71	2.50	200.00	30.03	.01	170.29
AVERAGE	10.01	3.85	1300.00	6.05	38.39	17.67	80.21	2.55	200.00	30.03	.01	175.29
PCT DIFF	1.00	1.30	0	.83	2.60	56.58**	.62	1.96	0	.00	0	2.85
31801	14.11	2.80	650.00	5.20	37.39	27.69	91.71	2.30	180.00	20.04	.01	110.30
31801	14.31	2.90	620.00	5.10	34.39	37.69	92.71	2.30	180.00	30.04	.01	120.30
AVERAGE	14.21	2.80	635.00	5.15	35.89	32.69	92.21	2.30	180.00	25.04	.01	115.30
PCT DIFF	.70	0	1.80	.97	4.18	15.30**	.54	0	0	19.97**	0	4.34
31802	14.01	3.00	900.00	5.30	38.39	27.69	75.71	2.30	170.00	30.04	.01	110.30
31803	12.01	3.10	750.30	5.50	34.39	17.68	78.71	2.20	180.00	30.03	.01	120.30
31804	14.11	2.80	580.00	5.30	29.39	27.69	73.71	2.10	170.00	40.04	.01	110.30
31805	20.02	2.20	1000.00	3.90	29.39	37.71	61.71	2.00	160.00	40.05	.01	90.33
31806	9.81	3.80	820.00	5.70	30.39	27.67	83.71	2.30	160.00	30.03	.01	100.29
31808	11.21	3.60	850.00	5.50	34.39	27.68	86.71	2.20	190.00	40.03	.01	120.29
31809	15.12	2.90	700.00	4.90	32.39	27.69	71.71	2.20	170.00	40.04	.01	100.31
31809	.40	46.00	220.00	.25	26.77	.01	25.41	.10	80.00	40.03	.01	340.50
AVERAGE	7.76	24.45	460.00	2.55	29.58	13.85	48.56	1.15	125.00	40.03	.01	220.40
PCT DIFF	34.64**	88.14**	52.17**	92.16**	3.50	99.93**	47.66**	91.30**	36.00**	.01	0	54.49**
31810	17.32	2.60	1300.00	4.40	31.39	27.70	73.71	1.90	150.00	40.04	.01	100.32
31810	17.42	2.70	1300.00	4.50	32.39	37.70	73.71	2.00	160.00	20.04	.01	100.32
AVERAGE	17.37	2.65	1300.00	4.45	31.89	32.70	73.71	1.95	155.00	30.04	.01	100.32
PCT DIFF	.29	1.89	0	1.12	1.57	15.29**	.00	2.56	3.23	33.29**	0	.00
31205	9.11	3.90	1700.00	7.00	37.39	17.67	87.71	2.00	180.00	20.03	.01	90.28

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES

(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31901	20.98	2.20	1100.00	3.80	30.90	21.31	55.43	2.30	130.00	5.29	.01	77.90
31901	20.48	2.20	1200.00	3.80	31.90	11.30	58.43	2.25	130.00	.01	.01	77.90
AVERAGE	20.73	2.20	1150.00	3.80	31.40	16.31	56.93	2.27	130.00	2.65	.01	77.90
PCT DIFF	1.20	0	4.35	0	1.59	30.67**	2.63	1.10	0	99.62**	0	.00
31902	20.48	2.10	860.00	3.70	24.90	11.30	55.43	2.45	120.00	.01	.01	77.90
3193A	20.17	1.80	1000.00	2.10	29.90	11.34	34.43	2.70	80.00	5.32	.91	37.93
3193B	20.78	2.40	1300.00	4.10	39.90	21.31	58.43	2.15	130.00	15.29	.01	87.90
3193C	17.98	2.70	1400.00	4.10	41.90	1.29	60.43	2.25	140.00	15.28	.01	87.90
3194A	20.77	1.80	600.00	1.40	19.90	21.34	33.43	2.93	80.00	5.33	.91	17.93
3194B	23.48	1.88	820.00	3.00	32.90	11.32	52.43	2.08	100.00	5.30	.01	37.91
31905	24.48	1.88	780.00	2.50	18.90	21.32	48.43	1.80	108.00	.01	.01	37.91
31906	16.48	3.00	1200.00	4.40	32.90	11.29	64.43	2.18	140.00	.01	.01	37.89
31907	15.48	2.70	620.00	5.00	33.90	1.28	78.43	2.20	140.00	5.27	.01	87.89
31908	25.97	1.44	860.00	2.70	36.90	21.33	38.43	2.25	100.00	5.31	.01	37.92
31909	23.49	1.74	1200.00	3.10	24.90	11.32	48.43	1.64	120.00	5.30	.01	57.91
31909	23.78	1.79	1200.00	3.10	24.90	21.32	47.43	1.67	120.00	5.30	.01	57.91
AVERAGE	23.63	1.77	1200.00	3.10	24.90	16.32	47.93	1.66	120.00	5.30	.01	57.91
PCT DIFF	.63	1.42	0	0	.00	30.69**	1.04	.91	0	.01	0	.00
32001	16.18	2.40	980.00	4.10	24.90	1.29	66.43	1.80	120.00	5.27	.01	47.89
32001	15.98	2.40	1000.00	4.10	25.90	21.29	67.43	1.80	120.00	.01	.01	37.89
AVERAGE	16.08	2.40	990.00	4.05	25.40	21.29	66.93	1.80	120.00	2.64	.01	42.89
PCT DIFF	.62	0	1.01	1.23	1.97	88.60**	.75	0	0	99.62**	0	11.66
32002	18.79	2.40	1100.00	4.20	27.90	21.30	78.43	2.10	130.00	5.28	.01	77.91
32003	19.98	2.60	2900.00	4.20	25.90	11.30	71.43	2.00	130.00	5.29	.01	57.90
32004	18.28	2.60	2500.00	4.50	59.90	21.29	82.43	1.70	160.00	5.28	.01	107.91
32005	15.98	2.80	700.00	4.60	59.90	11.29	70.43	1.83	160.00	5.27	.01	107.90
32006	17.28	2.80	960.00	4.20	45.90	1.29	66.43	2.10	140.00	5.27	.01	77.89
32007	15.68	2.60	930.00	4.30	31.90	1.28	67.43	2.17	130.00	5.27	.01	77.89
32008	14.79	2.90	910.00	4.40	22.90	11.28	61.42	2.30	130.00	.01	.01	77.89
32009	2.00	2.40	1300.00	7.00	7.80	41.23	108.42	.95	60.00	.01	.01	.01
32010	16.38	2.60	1400.00	4.00	43.90	31.29	59.43	2.00	140.00	5.27	.01	77.89
32011	15.39	1.71	730.00	2.30	23.90	31.26	38.42	1.17	90.00	.01	.01	47.89
32012	17.43	2.90	1300.00	3.60	55.90	31.29	64.43	1.70	150.00	5.28	.01	117.89

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(PRIOR TO CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	NI(PPM)
32013	16.66	2.34	820.CC	4.90	42.90	21.29	71.43	1.95	150.00	15.27	87.69
32013	16.99	2.40	810.00	4.28	42.90	31.29	63.43	1.95	150.00	15.27	87.59
AVERAGE	16.78	2.35	815.CC	4.13	42.90	26.29	67.43	.95	150.00	15.27	87.89
PCT DIFF	.61	.61		2.44	.00	19.02**	5.93	0	0	.00	.CC
32301	17.68	3.30	1200.00	4.30	52.90	1.29	66.43	2.25	180.00	15.24	137.89
32301	17.68	3.24	1200.00	4.20	51.90	21.29	69.43	2.25	170.00	15.28	137.89
AVERAGE	17.68	3.25	1200.00	4.25	52.40	11.29	68.43	2.25	175.00	15.26	137.99
PCT DIFF	0	1.54	0	1.28	.95	86.56**	0	0	2.86	48.66**	0
32328	26.77	1.63	530.03	1.60	15.90	21.34	35.43	2.75	90.60	5.33	1.91	37.93
32329	19.79	2.50	720.00	3.63	33.90	2.35	59.43	2.45	140.00	5.29	.01	97.90
32330	24.48	1.72	600.00	2.60	30.90	1.32	46.43	2.40	110.00	5.31	.01	67.91
32320	18.49	2.60	740.00	3.70	38.93	11.30	60.43	2.40	150.00	5.28	5.90	97.90
32333	16.58	2.80	820.00	4.53	27.93	11.29	66.43	2.40	140.00	5.27	.01	97.09
32306	15.79	3.10	780.00	4.80	32.90	11.28	63.43	2.30	130.00	5.27	.01	87.99
32354	29.47	1.18	1100.00	1.53	30.91	31.34	37.43	2.55	90.00	5.33	.01	47.93
32359	18.68	3.00	1200.00	4.20	52.90	4.34	63.43	2.58	160.00	5.28	.01	127.90
32306	18.00	3.20	1100.00	4.50	33.90	11.29	68.43	2.13	130.00	5.28	.01*	.1E+07
32317	15.98	3.70	1300.00	5.10	34.90	11.29	76.43	2.10	120.00	5.27	.01	67.09
32394	4.99	6.10	1200.00	7.03	23.90	1.24	105.42	1.70	60.03	.02	.01	.11
32398	8.49	4.90	1100.00	6.80	34.90	11.25	89.42	1.87	90.00	.01	.01	17.87
32401	19.40	2.70	1300.00	3.93	34.90	11.30	61.43	2.30	170.00	5.28	.01	117.90
32401	19.49	2.98	1300.00	4.00	34.90	11.30	63.43	2.30	160.00	.01	.01	117.90
AVERAGE	19.49	2.75	1303.00	3.95	34.90	11.33	62.43	2.30	165.00	2.25	.01	117.90
PCT DIFF	0	1.82	0	1.27	0	0	1.66	0	3.03	99.62**	0	0
32402	21.59	2.20	1100.00	3.70	103.90	11.31	55.43	2.40	130.00	5.29	.01	67.91
32403	18.40	2.90	1300.00	4.20	53.30	11.30	63.43	2.38	150.00	5.28	.01	107.90
32434	17.48	3.00	1030.00	4.40	37.90	1.29	67.43	2.52	150.00	5.28	.01	137.89
32405	15.98	3.10	1800.00	4.40	36.90	2.29	73.43	2.90	160.00	5.27	.01	127.89
32406	5.99	2.70	1130.00	6.40	24.90	1.24	79.42	1.10	70.00	.01	.01	7.86
32416	5.89	2.60	1100.00	6.40	23.90	1.24	68.42	.24	60.00	.01	.01	7.06
AVERAGE	5.94	2.65	1100.00	6.40	24.40	1.24	61.42	1.10	65.00	.01	.01	7.46
PCT DIFF	.84	1.89	0	1	2.85	.42	2.46	1	7.69	0	0	.36

METAL CONCENTRATIONS.
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CO(PPM)	NI(PPM)	TI(PPM)
69901	46.35	19.87	4.88	2021.10	13.71	87.46	176.38	129.51	4.25	302.60	83.48	4.52	317.67	4181.59
69902	6.93	4.38	2.68	1125.99	13.00	27.68	61.56	73.38	.99	80.43	21.36	.01	49.37	2814.98
69903	5.25	3.71	3.29	823.46	14.22	17.97	47.30	72.68	.92	65.83	20.98	.01	35.32	3554.83
69904	43.08	18.58	5.05	2062.15	13.60	76.31	144.62	126.68	4.17	307.13	78.84	2.68	409.66	4168.20
69905	39.66	17.24	4.96	1674.57	13.23	123.32	138.29	140.96	3.93	351.45	94.97	4.62	489.61	3721.26
69906	44.48	19.13	5.18	1269.74	13.06	125.28	125.99	145.77	4.19	337.70	96.90	4.38	513.67	3827.26
69907	39.07	17.01	4.72	1764.29	13.33	58.77	114.73	116.47	4.18	307.72	73.72	.02	383.28	4513.30
69908	36.34	15.94	4.51	1315.02	12.95	83.71	109.76	121.19	4.20	294.41	90.16	3.62	386.32	4121.70
69911	39.66	17.24	5.17	2067.37	12.82	81.97	94.94	113.18	5.02	330.78	74.29	1.96	406.92	3514.52
69912	39.72	17.27	5.18	1409.45	13.27	65.69	74.46	111.40	4.89	352.36	74.48	1.96	467.97	3933.17
69913	36.36	15.94	4.13	1316.18	11.20	46.45	70.57	97.72	4.32	412.51	50.95	3.82	366.99	3333.35
69914	39.07	17.01	3.90	1251.41	10.46	41.31	94.21	79.49	4.57	307.72	53.21	3.99	342.25	3487.55
69805	48.43	20.69	2.90	1403.00	9.22	37.65	111.09	79.21	3.92	362.85	62.74	11.97	234.23	2660.96
69806	41.01	17.77	2.96	1141.91	9.30	33.09	75.97	81.94	3.68	317.20	54.85	8.34	289.35	3333.45
69807	41.10	17.81	3.40	1230.84	10.19	35.33	76.24	83.10	3.42	318.32	55.04	6.25	293.37	3335.42
69808	55.23	23.36	3.07	1645.82	7.25	35.29	72.32	89.19	5.10	278.95	72.35	11.31	270.11	3063.49
69809	49.88	21.23	5.22	1616.25	22.13	83.67	114.19	131.16	3.06	248.55	64.49	4.84	240.77	4227.11
69101	29.57	13.27	5.14	1631.21	10.64	79.30	45.96	81.11	6.24	407.88	63.72	1.68	653.41	3723.42
69102	29.55	13.27	5.85	1240.22	11.87	66.73	45.93	130.54	6.84	442.94	63.67	.31	726.83	3897.84
69103	29.57	13.27	5.50	1205.68	10.99	63.21	63.69	95.29	6.56	425.53	63.72	.01	763.60	3933.72
69104	29.55	13.27	5.67	1204.79	10.81	63.16	63.65	104.68	6.68	442.94	63.67	.01	703.08	3897.84
69105	29.57	13.27	5.32	1258.87	10.82	72.07	81.43	109.48	7.00	443.26	63.72	.01	703.60	3933.72
69201	49.21	20.99	4.68	1771.98	11.81	53.28	137.63	100.28	3.69	319.94	63.83	9.71	459.80	4429.96
69202	46.45	19.91	7.00	1819.07	14.59	90.13	107.13	134.01	7.39	513.07	83.81	2.21	808.80	4837.49
69203	29.60	13.29	5.33	1456.05	11.54	72.19	63.79	109.64	5.47	461.68	63.81	3.45	615.86	3996.59
69301	37.02	16.20	5.36	1507.67	13.09	90.56	117.94	110.59	4.48	337.24	71.29	1.88	412.38	4165.92
69302	38.32	15.93	4.90	1303.17	12.55	79.72	70.45	113.25	5.04	372.61	95.08	1.85	503.67	4516.55

METAL CONCENTRATIONS.

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)	TI(PPM)
69303	35.01	15.41	5.39	1173.31	11.93	51.26	69.10	97.61	5.42	346.22	69.12	1.02	49[illegible]	3345.91
69304	32.27	14.34	5.35	1069.39	11.99	50.35	84.67	106.47	4.87	331.88	66.26	.01	436.66	4056.31
69305	30.57	13.67	5.21	1222.35	11.85	69.47	46.60	101.21	5.05	359.52	82.57	.01	497.62	3774.92
69306	32.98	14.62	5.41	2797.86	11.94	80.88	48.35	115.17	4.74	354.40	85.68	.01	497.7[illegible]	4133.53
69401	22.84	10.63	5.02	972.35	13.28	52.89	58.20	106.51	3.40	388.82	58.22	1.53	318.88	5726.22
69402	22.82	10.62	5.02	906.03	12.62	57.68	58.12	106.37	3.40	372.12	58.14	.01	318.45	5482.99
69403	24.17	11.15	5.60	889.23	12.35	62.00	59.16	104.97	3.46	378.75	59.18	.01	324.12	5952.25
69404	21.14	9.96	5.07	871.39	12.67	42.22	56.91	129.51	3.37	396.08	72.78	.01	327.69	4219.24
69405	26.22	11.96	.47	982.71	12.54	62.09	77.81	109.70	3.63	372.75	60.69	.01	333.49	4066.38
69501	21.49	10.10	4.78	1146.38	12.74	45.61	57.20	99.90	3.57	350.28	57.22	6.28	313.39	4[illegible]0.78
69502	21.49	10.10	4.62	796.10	12.10	47.21	57.20	101.49	3.50	350.28	41.29	.01	313.39	3[illegible]2.67
69503	21.49	10.10	4.94	859.79	12.53	51.98	73.12	109.46	3.81	366.20	41.29	.01	313.39	4458.24
69601	33.66	14.88	4.90	1318.98	12.44	63.40	86.53	108.81	3.99	282.64	67.71	7.43	3[illegible].35	4335.78
69602	39.72	17.27	4.97	1160.73	12.64	57.31	136.64	111.40	4.56	331.64	74.48	4.63	283.61	4245.45
69603	31.93	14.20	4.77	898.97	12.84	61.73	47.56	104.21	3.85	311.89	47.58	1.73	306.17	3852.72
69604	38.39	16.74	4.67	1014.49	12.58	86.53	93.18	109.65	4.22	324.64	72.91	.62	338.49	4[illegible]57.97
69605	40.38	17.52	5.03	733.04	12.15	101.89	75.24	133.51	3.90	356.05	75.26	1.98	329.46	3[illegible]9.35
69606	41.73	18.05	4.93	4328.74	13.07	89.25	98.41	132.32	3.99	364.30	77.01	4.17	336.08	4[illegible]5.88
69607	45.80	19.66	4.84	1475.39	13.37	82.18	105.87	128.51	4.36	345.80	82.84	11.43	315.43	4[illegible]9.02
69701	41.13	17.81	4.68	1994.81	12.72	103.24	76.24	107.69	3.90	297.13	97.48	6.25	311.59	4[illegible]2.05
69702	91.87	33.83	5.16	2545.23	16.51	170.45	384.72	177.14	5.64	481.55	247.22	27.17	597.32	6879.26
69703	34.72	17.27	5.39	2197.03	14.10	123.64	95.19	121.77	4.06	310.91	74.48	1.96	329.[illegible]6	4352.72
69704	37.72	16.48	4.42	2027.03	12.84	93.64	92.17	111.88	3.83	280.97	92.19	.82	294.63	3[illegible]3.23
69705	73.47	30.53	3.91	2777.03	[illegible] 3	167.80	263.23	149.44	3.25	376.54	169.15	23.[illegible]	361.63	4236.21
69706	39.74	17.27	4.98	1825.57	13.28	82.25	116.02	105.27	3.63	290.43	74.55	1.96	283.85	4149.63
69707	36.36	15.94	5.70	2573.25	13.36	56.27	109.85	117.36	3.81	373.22	70.59	3.82	288.42	3928.64
69708	44.45	19.12	4.72	2676.57	13.05	125.17	148.28	136.63	4.00	449.84	58.34	2.13	332.25	4[illegible]8.44

METAL CONCENTRATIONS.

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CA(PCT)	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)	TI(PPM)
69709	37.64	16.21	4.17	3216.37	12.32	102.54	111.03	104.72	3.28	297.81	71.35	.62	291.52	3573.74
69710	43.08	18.58	5.05	10310.61	11.63	135.24	144.62	120.10	3.69	329.07	78.84	2.68	344.05	3729.44
69711	42.36	18.30	4.98	1731.32	12.12	157.22	99.39	129.30	3.73	346.26	77.77	4.21	339.40	3679.16
69712	43.03	18.57	5.04	1335.77	11.17	135.00	122.46	124.26	3.61	306.57	78.69	4.26	365.32	3284.68
69713	39.37	16.73	5.27	1216.35	11.76	116.87	113.37	127.20	3.73	344.09	72.85	5.97	358.48	3243.64
69714	37.65	16.45	5.21	1121.69	11.61	111.40	111.96	109.60	3.60	280.27	51.92	3.89	354.60	3203.10
69715	35.69	15.68	5.44	835.78	10.11	106.16	69.82	110.30	3.13	272.11	69.85	3.78	363.13	2526.77
69716	36.34	15.94	5.10	981.35	11.97	109.22	109.76	113.34	3.79	372.92	50.90	5.78	347.07	3532.89
69717	37.67	16.46	5.61	1142.65	13.82	151.57	112.05	115.70	3.21	280.51	72.60	7.91	314.22	3099.42
69718	43.13	18.60	4.62	2351.65	11.87	100.33	122.91	124.72	3.30	285.72	57.00	2.08	303.72	3735.27
69719	36.28	15.91	4.89	1893.17	11.75	97.21	89.91	97.40	3.66	313.27	50.78	.62	287.48	3524.24
69720	36.36	15.94	4.91	1669.67	12.57	125.03	90.21	115.40	3.58	294.65	70.59	1.66	288.42	3535.78
69721	33.62	14.87	4.70	1392.16	12.42	67.07	86.43	106.76	3.69	263.38	46.79	.62	276.23	3762.59
69722	43.08	18.58	4.83	3970.75	11.85	203.83	122.69	139.85	3.47	285.19	78.84	.62	300.18	3729.44
69723	31.26	13.94	4.90	1634.94	13.26	137.42	83.43	117.62	3.63	254.32	47.11	.61	284.90	3451.55
69724	45.65	19.36	4.77	4245.74	12.26	335.23	126.97	115.22	3.52	295.16	104.30	8.96	311.66	3859.77
69725	36.32	15.93	5.10	1392.39	13.53	81.68	70.45	119.13	3.94	372.61	76.47	7.74	287.95	3922.22
69801	48.48	20.71	4.85	1817.89	12.12	110.65	159.79	123.00	4.13	290.86	111.34	9.57	283.18	4120.55
69802	45.78	19.65	6.68	6903.27	11.52	120.16	128.83	174.45	3.48	345.46	105.79	9.09	361.19	3454.64
69803	43.71	18.83	5.98	797.77	13.85	152.13	123.93	132.40	3.21	288.08	101.80	13.18	347.54	3324.64
69804	43.05	18.57	5.26	1008.22	12.71	100.05	100.66	115.61	3.95	284.93	78.76	4.27	299.90	3945.21
69805	47.83	20.45	5.51	1293.24	13.89	85.37	109.98	126.72	4.69	335.28	86.36	9.45	279.79	4553.27
69806	39.70	17.26	4.97	1656.75	13.05	102.82	115.81	113.38	3.73	310.64	74.42	1.98	283.39	4241.37
69807	.52	1.85	2.63	1140.63	15.26	86.00	73.06	123.70	.68	75.17	32.49	2.43	58.66	2535.57
69808	35.67	15.67	5.05	1456.57	12.82	134.19	108.61	116.21	3.79	252.47	50.37	3.78	265.74	4406.03
69809	44.48	19.13	4.95	15534.17	12.83	215.34	103.39	132.26	4.57	315.19	176.96	4.38	443.13	4502.66
69810	33.62	14.87	5.08	2125.85	13.17	130.93	105.21	112.40	3.46	282.19	67.61	3.66	276.23	3762.59

METAL CONCENTRATIONS,

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CO(PPM)	NI(PPM)	TI(PPM)
69811	44.38	19.10	5.16	3812.95	13.01	106.87	103.00	122.79	3.81	291.58	80.60	4.37	[illegible]	3812.95
69901	37.59	16.43	4.19	1218.13	10.58	91.16	111.68	113.32	3.51	279.57	71.76	1.89	275.24	3394.83
69902	38.35	16.73	4.25	1073.55	10.94	92.46	93.02	96.71	3.61	263.32	72.79	1.92	277.16	3443.45
69903	32.98	14.62	3.73	988.59	9.33	103.80	85.66	87.19	2.52	205.18	67.03	1.76	194.26	2984.39
69904	35.01	15.41	4.42	1692.64	11.73	95.50	107.57	111.07	3.42	269.28	69.12	1.82	263.19	3462.22
69905	34.97	15.40	4.42	1536.30	11.52	91.50	107.39	108.97	3.38	230.44	69.01	1.82	262.76	3456.67
69906	34.97	15.40	4.22	1459.43	11.52	101.10	88.19	110.69	3.40	230.44	49.81	3.74	301.17	3456.67
69907	34.93	15.38	4.22	1418.81	11.31	91.36	88.05	101.13	3.45	268.42	49.73	3.73	281.52	3259.42
69908	35.61	15.69	4.46	1511.17	11.64	92.31	88.97	111.88	3.51	271.24	69.62	3.77	303.64	3437.32
69909	33.57	14.84	4.13	1445.20	10.14	91.31	86.19	117.77	3.32	262.76	67.45	3.65	275.50	3566.07
69910	35.63	15.66	4.46	1589.95	11.25	98.21	89.04	111.97	3.37	271.45	69.68	[illegible]	265.31	3584.02
69911	36.34	15.94	4.71	1648.68	11.78	89.59	109.76	115.30	3.47	294.41	70.53	7.74	263.56	3729.16
69912	36.32	15.93	4.71	1666.94	11.95	99.33	90.66	113.25	3.67	294.17	90.68	3.82	287.95	3533.00
69913	36.26	15.91	4.70	1525.92	11.74	97.13	109.43	109.06	3.48	273.68	70.30	3.81	267.66	3325.73
69914	36.26	15.91	4.70	1584.61	11.54	97.13	89.84	112.97	3.52	273.88	70.30	1.85	267.68	3716.99
69915	36.30	15.92	4.70	1508.62	11.73	95.33	109.58	107.28	3.53	274.33	70.42	1.85	287.71	3135.21
69916	36.92	16.16	4.74	1521.22	11.65	94.13	110.48	108.16	3.58	296.34	71.99	5.82	270.32	3358.53
69917	36.24	15.90	4.50	1563.32	11.34	93.14	109.32	108.97	3.44	273.66	70.24	1.85	267.46	3518.49
69918	37.04	16.21	4.57	1647.89	11.91	90.63	130.89	112.66	3.61	277.96	71.35	1.88	291.52	3375.20

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
69918	39.11	17.02	4.93	1935.00	13.63	107.01	91.84	145.74	296.40
69919	39.64	17.23	4.97	1905.10	13.42	117.04	109.21	138.74	309.50
69920	39.64	17.23	4.80	1855.40	13.52	108.75	109.21	138.74	309.50
69921	39.64	17.23	4.97	1855.40	13.25	108.75	109.21	135.42	309.50
69922	38.58	16.82	4.72	1798.93	13.02	102.26	107.33	141.04	287.90
69923	38.58	16.82	4.72	1807.21	13.02	102.00	107.33	134.72	287.90
69924	22.74	10.59	1.68	530.65	5.82	20.25	59.44	34.62	73.55
69925	39.64	17.23	4.97	1871.97	13.75	112.37	125.78	147.42	326.07
69926	38.53	16.82	4.83	1730.93	13.02	106.38	91.05	136.35	434.43
69927	39.64	17.23	4.80	1871.97	13.42	108.75	109.21	143.71	326.07
69929	37.79	16.50	4.66	1671.69	12.72	105.52	154.19	126.56	306.31
69930	40.69	17.65	5.06	1773.42	13.83	103.95	111.16	142.89	315.02
69931	40.69	17.65	4.89	1834.14	13.66	116.69	123.82	146.27	315.02
69932	38.71	16.87	4.89	1698.83	13.05	103.85	107.56	138.28	304.84
69933	38.05	16.61	4.68	1630.38	12.43	101.13	138.70	117.43	285.45
69934	37.92	16.56	4.67	1611.81	12.89	100.92	93.08	118.79	317.05
69935	36.47	15.99	4.56	1573.93	12.59	97.03	135.24	120.60	309.81
69936	38.53	16.82	4.83	1725.81	13.68	115.03	107.33	134.72	304.18
69937	40.69	17.65	5.06	1770.42	13.83	110.69	94.29	141.21	331.88
69938	35.94	15.78	4.53	1592.23	12.33	100.92	149.74	119.60	276.03
69939	40.69	17.65	4.89	1736.69	13.49	114.69	111.16	141.21	315.02
69940	26.96	12.25	4.11	1423.90	11.23	95.36	93.20	114.66	242.10
69941	36.47	15.99	4.56	1495.23	12.59	103.33	103.76	131.62	262.59
69942	28.55	12.87	4.20	1203.56	10.92	93.47	134.24	101.31	695.31
69943	39.64	17.23	4.97	1841.25	13.25	108.75	125.78	130.45	309.50
69944	38.32	16.71	4.73	1410.40	12.97	103.19	100.87	127.66	286.67
69945	40.16	17.44	4.85	1470.68	13.34	111.39	110.17	139.96	295.52
69947	40.69	17.65	4.72	1534.35	13.15	107.32	111.16	134.40	315.02
69948	37.82	16.40	4.64	1392.52	12.08	100.28	153.54	113.04	267.03
69949	30.39	13.60	4.17	1307.35	10.92	91.04	109.08	111.69	225.31
69950	43.65	19.89	5.17	1638.78	13.54	116.94	135.24	152.74	332.90
69950	40.69	17.65	5.23	1551.22	12.31	102.20	123.02	131.09	290.13
AVERAGE	42.24	18.27	5.20	1595.00	13.15	109.60	131.63	141.92	315.48
PCT DIFF	3.75	3.41	.59	2.74	2.74	6.76	2.74	7.63	5.49
69951	39.11	17.02	4.93	1479.02	12.65	102.66	108.25	130.46	293.40
69952	33.30	14.74	4.65	1304.32	11.54	93.42	90.83	101.57	295.09
69953	38.53	16.82	4.56	1351.34	11.72	103.63	139.93	113.56	255.34
69954	36.65	13.70	3.89	865.27	13.67	100.44	95.07	107.79	211.75
69955	40.69	17.65	5.06	1382.61	13.15	112.39	123.02	127.72	264.45

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
53956	37.52	16.40	4.48	2163.60	11.20	103.43	105.52	113.24	299.04
70001	36.13	13.43	4.15	1233.65	10.73	83.33	108.66	111.27	267.39
70002	39.64	17.23	4.30	3777.37	12.92	77.28	158.91	121.51	326.07
70003	38.58	16.82	4.72	1188.53	13.32	66.18	91.65	118.44	320.45
70004	47.33	20.14	4.91	1038.31	13.33	110.72	143.33	146.78	447.13
70005	44.12	19.38	4.65	912.75	11.45	116.75	135.08	123.04	996.56
70006	24.32	11.21	3.56	832.46	9.51	61.64	87.11	69.52	246.67
70007	41.22	17.85	5.13	1412.03	13.61	77.66	112.15	133.97	504.99
70008	38.05	16.61	5.00	1275.25	12.11	96.29	154.64	117.43	317.73
70009	41.48	17.96	4.96	1555.13	14.19	74.59	112.65	137.99	336.37
70010	45.44	19.51	5.32	1173.13	13.26	111.17	120.84	155.34	360.79
70011	41.75	18.06	5.13	1407.69	14.08	81.80	113.17	145.49	337.69
70201	36.47	15.99	3.31	3273.69	9.64	42.94	150.98	73.58	215.37
70202	39.93	17.33	5.32	2346.53	13.64	105.90	109.69	127.70	310.85
70204	39.11	17.02	4.93	2065.65	13.47	107.81	157.53	129.32	306.82
70205	38.05	16.61	4.84	2001.65	12.91	99.52	154.04	120.66	301.59
70206	38.58	16.82	5.05	2067.71	13.35	105.26	107.33	129.84	304.19
70207	41.16	17.44	5.35	2122.46	13.87	106.37	160.31	123.25	328.95
70301	42.16	17.44	5.31	2172.60	13.21	108.04	160.31	119.91	326.95
70302	39.64	17.23	5.30	1855.40	13.75	97.16	109.21	123.83	359.20
70303	42.60	18.48	5.59	2272.90	14.85	113.03	132.75	151.67	379.10
70304	41.75	18.06	5.49	2197.35	14.42	121.28	164.67	136.96	355.36
70305	43.86	18.39	5.78	2169.10	15.54	124.29	117.43	154.69	368.42
70309	40.69	17.55	5.41	2191.94	14.15	111.69	101.74	137.04	348.74
AVERAGE	42.28	18.27	5.55	2280.52	14.83	110.49	133.58	147.96	359.53
PCT DIFF	3.75	3.41	2.74	3.08	4.36	4.38	15.87**	8.84	2.74
70401	42.54	18.37	5.06	1931.73	13.75	110.77	149.54	126.35	325.15
70402	42.60	18.48	6.12	833.23	13.84	130.52	115.26	130.69	361.62
70403	38.05	16.61	5.49	968.54	12.91	109.20	74.13	122.27	301.59
70404	35.41	15.57	5.26	1254.03	15.32	140.35	86.58	138.95	289.26
70405	39.11	17.02	5.75	2003.53	13.77	283.35	91.84	147.39	339.66
70406	34.68	15.36	5.07	1965.68	13.82	111.33	85.68	119.40	302.27
70407	4.25	3.32	3.03	1451.73	15.36	61.65	68.85	126.29	142.93
70408	35.41	15.57	4.95	6657.45	13.01	117.12	117.55	117.28	304.74
70409	32.51	14.43	5.04	3081.77	13.33	112.08	112.49	118.15	321.25
70501	45.97	19.72	4.81	1983.49	12.03	104.85	122.02	117.99	327.33
70502	58.94	24.78	4.15	2133.15	11.69	118.21	208.77	157.32	308.15
70503	67.07	28.01	3.40	1821.81	8.81	102.17	230.54	220.90	385.13
70504	46.53	19.93	4.67	1775.74	14.15	103.69	123.23	208.98	311.84
70505	32.24	14.32	4.72	1313.50	12.40	74.75	82.54	123.64	305.25
70506	32.24	14.32	4.72	1652.93	12.54	111.65	82.54	157.54	320.01
70507	29.17	13.08	4.79	2002.17	12.53	103.54	73.85	136.40	348.01
70508	30.66	13.70	4.93	1384.44	11.01	113.42	95.37	132.31	364.03
70509	31.93	14.22	5.15	1234.98	12.21	102.39	82.21	137.02	332.27

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

70510	29.61	13.29	5.11	1207.41	12.07	103.23	93.64	136.31	374.33
70511	33.13	13.49	4.53	1130.67	11.43	102.55	94.35	131.31	367.58
70512	32.77	14.53	5.21	1270.96	11.90	105.09	112.93	128.06	367.14
70513	33.13	13.49	5.01	1134.43	11.68	106.84	94.35	151.35	367.58
70514	33.13	13.49	5.44	1301.66	11.31	102.55	108.66	142.76	367.58
70515	37.52	16.43	5.76	976.35	13.33	133.69	121.52	159.66	383.66
70516	31.19	13.91	4.94	1113.96	12.53	124.46	95.61	131.42	315.09
70517	24.58	11.31	4.51	888.41	12.37	73.79	87.41	113.70	287.51
70518	26.96	12.25	4.93	1081.62	12.32	92.62	76.57	128.35	324.25
70519	32.77	14.53	4.61	1213.70	12.33	105.09	112.93	127.54	337.65
70519	32.77	14.53	4.75	1219.70	12.64	112.52	112.93	127.54	337.65
AVERAGE	32.77	14.53	4.69	1216.70	12.49	108.80	112.93	127.54	337.65
PCT DIFF	0	0	1.59	0	1.19	3.42	0	0	0
70601	27.49	12.46	4.41	1434.27	11.17	76.75	104.71	119.63	476.31
70602	28.02	12.66	5.28	3473.43	11.81	77.31	115.48	126.07	551.23
70603	26.96	12.25	4.93	1837.23	11.91	74.82	103.95	126.35	557.40
70604	26.73	12.14	5.16	1200.53	11.67	55.45	89.93	175.64	459.50
70605	28.28	12.77	5.33	1213.07	12.13	63.65	91.92	124.32	469.65
70606	33.13	13.49	4.72	1359.65	12.59	60.76	94.35	118.43	467.77
70607	26.43	12.04	5.17	1304.93	11.96	77.06	89.61	127.43	471.45
70608	25.64	11.73	4.84	1398.62	12.16	64.08	75.21	134.14	439.53
70609	26.43	12.04	5.44	1359.30	12.23	52.53	76.32	120.07	417.07
70610	33.13	13.49	5.44	1431.22	12.74	82.51	83.34	119.66	553.64
70611	26.43	12.04	5.65	1253.50	10.47	76.21	89.61	132.87	539.41
70612	23.79	11.03	4.99	1194.11	11.23	58.59	86.51	121.70	481.35
70613	25.91	11.83	4.99	1174.17	11.61	67.11	88.97	126.52	454.59
70614	26.17	11.94	5.01	1178.37	11.21	61.83	89.29	135.10	456.22
70701	35.41	15.57	5.88	1424.39	13.73	78.42	133.33	149.79	428.60
70702	34.35	15.15	4.57	1518.37	12.19	84.77	85.19	138.24	497.07
70703	21.42	10.07	4.23*	.1E+05	9.83	75.36	58.44	118.32	326.82
70704	35.41	15.57	3.87	2415.27	8.32	132.61	102.67	155.98	459.57
70705	36.47	15.99	5.19	1211.97	12.43	119.37	80.32	145.96	482.95
70706	34.35	15.15	4.72	1366.34	11.43	112.19	85.19	138.24	497.97
70707	34.88	15.36	5.07	1359.63	11.93	113.13	85.68	151.64	471.20
70707	33.30	14.74	5.10	1334.45	11.79	107.42	83.64	140.55	445.41
AVERAGE	34.09	15.05	5.08	1347.04	11.99	107.22	84.66	146.10	458.10
PCT DIFF	2.32	2.07	.29	1.20	5.20	2.62	1.20	3.80	2.36
70708	33.30	14.74	5.10	1349.45	11.49	85.43	95.33	139.05	415.33
70709	35.41	15.57	5.11	1192.15	12.54	92.35	102.67	140.50	444.68
70710	35.05	16.61	4.84	1404.39	12.31	82.76	106.42	146.49	446.87
70711	37.52	16.40	5.44	1456.54	12.15	65.26	121.52	143.65	443.09
70712	35.41	15.57	5.11	1532.75	11.32	50.35	117.55	136.45	382.15
70713	34.35	15.15	5.33	1503.10	11.53	60.40	100.42	142.81	406.47

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
70801	37.79	16.50	4.66	2411.08	11.89	94.27	105.97	124.97	380.68
70802	48.61	20.76	4.48	5915.96	14.40	108.30	126.29	118.22	421.95
70803	11.65	6.23	2.15	1018.63	8.94	33.56	74.61	71.41	98.27
70804	13.06	5.61	4.11	1601.10	14.90	28.52	62.18	85.33	40.95
70805	8.21	4.88	2.29	1459.90	8.35	29.03	71.32	77.07	61.91
70901	33.83	14.95	4.84	2176.10	11.48	118.85	84.51	126.56	388.12
70902	31.71	14.12	4.69	688.28	13.84	72.71	96.54	115.32	348.62
70903	31.71	14.12	4.98	776.15	11.72	110.78	81.90	119.71	390.75
70904	24.85	11.42	4.13	652.02	10.65	82.03	61.11	103.45	381.67
70905	24.32	11.21	3.83	621.04	9.78	94.67	60.68	98.77	352.58
70906	28.02	12.66	4.03	722.40	10.84	91.20	77.69	103.84	426.25
70907	23.26	10.80	4.04	586.43	9.38	84.25	72.88	90.89	334.69
70908	19.57	9.34	3.98	559.48	8.95	84.11	57.10	95.42	356.61
70909	19.57	9.34	3.61	559.48	9.20	94.05	69.53	84.23	306.38
70910	24.65	11.42	3.86	665.32	9.71	91.35	74.41	94.14	394.97
70911	19.04	9.13	3.58	555.83	8.52	79.65	56.72	84.91	317.23
70912	24.85	11.42	3.59	691.94	9.98	83.36	74.41	94.14	381.67
70913	20.89	9.86	3.92	594.09	9.47	77.93	58.05	86.90	349.92
70914	17.19	8.41	3.50	543.42	7.73	81.69	67.53	89.05	273.92
70915	17.46	8.51	3.15	545.15	8.00	81.95	55.63	84.49	286.91
70916	20.36	9.65	4.27	590.15	9.79	82.43	70.22	95.11	335.04
70917	20.36	9.65	4.65	627.82	10.05	82.43	70.22	101.39	347.60
70918	17.46	8.51	3.63	557.27	8.95	79.53	55.63	84.49	274.79
70919	15.87	7.89	4.04	475.46	7.96	73.28	66.47	80.52	281.51
70920	14.81	7.47	2.70	434.35	6.57	67.67	65.65	67.79	242.80
70920	15.13	7.99	2.98	476.96	7.51	77.09	66.68	76.01	258.54
AVERAGE	15.47	7.73	2.84	455.65	7.04	72.38	66.17	71.90	250.67
PCT DIFF	4.27	3.36	4.95	4.68	6.66	6.50	.78	5.72	3.14
70921	15.87	7.89	3.68	451.69	7.49	68.52	66.47	69.83	245.85
70922	14.81	7.47	2.35	469.56	8.22	67.67	65.65	68.96	242.80
70923	15.34	7.68	2.60	460.68	8.50	74.00	66.06	75.30	244.31
70924	19.57	9.34	3.73	621.64	9.21	76.65	69.53	80.50	306.88
70925	16.51	8.93	3.66	552.22	8.59	71.97	68.63	77.00	290.63
70926	27.23	12.35	3.98	700.73	10.93	72.34	76.84	95.64	306.39
70927	20.62	9.76	3.53	629.91	8.69	77.67	57.86	82.83	323.56
70928	24.32	11.21	3.44	713.54	8.45	81.46	73.90	110.66	326.15
70929	21.68	10.17	2.81	663.94	9.19	83.62	71.40	87.78	276.85
70930	19.83	9.45	3.37	798.32	9.11	81.69	69.76	79.51	282.94
70931	19.83	9.45	3.74	810.79	9.61	85.63	57.28	100.72	320.36

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
71101	29.60	13.29	3.55	1164.90	13.21	85.99	79.44	101.91	194.35
71102	38.65	16.51	4.52	1865.40	12.11	67.23	91.28	122.27	398.44
71103	34.35	15.15	5.18	1112.34	12.33	144.18	85.19	116.91	376.60
71104	40.16	17.44	5.53	1721.37	13.37	113.06	93.46	139.96	395.63
71201	35.94	15.78	4.84	2513.23	12.43	89.99	87.30	118.24	406.91
71202	17.46	8.51	3.76	1502.21	9.57	77.11	67.75	89.34	299.02
71203	36.47	15.99	4.88	1967.43	12.59	97.03	88.02	114.50	368.51
71204	36.47	15.99	5.04	1983.22	12.59	96.61	88.02	122.37	372.77
71205	35.41	15.57	4.84	1935.31	12.08	106.29	86.56	117.26	351.19
71206	36.47	15.99	5.04	2014.70	12.43	106.48	88.02	123.95	372.77
71207	37.52	16.40	5.12	2080.77	12.96	135.08	89.51	154.65	383.05
71301	46.58	19.93	4.86	1607.51	12.34	115.23	123.23	126.64	311.84
71302	40.16	17.44	5.18	7013.17	11.53	103.03	110.17	119.91	328.95
71303	34.68	15.36	5.22	737.13	11.05	137.67	85.86	143.97	345.34
71304	37.52	16.40	4.96	840.24	10.58	127.49	89.51	136.54	411.08
71305	40.69	17.65	4.22	1311.67	11.80	109.01	94.29	122.06	382.45
71306	39.11	17.02	4.93	1149.57	12.32	73.32	91.04	124.46	356.09
71307	40.16	17.44	4.85	2774.24	12.03	124.76	93.46	125.26	362.37
71308	35.41	15.57	5.11	2028.20	12.23	98.54	86.56	121.92	320.22
71309	35.20	15.88	5.17	2993.67	12.54	149.93	87.66	116.73	277.18
71401	31.19	13.91	4.65	1583.93	13.94	80.67	95.83	112.98	431.35
71402	24.65	11.42	3.46*	.1E+05	7.98	74.65	74.41	91.46	394.97
71403	35.67	15.67	4.82	1399.14	13.68	92.73	86.94	122.42	392.54
71404	36.20	15.88	4.66	1504.77	12.23	76.26	87.66	116.73	380.95
71405	29.60	13.29	4.69	1264.23	12.36	115.98	79.44	124.38	435.65
71406	34.35	15.15	5.03	1675.67	11.73	62.40	85.19	116.82	406.47
71407	31.19	13.91	5.38	1482.23	12.03	54.71	84.27	112.98	402.29
71501	49.67	21.18	4.37	1351.68	11.92	56.92	130.95	124.67	351.34
71501	49.67	21.18	4.37	1351.68	13.71	62.65	111.12	124.67	331.47
AVERAGE	49.67	21.18	4.37	1351.68	12.82	59.90	121.05	124.67	341.41
PCT DIFF	0	0	0	0	5.98	4.48	8.21	0	2.91
71502	44.92	19.31	4.16	944.03	11.98	55.64	101.53	112.10	339.18
71503	44.92	19.31	4.54	907.72	12.34	46.56	101.53	117.55	357.33

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
70101	34.88	15.36	4.61	998.20	12.44	93.14	141.24	122.47	236.91
70102	43.36	18.39	4.28	1359.41	11.34	104.47	117.43	115.33	368.42
70103	35.41	15.57	4.34	1857.93	10.99	114.33	117.35	120.37	351.19
70104	35.41	15.57	4.13	1362.46	11.77	72.22	142.47	125.12	351.19
70105	37.26	16.38	4.46	1253.15	11.48	88.73	135.07	117.54	377.47
70106	38.32	16.71	4.21	1283.71	12.15	96.73	123.08	119.56	400.15
70107	37.60	16.19	4.29	1395.72	11.43	93.49	88.76	117.45	391.73
70107	38.53	16.32	4.43	1465.31	12.05	90.61	123.81	116.31	416.15
AVERAGE	37.79	16.58	4.34	1431.51	11.74	91.84	140.19	116.93	404.95
PCT DIFF	2.10	1.59	1.27	2.40	2.54	2.35	10.41**	.82	3.28
70108	40.43	17.54	4.73	1466.41	11.75	91.74	115.66	115.40	363.98
70108	40.43	17.54	4.53	1493.99	11.75	91.74	127.45	130.51	397.55
AVERAGE	40.43	17.54	4.62	1477.20	11.75	91.74	119.06	122.96	380.77
PCT DIFF	0	0	1.92	1.14	0	0	7.05	6.14	4.41
70109	44.12	19.10	5.01	1771.80	11.99	96.62	135.08	126.62	423.85
70110	30.39	13.60	6.75	1391.85	13.77	111.55	65.98	124.62	713.77
70110	29.07	13.06	6.49	1371.53	13.43	105.07	64.75	120.53	672.29
AVERAGE	29.73	13.34	6.62	1381.69	13.60	179.81	65.36	125.58	693.03
PCT DIFF	2.22	1.95	2.01	.97	1.61	1.59	.94	.76	2.99
70111	46.58	19.93	3.93	1644.93	11.84	86.04	123.23	104.20	386.61
70112	42.80	19.48	4.02	1466.13	11.36	76.32	115.26	111.46	431.55
70113	47.56	20.34	4.23	1430.13	11.44	87.05	125.71	115.84	394.39
70114	45.97	19.72	4.07	1721.35	11.48	82.64	103.51	114.29	450.65
70115	47.56	20.34	4.39	1862.71	12.31	75.62	144.78	113.53	394.39
11081	33.30	14.74	2.73	764.63	9.59	23.46	96.83	66.58	130.19
11082	45.71	19.62	4.60	1293.55	15.84	36.29	84.59	108.21	123.10
11083	38.32	16.71	4.54	1248.29	15.75	38.34	74.45	106.59	92.13
11084	14.29	7.27	5.60	1401.01	12.93	33.42	53.58	177.34	42.97
11085	5.31	3.74	3.70	982.14	12.67	20.75	59.00	94.77	49.45
11091	29.07	13.38	3.10	1293.02	11.98	38.98	122.25	101.16	136.52
11092	34.33	15.36	3.33	2149.97	11.93	53.21	101.24	94.82	210.13
11093	42.01	18.16	3.62	896.74	11.95	56.30	163.42	96.14	235.95
11094	41.49	17.96	3.59	815.22	12.13	60.92	146.84	98.98	233.63
11095	25.64	11.73	2.96	672.41	11.15	46.60	88.66	93.84	136.22
11101	47.23	20.14	3.96	1342.32	11.93	78.48	199.97	109.12	314.95
11101	46.51	19.93	4.11	1733.35	11.22	77.65	123.23	106.97	311.84
AVERAGE	46.87	20.03	4.04	1775.34	11.55	78.48	161.60	107.55	313.39
PCT DIFF	.96	.52	1.83	2.08	2.93	4.05	23.74**	1.37	.50
11102	39.37	17.13	4.12	1212.31	12.04	75.29	106.74	103.20	324.65
11103	37.26	16.38	4.46	968.19	12.59	56.35	121.21	106.39	313.72
11104	38.53	16.82	4.72	1314.13	12.95	79.21	91.05	114.33	271.02
11105	42.54	18.37	4.52	1568.14	12.13	81.19	114.73	112.68	342.55
11106	41.43	17.96	4.61	2221.62	12.43	107.16	122.66	122.36	336.37
11107	50.73	21.59	3.65	1014.73	13.71	68.29	133.73	100.96	335.59

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	NI(PPM)
11111	46.50	19.93	3.38	2373.88	11.22	46.47	163.61	115.42	199.89
11112	44.65	19.20	3.29	867.25	11.92	40.92	155.25	116.99	193.02
11113	38.05	16.61	3.02	774.84	11.52	34.95	122.56	91.60	150.31
11114	38.05	16.61	3.15	713.27	11.73	36.56	122.56	102.90	204.73
11115	30.13	13.49	3.28	629.74	12.45	43.86	122.98	114.14	195.83
11116	50.62	21.55	2.63	789.80	10.73	31.69	113.25	106.82	196.09
11117	51.53	25.85	2.60	911.09	10.67	30.33	171.61	96.27	252.66
11118	56.10	23.70	2.41	683.41	10.25	26.54	172.96	81.44	220.53
11119	48.61	20.76	2.34	642.13	10.31	24.62	167.21	75.41	188.44
11119	48.61	20.76	2.35	661.65	10.51	26.56	102.83	77.35	188.44
AVERAGE	48.61	20.76	2.34	651.92	10.41	25.59	138.32	76.38	188.44
PCT DIF=	0	0	.41	1.49	.93	3.80	21.25**	1.27	0
11121	61.58	25.86	3.83	2446.83	11.19	56.36	249.71	119.09	278.09
11122	35.94	15.78	3.47	1436.13	10.93	40.04	143.74	88.58	151.15
11123	64.32	26.94	3.64	672.74	9.81	52.28	244.85	111.42	327.49
11124	78.03	32.32	1.73	955.82	6.31	43.92	436.61	89.90	440.73
11131	56.10	23.70	3.60	1640.17	11.62	53.67	215.52	122.44	243.36
11132	43.07	18.58	3.62	1475.45	12.12	45.65	163.49	97.92	170.08
11133	43.33	18.68	4.16	1764.69	12.35	54.09	133.98	110.73	259.11
11134	32.77	14.53	4.22	509.65	14.29	67.93	127.81	116.62	233.27
11135	48.61	20.76	3.68	700.57	11.63	36.29	186.67	96.81	188.44
11136	37.52	16.48	2.54	608.23	11.34	25.35	153.54	78.12	138.98
11141	46.61	20.76	3.62	1576.29	10.96	59.64	206.13	106.54	227.36
11142	46.69	17.65	3.57	792.47	11.63	51.68	144.60	99.06	213.85
11143	40.69	17.65	3.54	843.06	11.13	44.93	162.74	102.43	196.99
11144	42.54	18.37	2.87	800.56	12.18	30.72	97.33	83.10	133.71
11151	50.62	21.55	3.44	1721.35	10.13	60.04	194.26	121.00	236.60
11152	46.50	19.93	3.55	1551.44	11.22	55.42	179.33	100.47	218.38
11153	6.36	4.15	2.66	982.54	12.17	28.46	72.40	71.28	50.01
11161	53.36	22.63	4.05	1758.20	12.65	61.43	227.12	119.53	250.53
11162	23.79	11.00	3.35	1312.21	13.12	34.97	86.51	93.65	127.05
11191	44.92	19.31	4.18	2160.37	11.83	64.69	192.31	112.10	321.02
11192	36.47	15.99	4.56	1904.52	12.59	68.70	150.98	108.21	262.59
11193	14.29	7.27	5.25	2150.35	15.29	39.26	106.24	110.04	54.63
11193	14.81	7.47	5.23	2195.21	15.97	33.33	102.67	104.15	54.97
AVERAGE	14.55	7.37	5.27	2175.78	15.62	38.79	104.50	102.11	54.80
PCT DIFF	1.31	1.41	.31	.05	2.16	1.20	.31	2.03	.31
11194	26.17	11.94	3.45	1205.45	12.73	61.63	102.83	89.05	185.33
11195	6.36	4.15	2.93	779.62	13.67	27.39	81.08	72.35	135.45
11196	42.69	17.65	4.54	2006.47	12.31	76.97	128.02	115.86	281.29
11197	15.34	7.68	4.49	1949.03	15.35	33.64	113.31	87.11	55.32
11198	32.77	14.53	4.03	2166.53	13.63	56.97	157.50	104.77	188.65
11234	6.36	4.15	5.66	1302.93	15.59	22.05	72.43	128.45	39.33

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METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
30601	21.29	10.02	5.08	1651.61	8.04	55.46	121.87	125.46	2.54	254.13	58.36	.01	166.25
30601	18.74	9.02	4.92	1599.87	8.25	56.10	119.05	122.29	2.34	246.13	56.53	.01	150.08
AVERAGE	20.02	9.52	5.00	1625.78	8.14	55.82	119.96	122.88	2.44	250.12	57.45	.01	158.02
PCT DIFF	6.37	5.26	1.59	1.59	2.33	.65	1.59	2.10	4.16	1.59	1.59	11.91	5.69
30602	21.29	10.02	4.96	1524.63	7.37	51.64	109.17	124.19	2.54	241.40	45.66	.01	173.04
30602	20.78	9.82	5.05	1514.82	7.35	48.79	106.47	110.77	2.52	252.47	45.36	.01	147.48
AVERAGE	21.04	9.92	5.01	1519.72	7.36	50.22	108.82	117.48	2.53	246.93	45.51	.01	160.66
PCT DIFF	1.21	1.01	.94	.32	3.31	2.84	.32	5.71	.32	2.24	.32	11.91	8.21
30603	21.29	10.02	4.96	1270.52	8.51	49.11	121.87	119.11	2.54	254.10	45.66	.01	186.25
30603	21.29	10.02	4.96	1272.52	8.00	52.96	121.87	112.75	2.54	292.22	32.95	.01	161.14
AVERAGE	21.29	10.02	4.96	1271.52	8.25	51.01	121.87	115.93	2.54	273.16	39.30	.01	173.64
PCT DIFF	0	0	0	0	3.18	3.74	0	2.74	0	6.98	16.16**	11.91	7.51
30604	21.29	10.02	5.46	3303.35	8.39	65.02	83.76	121.65	2.80	292.22	45.66	.01	214.90
30604	17.21	8.42	5.31	3261.42	7.49	62.39	103.79	118.37	2.54	301.98	43.41	.01	177.36
AVERAGE	19.25	9.22	5.39	3282.39	7.94	64.04	93.77	119.66	2.67	297.10	44.53	.01	196.66
PCT DIFF	10.59	8.70	1.38	.64	5.55	2.53	10.68	1.49	4.85	1.64	2.53	11.91	9.89
30605	21.29	10.02	5.34	1397.58	8.64	55.46	96.40	120.30	2.80	266.81	45.66	.01	186.55
30605	17.72	8.62	4.86	1336.95	7.35	45.76	116.59	110.29	2.43	279.55	43.68	.01	154.15
AVERAGE	19.51	9.32	5.10	1367.27	7.84	50.61	106.53	115.33	2.61	273.18	44.67	.01	170.35
PCT DIFF	9.15	7.53	4.65	2.22	10.14	9.58	9.45	4.37	6.97	2.33	2.22	11.91	9.51
30606	16.45	8.12	5.03	1555.94	8.26	42.67	102.84	109.01	2.51	263.31	54.98	.01	175.74
30606	16.19	8.32	5.13	1551.21	7.99	40.15	102.53	110.63	2.39	238.65	42.88	.01	163.27
AVERAGE	16.32	8.07	5.08	1553.57	8.13	41.41	102.68	110.22	2.45	250.98	48.93	.01	169.50
PCT DIFF	.78	.62	1.02	.15	1.62	3.04	.15	3.01	2.59	4.91	12.36	8.96	3.63
30607	10.08	5.61	4.78	1004.85	7.79	38.53	73.31	99.80	2.34	211.29	26.84	.01	141.04
30607	9.82	5.51	4.88	942.59	7.65	32.88	84.19	102.85	2.33	210.69	39.85	.01	140.64
AVERAGE	9.95	5.56	4.83	971.72	7.72	35.70	78.75	101.32	2.33	210.99	34.34	.01	140.84
PCT DIFF	1.20	.90	1.01	3.00	.36	7.92	6.91	1.50	.14	.14	16.03**	5.31	.14
30608	9.57	5.41	5.09	917.81	7.96	37.21	83.96	102.56	2.43	232.62	39.74	.01	151.36
30608	8.55	5.01	5.14	787.29	7.54	34.61	83.32	94.65	2.36	207.76	39.29	.01	149.52
AVERAGE	9.06	5.21	5.11	852.55	7.75	35.91	83.49	98.70	2.39	219.99	39.51	.01	150.45
PCT DIFF	5.63	3.85	.51	7.65	2.59	3.62	.56	3.90	2.89	5.56	.56	5.02	.56
30701	17.21	8.42	5.07	4130.97	8.33	57.50	127.95	354.82	2.42	265.75	55.49	.01	177.56
30701	18.23	8.82	5.30	4158.19	8.81	57.25	141.77	408.17	2.45	269.06	56.18	.01	179.57
AVERAGE	17.72	8.62	5.23	4132.53	8.57	57.38	134.86	381.50	2.43	267.40	55.83	.01	178.46
PCT DIFF	2.88	2.33	2.94	.62	2.75	.44	5.13	6.99	.62	.62	.62	9.42	.62

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METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA (PCT)	FE (PCT)	MN (PPM)	AL (PCT)	CU (PPM)	PB (PPM)	ZN (PPM)	MG (PCT)	CR (PPM)	CO (PPM)	CD (PPM)	NI (PPM)
30703	21.29	10.02	533.62	1778.73	8.89	64.35	121.87	126.73	2.80	317.63	71.07	.01	106.55
30703	19.76	9.42	5.49	1669.45	9.11	56.89	94.62	116.08	2.74	311.56	57.25	.01	195.46
AVERAGE	20.53	9.72	269.55	1724.10	8.53	60.62	108.25	122.41	2.77	314.60	64.16	.01	191.30
PCT DIFF	3.73	3.09	97.97**	2.49	4.66	6.15	12.59	3.53	.96	.96	10.77	11.91	2.33
30704	16.45	8.12	5.39	2154.39	9.53	63.91	90.87	130.15	2.63	287.25	54.98	.01	187.70
30704	16.70	8.22	5.52	2281.03	9.04	59.66	115.16	119.75	2.75	300.14	43.14	.01	242.69
AVERAGE	16.58	8.17	5.45	2217.70	8.27	61.31	103.02	124.95	2.70	293.69	49.06	.01	230.00
PCT DIFF	.77	.61	1.25	2.86	2.75	2.78	11.79	4.46	2.37	2.49	12.06	8.96	6.15
30705	21.23	10.02	5.53	4132.73	9.51	59.27	90.46	131.81	3.05	304.93	58.36	.01	211.96
30705	19.25	9.22	5.45	4210.69	9.17	51.58	94.03	124.77	2.85	309.61	44.50	.01	266.61
AVERAGE	20.27	9.62	5.52	4201.71	8.34	55.42	95.24	128.29	2.95	307.27	51.43	.01	239.29
PCT DIFF	5.03	4.17	1.28	.21	2.03	6.94	1.28	2.75	3.41	.76	13.47	11.91	1.28
30706	14.16	7.21	5.47	2674.23	9.04	46.19	76.79	117.36	3.03	267.93	53.51	.01	240.93
30706	14.16	7.21	5.47	2795.74	7.93	43.06	88.44	116.19	3.03	291.22	53.51	.01	229.29
AVERAGE	14.16	7.21	5.47	2737.50	7.92	45.62	82.62	116.77	3.03	279.57	53.51	.01	235.11
PCT DIFF	0	0	0	2.13	1.47	2.59	7.05	.50	0	4.17	0	7.62	2.49
30707	9.06	5.21	5.26	3738.62	7.92	42.50	72.49	109.68	2.75	252.91	50.51	.01	194.44
30707	9.06	5.21	5.29	3848.53	7.92	43.60	83.48	109.68	2.64	263.90	39.51	.01	205.43
AVERAGE	9.06	5.21	5.28	3793.60	7.92	43.05	77.99	109.68	2.69	258.40	45.01	.01	199.94
PCT DIFF	0	0	0	1.45	0	1.28	7.05	0	2.04	2.13	12.21	4.74	2.75
30801	14.65	7.41	5.51	2343.75	9.21	62.87	124.13	149.70	2.58	292.96	53.83	.01	183.78
30801	19.78	9.42	5.98	2617.24	9.85	64.37	113.95	144.25	2.74	286.65	69.71	.01	207.92
AVERAGE	17.21	8.42	5.74	2480.47	9.53	63.62	121.04	146.98	2.66	289.81	61.77	.01	195.85
PCT DIFF	14.81	11.90	4.13	5.51	3.79	1.18	1.88	1.85	3.08	1.49	12.86	7.91	6.16
30802	16.19	8.02	5.25	2386.47	8.47	58.05	126.39	129.76	2.74	262.51	54.81	.01	187.13
30802	16.19	8.02	5.25	2505.80	9.35	52.08	70.66	127.37	2.63	274.44	86.74	.01	187.13
AVERAGE	16.19	8.02	5.25	2446.14	8.91	55.07	102.53	128.57	2.69	268.48	66.78	.01	187.13
PCT DIFF	0	0	0	2.44	.71	5.42	23.28**	.93	2.22	2.22	9.82	8.81	0
30803	15.68	7.82	5.57	1897.64	8.46	54.14	78.19	139.85	2.73	264.92	42.62	.01	197.86
30803	16.19	8.02	5.61	1901.15	8.35	52.08	66.73	130.95	2.74	262.51	54.81	.01	199.07
AVERAGE	15.94	7.92	5.59	1903.41	8.39	53.11	72.46	135.30	2.74	261.72	48.72	.01	198.46
PCT DIFF	1.60	1.27	.30	.36	.41	1.94	7.91	3.21	.30	.30	12.51	8.51	.30
30804	17.72	8.62	5.47	2167.75	7.95	56.72	89.42	124.58	2.92	303.85	67.98	.01	202.77
30804	16.19	8.02	5.37	2147.63	9.11	52.08	66.73	126.10	2.74	298.31	54.81	.01	199.07
AVERAGE	16.96	8.32	5.42	2167.79	8.53	54.39	73.43	125.53	2.83	301.08	61.40	.01	200.92
PCT DIFF	4.51	3.61	.92	.92	1.34	4.24	9.12	.52	3.05	.92	10.73	9.72	.92
30805	16.70	8.22	5.28	1680.75	8.82	47.60	91.15	134.15	2.88	312.14	67.15	.01	212.23
30805	16.41	8.10	5.38	1674.80	9.32	42.65	54.94	116.93	2.87	311.03	54.95	.01	199.58
AVERAGE	16.56	8.16	5.33	1677.78	8.27	45.12	73.04	125.54	2.88	311.59	61.05	.01	205.93
PCT DIFF	.89	.71	.95	.18	3.09	5.49	24.79**	6.86	.18	.18	9.99	9.11	3.09

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METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
30806	14.66	7.41	5.51 2103.33	7.56	59.35	80.97	110.89	2.81	292.96	53.83	.01	230.65
30806	15.17	7.62	5.65 2239.90	8.02	62.17	124.87	124.66	2.83	294.72	54.15	.01	243.83
30806	15.17	7.62	5.66 2239.90	8.37	58.53	89.51	123.48	2.83	341.88	54.15	.01	232.14
30806	16.19	8.02	5.61 2267.15	8.11	55.06	54.80	126.18	2.85	310.24	56.74	.01	234.86
AVERAGE	15.30	7.67	5.61 2212.67	8.00	58.28	89.54	122.66	2.83	309.95	57.22	.01	235.35
PCT DIFF	2.92	2.29	.90 2.37	3.13	3.37	19.73**	2.41	.53	5.20	8.32	6.18	1.80
30808	10.08	5.61	5.12 1223.27	7.67	39.64	64.43	115.37	3.11	278.02	51.08	.01	241.13
30808	10.59	5.81	5.37 1118.43	7.83	40.99	62.54	109.32	3.30	290.78	51.37	.01	253.68
AVERAGE	10.33	5.71	5.24 1170.83	7.75	40.31	73.49	112.34	3.23	284.40	51.23	.01	247.41
PCT DIFF	2.47	1.75	2.41 4.46	1.00	1.67	14.89	2.69	3.73	2.24	.28	5.31	2.54
30809	11.11	6.01	3.94 854.85	6.64	24.35	74.15	72.83	2.92	247.46	51.67	.01	190.96
30809	10.59	5.81	4.03 861.17	6.71	18.62	51.36	74.65	3.13	257.23	51.37	.01	186.58
AVERAGE	10.84	5.91	3.98 858.01	6.67	21.48	62.76	73.74	3.03	252.35	51.52	.01	192.74
PCT DIFF	2.35	1.69	1.12 .37	.55	13.34	18.16**	1.24	3.42	1.94	.29	5.87	3.20
30810	9.57	5.41	4.75 1216.37	7.13	35.00	61.84	114.72	3.18	243.27	50.79	.01	226.71
30810	9.06	5.21	4.84 1319.51	7.45	30.46	61.49	95.38	3.19	252.91	50.51	.01	205.43
AVERAGE	9.31	5.31	4.80 1267.94	7.33	32.73	61.67	105.05	3.19	248.09	50.65	.01	217.07
PCT DIFF	2.74	1.89	.87 4.07	1.97	7.03	.28	9.20	1.47	1.94	.28	5.02	5.36
30901	14.16	7.21	4.78 3261.70	7.57	48.52	76.79	210.55	2.33	304.41	53.51	.01	229.28
30901	14.12	7.20	4.66 3261.31	7.57	47.33	76.76	206.97	2.33	232.80	53.49	.01	147.68
AVERAGE	14.14	7.21	4.72 3261.50	7.57	47.92	76.78	208.76	2.33	308.65	53.50	.01	188.48
PCT DIFF	.13	.10	1.26 .02	.02	1.24	.02	.86	.02	24.55**	.02	7.62	21.65**
30902	13.65	7.01	4.40 1158.62	7.64	43.66	76.34	99.29	2.08	196.86	41.61	.01	123.71
30902	13.65	7.01	4.40 1158.62	7.64	36.65	76.34	103.93	2.08	243.18	53.19	.01	123.71
AVERAGE	13.65	7.01	4.40 1158.62	7.64	40.12	76.34	101.61	2.08	220.02	47.40	.01	123.71
PCT DIFF	0	0	0 0	0	8.66	0	2.28	0	10.53	12.21	7.32	0
30903	13.14	6.91	4.49 1151.22	7.83	39.69	52.87	96.41	2.07	195.71	41.37	.01	111.47
30903	13.65	7.01	4.40 1273.82	7.87	40.12	76.34	95.82	2.08	196.86	41.61	.01	123.71
AVERAGE	13.39	6.91	4.45 1212.52	7.85	40.61	64.60	96.11	2.08	196.29	41.49	.01	117.59
PCT DIFF	1.90	1.45	1.06 5.36	.29	.29	18.17**	.31	.29	.29	.29	7.03	5.23
30904	11.35	6.11	4.29 2443.29	7.57	39.68	74.36	98.98	2.03	192.77	40.54	.01	169.23
30904	14.60	7.41	4.57 2226.52	7.62	44.12	77.25	100.48	2.11	199.21	53.83	.01	136.91
AVERAGE	13.61	6.76	4.43 2184.91	7.64	44.60	75.81	99.73	2.07	195.49	47.18	.01	123.07
PCT DIFF	12.74	9.63	3.20 1.90	.35	8.65	1.90	.75	1.90	1.90	14.09	6.02	11.25
30905	11.61	6.21	4.53 1583.62	7.81	41.46	85.89	98.13	2.04	203.63	40.65	.01	120.85
30905	12.37	6.51	4.56 1597.84	7.99	42.96	86.64	102.41	2.17	182.59	41.01	.01	121.91
AVERAGE	11.99	6.36	4.54 1590.73	7.90	42.21	86.27	100.27	2.10	193.11	40.83	.01	121.38
PCT DIFF	3.19	2.36	.43 .43	1.15	2.78	.43	2.13	3.14	5.45	.43	5.16	.43

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	HG(PCT)	CR(PPM)	CO(PPM)	CO(PPM)	NI(PPM)
30902	16.45	8.12	5.27	3111.83	9.85	60.17	99.21	123.09	2.39	263.31	69.37	1.00	169.43
30907	16.19	8.02	5.97	1670.53	9.23	71.91	51.18	126.33	3.10	334.11	69.16	2.85	240.51
30906	12.12	6.41	3.75	1137.65	5.63	35.58	43.83	82.69	1.93	182.06	43.20	.44	81.42
30907	21.29	10.02	4.70	1397.59	8.25	41.00	41.79	100.18	2.03	190.58	66.94	.09	103.63
30909	17.72	8.62	4.38	1944.87	7.65	46.44	52.13	86.12	2.07	182.31	58.29	.07	111.28
30909	17.47	8.52	4.24	1933.85	7.85	46.31	64.08	87.05	2.18	193.87	58.11	.01	86.71
AVERAGE	17.60	8.57	4.31	1941.66	7.77	46.37	58.11	86.58	2.12	188.09	58.20	.04	99.00
PCT DIFF	.72	.58	1.56	.15	1.41	.15	10.29	.35	2.70	3.07	.15	95.82**	12.41
31001	16.19	8.02	5.37	1431.89	9.35	56.44	75.04	125.41	2.67	242.85	57.23	.06	121.48
31001	15.94	7.92	4.88	1300.58	8.45	50.28	86.71	131.87	2.26	237.92	57.06	.01	122.82
AVERAGE	16.07	7.97	5.12	1376.23	8.90	53.36	80.88	128.49	2.26	220.39	57.14	.04	121.30
PCT DIFF	.79	.63	4.80	4.91	.56	.15	7.21	2.63	.15	7.95	.15	95.75**	.15
31002	17.47	8.52	5.33	969.33	9.60	52.43	88.32	116.08	2.30	205.98	70.23	.47	123.06
31003	20.79	9.92	5.43	782.65	8.84	52.13	79.39	116.89	2.52	214.60	60.55	.01	115.59
31004	14.66	7.41	5.04	823.33	7.83	46.32	97.13	117.63	2.34	234.37	44.49	.45	119.31
31005	8.55	5.01	4.49	765.42	7.11	43.13	68.77	101.52	2.13	210.69	41.51	.42	121.99
31006	7.53	4.61	4.65	865.13	7.16	43.30	57.19	93.92	2.27	216.28	41.05	.01	109.82
31007	12.63	6.51	5.38	1144.56	9.24	44.51	37.64	105.12	2.17	230.01	54.69	.01	116.23
31007	12.12	6.41	4.55	1251.65	7.97	43.54	60.18	103.37	2.16	193.44	54.57	.01	115.56
AVERAGE	12.37	6.51	4.97	1198.08	8.10	42.53	49.91	104.24	2.17	199.72	54.63	.01	115.89
PCT DIFF	2.06	1.54	8.33	4.47	1.70	2.39	23.04**	.84	.29	3.15	.29	6.74	.29
31101	14.66	7.41	5.27	1523.41	9.32	57.74	85.42	173.25	2.23	210.93	56.20	1.62	142.45
31101	14.16	7.21	5.24	1397.87	9.62	57.39	73.26	167.57	2.33	199.63	55.87	.45	129.95
AVERAGE	14.41	7.31	5.26	1460.64	9.47	57.56	79.34	170.41	2.28	204.48	56.04	1.04	136.20
PCT DIFF	1.77	1.37	.38	4.30	1.77	.30	7.06	1.67	2.27	3.15	.30	56.66**	4.59
31102	17.21	8.42	4.95	845.55	8.21	43.85	51.81	112.15	2.30	193.27	57.94	.47	134.76
31103	20.27	9.62	4.83	1003.42	8.53	53.62	53.80	117.71	2.51	225.77	60.16	.48	139.93
31104	15.43	7.72	4.61	1087.85	9.51	57.06	38.89	115.70	2.35	236.49	56.71	.01	131.91
31105	13.93	7.11	5.61	5453.79	7.67	58.38	49.01	113.64	2.32	220.67	44.09	.45	152.80
31106	17.47	8.52	5.09	1211.65	8.24	52.43	64.08	118.56	2.30	218.10	46.04	.01	135.17

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31107	11.61	6.21	5.09	1131.53	8.25	45.56	82.46	112.96	2.26	226.26	42.95	.44	126.23
31108	9.31	5.31	5.29	1014.47	7.72	47.71	69.35	112.30	2.43	220.54	41.86	.42	123.01
31109	9.57	5.41	4.75	1105.79	8.07	42.32	69.54	105.99	2.32	216.16	41.98	1.53	123.35
31109	9.06	5.21	4.84	989.63	7.73	39.88	69.15	109.79	2.31	208.92	41.74	.01	133.69
AVERAGE	9.31	5.31	4.80	1047.71	7.88	41.10	69.35	107.89	2.32	209.51	41.86	.77	128.51
PCT DIFF	2.74	1.89	.87	5.54	2.38	2.96	.28	1.76	.28	.28	.28	98.73**	4.01	
31201	14.92	7.51	4.94	2115.65	8.76	53.21	97.43	154.97	2.35	211.57	56.37	.01	131.12
31201	15.17	7.62	5.07	2122.81	8.25	53.37	97.72	150.72	2.59	212.20	56.54	.01	131.52
AVERAGE	15.05	7.57	5.00	2118.83	8.47	53.29	97.57	152.84	2.47	211.88	56.46	.01	131.32
PCT DIFF	.85	.66	1.33	.15	2.63	.15	.15	1.39	4.91	.15	.15	8.06	.15	
31202	11.10	6.01	4.95	1349.78	8.13	56.54	93.23	121.31	2.36	191.22	53.95	.01	125.48
31203	13.65	7.01	4.75	1389.62	8.34	52.42	95.99	116.78	2.32	208.44	67.12	.45	129.19
31204	19.51	9.32	4.72	1496.83	8.57	50.03	78.13	112.86	2.61	223.62	72.01	1.72	126.18
31206	16.45	8.12	4.91	1477.19	8.38	50.59	87.24	114.72	2.63	215.44	45.44	1.66	133.52
31207	11.65	6.31	4.65	964.39	7.94	52.50	71.35	111.01	2.56	204.22	43.07	.44	137.91
31208	12.63	6.61	4.58	1373.46	9.35	46.37	94.67	115.42	2.46	206.91	43.45	.44	104.79
31209	12.67	6.51	4.68	1027.45	8.67	39.11	74.77	116.62	2.62	205.41	43.32	1.56	115.89
31209	11.86	6.31	4.65	1043.81	8.17	42.26	71.35	111.01	2.61	204.22	43.07	.44	115.22
AVERAGE	12.12	6.41	4.67	1035.63	8.42	40.73	71.56	113.62	2.62	204.82	43.20	1.01	115.56
PCT DIFF	2.10	1.56	.29	.51	2.99	3.91	.29	2.29	.29	.29	.29	56.65**	.29	
31301	21.80	10.22	4.96	2046.09	9.57	57.89	106.01	160.93	2.61	217.48	61.33	.49	142.67
31301	21.55	10.12	5.21	2039.44	9.41	53.66	110.43	162.96	2.55	229.44	48.39	1.77	142.21
AVERAGE	21.67	10.17	4.98	2042.77	9.49	55.68	112.20	161.95	2.68	223.42	54.86	1.13	142.44
PCT DIFF	.59	.49	2.40	.16	.91	3.59	5.53	.63	4.92	2.69	11.80	56.32**	.16	
31302	26.14	11.92	4.74	2033.74	8.62	58.53	139.31	165.39	2.84	263.07	64.93	1.88	170.12
31303	26.65	12.12	5.04	1772.21	9.32	56.26	113.01	166.65	3.14	231.75	65.38	3.25	165.73

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	A_(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31304	28.68	12.93	5.05	4907.75	8.41	62.07	102.21	111.96	3.23	252.40	67.25	4.75	184.49
31305	27.66	12.53	4.98	3594.37	8.57	55.67	106.77	109.06	3.04	248.84	66.31	3.36	168.07
31306	23.68	10.72	4.55	1429.99	8.32	62.75	81.76	110.30	2.86	247.60	62.35	3.16	171.03
31307	20.02	9.52	4.50	3625.61	7.75	69.10	66.13	112.33	3.13	287.56	59.97	1.73	214.50
31308	25.88	11.82	4.18	1484.69	7.55	46.23	111.84	106.38	3.24	283.33	51.22	3.22	164.62
31308	26.39	12.02	4.89	1494.37	8.02	50.63	112.61	107.11	3.25	271.76	51.57	1.68	165.15
AVERAGE	26.14	11.92	4.54	1489.23	7.73	48.43	112.22	106.75	3.25	277.51	51.40	2.55	164.59
PCT DIFF	.98	.84	7.81	.35	2.35	4.54	.35	.35	.35	2.09	.35	25.19**	.35
31406	43.72	18.84	4.62	3376.17	7.45	53.78	129.53	113.45	4.09	284.31	103.00	4.24	216.65
31410	16.70	8.22	4.68	1680.76	7.92	51.95	75.50	104.26	3.36	264.12	69.59	.46	217.97
31410	17.21	8.42	5.07	1570.31	7.37	53.47	75.97	103.70	3.26	229.51	70.01	.47	214.31
AVERAGE	16.96	8.32	4.88	1625.53	7.65	52.71	75.73	103.98	3.31	246.81	69.80	.46	216.64
PCT DIFF	1.50	1.20	4.01	3.40	.31	1.45	.31	.27	1.51	7.01	.31	.31	.31
31501	34.55	15.23	4.58	6875.15	7.43	67.03	141.93	121.99	4.28	275.01	103.83	.59	246.86
31501	37.61	16.43	4.81	7251.93	7.69	67.74	100.03	119.96	4.81	288.49	100.93	5.43	274.99
AVERAGE	36.08	15.83	4.70	6963.54	7.56	67.09	121.36	120.98	4.54	281.75	102.38	3.01	260.93
PCT DIFF	4.24	3.80	2.39	1.27	1.36	.68	16.94**	.64	5.84	2.39	2.39	80.37**	5.39
31502	34.55	15.23	4.74	1660.59	7.79	66.12	65.53	114.35	3.67	290.28	88.56	5.17	262.14
31503	26.39	12.02	4.62	8556.65	7.74	60.29	58.27	116.62	3.12	285.29	65.16	3.24	266.25
31505	37.66	16.53	4.83	2413.93	7.40	45.49	85.12	102.75	3.86	289.67	77.19	3.64	243.94
31507	19.76	9.42	4.74	1744.63	7.72	46.45	53.45	98.27	3.61	249.26	72.24	1.73	213.62
31508	19.76	9.42	4.49	1370.94	8.13	53.93	46.99	103.25	3.49	274.19	59.78	1.73	226.28
31508	20.02	9.52	4.63	1375.31	7.75	52.85	41.12	101.08	3.03	287.56	72.47	.46	252.01
AVERAGE	19.89	9.47	4.56	1373.12	7.93	53.39	41.06	102.17	3.25	280.88	66.12	1.10	239.15
PCT DIFF	.64	.53	1.53	.16	2.20	1.01	.16	1.06	7.53	2.38	9.60	86.33**	5.38

AEGEAN SEDIMENTS

METAL CONCENTRATIONS. WITH AVERAGES AND PRECISIONS ON DUPLICATES

(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31401	21.52	10.11	4.97	3058.15	8.5*	68.03	60.75	361.51	2.68	318.56	25.52	.01	166.12
31401	21.27	10.01	4.95	3046.27	8.38	65.27	60.55	360.34	2.67	330.23	38.14	.01	152.78
AVERAGE	21.39	10.06	4.96	3052.22	8.46	66.65	60.65	360.93	2.67	324.39	31.83	.1	159.45
PCT DIFF	.60	.50	.16	.16	.91	2.07	.16	.16	.16	1.80	19.82**	12.06	4.15
31402	39.35	17.12	4.95	2967.68	8.01	73.19	45.67	108.34	3.96	313.25	66.02	.02	264.31
31403	39.35	17.12	4.78	2308.13	8.24	66.59	45.67	108.34	3.96	313.25	66.02	.02	247.83
31404	29.42	13.21	5.38	1983.44	7.93	65.72	39.22	115.76	3.12	311.68	42.55	.01	241.27
31405	27.38	12.41	5.65	6196.43	7.44	105.19	51.89	123.53	2.83	302.94	55.13	.01	262.34
31407	21.27	10.31	4.95	1778.15	7.52	50.03	35.15	101.24	3.05	266.72	38.14	.01	210.28
31408	19.74	9.41	4.98	1744.31	7.48	46.58	34.48	96.07	3.11	249.19	37.41	.01	212.10
31409	20.50	9.71	4.53	1761.07	8.05	54.58	34.81	102.78	3.14	264.16	37.77	.01	214.20
31504	38.84	16.92	4.58	2942.96	7.68	69.31	45.29	105.80	3.76	294.30	65.47	.02	229.41
31506	23.56	10.31	4.64	1931.47	7.72	50.22	36.21	102.97	3.14	274.72	39.29	.01	240.94
31601	26.61	12.11	4.91	1907.73	8.04	53.67	37.72	104.44	3.41	299.79	40.93	.01	266.56
31601	26.36	12.01	4.75	1765.34	8.15	50.77	37.59	97.38	3.39	285.17	40.78	.01	285.57
AVERAGE	26.49	12.06	4.83	1836.53	8.09	52.22	37.66	98.91	3.40	292.48	40.85	.01	266.07
PCT DIFF	.48	.41	1.58	3.88	.57	2.78	.17	1.55	.17	2.50	.17	15.35**	.17
31602	25.34	11.61	4.55	1272.45	7.98	48.74	37.07	102.75	3.08	281.28	26.83	.01	228.10
31603	24.58	11.31	3.31	729.22	5.97	27.03	36.73	71.21	2.52	212.14	26.56	.1	132.97
31603	24.58	11.31	3.13	742.48	6.13	27.03	23.44	65.91	2.39	196.68	26.56	.01	132.97
AVERAGE	24.58	11.31	3.25	735.85	6.03	27.03	30.07	68.56	2.45	205.51	26.56	.01	132.97
PCT DIFF	0	0	2.04	.90	1.10	0	22.05**	3.87	2.70	3.23	0	14.01	0
31604	21.52	10.11	4.33	1783.93	7.77	42.54	9.78	88.03	2.55	229.36	25.52	.01	153.27
31605	24.32	11.21	4.76	1189.25	7.93	48.08	.01	97.40	3.70	294.71	39.68	.01	334.31
31606	24.32	11.21	4.76	951.41	8.05	46.76	36.57	98.72	3.70	303.92	39.68	.01	334.31
31607	23.30	10.81	3.26	586.73	5.74	21.37	36.09	64.81	3.13	234.69	26.12	.01	182.92
31607	24.07	11.11	3.42	592.63	5.79	22.93	36.45	66.10	3.16	223.58	26.38	.01	184.70
AVERAGE	23.69	10.96	3.34	589.68	5.77	22.15	36.27	66.46	3.14	229.29	26.25	.1	183.84
PCT DIFF	1.61	1.37	2.46	.50	.50	3.46	.50	2.47	.50	2.36	.50	13.19	.93

AEGEAN SEDIMENTS

METAL CONCENTRATIONS, WITH AVERAGES AND PRECISIONS ON DUPLICATES
(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31608	32.47	14.41	3.70	829.27	5.33	27.23	26.29	69.17	3.25	236.94	44.48	.01	207.77
31608	31.96	14.21	3.67	808.37	5.44	24.39	26.00	73.06	3.38	249.86	29.45	.01	206.21
AVERAGE	32.22	14.31	3.69	818.82	5.38	25.66	26.10	71.12	3.32	243.40	36.96	.01	206.99
PCT DIFF	.79	.70	.38	1.26	.99	6.13	.38	2.74	1.85	2.65	20.33**	19.38**	.38
31609	19.48	9.31	4.60	1614.53	7.58	55.13	21.95	88.24	2.98	285.66	37.36	.01	243.91
31610	23.30	10.81	4.30	647.50	5.91	34.41	10.61	83.07	3.13	234.69	26.12	.01	222.63
31611	24.83	11.41	3.33	691.79	6.52	24.46	23.52	71.45	2.93	226.16	26.05	.01	180.64
31612	23.56	10.91	4.97	1362.29	7.98	48.91	23.13	102.97	3.46	287.84	26.21	.01	248.94
31613	21.76	10.21	3.58	715.89	7.29	31.18	22.60	77.61	3.07	230.11	25.61	.01	179.34
31613	21.01	9.91	3.54	721.63	5.84	30.83	.01	76.12	2.91	215.22	25.36	.01	190.27
AVERAGE	21.39	10.06	3.56	718.76	7.05	31.03	11.30	77.87	2.99	222.67	25.48	.01	184.80
PCT DIFF	1.79	1.49	.49	.40	3.19	.49	99.91**	.33	2.61	3.34	.49	12.22	2.96
31614	19.23	9.21	2.60	544.73	5.26	20.29	9.50	55.35	2.23	185.71	24.60	.01	120.40
31614	19.48	9.31	2.61	546.48	5.09	20.35	21.95	56.01	2.24	186.30	24.88	.01	112.33
AVERAGE	19.36	9.26	2.60	545.62	5.18	20.32	15.72	56.68	2.23	186.01	24.84	.01	116.15
PCT DIFF	.66	.54	.16	.16	1.05	.16	39.59**	2.35	.16	.16	.16	10.64	5.09
31615	19.74	9.41	4.61	747.56	7.48	31.63	22.02	89.34	3.86	274.11	37.41	.01	206.92
31615	19.74	9.41	4.49	747.56	7.35	32.88	34.48	93.08	3.99	268.57	37.41	.01	299.38
AVERAGE	19.74	9.41	4.55	747.56	7.41	32.25	28.25	91.21	3.92	280.34	37.41	.01	293.15
PCT DIFF	0	0	1.37	0	.84	1.93	22.05**	2.05	1.59	2.22	0	1.95	2.13
31701	39.09	17.02	4.76	5253.81	7.39	69.04	61.89	129.23	4.10	295.53	82.16	.02	246.79
31701	39.09	17.02	4.76	5417.99	7.55	71.24	61.89	124.31	4.10	295.53	82.16	.01	230.37
AVERAGE	39.09	17.02	4.76	5335.90	7.47	70.42	61.89	126.77	4.10	295.53	82.16	.01	238.58
PCT DIFF	0	0	0	1.54	1.10	1.17	0	1.94	0	0	0	24.29**	3.44
31702	36.04	15.82	4.69	2345.67	7.82	66.27	58.93	126.18	2.35	297.64	46.96	.02	219.36
31703	36.83	16.12	4.91	1898.74	7.75	68.65	43.82	116.63	3.96	316.46	47.53	.02	237.84
31704	27.63	12.51	5.39	2349.13	8.15	79.38	38.25	129.49	3.45	345.46	41.58	.01	262.96
31705	26.36	12.01	5.38	4617.64	7.22	92.07	37.59	127.25	3.12	298.75	54.36	.01	271.99

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(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31706	35.53	15.62	4.65	2636.75	7.75	76.60	58.46	117.43	3.57	294.70	62.10	.02	246.65
31707	39.09	17.02	4.76	2626.91	7.55	54.82	61.89	106.25	3.94	295.53	49.32	.02	246.79
31708	21.27	10.31	5.68	1524.14	8.38	47.49	22.45	103.78	3.18	266.72	38.14	.01	241.69
31709	21.52	10.11	4.97	1656.53	7.65	47.04	9.78	102.64	3.31	254.05	38.27	.01	225.73
31709	21.01	9.91	4.81	1645.82	7.72	49.97	35.14	100.91	3.17	253.28	38.02	.01	215.59
AVERAGE	21.27	10.01	4.89	1651.15	7.68	48.75	22.41	101.68	3.24	254.03	38.14	.01	222.66
PCT DIFF	1.20	1.00	1.62	.32	.50	2.28	56.36**	.95	2.26	.32	.32	12.36	3.13
31801	31.71	14.11	4.13	1244.64	7.31	54.75	40.54	134.29	3.37	263.57	29.34	.01	161.52
31801	32.22	14.31	4.13	1209.73	7.52	50.73	55.60	130.77	3.39	265.55	44.31	.01	177.46
AVERAGE	31.96	14.21	4.12	1227.19	7.57	52.74	48.07	135.53	3.38	264.56	36.83	.01	169.50
PCT DIFF	.80	.70	.37	1.42	.56	3.81	15.66**	.92	.37	.37	20.33**	15.84**	4.71
31802	31.45	14.01	4.38	1312.95	7.73	56.66	48.39	110.45	3.35	248.66	43.82	.01	160.92
31803	26.36	12.01	4.21	1018.45	7.47	46.76	24.01	106.88	2.99	244.43	40.78	.01	163.36
31804	31.71	14.11	4.13	849.23	7.75	43.63	40.54	107.93	3.07	246.93	58.62	.01	161.52
31805	46.73	20.02	4.13	1877.27	7.32	52.17	76.73	115.85	3.75	300.36	75.18	.02	169.57
31806	20.76	9.81	4.80	1134.83	7.13	38.35	34.92	105.64	2.93	241.91	37.90	.01	126.56
31808	24.32	11.21	4.76	1123.19	7.27	45.44	36.57	114.58	2.91	251.07	52.90	.01	153.95
31809	34.25	15.12	4.41	1364.70	7.45	49.26	42.12	109.07	3.35	258.57	61.96	.06	152.57
31809	.01	.40	46.00	220.00	.26	26.77	.01	25.41	.10	63.00	46.03	.01	346.56
AVERAGE	17.13	7.76	25.21	642.35	3.83	38.02	21.06	67.24	1.72	169.26	50.46	.01	249.53
PCT DIFF	99.94**	94.84**	82.50**	65.75**	94.77**	29.58**	99.95**	62.21**	94.26**	52.74**	20.67**	23.67**	38.11**
31810	39.86	17.32	4.32	1662.67	7.32	52.19	46.36	122.56	3.15	249.40	66.58	.02	166.79
31810	40.11	17.42	4.51	1669.74	7.51	54.68	62.95	123.08	3.34	267.16	33.46	.01	167.53
AVERAGE	39.99	17.37	4.42	1666.20	7.41	53.14	54.50	122.82	3.25	258.28	50.02	.01	167.15
PCT DIFF	.32	.29	2.10	.21	1.34	1.78	15.56**	.21	2.78	3.44	33.10**	24.89**	.21
31205	18.98	9.11	4.69	2398.12	8.64	46.14	21.81	138.25	2.47	222.15	24.72	.01	111.43

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IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
31901	43.17	20.38	4.33	2164.11	7.48	64.86	41.92	109.45	4.32	255.76	14.41	.02	153.27
31901	47.90	20.49	4.22	2303.25	7.29	61.23	22.73	112.14	4.32	249.52	.01	.01	149.53
AVERAGE	45.54	20.43	4.28	2233.68	7.38	61.41	32.81	110.80	4.32	252.64	5.21	.01	151.40
PCT DIFF	1.31	1.20	1.23	3.11	1.23	.36	31.79**	1.40	2.33	1.23	99.81**	32.68**	1.24
31902	47.90	20.49	4.03	1650.67	7.13	47.89	21.79	106.39	4.78	236.33	.02	.02	149.53
31938	67.47	28.17	3.14	3873.93	6.45	64.26	34.85	105.84	8.33	245.91	16.36	2.79	116.38
31939	48.66	20.78	4.67	2532.26	7.99	75.78	41.53	113.81	4.13	253.23	29.78	.02	171.23
31930	41.55	17.38	4.62	2395.67	7.01	72.65	2.21	103.38	3.85	239.51	26.14	.02	150.37
31948	68.99	28.77	3.29	1935.05	4.52	64.20	60.02	107.82	9.45	258.01	17.18	2.93	57.92
31949	55.52	23.48	4.23	1843.69	6.73	73.98	25.45	117.68	5.35	224.84	11.92	.02	89.24
31905	58.07	24.48	4.48	1866.04	5.95	45.08	54.84	115.49	4.23	238.47	.02	.02	96.41
31906	37.73	16.48	4.82	1927.24	7.37	52.84	18.13	103.47	3.56	224.84	.02	.02	144.16
31907	35.19	15.48	4.17	950.69	7.72	52.31	1.98	121.01	3.39	216.63	8.13	.02	135.62
31908	51.89	25.97	3.78	2255.69	7.08	36.80	55.95	106.82	5.90	262.31	13.94	.03	99.47
31919	55.52	23.48	3.91	2691.19	5.97	52.99	25.45	108.89	4.69	269.81	11.92	.02	134.21
31909	56.29	23.78	4.09	2745.14	7.39	56.97	40.77	108.50	3.82	274.51	12.13	.01	132.49
AVERAGE	55.91	23.63	4.00	2721.62	7.03	56.49	37.11	108.69	3.75	272.16	12.03	.02	131.35
PCT DIFF	.68	.63	2.28	.86	.56	.66	31.43**	.16	1.77	.86	.88	38.43**	.87
32001	38.97	16.18	3.81	1554.87	6.51	39.51	2.04	105.39	2.83	190.39	8.36	.02	75.98
32001	38.46	15.98	3.78	1573.91	5.32	42.76	33.53	106.12	2.83	188.87	.01	.01	59.64
AVERAGE	38.72	16.08	3.79	1564.39	5.92	40.13	17.77	105.76	2.84	189.63	4.19	.01	67.51
PCT DIFF	.69	.62	.40	.51	1.54	1.57	88.52**	.35	.40	.40	99.76**	22.68**	12.65
32002	43.58	18.78	4.25	1949.65	7.44	49.45	37.75	139.00	3.72	233.41	9.36	.02	136.27
32003	46.63	19.98	4.87	5433.73	7.87	43.53	21.18	133.03	3.75	243.58	9.91	.02	106.49
32004	42.31	18.28	4.51	4333.44	7.83	132.10	36.91	142.38	2.95	277.34	9.15	.02	187.23
32005	36.46	15.98	4.41	1131.74	7.24	34.28	17.76	110.04	2.69	251.63	8.29	.02	169.81
32006	39.77	17.28	4.65	1593.83	5.97	81.19	2.14	111.28	3.49	232.43	8.76	.02	129.32
32007	35.73	15.58	4.64	1440.38	6.69	43.61	2.00	104.66	3.37	202.18	8.19	.02	121.14
32008	33.41	14.79	4.36	1369.65	5.51	34.39	16.34	92.25	3.01	195.24	.02	.02	116.97
32009	.69	2.36	2.42	1311.61	7.05	7.96	41.59	119.39	.55	60.54	.01	.01	.1
32010	39.21	16.98	4.26	2295.29	5.55	71.97	51.30	97.43	3.28	229.53	8.65	.02	127.71
32011	34.94	15.38	2.63	1122.03	3.54	36.73	48.08	59.06	1.80	138.33	.02	.02	73.01
32012	40.28	17.48	4.66	2176.68	5.02	112.02	52.39	107.87	2.65	251.16	8.83	.02	197.40

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(AFTER CARBONATE FREE CALCULATIONS)

IDENT.	CALCITE	CA(PCT)	FE(PCT)	MN(PPM)	AL(PCT)	CU(PPM)	PB(PPM)	ZN(PPM)	MG(PCT)	CR(PPM)	CO(PPM)	CD(PPM)	NI(PPM)
32013	38.24	16.68	3.72	1327.73	6.48	69.47	34.47	115.06	3.16	242.89	24.73	.02	142.02
32013	38.75	16.98	3.92	1322.46	5.85	70.04	51.39	109.55	3.18	244.96	24.94	.01	143.59
AVERAGE	38.50	16.78	3.82	1325.13	6.17	69.75	42.93	109.60	3.17	243.90	24.83	.01	142.91
PCT DIFF	.66	.60	2.54	.26	2.95	.41	19.42**	5.52	.41	.41	.42	23.64**	.01
32301	40.28	17.48	5.53	2009.24	7.26	88.57	2.16	114.57	3.77	301.39	8.83	.02	230.89
32301	40.28	17.48	5.35	2009.24	7.03	86.90	35.65	114.57	3.77	284.64	25.58	.01	230.89
AVERAGE	40.28	17.48	5.44	2009.24	7.12	87.74	18.91	114.57	3.77	293.01	17.21	.01	230.89
PCT DIFF	0	0	1.54	0	1.19	.95	88.56**	0	0	2.86	48.66**	25.22**	0
3232A	68.99	28.77	3.32	1709.38	5.16	51.29	66.82	114.27	6.87	290.26	17.18	6.15	122.32
3232B	46.12	19.78	4.64	1336.33	6.68	72.26	2.42	110.30	4.55	259.84	9.81	.02	181.71
3232C	58.67	24.48	4.13	1430.61	6.26	73.69	3.15	110.72	5.72	262.31	12.66	.02	161.95
3232D	42.62	18.48	4.55	1294.10	6.47	68.03	19.75	105.67	4.26	262.32	9.23	10.32	171.20
32333	37.99	16.58	4.52	1322.34	7.25	44.49	18.23	107.12	3.87	225.77	8.50	.02	157.96
32334	35.96	15.78	4.64	1217.91	7.49	51.37	17.62	94.03	3.59	202.98	8.23	.02	137.23
3235A	70.77	29.47	4.04	3763.52	5.13	105.74	107.24	128.07	8.72	307.92	18.23	.03	163.98
3235B	42.82	18.48	5.25	2196.54	7.34	92.52	2.27	111.92	4.51	279.61	9.23	.02	223.67
32306	41.59	18.00	5.48	1883.32	7.73	58.34	19.34	117.15	3.65	222.57	9.04	.02*	.26+07
32307	36.46	15.96	5.82	1573.91	8.33	54.93	17.76	110.84	3.31	188.87	8.29	.02	100.35
3238A	8.51	4.39	6.67	1311.61	8.63	26.12	1.35	115.22	1.86	65.58	.01	.01	.01
3238E	17.40	8.49	5.93	1331.79	9.23	42.25	13.62	108.26	2.26	108.96	.01	.01	21.63
32401	45.36	19.48	4.94	2373.15	7.14	63.87	20.68	112.42	4.21	311.16	9.67	.02	215.77
32401	45.36	19.48	5.12	2379.15	7.32	63.67	20.68	116.08	4.21	292.82	.01	.01	215.77
AVERAGE	45.36	19.48	5.03	2379.15	7.23	63.87	20.68	114.25	4.21	301.97	4.84	.01	215.77
PCT DIFF	0	0	1.82	0	1.27	0	0	1.60	0	3.03	99.79**	29.33**	0
32402	50.70	21.58	4.46	2231.03	7.50	210.74	22.94	112.42	4.87	263.67	10.74	.02	137.73
32403	42.82	18.48	5.07	2273.42	7.34	94.26	19.75	118.92	4.16	262.32	9.23	.02	188.59
32404	40.28	17.48	5.02	1674.37	7.37	63.46	2.16	112.96	4.22	251.16	8.83	.02	230.89
32405	36.46	15.98	4.83	2633.84	6.93	61.22	2.02	115.56	4.56	251.83	8.29	.02	201.29
32406	11.05	5.99	3.04	1235.65	7.21	27.99	1.40	89.29	1.24	76.76	.01	.01	8.64
32406	10.80	5.89	2.91	1233.14	7.17	26.79	1.39	93.52	1.23	67.26	.01	.01	8.81
AVERAGE	10.92	5.94	2.98	1234.90	7.18	27.39	1.39	91.40	1.23	72.98	.01	.01	8.83
PCT DIFF	1.16	.84	2.03	.14	.14	2.19	.16	2.31	.14	7.83	5.65	5.85	.14