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Carbon and Sulfur Relationships in Marine Senonian Organic-rich, Iron-poor Sediments from Israel. A Case Study.

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Carbon and Sulfur Relationships in Marine Senonian Organic-rich, Iron-poor Sediments from Israel. A Case Study.

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Abstract

In iron-poor and organic-rich marine sediments, reduced S is mainly organic due to the lack of reactive iron. These sediments (e.g. carbonates, cherts, phosphates) have high C/S (organic carbon / total reduced sulfur) ratios which are, as a rule, above 3 and may reach 5 or 6 (at times even more than 10) in organic-rich rocks. These high ratios are characteristic for these iron-starved sediments and are very different from those found in marine sediments where pyritic S is the main reduced sulfur species. They may be explained by the escape of H_2S to the atmosphere.

The interpretation of C/S plots in these sediments is also quite different. One reason for the S intercept in these plots is the presence of pyritic S and thus contrary to the conventional plots this intercept seems to have no environmental significance, on the other hand the S/C slope appears to be a paleoenvironmental indicator. Low slopes (< 0.2) indicate

restricted to inhospitable (euxinic) environments whereas higher slopes (> 0.2) indicate restricted to open (aerobic) environments.

C/S plots have been used to interpret environments of deposition in such sediments from two cycles of organic-rich, iron-poor Senonian sediments in several basins in central and southern Israel. Both cycles appear to have been deposited in restricted environments. The Campanian (Mishash Formation) environments of deposition appear to be in general more oxic than those of the Maastrichtian (Ghareb Formation). As an independent comparison for the C/S results, the Degree of Pyritization (DOP) was calculated for some samples. The DOP results confirmed the C/S results. It should be stressed that in such low-iron environments, even DOP results should be used with caution.

Introduction

Correlation between pyritic sulfur and organic carbon in recent sediments has been shown (Berner, 1970; Sweeney, 1972; Goldhaber and Kaplan, 1974). From a comprehensive compilation of existing data, Sweeney (1972), found a C/S ratio of about 3 for recent sediments in normal marine conditions, with a correlation line that intercepts the origin. The C/S relationship was explained by the formation of pyrite as a result of: a) bacterial sulfate reduction (under anoxic conditions) using metabolizable organic matter and b) the subsequent reactions of HS and H S with available Fe to form pyrite. The relatively good C to S correlation shows that the fraction of the organic matter which can be metabolized by sulfate reducers is more or less constant in marine organic matter (the scatter showed some variation). Furthermore, passing of the line defined by this correlation through the origin, was taken as an indication that the environment of deposition was oxic.

In the Black Sea, C/S ratios significantly lower than 3 were found and the linear regression of S vs C plots show positive intercepts on the S axis (Leventhal, 1983; Berner and Raiswell, 1983; Raiswell and Berner, 1985). This is because, when there are anoxic conditions in the water column, sulfide (pyrite) is produced (and deposited) without equivalent deposition of non-reactive organic matter. The use of C/S plots as indicators of environment of deposition and, more specifically, to distinguish between euxinic and normal environments (Leventhal, 1987; Donnelly et al., 1988) is based on the above-noted findings.

It should be emphasized that the constraints detailed by Berner and

Raiswell (1984), namely, availability of sulfate, metabolizable organic matter and reactive Fe, for the use of C/S plots to distinguish between freshwater and marine sedimentary rocks, apply to the use of C/S plots in general. There is no problem regarding availability of organic matter, in distinguishing between marine oxic and anoxic environments, since it is difficult to imagine an unweathered sediment, having been deposited in anoxic conditions, to be devoid of organic matter; the same is true of sulfate availability because of the relatively high sulfate concentration in seawater. On the other hand, availability of reactive Fe may be a limiting factor, especially in calcareous rocks (Berner, 1984; Davis et al. 1988), and in this case the usual interpretation of C/S ratios is not necessarily applicable. Total sulfur has already been used in C/S plots (Leventhal, 1987) but it implicitly represented mainly pyritic sulfur (Berner and Raiswell, 1984). We propose to use total sulfur when it represents mainly reduced sulfur, also where organic sulfur is significantly more abundant than pyritic sulfur, as is the case in our study. The rationale for this and our interpretation of the C/S ratios in these rocks is presented in the discussion.

We use the C/S relationships in an attempt to compare two cycles of organic-rich, iron-poor, sedimentation in central and southern Israel during the Senonian. The Degree of Pyritization - DOP - of iron, defined as the ratio of pyritic Fe to pyritic Fe + acid-soluble Fe (Berner, 1970), has been recently proposed by Raiswell et al. (1988) as a paleoenvironmental indicator to distinguish between aerobic ($\mathrm{DOP} < 0.42$), restricted ($0.46 < \mathrm{DOP} < 0.80$) and inhospitable, euxinic, ($0.55 < \mathrm{DOP} < 0.93$) bottom conditions. The DOP was calculated for some samples to provide an idependent comparison.

Geological setting

The Senonian sequence in the Negev (southern Israel) includes at least two formations, containing organic-rich sediments, the Mishash (Campanian) and the Ghareb (Maastrichtian). A generalized geological section is presented in Figure 1. These two formations have been intensively studied with emphasis on the Mishash Formation's economic phosphorites. Reiss (1988) discusses the paleoenvironmental conditions of the Senonian in Israel in view of its fossil assemblages. He distinguishes the Mishash Fm where conditions of high photic zone fertility prevailed.

The organic-rich sediments are restricted to synclinal facies attaining thicknesses of up to 200 m. In most of the synclines studied the organic-matter content can be used as a stratigraphic tool; in the lower part of the Ghareb Formation it increases gradually downwards, from negligible values (less than 0.1%) up to 17% organic carbon, towards the boundary with the Mishash, where it drops sharply to less than 5% (Minster and Padan, 1986). Below the phosphorite unit, organic-rich sediments are found, in places up to 20 m thick. There probably are other organic-rich sediments lower in the sequence, but as the existing data on them is only preliminary, they are not dealt with in this work.

The organic-rich sediments of the Ghareb Formation have been termed "oil shales" although the inorganic part is dominated by carbonates rather than clays. Figure 2 shows the geographical distribution of the known Ghareb oil shales deposits. Of these Mishor Rotem (Shahar, 1965; Shirav, 1975; Minster, 1983), Oron (Minster, 1985), Nahal Zin (Hildebrandt-Mittlefehldt and Shiloni 1985) and Nabi Musa (Shirav, 1976) have been studied and are well known. Detailed work was carried out on part of the Mishor Rotem deposit - Nahal Havarbar - in which a medium-scale oil shale open pit mine was recently developed (Raveh, 1986; Padan and Leichter, 1988). However, only initial information exists on other Ghareb oil shale occurrences e.g. in the Arava, Biq'at Zin, Avedat, Nevatim and Shivta basins. Organic-rich sediments occur also in equivalent time units (Maastrichtian) in central and northern Israel (Gvirtzman et al., 1985); but the only deposit studied in this area is Hartuv (Shirav and Ginzburg, 1980; Halicz, 1983). Both organic and inorganic properties of Ghareb oil shales have been extensively studied (Spiro, 1980; Shirav and Ginzbourg, 1983; Spiro et al., 1983: Shirav, 1987; Aizenshtat, 1989).

The organic-rich sediments of the Mishash Formation, namely, the black sediments which occur in places below the phosphorite unit, are less well-known. They have been found in several basins such as Mishor Yamin (Minster and Shirav, 1983), Oron (Minster, 1985), and Nahal Zin (Hildebrandt-Mittlefehldt and Shiloni, 1985), among others. The lateral distribution of the organic-rich sediments within the deeper synclinal facies in the Mishash Formation is in the main similar to that of the Ghareb oil-shales (Fig. 2). Nevertheless, in places they may be well-developed while the overlying Ghareb sequence is totally non-bituminous, the opposite, a well-developed Ghareb oil-shale sequence overlying a non-bituminous Mishash sequence occurs as well (Minster and Shirav, 1983).

Samples and methods

Only samples from cores with an organic carbon content above 1.5% were used in this study. Outcrop samples are not suitable because of surface oxidation even when they contain appreciable amounts of organic matter; nor are samples which contain appreciable concentrations of sulfates (mainly gypsum). Therefore samples in which gypsum constituted more than 10% of the total sulfur, were not included; this allowed us to use total sulfur (instead of total reduced sulfur) in the C/S ratio. Table 1 gives the location and depth of the samples analysed in this study together with the relevant results published by Spiro (1980), Halicz (1983) and Shirav (1987) in their respective doctorate theses. In all, this study is based on more than 300 samples from 65 drillholes representing 5 basins (synclines).

The organic matter content in the samples was determined by its oxidation by acidified potassium dichromate (Allison, 1960). The limitations of this method have been discused by Nathan et al., (1982). who have shown that for all its limitations, the method offers a simple and rapid way for comparing (and calculating) the carbon content of similar samples. Fig. 3 shows the variations in organic matter content (easily oxidised matter - EOM) in three boreholes. Organic carbon was determined in most of the samples by a Leco Carbon Analyser, after acid dissolution of the carbonate. In some cases where samples were no longer available, the carbon content was calculated from the previously determined organic matter concentration (EOM). Total sulfur was determined by a variety of methods: Leco Sulfur Analyser (PAMA lab.), Eschka, and X-ray fluorescence (Geological Survey lab.). Comparison of results between the different methods showed fair correlations; the X-ray results were generally slightly lower than the

Leco results. Organic sulfur, pyritic sulfur, total iron and HCl soluble iron were determined in a number of samples.

Results

The relevant data for all samples are presented in Tables 1 and 2, Table 3 summarizes the averages for all basins. Figs. 3a-3c show the borehole sections for Mishor Rotem, Oron and Nahal Zin, respectively, each typifying its given basin. The C/TS (Organic carbon vs Total sulfur) plots for the various basins studied are given in Figs. 4-11. The C/OS (Organic carbon vs Organic sulfur) plot for the Rotem basin (Ghareb samples) is given in Fig. 12. Table 2 gives the degree of pyritisation (DOP), for selected samples in Mishor Rotem from the Mishash and Ghareb formations (Minster et al., in Press)

Discussion

In 1953, Ostroumov (1953a) showed that organic derivatives of sulfur were formed in recent marine sediments during sulfate reduction. Most of the organic sulfur appears to be within the humified organic matter (Ostroumov, 1953b; Brown et al., 1972; Francois, 1987). The abundance and origin of humic substances in phosphorites was recently reviewed by Nathan (1990). In recent marine sediments, organic sulfur accounts for less than 10% of the reduced sulfur content (Goldhaber and Kaplan, 1974). However, in the organic-rich sediments of the Ghareb and the Mishash formations, it constitutes 50 to 95% of the reduced sulfur (Dinur et al., 1980). This proves that lack of reactive Fe was indeed a limiting element for the formation of pyrite in these rocks; since the rate of formation of organic sulfur in sediments is much slower than that of pyritization (Ivanov et al., 1976), and pyrite would have formed first if Fe had been available. Aizenshtat and his co-workers have intensively researched the sulfur enrichment in the organic matter of the Ghareb oil-shales, and recently proposed specific mechanisms for the sulfur enrichment in the organic matter (Aizenshtat, 1989) . Within the sediments and during diagenesis, in an iron-poor environment, the residence time of the sediments (contact with H S), which is a function of the sedimentation rate, is critical, since the uptake of sulfur by organic matter is a relatively slow reaction. Therefore in basins with rapid sedimentation rates, we expect lower organic S concentrations and escape of H_2S to the bottom waters. It should be pointed out that in the case of very low sedimentation rates, saturation of organic matter with sulfur occur, in this case H_2S will also escape to the water body in spite of the long residence time. In the case of the water column the short residence time of sediments in it will probably cause a significant difference in sulfur content, and a lower sulfur content is expected when reduced sulfur is mainly organic. This is due to the fact that most of the H_2S will not react in the water column (when no reactive iron is available) and will eventually oxidize. Circulation in the basin is therefore critical in these environments, basins with restricted circulation will have inhospitable (euxinic) bottoms, while others with the same amount of H S coming into the bottom waters will be only restricted. Taking the above into consideration, C/S plots may be used to interpret environments of deposition, even for iron-poor sediments whose S is mainly organic. The main differences, compared to C/S plots where S is mainly pyritic, are: a) higher C/S ratios, because of the escape of part of the H S in all cases and b) milder slopes for the regression equations, due to the even higher C/S ratios for samples with high C concentrations, where more H S was formed and escaped compared to the samples with low C concentrations. Fig. 13 plots C vs C/TS and shows a good correlation confirming the above. It should be noted that in our case, one of the reasons for the S intercept of the C/S plots is the presence of pyrite. This is proved by the organic carbon / organic sulfur plot (Fig. 12) which has no significant intercept. This precludes the use of this intercept for environmental interpretations.

Another explanation for this phenomenon (High C/S ratios and higher C/S ratios for higher organic C contents) was given by Bein et al. (1990) who studied the same sediments from 4 boreholes in two basins (Zin valley and Shefela). Their explanation is that the whole system was generally sulfate limited. We differ for the following reasons: a) High C/S ratios occur in places where no sulfate limitation is possible. Davis et al. (1988) in their study of the Mowry shales divided one set of their samples (subset D) according to their C/S ratios to group I and II. Both groups had similar amounts of organic carbon, (group I 2.78 % and group II 3.05 %) and both groups had a hydrogen index (HI) greater than 150, i.e. contained enough reactive organic matter. The average C/S ratio of group I was 1.9, while the average C/S of group II was 11.4. The only significant difference between the two groups was the iron content, 2.47 % for group I and 1.03 % for group II. Escape of H S from the sediments appears to be a reasonable explanation for the differences in C/S ratios. b) Higher C/S ratios in rocks with higher organic C concentration were found in environments where sulfate limitation is improbable. Gibson (1985) studied C/S relationships in iron-poor silty limestones from the Georgina Basin, Australia. He divided his samples into two groups, organic-rich samples (> 3 % TOC) and organic-poor samples (< 3 % TOC). The average C/S for the organic-rich group was 11.4 while it was only 3.3 in the organic-poor. Again the only reasonable explanation for this difference is H_2S escape. Gibson's assumption that organic S content is insignificantly small is probably incorrect as far as the organic-rich samples are concerned. c) In their discussion Bein et al. (1990, p.906) reach the conclusion that sulfate limitation occurs only for samples which contain above 17-20 % organic C. Very few samples in the sequence have these concentrations, only 4 out of the 314 samples dealt with in this study have concentrations above 17 % and none contain more than 20 % organic C. Therefore if sulfate limation occurs, its effects are marginal. d) Sulfur isotope results (Dinur et al., 1980; Bein et al. 1990) do not show correlation with organic C %, which would be expected if sulfate limitation occurs. On the other hand, organically bonded S is systematically heavier (by about 10 %) than pyritic S (within the same sample), confirming the escape of light reduced sulfur.

The results vary widely. Each basin has a C/S plot, distinct from the others. This indicates independent regimes for the various basins, restricted circulation, and to a certain extent (for limited time) for them to be cut off from the open sea. In two basins, Oron and Mishor Rotem, the S/C slopes for oil shales of the Ghareb Formation, the Maastrichtian event, are significantly lower (0.13 - 0.15) than in the Mishash Formation, the Campanian event (0.21 - 0.22) indicating that the environment of deposition in these two basins was less restricted and more oxygenated in the Campanian than in the Early Maastrichtian. This may be due to the shallower depth of the basins during the Mishash times. The DOP results confirm the above. However the significant differences between our DOP results and those of Bein et al. (1990) should induce to caution. In such iron-starved environments, small analytical errors (e.g. in pyritic S) may cause significant errors in the DOP, furthermore since most of the iron in these formations is located in the clay, the HCl iron is not necessarily reactive iron. Nevertheless, considering that the Mishash Formation contains even less iron than the Ghareb, and that we used the same analytical techniques in both, the lower DOP's obtained for the Mishash samples appear to be significant.

Conclusions

1) In organic-rich and iron-poor environments, e.g. upwelling areas, with mainly biogenic sediments such as carbonates, phosphates and cherts, organic sulfur is the main reduced sulfur species. Total S represents mainly reduced S in unweathered samples.

2) In these environments, high C/S (organic C/total S), ratios, above 3, are found. This is due to H_2S escape from the sediments.

3) C/S plots may be used to interpret environments of deposition.

4) The various basins (synclines) during the Mishash and Ghareb times were intermittently cut off from the open sea and had at times independent regimes.

5)The Mishash (Campanian) environments of deposition generally appear to have been more oxic than those of the Ghareb (Maastrichtian).

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Table 1

Oil Shale Field	Formation	Borehole/ Sample Id.	From m	To m	Organic Carbon (%)	Total Sulfur (%)	C\S	Source
ZIN	2	K-1074	22.0	22.6	3.36	1.13	2.97	I
ZIN	2	K-1074	[illegible]	24.8	7.10	1.84	3.86	I
ZIN	2	K-1074	29.2	29.6	10.10	2.28	4.43	I
ZIN	2	K-1074	30.2	31.4	8.14	1.72	4.73	I
ZIN	2	K-1074	30.6	31.4	6.97	1.64	4.25	I
ZIN	2	K-1074	37.4	37.6	2.14	0.93	2.30	I
ZIN	2	K-1074	38.4	39.4	4.87	1.38	3.53	I
ZIN	2	K-1077	45.0	46.0	5.46	1.47	3.71	I
ZIN	2	K-1077	46.2	46.8	3.65	0.93	3.92	I
ZIN	2	K-1077	48.6	49.4	2.09	1.30	1.61	I
ZIN	2	K-1077	50.8	51.2	4.10	1.07	3.83	I
ZIN	2	K-1077	58.8	59.6	4.67	1.53	3.05	I
ZIN	2	K-1390b	3.2	6.8	2.09	1.22	1.71	I
ZIN	2	K-1390b	6.4	6.8	2.95	1.06	2.78	I
ZIN	2	K-1390b	8.6	11.8	2.07	1.09	1.90	I
ZIN	2	K-1390b	12.2	12.6	5.25	1.68	3.12	I
ZIN	2	K-1390b	13.2	14.8	2.40	1.03	2.33	I
ZIN	2	K-1390c	1.2	2.2	2.66	0.80	3.33	I
ZIN	2	K-1390c	3.8	4.8	2.53	1.01	2.50	I
ZIN	1	K-4	16.0	17.0	4.70	1.50	3.13	I
ZIN	1	K-4	23.0	24.0	4.70	1.10	4.27	I
ZIN	1	K-4	27.0	28.0	7.80	1.60	4.88	I
ZIN	1	K-4	31.0	32.0	5.30	1.30	4.08	I
ZIN	1	K-4	34.0	35.0	11.00	2.40	4.58	I
ZIN	1	ZS-11	14.0	15.0	1.80	1.60	1.12	I
ZIN	1	ZS-11	17.0	18.0	9.10	2.60	3.50	I
ZIN	1	ZS-11	20.0	21.0	10.80	2.80	3.86	I
ZIN	1	ZS-11	22.0	23.0	13.50	2.90	4.66	I
ZIN	2	ZS-11	25.0	35.0	5.95	1.56	3.81	I
ZIN	2	ZS-11	35.0	42.0	4.42	1.20	3.68	I
ZIN	2	ZS-11	42.0	45.0	6.24	1.56	4.00	I
ZIN	1	ZS-16	8.0	9.0	3.90	1.00	3.90	I
ZIN	1	ZS-16	12.0	13.0	5.20	1.60	3.25	I
ZIN	1	ZS-16	18.0	19.0	11.60	2.50	4.64	I
ZIN	1	ZS-16	20.0	21.0	11.50	2.70	4.26	I
ZIN	1	ZS-16	22.0	23.0	11.80	2.80	4.21	I
ZIN	1	ZS-16	26.0	27.0	11.80	2.70	4.37	I
ZIN	1	ZS-28	15.0	16.0	12.70	2.80	4.54	I
ZIN	1	ZS-28	18.0	19.0	13.20	2.70	4.89	I
N. MUSA	1	NM-3	42.0	43.0	12.60	2.90	4.34	I
N. MUSA	1	NM-4	4.0	5.0	8.90	2.30	3.87	I
N. MUSA	1	NM-4	7.0	8.0	14.50	2.70	5.37	I
N. MUSA	1	NM-4	9.0	10.0	14.80	2.50	5.92	I
N. MUSA	1	NM-4	12.0	13.0	15.20	2.80	5.43	I
N. MUSA	1	NM-4	14.0	15.0	15.10	2.60	5.81	I
N. MUSA	1	NM-4	15.0	16.0	12.60	2.30	5.48	I
N. MUSA	1	NM-4	18.0	19.0	14.60	2.40	6.08	I
N. MUSA	1	NM-4	19.0	20.0	15.40	2.80	5.50	I
N. MUSA	1	NM-4	21.0	22.0	10.40	2.70	3.85	I
N. MUSA	1	NM-4	25.0	26.0	11.30	1.70	6.65	I
N. MUSA	1	NM-4	26.0	27.0	9.80	1.50	6.53	I
N. MUSA	1	NM-4	29.0	30.0	6.80	1.10	6.18	I
N. MUSA	1	NM-5	44.0	45.0	12.60	3.20	3.94	I
N. MUSA	1	NM-5	46.0	47.0	10.70	2.70	3.96	I
N. MUSA	1	NM-5	48.0	49.0	10.10	2.60	3.88	I
N. MUSA	1	NM-5	50.0	51.0	10.00	3.00	3.33	I
N. MUSA	1	NM-5	52.0	53.0	9.00	2.30	3.91	I
N. MUSA	1	NM-5	54.0	55.0	12.10	2.80	4.32	I
N. MUSA	1	NM-5	56.0	57.0	10.60	2.90	3.66	I
N. MUSA	1	NM-5	58.0	59.0	12.40	2.80	4.43	I
N. MUSA	1	NM-6	29.0	30.0	8.00	2.30	3.48	I
N. MUSA	1	NM-6	40.0	41.0	9.70	2.10	4.62	I
N. MUSA	1	NM-6	43.0	44.0	12.00	2.50	4.80	I
N. MUSA	1	NM-6	51.0	52.0	11.10	2.30	4.83	I
N. MUSA	1	NM-6	57.0	58.0	12.40	2.60	4.77	I
N. MUSA	1	NM-6	62.0	63.0	14.20	2.90	4.90	I
N. MUSA	1	NM-6	66.0	67.0	12.70	2.60	4.88	I
N. MUSA	1	NM-6	70.0	71.0	10.70	2.30	4.65	I
HARTUV	1	HAR-3	61.0	72.0	13.60	2.90	4.69	II
HARTUV	1	HRB-1	26.0	48.0	6.90	1.50	4.60	II
HARTUV	1	HRB-1	65.0	83.0	9.50	1.80	5.28	II
HARTUV	1	HRB-1	83.0	92.0	14.50	2.50	5.80	II
HARTUV	1	HRB-1	102.0	129.0	13.90	2.50	5.56	II
HARTUV	1	HRB-1	129.0	150.0	13.20	2.50	5.28	II
HARTUV	2	HRB-1	150.0	163.0	6.60	1.50	4.40	II
HARTUV	2	HRB-1	163.0	190.0	7.90	1.80	4.39	II
HARTUV	2	HRB-1	190.0	212.0	6.90	1.80	3.83	II
HARTUV	2	HRB-1	212.0	218.0	7.10	1.70	4.18	II
HARTUV	2	HRB-1	218.0		6.90	1.70	4.06	II
HARTUV	1	L-30	33.0	36.0	6.30	1.60	3.94	II
HARTUV	1	ZRB-2	43.0	50.0	6.30	1.40	4.50	II
HARTUV	1	ZRB-2	50.0	65.0	7.20	1.70	4.24	II
HARTUV	1	ZRB-2	65.0	84.0	8.70	1.80	4.83	II
HARTUV	1	ZRB-2	94.0	110.0	9.30	2.20	4.23	II
HARTUV	1	ZRB-2	133.0	149.0	11.70	2.40	4.88	II
HARTUV	2	ZRB-2	152.0	161.0	9.00	1.80	5.00	II
HARTUV	2	ZRB-2	180.0	197.0	8.20	2.00	4.10	II
ORON	1	OS-01	13.0	21.0	11.90	2.88	4.13	I
ORON	2	OS-01	21.0	33.0	6.20	1.71	3.63	I
ORON	2	OS-01	33.0	47.0	9.10	2.23	4.08	I
ORON	2	OS-01	47.0	69.0	2.80	0.84	3.33	I
ORON	2	OS-04	49.0	56.0	11.10	2.64	4.20	I
ORON	1	OS-05	28.0	46.0	12.10	2.86	4.23	I
ORON	2	OS-05	46.0	58.0	4.90	1.44	3.40	I
ORON	2	OS-05	58.0	60.0	10.00	2.42	4.13	I
ORON	2	OS-05	62.0	68.0	10.20	2.59	3.94	I
ORON	1	OS-06	32.0	37.0	6.50	2.07	3.14	I
ORON	1	OS-06	37.0	44.0	8.70	2.25	3.87	I
ORON	1	OS-06	44.0	58.0	11.60	2.73	4.25	I
ORON	1	OS-06	58.0	69.0	14.80	3.04	4.87	I
ORON	1	OS-06	64.0	65.0	16.90	3.56	4.75	I
ORON	2	OS-06	72.0	85.0	5.20	1.37	3.80	I
ORON	2	OS-06	79.0	80.0	2.70	1.08	2.50	I
ORON	2	OS-07	37.0	43.0	9.20	2.54	3.62	I
ORON	1	OS-08	10.0	24.0	5.10	1.73	2.95	I
ORON	1	OS-08	24.0	33.0	8.50	2.40	3.54	I
ORON	1	OS-08	33.0	43.0	11.70	2.83	4.13	I
ORON	1	OS-08	43.0	50.0	11.30	3.10	3.65	I
ORON	1	OS-09	20.0	29.0	8.30	2.37	3.50	I
ORON	1	OS-09	29.0	44.0	13.00	2.86	4.55	I
ORON	2	OS-09	44.0	55.0	5.42	1.37	3.96	I
ORON	2	OS-09	55.0	60.0	8.60	2.00	4.30	I
ORON	2	OS-09	61.0	65.0	9.00	2.22	4.05	I
ORON	2	OS-09	66.0	71.0	11.80	2.84	4.15	I
ORON	2	OS-09	68.0	69.0	13.40	3.39	3.95	I
ORON	2	OS-10	27.0	35.0	8.60	2.78	3.09	I
ORON	1	OS-11	52.0	62.0	4.90	1.76	2.78	I
ORON	1	OS-11	62.0	73.0	8.70	2.28	3.82	I
ORON	1	OS-11	73.0	83.0	11.70	2.75	4.25	I
ORON	1	OS-11	84.0	96.0	11.10	2.92	3.80	I
ORON	2	OS-11	96.0	112.0	5.70	1.50	3.80	I
ORON	2	OS-11	104.0	107.0	8.10	1.86	4.35	I
ORON	1	OS-12	40.0	53.0	6.50	1.95	3.33	I
ORON	1	OS-12	53.0	75.0	9.80	2.60	3.77	I
ORON	1	OS-12	75.0	87.0	12.20	3.14	3.89	I
ORON	2	OS-12	91.0	111.0	5.80	1.33	4.36	I
ORON	1	OS-13	45.0	72.0	12.70	2.82	4.50	I
ORON	2	OS-13	72.0	87.0	4.90	1.40	3.50	I
ORON	2	OS-13	77.0	79.0	6.80	1.77	3.84	I
ORON	2	OS-13	87.0	90.0	10.70	2.50	4.28	I
ORON	2	OS-13	92.0	97.0	10.30	2.34	4.40	I
ORON	2	OS-13	97.0	100.0	11.50	3.75	3.07	I
ORON	2	OS-13	100.0	105.5	4.20	1.14	3.68	I
ORON	1	OS-14	80.0	112.0	11.70	2.72	4.30	I
ORON	2	OS-14	112.0	130.0	6.20	1.69	3.67	I
ORON	1	OS-15	69.0	98.0	11.80	2.64	4.47	I
ORON	2	OS-15	98.0	116.0	5.20	1.46	3.56	I
ORON	2	OS-15	116.0	119.0	8.30	1.92	4.32	I
ORON	2	OS-15	122.0	126.0	7.20	1.83	3.93	I
ORON	2	OS-15	126.0	130.0	9.60	2.25	4.27	I
ORON	2	OS-15	130.0	137.0	2.20	0.70	3.14	I
ORON	2	OS-15	137.0	140.0	13.60	2.79	4.87	I
ORON	2	OS-15	140.0	145.5	4.90	1.27	3.86	I
ORON	1	OS-16	73.0	87.0	14.00	2.97	4.71	I
ORON	2	OS-16	91.5	92.4	12.60	3.88	3.25	I
ORON	1	OS-17	52.0	67.0	12.80	2.85	4.49	I
ORON	2	OS-17	72.0	74.0	7.10	1.73	4.10	I
ORON	2	OS-17	86.0	91.0	11.10	2.56	4.34	I
ORON	1	OS-18	101.0	128.0	10.50	2.53	4.15	I
ORON	1	OS-18	128.0	142.0	11.20	3.13	3.58	I
ORON	2	OS-18	148.0	162.0	4.30	1.44	2.99	I
ORON	1	OS-20	0.0	6.0	4.72	1.33	3.55	I
ORON	2	OS-20	19.0	21.0	10.40	2.32	4.48	I
ORON	2	OS-20	22.0	26.0	10.00	2.22	4.50	I
ORON	1	K-2	54.0	58.0	12.00	2.65	4.53	I
ORON	2	K-2	83.0	88.0	4.50	1.34	3.36	I
ORON	2	K-2	101.9	108.8	10.40	2.37	4.39	I
ORON	1	K-3	31.0	32.0	5.50	1.72	3.20	I
ORON	1	K-3	42.0	62.0	10.30	2.37	4.35	I
ORON	1	K-3	62.0	77.0	15.10	3.05	4.95	I
ORON	2	K-3	79.0	83.3	6.00	1.53	3.92	I
ORON	2	K-3	83.3	83.6	5.40	1.50	3.60	I
ORON	2	K-3	83.6	83.9	13.20	2.69	4.91	I
ORON	2	K-3	83.9	84.2	9.70	2.19	4.43	I
ORON	2	K-3	84.2	84.5	5.70	1.38	4.13	I
ORON	2	K-3	84.5	84.8	4.40	0.97	4.54	I
ORON	2	K-3	84.8	85.1	5.70	1.37	4.16	I
ORON	2	K-3	85.1	91.4	7.00	1.75	4.00	I
ORON	2	K-4	41.7	42.0	3.90	1.19	3.28	I
ORON	2	K-4	42.0	42.3	6.00	1.51	3.97	I
ORON	2	K-4	42.3	42.6	8.40	1.94	4.33	I
ORON	2	K-4	42.6	42.9	4.30	1.39	3.09	I
ORON	2	K-4	42.9	43.2	11.30	2.53	4.47	I
ORON	1	OP-2	54.9	61.0	11.10	2.57	4.32	I
ORON	2	OP-2	61.0	73.0	4.90	1.39	3.53	I
ORON	2	OP-2	82.0	87.0	11.70	2.76	4.24	I
ORON	1	OP-3	62.0	76.0	4.60	1.53	3.01	I
ORON	2	OP-3	81.0	87.0	11.30	2.64	4.28	I

Formation: 1 - Ghareb Fm.; 2 - Mishash Fm.
Source: I - This work; II - Hallcz, 1983.

Table 2
Mishor Rotem Samples and Data

Formation	Borehole	From	To	Organic Carbon	Total Sulfur	C/S	Organic Sulfur	Pyritic Sulfur	Total Iron	HCl Iron	DOP	Source
1	T- 1	40.0	41.0	9.5	2.8	3.4	*	*	2.7	*	*	III
1	T- 1	42.0	43.0	10.0	2.7	3.7	*	*	2.3	*	*	III
1	T- 1	47.0	48.0	8.5	2.4	3.5	*	*	2.0	*	*	III
1	T- 1	52.0	53.0	10.3	2.7	3.8	*	*	1.5	*	*	III
1	T- 1	53.0	54.0	12.0	3.0	4.0	*	*	1.7	*	*	III
1	T- 1	55.0	56.0	11.8	3.2	3.7	*	*	2.0	*	*	III
1	T- 1	58.0	59.0	13.3	3.1	4.3	*	*	0.7	*	*	III
1	T- 1	60.0	61.0	15.6	3.3	4.7	*	*	3.3	*	*	III
1	T- 1	61.0	62.0	15.8	3.4	4.7	*	*	3.4	*	*	III
1	Bit- 1	18.0	22.0	5.5	1.4	3.9	*	*	2.8	*	*	III
1	Bit- 1	21.0	26.0	6.2	1.9	3.3	1.0	0.4	2.2	0.8	0.31	I
1	Bit- 1	22.0	53.0	10.7	2.6	4.1	*	*	2.5	*	*	III
1	Bit- 1	27.0	53.0	9.5	2.8	3.4	1.4	0.5	1.7	0.7	0.38	I
1	Bit- 1	53.0	60.0	13.9	3.0	4.6	*	*	1.6	*	*	III
1	Bit- 1	60.0	70.0	17.0	3.1	5.5	*	*	0.7	*	*	III
1	Bit- 1	53.0	73.0	13.5	3.1	4.4	2.4	0.2	0.7	0.2	0.49	I
1	Bit- 1	70.0	75.0	13.2	2.4	5.5	*	*	0.9	*	*	III
1	Bit- 4	23.0	29.0	8.8	2.0	4.4	*	*	2.6	*	*	III
1	Bit- 4	29.0	50.0	12.3	2.5	4.9	*	*	2.6	*	*	III
1	Bit- 4	50.0	54.0	17.7	2.9	6.1	*	*	0.9	*	*	III
1	Bit- 4c	42.0	48.0	10.7	2.6	4.1	*	*	*	*	*	IV
1	Bit- 6	23.0	37.0	11.1	2.1	5.3	*	*	2.2	*	*	III
1	Bit- 6	37.0	45.0	12.4	1.9	6.5	*	*	2.3	*	*	III
2	Bit- 6	45.0	50.0	1.9	0.3	6.3	*	*	*	*	*	III
1	Bit- 6b	21.0	26.0	8.1	2.0	4.0	*	*	*	*	*	IV
1	Bit- 7	32.0	43.0	11.5	2.0	5.8	*	*	1.9	*	*	III
1	Bit- 7	43.0	55.0	15.2	1.7	8.9	*	*	0.6	*	*	III
1	Bit- 8	36.0	50.0	6.2	1.4	4.4	*	*	2.0	*	*	III
1	Bit- 8	50.0	61.0	7.4	1.4	5.3	*	*	2.4	*	*	III
2	Bit- 20	70.0	71.5	2.2	1.1	2.0	*	*	*	*	*	III
2	Bit- 20	70.0	73.0	3.4	1.1	3.1	0.6	0.1	*	*	*	I
1	Bit- 24	35.0	42.0	8.6	3.0	2.9	1.3	0.6	1.8	0.71	0.44	I
1	Bit- 24	48.0	70.0	12.2	3.1	3.9	2.1	0.3	0.7	0.2	0.52	I
1	Bit- 26	35.0	55.0	7.0	1.9	3.7	1.0	0.5	1.7	0.5	0.44	I
1	Bit- 26	55.0	83.0	9.5	2.6	3.7	1.4	0.6	1.7	0.4	0.54	I
1	Bit- 26	89.0	100.0	14.8	3.0	4.9	2.5	0.1	0.5	0.1	0.48	I
1	Bit- 27	21.0	39.0	6.9	2.1	3.3	1.1	0.4	1.7	0.6	0.34	I
1	Bit- 27	40.0	61.0	10.0	2.6	3.9	1.6	0.5	1.7	0.6	0.41	I
1	Bit- 29	23.0	27.0	5.9	2.3	2.6	0.8	0.3	1.6	0.6	0.33	I
1	Bit- 29	28.0	59.0	10.1	2.9	3.5	1.5	0.5	1.7	0.5	0.45	I
1	Bit- 29	59.0	67.0	13.8	2.9	4.8	2.3	0.1	0.5	0.2	0.39	I
2	Bit- 68	77.6	78.6	1.3	1.0	1.3	*	*	*	*	*	I
2	Bit- 68	79.6	80.6	3.9	1.0	3.9	*	*	*	*	*	I
2	Bit- 68	82.6	83.6	6.0	1.4	4.29	*	*	*	*	*	I
2	Bit- 68	85.6	86.6	2.4	1.1	2.2	*	*	*	*	*	I
2	Bit- 68	88.6	89.6	5.8	1.7	3.4	*	*	*	*	*	I
2	Bit- 68	91.6	92.6	13.2	4.0	3.3	*	*	*	*	*	I

					S_{tot}	C/S	S_{org}	S_{pyr}	Fe_{tot}	HCl	DOP	
2	Bit- 68	93.6	94.6	5.5	1.7	3.2	*	*	*	*	*	I
2	Bit- 71	50.0	51.0	1.0	1.1	0.9	*	*	*	*	*	I
2	Bit- 71	54.0	55.0	1.4	1.1	1.3	*	*	*	*	*	I
2	Bit- 71	57.0	58.0	4.7	1.4	3.4	*	*	*	*	*	I
2	Bit- 71	60.0	61.0	2.5	1.0	2.5	*	*	*	*	*	I
2	Bit- 71	62.0	63.0	6.0	1.8	3.3	*	*	*	*	*	I
2	Bit- 71	64.0	65.0	2.5	1.0	2.5	*	*	*	*	*	I
2	Bit- 78	86.0	87.0	3.3	1.3	2.5	*	*	*	*	*	I
2	Bit- 78	90.0	91.0	1.9	1.0	1.9	*	*	*	*	*	I
2	Bit- 78	92.0	93.0	3.7	1.0	3.7	*	*	*	*	*	I
2	Bit- 78	96.0	97.0	4.3	1.4	3.1	*	*	*	*	*	I
2	Bit- 78	100.0	101.0	7.1	2.3	3.1	*	*	*	*	*	I
2	Bit- 78	102.0	103.0	5.7	1.8	3.2	*	*	*	*	*	I
1	Bit- 83	27.0	53.0	8.9	2.6	3.4	1.4	0.5	1.7	0.5	0.48	I
1	Bit- 83	57.0	72.0	13.4	3.1	4.3	2.5	0.3	0.7	0.2	0.50	I
1	Bit- 84	25.0	54.0	9.1	2.6	3.5	1.5	0.5	1.7	0.6	0.43	I
1	Bit- 84	26.0	27.0	5.9	2.0	2.9	0.8	0.4	3.1	*	*	I
1	Bit- 84	27.0	28.0	6.8	2.0	3.4	1.0	0.5	3.4	*	*	I
1	Bit- 84	32.0	33.0	9.8	2.6	3.8	1.6	0.4	3.1	*	*	I
1	Bit- 84	40.0	41.0	8.8	2.6	3.4	1.3	0.6	3.1	*	*	I
1	Bit- 84	48.0	49.0	7.6	2.0	3.8	1.1	0.3	2.9	*	*	I
1	Bit- 84	51.0	52.0	9.3	2.5	3.8	1.6	0.5	3.4	*	*	I
1	Bit- 84	57.0	58.0	11.9	3.2	3.7	2.0	0.5	2.4	*	*	I
1	Bit- 84	58.0	73.0	11.9	2.7	4.4	2.0	0.3	0.8	0.3	0.44	I
1	Bit- 84	59.0	60.0	12.3	2.6	4.7	2.0	0.4	2.1	*	*	I
1	Bit- 84	65.0	66.0	16.4	4.0	4.1	2.9	0.2	0.8	*	*	I
1	Bit- 84	66.0	67.0	17.5	3.8	4.6	3.0	0.2	0.8	*	*	I
1	Bit- 84	69.0	70.0	16.4	3.4	4.8	2.6	0.2	1.1	*	*	I
1	Bit- 84	70.0	71.0	12.9	3.0	4.3	2.2	0.1	0.9	*	*	I
1	Bit- 84	71.0	72.0	13.1	2.7	4.8	2.0	0.1	0.8	*	*	I
1	Bit- 84	72.0	73.0	14.4	3.6	4.0	2.7	0.1	0.9	*	*	I
1	Bit- 84	73.0	74.0	12.3	3.3	3.7	2.3	0.1	0.9	*	*	I
2	Bit- 84	74.0	77.0	6.8	1.8	3.8	1.2	0.04	0.3	0.1	0.27	I
2	Bit- 84	74.0	75.0	6.4	1.7	3.8	1.1	0.10	*	*	*	I
2	Bit- 84	75.0	76.0	3.9	1.1	3.5	*	*	*	*	*	I
2	Bit- 84	78.0	79.0	4.0	1.4	2.9	0.8	0.06	*	*	*	I
2	Bit- 84	79.0	80.0	4.0	1.2	3.3	*	*	*	*	*	I
2	Bit- 84	80.0	81.0	1.8	0.9	2.0	0.4	0.03	*	*	*	I
2	Bit- 84	82.0	83.0	3.0	1.1	2.7	*	*	*	*	*	I
2	Bit- 84	83.0	84.0	3.5	1.1	3.2	0.6	0.12	*	*	*	I
1	Bit- 85	26.0	50.0	6.1	1.9	3.2	1.0	0.3	1.6	0.6	0.35	I
1	Bit- 85	50.0	73.0	9.3	2.7	3.4	1.5	0.5	1.7	0.5	0.49	I
1	Bit- 85	75.0	85.0	12.7	3.1	4.1	2.4	0.2	.8	0.2	0.44	I
2	Bit- 85	88.0	95.0	3.6	1.3	2.7	0.3	0.06	.4	0.2	0.21	I
1	Bit- 86	26.0	49.0	6.8	2.1	3.2	1.1	0.4	1.6	0.6	0.36	I
1	Bit- 86	50.0	73.0	9.7	2.7	3.6	1.7	*	1.7	0.6	0.42	I
1	Bit- 86	75.0	91.0	12.8	3.0	4.3	2.2	0.1	0.7	0.3	0.31	I
2	Bit- 86	91.0	107.0	3.0	1.2	2.5	0.01	0.06	*	*	*	I
1	Bit- 87	20.0	34.0	7.0	2.1	3.3	0.8	0.3	1.6	0.6	0.30	I
1	Bit- 87	34.0	60.0	9.1	3.1	1.5	0.4	2.5	1.9	0.6	0.40	I
1	Bit- 87	62.0	78.0	13.6	3.4	4.0	2.3	0.3	0.7	0.2	0.48	I
2	Bit- 87	78.0	87.0	5.7	1.7	3.1	1.0	0.08	0.3	0.1	0.35	I
1	Bit- 88	40.0	51.0	8.6	2.5	3.4	*	*	*	*	*	I
1	Bit- 93	31.0	49.0	7.0	2.3	3.0	1.2	0.4	1.7	0.4	0.47	I
1	Bit- 93	49.0	53.0	9.5	2.7	3.5	1.5	0.4	1.7	0.5	0.40	I

					S_{tot}	C/S	S_{py}	S_{pyr}	Fe_{tot}	Fe_{Hd}	DOP	
1	Bit- 94	28.0	53.0	9.7	2.7	3.6	1.6	0.5	1.5	0.6	0.43	I
1	Bit- 94	53.0	71.0	13.1	3.0	4.4	2.5	0.1	0.7	0.2	0.32	I
1	Bit- 95	21.0	22.0	6.6	1.9	3.4	*	*	*	*	*	I
1	Bit- 95	21.0	28.0	7.1	2.5	2.8	1.1	0.3	1.6	0.4	0.40	I
1	Bit- 95	41.0	42.0	9.0	2.6	3.5	*	*	*	*	*	I
1	Bit- 95	28.0	62.0	10.0	3.3	3.0	1.7	0.4	1.5	0.4	0.49	I
1	Bit- 95	65.0	66.0	16.4	3.4	4.9	*	*	*	*	*	I
1	Bit- 95	62.0	71.0	13.9	3.5	4.0	1.8	0.4	2.1	*	*	I
1	Bit- 97	33.0	38.0	6.9	1.9	3.6	1.0	0.3	1.7	0.6	0.33	I
1	Bit- 97	38.0	52.0	9.6	3.4	2.8	1.6	0.7	1.6	0.5	0.56	I
1	Bit- 97	53.0	69.9	12.7	2.7	4.7	2.2	0.3	0.5	0.2	0.53	I
2	Bit-102	51.5	52.0	4.8	1.2	4.0	*	*	*	*	*	I
2	Bit-102	55.5	56.0	7.1	1.3	5.5	*	*	*	*	*	I
2	Bit-102	59.5	60.0	8.0	1.3	6.2	*	*	*	*	*	I
2	Bit-102	62.5	63.0	13.0	2.9	4.5	*	*	*	*	*	I
2	Bit-102	64.0	64.5	18.8	4.2	4.5	*	*	*	*	*	I
2	Bit-102	67.0	67.5	3.8	1.2	3.2	*	*	*	*	*	I
1	L- 20	*	*	9.7	2.5	3.9	*	*	*	*	*	II
2	PM- 15	52.0	53.0	5.1	1.2	4.3	*	*	*	*	*	I
2	PM- 15	56.0	57.0	6.9	1.3	5.3	*	*	*	*	*	I
2	PM- 15	60.0	61.0	6.3	1.2	5.3	*	*	*	*	*	I
2	PM- 15	62.0	63.0	10.4	1.3	8.0	*	*	*	*	*	I
2	PM- 15	65.0	66.0	3.5	1.0	3.5	*	*	*	*	*	I
2	PM- 15	67.0	68.0	2.8	1.0	2.8	*	*	*	*	*	I
2	PM- 15	71.0	72.0	8.0	1.8	4.4	*	*	*	*	*	I
1	R- 2	22.0	24.0	7.1	2.0	3.6	0.8	*	2.0	*	*	I
1	R- 2	26.0	28.0	9.7	2.5	3.9	1.1	*	2.1	*	*	I
1	R- 2	30.0	32.0	11.4	2.7	4.3	1.2	*	1.9	*	*	I
1	R- 2	34.0	36.0	9.6	2.9	3.3	1.4	*	2.8	*	*	I
1	R- 2	40.0	42.0	9.0	2.9	3.1	1.0	*	3.0	*	*	I
1	R- 2	46.0	48.0	10.4	3.0	3.5	1.1	*	2.4	*	*	I
1	R- 2	55.0	57.0	12.5	3.1	4.1	1.8	*	1.7	*	*	I
1	R- 2	59.0	61.0	13.7	2.9	4.7	1.9	*	0.7	*	*	I
1	R- 2	63.0	65.0	15.5	3.2	4.9	2.2	*	0.7	*	*	I
2	R- 2	70.0	73.0	3.4	1.2	3.0	0.6	*	*	*	*	I

Formation: 1 - Ghareb Fm.; 2 - Mishash Fm.
Source: I - This work; II - Halicz, 1983;
III - Shirav, 1987;
IV - Spiro, 1980.

Table 3
Summary of data obtained from the various basins

Basin	Formation	Number of boreholes	Number of samples	Org. C	Average Tot. S (Org. S)	Average C/S	Average S/C	Slope S/C	Intercept with S	Correlation coef.
Rotem	Ghareb	28	89	10.82	2.68	4.05	.25	0.13	1.30	0.76
(Organic S)			55		1.67	6.64	.15	0.18	-0.31	0.93
Rotem	Ghareb (high)		44	13.40	2.96	4.61	.22	0.11	1.51	0.45
(Organic S)			26		2.16	6.35	.21	0.21	-0.58	0.80
Rotem	Ghareb (low)		45	8.29	2.40	3.45	.29	0.26	0.24	0.80
(Organic S)			29		1.22	6.90	.14	0.16	-0.10	0.81
Rotem	Mishash		44	5.14	1.44	3.48	.29	0.22	0.28	0.88
Zin	Ghareb	7	17	8.85	2.11	4.09	.24	0.16	0.68	0.92
Zin	Mishash		23	4.05	1.28	2.99	.33	0.15	0.67	0.89
Hartuv	Ghareb	4	12	10.09	2.07	4.82	.21	0.15	0.67	0.94
Hartuv	Mishash		8	9.17	1.98	4.58	.22	0.11	0.92	0.65
Oron	Ghareb	22	33	10.19	2.53	3.93	.25	0.15	0.95	0.94
Oron	Mishash		55	7.76	1.95	3.95	.25	0.22	0.28	0.94
Nebimusa	Ghareb	4	29	11.73	2.49	4.81	.21	0.11	1.26	0.53

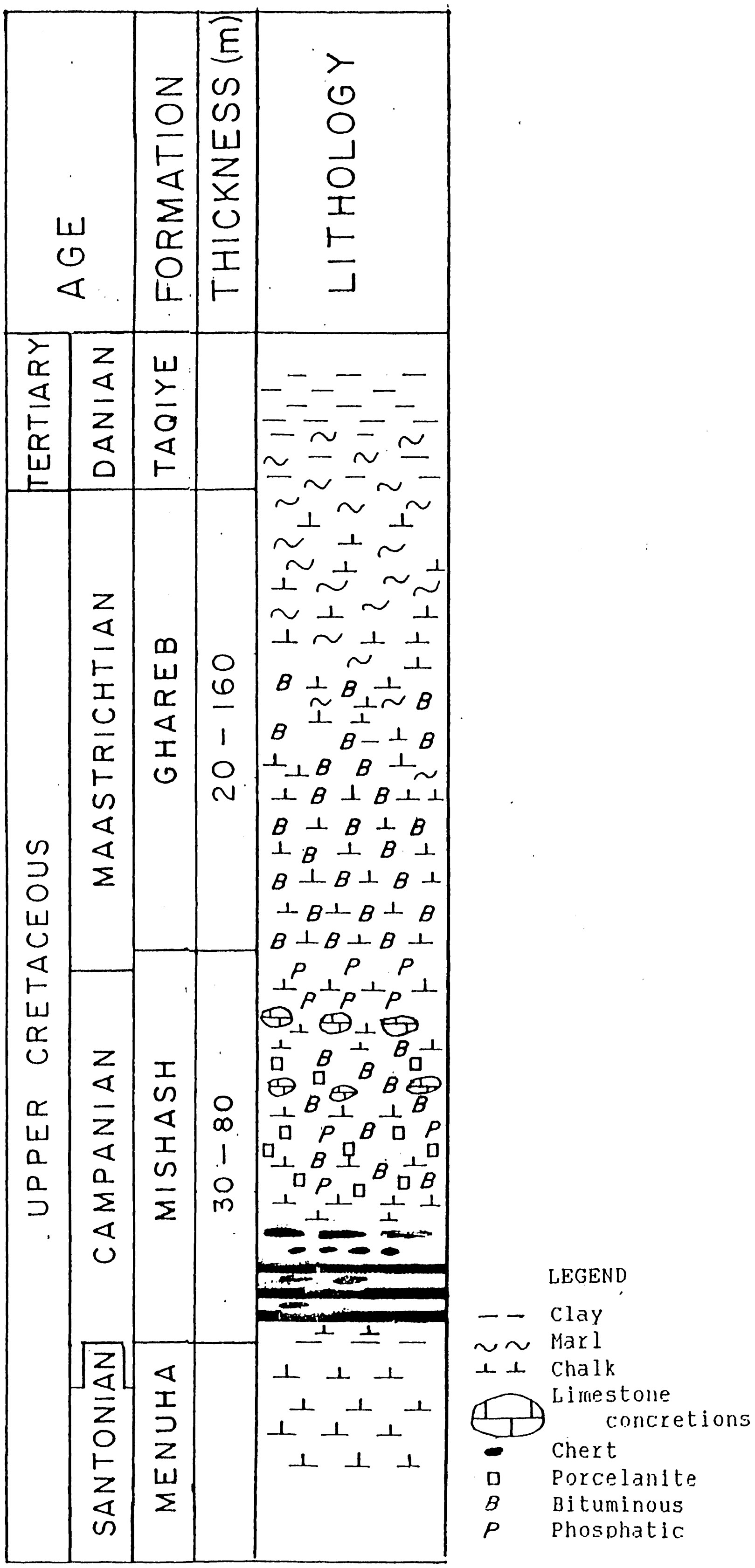
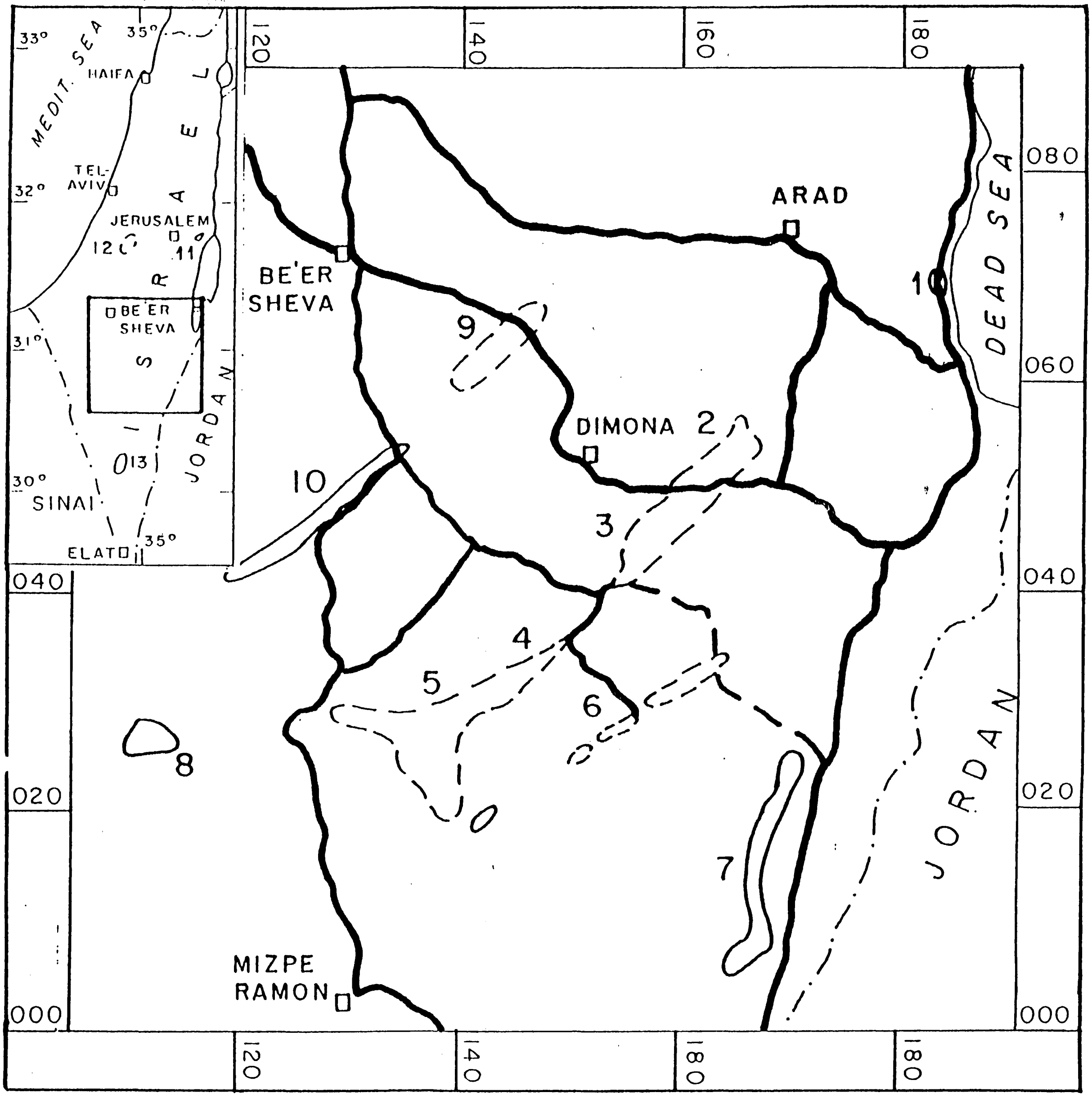


Figure 1 - Schematic columnar geological section of Mount Scopus Group in the Northern Negev.



◌ Basins in which organic-matter enriched sequences were discovered and defined in both Ghareb and Mishash Formations.

○ Basins in which only oil shales of the Ghareb Formation are reported.

Figure 2 - Location Map - Basins in central and southern Israel known to contain organic-rich sediments in the Mount Scopus Group.

1) 'En Boqeq
2) Mishor Rotem*
3) Mishor Yamin
4) Oron*
5) Biq'at Zin
6) Nahal Zin*
7) Arava
8) Shivta
9) Nevatim
10) Ashalim
11) Nabi Musa*
12) Hartuv* - Shephela
13) Zenifim

* Basins from which samples were taken for the present study.

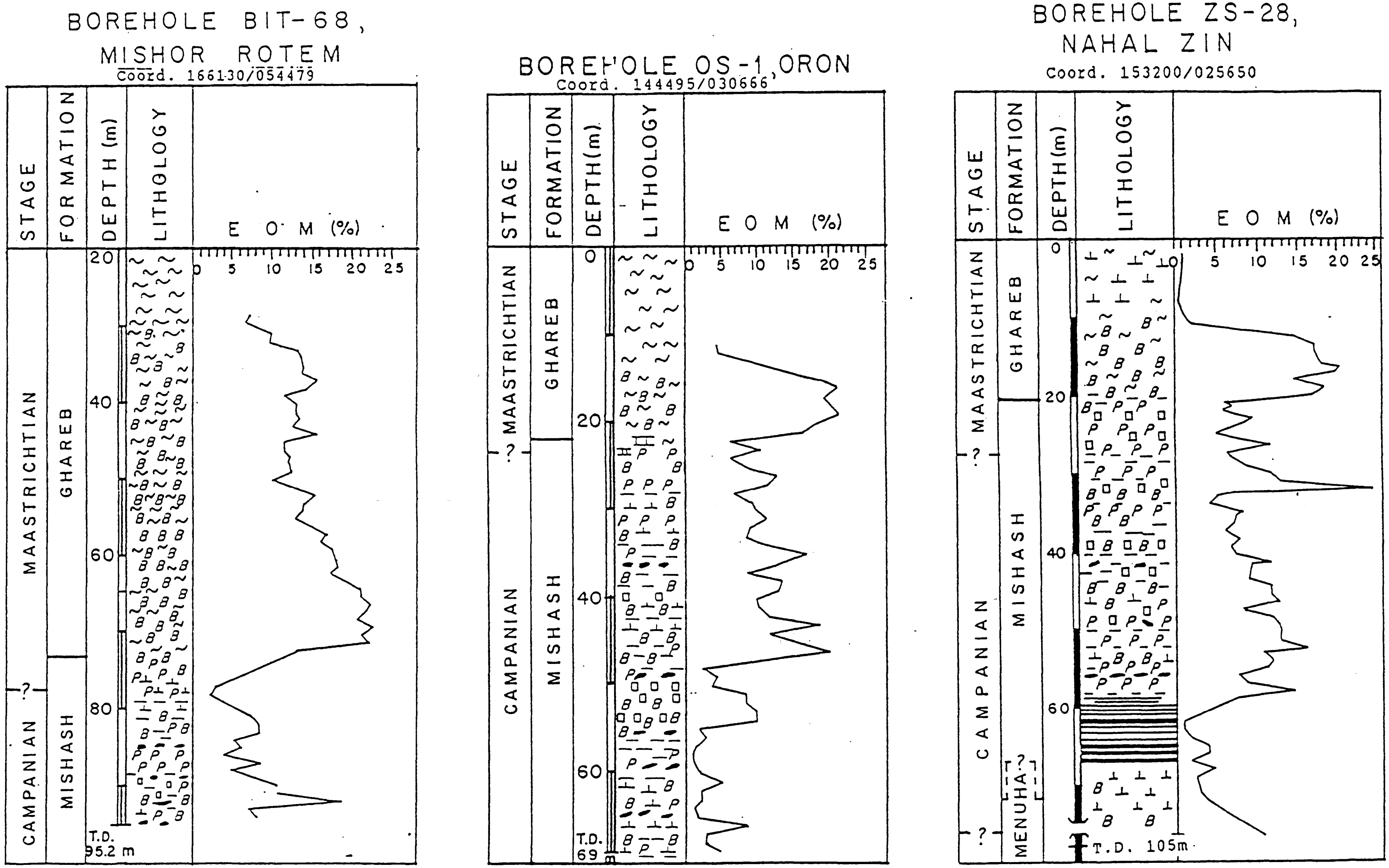


Figure 3 - Variations in EOM content in three of the examined oil shale basins: 3 a) Mishor Rotem; 3 b) Oron; 3 c) Nahal Zin.

Figure 4 - C/TS relationship, Mishor Rotem - Ghareb Formation.

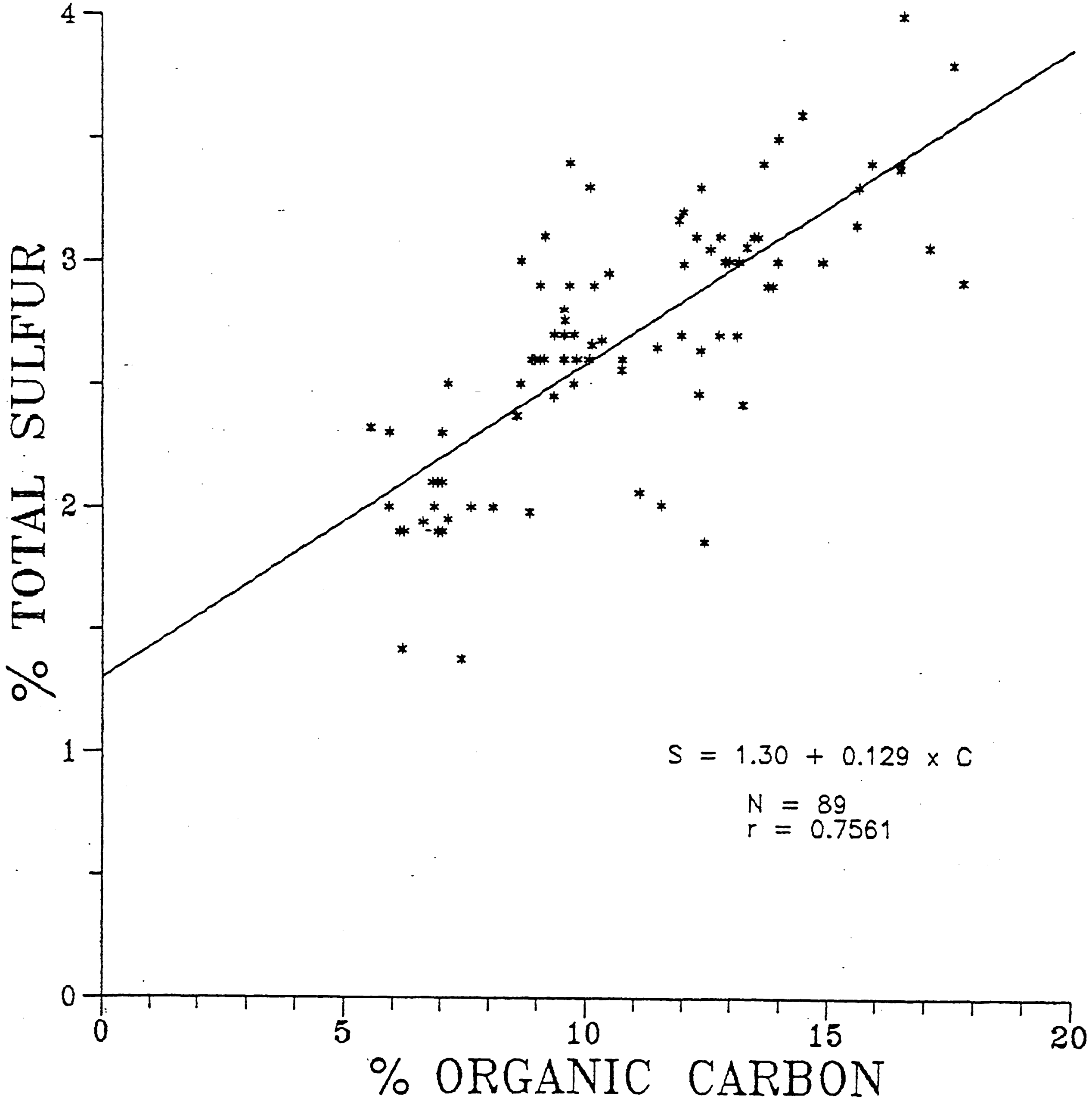


Figure 5 - C/TS relationship, Mishor Rotem - Mishash Formation.

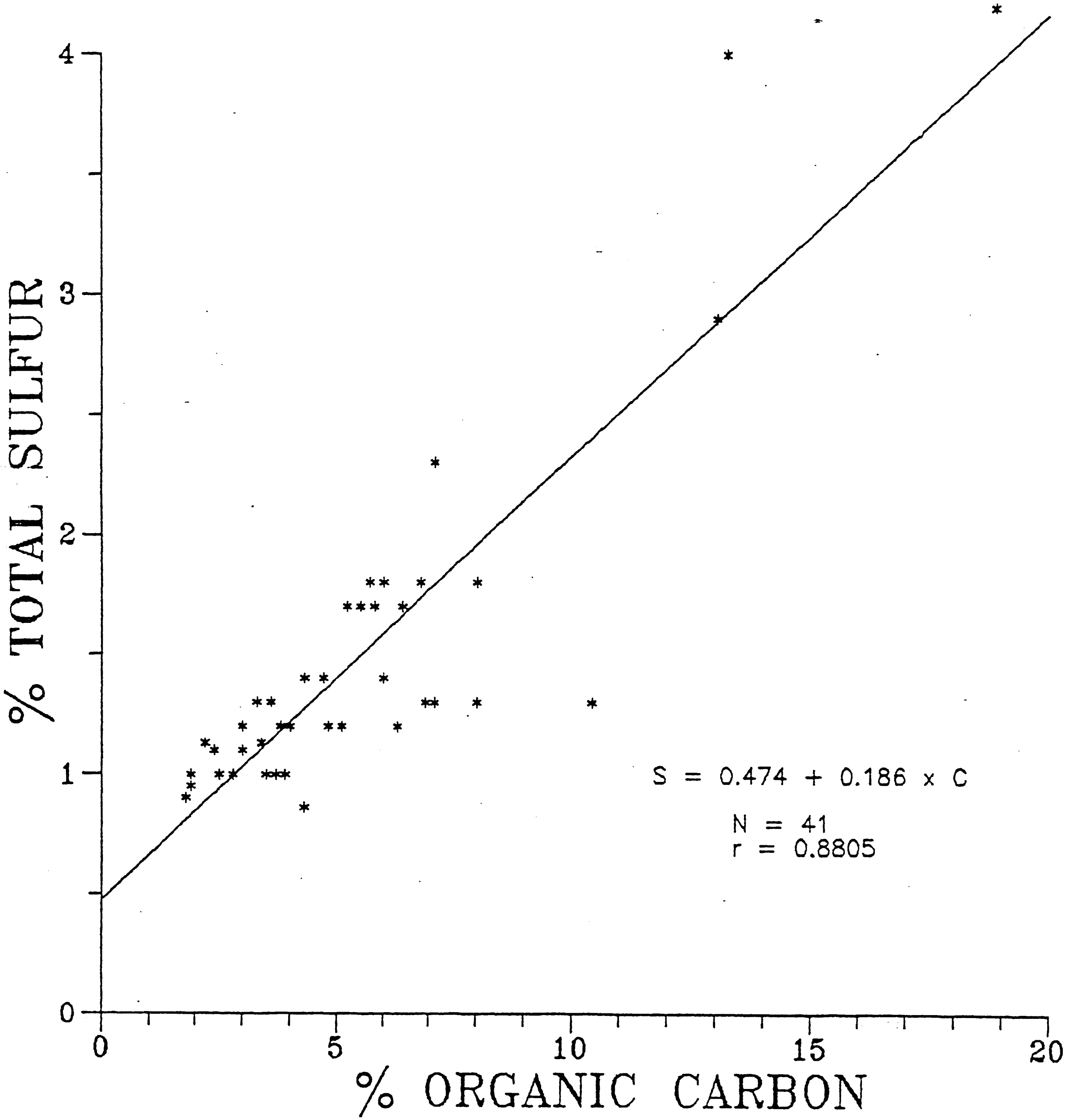


Figure 6 - C/TS relationship, Oron - Ghareb Formation.

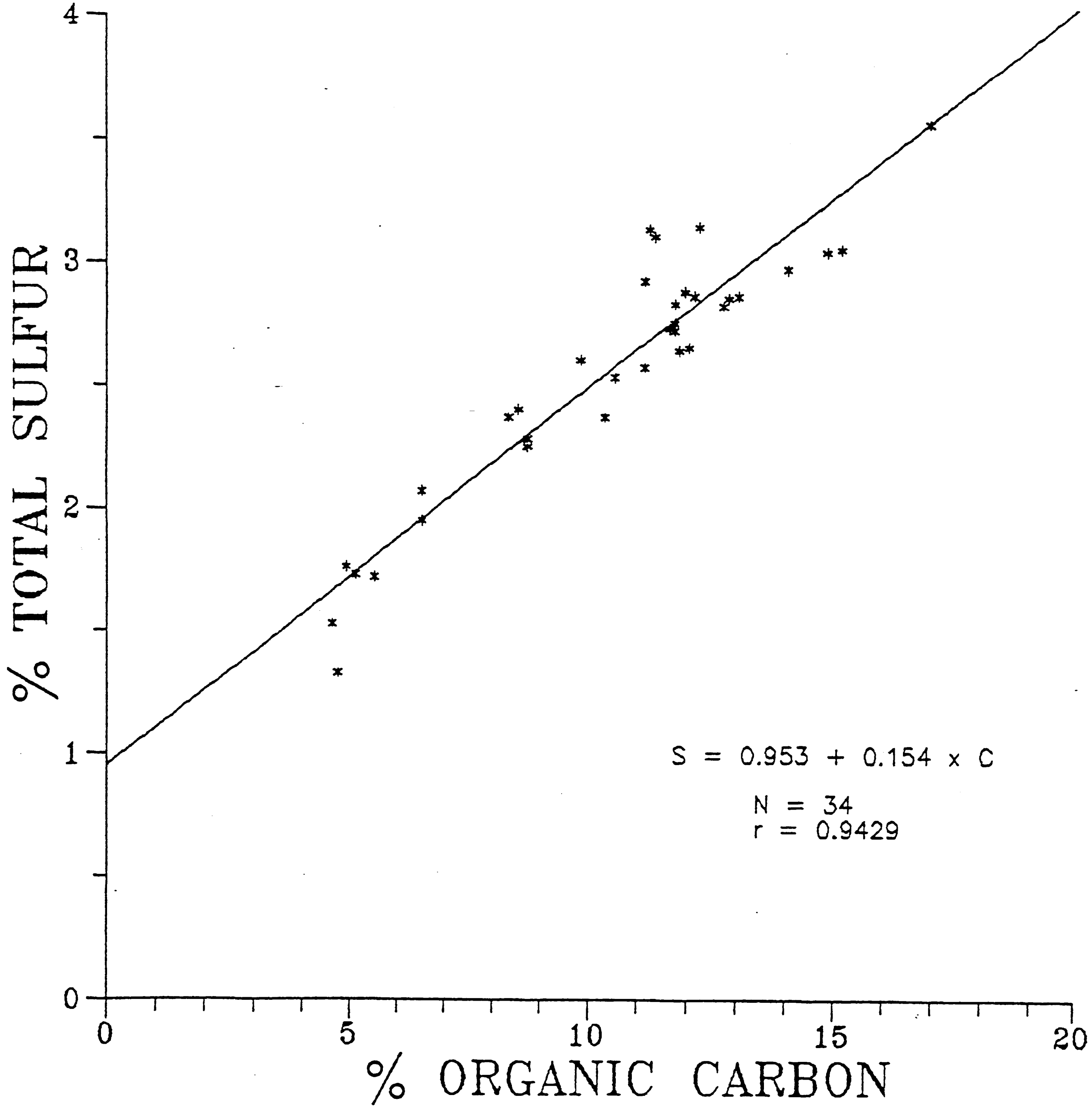


Figure 7 - C/TS relationship, Oron - Mishash Formation.

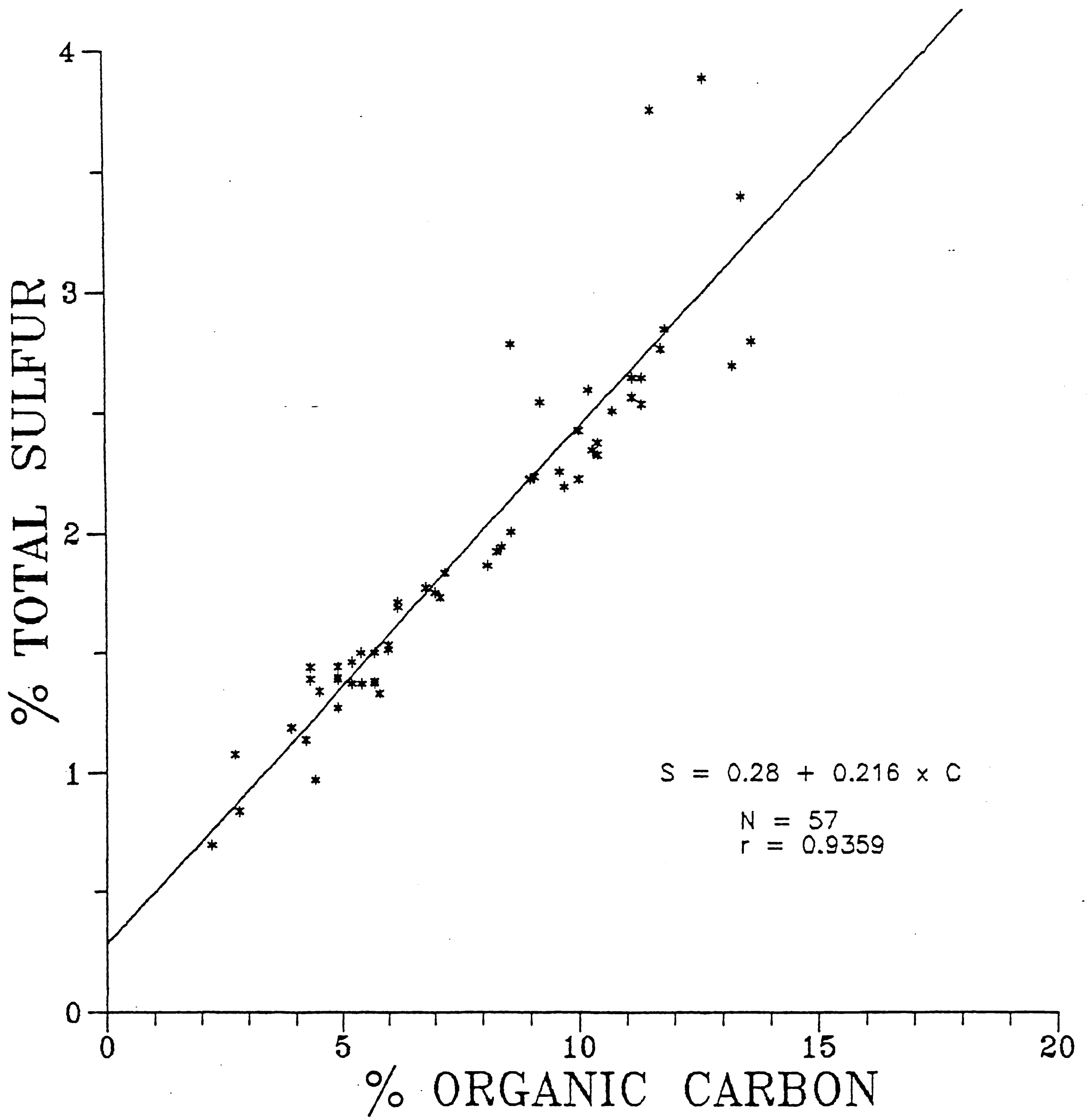


Figure 8 - C/TS relationship, Nahal Zin - Ghareb Formation.

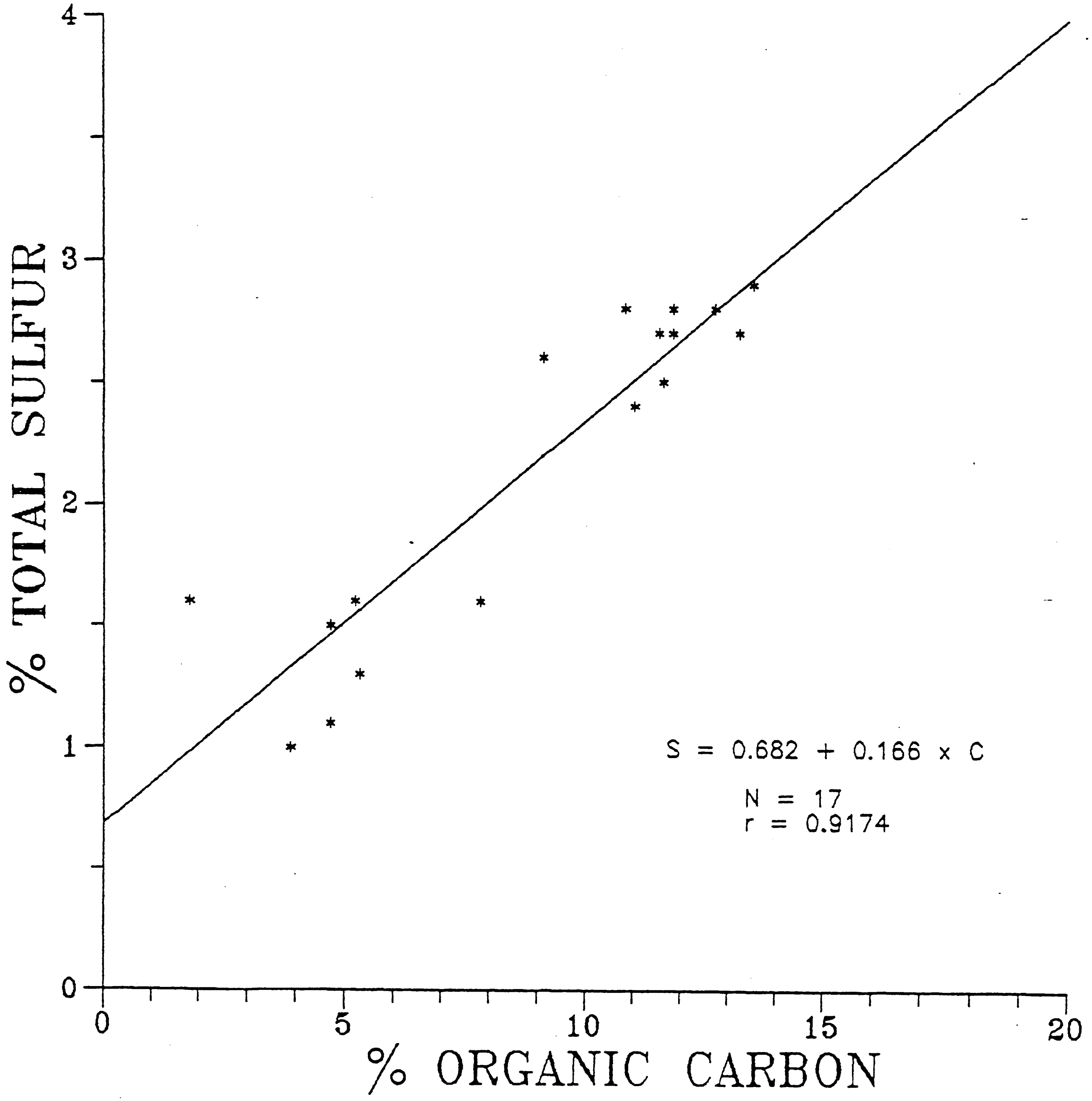


Figure 9 - C/TS relationship, Nahal Zin - Mishash Formation.

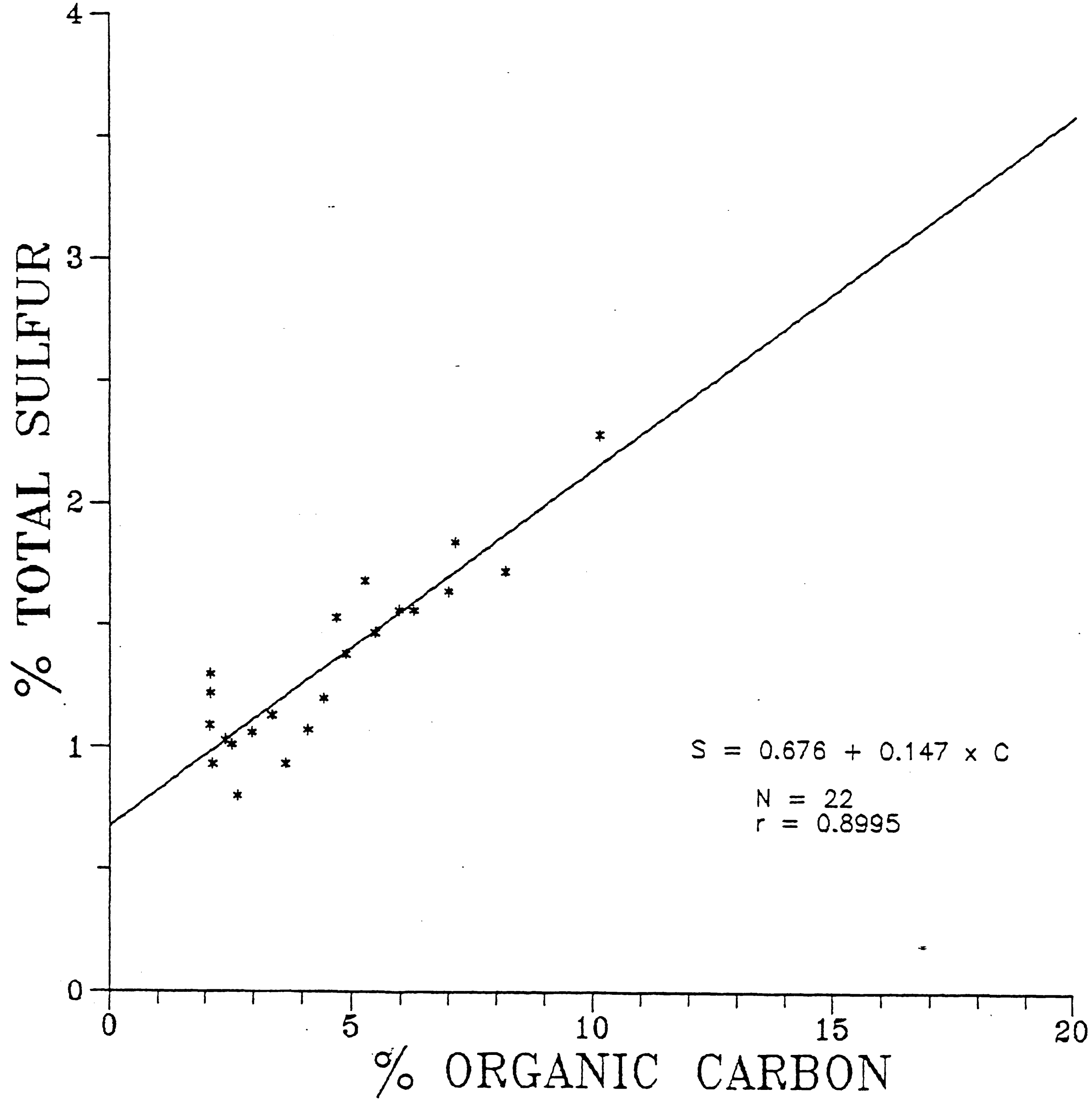


Figure 10 - C/TS relationship, Nabi Musa - Ghareb Formation.

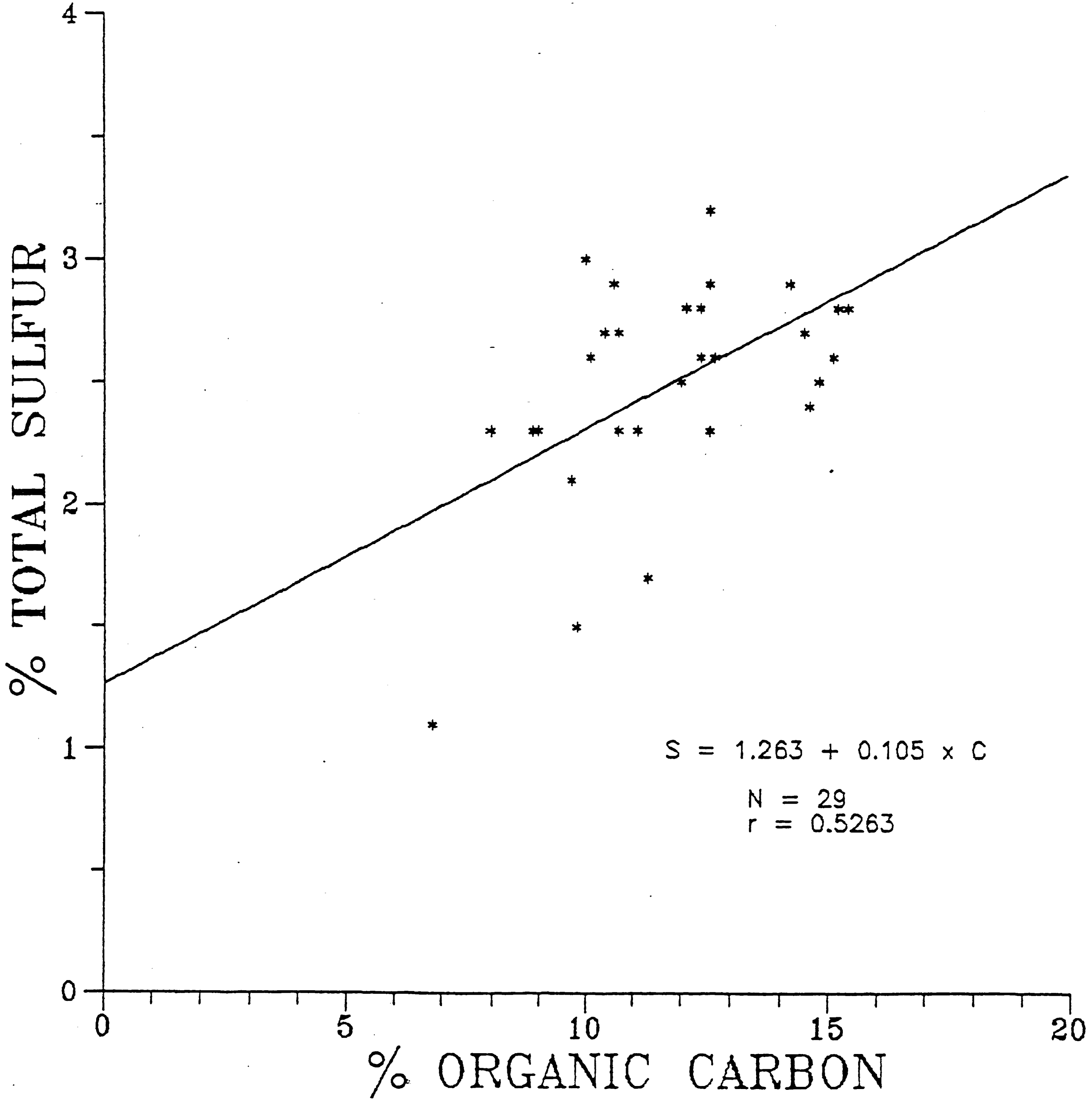


Figure 11 - C/TS relationship, Hartuv - Ghareb Formation.

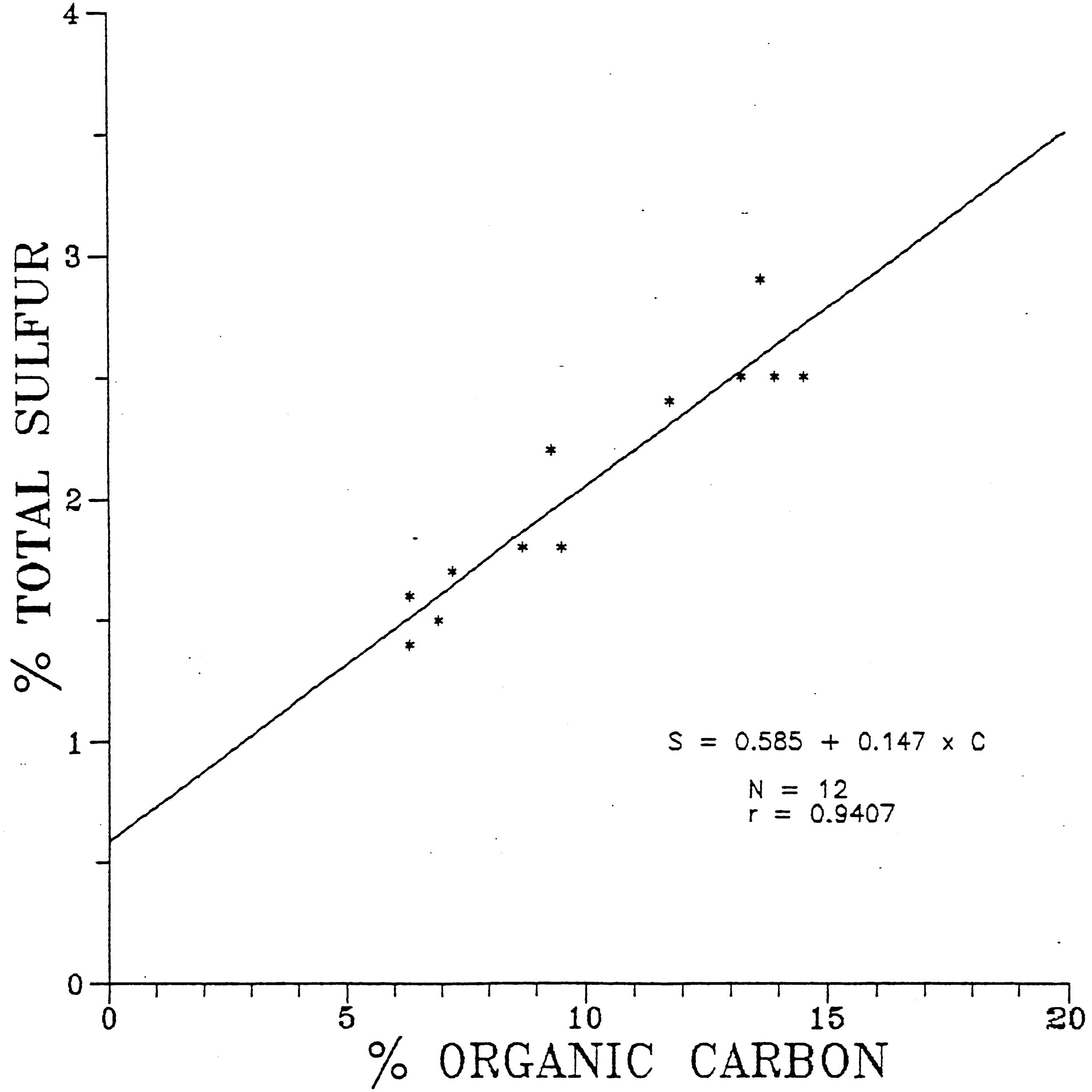


Figure 12 - C/OS relationship, Mishor Rotem - Ghareb Formation.

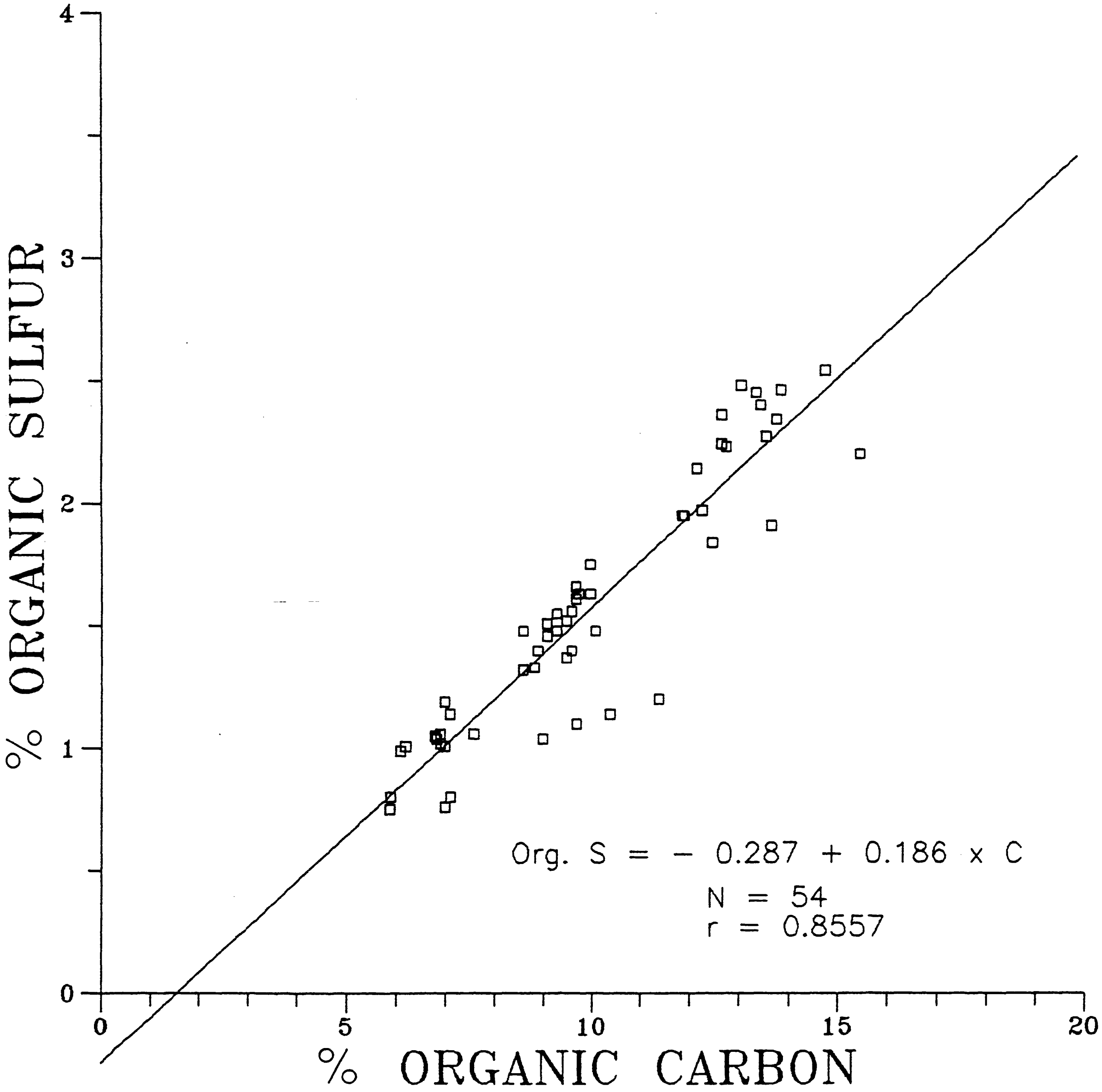


Figure 13 - C vs C/TS in Mishor Rotem - Ghareb Formatiom.