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DEPARTMENT OF REGISTRATION AND EDUCATION

PREDICTION OF SILURIAN REEF LOCATIONS THROUGH TRACE ELEMENT PROFILES

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Prediction of Silurian Reef Locations through Trace Element Profiles

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ABSTRACT

This investigation studies the use of certain trace element concentrations as geochemical indicators to distinguish between reef and nonreef material in southern Illinois carbonates. In addition, geochemical criteria were used to predict the distance of a sample from a reef. Thirty-two elements were determined on 63 Silurian rock samples grouped according to their locations. With the use of a discriminant analysis function, 50 of the 63 samples were correctly classified. This method has potential for predicting the locations of unknown reefs and possible petroleum accumulations.

INTRODUCTION

In today's energy demanding world, the need to increase known petroleum reserves is critical. Former areas of production must now be reinvestigated for untapped small deposits or for application of secondary and tertiary recovery techniques. In many parts of the world organic reefs and reef facies have proven to be associated with highly productive petroleum reservoirs. In the Great Lakes area and in Illinois in particular, Silurian reefs have been sought for 30 years, since Lowenstam and Dubois (1946) found that the oil-producing horizon in the Marine field was a Silurian reef structure. For the thick Silurian section of southwestern Indiana, future exploration is advocated by Becker and Keller (1976).

But the problem of locating and defining ancient reefs in the subsurface is complex and requires extensive investigation. The American Association of Petroleum Geologists in a reprint series (1975) noted that over 75 major papers had addressed the subject in its bulletin alone. The difficulty in locating ancient reefs led Shaver (1974) to note in his study area of northern Indiana that perhaps thousands of reefs are yet undiscovered or were destroyed by Devonian erosion. In an extensive literature survey of both recent and ancient reefs, Braithwaite (1973) defined "reef" and suggested the following criteria for recognition of reefs: (1) relief, (2) environmental variation, (3) zonation, (4) nature of organisms, and (5) internal structure.

Geochemical data can be used to supplement lithologic and paleontologic methods in establishing sediment facies. Trace element analysis and relations between elements can indicate past Eh, pH, and the depositional environment. Variations in trace elements may be due to sorption, presence of organic matter, diagenesis, biological activity, and leaching. With the advent of more accurate and multielemental analytical techniques, the geochemist is often provided with a large amount of chemical data for problem solving. Considerable work has been done on the nature of trace element association in coal and petroleum to elucidate past geological environments and the source of mineral deposits; for example: Gluskoter et al. (1977), Swanson et al. (1976), Bonham (1956), Bailey et al. (1974), and Hitchon et al. (1974).

The application of trace element data to the study of carbonates in general and reef structures in particular has been investigated by various workers. Trace element concentrations in carbonate rocks have been summarized by Graf (1960) as well as (Krauskopf, (1955); Keith and Degens, (1959); Chester, (1965); Kitano et al., (1973); Klemm, (1973); Al-Shahristani et al., (1973); and Barber, (1974). Using published data, Graf (1960) separated elements associated with carbonate rocks into four groups: (1) those being absorbed on surfaces, (2) those incorporated into a solid solution with the carbonate minerals and accessory authigenic precipitates, (3) noncarbonate skeletel material, and (4) organic matter altered during diagenesis. Kitano et al. (1973) measured the difference in distribution coefficient values for Zn, Cu, Mg, Sr, Ba, and U between carbonate precipitates and solutions. Among the controlling factors that he found for trace element concentration in marine calcareous skeletons were the crystal form of the calcite precipitate, type and concentration of organic matter, temperature, salinity, and trace element concentration in the initial solution. The organic material in carbonate rocks has often been suspected of being the source of enrichment for many trace elements.

The use of trace element concentrations as indicators of the environment of deposition of sediments was investigated by Keith and Degens (1959), in an attempt to distinguish marine from nonmarine shales. The variation in the trace element content of a series of carbonate rocks of Devonian age was studied by Chester (1965), who found that Co, V, Cr, Ni, and Ba concentrations and ratios could be used as indicators in distinguishing reef from nonreef carbonate materials.

Chester (1965) also suggested that the distribution of trace elements in the total sample as well as in the acid-soluble (nondetrital) fraction should be analyzed, since the detrital source material would be influenced by the physical variables in the area which may have been perturbed by the presence of reef structures, which would affect current and depositional patterns. He also pointed out that if significant variability in a trace element concentration across a basin of deposition can be related to the type of environment in the area, then that element may be a useful geochemical indicator.

Our study is an investigation of the feasibility of using trace element concentrations as geochemical indicators to distinguish between reef and nonreef material in southern Illinois Silurian carbonates. In addition, we explored the feasibility of using geochemical parameters to predict the distance from a sample to a reef, a more difficult problem but of greater significance in exploring for new reef structures.

The elements determined in the study were: by X-ray fluorescence—aluminum, calcium, iron, phosphorus, silicon, titanium, vanadium, magnesium, and sulfur; by instrumental neutron activation—bromine, potassium, sodium, arsenic, gallium, manganese, scandium, samarium, europium, lanthanum, and antimony; and by radiochemical separation—mercury. Most of the data obtained by optical emission spectroscopy were below the method limit of detectability. Further refinement of the technique for the analysis of carbonate material is one area which can be explored to include a number of potentially useful elements.

GENERAL GEOLOGY OF THE AREA

In the counties of Clinton, Madison, Marion, Randolph, St. Clair, and Washington in Southwestern Illinois (fig. 1), petroleum-bearing reefs have been found in rocks of the Silurian System (fig. 2). The Silurian stratigraphy is described in detail by Willman (1975). Reef growth started in the Illinois Basin during deposition of the St. Clair Limestone. The large reefs studied in this report are in the Moccasin Springs Formation and commonly are roughly circular, (figs. 3 to 8) with diameters ranging up to about 3.5 miles (5.6 km) and vertical dimensions ranging up to nearly 1000 feet (300 m). More than one center of growth may result in a complex (figs. 9 to 11), so that the large Marine reef, for example, is rather like a horseshoe.

The Moccasin Springs reefs of this report, consisting of relatively pure carbonate rock, are surrounded by an interreef facies of impure carbonates and calcareous siltstones. Lowenstam (1949) describes their composition:

> "The reef-rock proper always consists of practically pure carbonates, either limestone or dolomite, that have higher electrical resistivity than normal interreef rocks. Reef dolomites are invariably blue-gray in color, coarse-grained, and vesicular. Reef limestones are pink to white coquinas, formed almost exclusively of coarse unsorted fossil debris in which corals and stromatoporoids are important constituents. Chert is never present."

The interreef facies is variable but consists predominantly of red and greenish-gray, very fine-grained silty, argillaceous carbonate and calcareous argillaceous siltstone. In the south the carbonate is mainly red limestone. To the north the red portion thins, and more and more of the upper part of the facies is greenish-gray, very cherty dolomite.

Some of the interreef samples are from the Lower Devonian Bailey Limestone (fig. 12) a thick, gray to greenish-gray, silty, cherty, very hard limestone. The tops of the reefs stood above the sea bottom in Early Devonian time, so that some reef wash may have been included in the Bailey. There is even a possibility that reef growth may have persisted from the Silurian into Early Devonian time. The fossils in the Bailey are sparse, but a few found in the lower part of the formation indicate a Silurian age. The entire Bailey has been assigned to the Devonian because no obvious lithologic indication of a difference between the Silurian and Devonian portions is known.

The reef-rocks are characterized by their high purity, being, as a rule, 98 percent or more carbonates. The only common insoluble material is secondary pyrite. In contrast, the interreef rocks in the region of the reef archipelago average about 40 percent insoluble. The reef cores are flanked by beds of reef-derived detritus which dip radially away from the core. Reef-wash, beds of well sorted fossil debris, may extend some distance from a reef, fingering out into the impure interreef strata.

SAMPLE DESCRIPTION AND EXPERIMENTAL PROCEDURES

All the samples analyzed were taken from drill cores submitted to the Illinois State Geological Survey by petroleum companies. The descriptions of the 63 Silurian rock samples analyzed are given in table 1. Table 2 lists the locations and depth intervals of 19 individual samples taken from 5 cores, which were analyzed to study the vertical variation of trace elements within an individual core. Figure 13 is an index map of the samples studied.

Chemical analyses were performed on core samples which had been ground to less than 100 mesh. The precision and accuracy vary for each element and also according to the method employed. For instrumental neutron activation the results for sodium, potassium, gallium, lanthanum, manganese, samarium, and europium are 10 percent or less relative error, while for bromine, arsenic, antimony, and scandium the relative error is higher (15 to 30 percent) largely due to poorer counting statistics. The errors involved in X-ray fluorescence are due primarily to matrix effects but are less than ±10 percent relative concentrations for most elements. Details of the two methods of analyses are found elsewhere (Gluskoter et al., 1977). Of particular note here is that absolute accuracy is not critical since the establishment of relative differences between samples is the primary interest. Any particular bias a method or element has (unless severe) would not adversely affect the final outcome of the stated objectives of the study.

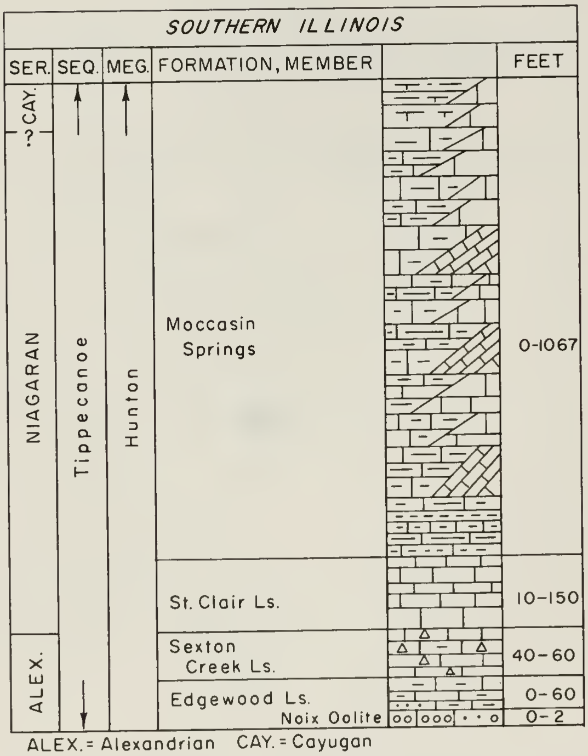


Fig. 1 - Columnar section of the Silurian System in southern Illinois.

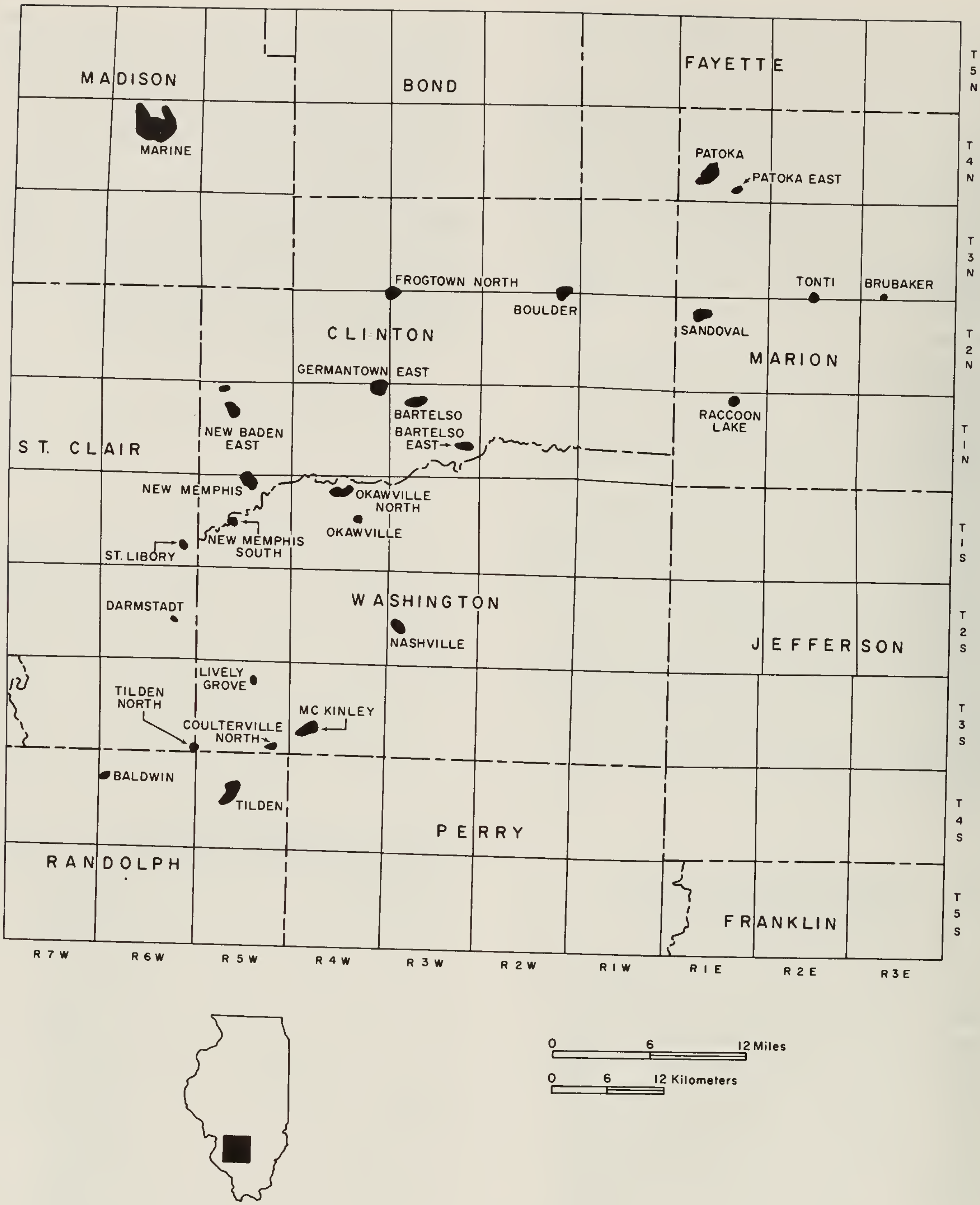


Fig. 2 - Silurian reefs, Southwestern Illinois, July 1973.

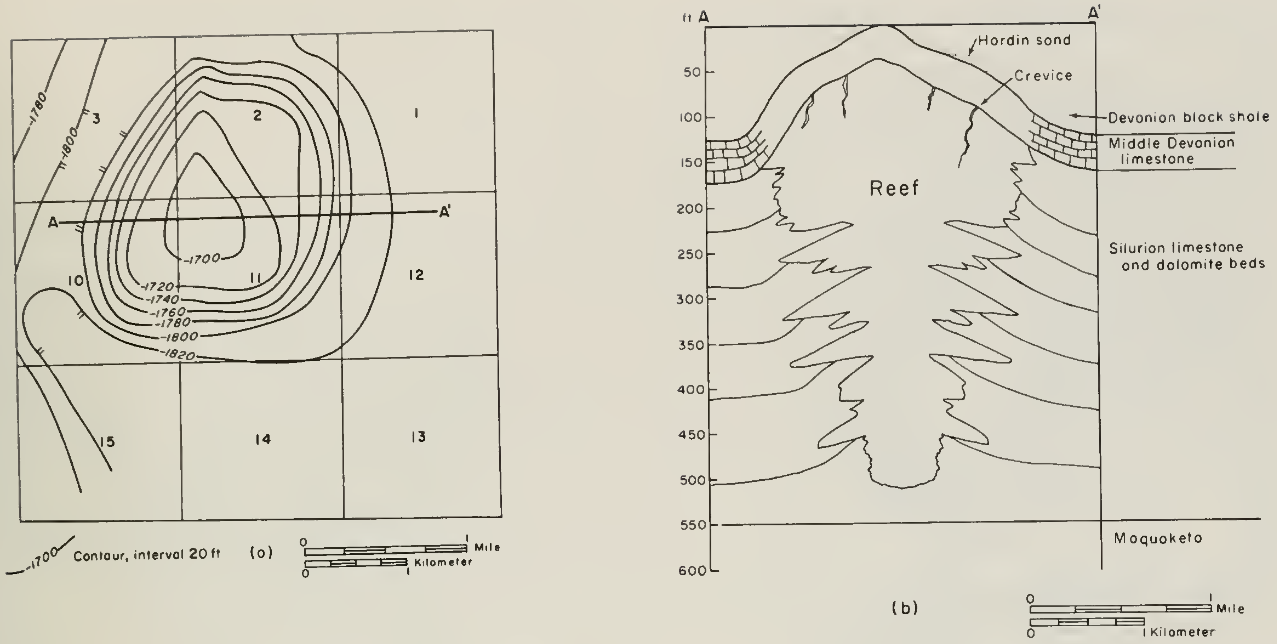


Fig. 3 - Structure map (A) of a typical pinnacle reef contoured on the top of the Hunton Megagroup and a cross section (B) of the reef (vertical x 25).

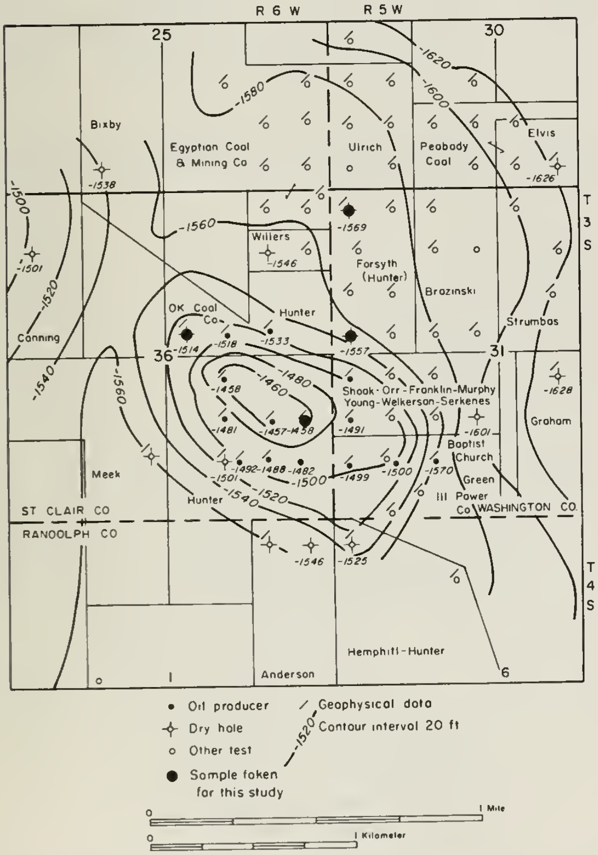


Fig. 4 - Structure map of the Tilden North field drawn on top of the Silurian reef.

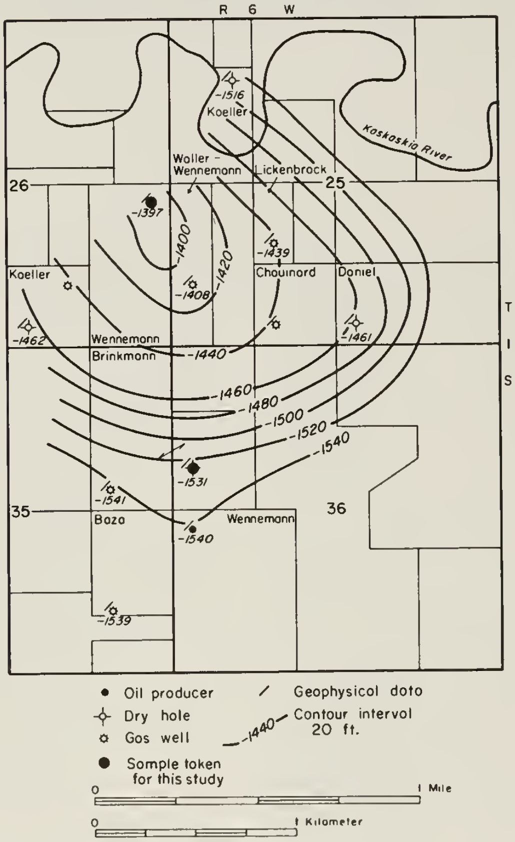


Fig. 5 - Structure map of the St. Libory gas field drawn on top of the Silurian reef.

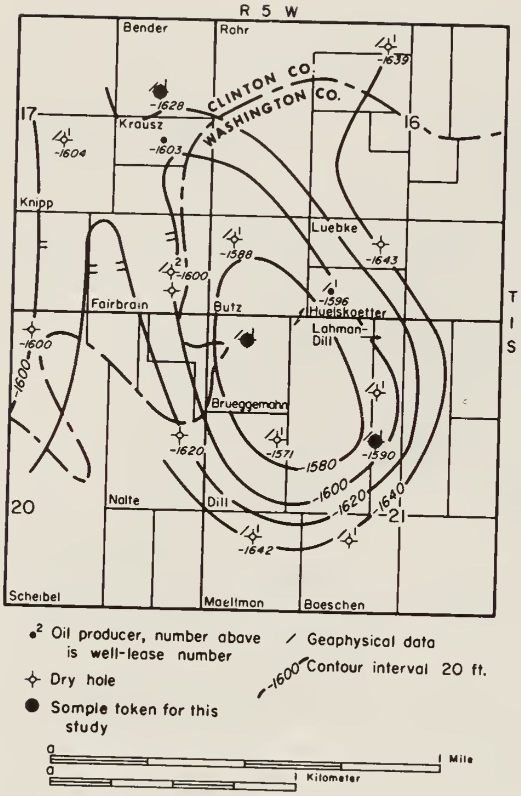


Fig. 6 - Structure map of the New Memphis South field drawn on top of the Silurian reef.

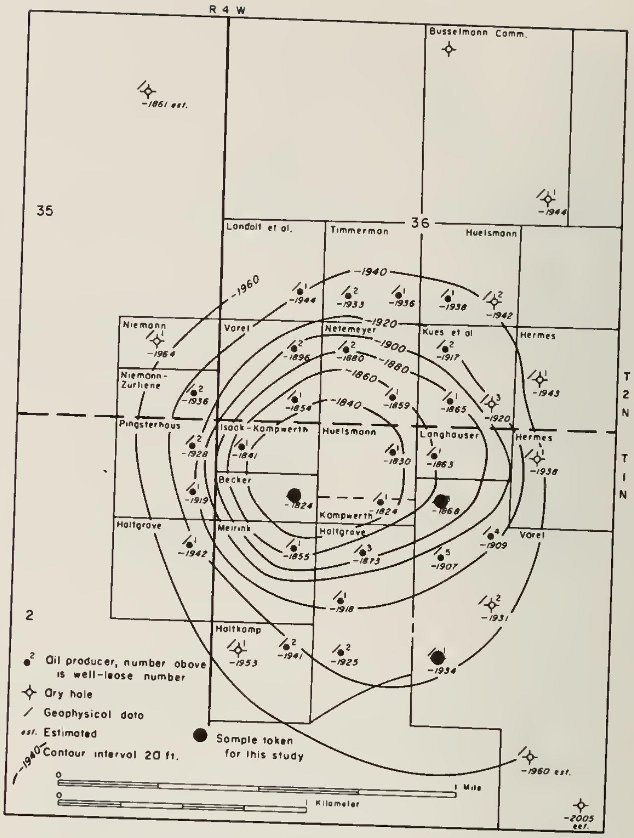


Fig. 7 - Structure map of the Germantown East field drawn on top of the Silurian reef.

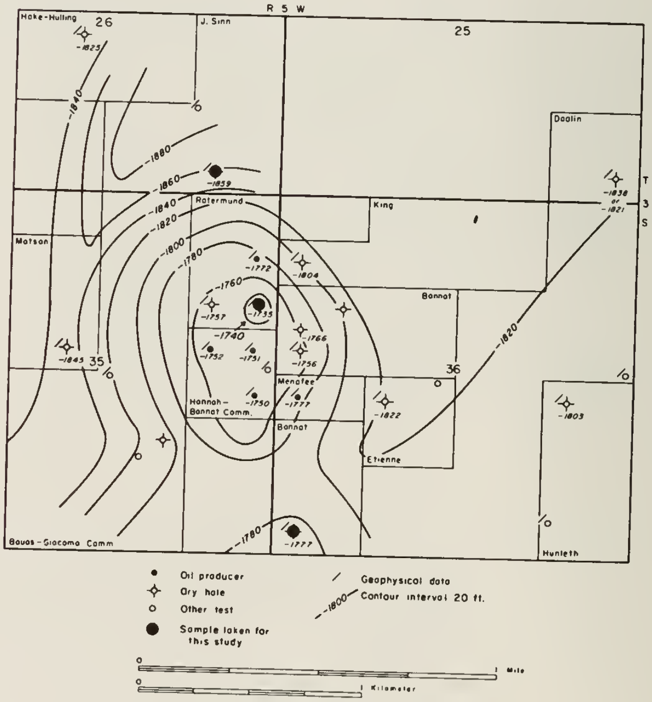


Fig 8 - Structure map of the Coulterville North field drawn on top of the Silurian reef.

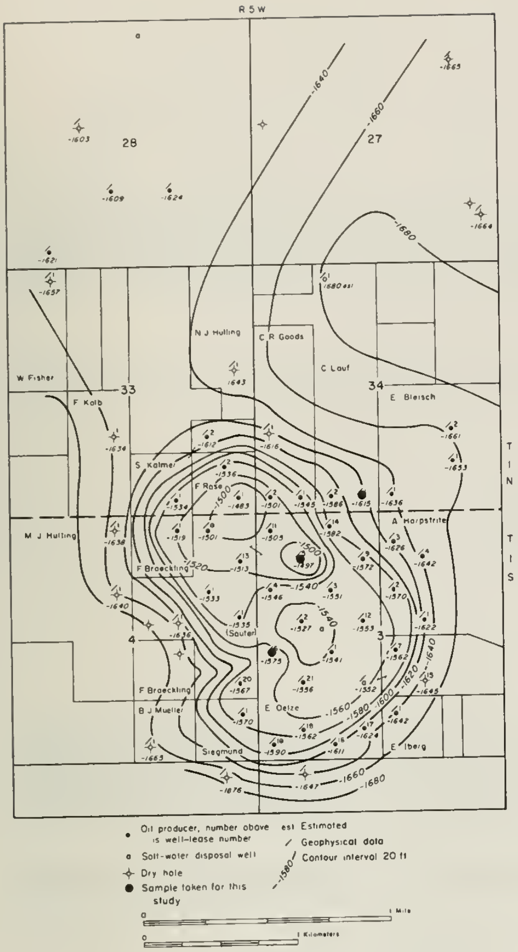


Fig. 9 - Structure map of the New Memphis field drawn on top of the Silurian reef.

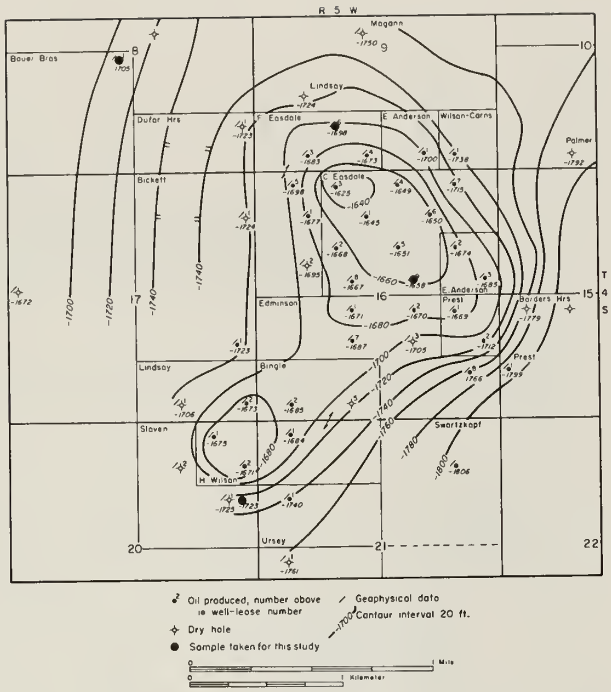


Fig. 10 - Structure map of the Tilden field drawn on top of the Silurian reef.

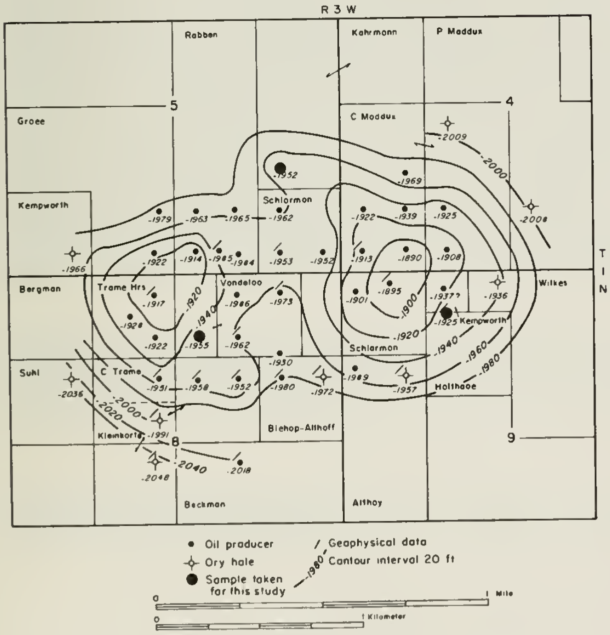
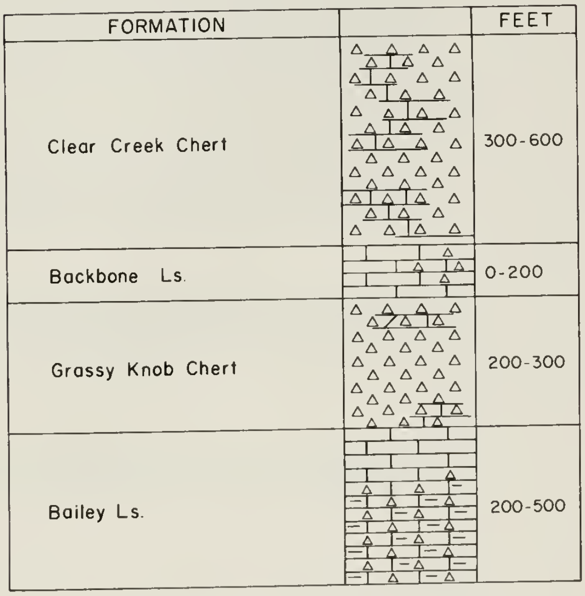


Fig. 11 - Structure map of the Bartelso field drawn on top of the Silurian reef.



FORMATION	FEET
Clear Creek Chert	300-600
Backbone Ls.	0-200
Grassy Knob Chert	200-300
Bailey Ls.	200-500

Fig. 12 - Columnar section of the Lower Devonian Series.

TABLE 1 - DESCRIPTIONS OF SAMPLES

Sample No.	Core Index No.	Anal. Lab. No.	Sample Locations	Depth	Rock type	Distance from reef (miles)	Distance below shale capping (ft)	Remarks
28	C-2629	R-11805	S1/2SE NE 17-1S-5W, Clinton County	2040	Dolomitic limestone	Touching	18	New Memphis South Pool
42	C-2656	R-11806	NW NW SE 22-1S-4W, Washington County	2455	Interreef dolomite	0.5	13	Wildcat
9	C-2672	R-11807	S1/2SW NE 16-4S-5W, Randolph County	2200	Reef rock	0	59	Tilden Pool
55	C-2679	R-11808	SW SW 35-4S-5W, Randolph County	2390	Interreef limestone	Far away	13	Wildcat
43	C-2710	R-11809	SW 8-4S-5W, Randolph County	2302	Interreef limestone	0.5	127	Wildcat
29	C-2720	R-11810	SW SW SW 36-3S-5W, Washington County	2300	Interreef limestone	0.25	25	Wildcat
56	C-2721	R-11811	NW NE NW 1-3S-6W, St. Clair County	2070	Interreef limestone	2	18	Wildcat
30	C-2722	R-11812	N1/2 SE NE 20-4S-5W, Randolph County	2255	Limestone	Touching	30	Edgewell, Tilden Pool
31	C-2728	R-11813	NE NE SE 20-3S-4W, Washington County	2370	Cherty Limestone	Touching	10	Wildcat
32	C-2769	R-11814	E1/2 NE SE 36-3N-4W, Clinton County	2350	Dolomite	0.25	15	Wildcat
57	C-2778	R-11815	SW SW NE 34-1S-5W, Washington County	2129	Limestone	0.25	9	Wildcat
58	C-2787	R-11816	SE SE SE 16-2S-5W, Washington County	2200	Limestone	3	20	Wildcat
10	C-2793	R-11817	SW SW NE 7-4S-6W, Randolph County	1600	Reef rock	0	20	Wildcat
33	C-2861	R-11818	SE SE SW 34-1N-5W, Clinton County	2030	Cherty dolomite	Touching	10	New Memphis Pool
59	C-2866	R-11819	NW NW NW 25-1S-4W, Washington County	2490	Limestone	1.5	12	Wildcat
11	C-2894	R-11820	NW 6-2N-3W, Clinton County	2260	Reef rock	0	36	Frogtown Pool
44	C-2979	R-11821	NW NW SW 17-4S-6W, Randolph County	1700	Limestone	1	26	Wildcat
12	C-3152	R-11822	NW NW SW 3-1S-5W, Clinton County	2009	Reef rock	0	31	New Memphis Pool
13	C-3162	R-11823	SW SW SE 24-1N-3W, Clinton County	2561	Reef rock	0	35	Bartelso East Pool
45	C-3223	R-11824	NE corner 19-1N-2W, Clinton County	2781	Limestone	0.75	61	Wildcat
60	C-3233	R-11825	NE NE SE 12-5S-6W, Randolph County	2177	Limestone	5	17	Wildcat
34	C-3243	R-11826	SW NE SE 5-1N-3W, Clinton County	2437	Dolomite	Touching	17	Bartelso Pool
14	C-3250	R-11827	N1/2 NW NW 21-1S-5W, Washington County	2004	Reef rock	0	17	New Memphis South Pool
15	C-3337	R-11828	SW corner NW NE 29-3S-4W, Wash. County	2251	Reef rock	0	9	McKinley Pool
61	C-3356	R-11829	SW SW SW 36-2S-4W, Washington County	2663	Limestone	3	19	Wildcat
23	C-3375	R-11830	SW NW SE 4-1S-4W, Washington County	2260	Dolomite	Touching	16	Wildcat
24	C-3377	R-11831	NW SE SE 35-2N-4W, Clinton County	2399	Limestone	Touching	13	Wildcat
1	C-3386	R-11832	SE NW NW 1-1N-4W, Clinton County	2300	Reef rock	0	54	Germantown East Pool
47	C-3465	R-11833	NE NE NE 14-2S-5W, Washington County	2294	Limestone	5	14	Wildcat
25	C-3473	R-11834	NW NW NW 31-3S-5W, Washington County	2094	Limestone	0.5	14	Wildcat
48	C-3485	R-11835	SE SE SE 12-1S-4W, Washington County	2552	Limestone	1.5	22	Wildcat
38	C-3495	R-11836	S1/2 SE NW 8-1S-4W, Washington County	2250	Limestone	1.5	15	Wildcat
49	C-3511	R-11837	SW SE NE 3-5S-5W, Randolph County	2356	Limestone	4	23	Wildcat
50	C-3525	R-11838	SE SE NE 6-1S-4W, Washington County	2206	Dolomite	1.5	24	Wildcat
39	C-3537	R-11839	SW SW SE 8-1S-4W, Washington County	2300	Limestone	1.5	13	Wildcat
26	C-3544	R-11840	SW SE SE 26-3S-5W, Washington County	2340	Limestone	0.25	13	Wildcat
2	C-3571	R-11841	NE SE NE 35-3S-5W, Washington County	2259	Reef rock	0	11	Coulterville North Pool
40	C-3751	R-11842	W1/2 NE NW 2-4S-5W, Randolph County	2820	Limestone	3.25	5	Wildcat
3	C-3755	R-11843	SW SE SW 3-1S-4W, Washington County	2215	Reef rock	0	11	Okawville Pool
41	C-3768	R-11844	NE NE NE 31-2N-5W, Clinton County	2023	Limestone	2	6	Wildcat
51	C-3769	R-11845	NE NW 18-1S-4W, Washington County	2197	Limestone	2.5	8	Wildcat
27	C-3778	R-11846	SW SW NE 36-3S-6W, St. Clair County	2050	Limestone	Touching	19	Wildcat
52	C-3796	R-11847	NE NE SW 9-5S-5W, Randolph County	2260	Limestone	4.5	10	Wildcat
4	C-3897	R-11848	NE SE NW 21-1S-5W, Washington County	2025	Reef rock	0	35	New Memphis Pool
5	C-3960	R-11849	S1/2 SE NW 9-1N-5W, Clinton County	1960	Reef rock	0	7	New Baden Pool
53	C-3965	R-11850	N1/2 NW SE 29-1S-5W, Washington County	2030	Limestone	1.5	15	Wildcat
54	C-3966	R-11851	NW NW SE 25-1S-4W, Washington County	2522	Limestone	2	24	Wildcat
6	C-3999	R-11852	NW NE 8-1N-3W, Clinton County	2454	Reef rock	0	10	Bartelso Pool
7	C-4385	R-11853	W1/2 NE NW 9-1N-3W, Clinton County	2450	Dolomite	Touching	46	Bartelso Pool

8	C-4428	R-11854	NW SE SW 9-4S-5W, Randolph County	2219	Reef rock	0	29	Tilden Pool
16	C-4474	R-11855	NE SE 26-1S-6W, St. Clair County	1813	Reef rock	0	17	St. Libory Pool
62	C-4564	R-11856	NE SW 15-2S-5W, Washington County	2274	Limestone	4	7	Wildcat
35	C-4565	R-11857	W1/2 SW NW 36-1S-6W, St. Clair County	1960	Dolomite	0.25	32	St. Libory Pool
17	C-6985	R-11858	NE SE 36-3S-6W, St. Clair County	2055	Reef rock	0	67	Tilden North Pool
18	C-6986	R-11859	NE SW NE 10-3S-5W, Washington County	2237	Reef rock	0	14	Wildcat
36	C-7153	R-11860	SW NW 31-3S-5W, Washington County	2086	Limestone	Touching	17	Tilden North Pool
19	C-8958	R-11861	SW corner NE 23-2S-6W, St. Clair County	1872	Reef rock	0	10	Wildcat, Stromatoporoid
20	C-9148	R-11862	NW SE NW 23-2S-6W, St. Clair County	1879	Reef rock	0	25	Wildcat
63	C-9790	R-11863	SE corner 28-3S-6W, St. Clair County	1840	Limestone	3	10	Wildcat
37	C-9861	R-11864	NE NW NE 30-2S-3W, Washington County	2700	Limestone	Touching	72	Nashville Pool
46	C-9863	R-11865	SE SE SW 30-2S-3W, Washington County	2715	Limestone	1	15	Wildcat
21	C-9868	R-11866	NE NW SW 20-2S-3W, Washington County	2565	Reef rock	0	15	Nashville Pool
22	C-8958	R-11867	SW corner NE 23-2S-6W, St. Clair Co.	1872	Reef rock	0	10	Wildcat, above Stromatoporoid

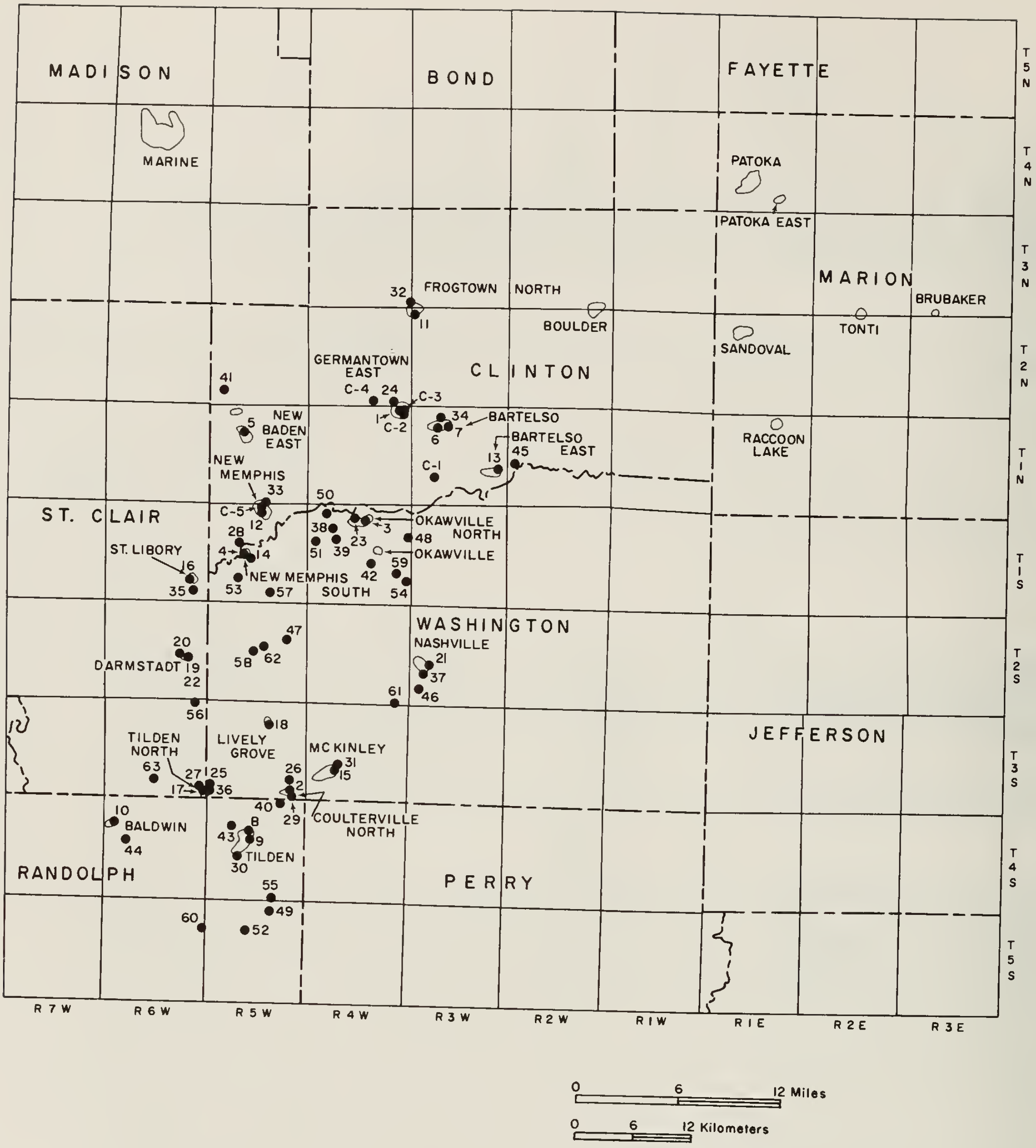


Fig. 13 - Sample index map.

TABLE 2 - LOCATION AND DEPTH INTERVAL OF 19 SAMPLES
FROM 5 INDIVIDUAL CORES

Core Index No.	Anal. Lab. No.	Sample Location	Distance from reef (miles)	Depth (ft)	Rock type
C-2758	R-12708	SW NE NW 29-1N-3W, Clinton County	3.5	2478	Dolomitic limestone
C-2758	R-12709	SW NE NW 29-1N-3W, Clinton County	3.5	2503	Dolomitic limestone
C-2758	R-12710	SW NE NW 29-1N-3W, Clinton County	3.5	2527	Dolomitic limestone
C-2758	R-12711	SW NE NW 29-1N-3W, Clinton County	3.5	2548	Dolomitic limestone
C-2957	R-12712	NW NW SE 1-1N-4W, Clinton County	Touching	2384	Dolomitic limestone
C-2957	R-12713	NW NW SE 1-1N-4W, Clinton County	Touching	2402	Dolomitic limestone
C-2957	R-12714	NW NW SE 1-1N-4W, Clinton County	Touching	2423	Dolomitic limestone
C-3365	R-12715	SW NW NE 1-1N-4W, Clinton County	0	2323	Reef rock
C-3365	R-12716	SW NW NE 1-1N-4W, Clinton County	0	2352	Reef rock
C-3365	R-12717	SW NW NE 1-1N-4W, Clinton County	0	2381	Reef rock
C-3365	R-12718	SW NW NE 1-1N-4W, Clinton County	0	2410	Reef rock
C-3367	R-12719	NE NW SE, 34-2N-4W, Clinton County	1.5	2437	Dolomitic limestone
C-3367	R-12720	NE NW SE, 34-2N-4W, Clinton County	1.5	2459	Dolomitic limestone
C-3367	R-12721	NE NW SE, 34-2N-4W, Clinton County	1.5	2482	Dolomitic limestone
C-3367	R-12722	NE NW SE, 34-2N-4W, Clinton County	1.5	2505	Dolomitic limestone
C-3961	R-12723	SE NW NW 3-1S-5W, Clinton County	0	2164	Reef rock
C-3961	R-12724	SE NW NW 3-1S-5W, Clinton County	0	2186	Reef rock
C-3961	R-12725	SE NW NW 3-1S-5W, Clinton County	0	2207	Reef rock
C-3961	R-12726	SE NW NW 3-1S-5W, Clinton County	0	2229	Reef rock

RESULTS AND DISCUSSION

The initial work was done on 63 Silurian rock samples which are grouped into four categories according to their location. Group I (22 samples) is in the reef. Group II (15 samples) is touching or less than 0.5 mile (0.8 km) from a reef. Group III (9 samples) is near a reef, 0.5 to 1.5 miles (0.8 to 2.4 km). Group IV (17 samples) is far from a reef, more than 1.5 miles (2.4 km). An immediate concern for statistical treatment of the data was the small number of samples in Group III which possibly could have been placed in either Group II or IV. Table 3 lists the data for the initial 63 samples.

In a second phase of the study we investigated the vertical variation of trace elements within an individual core in Group I (2 cores), Group II (1 core), Group III (1 core), and Group IV (1 core). The data for 19 individual vertical samples are listed in table 4 along with the depth intervals that they represent.

The results of the 63 analyses were first placed into one of the four groups according to proximity of the samples to a known reef formation. The mean value for each element in each group is tabulated in table 5. Most trace elements are depleted in Group III with the exception of calcium, sulfur, and arsenic. The differences between means for Groups II, III, and IV are not very distinct and often are rather uniform, such as those for europium, samarium, lanthanum, gallium, and sodium.

Scatter plots were made for each element to further establish whether or not any trends were apparent between Groups II, III, and IV. Figure 14 illustrates scatter plots for lanthanum and manganese, again showing little clear-cut distinction between the three nonreef groups. This lack of distinction is especially apparent for lanthanum, while for manganese no clear distinction is made between any of the groups.

Linear correlations were computed for each individual group and then for all the samples to establish a possible basis for determining which of the many elements analyzed would be most useful for further investigation. Several combinations of elements were tested to establish which group had either high positive or high negative correlations with respect to their geographic groupings. Most major constituents were discarded from consideration, since they all showed little relation to their geographical sites although all showed high correlations with one another; for example, the high-calcium samples were very low in silica and the high-silica samples were low in calcium. The elements which showed the highest positive correlations with each group of samples were Br, K, V, Mn, As, Ga,

TABLE 3 - DATA FOR 63 REEF AND NONREEF SAMPLES

LAB.NO.	AL	BR	CA	FE	P	K	SI	TI	V
R11832	0.76 %	1.5 PPM	45.48 %	0.50 %	0.01 %	0.27 %	3.92 %	0.02 %	22.9 PPM
R11841	0.22 %	0.57PPM	52.06 %	0.02 %	0.01 %	0.01 %	2.48 %	0.04 %	19.1 PPM
R11843	0.10 %	1.3 PPM	51.70 %	0.04 %	0.01 %	0.01 %	2.03 %	0.01 %	18.6 PPM
R11848	0.84 %	1.3 PPM	47.35 %	1.72 %	0.02 %	0.27 %	4.01 %	0.02 %	22.7 PPM
R11849	0.33 %	1.2 PPM	51.27 %	0.31 %	0.03 %	0.04 %	2.45 %	0.01 %	18.2 PPM
R11852	0.97 %	4.1 PPM	6.01 %	0.53 %	0.01 %	0.26 %	82.80 %	0.04 %	25.5 PPM
R11853	0.41 %	1.0 PPM	43.81 %	0.20 %	0.03 %	0.08 %	2.97 %	0.01 %	8.2 PPM
R11854	0.36 %	0.98PPM	49.68 %	2.82 %	0.05 %	0.02 %	3.77 %	0.01 %	5.5 PPM
R11807	0.28 %	0.74PPM	52.75 %	0.86 %	0.04 %	0.06 %	1.84 %	0.01 %	11.4 PPM
R11817	0.09 %	1.1 PPM	53.75 %	0.03 %	0.01 %	0.01 %	1.02 %	0.01 %	3.0 PPM
R11820	0.92 %	2.6 PPM	33.77 %	0.51 %	0.01 %	0.25 %	4.20 %	0.04 %	13.7 PPM
R11822	0.10 %	0.91PPM	54.07 %	0.04 %	0.01 %	0.03 %	1.12 %	0.01 %	2.5 PPM
R11823	0.23 %	0.89PPM	53.05 %	0.07 %	0.01 %	0.01 %	1.65 %	0.01 %	29.8 PPM
R11827	0.20 %	0.64PPM	54.01 %	0.01 %	0.02 %	0.02 %	1.35 %	0.01 %	2.7 PPM
R11828	7.41 %	0.68PPM	53.89 %	0.07 %	0.03 %	0.01 %	2.44 %	0.01 %	11.4 PPM
R11855	0.47 %	1.1 PPM	50.46 %	0.12 %	0.08 %	0.05 %	2.79 %	0.01 %	15.3 PPM
R11858	0.52 %	0.55PPM	50.90 %	0.14 %	0.01 %	0.13 %	3.00 %	0.01 %	17.3 PPM
R11859	1.28 %	2.3 PPM	52.70 %	0.08 %	0.02 %	0.01 %	1.12 %	0.01 %	0.9 PPM
R11861	0.20 %	0.36PPM	54.16 %	0.01 %	0.02 %	0.01 %	0.32 %	0.01 %	1.8 PPM
R11862	0.20 %	1.3 PPM	52.91 %	0.21 %	0.01 %	0.03 %	1.40 %	0.01 %	5.5 PPM
R11866	0.21 %	1.3 PPM	53.77 %	0.03 %	0.01 %	0.01 %	0.94 %	0.11 %	35.9 PPM
R11867	0.08 %	0.51PPM	53.63 %	0.07 %	0.01 %	0.01 %	0.84 %	0.01 %	17.5 PPM
R11830	1.33 %	7.61PPM	27.91 %	0.63 %	0.01 %	0.34 %	10.93 %	0.06 %	23.4 PPM
R11831	1.56 %	9.31PPM	30.00 %	0.35 %	0.02 %	0.57 %	12.52 %	0.06 %	34.5 PPM
R11834	3.09 %	1.8 PPM	35.22 %	1.22 %	0.01 %	0.86 %	24.39 %	0.13 %	49.3 PPM
R11840	1.66 %	3.6 PPM	33.90 %	1.47 %	0.09 %	0.28 %	11.71 %	0.06 %	28.4 PPM
R11846	1.27 %	1.1 PPM	44.80 %	0.56 %	0.02 %	0.36 %	9.85 %	0.04 %	17.5 PPM
R11805	0.62 %	0.65PPM	37.86 %	0.85 %	0.04 %	0.21 %	6.49 %	0.06 %	13.0 PPM
R11810	0.01 %	0.79PPM	53.34 %	0.18 %	0.01 %	0.01 %	2.87 %	0.01 %	0.53PPM
R11812	1.05 %	2.4 PPM	40.08 %	0.54 %	0.01 %	0.33 %	13.07 %	0.07 %	19.6 PPM
R11813	0.65 %	0.43PPM	49.53 %	0.23 %	0.01 %	0.10 %	4.51 %	0.01 %	5.7 PPM
R11814	1.63 %	5.8 PPM	25.25 %	0.77 %	0.05 %	0.66 %	14.36 %	0.28 %	65.9 PPM
R11818	0.76 %	5.4 PPM	8.81 %	0.60 %	0.02 %	0.12 %	74.99 %	0.04 %	14.5 PPM
R11826	1.22 %	6.7 PPM	28.53 %	0.42 %	0.01 %	0.50 %	10.96 %	0.06 %	28.0 PPM
R11857	3.22 %	4.8 PPM	30.04 %	1.24 %	0.02 %	1.02 %	21.31 %	0.14 %	58.0 PPM
R11860	2.62 %	6.7 PPM	31.92 %	1.60 %	0.01 %	0.79 %	14.97 %	0.13 %	52.3 PPM
R11864	1.74 %	9.6 PPM	26.25 %	0.72 %	0.02 %	0.50 %	22.43 %	0.10 %	35.5 PPM
R11836	0.54 %	2.7 PPM	46.34 %	0.15 %	0.01 %	0.13 %	6.83 %	0.01 %	14.1 PPM
R11839	1.27 %	1.2 PPM	46.65 %	0.38 %	0.03 %	0.18 %	6.21 %	0.02 %	24.6 PPM
R11842	0.55 %	2.8 PPM	33.17 %	1.14 %	0.01 %	0.07 %	26.48 %	0.01 %	32.7 PPM
R11844	2.50 %	1.4 PPM	30.04 %	0.92 %	0.02 %	0.84 %	30.17 %	0.13 %	40.7 PPM
R11806	1.02 %	0.89PPM	44.27 %	0.62 %	0.02 %	0.18 %	7.23 %	0.02 %	14.1 PPM
R11809	1.06 %	4.4 PPM	35.33 %	0.27 %	0.04 %	0.35 %	24.55 %	0.03 %	11.4 PPM
R11821	2.03 %	1.6 PPM	30.58 %	1.40 %	0.01 %	0.48 %	33.39 %	0.09 %	23.6 PPM
R11824	16.72 %	14.7 PPM	12.14 %	11.82 %	0.11 %	0.42 %	38.72 %	0.76 %	18.3 PPM
R11865	0.31 %	< 0.3 PPM	52.43 %	0.29 %	0.02 %	0.06 %	2.36 %	0.01 %	4.6 PPM
R11833	0.56 %	1.1 PPM	50.43 %	0.16 %	0.18 %	0.10 %	4.40 %	0.01 %	16.1 PPM
R11835	0.74 %	2.0 PPM	45.49 %	0.42 %	0.01 %	0.21 %	7.07 %	0.02 %	15.0 PPM
R11837	0.80 %	1.7 PPM	48.20 %	0.33 %	0.03 %	0.14 %	7.16 %	0.01 %	24.6 PPM
R11838	1.04 %	4.2 PPM	34.06 %	0.26 %	0.02 %	0.18 %	28.26 %	0.02 %	19.5 PPM
R11845	2.23 %	4.7 PPM	32.46 %	0.86 %	0.01 %	0.60 %	12.66 %	0.12 %	31.2 PPM
R11847	1.76 %	1.5 PPM	35.45 %	1.41 %	0.01 %	0.62 %	17.63 %	0.08 %	43.7 PPM
R11850	1.75 %	3.9 PPM	34.05 %	1.34 %	0.03 %	0.62 %	11.19 %	0.09 %	26.4 PPM
R11851	0.62 %	1.0 PPM	50.92 %	0.13 %	0.02 %	0.11 %	3.17 %	0.01 %	20.9 PPM
R11808	0.46 %	1.3 PPM	48.05 %	0.56 %	0.02 %	0.06 %	5.95 %	0.01 %	4.8 PPM
R11811	4.15 %	1.9 PPM	30.54 %	1.81 %	0.01 %	1.27 %	24.00 %	0.21 %	52.3 PPM
R11815	0.48 %	2.0 PPM	46.11 %	0.39 %	0.06 %	0.14 %	6.28 %	0.08 %	10.5 PPM
R11816	0.20 %	0.3 PPM	51.70 %	0.45 %	0.03 %	0.04 %	3.83 %	0.01 %	4.3 PPM
R11819	1.10 %	2.8 PPM	34.50 %	0.81 %	0.01 %	0.25 %	17.63 %	0.05 %	13.4 PPM
R11825	0.23 %	0.84PPM	43.19 %	0.25 %	0.07 %	0.06 %	18.02 %	0.01 %	16.8 PPM
R11829	0.81 %	1.2 PPM	44.51 %	0.36 %	0.01 %	0.23 %	11.53 %	0.02 %	32.7 PPM
R11856	2.62 %	5.1 PPM	30.00 %	1.53 %	0.01 %	0.76 %	18.33 %	0.13 %	47.7 PPM
R11863	11.18 %	1.4 PPM	36.61 %	1.40 %	0.04 %	0.64 %	22.09 %	0.12 %	32.8 PPM

TABLE 3 - continued

LAB.NO.	MG	MN	NA	S	SN*	CU*	CO*	NI*	BE*
R11832	5.52 %	247 PPM	0.21 %	0.10 %	43 PPM		5.8 PPM		
R11841	1.61 %	93 PPM	0.40 %	0.02 %	38 PPM				
R11843	2.53 %	132 PPM	0.05 %	0.04 %	38 PPM				
R11848	3.33 %	269 PPM	0.45 %	0.68 %				29 PPM	7.0 PPM
R11849	2.18 %	178 PPM	0.12 %	0.06 %	39 PPM				
R11852	4.33 %	263 PPM	0.17 %	0.07 %					
R11853	8.50 %	516 PPM	0.13 %	0.04 %					
R11854	1.35 %	208 PPM	0.34 %	1.13 %	36 PPM				
R11807	1.40 %	118 PPM	0.43 %	0.06 %			8.6 PPM	4.2 PPM	
R11817	1.26 %	146 PPM	0.50 %	0.01 %			8.1 PPM	3.9 PPM	
R11820	16.01 %	349 PPM	0.51 %	0.16 %		3.5 PPM	6.5 PPM	7.4 PPM	
R11822	1.24 %	97 PPM	0.06 %	0.02 %					
R11823	1.50 %	76 PPM	0.25 %	0.02 %			7.3 PPM		
R11827	1.03 %	121 PPM	0.16 %	0.03 %	43 PPM				
R11828	1.74 %	119 PPM	0.56 %	0.02 %					
R11855	2.81 %	173 PPM	0.18 %	0.03 %					
R11858	2.40 %	187 PPM	0.09 %	0.03 %					
R11859	1.28 %	189 PPM	0.77 %	0.02 %					
R11861	1.33 %	174 PPM	0.03 %	0.02 %	44 PPM	3.5 PPM			
R11862	2.11 %	198 PPM	0.09 %	0.02 %	37 PPM				
R11866	1.03 %	97 PPM	0.24 %	0.02 %	42 PPM				
R11867	1.50 %	163 PPM	0.01 %	0.02 %					
R11830	17.48 %	201 PPM	0.09 %	0.11 %	38 PPM	4.2 PPM			
R11831	14.75 %	253 PPM	0.33 %	0.09 %	41 PPM		5.5 PPM		6.0 PPM
R11834	3.53 %	993 PPM	0.23 %	0.01 %		4.2 PPM		13 PPM	3.5 PPM
R11840	12.57 %	365 PPM	0.04 %	0.11 %	42 PPM				
R11846	3.54 %	812 PPM	0.19 %	0.02 %	38· PPM				5.3 PPM
R11805	10.87 %	276 PPM	0.03 %	0.08 %			8.9 PPM		
R11810	1.25 %	226 PPM	0.05 %	0.01 %					
R11812	6.40 %	179 PPM	0.37 %	0.13 %			4.8 PPM		
R11813	2.65 %	312 PPM	0.03 %	0.04 %			4.8 PPM		
R11814	17.78 %	359 PPM	0.22 %	0.12 %			3.2 PPM		
R11818	3.83 %	103 PPM	0.05 %	0.13 %	9.7 PPM		2.2 PPM		
R11826	17.00 %	439 PPM	0.42 %	0.07 %					
R11857	8.84 %	303 PPM	0.46 %	0.24 %		8.4 PPM			3.4 PPM
R11860	10.59 %	526 PPM	0.42 %	0.10 %		5.1 PPM		10 PPM	3.4 PPM
R11864	12.99 %	262 PPM	0.42 %	0.17 %		4.4 PPM			5.3 PPM
R11836	4.68 %	189 PPM	0.22 %	0.04 %	42 PPM				
R11839	3.90 %	245 PPM	0.36 %	0.10 %	43 PPM	3.4 PPM			4.4 PPM
R11842	5.87 %	266 PPM	0.02 %	0.04 %					
R11844	5.51 %	258 PPM	0.66 %	0.09 %		3.9 PPM			3.9 PPM
R11806	5.79 %	415 PPM	0.08 %	0.09 %					
R11809	5.20 %	59 PPM	0.24 %	0.06 %					
R11821	3.84 %	501 PPM	0.41 %	0.12 %			8.7 PPM		
R11824	4.53 %	922 PPM	0.10 %	0.09 %	18 PPM				
R11865	1.14 %	390 PPM	0.18 %	0.06 %					
R11833	2.19 %	152 PPM	0.01 %	0.18 %	43 PPM	3.8 PPM	5.2 PPM		
R11835	4.70 %	455 PPM	0.53 %	0.10 %					
R11837	2.46 %	269 PPM	0.18 %	0.05 %	41 PPM		5.0 PPM		
R11838	4.40 %	127 PPM	0.35 %	0.05 %					
R11845	12.06 %	726 PPM	0.48 %	0.08 %	50 PPM	3.9 PPM			3.2 PPM
R11847	7.02 %	314 PPM	0.50 %	0.16 %	39 PPM				4.1 PPM
R11850	11.49 %	346 PPM	0.40 %	0.11 %					4.2 PPM
R11851	2.35 %	258 PPM	0.08 %	0.05 %	38 PPM				
R11808	3.34 %	327 PPM	0.33 %	0.06 %			8.6 PPM		
R11811	6.68 %	886 PPM	0.47 %	0.06 %		6.7 PPM	4.3 PPM	18 PPM	
R11815	4.25 %	231 PPM	0.53 %	0.06 %			3.2 PPM		
R11816	1.48 %	296 PPM	0.04 %	0.16 %			4.7 PPM		
R11819	8.31 %	373 PPM	0.04 %	0.12 %			7.1 PPM		
R11825	1.64 %	80 PPM	0.34 %	0.07 %					
R11829	3.64 %	244 PPM	0.24 %	0.07 %	40 PPM		6.7 PPM		7.5 PPM
R11856	10.76 %	504 PPM	0.34 %	0.10 %		6.8 PPM			3.4 PPM
R11863	4.00 %	0.13 %	0.36 %	0.11 %		3.8 PPM		16 PPM	4.0 PPM

* ALL MISSING VALUES WERE BELOW THE LIMITS OF DETECTION. APPROXIMATE L/D-SN:120 PPM;CU: 3.3 PPM;CO: 4 PPM;NI: 3.2 PPM;BE: 3.1 PPM

TABLE 3 - continued

LAB.NO.	CR*	MO*	GE*	ZR	PB*	ZN	AS	GA	HG
R11832				10 PPM		210 PPM	1.12PPM	0.79PPM	0.22PPM
R11841				< 3.3 PPM		28 PPM	0.35PPM	< 0.2 PPM	0.08PPM
R11843				< 3.3 PPM		28 PPM	0.37PPM	0.18PPM	0.13PPM
R11848	14 PPM			25 PPM		24 PPM	9.61PPM	0.85PPM	0.03PPM
R11849				< 3.3 PPM		83 PPM	1.61PPM	0.36PPM	0.18PPM
R11852				16 PPM		130 PPM	1.04PPM	0.47PPM	1.54PPM
R11853				< 5.1 PPM		89 PPM	0.15PPM	0.42PPM	0.06PPM
R11854				46 PPM		95 PPM	0.85PPM	0.25PPM	0.30PPM
R11807		8.6 PPM		3.3 PPM		64 PPM	1.01PPM	0.10PPM	0.02PPM
R11817				2.4 PPM		30 PPM	0.2 PPM	0.25PPM	0.02PPM
R11820	3.6 PPM			13 PPM		23 PPM	3.87PPM	0.75PPM	0.06PPM
R11822				< 3.1 PPM		28 PPM	0.41PPM	0.42PPM	0.23PPM
R11823				2.9 PPM		30 PPM	0.16PPM	0.10PPM	0.05PPM
R11827				< 3.3 PPM		31 PPM	1.11PPM	0.10PPM	0.90PPM
R11828				< 4.8 PPM		33 PPM	0.25PPM	0.10PPM	0.09PPM
R11855				< 4.4 PPM		67 PPM	0.26PPM	0.39PPM	0.48PPM
R11858				7.8 PPM		13 PPM	0.52PPM	0.61PPM	0.04PPM
R11859				< 3.3 PPM		28 PPM	0.11PPM	< 0.2 PPM	0.05PPM
R11861				< 3.3 PPM	84 PPM	130 PPM	0.58PPM	0.22PPM	0.02PPM
R11862				< 4.3 PPM		48 PPM	0.22PPM	0.17PPM	0.06PPM
R11866				< 3.3 PPM	39 PPM	72 PPM	< 0.1 PPM	0.22PPM	0.03PPM
R11867				< 4 PPM		63 PPM	< 0.1 PPM	0.30PPM	0.03PPM
R11830				56 PPM		240 PPM	0.33PPM	0.73PPM	1.40PPM
R11831				29 PPM		300 PPM	0.37PPM	1.1 PPM	0.44PPM
R11834	18 PPM			44 PPM		680 PPM	< 0.1 PPM	2.4 PPM	0.25PPM
R11840				36 PPM		36 PPM	< 0.08PPM	1.7 PPM	0.44PPM
R11846				54 PPM		28 PPM	0.21PPM	1.0 PPM	1.7 PPM
R11805	8.7 PPM	6.7 PPM		38 PPM		250 PPM	0.37PPM	0.49PPM	0.07PPM
R11810		4.5 PPM		< 1 PPM		30 PPM	0.2 PPM	0.10PPM	1.4 PPM
R11812	12 PPM			100 PPM		350 PPM	1.2 PPM	1.1 PPM	0.05PPM
R11813				26 PPM		160 PPM	0.42PPM	0.45PPM	0.03PPM
R11814	8.6 PPM			47 PPM		350 PPM	0.81PPM	1.7 PPM	0.05PPM
R11818	7.5 PPM			14 PPM		110 PPM	1.3 PPM	0.67PPM	0.06PPM
R11826				70 PPM		280 PPM	0.10PPM	1.3 PPM	1.1 PPM
R11857	21 PPM			43 PPM		610 PPM	2.3 PPM	2.3 PPM	0.68PPM
R11860	11 PPM			32 PPM		530 PPM	2.2 PPM	0.54PPM	0.14PPM
R11864				51 PPM		400 PPM	1.6 PPM	4.5 PPM	0.09PPM
R11836				40 PPM		130 PPM	< 0.1 PPM	< 0.1 PPM	1.1 PPM
R11839				11 PPM		170 PPM	0.26PPM	0.76PPM	0.30PPM
R11842				14 PPM		75 PPM	< 0.08PPM	0.50PPM	0.78PPM
R11844	19 PPM			54 PPM		500 PPM	2.1 PPM	2.2 PPM	2.2 PPM
R11806				28 PPM		200 PPM	0.37PPM	0.49PPM	0.05PPM
R11809				38 PPM	25 PPM	270 PPM	0.29PPM	0.76PPM	0.03PPM
R11821	17 PPM			20 PPM		370 PPM	1.3 PPM	2.2 PPM	0.63PPM
R11824				13 PPM		140 PPM	0.2 PPM	0.71PPM	0.60PPM
R11865				3.3 PPM		55 PPM	0.12PPM	3.7 PPM	0.04PPM
R11833				39 PPM		140 PPM	0.67PPM	0.42PPM	0.44PPM
R11835				11 PPM		210 PPM	0.27PPM	0.94PPM	0.27PPM
R11837				13 PPM		170 PPM	0.29PPM	0.46PPM	0.37PPM
R11838				20 PPM		230 PPM	0.19PPM	0.88PPM	0.49PPM
R11845	14 PPM			60 PPM		600 PPM	< 0.1 PPM	1.7 PPM	0.88PPM
R11847	15 PPM			69 PPM		440 PPM	2.0 PPM	1.4 PPM	0.24PPM
R11850	11 PPM			82 PPM		450 PPM	< 0.1 PPM	1.3 PPM	0.48PPM
R11851				4.5 PPM		110 PPM	0.17PPM	0.48PPM	1.0 PPM
R11808	< 2.7 PPM	7.8 PPM		18 PPM		97 PPM	0.28PPM	0.19PPM	0.02PPM
R11811	28 PPM	6.3 PPM		70 PPM		660 PPM	0.2 PPM	5.0 PPM	0.03PPM
R11815	6.6 PPM			68 PPM		140 PPM	0.55PPM	0.32PPM	0.04PPM
R11816				2.2 PPM		64 PPM	0.86PPM	0.36PPM	0.04PPM
R11819	8.8 PPM			51 PPM		250 PPM	0.2 PPM	1.0 PPM	0.02PPM
R11825				4 PPM		52 PPM	0.32PPM	0.26PPM	0.10PPM
R11829				10 PPM		190 PPM	0.19PPM	0.76PPM	0.32PPM
R11856	17 PPM			86 PPM		640 PPM	2.0 PPM	1.6 PPM	0.46PPM
R11863	18 PPM			30 PPM		610 PPM	2.5 PPM	1.6 PPM	0.20PPM

* ALL MISSING VALUES WERE BELOW THE LIMITS OF DETECTION. APPROXIMATE L/D-CR: 6.1 PPM;MO: 4.9 PPM;GE: 28 PPM;PB: 8.4 PPM

TABLE 3—concluded

LAB.NO.	LA	AG*	SC	SM	EU	SB
R11832	2.7 PPM		0.82PPM	0.33PPM	0.07PPM	1.0 PPM
R11841	1.7 PPM		0.37PPM	0.23PPM	0.05PPM	< 0.3 PPM
R11843	1.0 PPM		0.35PPM	0.10PPM	0.02PPM	0.59PPM
R11848	5.4 PPM		0.47PPM	0.59PPM	0.11PPM	1.4 PPM
R11849	2.6 PPM		0.4 PPM	0.28PPM	0.05PPM	0.28PPM
R11852	3.1 PPM		0.2 PPM	0.31PPM	0.06PPM	< 0.2 PPM
R11853	2.8 PPM		0.18PPM	0.28PPM	0.06PPM	< 0.1 PPM
R11854	3.1 PPM		0.19PPM	0.34PPM	0.06PPM	0.25PPM
R11807	2.4 PPM		1.24PPM	0.21PPM	0.04PPM	0.28PPM
R11817	1.6 PPM		0.44PPM	0.15PPM	0.03PPM	< 0.1 PPM
R11820	2.8 PPM		0.58PPM	0.37PPM	0.09PPM	0.25PPM
R11822	0.98PPM		0.23PPM	0.11PPM	0.02PPM	0.12PPM
R11823	0.42PPM		0.10PPM	0.04PPM	4 PPB	0.20PPM
R11827	2.3 PPM		0.3 PPM	0.22PPM	0.04PPM	0.12PPM
R11828	0.84PPM		0.19PPM	0.09PPM	0.02PPM	< 0.06PPM
R11855	1.8 PPM		0.24PPM	0.22PPM	0.04PPM	0.13PPM
R11858	3.7 PPM		0.87PPM	0.41PPM	0.08PPM	0.55PPM
R11859	1.1 PPM		0.47PPM	0.10PPM	0.01PPM	< 0.2 PPM
R11861	0.75PPM		0.2 PPM	0.09PPM	0.01PPM	0.22PPM
R11862	1.9 PPM		0.46PPM	0.18PPM	0.03PPM	< 0.2 PPM
R11866	0.72PPM		< 0.1 PPM	0.08PPM	0.01PPM	0.23PPM
R11867	2.2 PPM		0.26PPM	0.20PPM	0.04PPM	0.18PPM
R11830	13 PPM		0.96PPM	1.57PPM	0.29PPM	< 0.1 PPM
R11831	12 PPM		1.7 PPM	1.4 PPM	0.30PPM	< 0.1 PPM
R11834	13 PPM		4.5 PPM	1.3 PPM	0.28PPM	1.2 PPM
R11840	14 PPM		1.4 PPM	1.6 PPM	0.34PPM	1.9 PPM
R11846	7.6 PPM		0.76PPM	0.82PPM	0.18PPM	0.47PPM
R11805	12.7 PPM		2.1 PPM	1.7 PPM	0.35PPM	0.20PPM
R11810	7.7 PPM		0.91PPM	0.76PPM	0.16PPM	0.19PPM
R11812	13 PPM		3 PPM	1.3 PPM	0.27PPM	< 0.1 PPM
R11813	19 PPM		2.8 PPM	1.7 PPM	0.38PPM	0.53PPM
R11814	8.4 PPM		3.0 PPM	1.3 PPM	0.25PPM	0.14PPM
R11818	3.3 PPM		0.2 PPM	0.38PPM	0.07PPM	0.25PPM
R11826	22 PPM		1.9 PPM	2.1 PPM	0.49PPM	0.17PPM
R11857	11 PPM		2.7 PPM	1.4 PPM	0.30PPM	< 0.1 PPM
R11860	8.2 PPM		1.5 PPM	0.99PPM	0.20PPM	< 0.2 PPM
R11864	13 PPM		< 0.2 PPM	1.6 PPM	0.31PPM	0.37PPM
R11836	14 PPM		1.4 PPM	1.3 PPM	0.27PPM	< 0.2 PPM
R11839	17 PPM		1.5 PPM	1.7 PPM	0.35PPM	1.1 PPM
R11842	9.5 PPM		1.3 PPM	1.0 PPM	0.22PPM	1.1 PPM
R11844	10 PPM		1.6 PPM	1.3 PPM	0.25PPM	0.41PPM
R11806	11 PPM		1.6 PPM	1.1 PPM	0.26PPM	0.15PPM
R11809	8.6 PPM		1.7 PPM	0.9 PPM	0.20PPM	0.25PPM
R11821	9.9 PPM		3.1 PPM	1.2 PPM	0.24PPM	0.38PPM
R11824	7.9 PPM		1.5 PPM	1.1 PPM	0.22PPM	< 0.2 PPM
R11865	15 PPM		1.1 PPM	1.5 PPM	0.33PPM	< 0.1 PPM
R11833	9.1 PPM		0.44PPM	1.0 PPM	0.24PPM	< 0.2 PPM
R11835	8.1 PPM		1.1 PPM	0.80PPM	0.17PPM	0.32PPM
R11837	22 PPM		1.6 PPM	2.0 PPM	0.42PPM	1.1 PPM
R11838	9.8 PPM		1.3 PPM	1.1 PPM	0.21PPM	< 0.3 PPM
R11845	17 PPM		2.7 PPM	1.6 PPM	0.38PPM	< 0.1 PPM
R11847	14 PPM		2.0 PPM	1.6 PPM	0.30PPM	< 0.1 PPM
R11850	11 PPM		0.46PPM	1.3 PPM	0.26PPM	0.41PPM
R11851	8.2 PPM		0.98PPM	0.70PPM	0.14PPM	0.34PPM
R11808	15 PPM		1.7 PPM	1.8 PPM	0.35PPM	0.24PPM
R11811	13 PPM		8.6 PPM	1.7 PPM	0.38PPM	1.2 PPM
R11815	11 PPM		1.5 PPM	1.1 PPM	0.25PPM	0.19PPM
R11816	6.2 PPM		0.63PPM	0.67PPM	0.14PPM	0.11PPM
R11819	10.9 PPM		2.4 PPM	1.1 PPM	0.25PPM	0.21PPM
R11825	11 PPM		1.2 PPM	1.3 PPM	0.26PPM	0.12PPM
R11829	10 PPM		1.1 PPM	1.0 PPM	0.22PPM	0.10PPM
R11856	13 PPM		3.8 PPM	1.4 PPM	0.29PPM	< 0.2 PPM
R11863	11 PPM		1.5 PPM	1.3 PPM	0.29PPM	< 0.2 PPM

* ALL MISSING VALUES WERE BELOW THE LIMITS OF DETECTION. APPROXIMATE L/D- AG: 1 PPM.

TABLE 4 - DATA FOR 19 VERTICAL SAMPLES FROM 5 CORES

STATE	COUNTY	QUARTER	SEC	TWP.	RNG.	DEPTH (ft)	GROUP	LAB.NO.	CORE INDEX NO.	SAMPLE NO.	Al_2O_3 (%)	Br (ppm)	CaO (%)	Fe_2O_3 (%)	K_2O (%)
IL	CLINTON	SW-NE-NW-	29	1N	3W	2478	IV	R12708	C 2758	C1	1.05	3.4	29.76	0.53	0.36
IL	CLINTON	SW-NE-NW-	29	1N	3W	2503		R12709	C 2758	C1	0.42	2.1	44.36	0.13	0.08
IL	CLINTON	SW-NE-NW-	29	1N	3W	2527		R12710	C 2758	C1	1.92	3.1	41.25	0.28	0.21
IL	CLINTON	SW-NE-NW-	29	1N	3W	2548		R12711	C 2758	C1	0.88	2.7	39.07	0.34	0.37
IL	CLINTON	NW-NW-SE-	1	1N	4W	2384	II	R12712	C 2957	C2	0.97	8.1	13.37	0.62	0.28
IL	CLINTON	NW-NW-SE-	1	1N	4W	2402		R12713	C 2957	C2	1.00	1.2	46.57	0.18	0.11
IL	CLINTON	NW-NW-SE-	1	1N	4W	2423		R12714	C 2957	C2	0.96	3.9	31.00	0.42	0.45
IL	CLINTON	SW-NW-NE-	1	1N	4W	2323	I	R12715	C 3365	C3	0.58	2.6	34.22	0.74	0.21
IL	CLINTON	SW-NW-NE-	1	1N	4W	2337		R12716	C 3365	C3	0.69	1.4	50.45	0.18	0.05
IL	CLINTON	SW-NW-NE-	1	1N	4W	2362		R12717	C 3365	C3	<0.01	1.0	46.76	0.16	0.13
IL	CLINTON	SW-NW-NE-	1	1N	4W	2381		R12718	C 3365	C3	0.08	2.1	51.66	0.02	0.01
IL	CLINTON	NE-NW-SE-	34	2N	4W	2437	III	R12719	C 3367	C4	1.39	7.2	35.94	0.58	0.19
IL	CLINTON	NE-NW-SE-	34	2N	4W	2459		R12720	C 3367	C4	0.93	15.6	12.93	0.84	0.39
IL	CLINTON	NE-NW-SE-	34	2N	4W	2482		R12721	C 3367	C4	3.76	8.5	23.84	1.35	1.00
IL	CLINTON	NE-NW-SE-	34	2N	4W	2505		R12722	C 3367	C4	3.00	5.8	38.32	0.82	0.61
IL	CLINTON	SE-NW-NW-	3	1S	5W	2164	I	R12723	C 3961	C5	0.16	1.5	45.10	0.18	0.12
IL	CLINTON	SE-NW-NW-	3	1S	5W	2186		R12724	C 3961	C5	0.27	3.0	49.13	0.04	0.06
IL	CLINTON	SE-NW-NW-	3	1S	5W	2207		R12725	C 3961	C5	0.96	2.5	45.91	0.02	0.05
IL	CLINTON	SE-NW-NW-	3	1S	5W	2229		R12726	C 3961	C5	<0.01	1.5	47.23	0.23	0.05

LAB.NO	SiO_2 (%)	TiO_2 (%)	MgO (%)	MnO (ppm)	Na_2O (%)	As (ppm)	Ga (ppm)	La (ppm)	Sc (ppm)	Sm (ppm)	Eu (ppm)
R12708	29.08	0.11	6.48	250	0.15	1.1	1.9	12	3.2	1.3	0.25
R12709	11.76	0.02	1.81	216	0.13	<0.5	<1	9	<1	0.7	0.12
R12710	14.00	0.06	4.18	112	0.14	1.2	1.5	16	<1	1.9	0.35
R12711	14.97	0.08	6.30	110	0.20	1.2	1.8	14	<1	1.4	0.29
R12712	67.53	0.08	6.34	236	0.46	<0.5	1.5	8	1.2	1.7	0.18
R12713	6.32	0.02	2.64	255	0.05	<0.5	<1	11	1.2	0.8	0.19
R12714	28.16	0.09	8.43	100	0.18	0.7	1.5	14	1.7	1.5	0.28
R12715	5.90	0.05	13.51	285	0.10	1.7	0.6	11	0.7	1.1	0.23
R12716	0.82	0.01	2.26	248	0.03	2.0	0.1	2.2	<1	0.3	0.05
R12717	2.05	0.02	5.77	191	0.04	0.3	0.3	3	<1	0.4	0.07
R12718	1.57	0.01	1.46	170	0.04	<0.5	<0.5	0.7	<1	0.08	0.09
R12719	10.64	0.06	11.35	230	0.19	0.5	<1	13	<1	1.6	0.31
R12720	63.82	0.12	6.37	100	0.42	<0.5	1.4	7	<1	0.9	0.17
R12721	32.81	0.20	10.42	210	0.42	0.8	3.6	12	1.7	1.6	0.33
R12722	19.98	0.12	3.37	280	0.20	<0.5	<1	10	2.0	1.2	0.25
R12723	0.79	0.01	7.46	168	0.03	<0.5	0.3	2.6	<1	0.3	0.06
R12724	0.39	0.01	4.63	294	0.03	0.2	0.2	2.8	<1	0.3	0.07
R12725	0.07	0.01	7.12	254	0.04	<0.5	0.2	1.5	<0.5	0.2	0.03
R12726	0.12	0.01	6.35	236	0.03	<0.5	0.2	1.4	<0.5	0.2	0.03

TABLE 5 - MEAN VALUES OF SILURIAN ROCK SAMPLES

Element	Group I (22)	Group II (15)	Group III (9)	Group IV (17)
Al (%)	0.73	1.49	2.89	1.72
Br	1.25	4.48	3.36	2.11
Ca (%)	48.7	33.6	36.8	41.59
Fe (%)	0.38	0.76	1.89	0.71
P (%)	0.021	0.023	0.030	0.033
K (%)	0.073	0.44	0.30	0.34
Si (%)	5.84	17.02	19.55	12.31
Ti (%)	0.019	0.083	0.12	0.056
V	14.1	29.7	20.4	23.2
Mg (%)	3.00	9.60	4.49	5.11
Mn	186	374	360	404
Na (%)	0.26	0.22	0.25	0.30
S (%)	0.12	0.095	0.076	0.092
As	1.09	0.78	0.55	0.61
Ga	0.34	1.37	1.28	1.26
La	2.12	12.12	11.82	12.33
Sc	0.39	1.87	1.67	1.93
Sm	0.22	1.37	1.28	1.31
Eu	0.04	0.28	0.26	0.27
Sb	0.32	0.40	0.43	0.31
Hg	0.21	0.53	0.64	0.32

La, Sc, and Hg. Table 6 gives correlations observed between all the samples. Several elements have a very high degree of correlation, especially the rare earth elements which have similar geochemical properties.

A Parks cluster analysis program (Parks, 1966), based in part upon correlation coefficients, was then computed to attempt to separate the samples into similar populations. Clusters were computed using several combinations of elements. The cluster using Ga, Br, As, La, K, and Sm is shown in figure 15. Ideally, the cluster analyses should indicate four distinct clusters or groups, corresponding to Groups I, II, III, and IV, although not necessarily in that order. Failing this, the three or fewer groups should show subgroupings corresponding more or less to the several groups. In our cluster analysis, although samples 1 to 22 (reef) were successfully grouped into one cluster along with sample 33, which conceivably might be an unknown reef sample, the other three groups are randomly scattered through the large singular remaining cluster. This program was able to segregate reef from nonreef material but could not separate Groups II, III, and IV distinctly. Because it is highly possible that other factors such as percentages of clay, organic carbon, and carbonate carbon might be helpful in this matter, these factors will be included in future studies.

The data were subjected to discriminant analysis, and coefficients and centroids were obtained. Discriminant analysis (Bryan, 1951) is a statistical grouping technique which sets a predetermined number of groups (B_n) in which the coefficients ($a_1, a_2, \ldots a_n$) are adjusted to maximize the mathematical difference between $B_a, B_b, \ldots$ *etc.* according to the equations:

$$a_1 b_{1_a} + a_2 b_{2_a} + a_3 b_{3_a} + - - - a_n b_{n_a} = B_a$$

$$a_1 b_{1_b} + a_2 b_{2_b} + a_3 b_{3_b} + - - - a_n b_{n_b} = B_b$$

The terms $b_{1_a}, b_{2_a}, \ldots$ are elemental concentrations of selected elements. In this statistical treatment individual samples were then withdrawn from the main block of data, and an attempt was made to classify them according to the original discriminant. For Br, K, Ga, Hg, La, and Sm, the results are shown in table 7. This attempt, while far from perfect, succeeded in correctly classifying all of the reef samples (Group I), with all but one indicating a probability of 99+ percent. Ten of the 15 samples from Group II were classified correctly, three incorrectly, and two ambiguously. The ambiguity, however, arose out of confusion with the Group III classification, which might be more nearly the correct classification in those cases. Group III, a set of only nine samples statistically rather insignificant, contained only three correctly classified members. Four classified as Group IV, and two as ambiguities. Group IV (17 samples) contained 15 correct and two ambiguous samples. Many that were correctly classified showed high degrees of probability (75 percent or above) but not as high as for the reef samples.

The preliminary investigation of vertical distribution of trace elements within several cores (see table 4) added little information other than to indicate some potential problems. The reef and nonreef cores can

TABLE 6 - CORRELATIONS FOR 21 ELEMENTS

	AL	BR	CA	FE	P	K	SI	TI	V
BR	0.51296	1.00000							
CA	-0.41557	-0.74049	1.00000						
FE	0.78501	0.60497	-0.45103	1.00000					
P	0.28380	0.14562	-0.03144	0.35453	1.00000				
K	0.40612	0.43849	-0.61771	0.28813	-0.09570	1.00000			
SI	0.30303	0.4513SI	-0.85352	0.30456	-0.00421	0.37332	1.00000		
TI	0.79816	0.68869	-0.55239	0.88834	0.29309	0.49118	0.34106	1.00000	
V	0.25318	0.37755	-0.52565	0.15481	-0.08482	0.81067	0.31778	0.40306	1.00000
MG	0.09653	0.60965	-0.61177	0.09528	-0.04981	0.55354	0.15244	0.26890	0.50898
MN	0.64652	0.25738	-0.37298	0.47118	0.02685	0.61054	0.22114	0.52703	0.37619
NA	0.15287	0.08015	-0.09222	-0.00596	-0.17733	0.38739	0.00720	0.07326	0.25881
S	-0.01035	0.02134	-0.04649	0.23942	0.15243	0.05054	-0.00125	-0.00259	0.01218
SN	-0.49324	-0.51018	0.68175	-0.53412	-0.13981	0.03865	-0.86095	-0.49216	0.18092
CU	-0.10209	-0.05896	0.11524	0.58967	-0.14171	0.11483	-0.09937	-0.01907	0.16680
CO	-0.22166	-0.41616	0.40734	0.06726	-0.18349	-0.26006	-0.39625	-0.38408	-0.32979
NI	0.27468	-0.08819	-0.21094	0.76261	0.00992	0.36631	0.30667	0.26437	0.37450
BE	-0.36322	-0.07291	0.53827	-0.39744	0.03710	-0.74063	-0.50475	-0.82040	-0.55362
CR	0.52333	-0.19864	-0.01476	0.69407	-0.33146	0.83200	0.14873	0.44054	0.58006
MO	-0.10100	-0.01003	0.09155	0.20915	0.65757	-0.14297	-0.16213	-0.18454	-0.01320
ZR	0.04336	0.18820	-0.25546	0.00305	-0.01186	0.55562	0.00645	0.15773	0.35452
PB	- TOO FEW VALUES FOR STATISTICAL VALIDITY								
ZN	0.37242	0.27620	-0.44886	0.11396	-0.19123	0.89449	0.26862	0.33109	0.73258
AS	0.06094	0.01256	-0.13437	0.10043	-0.08331	0.25344	0.07329	0.02247	0.24679
GA	0.21739	0.34233	-0.41132	0.12556	-0.11248	0.71589	0.25810	0.29503	0.53684
HG	0.06390	0.17370	-0.29976	0.06843	-0.04882	0.22185	0.29441	0.08698	0.13665
LA	0.12012	0.28723	-0.32740	0.09140	0.02208	0.45706	0.12039	0.14506	0.32525
SC	0.22467	0.17262	-0.42680	0.17213	-0.14046	0.74237	0.32355	0.36570	0.57642
SM	0.19453	0.36909	-0.43240	0.17137	0.09227	0.56219	0.18283	0.25873	0.42412
EU	0.19321	0.34703	-0.40878	0.15537	0.08749	0.55404	0.16142	0.24024	0.40236
SB	0.46421	0.04237	-0.15723	0.43610	0.07974	0.34163	0.09958	0.13057	0.38523

	MG	MN	NA	S	SN	CU	CO	NI	BE
MG	1.00000								
MN	0.23039	1.00000							
NA	0.14796	0.10689	1.00000						
S	0.03358	-0.01920	0.15176	1.00000					
SN	0.12736	-0.13661	0.31113	-0.10076	1.00000				
CU	-0.15940	-0.11344	0.24018	0.88598	-0.26950	1.00000			
CO	-0.15340	-0.05822	0.17296	-0.28619	0.90057	-0.85605	1.00000		
NI	-0.10674	0.31917	-0.14427	0.77951	0.0	0.90762	-0.96641	1.00000	
BE	-0.23496	-0.37990	-0.32045	0.40510	-0.58270	0.69019	1.00000	0.98686	1.00000
CR	-0.38660	0.52817	0.34858	-0.01763	0.92480	0.11698	0.04620	0.40873	-0.22047
MO	-0.03803	-0.22039	0.59404	0.68887	0.0	0.0	0.62374	-1.00000	0.0
ZR	0.46703	0.20216	0.29073	0.09083	0.31332	-0.01412	-0.37872	0.52343	-0.52178
PB	- TOO FEW VALUES FOR STATISTICAL VALIDITY								
ZN	0.39071	0.53117	0.50833	-0.05538	0.26087	-0.13591	-0.11654	0.05095	-0.80586
AS	0.13009	0.09613	0.28253	0.49123	-0.10944	0.81484	-0.06646	0.73211	0.20506
GA	0.36051	0.46640	0.34505	0.02436	0.13358	0.04023	-0.21436	0.39803	-0.21637
HG	0.15737	0.12218	0.00881	-0.06461	0.12977	-0.20505	0.11930	0.06574	-0.16696
LA	0.43354	0.36304	0.09037	-0.03134	0.25191	-0.20142	-0.14354	0.44977	-0.44855
SC	0.29212	0.51780	0.17587	-0.09534	0.32628	0.00350	-0.14735	0.23042	-0.58652
SM	0.52371	0.39455	0.11622	-0.00540	0.18145	-0.16670	-0.10310	0.45807	-0.49867
EU	0.51233	0.42721	0.10506	-0.02234	0.21628	-0.18723	-0.13500	0.42836	-0.53000
SB	0.09559	0.39046	0.03085	0.11043	0.25116	0.60499	-0.18724	0.86852	-0.13583

	CR	MO	ZR	PB	ZN	AS	GA	HG
CR	1.00000							
MO	-1.00000	1.00000						
ZR	0.22645	-0.94813	1.00000					
PB	- TOO FEW VALUES FOR STATISTICAL VALIDITY							
ZN	0.75126	-0.85091	0.55766		1.00000			
AS	-0.00354	0.72158	0.04594		0.07764	1.00000		
GA	0.86687	-0.17084	0.46299		0.60202	0.11057	1.00000	
HG	0.35983	-0.82521	0.17333		0.09578	-0.04200	0.06129	1.00000
LA	0.48847	-0.15992	0.46118		0.44108	-0.07149	0.45851	0.20294
SC	0.69757	-0.11752	0.45154		0.68888	-0.02924	0.74549	-0.02482
SM	0.54597	-0.09746	0.51885		0.52563	-0.03866	0.53681	0.18902
EU	0.54622	-0.15585	0.51079		0.51844	-0.05622	0.52752	0.18377
SB	0.69157	-0.10272	-0.00952		0.15488	0.42397	0.36237	0.00544

	LA	SC	SM	EU	SB
LA	1.00000				
SC	0.54417	1.00000			
SM	0.96761	0.61027	1.00000		
EU	0.97842	0.61772	0.99260	1.00000	
SB	0.32558	0.33799	0.30807	0.31482	1.00000

clearly be separated (probably due to variations in clay and carbonate); however, the range of elemental concentrations varies much more for the nonreef cores than for the reef cores, as might be expected. These data point out the need for further extensive investigations of the area and the importance of carefully choosing samples for analysis and testing.

This empirical method of classification looks promising for additional study, but several modifications of it should be explored. Other factors such as percentages of clay and carbonate, along with analysis of acid-extracted portions must be considered. A statistically larger set of samples is necessary to enable the discriminant to be more selective. The geographic interval should be adjusted or reevaluated, or the number of intervals reduced by combining Groups II and III. Finally, other elements not analyzed in this study should be characterized.

CONCLUSION

Reef and nonreef material can thus be differentiated on the basis of trace element data. This method can be used to supplement conventional paleontologic and geologic identification of reef structures

The capacity of the technique to predict the location of a particular sample in relation to a known or unknown reef is less certain. Discriminant function analysis shows great promise even considering the relatively small number of samples studied. The analysis of more samples would greatly increase the reliability of any predictions made of the location of unknown reefs. Further studies will also include additional statistical techniques.

Although the relationship between Silurian reefs and petroleum accumulation cannot always be assumed, numerous petroleum deposits have been associated with reef structure acting as either a source or reservoir rock. Because the trace element distribution patterns observed in the oils may give an indication of their source, the analysis of oils associated with reef and nonreef structures for trace elements is an area demanding further investigation.

Why particular elemental associations seem to have the ability to differentiate reef and nonreef material is a difficult question. Trace elements have often been investigated as indicators of ore deposits and past geological conditions. Although many studies have been made on the geochemistry of trace elements (Boyle, 1974), very little is known about them. Numerous factors may account for the ability of several trace elements to serve as indicators of reef structures. Among them are: concentration by biological processes, adsorption of ions in clay or pore structures, properties and composition of the ground water, weathering processes, depositional patterns and composition of the overlying strata, and others. Speculation on the geochemistry of an individual element or group of elements is at best difficult and was not the primary goal of this initial study. Future efforts will include an attempt to resolve some of these fundamental questions through gathering and statistically evaluating considerable analytical data.

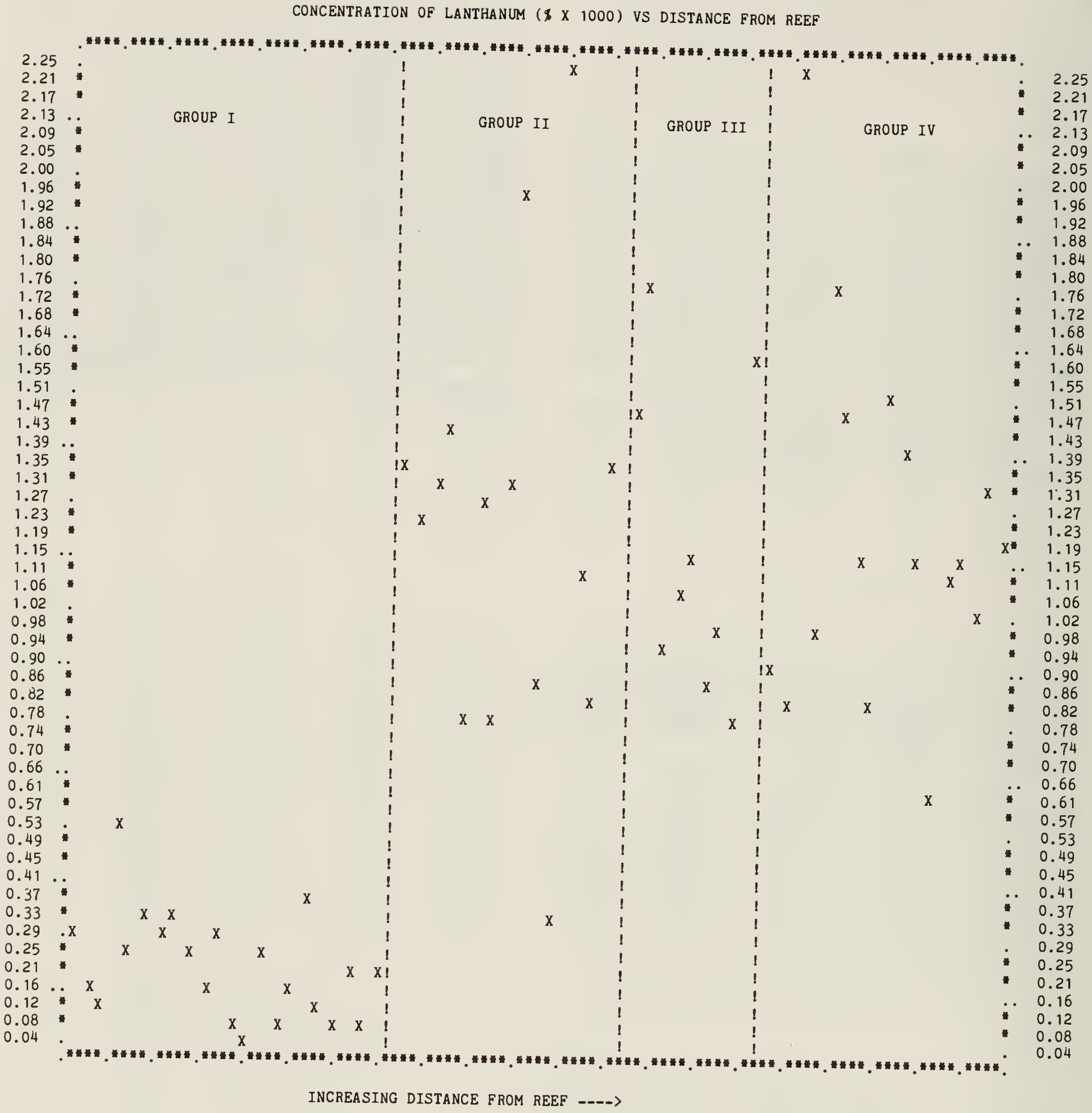


Fig. 14 - Scatter plots of Silurian rock samples. (A) Lanthanum. (B) Manganese.

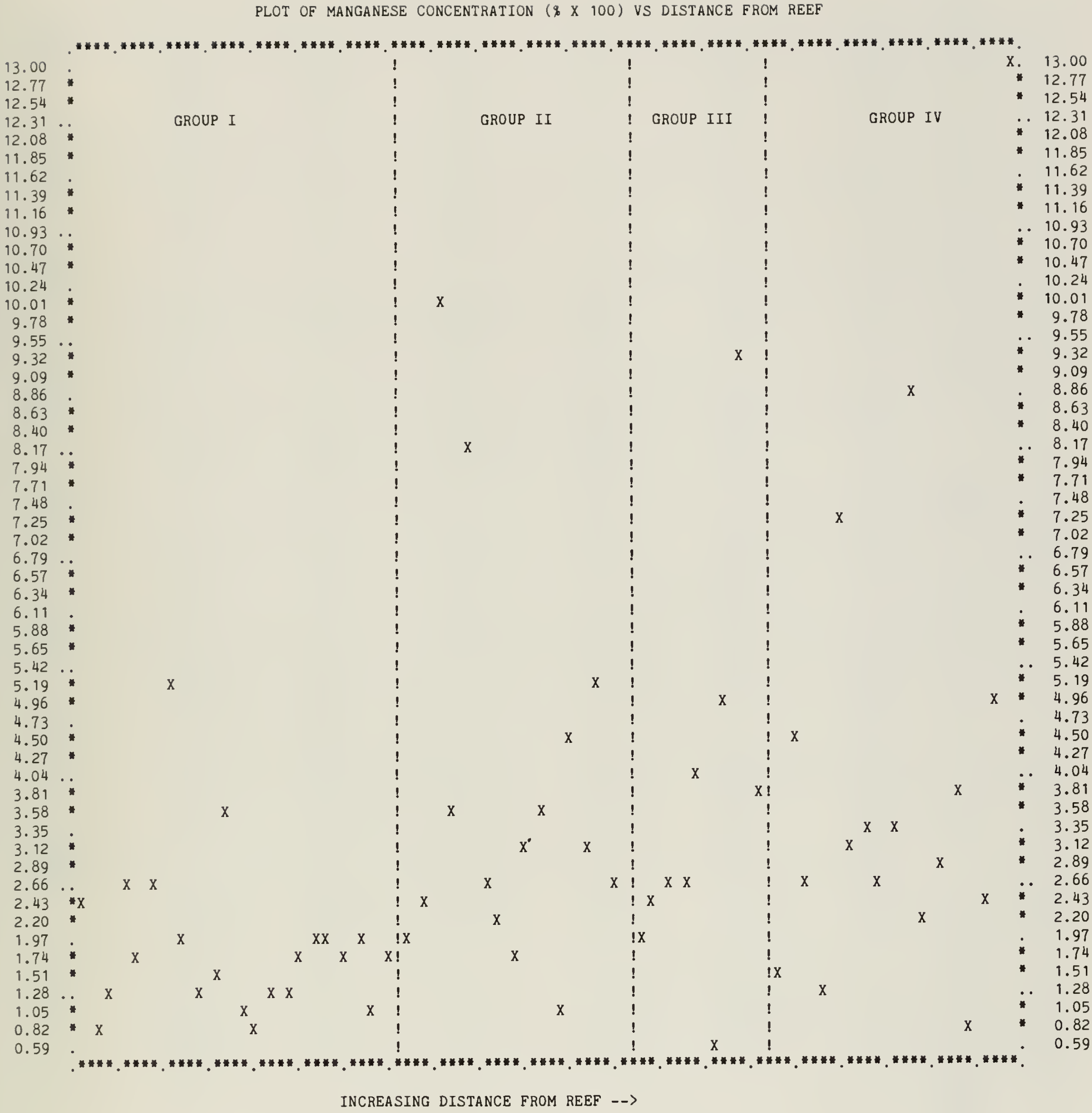

PLOT OF MANGANESE CONCENTRATION (% X 100) VS DISTANCE FROM REEF
GROUP I
GROUP II
GROUP III
GROUP IV
13.00
12.77
12.54
12.31
12.08
11.85
11.62
11.39
11.16
10.93
10.70
10.47
10.24
10.01
9.78
9.55
9.32
9.09
8.86
8.63
8.40
8.17
7.94
7.71
7.48
7.25
7.02
6.79
6.57
6.34
6.11
5.88
5.65
5.42
5.19
4.96
4.73
4.50
4.27
4.04
3.81
3.58
3.35
3.12
2.89
2.66
2.43
2.20
1.97
1.74
1.51
1.28
1.05
0.82
0.59
INCREASING DISTANCE FROM REEF -->

Fig. 14B

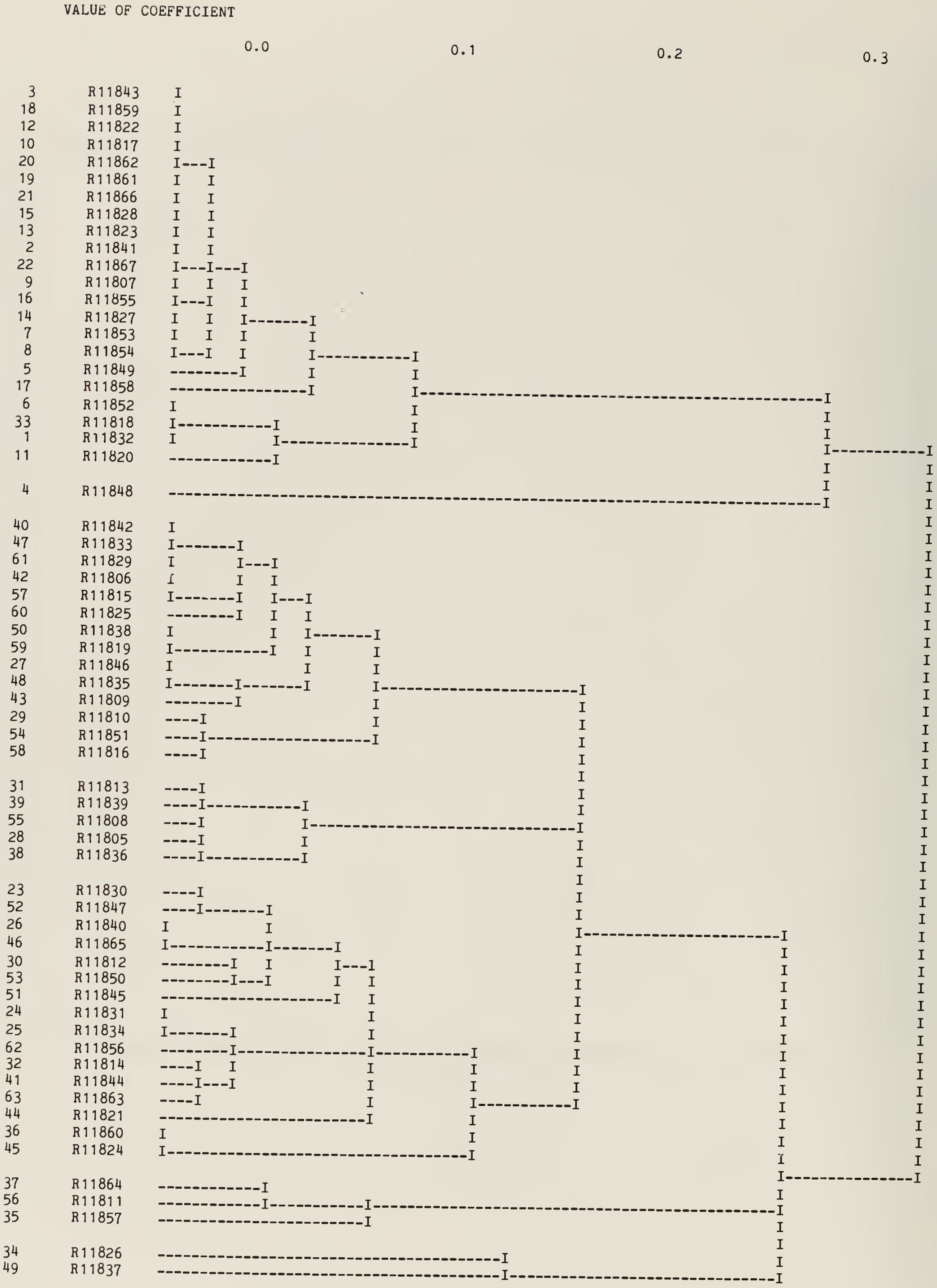


Fig. 15 - Cluster analysis of 63 samples using Br, K, As, Ga, La, and Sm.

TABLE 7 - DISCRIMINANT ANALYSIS USING BR, K, Ga, Hg, La, Sm FOR 63 SILURIAN ROCK SAMPLES

SUBJECT	1	10	19	28	37	46	55
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.99164	0.99906	0.99932	0.00000	0.00000	0.00000	0.00000
2	0.00249	0.00029	0.00028	0.14226	0.56469	0.18170	0.16336
3	0.00000	0.00000	0.00000	0.00400	0.43531	0.81768	0.00584
4	0.00586	0.00065	0.00041	0.85374	0.00000	0.00062	0.83081
SUBJECT	2	11	20	29	38	47	56
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.99845	0.91746	0.99882	0.00000	0.00000	0.00000	0.00000
2	0.00048	0.03176	0.00036	0.67036	0.25212	0.09850	0.18764
3	0.00000	0.00010	0.00000	0.13399	0.46387	0.12839	0.00760
4	0.00107	0.05068	0.00083	0.19566	0.28401	0.77312	0.80476
SUBJECT	3	12	21	30	39	48	57
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.99879	0.99825	0.99890	0.00000	0.00000	0.00099	0.00000
2	0.00034	0.00037	0.00038	0.09180	0.19865	0.09461	0.09503
3	0.00000	0.00000	0.00000	0.07084	0.07440	0.02239	0.09327
4	0.00087	0.00137	0.00072	0.83736	0.72695	0.88200	0.81170
SUBJECT	4	13	22	31	40	49	58
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.63479	0.99919	0.99838	0.00000	0.00000	0.00000	0.01067
2	0.09562	0.00035	0.00049	0.48921	0.36347	0.49760	0.14704
3	0.00336	0.00000	0.00000	0.28949	0.38146	0.01243	0.01132
4	0.26623	0.00046	0.00113	0.22130	0.25508	0.48997	0.83097
SUBJECT	5	14	23	32	41	50	59
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.99624	0.90837	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00066	0.01487	0.77889	0.77406	0.51749	0.36855	0.09186
3	0.00000	0.00000	0.22111	0.21269	0.48128	0.44281	0.09011
4	0.00309	0.07676	0.00000	0.01325	0.00123	0.18864	0.81804
SUBJECT	6	15	24	33	42	51	60
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.33153	0.99924	0.00000	0.10562	0.00000	0.00000	0.00000
2	0.65372	0.00028	0.78836	0.65158	0.12356	0.34200	0.08855
3	0.00136	0.00000	0.21149	0.00190	0.13219	0.08969	0.09352
4	0.01338	0.00048	0.00015	0.24090	0.74424	0.56832	0.81793
SUBJECT	7	16	25	34	43	52	61
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.99773	0.99405	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00061	0.00096	0.25306	0.99788	0.28945	0.16814	0.08543
3	0.00000	0.00000	0.07588	0.00027	0.14166	0.00869	0.08622
4	0.00166	0.00500	0.67106	0.00185	0.56888	0.82317	0.82835
SUBJECT	8	17	26	35	44	53	62
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.98342	0.98426	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00230	0.00402	0.62580	0.81051	0.20720	0.23847	0.42481
3	0.00000	0.00001	0.29909	0.06142	0.30794	0.10861	0.06488
4	0.01428	0.01171	0.07511	0.12808	0.48487	0.65293	0.51030
SUBJECT	9	18	27	36	45	54	63
GROUP	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY	PROBABILITY
1	0.99899	0.99684	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00049	0.00120	0.63574	0.88650	0.12291	0.20013	0.19430
3	0.00000	0.00000	0.24712	0.11134	0.87709	0.02607	0.05680
4	0.00053	0.00196	0.11715	0.00216	0.00000	0.77380	0.74890

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