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WTWI INTERIM REPORT: COMPLETION OF ANALYSES, WOLFCAMP GEOCHEMISTRY

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BY:

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Evaporite strata in Permian rocks of the Palo Duro Basin, Texas, are the focus of nuclear waste isolation feasibility studies by the Bureau of Economic Geology, The University of Texas at Austin. One phase of the study is to determine the extent, if any, to which fluids have migrated through the evaporite aquitard, the target horizon of potential nuclear waste storage. Part of the study of possible fluid leakage is a study of fluid/rock equilibrium in the Wolfcamp aquifer, the first significant brine aquifer below the aquitard.

This report presents the isotopic and trace element data from lime mudstones, dolomite mudstones, and anhydrite which were gathered for part of the examination of fluid/rock equilibrium. The report includes trace element data for each of the three major lithotypes examined, carbon and oxygen isotope data for dolomite and limestone, sulfur isotope information for bedded anhydrite, anhydrite nodules, and anhydrite cements, and strontium isotope information for anhydrite beds and nodules, dolomite, and limestone. Microprobe data from a single thin section are reported. Additionally, homogenization temperatures and freezing point determinations from a single sample of sphalerite are reported.

Microprobe examination of several sections proved to be of low utility due to low concentrations of elements of interest, and these data are not reported. Oxygen isotopic examinations of quartz and anhydrite were not completed due to time constraints and to instrument difficulties.

All of the analyses are included without evaluation or interpretation in this report. Accounts of the validity, accuracy, and precision of the analyses are included. Vendor lab procedures are also reported.

CONTENTS

PART I

TRACE ELEMENT AND MAJOR ELEMENT ANALYSES FROM:

ANALYSES AND REPORT PREPARED BY

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INTRODUCTION

The purpose of this study was to determine the trace element composition of carbonate and sulfate minerals of the Upper Wolfcamp and Lower Wichita Formations. These compositions could be used for thermodynamic calculations of equilibrium state, and for the determination of depositional and diagenetic fluid compositions.

During this study the standard procedure for treating carbonate rocks prior to trace element analyses was changed. Most of the trace element analyses reported by Posey et al., 1985 (OF-WTWI-1985-5) were prepared from carbonate and anhydrite samples which were dissolved in 0.36N and 1N HCl, respectively. However, because this method so severely attacked clay minerals, thus contributing very high concentrations of minor elements to carbonate or anhydrite solutions, it was found that the clays had to either be removed from the carbonate/anhydrite matrix, or treated so that clays would not be dissolved or exchangeable cations displaced.

The present method of pre-leaching the carbonate and anhydrite samples with 1.0N ammonium acetate prior to digestion with hydrochloric acid seems to be suitable for

removing some of the loosely bound elements in clays--for instance Sr, Ca and Mg, but not other elements. Also, it is possible that Br is selectively leached from anhydrite during this process.

Future research on trace element characteristics of carbonate minerals and anhydrite will employ either improved microprobe techniques, or whole rock digestion techniques coupled with refined statistical treatments. Selective mineral digestion techniques will also be tested further.

The following data report, written by Steven W. Tweedy and David W. Koppenaal, Bureau of Economic Geology, Mineral Studies Laboratory, detail this trace element geochemical study.

EVALUATION

This report and the attached analyses and reports constitute the final report and compilation of data on the Mineral Studies Laboratory analyses of 118 samples for the Wolfcamp Geochemistry project. The sample processing and analysis schemes are given in the first several pages of the report.

Tables 1 through 3 provide concentration data on the constituents of interest in the soluble extracts of the project anhydrites, dolomites, and limestones, respectively. Sulfate data on the anhydrite extracts were considered unimportant and therefore are not reported.

Tables 4 through 6 provide extract concentration data for duplicate samples of anhydrite, dolomite, and limestone, respectively.

Table 7 provides extract concentration data and statistics for the control samples developed during the early stages of this project. The designations CS-1, CS-2, and CS-3 represent composite limestone, anhydrite, and dolomite control samples (cf. reports dated 12/19/84 and 1/16/85). These three samples were processed and analyzed six times during

the course of the project, and provide an estimate of the processing/analysis variability associated with this effort.

Table 8 provides information on the ICP solution standards and instrument conditions used in the determination of element concentrations by this technique.

Table 9 presents ICP data on an EPA reference water sample and the certified concentrations given by EPA. Except for Na all found values are within 25% of the certified values. Na, however, is 100% higher than the certified value. The sodium data are disconcerting and therefore these data should be viewed with some caution in the other tables.

Tables 10-12 provide statistical information on replicate determinations of constituents from the same sample extract, and as such can be interpreted as an estimate of the analytical precision associated with the analyses. Three dolomite sample solutions were used for this purpose.

Table 13 compares extract concentration data from several samples with and without prior ammonium acetate extraction. While it appears that the pre-extraction with NH4OAc removes certain constituents, this conclusion must be considered carefully in terms of the manner in which the data are expressed, the amount of sample dissolved, and the pretreatment.

Finally, Table 14 presents data on the element concentrations found in selected NH4OAc extract solutions. The data indicate that Ca, Mg, and Sr are always removed with this treatment while Si, Na, K, Al, Ti and other trace elements are sometimes removed.

The information provided in this report is the result of a group effort: Cynthia Mahan, Judy Mazoh, and Jean Ray were of considerable assistance.

Data recorded on the following tables are listed with two prefixes: MSL ID # and SPL ID #. MSL ID # is a sequential code assigned to each sample by the Mineral Studies Laboratory as it is received in the lab. The number 85-175 signifies the 175th sample received in 1985, regardless of sample type. This number is traced throughout all analytical processes. SPL ID # is the researcher-assigned code which tells the well name and depth to the nearest 0.1 foot. The prefixes D, F, M, and Z refer to Donley County #1 Sawyer, Deaf Smith County #1 J. Friemel, Oldham County #1 Mansfield, and Swisher County #1 Zeeck wells, respectively.

SAMPLE PROCESSING--WOLFCAMP TRACE ELEMENT STUDY--APRIL 1985

(modified procedure from H. Posey memo, February 6, 1985)

I. Divide samples into groups according to the minerals present: (chert, anhydrite, or carbonate).

II. Process for CHERT:

1. Place coarse sample in a beaker and add enough concentrated hydrochloric acid to cover the entire sample and swirl (in a fume hood°).
2. Decant, and rinse thoroughly with water.
3. Transfer to a #20 sieve and rinse with tap water to eliminate grit.
4. Rinse with distilled-deionized (DD) water and dry at 105 degrees C.
5. Shatterbox with tungsten carbide container (WC).
6. Wash three times with DD-water.

III. Process for ANHYDRITE:

1. Shatterbox with WC container.
2. Blend and split with riffle splitter to obtain archive sample (store).
3. Transfer analysis sample to a large plastic beaker.
4. Add ~200 ml. of 1.0N hydrochloric acid and disperse.
5. Let react until bubbling stops (to dissolve any carbonates present).
6. Decant, and rinse thoroughly with DD-water.
7. Separate via filtration and save the solid (anhydrite).
8. Dry at 105 degrees C in a drying oven.
9. Run an XRD scan (at least 20 to 35 degrees "two theta").
10. Retain the sample for ICP and sulfur isotope analyses.

IV. Process for CARBONATES:

1. Coarse crush to -10 mesh with disc grinder or mortar and pestle.
2. Blend and split with riffle splitter to obtain archive sample (store).
3. Transfer analysis sample to a large plastic beaker.

4. Wash sample by dispersing into ~200 ml. DD-water; decant; repeat 2X.
5. Dry sample in drying oven at 105 degrees C.
6. Split out approximately 2 g. and grind to a fine powder for XRD and ICP.
7. Run an XRD scan (at least 20 to 35 degrees "two theta").
8. Retain the bulk of the sample for isotope analysis.

SOLUTION PROCEDURE--WOLFCAMP TRACE ELEMENT STUDY--APRIL 1985

I. SAMPLE CHARACTERIZATION

A. Grind samples to powder via shatterbox (tungsten carbide).
Note: some samples (i.e. carbonates for isotope analysis) will require special processing.

B. Run whole rock X-ray diffraction to determine mineral content.
Note: desired range to be indicated for each sample (or group).

II. PRETREATMENT with 1.0N ammonium acetate

A. Purpose: to eliminate easily exchangeable cations

B. Procedure:

1. Disperse ~1.2-1.8 g. powdered sample in ~30 ml. 1.0N ammonium acetate solution.

2. Disperse constantly for 5 minutes; centrifuge; decant.

3. Repeat steps 1-2.

4. Rinse with distilled deionized water at least twice; centrifuge; decant.

5. Dry the remaining solid in the drying oven (< 100 degrees C).

III. EXTRACTION PROCEDURE

A. Purpose: to dissolve the mineral of interest (calcite, anhydrite or dolomite) in the minimum amount of nitric acid in order to minimize the solution of clay minerals that are present

B. Procedure:

1. Weigh accurately ~1.0 g. dried sample (from II.B.5.).
Note: use all material remaining after treatment to avoid subsample that is not representative.

2. (Refer to mineral content results section I.B.).

a. calcite-clay mixtures:
dissolve in ~80 ml. 0.4N HNO_3 for one hour

b. anhydrite-clay mixtures:
dissolve in ~80 ml. 0.6N HNO_3 for eighteen hours

c. dolomite-clay mixtures:
dissolve in ~80 ml. 0.5N HNO_3 for three hours

3. Remove and gravimetrically determine the amount of insoluble residue by filtration.

4. Add concentrated HNO3 to the solutions to match analytical calibrations

5. Analyze the solutions for:

   a. major, minor, trace cations by ICP-AES

   b. sulfate by turbidimetric method

   c. bromide by ion selective electrode method

   d. chloride by colorimetric method.

6. Report (micrograms of constituent per gram of dissolved mass):

   a. SO^4, Ca, Mg, Sr, Na, K, Si, Al, Br, Fe, Mn, Ba, V, P, Zn, Li, Cu, Ni, As, La, Ce, Ti, Pb, Se, Mo, Cl, U, Th

   b. weight % soluble.

7. Quality Assurance (for the initial set of 100+ samples):

   a. Analyze the three Wolfcamp control samples at least six times each to establish precision for the entire procedure.

   b. Verify the accuracy of the calibration of the ICP-AES system by analyzing an appropriate EPA multi-element solution standard.

   c. Analyze at least ten percent of the samples in duplicate.

IV. TESTS

A. Other analyses (select group of samples):

1. Analyze the leachates of our samples from each mineral group (from section II.B.) for:

   a. major, minor, trace cations by ICP-AES

   b. bromide, sulfate, chloride by described methods.

2. Analyze before and after ammonium acetate treatment for:

   a. a real sample with 5% bentonite added (WARDS specimen)

   b. a real sample with a reasonable amount of clay inherent.

3. Analyze for one sample (sample used in section IV.2.b.):

   a. insoluble residue: total elements by ICP and other methods

b. untreated sample: total elements by ICP and other methods

c. pretreated sample (section II): total elements by ICP and other methods.

TABLE 1

WOLFCAMP ANHYDRITES

All data are expressed in micrograms of constituent per gram of dissolved material

	MSL ID # / SL ID #	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn
1	85-175 / Z5339.9	98.8	309900		<3.6	<9.1	41.3	<27	9.1	8.38	<1.8	<0.90	<0.90	<1.81	<0.90	5.14
2	85-180 / Z5370.9	98.9	305000		10.8	66.2	114.0	<26	51.7	66.10	<1.8	<0.85	<0.85	<1.80	<0.85	2.49
3	85-182 / Z5380.9	99.1	305300		⋆3.85	<9.8	43.6	<29	15.8	9.28	<2.0	<0.98	<0.98	<1.80	<0.98	2.82
4	85-183 / Z5381.2	98.5	310000		⋆3.14	<9.6	51.4	<28	<9.6	9.83	<1.9	<0.94	<0.94	<1.90	<0.94	3.51
5	85-184 / Z5386.9	89.1	338800		37.9	360.0	72.0	<50	211.0	369.00	<3.3	<1.70	<1.65	<3.29	<1.65	8.86
6	85-188 / Z5406.2	95.2	319600		<6.3	<15.6	76.3	<47	<16	17.90	<3.2	<1.56	<1.56	<3.11	<1.56	12.90
7	85-190 / Z5411.9	98.1	310800		23.5	53.0	116.0	⋆30	65.1	73.70	⋆3.0	<0.94	⋆1.51	<1.90	<0.94	2.90
8	85-196 / Z5421.9	20.0	337100		⋆48	511.0	237.0	<150	248.0	619.00	<10.3	<5.11	<5.11	<10.2	<5.11	40.60
9	85-198 / Z5437.8	80.3	309900		<4.5	11.0	74.2	<33	<11	14.90	<2.2	<1.11	<1.10	<2.20	<1.10	4.16
10	85-200 / Z5442.0	66.0	366400		15400.0	1900.0	140.0	218	974.0	4150.00	⋆8.9	88.5	5.29	⋆3.28	<1.14	7.32
11	85-211 / Z5511.4	99.4	287400		<4.4	⋆13.8	<16.4	<33	⋆12	24.90	<2.2	<1.09	<1.09	<2.18	<1.09	⋆2.71
12	85-218 / M4424.2	97.5	316600		37.7	162.0	264.0	<39	125.0	189.00	<2.7	<1.31	<1.31	<2.63	<1.31	6.77
13	85-220 / M4450.1	98.7	304200		20.9	68.4	138.0	<26	61.8	89.50	<1.8	<0.86	<0.86	<1.73	<0.86	⋆1.09
14	85-223 / M4467.6	99.1	302100		⋆4.5	<8.7	80.3	<26	⋆9.3	4.63	<1.8	<0.87	<0.87	<1.74	<0.87	⋆1.16
15	85-225 / M4485.6	95.5	332500		<5.9	<14.7	⋆45.9	<44	<16	6.22	<3.0	<1.47	<1.47	<2.95	<1.47	8.45
16	85-227 / M4499.7	85.6	363600		<7.0	<17.4	⋆63.4	<52	<17	11.30	<3.5	<1.74	<1.74	<3.48	<1.74	6.88
17	85-229 / M4516.5	26.2	308500		<11.5	129.0	⋆59.0	<86	58.0	149.00	<5.8	<2.87	<2.87	<5.75	<2.87	8.77
18	85-250 / F5651.8	90.5	303700		<4.6	232.0	53.0	<34	10.0	1450.00	<2.3	⋆1.60	<1.13	<2.26	<1.13	20.10
19	85-258 / F5733.9	100.0	303800		<3.9	<9.8	⋆26.1	<29	⋆21	14.70	<2.0	<0.98	<0.98	<1.95	<0.98	<0.98
20	85-261 / F5760.7	62.6	311200		<5.4	51.4	53.5	<61	42.0	10500.00	<2.7	<1.33	⋆2.75	<2.66	<1.33	4.60
21	85-263 / F5793.8	100.0	298700		<12.3	<30.7	⋆104	<92	<3	23.60	<6.2	<3.06	<3.07	<6.13	<3.06	<3.08
22	85-265 / F5803.0	99.7	301600		13.3	51.1	48.4	<27	34.4	146.00	<1.8	<0.89	<0.89	<1.78	<0.89	⋆1.19
23	85-277 / D2858.6	99.3	304500		23.2	50.1	165.0	<25	60.2	88.70	⋆3.0	<0.84	⋆1.98	<1.67	<0.83	⋆2.00
24	85-278 / D2867.2	99.0	308400		22.0	65.9	173.0	<27	63.3	95.50	⋆2.0	<0.89	⋆2.13	<1.78	<0.89	3.89
25	85-279 / D2882.4	100.0	312000		⋆4.3	<9.0	143.0	<27	⋆12.9	18.90	<1.8	<0.90	<0.90	<1.80	<0.90	⋆0.92
26	85-280 / D2885.7	93.1	305700		9.7	<8.5	135.0	<26	⋆12.5	14.90	<2.0	<0.85	<0.98	<1.70	<0.85	⋆0.97
27	85-281 / D3070.2	90.6	304400		10.0	<9.3	⋆37.4	<28	⋆17.7	7.21	<2.1	<0.93	⋆1.17	<2.10	<0.93	<1.04
28	85-282 / D3101.8	92.0	297800		44.0	122.0	74.1	<24	97.4	747.00	⋆1.9	⋆0.81	⋆1.60	<1.61	⋆1.20	⋆1.69
29	85-283 / D3108.3	86.0	303700		12.9	<7.9	63.3	<24	⋆16.6	12.40	<1.6	<0.80	⋆1.08	<1.59	<0.79	⋆0.90

⋆ -- value close to detection limit, view accordingly

TABLE 1 (cont.)

WOLFCAMP ANHYDRITES

All data are expressed in micrograms of constituent per gram of dissolved material

	MSL ID # / SPL ID #	As	V	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
1	85-175 / Z5339.9	<5.4	<1.8	<9.0	<27	<1.8	1330	<0.90	<27	<9.0	<23	<27	⋆4.2	120	<18
2	85-180 / Z5370.9	<5.1	<1.7	<8.5	<28	<1.7	1690	2.77	<26	<8.5	<22	<25	⋆3.2	150	<18
3	85-182 / Z5380.9	<5.9	<2.0	<9.8	<29	<2.0	1310	<0.91	<30	<9.8	<24	<29	⋆4.6	120	<19
4	85-183 / Z5381.2	<5.6	<1.9	<9.4	<29	<1.9	1250	<0.94	<29	<9.6	<24	<28	⋆3.1	105	<19
5	85-184 / Z5386.9	<9.9	<3.3	<16.5	<50	<3.3	1330	⋆2.65	<50	<17	<42	<50	<5.0	245	<33
6	85-188 / Z5406.2	<9.4	<3.2	<15.6	<47	<3.1	1840	<1.56	<47	<16	<40	<47	<4.7	180	<31
7	85-190 / Z5411.9	<5.7	⋆2.1	<9.4	⋆33	<1.9	1270	<0.94	97	<9.4	<24	<29	6.9	195	<19
8	85-196 / Z5421.9	<30.8	<10.3	<51.1	<150	<10.3	3260	24.20	<150	<51	<130	<150	<15	820	<100
9	85-198 / Z5437.8	<6.7	<2.2	<11.3	<34	<2.2	1310	<1.10	<33	<11	<28	<33	⋆2.6	140	<21
10	85-200 / Z5442.0	<6.9	⋆3.5	<11.4	<34	<2.3	499	2.46	<35	<12	89	<35	9.5		<23
11	85-211 / Z5511.4	<6.6	<2.2	<10.9	<33	<2.2	873	<1.09	<33	<11	<27	<33	⋆3.9	210	<22
12	85-218 / M4424.2	<7.9	<2.7	<13.1	<39	<2.7	1470	<1.31	<39	<13	<33	<40	<4.0	195	<26
13	85-220 / M4450.1	<5.2	<1.8	<8.6	⋆30	<1.8	1610	⋆1.20	⋆37	<8.6	<22	<26	⋆4.6	125	<17
14	85-223 / M4467.6	<5.2	<1.8	<8.7	<26	<1.8	1530	<0.87	⋆30	<8.7	<22	<26	⋆4.2	73	<18
15	85-225 / M4485.6	<8.9	<3.0	<14.7	<44	<3.0	1550	<1.47	<44	<15	<37	<44	<4.5	125	<30
16	85-227 / M4499.7	<10.5	<3.5	<17.4	<52	<3.5	1510	<1.74	<52	<17	<44	<52	<5.3	225	<35
17	85-229 / M4516.5	<17.2	<5.8	<28.7	<86	<5.8	1130	<2.87	<86	<29	<72	<86	<8.6	390	<57
18	85-250 / F5651.8	<6.8	<2.3	<11.3	<34	<2.3	922	<1.13	<34	<11	<28	<34	<3.4	220	<23
19	85-258 / F5733.9	<5.9	<2.0	<9.8	⋆30	<2.0	2680	<0.98	⋆44	<9.8	<24	<29	⋆3.8		<20
20	85-261 / F5760.7	<8.1	<2.7	<13.3	<40	<2.7	1370	<1.33	<40	<13	<33	<40	<4.0	200	<27
21	85-263 / F5793.8	<18.6	<6.2	<30.6	⋆110	<6.2	1760	<3.06	<92	<31	<77	<92	<9.3	335	<62
22	85-265 / F5803.0	<5.4	<1.8	<8.9	⋆48	<1.8	2180	<0.89	<27	<8.9	<22	<27	⋆3.4	120	<18
23	85-277 / D2858.6	<5.1	⋆2.0	<8.4	⋆57	6.7	1650	4.62	88	<8.3	⋆24	<25	⋆6.3	125	<17
24	85-278 / D2867.2	<5.4	<1.8	<8.9	⋆37	6.2	1320	<0.89	⋆62	<8.9	<22	<27	⋆5.2	125	<18
25	85-279 / D2882.4	<5.5	<1.8	<9.0	⋆47	⋆2.1	1380	<0.90	<27	<9.0	<23	<27	⋆3.5	110	<18
26	85-280 / D2885.7	<5.1	<2.0	<8.5	⋆31	5.0	1260	<0.98	⋆49	<8.5	<24	<26	⋆4.7	140	<19
27	85-281 / D3070.2	<5.6	<2.1	<9.3	<32	<1.9	845	<1.04	⋆78	<9.3	<26	<31	⋆5.1	120	<21
28	85-282 / D3101.8	<4.9	<1.6	<8.0	⋆37	<1.6	1690	<0.80	⋆40	<8.0	⋆22	<24	⋆3.9	140	<16
29	85-283 / D3108.3	<4.8	<1.6	<7.9	⋆32	<1.6	923	<0.79	⋆46	<7.9	<24	<24	⋆4.7	97	<16

⋆ value is close to the detection limit and should be viewed accordingly

TABLE 2

WOLFCAMP DOLOMITES

All data are expressed in micrograms of constituent per gram of dissolved material

	MSL ID# / SPL ID#	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo
1	85-176 / Z5339.9	85.7	237100	1260	133900	438.1	364	< 24.	214.1	1849	< 1.64	144.4	< 0.82	< 1.6	< 0.82
2	85-177 / Z5347.9	89.1	237100	1110	136700	449.6	399	< 26.	185.8	1050	< 1.76	67.0	< 0.88	< 1.7	< 0.88
3	85-178 / Z5359.1	92.6	234400	890	137200	303.6	390	< 26.	117.8	1701	< 1.75	84.7	< 0.88	< 1.7	< 0.88
4	85-179 / Z5369.8	87.0	239900	1090	137700	477.3	462	< 24.	209.2	925.8	< 1.61	71.1	< 0.88	< 1.6	< 0.88
5	85-181 / Z5380.9	90.1	238400	5300	134800	345.1	336	< 32	163.6	1902	< 1.77	91.9	< 0.88	< 1.7	< 0.88
6	85-185 / Z5386.9	87.7	240500	1160	136400	320.8	318	* 35.	149.6	1811	< 1.60	92.2	< 0.81	< 1.6	< 0.88
7	85-186 / Z5391.1	91.6	241900	1500	138500	716.9	308	6	242.0	1535	< 1.50	87.0	< 0.76	< 1.5	< 0.76
8	85-187 / Z5399.5	94.2	237100	770	137200	142.0	218	< 22.	82.1	1625	< 1.49	70.9	< 0.75	< 1.4	< 0.75
9	85-189 / Z5406.2	85.2	294300	15200	141300	87.6	766	< 30.	31.1	578.3	< 2.02	40.2	< 1.03	< 2.0	< 1.03
10	85-191 / Z5411.9	93.6	244400	13900	126500	208.0	332	< 23.	96.5	602.0	< 1.56	32.9	< 0.79	< 1.5	< 0.79
11	85-192 / Z5412.2	90.7	236300	1570	129900	199.2	295	< 23.	95.0	697.1	< 1.54	37.2	< 0.78	< 1.5	< 0.78
12	85-193 / Z5418.8	97.2	315400	23700	70300	51.3	104	< 22.	19.1	894.8	< 1.47	46.7	< 0.75	< 1.4	< 0.75
13	85-195 / Z5421.9	94.6	306300	590	82400	98.9	155	< 2.	40.4	909.5	< 1.49	49.6	< 0.76	< 1.4	< 0.76
14	85-197 / Z5430.4	94.3	432100	1370	23160	49.0	134	< 22.	35.3	625.5	< 1.50	62.6	< 0.78	< 1.5	< 0.78
15	85-199 / Z5437.8	93.2	240500	7040	132000	132.0	253	< 26.	53.4	1397	< 1.79	64.5	< 0.89	< 1.7	< 0.89
16	85-201 / Z5442.0	58.9	272300	5050	126600	2480.0	982	417	1320.0	2960	< 2.83	163.0	< 1.41	4.0	< 1.41
17	85-202 / Z5446.1	92.7	443600	5220	14610	35.8	230	< 23.	31.4	1607	< 1.56	91.6	< 0.81	< 1.5	< 0.81
18	85-204 / Z5448.9	93.4	404700	1970	27250	101.7	226	< 25.	75.0	1766	< 1.67	83.2	< 0.86	< 1.6	< 0.86
19	85-205 / Z5472.3	95.2	258600	1045	117300	87.9	188	< 22.	31.5	1953	< 1.46	111.6	< 0.74	< 1.4	< 0.74
20	85-206 / Z5492.7	100.0	241800	193	138500	21.3	380	< 24.	* 15.2	463.9	< 1.58	53.6	< 0.81	< 1.5	< 0.81
21	85-207 / Z5498.2	100.0	241200	177	138200	24.0	410	< 22.	* 10.5	700.2	< 1.45	64.7	< 0.74	< 1.4	< 0.74
22	85-210 / Z5509.6	93.4	260700	320	135600	187.7	220	23.	46.6	3405	< 1.51	206.0	< 0.77	* 2.0	< 0.77
23	85-212 / Z5511.4	98.0	255400	2230	131600	170.1	302	< 21.	60.1	5163	< 1.43	265.6	< 0.71	< 1.4	< 0.71
24	85-213 / Z5514.6	94.7	378100	480	56260	84.0	165	< 22.	28.9	827.6	< 1.50	85.2	< 0.77	< 1.5	< 0.77
25	85-214 / Z5521.7	99.0	420500	860	20340	47.6	187	< 28.	26.8	412.6	< 1.90	47.5	< 0.98	< 1.9	< 0.98
26	85-215 / Z5531.6	94.9	457900	1330	9266	* 11.4	241	< 22.	* 9.47	482.3	< 1.49	84.8	< 0.77	< 1.4	< 0.77
27	85-219 / M4435.6	93.9	246300	72700	125800	190.1	305	< 23.	89.6	1870	< 1.53	90.6	< 0.78	< 1.5	< 0.78
28	85-221 / M4453.2	92.2	257200	10400	119700	183.2	304	< 26.	89.2	2274	< 1.71	101.8	< 0.87	* 2.6	< 0.87
29	85-222 / M4467.3	91.4	242100	9120	141300	86.5	247	< 23.	53.3	1675	< 1.56	93.7	< 0.79	< 1.5	< 0.79
30	85-224 / M4485.6	95.5	243600	24400	137700	63.6	350	< 22.	58.9	722.1	< 1.48	60.8	< 0.76	< 1.4	< 0.76
31	85-226 / M4499.7	93.8	236100	29600	129300	108.6	289	< 24.	80.8	1604	< 1.58	95.9	< 0.81	< 1.5	< 0.81
32	85-228 / M4516.5	78.0	241400	12000	120300	176.2	181	<28.	137.6	2546	< 1.85	79.4	< 0.95	* 3.7	< 0.95
33	85-230 / M4527.0	90.2	251300	7060	126800	123.6	179	< 23.	116.7	2255	< 1.54	80.9	< 0.79	< 1.5	< 0.79
34	85-232 / M4552.5	94.3	415700	870	21950	89.6	136	< 25.	60.2	702.1	< 1.69	41.7	< 0.87	< 1.6	< 0.87
35	85-247 / F5542.4	94.8	239100	18700	136800	218.5	234	< 2.	97.6	925.5	< 1.50	71.3	< 0.77	< 1.5	< 0.77
36	85-248 / F5577.5	98.0	237500	16100	136200	84.5	240	< 22.	42.4	399.2	< 1.47	37.8	< 0.73	< 1.4	< 0.73
37	85-249 / F5614.3	92.7	234500	5410	136600	133.4	366	< 23.	49.0	1086	< 1.56	35.8	< 0.78	< 1.5	< 0.78
38	85-251 / F5651.8	98.4	238600	22300	133000	34.6	490	< 23.	< 7.63	116.5	< 1.50	29.3	< 0.77	< 1.5	< 0.77
39	85-252 / F5653.3	93.5	250500	3110	144000	56.7	511	< 23.	14.7	383.0	< 1.57	29.6	< 0.78	< 1.5	< 0.78
40	85-254 / F5711.9	95.3	261900	146	132900	33.9	157	< 22.	74.4	135.8	< 1.51	21.6	< 0.75	< 1.5	< 0.75
41	85-255 / F5718.0	56.5	248600	370	130800	190.0	147	< 37.	134.0	903	< 2.46	27.2	< 1.23	< 2.5	< 1.23
42	85-257 / F5733.9	97.7	258600	3780	123500	52.4	121	< 22.	85.6	312.9	< 1.47	22.4	< 0.76	< 1.4	< 0.76
43	85-260 / F5748.6	98.1	406400	1230	18440	20.8	91	< 22.	< 7.30	93.3	< 1.45	22.2	< 0.75	< 1.4	< 0.75
44	85-262 / F5793.8	91.3	288800	27000	101900	50.2	120	< 35.	52.3	450.6	< 2.36	24.4	< 1.23	< 2.3	< 1.23
45	85-267 / F5839.2	91.2	427500	810	31350	161.2	94	< 23.	37.3	207.1	< 1.53	13.2	< 0.79	< 1.5	< 0.79
46	85-268 / F5851.0	98.9	437800	690	7864	< 10.4	132	< 31.	< 10.3	82.8	< 2.05	9.3	< 1.07	< 2.0	< 1.07
47	85-270 / F5903.8	95.9	418300	2260	17000	32.2	194	< 31.	* 12.8	159.6	< 2.06	18.5	< 1.06	< 2.0	< 1.06
48	85-271 / F5953.7	88.3	351900	910	56300	227.7	210	< 33.	178.2	718.0	< 2.23	30.8	< 1.15	< 2.2	< 1.15

* -- value close to detection limit, view accordingly

TABLE 2 (cont.)

WOLFCAMP DOLOMITES

All data are expressed in micrograms of constituent per gram of dissolved material

MSL ID# / SPL ID#	Zn	As	V	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
1 85-176 / Z5339.9	★ 1.41	< 4.94	★ 3.3	<8.3	<25	<1.6	141.6	★ 1.9	<25	<8.3	87.1	<25	<2.5	450	<17
2 85-177 / Z5347.9	★ 0.89	< 5.30	★ 2.4	<8.9	<26	<1.8	156.3	★ 1.3	<26	<8.9	★ 54.9	<26	<2.6	520	<18
3 85-178 / Z5359.1	2.33	< 5.27	★ 1.8	<8.8	★38	<1.8	88.0	★ 0.9	<26	<8.8	126.2	<26	<2.6	285	<18
4 85-179 / Z5369.8	★ 1.01	< 4.86	★ 2.9	<8.1	<24	<1.6	106.5	★ 1.4	<24	<8.1	78.7	<24	<2.4	560	<16
5 85-181 / Z5380.9	1.50	< 5.32	2.0	<8.9	<27	<1.8	1235.0	41.3	<27	<8.9	65.5	<27	<2.7	395	<19
6 85-185 / Z5386.9	★ 1.19	< 4.86	★ 3.0	<8.1	★30	<1.6	286.6	10.9	<24	<8.1	54.4	<24	<2.4	450	<16
7 85-186 / Z5391.1	3.86	< 4.55	7.4	<7.6	<23	<1.5	159.6	5.0	<23	<7.6	341.4	<23	<2.3	280	<15
8 85-187 / Z5399.5	2.35	< 4.53	★ 3.5	<7.6	<23	<1.5	80.4	★ 1.3	<23	<7.6	< 18.8	<23	<2.3	390	<15
9 85-189 / Z5406.2	★ 1.89	< 6.15	★ 5.0	<10.3	<31	<2.0	257.1	< 1.0	<31	<10.3	< 25.5	<31	<3.1	580	<20
10 85-191 / Z5411.9	★ 1.47	< 4.74	★ 2.2	<7.9	<24	<1.6	157.9	2.4	<24	<7.9	< 19.7	<24	<2.4	420	<16
11 85-192 / Z5412.2	★ 1.87	< 4.69	★ 3.1	<7.9	<24	<1.5	92.7	★ 1.3	<24	<7.9	< 19.5	<24	<2.4	420	<16
12 85-193 / Z5418.8	4.06	< 4.48	5.1	<7.5	<22	<1.5	249.1	< 0.7	<22	<7.5	< 18.6	<22	<2.3	310	<15
13 85-195 / Z5421.9	★ 1.78	< 4.55	4.1	<7.6	★28	<1.5	160.7	< 0.7	<23	<7.6	< 18.9	<23	<2.3	340	<15
14 85-197 / Z5430.4	★ 1.50	< 4.56	4.0	<7.8	★25	<1.5	190.3	6.8	<23	<7.8	★ 22.5	<23	5.9	210	<15
15 85-199 / Z5437.8	1.63	< 5.37	2.8	<9.0	<32	<1.8	82.2	< 0.8	<27	<8.6	< 22.4	<27	<2.7	470	<18
16 85-201 / Z5442.0	7.82	< 8.49	< 2.8	<14.1	<43	<2.8	292.5	5.9	<43	<14.1	390.0	<43	<4.3	520	<28
17 85-202 / Z5446.1	★ 1.13	< 4.73	4.5	<8.1	★45	<1.6	3012.0	96.2	<4	<8.1	★ 32.4	<24	★5.7	270	<16
18 85-204 / Z5448.9	14.15	< 5.05	< 1.6	<8.7	<25	<1.7	197.5	< 0.8	<25	<8.7	★ 30.7	<25	★5.8	300	<17
19 85-205 / Z5472.3	★ 0.78	< 4.45	★ 3.4	<7.5	<22	<1.5	101.0	★ 1.3	<22	<7.5	★ 30.2	<22	<2.2	310	<15
20 85-206 / Z5492.7	★ 1.65	< 4.82	< 1.6	<8.1	<24	<1.6	48.0	★ 1.3	<24	<8.1	< 20.0	<24	<2.4	700	<16
21 85-207 / Z5498.2	< 0.73	< 4.42	< 1.4	<7.4	★25	<1.5	48.1	< 0.7	<22	<7.4	< 18.3	<22	<2.2	750	<15
22 85-210 / Z5509.6	10.71	< 4.60	< 1.5	<7.8	★27	<1.5	75.1	< 0.7	<23	<7.8	< 19.0	<23	<2.3	450	<15
23 85-212 / Z5511.4	10.73	< 4.29	2.4	<7.2	<22	<1.4	79.0	1.3	<22	<7.2	< 20	<22	<2.1	610	<16
24 85-213 / Z5514.6	★ 1.55	< 4.54	< 1.5	<7.8	★37	<1.5	308.5	< 0.7	<23	<7.8	< 18.5	<23	<2.3	260	<15
25 85-214 / Z5521.7	8.66	< 5.74	< 1.9	<9.8	<29	<1.9	519.3	< 0.9	<29	<9.8	< 23.4	<29	<2.9	180	<19
26 85-215 / Z5531.6	★ 0.85	< 4.51	< 1.5	<7.7	★51	<1.5	619.0	< 0.7	<23	<7.7	< 18.4	<23	★2.6	260	<15
27 85-219 / M4435.6	3.19	< 4.67	4.8	<7.9	<23	<1.5	993.1	8.0	<23	<7.9	★ 28.2	<23	<2.3	360	<16
28 85-221 / M4453.2	2.60	< 5.20	4.5	<8.8	<26	<1.7	5197.0	150.0	<26	<8.8	63.5	<26	★3.0	330	<17
29 85-222 / M4467.3	★ 1.08	< 4.74	4.7	<8.0	<24	<1.6	183.0	3.2	<24	<8.0	★ 31.0	<24	<2.4	370	<I6
30 85-224 / M4485.6	★ 1.07	< 4.51	12.0	<7.6	<23	<1.5	323.4	★ 1.5	<22	<7.6	< 18.6	<23	<2.3	400	<15
31 85-226 / M4499.7	< 0.80	< 4.81	6.8	<8.1	<24	<1.6	1208.0	36.3	<24	<8.1	< 19.8	<24	<2.4	350	<16
32 85-228 / M4516.5	2.35	< 5.64	21.1	<9.5	<28	<1.9	2614.0	29.7	<28	<9.5	< 23.2	<28	<2.8	390	<19
33 85-230 / M4527.0	1.99	< 4.70	7.4	<7.9	<24	<1.5	522.6	12.3	<24	<7.9	★ 24.7	<24	<2.4	360	<16
34 85-232 / M4552.5	8.51	< 5.12	★ 4.0	<8.8	★38	<1.7	268.9	★ 1.8	<26	<8.8	< 20.9	<26	★3.7	250	<17
35 85-247 / F5542.4	★ 0.94	< 4.57	★ 2.5	<7.7	<23	<1.5	529.7	5.9	<28	<28	< 18.8	<23	<2.3	280	<15
36 85-248 / F5577.5	< 0.73	< 4.40	4.8	<7.3	<22	<1.5	357.3	12.1	<22	<7.3	< 18.0	<22	<2.2	220	<14
37 85-249 / F5614.3	< 0.78	< 4.69	5.0	<7.8	<23	<1.6	155.6	2.8	<23	<23	< 19.4	<23	<2.3	310	<16
38 85-251 / F5651.8	1.99	< 4.58	13.4	<7.7	<23	<1.5	211.0	< 0.7	<23	<7.7	50.6	<23	<2.3	470	<15
39 85-252 / F5653.3	2.96	< 4.70	25.0	<7.8	<24	<1.6	95.7	< 1.6	<24	<7.8	26.7	<24	<2.4	560	<22
40 85-254 / F5711.9	< 1.6	< 4.52	2.8	<7.5	<23	<1.5	64.6	< 0.7	<23	<7.5	< 18.8	<23	<2.3	420	<21
41 85-255 / F5718.0	4.12	< 7.39	3.3	<12.3	<37	<2.5	62.6	< 1.2	<37	<12.3	< 30.8	<37	<3.7	500	<25
42 85-257 / F5733.9	2.54	< 4.47	★ 3.2	<12.6	<37	<2.4	62.6	< 0.7	<22	<7.6	< 18.4	<22	<2.2	380	<15
43 85-260 / F5748.6	3.90	< 4.40	11.6	<7.5	<22	<1.5	205.3	< 0.7	<22	<7.5	< 18.1	<22	<2.2	260	<15
44 85-262 / F5793.8	★ 1.79	< 7.16	★ 4.0	<12.3	<36	<2.4	14661	311.7	<36	<12.3	< 29.3	<36	<3.6	380	<18
45 85-267 / F5839.2	7.75	< 4.65	6.9	<8.0	<23	<1.5	456.5	5.1	<23	<8.0	★ 35.1	<23	<2.3	250	<15
46 85-268 / F5851.0	5.84	< 6.24	★ 3.5	<10.7	<31	<2.1	218.9	< 1.0	<31	<10.7	< 25.5	<31	<3.1	330	<21
47 85-270 / F5903.8	3.38	< 6.22	★ 4.6	<10.6	★46	<2.1	1625.0	24.3	<31	<10.6	★ 62.8	<31	★3.3	340	<21
48 85-271 / F5953.7	5.12	< 6.74	★ 4.5	<11.5	★51	<2.2	725.5	7.4	<34	<11.5	155.7	<34	★3.5	240	<22

★ -- value close to detection limit, view accordingly

TABLE 2 (cont.)

WOLFCAMP DOLOMITES

All data are expressed in micrograms of constituent per gram of dissolved material

MSL ID# / SPL ID#	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo
49 85-325 / D2894.2	86.6	234900	2100	138700	272.9	373	< 2.	143.1	1871	< 1.58	119.8	< 0.82	< 1.5	< 0.82
50 85-326 / D2911.6	94.9	251200	151300	104000	94.8	338	< 26.	41.3	1014	< 1.73	87.0	< 0.89	< 1.7	< 0.89
51 85-327 / D2961.9	95.8	235000	2830	139000	41.7	348	< 2.	⋆ 15.3	768.6	< 1.47	54.1	< 0.75	< 1.4	< 0.75
52 85-328 / D3012.7	96.9	239500	53000	127500	51.3	419	< 23.	⋆ 18.6	564.9	< 1.56	38.3	< 0.80	< 1.5	< 0.80
53 85-329 / D3026.2	97.7	234300	1260	139300	63.9	358	< 21.	32.8	496.1	< 1.42	63.0	< 0.73	< 1.4	< 0.73
54 85-330 / D3030.2	93.9	236500	550	141000	84.9	297	< 22.	50.1	594.3	< 1.46	76.0	< 0.75	< 1.4	< 0.75
55 85-331 / D3054.4	97.5	247500	118600	95600	38.6	382	< 24.	24.2	413.6	< 1.58	29.1	< 0.81	< 1.5	< 0.81
56 85-332 / D3059.2	95.2	236100	10300	135600	90.5	280	< 22.	49.2	610.0	< 1.46	61.4	< 0.75	⋆ 2.4	< 0.75
57 85-333 / D3101.8	95.1	236300	20400	132900	71.1	291	< 23.	46.1	870.2	< 1.56	45.3	< 0.80	4.9	< 0.80
58 85-334 / D3108.3	95.2	243200	1000	140300	76.3	332	< 22.	29.6	418.3	< 1.50	39.5	< 0.77	< 1.5	< 0.77
59 85-335 / D3130.4	91.3	261000	1750	127800	122.2	268	< 23.	27.1	1576	< 1.57	91.7	< 0.81	< 1.5	< 0.81
60 85-336 / D3136.2	96.2	269000	1520	116600	72.0	148	< 22.	⋆ 10.0	1695	< 1.46	97.3	< 0.75	< 1.4	< 0.75
61 85-337 / D3142.5	94.0	319400	1280	81000	156.1	205	< 31.	39.2	1759	< 2.07	117.1	< 1.08	< 2.0	< 1.08
62 85-338 / D3146.8	88.6	264600	1680	121100	233.8	216	< 23.	114.1	2386	< 1.52	116.6	< 0.79	10.1	< 0.79
63 85-340 / D3176.9	91.6	319100	1900	150600	116.3	285	< 27.	59.9	6706	< 1.82	319.7	< 0.94	< 1.8	< 0.94
64 85-341 / D3195.1	93.6	413400	630	26500	120.0	136	< 30.	38.4	1053	< 1.98	148.1	< 1.03	< 1.9	< 1.03

MSL ID# / SPL ID#	Zn	As	V	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
49 85-325 / D2894.2	< 0.79	< 4.78	6.3	<8.2	<24	<1.6	147.8	87	<24	<8.2	⋆ 36.2	<24	<2.4	320	<16
50 85-326 / D2911.6	< 0.86	< 5.22	5.3	<9.0	<26	<1.7	886.7	⋆ 1.3	<26	<9.0	⋆ 44.7	<26	<2.6	250	<17
51 85-327 / D2961.9	< 0.73	< 4.43	< 1.4	<7.6	<22	<1.5	75.8	3.7	<22	<7.6	⋆ 23.4	<22	<2.2	520	<15
52 85-328 / D3012.7	< 0.77	< 4.70	⋆ 1.9	<8.1	<24	<1.6	307.5	2.5	<24	<8.1	170.0	<24	<2.4	440	<16
53 85-329 / D3026.2	< 0.70	< 4.28	⋆ 2.4	<7.3	<21	<1.4	63.3	< 0.7	<22	<7.3	49.1	<22	<2.2	420	<14
54 85-330 / D3030.2	< 0.73	< 4.41	⋆ 1.8	<7.6	<22	<1.5	55.5	2.6	<22	<7.6	49.8	<22	<2.2	420	<15
55 85-331 / D3054.4	3.20	< 4.77	6.5	<8.2	<24	<1.6	410.3	< 0.8	<24	<8.2	73.4	<24	<2.4	530	<16
56 85-332 / D3059.2	3.28	< 4.40	5.6	<7.6	<22	<1.5	94.8	2.9	<22	<7.6	85.3	<22	<2.2	330	<15
57 85-333 / D3101.8	< 0.77	< 4.69	11.1	<8.1	<24	<1.6	161.7	6.2	<24	<8.1	59.2	<24	<2.4	380	<16
58 85-334 / D3108.3	< 0.75	< 4.52	8.1	<7.8	<23	<1.5	54.2	< 0.7	<23	<7.8	⋆ 39.3	<23	<2.3	410	<15
59 85-335 / D3130.4	< 0.78	< 4.73	5.4	<8.1	<24	<1.6	53.4	⋆ 0.8	<24	<8.1	343.8	<24	<2.4	230	<16
60 85-336 / D3136.2	< 0.73	< 4.41	15.8	<7.6	<22	<1.5	55.1	⋆ 0.9	<22	<7.6	171.3	<22	<2.2	200	<15
61 85-337 / D3142.5	2.61	< 6.26	⋆ 4.4	<10.8	<32	<2.1	88.0	⋆ 1.2	<32	<10.8	214.1	<32	⋆3.4	190	<21
62 85-338 / D3146.8	2.49	< 4.60	14.1	<7.9	<23	>1.5	60.3	2.1	<23	<7.9	191.6	<23	8.3	250	<15
63 85-340 / D3176.9	7.05	< 5.49	8.8	<9.5	<28	<1.8	106.3	11.1	<28	<9.5	⋆ 48.6	<28	<2.8	330	<18
64 85-341 / D3195.1	4.28	< 5.98	< 2.0	<10.3	<30	<2.0	942.0	⋆ 2.2	<30	<10.3	< 24.5	<30	⋆4.1	220	<20

⋆ -- value close to detection limit, view accordingly

TABLE 3

WOLFCAMP LIMESTONES

All data are expressed in micrograms of constituent per gram of dissolved material

	MSL ID # / SPL ID #	WT % SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo
1	85-208 / Z5501.8	93.5	468900	1580	1980	* 18.1	281	< 2	< 10.5	112.0	< 2.1	39.3	< 1.10	< 2.1	< 1.1
2	85-209 / Z5506.8	98.2	441100	1300	2400	22.9	171	< 23	< 7.5	274.0	< 1.5	44.0	< 0.76	< 1.5	< 0.8
3	85-216 / Z5539.6	93.6	278300	1600	133300	59.4	280	< 28	43.0	3280.0	< 1.9	253.0	< 0.95	< 1.9	< 1.0
4	85-217 / Z5548.5	95.3	449400	1740	6250	23.3	277	< 28	31.2	557.0	< 1.9	118.0	< 0.93	< 1.9	< 1.0
5	85-231 / M4540.6	91.9	471100	1650	4950	< 9.9	218	< 30	< 9.9	190.0	< 2.0	37.7	< 0.99	< 2.0	< 1.0
6	85-234 / M4598.1	96.1	460500	674	3630	* 11.1	171	< 28	< 9.2	181.0	< 1.9	30.3	< 0.93	< 1.9	< 1.0
7	85-235 / M4605.1	96.7	461200	1000	3840	< 9.5	175	< 29	< 9.5	189.0	< 1.9	33.7	< 0.96	< 1.9	< 1.0
8	85-236 / M4821.5(C)	95.4	471600	<300	3270	< 9.3	< 14	< 28	< 9.3	132.0	< 1.8	63.8	< 0.94	< 1.9	< 1.0
9	85-237 / M4821.5	91.1	453200	694	5750	35.5	165	< 31	* 23.3	369.0	< 2.1	48.0	< 1.01	< 2.0	< 1.1
10	85-239 / M4825.9	97.4	453100	1890	1680	29.4	100	< 29	* 11.6	84.8	< 1.9	17.4	< 0.95	< 1.9	< 1.0
11	85-240 / M4835.2	99.1	442900	876	2030	26.5	106	< 27	* 15.8	96.7	< 1.8	18.8	< 0.90	< 1.8	< 0.9
12	85-241 / M4855.2	98.2	436300	299	2840	< 9.1	101	< 2	< 9.2	101.0	< 1.8	31.9	< 0.92	< 1.8	< 1.0
13	85-243 / M4868.3	98.9	433800	470	3690	* 17.2	154	< 30	< 10.0	175.0	< 2.1	43.1	< 1.10	< 2.1	< 1.1
14	85-244 / M4878.2	96.2	444800	414	4070	< 9.0	152	< 27	< 8.9	149.0	< 1.8	36.5	< 0.90	< 1.8	< 1.0
15	85-245 / M4912.3(C)	100.0	452300	<300	3970	< 9.5	< 14	29	< 9.4	* 1.5	< 1.9	55.5	< 0.95	< 1.9	< 1.0
16	85-246 / M4912.3	60.0	430100	<490	15300	94.8	413	< 44	101.0	394.0	< 2.9	54.7	< 1.49	< 2.9	< 1.5
17	85-264 / F5803.0	100.0	429800	4470	6190	< 10.9	140	< 33	< 10.9	98.7	< 2.2	19.0	< 1.10	< 2.2	< 1.1
18	85-339 / D3168.8	94.3	454700	<300	3490	32.9	53	< 34	< 11.2	433.0	< 2.2	237.0	< 1.14	< 2.2	< 1.2
19	85-342 / D3201.0	96.1	457700	<300	4310	* 13.6	< 20	< 30	< 10.1	588.0	< 2.1	155.0	< 1.01	< 2.1	< 1.1
20	85-343 / D3208.6	96.7	437200	275	3810	* 20.2	121	< 31	< 10.3	504.0	< 2.0	109.0	< 1.04	< 2.0	< 1.1
21	85-344 / D3220.4	97.3	434700	1100	5620	* 14.6	183	< 31	< 10.3	587.0	< 2.0	141.0	< 1.04	< 2.0	< 1.1
22	85-345 / D3250.4	79.6	446600	600	4220	181.0	136	< 38	51.1	2520.0	< 2.5	695.0	< 1.3	* 3.5	< 1.3
23	85-346 / D3265.3	80.6	441400	<410	4750	243.0	160	< 38	227.0	542.0	< 2.5	583.0	< 1.26	< 2.5	< 1.3
24	85-347 / D3279.5	79.0	446500	1030	3370	123.0	132	< 3	99.0	1860.0	< 2.6	1110.0	< 1.32	< 2.6	< 1.4
25	85-348 / D3296.4	69.0	451100	2110	3920	139.0	180	< 43	67.4	1930.0	< 2.9	1000.0	< 1.50	< 2.9	< 1.5
26	85-349 / D3305.3	85.1	473800	783	3720	116.0	138	< 37	98.6	651.0	< 2.4	806.0	< 1.22	< 2.4	< 1.3

* value is close to the detection limit, view accordingly

TABLE 3 (cont.)

WOLFCAMP LIMESTONES

All data are expressed in micrograms of constituent per gram of dissolved material

MSL ID # / SPL ID #	Zn	As	V	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
1 85-208 / Z5501.8	5.0	< 6.3	< 2.1	< 10.5	* 37	< 2.1	1840	< 1.1	< 32	< 10.5	< 27	< 32	< 3.2	190	<18
2 85-209 / Z5506.8	* 1.7	< 4.5	< 1.5	< 7.6	* 23	< 1.5	1050	< 0.8	< 23	< 7.6	< 19	< 23	< 2.3	240	<15
3 85-216 / Z5539.6	9.0	< 5.7	* 3.8	< 9.5	< 28	< 1.9	102	< 1.0	< 29	< 9.5	< 24	< 29	< 2.9	370	<19
4 85-217 / Z5548.5	8.1	< 5.6	* 3.8	< 9.4	< 28	< 1.9	935	< 1.0	< 28	< 9.4	* 50	< 28	* 3.4	170	<19
5 85-231 / M4540.6	7.4	< 5.9	7.2	< 9.9	< 30	< 2.0	27	< 1.0	< 30	< 9.9	< 25	< 29	* 4.6	250	<20
6 85-234 / M4598.1	8.2	< 5.5	* 3.5	< 9.3	* 33	< 1.9	192	< 1.0	< 28	< 9.3	* 30	< 28	* 4.9	250	<18
7 85-235 / M4605.1	6.4	< 5.7	5.3	< 9.5	* 36	< 1.9	436	4.2	< 29	< 9.5	66	< 29	* 6.5	310	<19
8 85-236 / M4821.5(C)	4.9	< 5.6	< 1.9	< 9.4	< 28	< 1.8	28	* 1.8	< 28	< 9.4	< 24	< 28	< 2.8	56	<19
9 85-237 / M4821.5	7.8	< 6.1	* 4.5	< 10.1	< 31	< 2.1	218	2.9	< 31	< 10.1	72	< 31	* 5.5	280	<20
10 85-239 / M4825.9	3.0	< 5.7	* 2.2	< 9.5	< 29	< 1.9	2980	16.4	* 30	< 9.5	< 24	< 24	* 4.8	240	<19
11 85-240 / M4835.2	5.4	< 5.4	* 2.8	< 9.0	< 27	< 1.8	1340	3.7	* 49	< 9.0	* 41	< 27	* 4.9	170	<18
12 85-241 / M4855.2	4.2	< 5.5	< 1.9	< 9.2	< 28	< 1.8	265	3.5	< 28	< 9.2	< 23	< 28	< 2.8	230	<18
13 85-243 / M4868.3	9.2	< 6.1	< 2.1	< 10.1	< 31	< 2.1	283	< 1.4	< 30	< 10.1	* 26	< 27	* 3.4	300	<18
14 85-244 / M4878.2	4.3	< 5.4	< 1.8	< 9.1	< 27	< 1.8	316	2.5	< 27	< 9.1	* 35	< 27	* 6.3	310	<18
15 85-245 / M4912.3(C)	* 1.7	< 5.6	< 1.9	< 9.5	< 29	< 1.9	215	< 1.0	< 29	< 9.5	< 24	< 29	* 5.5	410	<19
16 85-246 / M4912.3	4.4	< 8.9	< 3.0	< 14.9	< 45	< 2.9	1000	5.7	< 45	< 14.9	94	< 45	* 7.7	320	<30
17 85-264 / E5803.0	* 2.6	< 6.5	< 2.2	< 11.0	< 33	< 2.2	264	< 1.1	< 33	< 11.0	< 28	< 33	* 3.3	240	<22
18 85-339 / D3168.8	5.2	< 6.7	< 2.3	< 11.4	< 34	< 2.2	452	5.7	< 34	< 11.4	< 29	< 34	* 7.1	310	<22
19 85-342 / D3201.0	7.3	< 6.1	< 2.1	< 10.1	< 31	< 2.1	813	* 1.2	< 31	< 10.1	< 26	< 31	* 4.7	86	<21
20 85-343 / D3208.6	5.4	< 6.2	< 2.1	< 10.4	< 31	< 2.0	397	* 1.3	< 31	< 10.4	< 26	< 31	< 3.1	220	<20
21 85-344 / D3220.4	2.9	< 6.2	< 2.1	< 10.4	< 31	< 2.0	401	2.7	< 31	< 10.4	< 26	< 31	* 5.6	230	<20
22 85-345 / D3250.4	7.6	< 7.5	* 4.0	< 13.0	< 38	< 2.5	79	27.9	< 38	< 12.5	* 55	< 38	20.4	180	<25
23 85-346 / D3265.3	8.9	< 7.5	< 2.5	< 12.6	< 38	< 2.5	475	3.8	< 38	< 12.6	< 31	< 38	14.8	170	<25
24 85-347 / D3279.5	4.7	< 7.8	< 2.6	< 13.2	< 40	< 2.6	565	< 1.3	< 39	< 13.2	99	< 39	23.6	160	<26
25 85-348 / D3296.4	14.5	< 8.6	< 3.2	< 14.4	< 43	< 2.9	389	901.0	< 43	< 14.4	< 36	< 43	30.0	180	<29
26 85-349 / D3305.3	6.5	< 7.2	< 2.4	< 12.2	< 37	< 2.4	46	< 1.3	< 37	< 12.2	* 63	< 37	13.5	180	<24

* value is close to the detection limit, view accordingly

TABLE 4

Anhydrite Duplicates

SAMPLE ID#	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V	Pb
85-180-1	99.5	305200		14.8	72.3	102.0	<28	54.1	68.00	<1.8	<0.92	<0.92	<1.84	<0.92	2.92	<5.5	<1.8	<9.2
85-180-2	99.2	304900		6.9	60.2	127.0	<25	49.2	64.20	<1.7	<0.85	<0.85	<1.70	<0.85	2.05	<5.1	<1.7	<8.5
85-182-1	99.4	306600		<3.7	<9.2	35.7	<28	<9.2	9.19	<1.9	<0.92	<0.92	<1.84	<0.92	2.43	<5.5	<1.8	<9.2
85-182-2	98.8	304100		8.3	<9.8	51.4	<29	23.1	9.36	<2.0	<0.98	<0.98	2.54	<0.98	3.22	<5.9	<2.0	<9.8
85-183-1	98.0	310100		13.4	<9.6	52.6	<29	<9.6	10.90	<1.9	<0.96	<0.96	<1.92	<0.96	4.90	<5.8	<2.0	<9.6
85-183-2	99.0	309800		<3.7	<9.4	50.3	<29	<9.4	8.74	<1.9	<0.94	<0.94	<1.87	<0.94	2.13	<5.6	<1.9	<9.4
85-198-1	80.5	310800		<4.3	<10.6	64.3	<32	<10.6	14.80	<2.2	<1.06	<1.06	<2.13	<1.06	3.19	<6.4	<2.1	<10.6
85-198-2	80.3	309100		<4.5	12.2	84.2	<33	<11.1	14.90	<2.3	<1.11	<1.11	<2.23	<1.11	5.12	<6.7	<2.2	<11.1
85-280-1	99.6	307300		11.9	<9.7	125.0	<29	10.7	18.10	<2.0	<0.97	<0.98	<1.95	<0.97	1.23	<5.8	<2.0	<9.7
85-280-2	86.5	304100		7.4	<8.5	145.0	<26	14.3	11.60	<1.7	<0.85	0.88	<1.70	<0.85	<0.85	<5.1	<1.7	<8.5
85-281-1	96.5	310600		9.1	<10.4	35.7	<31	17.3	7.11	<2.1	<1.04	1.28	<2.08	<1.04	<1.04	<6.2	<2.1	<10.4
85-281-2	84.6	298200		10.8	<9.3	39.1	<28	18.1	7.31	<1.9	<0.93	1.06	<1.86	<0.93	<0.93	<5.6	<1.9	<9.3

SAMPLE ID#	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
85-180-1	<28	<1.8	1710	3.08	<28	<9.2	<23	<28	3.8	140	<18
85-180-2	<26	<1.7	1680	2.47	<26	<8.5	<21	<25	2.6	150	<17
85-182-1	<28	<1.9	1340	<0.92	<28	<9.2	<23	<28	4.3	95	<18
85-182-2	<30	<2.0	1290	9.82	46	<9.8	<24	<29	4.9	145	<19
85-183-1	<29	<1.9	1270	<0.96	<29	<9.6	<24	<29	3.5	105	<19
85-183-2	<28	<1.9	1230	<0.94	<28	<9.4	<23	<28	<2.8		<19
85-198-1	<32	<2.1	1350	<1.06	<32	<10.6	<27	<32	<3.2	135	<21
85-198-2	<33	<2.2	1270	<1.11	<33	<11.1	<28	<33	3.5	145	<22
85-280-1	33	4.8	1220	<0.97	56	<9.7	<24	<29	4.5	140	<17
85-280-2	28	5.3	1310	<0.85	42	<8.5	<21	<26	5.0		<19
85-281-1	<31	<2.1	860	<1.04	82	<10.4	<26	<31	5.2	120	<19
85-281-2	<28	<1.9	829	<0.93	74	<9.3	<23	<28	5.0	120	<21

All values except WT% SOL. are in micrograms of constituent per gram of dissolved material
Values near the detection limit (d.l.) are often unreliable and should be viewed accordingly

TABLE 5

Dolomite Duplicates

SAMPLE ID#	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As
85-181-1	90.1	239900	7400	135000	354.0	337	31.4	166.0	1930	<1.9	92.3	<0.93	<1.86	<0.93	1.36	<d.l.
85-181-2	90.1	236900	3150	134600	336.0	335	<26.6	162.0	1870	<1.8	91.5	<0.89	<1.77	<0.89	1.64	<d.l.
85-199-1	92.9	240600	5690	132300	143.0	244	<26.9	56.8	1420	<1.8	64.9	<0.90	<1.79	<0.90	2.05	<d.l.
85-199-2	93.5	240500	7040	131800	121.0	262	<26.9	50.0	1370	<1.8	64.2	<0.90	<1.79	<0.90	1.22	<d.l.
85-201-1	54.9	288700	6700	134700	2800.0	1020	426.0	1470.0	3660	<3.0	176.0	<1.50	3.66	<1.50	6.43	<d.l.
85-201-2	58.9	272300	5050	126600	2480.0	982	417.0	1320.0	2960	<2.8	163.0	<1.41	3.96	<1.41	7.82	<d.l.
85-212-1	97.9	258500	2350	133200	169.0	311	<23.3	63.4	5120	<1.6	266.0	<0.78	<1.55	<0.78	11.50	<d.l.
85-212-2	98.1	252400	2100	130100	171.0	293	<21.5	56.9	5210	<1.4	266.0	<0.72	<1.43	<0.72	9.97	<d.l.
85-249-1	93.3	230800	6650	134300	106.0	367	<23.3	39.7	1000	<1.6	35.0	<0.78	<1.55	<0.78	<0.78	<d.l.
85-249-2	92.1	238200	4170	139000	133.0	366	<23.4	49.0	1090	<1.6	36.6	<0.78	<1.56	<0.78	<0.78	<d.l.
85-248-1	98.3	237300	16700	136100	82.8	244	<21.7	44.0	406	<1.4	37.8	<0.72	<1.44	<0.72	<0.72	<d.l.
85-248-2	97.7	237800	15500	136400	86.3	236	<22.0	40.8	393	<1.5	37.8	<0.73	<1.47	<0.73	<0.73	<d.l.
85-252-1	93.6	250800	2080	143000	43.6	591	<32.6	<10.8	344	<2.2	29.5	<1.08	<2.17	<1.08	3.50	<d.l.
85-252-2	93.3	250200	4140	145000	69.8	432	<23.5	26.7	422	<1.6	29.6	<0.78	<1.57	<0.78	2.42	<d.l.
85-254-1	96.1	260600	155	131800	24.4	201	<31.0	65.6	122	<2.1	21.4	<1.03	<2.07	<1.03	1.53	<d.l.
85-254-2	94.4	263300	136	134000	43.4	113	<22.6	83.3	150	<1.5	21.9	<0.75	<1.51	<0.75	<0.75	<d.l.
85-255-1	56.5	248600	370	130800	190.0	147	<37.0	134.0	903	<2.5	27.4	<1.23	<2.46	<1.23	4.12	<d.l.
85-255-2	58.1	252000	450	133000	357.0	146	<34.8	157.0	3160	<2.3	50.2	<1.16	11.00	<1.16	6.39	<d.l.

All values except WT% SOL. are in micrograms of constituent per gram of dissolved material
Values near the detection limit (d.l.) are often unreliable, view accordingly

TABLE 6

Limestone Duplicates

SAMPLE ID#	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V	Pb
85-208-1	93.5	472600	1630	1960	22.3	258	<27	<8.9	116	<1.8	39.8	<0.89	<1.8	<0.9	6.7	<5.4	<1.8	<8.9
85-208-2	97.9	465300	1520	2010	14.0	303	<32	<10.5	107	<2.1	38.1	<1.05	<2.1	<1.1	3.2	<6.3	<2.1	<10.5
85-243-1	98.9	424800	501	3600	18.0	127	<26	<8.8	188	<1.8	42.6	<0.88	<1.8	<0.9	9.3	<5.3	<1.8	<8.8
85-243-2	98.1	442900	438	3780	16.4	181	<30	<10.1	162	<2.0	43.6	<1.01	<2.0	<1.0	9.0	<6.0	<2.0	<10.1
85-345-1	79.6	444900	683	4200	183.0	152	<37	61.9	2530	<2.5	691.0	<1.23	5.8	<1.2	8.5	<7.4	4.7	<12.3
85-345-2	78.6	448300	507	4230	180.0	120	<38	40.3	2500	<2.5	700.0	<1.25	<2.5	<1.3	6.7	<7.5	3.3	<12.5
85-348-1	69.0	445900		3880	152.0	199	<43	78.5	1920	<2.9	993.0	<1.43	<2.9	<1.4	14.5	<8.6	3.2	<14.3
85-348-2	68.8	456300		3970	127.0	161	<43	56.3	1950	<2.9	1010.0	<1.44	<2.9	<1.4	14.4	<8.6	<2.9	<14.4

SAMPLE ID#	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
85-208-1	36	<1.8	1840	<0.9	<27	<8.9	<22	<27	2.7	220	<18
85-208-2	38	<2.1	1850	<1.1	<32	<10.5	<26	<32	<3.2	160	<18
85-243-1	<26	<1.8	278	1.4	<26	<8.8	26	<26	2.8	300	<18
85-243-2	<30	<2.0	289	<1.0	<30	<10.1	26	<30	4.0	300	<18
85-345-1	<37	<2.5	782	31.3	<37	<12.3	58	<37	22.2	200	<25
85-345-2	<38	<2.5	757	24.4	<38	<12.5	52	<38	18.6	160	<25
85-348-1	<43	<2.9	381	897.0	<43	<14.3	<36	<43	31.3	180	<29
85-348-2	<43	<2.9	397	906.0	<43	<14.4	<36	<43	28.8		<29

All values except WT% SOL. are in micrograms of constituent per gram of dissolved material
Values near the detection limit are often unreliable and should be viewed accordingly

TABLE 6 (cont.)

Dolomite Duplicates (cont.)

SAMPLE ID#	V	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
85-181-1	1.87	<d.l.	<28	<d.l.	1210.0	40.60	<d.l.	<d.l.	63.1	<d.l.	<d.l.	490	<d.l.
85-181-2	2.08	<d.l.	<27	<d.l.	1260.0	42.10	<d.l.	<d.l.	68.0	<d.l.	<d.l.	350	<d.l.
85-199-1	2.78	<d.l.	<27	<d.l.	79.3	<0.90	<d.l.	<d.l.	<22	<d.l.	<d.l.	450	<d.l.
85-199-2	2.84	<d.l.	32	<d.l.	85.0	<0.90	<d.l.	<d.l.	<22	<d.l.	<d.l.	510	<d.l.
85-201-1	3.85	<d.l.	<45	<d.l.	304.0	6.33	<d.l.	<d.l.	419.0	<d.l.	<d.l.	540	<d.l.
85-201-2	<2.83	<d.l.	<43	<d.l.	293.0	5.86	<d.l.	<d.l.	390.0	<d.l.	<d.l.	520	<d.l.
85-212-1	3.85	<d.l.	<23	<d.l.	79.3	1.20	<d.l.	<d.l.	19.6	<d.l.	<d.l.	620	<d.l.
85-212-2	1.83	<d.l.	<22	<d.l.	78.7	1.31	<d.l.	<d.l.	<18	<d.l.	<d.l.	600	<d.l.
85-249-1	5.07	<d.l.	<23	<d.l.	164.0	4.61	<d.l.	<d.l.	<19	<d.l.	<d.l.	320	<d.l.
85-249-2	4.85	<d.l.	<23	<d.l.	147.0	1.07	<d.l.	<d.l.	<20	<d.l.	<d.l.	300	<d.l.
85-248-1	4.62	<d.l.	<22	<d.l.	431.0	9.82	<d.l.	<d.l.	<18	<d.l.	<d.l.	220	<d.l.
85-248-2	5.08	<d.l.	<22	<d.l.	284.0	14.40	<d.l.	<d.l.	<18	<d.l.	<d.l.	210	<d.l.
85-252-1	24.60	<d.l.	<33	<d.l.	93.9	1.52	<d.l.	<d.l.	<27	<d.l.	<d.l.	440	<d.l.
85-252-2	25.40	<d.l.	<24	<d.l.	97.5	<0.78	<d.l.	<d.l.	31.1	<d.l.	<d.l.	680	<d.l.
85-254-1	2.71	<d.l.	<31	<d.l.	64.8	<1.03	<d.l.	<d.l.	<26	<d.l.	<d.l.	470	<d.l.
85-254-2	2.82	<d.l.	<23	<d.l.	64.5	<0.75	<d.l.	<d.l.	<19	<d.l.	<d.l.	370	<d.l.
85-255-1	3.27	<d.l.	<37	<d.l.	62.6	<1.23	<d.l.	<d.l.	<31	<d.l.	<d.l.	500	<d.l.
85-255-2	6.76	<d.l.	<35	<d.l.	62.8	<1.16	<d.l.	<d.l.	<29	<d.l.	<d.l.	420	<d.l.

All values except WT% SOL. are in micrograms of constituent per gram of dissolved material
Values near the detection limit (d.l.) are often unreliable, view accordingly

TABLE 7

STATISTICS OF THE WOLFCAMP CONTROL SAMPLES

SAMPLE ID#	WT% SOL.	Ca	SO4	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V
CS1-1	96.3	448000	870	10690	< 9.4	169	<28	< 9.4	62.9	<1.87	13.8	<0.94	<1.87	<0.94	13.80	<5.61	2.59
CS1-2	97.3	443900	715	10660	< 9.4	181	<28	< 9.4	66.3	<1.87	13.7	<0.94	<1.87	<0.94	14.20	<5.61	2.96
CS1-3	98.0	451100	671	10900	<10.2	178	<31	<10.2	61.9	<2.03	13.7	<1.02	<2.03	<1.02	6.28	<6.10	<2.03
CS1-4	97.8	442200	619	10590	<10.3	190	<31	<10.3	61.8	<2.06	13.4	<1.03	<2.06	<1.03	6.63	<6.19	<2.06
CS1-5	97.9	448200	691	10870	<10.0	189	<30	<10.0	65.0	<2.00	13.6	<1.00	<2.00	<1.00	6.18	<6.01	2.78
CS1-6	98.2	442900	639	10640	<10.1	194	<30	<10.1	63.5	<2.03	13.5	<1.01	<2.03	<1.01	6.41	<6.08	3.45
COUNT	6.0	6	6	6	0	6	0	0	6.0	0	6.0	0	0	0	6.00	0	4.00
MEAN	97.6	446050	701	10725		183			63.6		13.6				8.92		2.95
STDEV	0.7	3558	90	128		9			1.8		0.1				3.94		0.37
RSD	0.7	0.8	13	1.2		5.0			2.8		1.1				44		13
CS2-1	100.0	309700		1950	30	101	<39	44	44.6	<2.59	<1.29	<1.29	<2.59	<1.29	8.95	<7.8	<2.59
CS2-2	100.0	308500		2000	35	92	<41	48	47.0	<2.69	<1.35	<1.35	<2.69	<1.35	11.50	<8.1	<2.69
CS2-A	99.7	316300		1960	41	77	<31	36	57.2	<2.03	1.1	<1.01	<2.03	<1.01	2.19	<6.1	2.15
CS2-B	100.0	315600		1940	46	110	<31	54	55.2	3.7	1.3	2.3	<2.02	<1.01	2.60	<6.1	2.88
CS2-3	85.4	304000		1740	47	103	<28	49	49.2	<1.85	1.0	<0.93	<1.85	<0.93	4.17	<5.6	1.93
CS2-4	88.3	296000		1600	41	89	<27	53	45.8	2.1	1.0	1.4	<1.77	<0.89	2.87	<5.3	2.39
COUNT	6.0	6	0	6	6	6	0	6	6.0	2	4.0	2	0	0	6.00	0	4.00
MEAN	95.6	308350		1865	40	95		47	49.8	2.9	1.1	1.9			5.38		2.34
STDEV	6.8	7603		159	6	12		7	5.2	1.2	0.1	0.6			3.90		0.41
RSD	7.1	2.5		8.5	16	12		14	10	40	13	33			72		17
CS3-1	93.8	240900		132400	554	343	<29	171	961.0	<1.96	35.2	<0.98	<1.96	<0.98	7.59	<5.9	2.57
CS3-2	91.5	243700		135700	533	265	<31	149	998.0	<2.05	36.2	<1.03	<2.05	<1.03	4.26	<6.2	<2.05
CS3-3	92.7	233500		127500	525	250	<26	154	973.0	<1.73	33.8	<0.87	<1.73	<0.87	<0.87	<5.2	<1.73
CS3-4	93.3	242600		131900	531	279	<26	161	999.0	<1.71	35.2	<0.86	<1.71	<0.86	<0.86	<5.2	<1.71
CS3-5	92.9	244900		133900	510	290	<26	160	989.0	<1.72	35.3	<0.86	<1.72	<0.86	<0.86	<5.2	<1.72
CS3-6	93.8	237800		130400	488	283	<26	151	975.0	<1.73	34.9	<0.87	<1.73	<0.87	<0.87	<5.2	2.60
COUNT	6.0	6	0	6	6	6	0	6	6.0	0	6.0	0	0	0	2.00	0	2.00
MEAN	93.0	240567		131967	523	285		158	982.5		35.1				5.93		2.59
STDEV	0.9	4253		2838	22	32		8	15.3		0.8				2.35		
RSD	0.9	1.8		2.2	4.3	11		5.1	1.6		2.2				40		

TABLE 7 (cont.)

STATISTICS (CONT.)

SAMPLE ID#	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La	Cl	Br
CS1-1	< 9.4	<28	<1.9	259	<0.94	<28	< 9.4	153	<28	3.81	310	<19
CS1-2	< 9.4	<28	<1.9	234	<0.94	<28	< 9.4	157	<28	<2.80	310	<19
CS1-3	<10.2	<31	<2.1	251	<1.02	<31	<10.2	155	<31	<3.05	250	<20
CS1-4	<10.3	<31	<2.1	257	<1.03	<31	<10.3	153	<31	<3.09	240	<20
CS1-5	<10.0	<31	<2.0	256	<1.00	<31	<10.0	164	<31	<3.01	260	
CS1-6	<10.1	<31	<2.1	250	<1.01	<31	<10.1	162	<31	<3.04	270	<20
COUNT	0	0	0	6	0	0	0	6	0	1.00	6	0
MEAN				251				157		3.81	273	
STDEV				9				5			30	
RSD				3.6				3.0			11	
CS2-1	<12.9	<39	<2.5	1250	<1.29	<39	<12.9	<32	<39	4.07	225	<26
CS2-2	<13.5	<41	<2.6	1220	<1.35	54	<13.5	<34	<41	<4.04	200	<27
CS2-A	<10.1	<31	<2.0	1230	<1.01	<31	<10.1	<26	<31	3.23	160	<19
CS2-B	<10.1	<31	4.0	1190	<1.01	110	<10.1	<26	<31	5.94		<18
CS2-3	< 9.3	<28	1.9	1180	<0.93	46	< 9.3	<24	<28	4.04	91	<20
CS2-4	< 8.9	<27	2.5	1110	<0.89	69	< 8.9	<23	<27	4.65	130	<20
COUNT	0	0	3	6	0	4	0	0	0	5.00	5	0
MEAN			2.8	1197		70				4.39	161	
STDEV			1.0	50		28				1.01	54	
RSD			37	4.2		41				23	33	
CS3-1	< 9.8	<29	<1.9	191	3.4	<29	< 9.8	<25	<30	<2.94	350	<20
CS3-2	<10.3	<31	<2.0	148	<1.03	<31	<10.3	<26	<31	<3.08	280	<19
CS3-3	< 8.7	<26	<1.7	205	<0.87	<26	< 8.7	<22	<26	<2.60	40	<18
CS3-4	< 8.6	<26	<1.7	231	<0.86	<26	< 8.6	<22	<26	<2.57	240	<17
CS3-5	< 8.6	<26	<1.7	223	1.0	<26	< 8.6	<22	<26	<2.58	230	<18
CS3-6	< 8.7	<26	<1.7	192	<0.87	<26	< 8.7	<22	<26	<2.60	300	<18
COUNT	0	0	0	6	2	0	0	0	0	0.00	6	0
MEAN				198	2.2						240	
STDEV				29	1.7						107	
RSD				15	77						45	

TABLE 8

ICP Calibration: 1. WOLFCAMP TRACE ELEMENT STUDY
2. all solutions are dilute nitric acid (0.5N)

Element (#)	Solution # 1	2	3	4	5	6	7	8	9	ATTEN. setting	LQC (sol.)
Na (1)	0	-	-	-	100	500	1000	-	-	10-4	0.65
K (2)	0	20	-	50	100	-	-	-	-	11-1	1.41
Mg (3)	0	-	-	50	100	500	1000	3000	-	10-3	0.19
Ca (17)	0	-	-	-	100	500	1000	3000	6000	5-9	0.22
Al (5)	0	20	-	50	100	-	-	-	-	8-9	0.41
Fe (6)	0	20	-	50	100	-	-	-	-	9-9	0.02
Ti (7)	0	20	-	50	100	-	-	-	-	9-6	0.06
Mn (11)	0	20	-	50	100	-	-	-	-	10-2	0.01
Co (8)	0	20	-	-	-	-	-	-	-	10-8	0.03
Cr (9)	0	20	-	-	-	-	-	-	-	10-7	0.03
Cu (10)	0	20	-	-	-	-	-	-	-	9-9	0.04
Ni (12)	0	20	-	-	-	-	-	-	-	10-9	0.06
Mo (13)	0	20	-	-	-	-	-	-	-	11-3	0.05
Zn (14)	0	20	-	-	-	-	-	-	-	11-10	0.03
As (15)	0	20	-	-	-	-	-	-	-	10-7	0.25
Cd (16)	0	20	-	-	-	-	-	-	-	11-3	0.04
V (4)	0	20	-	-	-	-	-	-	-	8-9	0.08
Pb (18)	0	-	20	-	-	-	-	-	-	10-3	0.32
Sb (19)	0	-	20	-	-	-	-	-	-	11-7	1.06
Se (20)	0	20	-	-	-	-	-	-	-	11-11	1.21
Sn (21)	0	-	20	-	-	-	-	-	-	10-7	0.10
Li (22)	0	20	-	-	-	-	-	-	-	9-8	0.07
Be (23)	0	20	-	-	-	-	-	-	-	10-3	0.004
Sr (24)	0	20	-	50	100	500	-	-	-	7-3	0.03
Ba (25)	0	20	-	-	-	-	-	-	-	8-6	0.01
Zr (26)	0	20	-	-	-	-	-	-	-	10-4	0.03
U (27)	0	20	-	-	-	-	-	-	-	8-4	1.14
Th (28)	0	20	-	-	-	-	-	-	-	9-2	0.28
B (29)	0	20	-	-	-	-	-	-	-	10-5	0.06
P (30)	0	-	20	-	-	-	-	-	-	10-8	1.10
Ce (31)	0	-	-	50	-	-	-	-	-	7-7	0.81
La (32)	0	-	20	-	-	-	-	-	-	9-4	0.07
Si (33)	0	-	-	50	-	-	-	-	-	10-5	0.33

LQDC - lowest quantifiable concentration (in solution)

Table 9.

EPA ICAP23
CERTIFIED SOLUTION

Element	Found(*) (ug/mL)	Certified (ug/mL)
Ca	1.07	1.0
SO_4		
Mg	1.14	1.0
Si		
Na	2.0	1.0
K	10.3	10.0
Al	1.20	1.0
Fe	1.03	1.0
Ti	1.01	1.0
Mn	1.02	1.0
Cu	1.01	1.0
Ni	1.01	1.0
Mo	1.17	1.2
Zn	1.02	1.0
As	1.25	1.0
V	0.99	1.0
Pb	0.90	1.0
Se	0.77	1.0
Li		
Sr		
Ba	1.24	1.0
U		
Th		
P		
Ce		
La		
Cl		
Br		

*Values presented are the average of four measurements.

TABLE 10

Dolomite referee sample

STATISTIC	Ca	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V	Pb	Se
	224400	127500	2140	363	270	821	2990	7.1	147	<0.90	<1.80	<0.90	3.59	<5.40	3.95	<9.00	<27
	226100	128900	2170	385	324	842	3020	11.1	147	2.60	2.20	<0.90	3.86	<5.40	5.28	<9.00	<27
	227500	129900	2170	390	349	859	3030	11.3	148	3.10	3.01	<0.90	4.34	<5.40	7.25	<9.00	<27
	226200	129100	2160	384	259	833	3010	7.4	147	2.16	<1.80	<0.90	3.87	<5.40	3.58	<9.00	<27
	226400	129000	2160	368	242	819	3010	4.9	148	<0.90	<1.80	<0.90	3.40	<5.40	<1.80	<9.00	<27
	230700	131700	2120	404	266	826	2970	9.7	146	3.54	<1.80	<0.90	4.68	<5.40	3.58	<9.00	<27
	232000	133300	2120	407	320	846	2990	11.6	147	4.52	2.56	<0.90	5.04	<5.40	5.47	<9.00	<27
	219600	124600	2080	378	277	812	2900	8.8	144	3.00	<1.80	<0.90	4.04	<5.40	4.43	<9.00	<27
	219400	124800	2090	370	255	811	2910	6.9	144	1.83	<1.80	<0.90	3.49	<5.40	4.80	<9.00	<27
COUNT	9	9	9	9	9	9	9	9.0	9	7.00	3.00	0	9.00	0.0	8.00	0.0	0
MEAN	225811	128756	2134	383	285	830	2981	8.8	146	2.96	2.59		4.03		4.79		
STDEV	4291	2857	34	15	37	16	47	2.3	2	0.90	0.41		0.56		1.23		
RSD	2	2	2	4	13	2	2	26.6	1	30.3	15.7		13.8		25.6		

STATISTIC	Li	Sr	Ba	U	Th	P	Ce	La
	<1.80	103.0	1.75	<27	<9.0	86.0	<27	<2.70
	<1.80	110.0	2.23	<27	<9.0	88.8	<27	<2.70
	2.10	106.0	2.41	<27	<9.0	97.8	<27	<2.70
	<1.80	107.0	1.98	<27	<9.0	95.0	<27	<2.70
	<1.80	104.0	1.64	<27	<9.0	93.1	<27	<2.70
	<1.80	108.0	2.27	<27	<9.0	83.7	<27	<2.70
	2.74	110.0	2.61	<27	<9.0	98.7	<27	<2.70
	<1.80	105.0	2.14	<27	<9.0	94.5	<27	<2.70
	<1.80	107.0	1.97	<27	<9.0	95.3	<27	<2.70
COUNT	2.00	9.0	9.00	0	0.0	9.0	0	0
MEAN	2.42	106.7	2.11			92.5		
STDEV	0.45	2.4	0.31			5.2		
RSD	18.7	2.3	14.7			5.6		

'<' data not included in the statics calculations

TABLE 11

Dolomite Referee Sample #2

STATISTIC	Ca	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V	Pb
	281200	141500	1240	303	<30.	229	5490	<2.00	278	<1.00	<2.00	<1.00	33.40	<6.00	<2.00	<10.0
	279300	140500	1220	290	<30.	218	5450	<2.00	275	<1.00	<2.00	<1.00	31.80	<6.00	<2.00	<10.0
	278300	140400	1230	295	<30.	224	5450	<2.00	274	<1.00	<2.00	<1.00	32.00	<6.00	<2.00	<10.0
	274600	138000	1210	285	<30.	212	5380	<2.00	270	<1.00	<2.00	<1.00	31.50	<6.00	<2.00	<10.0
	277300	139600	1230	231	<30.	236	5560	<2.00	278	<1.00	2.02	<1.00	33.10	<6.00	<2.00	<10.0
	272200	137600	1230	320	<30.	269	5750	<2.00	290	<1.00	<2.00	<1.00	31.80	<6.00	3.33	<10.0
COUNT	6	6	6	6	0	6	6	0.00	6	0.00	1.00	0.00	6.00	0.00	1.00	0.00
MEAN	277150	139600	1227	287		231	5513		278		2.02		32.27		3.33	
STDEV	3267	1524	10	30		20	130		7				0.78			
RSD	1	1	0	11		9	2		2				2.4			

STATISTIC	Se	Li	Sr	Ba	U	Th	P	Ce	La
	<30.0	<2.00	91	<1.00	<30.	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	91	<1.00	<30.	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	87	<1.00	<30.	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	87	<1.00	<30.	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	82	1.10	<30.	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	82	1.36	<30.	<10.0	37.5	<30.0	<3.00
COUNT	0.0	0.00	6	2.00	0	0.0	1.0	0	0.00
MEAN			87	1.23			37.5		
STDEV			4	0.18					
RSD			5	15.0					

'<' data not included in statistical analyses

TABLE 12

Dolomite Referee Sample #3

STATISTIC	Ca	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V	Pb
	282400	142300	1220	320	<30	256	5930	<2.00	298	<1.00	<2.00	<1.00	33.50	<6.00	<2.00	<10.0
	279700	141200	1220	332	<30	272	5860	<2.00	296	<1.00	2.24	<1.00	33.60	<6.00	<2.00	<10.0
	280700	141000	1200	334	<30	267	5870	<2.00	296	<1.00	<2.00	<1.00	33.30	<6.00	2.32	<10.0
	279200	142600	1200	321	<30	268	5830	<2.00	294	<1.00	<2.00	<1.00	33.70	<6.00	2.36	<10.0
	277900	142400	1200	335	<30	276	5810	<2.00	293	<1.00	3.11	<1.00	33.70	<6.00	4.04	<10.0
	281600	141500	1240	299	<30	244	5650	<2.00	286	<1.00	<2.00	<1.00	32.80	<6.00	<2.00	<10.0
	278800	141000	1230	281	<30	240	5590	<2.00	284	<1.00	<2.00	<1.00	32.50	<6.00	<2.00	<10.0
	277700	140200	1210	278	<30	236	5560	<2.00	283	<1.00	<2.00	<1.00	32.30	<6.00	<2.00	<10.0
COUNT	8	8	8	8	0	8	8	0.00	8	0.00	2.00	0.00	8.00	0.0	3.00	0.0
MEAN	279750	141525	1215	313		257	5762		291		2.67		33.18		2.91	
STDEV	1698	840	15	23		16	141		6		0.62		0.56		0.98	
RSD	0	0	1	7		6	2		2		23.0		1.7		33.8	

STATISTIC	Se	Li	Sr	Ba	U	Th	P	Ce	La
	<30.0	<2.00	88.4	1.10	<30	<10.0	25.3	<30.0	<3.00
	<30.0	<2.00	84.6	1.22	<30	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	86.3	1.06	<30	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	81.0	1.27	<30	<10.0	40.8	<30.0	<3.00
	31.4	<2.00	82.4	1.56	<30	<10.0	40.7	<30.0	<3.00
	<30.0	<2.00	90.8	<1.00	<30	<10.0	<25.0	<30.0	<3.00
	<30.0	<2.00	86.1	<1.00	<30	<10.0	26.8	<30.0	<3.00
	<30.0	<2.00	87.5	<1.00	<30	<10.0	<25.0	<30.0	<3.00
COUNT	1.0	0.00	8.0	5.00	0	0.0	4.0	0.0	0.00
MEAN	31.4		85.9	1.24			33.4		
STDEV			3.2	0.20			8.5		
RSD			3.7	15.9			25.5		

'<' data not included in statistical analyses

TABLE 13

Comparison of Results from Treatment with NH4OAC

SAMPLE ID#	NH4OAC TRTMNT	Ca	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V
85-176	YES	237100	133900	438	364	<25	214	1850	<d.l.	144.0	<d.l.	<1.64	<d.l.	1.41	<d.l.	3.39
85-176	NO	261100	142900	737	524	270	348	2230	<d.l.	155.0	<d.l.	<2.45	<d.l.	2.24	<d.l.	<2.45
85-228	YES	241400	120300	176	181	<28	138	2550	<d.l.	79.4	<d.l.	3.75	<d.l.	2.35	<d.l.	21.10
85-228	NO	273700	128200	212	364	<38	150	3250	<d.l.	88.0	<d.l.	6.49	<d.l.	2.74	<d.l.	20.30
85-325	YES	234900	138700	273	373	<24	143	1870	<d.l.	120.0	<d.l.	<1.59	<d.l.	<0.80	<d.l.	6.34
85-325	NO	263800	151200	432	888	<36	180	2200	<d.l.	128.0	<d.l.	<2.43	<d.l.	1.25	<d.l.	5.48
Bentonite.05	YES	256600	144400	314	453	<23	122	807	<d.l.	71.2	<d.l.	<1.54	<d.l.	<0.77	<d.l.	<1.54
Bentonite.05	NO	261400	146300	320	652	<34	122	821	<d.l.	73.4	<d.l.	<2.27	<d.l.	<1.13	<d.l.	<2.27

SAMPLE ID#	Pb	Se	Li	Sr	Ba	U	Th	P	Ce	La
85-176	<d.l.	<d.l.	<d.l.	142.0	1.96	<d.l.	<d.l.	87.1	<d.l.	<d.l.
85-176	<d.l.	<d.l.	<d.l.	275.0	4.99	<d.l.	<d.l.	50.1	<d.l.	<d.l.
85-228	<d.l.	<d.l.	<d.l.	2610.0	29.70	<d.l.	<d.l.	<24	<d.l.	<d.l.
85-228	<d.l.	<d.l.	<d.l.	3520.0	35.90	<d.l.	<d.l.	<31	<d.l.	<d.l.
85-325	<d.l.	<d.l.	<d.l.	148.0	8.67	<d.l.	<d.l.	36.3	<d.l.	<d.l.
85-325	<d.l.	<d.l.	<d.l.	266.0	13.10	<d.l.	<d.l.	<30	<d.l.	<d.l.
Bentonite.05	<d.l.	<d.l.	<d.l.	49.5	<0.77	<d.l.	<d.l.	<19	<d.l.	<d.l.
Bentonite.05	<d.l.	<d.l.	<d.l.	55.1	1.87	<d.l.	<d.l.	<28	<d.l.	<d.l.

All values are in micrograms per gram of dissolved material
Values near the detection limit (d.l.) are often unreliable, view accordingly

TABLE 14

Elements found in NH4OAC Solution

SAMPLE ID #	Ca	Mg	Si	Na	K	Al	Fe	Ti	Mn	Cu	Ni	Mo	Zn	As	V	Pb	Se	Li	Sr
1 CS1	22200	207	<8	<13	<25	<8	<0.9	<1.7	<0.9	<0.9	<1.7	<0.9	1.8	<5	<1.7	<9	<25	<1.7	19
2 CS2	118200	43	<6	<9	<17	<6	<0.6	<1.1	<0.6	<0.6	<1.1	<0.6	4.5	<4	<1.1	<6	17	<1.1	523
3 CS3	46600	1570	46	<10	<20	<7	<0.7	<1.4	1.2	<0.7	<1.4	<0.7	1.5	<4	<1.4	<7	<20	<1.4	655
4 85-180	125100	83	<6	13	<17	<6	<0.6	<1.1	<0.6	1.0	<1.1	<0.6	2.1	<4	<1.1	<6	19	<1.1	650
5 85-190	127000	20	<6	<9	<17	<6	<0.6	<1.1	<0.6	0.9	<1.1	<0.6	1.8	<4	<1.1	<6	19	<1.1	559
6 85-200	88100	245	28	33	32	<6	<0.6	1.3	3.5	1.4	<1.1	<0.6	1.2	<4	<1.1	<6	25	<1.1	312
7 85-211	113400	89	<6	<9	<17	<6	<0.6	<1.2	<0.6	1.1	<1.1	<0.6	3.0	<4	<1.1	<6	26	<1.1	425
8 85-178	4540	2160	31	74	122	20	<0.7	4.4	2.3	4.6	4.4	2.0	<0.7	13	<1.4	<7	28	3.2	14
9 85-179	5230	2840	40	155	174	19	<0.7	3.5	2.2	4.8	3.3	2.1	0.8	12	<1.4	<7	29	3.0	20
10 85-181	6360	2110	28	55	43	<7	<0.7	<1.3	2.9	1.6	<1.4	<0.7	<0.7	<4	<1.4	<7	<20	<1.4	450
11 85-201	6590	2340	52	465	308	<7	<0.7	<1.3	4.3	<0.7	<1.4	<0.7	<0.7	<4	<1.4	<7	<20	<1.4	11
12 85-197	23200	291	18	320	<25	<9	<0.9	<1.7	2.2	5.2	<1.7	<0.9	7.4	<5	<1.7	<9	<25	<1.7	18
13 85-202	22800	194	14	89	<25	<9	<0.9	<1.7	2.9	4.6	<1.7	<0.9	4.9	<5	<1.7	<9	<25	<1.7	1190
14 85-204	22900	296	25	86	<25	<9	<0.9	<1.7	2.7	4.2	<1.7	<0.9	4.2	<5	<1.7	<9	<25	<1.7	19
15 85-208	19600	84	11	128	<25	<9	<0.9	<1.7	2.7	5.4	<1.7	<0.9	6.8	<5	<1.7	<9	<25	<1.7	51

SAMPLE ID #	Ba	U	Th	P	Ce	La
1 CS1	<0.9	<25	<9	<21	<25	<2.5
2 CS2	<0.6	<17	<6	<14	<17	<1.7
3 CS3	<0.7	<20	<7	<17	<20	<2.0
4 85-180	7.8	30	<6	<14	<17	2.4
5 85-190	<0.6	25	<6	<14	<17	2.4
6 85-200	<0.6	44	<6	15	<17	2.7
7 85-211	<0.6	41	<6	<14	<17	2.8
8 85-178	1.1	52	15	30	<20	3.9
9 85-179	2.4	65	13	34	<20	2.7
10 85-181	13.6	<20	<7	<17	<20	<2.0
11 85-201	<0.7	<20	<7	<17	<20	<2.0
12 85-197	<0.9	<25	<9	26	<25	<2.5
13 85-202	33.1	<25	<9	28	<25	<2.5
14 85-204	<0.9	<25	<9	<21	<25	<2.5
15 85-208	<0.9	<25	<9	27	<25	<2.5

All values are in micrograms per gram of dried whole sample
Values near the detection limit are sometimes unreliable, view accordingly

PART II

$\delta^{13}C$ and $\delta 180$ ANALYSES OF

CALCITE AND DOLOMITE

ANALYSES PREPARED BY LYNTON LAND

THE UNIVERSITY OF TEXAS AT AUSTIN

AND COASTAL SCIENCE LABORATORIES

AUSTIN, TEXAS

ASSISTED BY: HARRY H. POSEY AND JEFFREY N. RUBIN

Dolomite mudstone, lime mudstone, calcite fossil replacements, and calcite vein fills were analyzed for $\delta^{13}C$ and $\delta^{18}O$ using conventional methods (see Craig, 1953). All data are reported in per mil values relative to the PDB standard and are considered precise to within 0.2 o/oo. Replicate analyses are shown on the table and discrepant analyses are discussed. Large intra-sample variations are noted in several samples, and operator notes suggest that hydrocarbons may be present in some of these samples. Other intra- and interlaboratory variations were found but are not well understood. Therefore, accuracy of the data may be some value less than reported.

TABLE 15.

$d^{13}C$ AND $d^{18}O$: WOLFCAMP AND WICHITA CARBONATES

SAMPLE		$d^{13}C$	$d^{18}O$	LAB	DATE	
D 2862.0	Dol	+1.48 ±.08	+2.28 ±.11 $	LL	12-17-84	
D 2943.9	Dol	+3.76 ±.13	+2.19 ±.44 *	LL	12-17-84	
" "	"	+3.71 ±.04	+0.68 ±.03 $	LL	07-10-85	
D 3012.7	Dol	+4.7	+1.0 ¶	CSL	07-31-85	
" "	"	+5.0	+0.8 ¶	"	" " "	
D 3084.8	Dol	-0.89 ±.08	-0.86 ±.07 $	LL	12-17-84	
D 3084.9	Dol	-0.5	-1.5 ¶	CSL	07-31-85	
" "	"	-0.4	-1.5 ¶	"	" " "	
D 3089.0	LS	-0.73 ±.05	-3.23 ±.17 $	LL	12-17-84	
" "	"	-0.7	-3.6 ¶	CSL	07-31-85	
" "	"	-0.6	-3.8 ¶	"	" " "	
D 3145.0	Dol	+2.96 ±.05	+1.15 ±.04 $	LL	12-17-85	
D 3168.1	LS	-2.92 ±.07	-3.07 ±.10 $	LL	12-17-84	
D 3168.8	LS	-2.30 ±.07	-2.57 ±.06 $	LL	06-18-85	
D 3189.0	Dol	+2.88 ±.03	-1.15 ±.22 $	LL	12-17-84	
D 3199.0	LS	+3.8	-2.9 ¶	CSL	07-31-85	
D 3199.0	Cc	+3.9	-2.9 ¶	CSL	07-31-85	
D 3206.8	LS	+1.89 ±.03	-3.07 ±.05 $	LL	12-17-84	
D 3226.6B	LS	+4.28 ±.02	-2.58 ±.04 $	LL	12-17-84	
D 3250.4	LS	-1.78 ±.40	-4.35 ±.17 *	LL	07-15-85	C drift;
" "	"	-2.50 ±.90	-4.34 ±.19 *	"	" " "	O = ok.
" "	"	-2.54 ±.91	-4.39 ±.16 *	"	" " "	
D 3254.3	LS	0.00 ±.52	-4.47 ±.48 *	LL	06-11-85	Hi error
" "	"	-0.02 ±.60	-4.34 ±.54 *	"	" " "	" "
" "	"	+0.25 ±.20	-5.06 ±.22 $	LL	06-18-85	
D 3279.5	LS	-1.57 ±.23	-3.44 ±.13 $	LL	07-15-85	
D 3305.8	LS	+0.61 ±.04	-3.58 ±.07 $	LL	12-17-84	
" "	"	+0.61 ±.06	-3.92 ±.09 $	LL	06-11-85	
" "	"	+0.61	-3.75 $$			

$,* See notes, last page

TABLE 15 (cont.).

SAMPLE		$d^{13}C$	$d^{18}O$	LAB	DATE	
JF 5564.9	Dol	+5.44 ±.08	+3.06 ±.09 $	LL	12-17-84	
JF 5615.8	Dol	+4.69 ±.05	+3.16 ±.06 $	LL	12-17-84	
JF 5627.9	Dol	+4.44 ±.07	+2.48 ±.02 $	LL	06-18-84	
" "	"	+4.62	+4.21 *	LL	07-10-85	Hi drift
JF 5653.3	Dol	+4.21 ±.10	+3.72 ±.29 *	LL	07-10-85	Hi drift
" "	"	+4.52 ±.12	+1.59 ±1.3 *	"	" " "	" "
" "	"	+4.45 ±.07	+0.50 ±.10 *	"	" " "	" "
" "	"	+4.5	+1.6 ¶	CSL	07-31-85	
JF 5665.7	Dol	+5.34 ±.07	+2.85 ±.06 $	LL	12-17-84	
" "	"	+5.37 ±.05	+2.61 ±.05 $	LL	06-18-85	
JF 5711.9	Dol	+5.1	-1.7 ¶	CSL	07-31-85	
" "	"	+5.3	-1.6 ¶	CSL	07-31-85	
JF 5723.9	Dol	+7.99 ±.12	-0.41 ±.06 *	LL	06-18-85	
" "	"	+5.44 ±.10	-0.50 ±.09 $	LL	07-10-85	
JF 5737.1	LS	+4.86 ±.16	-1.64 ±.20 $	LL	06-11-85	
" "	"	+4.98 ±.10	-1.56 ±.07 $	"	" " "	
" "	"	+4.92	-1.60 $$			
JF 5786.2	LS	+4.37 ±.07	-2.69 ±.14 $	LL	06-11-85	
" "	"	+4.44 ±.07	-2.84 ±.12 $	"	" " "	
JF 5801.0	LS	+4.01 ±.11	-4.64 ±.13 $	LL	12-17-84	
JF 5824.4	LS	+5.13 ±.10	-3.58 ±.07 $	LL	06-11-85	
" "	"	+6.15 ±.43	-2.75 ±.35 *	LL	07-15-85	
" "	"	+7.41 ±.64	-3.11 ±.40 *	"	" " "	
" "	"	+5.78 ±.44	-3.13 ±.47 *	"	" " "	
" "	"	+5.5	-3.1 ¶	CSL	07-31-85	
" "	"	+5.6	-2.8 ¶	"	" " "	
JF 5915.9	LS	+4.85 ±.01	-2.38 ±.04 $	LL	07-15-85	
" "	"	+5.3	-2.4 ¶	CSL	07-31-85	
" "	"	+5.2	-2.6 ¶	"	" " "	
" "	"	+5.87 ±.08	-1.47 ±.08 *	LL	06-08-85	
JF 5958.7	LS	+3.7	-2.5 ¶	CSL	07-31-85	
JF 5958.7	Cc	+2.9	-2.8 ¶	CSL	07-31-85	

$,*,¶ See notes, last page.

TABLE 15 (cont.).

SAMPLE		$d^{13}C$	$d^{18}O$		LAB	DATE	
M 4435.6	DOL	+3.8	+0.6	¶	CSL	07-31-85	
M 4527.0	DOL	+4.9	-1.8	¶	CSL	07-31-85	
" "	"	+4.9	-1.7	¶	"	" " "	
M 4540.6	LS	+6.95 ±.17	-2.94 ±.08	$	LL	04-03-85	
M 4789.0	CC	+4.6	-4.1	*	LL	07-10-85	
" "	"	+4.06 ±.14	-4.41 ±.14	$	LL	07-15-85	
M 4789.0	LS	+4.6	-3.0	*	LL	07-10-85	
" "	"	+4.62 ±.07	-2.61 ±.17	$	LL	07-15-85	
" "	"	+4.00 ±.47	-3.13 ±.53	*	"	" " "	Drift; oil?
M 4821.5	LS	+6.09 ±.14	-2.65 ±.16	$	LL	04-03-85	
M 4821.5	Cc	+4.13 ±.12	-4.63 ±.15	$	LL	06-17-85	
" "	"	+4.0	-5.0	¶	CSL	07-31-85	Several small bubbles in flask
M 4825.9	LS	+6.30 ±.16	-3.57 ±.09	$	LL	04-03-85	
M 4912.3	CC	+3.23 ±.03	-3.73 ±.07	$	LL	07-18-85	
" "	"	+3.1	-3.7	¶	CSL	07-31-85	
" "	"	+3.3	-3.5	¶	"	" " "	
M 4942.7	LS	+3.5	-2.8	¶	CSL	07-31-85	
" "	"	+3.2	-2.7	¶	"	" " "	
M 4942.7	Cc	+2.4	-5.3	¶	CSL	07-31-85	
" "	"	+2.1	-5.4	¶	"	" " "	
Z 5359.1	Dol	+5.06 ±.10	+1.30 ±.08	$	LL	07-10-85	
Z 5498.2	Dol	+6.15 ±.04	+1.20 ±.06	$	LL	07-10-85	
Z 5501.8	LS	+5.98 ±.08	-2.35 ±.12	$	LL	04-03-85	
" "	"	+6.3	-2.9	¶	CSL	07-31-85	
Z 5548.5	LS	+5.02 ±.08	-2.48 ±.05	$	LL	06-18-85	
" "	"	+5.7	-3.2	¶	CSL	07-31-85	
" "	Cc	+1.60 ±.19	-2.74 ±.09	?	LL	07-15-85	
Z 5626.5	LS	+3.5	-1.9	¶	CSL	07-31-85	
Z 5626.5	Cc	+1.1	-2.8	¶	CSL	07-31-85	
" "	"	+0.8	-2.7	¶	"	" " "	

$,*,¶ See notes, last page.

TABLE 15 (cont.).

NOTES: Carbonate $d^{13}C$-$d^{18}O$ data.

$ = Reliable value from single run.
$$ = Average of 2 or more reliable values.
* = Unreliable value; use with caution.
¶ = Reliable value from single run; error reported as $\pm$0.2
LL = Lynton Land (Univ. Texas) Lab
CSL = Coastal Science Lab-Austin, Tx

PART III

$\delta^{34}S$ ANALYSES OF ANHYDRITE

ANALYSES PREPARED BY

COASTAL SCIENCE LABORATORIES

AUSTIN, TEXAS

AND GEOCHRON LABORATORIES

CAMBRIDGE, MASSACHUSETTS

$\delta^{34}S$ analyses were prepared from several types of anhydrite: bedded, nodular mosaic; unaltered nodular; partly silicified, nodular; veins; fusulinid replacements; and anhydrite cements.

All samples were prepared according to methods described by Holt and Engelkemeir (1970) and Bailey and Smith (1972). Anhydrite or anhydrite-bearing materials were washed, crushed, X-rayed to evaluate sample purity, then extracted for seven to ten days in saturated NaCl solution in order to dissolve sulfate, and filtered through a millipore filter apparatus. To this solution BaCl was added to excess and BaSO4 was precipitated. The BaSO4 was filtered on millipore filter, rinsed in > 200 ml distilled H2O, and oven dried overnight at 105° C. Afterwards the BaSO4 was removed from the filter paper, re-pulverized, and splits made for analyses.

Selected duplicate samples were homogenized and sent to a referee lab for cross-checks.

Analyses are reported as per mil values relative to the Canon Diablo Troilite (CDT) sulfur standard, and are considered by both laboratories to be accurate to within 0.5 o/oo of the actual sample value. Duplicate analyses indicate that precision is better than 0.5 o/oo.

TABLE 16.

SULFUR ISOTOPE COMPOSITIONS OF
WOLFCAMP AND WICHITA FORMATION ANHYDRITES

D.O.E. STONE & WEBSTER #1 SAWYER
DONLEY COUNTY

SAMPLE NUMBER		MSL NO.	VENDOR NO.	$d^{34}S_{(CDT)}$ [2]
D 2850.7	ANHY BED	84-624		+13.2
D 2858.6	ANHY BED			+13.3
D 2867.2	ANHY BED			+13.3
D 2882.4	ANHY BED			+13.7
D 2885.7	ANHY BED			+14.2[2]
" "	" "			+14.0[2]
" "	" "			+13.5°
D 2898.3	ANHY CEM			+10.4[2]
" "	" "			+10.4[2]
" "	" "		R-5	+10.4°
" "	" "		"	+10.5°
D 2919.2	ANHY CEM			+13.4
D 2919.9	ANHY BED	84-625		+13.3
D 2929.1	ANHY BED	84-626		+14.1
" "	" "	" "		+14.1
D 2953.0	ANHY NOD			+13.4
D 3007.3	ANHY NOD	84-627		+12.9[2]
" "	" "	" "		+12.7[2]
D 3070.2	ANHY NOD-ALT			+12.8[2]
" "	" " "			+12.7[2]
D 3093.3	ANHY VEIN			+13.0
" "	ANHY CEM			+12.3
D 3101.8	ANHY NOD-CX	85-282		+14.2[2]
" "	" " "	"		+14.1[2]
D 3108.3	ANHY NOD			+12.5[2]
" "	" "			+12.5[2]
D 3118.5	ANHY NOD			+12.5[2]
" "	" "			+12.3[2]
D 3130.4	ANHY NOD			+12.5

SEE NOTES; LAST PAGE

TABLE 16 (cont.).

D.O.E. STONE & WEBSTER #1 J. FRIEMEL
DEAF SMITH COUNTY

SAMPLE NUMBER	MSL NO.	VENDOR NO.	$d^{34}S_{CDT}$
JF 5545.0 ANHY BED	84-641		+13.2
JF 5588.6 ANHY BED	84-643		+13.4[2]
" " " "	" "		+13.3[2]
" " " "	" "		+13.0°
JF 5608.0 ANHY CEM			+12.4
JF 5631.6 ANHY NOD	84-644		+13.0
" " " "	" "		+13.6°
JF 5651.8 ANHY NOD			+12.8[2]
" " " "			+12.9[2]
JF 5657.6 ANHY CEM			+ 6.0[2]
" " " "			+ 6.0[2]
JF 5681.6 ANHY NOD	84-645		+13.1
JF 5733.9 ANHY NOD-CX	85-258		+15.6[2]
" " " " "	" "		+15.5[2]
JF 5746.1 ANHY CEM			+13.4
JF 5752.6 ANHY FOSS			+15.4[2]
" " " "			+15.4[2]
JF 5760.7 ANHY FOSS			+13.9
JF 5793.8 ANHY VEIN			+14.9
JF 5803.0 ANHY VEIN	85-265		+15.2[2]
" " "			+15.2[2]
JF 5813.3 ANHY CEM			+14.1[2]
" " " "			+14.2[2]
" " " "		R-4	+14.1°
" " " "		"	+14.2°
JF 5831.0 ANHY VEIN			+14.7[2]
" " " "			+15.0[2]
JF 5914.1 ANHY NOD-ALT			+15.3
JF 5935.2 ANHY NOD-ALT			+15.1
JF 5937.6 ANHY VEIN	85-158		+16.7[2]
" " " "			+16.5[2]

SEE NOTES; LAST PAGE

TABLE 16 (cont.).

D.O.E. STONE & WEBSTER #1 MANSFIELD
OLDHAM COUNTY

SAMPLE NUMBER	MSL NO.	VENDOR NO.	$d^{34}S_{CDT}$
M 4424.2 ANHY BED			+13.1[2]
" " " "			+13.2[2]
M 4444.4 ANHY CEM			+11.1[2]
" " " "			+11.1[2]
M 4450.1 ANHY BED			+13.4
M 4453.2 ANHY CEM			+13.3
M 4467.6 ANHY BED	85-223		+13.9
M 4485.6 ANHY NOD			+13.8
M 4485.8A ANHY CEM			+11.4
" " B " "		R-1	+10.5°°
M 4499.7 ANHY NOD-CX	85-227		+13.8
" " " " "	85-227		+13.9°
M 4516.5 ANHY NOD-ALT	85-229		+15.0[2]
" " " " "	"		+15.1[2]

SEE NOTES; LAST PAGE

TABLE 16 (cont.).

D.O.E. STONE & WEBSTER #1 ZEECK
SWISHER COUNTY

SAMPLE NUMBER	MSL NO.	VENDOR NO.	$d^{34}S$
Z 5339.9 ANHY BED	85-175		+13.6
Z 5362.4A ANHY CEM			+11.0[2]
" " " "			+11.1[2]
" " B " "		R-2	+11.2°°
Z 5370.9 ANHY BED			+13.5
Z 5380.9 ANHY NOD			+13.4
" " "	85-182		+13.4°
" " "	"		+13.6°[2]
Z 5381.2 ANHY BED			+13.3
Z 5386.9 ANHY VEIN			+13.2
Z 5393.2A ANHY CEM			+11.8
" " B " "		R-3	+11.8°°
Z 5406.2 ANHY NOD-CX	85-188		+14.7[2]
" " " " "	"		+14.9[2]
Z 5411.9 ANHY NOD			+13.6
Z 5418.8 ANHY CEM			+13.6
Z 5421.9 ANHY NOD			+14.2
Z 5437.8 ANHY NOD-ALT	85-198		+14.1
" " " " "	"		+14.2°
Z 5442.0 ANHY NOD-ALT			+14.5
Z 5511.4 ANHY	85-211		+14.8[2]
" " "	"		+14.9[2]

SEE NOTES; LAST PAGE

Table 16 (cont.).

NOTES FOR $d^{34}S$ DATA

[2] Duplicate analysis; sample was prepared by vendor from two separate cuts of the same sample. Variation within adjacent values reflect combined intra-sample variation (i.e. sample homogeneity) and machine variation.

° Blind duplicate; sample was prepared by BEG from two separate cuts of the same same sample without vendors knowledge.

°° Blind duplicate; two separate cuts of the same initial sample were dissolved in saturated NaCl solution and two different barite samples precipitated from each cut.

[2]All $d^{34}S$ Values normalized to CDT (Canon Diablo Troilite standard) = 0 o/oo as calibrated from internal barite standard = +7.2 o/oo (CDT).

INTERLABORATORY VALIDATION OF $\delta^{34}S$ ANALYSES

Prepared as:

Quality Assurance Validation

for

West Texas Isolation Project

by

Harry H. Posey

August 22, 1985

SUMMARY

Anhydrite samples of Department of Energy drill cores from the Palo Duro Basin, Texas, were prepared for stable isotope analysis and sent to two independent laboratories, Coastal Science Laboratories (CSL), Austin, TX, and Geochron Laboratories (GCL), Cambridge, MA, in order to verify the precision of $\delta^{34}S$ analyses reported by those labs. For these analyses, both labs report an accuracy of ± 0.5 o/oo. All of the verification samples were within the reported error.

PROCEDURE

Each anhydrite sample was removed from its matrix, washed in distilled water, air dried, pulverized, and X-rayed in order to establish relative purity of the samples. Eight samples which were found to be "pure" at the scale of routine XRD examination were then chosen for laboratory cross-check.

Each sample was extracted in saturated NaCl solution for approximately 10 days (see Holt and Engelkemeier, 1970; and Bailey and Smith, 1972, for methods), after which the solutions were drawn through a millipore filter, and precipitated as $BaSO_4$ by adding BaCl solution to excess. $BaSO_4$ was removed from the solution by filtering through a millipore filter, rinsed on the filter with approximately 200 ml distilled water, then oven dried at 105° ernight. The dried $BaSO_4$ was then removed from the filter, repulverized, and stored in rinsed snap cap vials prior to segregation into separate samples for isotopic analyses. One of the eight samples was a $BaSO_4$ intralaboratory standard used by CSL, and needed no preparation. This sample was not X-rayed.

Splits of the eight samples were sent to CSL and GCL under blind labels. Analyses were reported in per mil values relative to the Canon Diablo Troilite (CDT) sulfur standard in the normal fashion employed by each lab. CSL typically prepares duplicate sets of analyses for several samples out of each batch that is submitted; that is, two different

gases are prepared from two separate cuts of the same sample. GCL does not employ this practice on outside submissions.

RESULTS

Results of both labs' analyses are shown on the attached table. Quality of $\delta^{34}S$ analyses is claimed to be within 0.5 °/oo of the actual value by each lab. Thus, a difference of 1.0 °/oo for interlab duplicates is considered to be within acceptable margins of error, unless a systematic discrepancy exists. The maximum difference between any two interlab duplicates is 0.3 °/oo. Of the eight samples two of the GCL analyses were lower (isotopically lighter) than the corresponding CSL value, one was the same, and five were heavier. The average discrepancy between labs was 0.04 °/oo.

PART IV

$^{87}SR/^{86}SR$ ANALYSES OF CARBONATE AND ANHYDRITE

ANALYSES PREPARED BY

GEOCHRON LABORATORIES

CAMBRIDGE, MASSACHUSETTS

$^{87}Sr/^{86}Sr$ analyses were prepared from "pure" limestone, "pure" dolomite, calcite veins, and several types of anhydrite: bedded, nodular mosaic; unaltered, nodular; partly silicified, nodular; and vein fill. Carbonate samples were considered "pure" provided no contaminants appeared in routine X-ray diffraction scans. As a practical consequence, carbonate samples with as much as 10 percent insoluble residue may have been labeled "pure." Qualitative estimates of the amounts of insoluble residue do not correlate with $^{87}Sr/^{86}Sr$ ratios, suggesting that the residues have contributed little if any radiogenic ^{87}Sr to the samples.

All samples were crushed, washed in distilled water in order to remove salts from evaporated pore water, homogenized, then X-rayed. Select samples were then split and forwarded to the vendor.

$^{87}Sr/^{86}Sr$ ratios were determined using standard analytical methods, ion exchange chromatography, and solid source mass spectrometry (see Nier, 1938; Faure and Powell, 1972).

$^{87}Sr/^{86}Sr$ analyses and machine error are reported in standard fashion. NBS $SrCO^3$ standard, analyzed along with each set of analyses, ranged from 0.71010 ($\pm$0.00005) to 0.71023 ($\pm$0.00002). Accepted value for this standard is 0.71015. None of the reported values have been normalized to the accepted value.

Table 17.
$\delta^{34}S$ analyses of $BaSO_4$, prepared from anhydrite.

	Sample numbers		Results CSL	GCL	$\Delta_{CSL-GCL}$
A-1	D 2919.9	84-625	+13.3	+13.2	-0.1
A-2	JF 5545.0	84-641	+13.2	+12.9	-0.3
B-1	D 3108.3		+12.5±0.0	+12.7	+0.2
B-2	M 4516.5		+15.05±0.05	+15.1	+0.05
C-1	M 4485.8A Cement		+11.4	+11.4	+0.0
C-2	Z 5393.2A Cement		+11.8	+12.1	+0.3
D-1	M 4485.8A Cement		+11.4	+11.5	+0.1
E-1	"CVB" Barium Sulfate Standard		+7.2	+7.3	+0.1
			Average $\Delta_{CSL-GCL}$ =		-0.04

Notes:

1. "A" samples were analyzed 12/84 by CSL (Coastal Science Labs).
2. "B" samples were analyzed 3/85 by CSL.
3. "C" samples were analyzed 5/85 by CSL.
4. Sample "D-1" is a blind duplicate of "C-1."
5. Sample "E-1" is CSL's intralab barium sulfate standard: accepted $\delta^{34}S$ value is +7.2 °/oo (CDT).
6. Only the table title and left hand column of sample numbers were sent to GCL (Geochron Labs); all other information in this table was excluded.

TABLE 18.

STRONTIUM ISOTOPE COMPOSITIONS OF
WOLFCAMP CARBONATES AND ANHYDRITE

SAMPLE NUMBER	MSL NO.	VENDOR NO.	$^{87}Sr/^{86}Sr$[1]
D 2850.7 ANHY			.70782 (10) @
D 2885.7 ANHY			.70753 (15) Δ
D 2929.1 ANHY			.70794 (10) @
D 2943.9 DOL		AA	.70840 (17) #
D 3007.3 ANHY			.70796 (10) Δ
D 3012.7 DOL	85-328	BB*¶	.70806 (10) #
D 3084.9 DOL		CC*	.70864 (07) #
D 3089.0 LS		DD*	.70786 (07) #
D 3101.8 ANHY	85-282		.70792 (11) @
D 3130.9 ANHY			.70841 (10) @
D 3199.0 LS		EE*	.70786 (08) #
D 3199.0 CALC		FF*	.70809 (08) #
JF 5545.0 ANHY			.70780 (04) Δ
JF 5588.6 ANHY			.70781 (08) Δ
JF 5653.3 DOL	85-252	GG*	.70917 (08) #
JF 5711.9 DOL	85-254	HH*	.70808 (20) #
JF 5733.9 ANHY	85-258		.70795 (08) @
JF 5803.0 ANHY	85-265		.70867 (07) @
JF 5824.4 LS		JJ*	.70874 (10) #
JF 5914.1 ANHY			.70785 (06) Δ
JF 5915.9 LS		KK*	.70835 (29) #
JF 5937.6 ANHY	85-158		.70828 (08) @
JF 5958.7 LS		LL*	.70802 (08) #
JF 5958.7 CALC		MM*	.70794 (08) #
M 4424.4 ANHY	85-218		.70788 (06) @
M 4435.3 DOL	85-219	NN*	.70786 (06) #
M 4467.6 ANHY	85-223		.70824 (08) @
M 4499.7 ANHY	85-227		.70820 (06) @
M 4516.5 ANHY	85-229		.70830 (06) @
M 4527.0 DOL	85-230	OO*	.70885 (06) #
M 4540.6 LS	85-231	PP	.70811 (07) #
M 4821.5 CALC	85-236	QQ*	.70828 (07) #
M 4912.3 CALC	85-245	RR*	.70785 (07) #
M 4942.7 LS		SS*	.70780 (07) #
M 4942.7 LS		TT*	.70823 (04) #
Z 5339.9 ANHY	85-175		.70775 (11) @
Z 5359.1 DOL	85-178	UU	.70758 (13) #
Z 5406.2 ANHY	85-188		.70787 (13) @
Z 5437.8 ANHY	85-198		.70777 (10) @
Z 5498.2 DOL	85-207	VV	.70776 (11) #
Z 5501.8 LS	85-208	WW*	.70711 (38) #
Z 5511.4 ANHY	85-211		.70895 (10) @
Z 5548.5 LS	85-217	XX*	.70740 (08) #
Z 5626.5 LS		YY*	.70765 (08) #
Z 5626.5 CALC		ZZ*	.70769 (14) #

[1]See notes on next page.

TABLE 18 (cont.).

NOTES:

* Sample has d13C, d18O, and 87Sr/86Sr analysis.
¶ Sample crushed only, not powdered.

Permian Seawater = 0.70680-0.70840 (including error envelope); best fit estimate = 0.70690-0.70810 (Burke, et al, 1982).

NBS-987 ($SrCO_3$ standard, accepted $^{87}Sr/^{86}Sr$ value = 0.71015) was monitored during all runs. Average standard value during analyses of groups of data is denoted by @,#, etc. None of the values shown above have been normalized to the accepted standard value of 0.71015.

@ NBS-987 = 0.71023 +/- .00002 (ave. of 2 analyses).
# NBS-987 = 0.71006 +/- .00006 (ave. of 7 analyses).
Δ NBS 987 = 0.71020 +/- .00006 (ave. of 3 analyses).

MICROPROBE ANALYSES

SAMPLES EVALUATED BY

MINERAL STUDIES LABORATORY

BUREAU OF ECONOMIC GEOLOGY

THE UNIVERSITY OF TEXAS AT AUSTIN

ASSISTED BY:

JEFFREY N. RUBIN

A survey of microprobe analyses of trace elements in calcite, and dolomite in crinoids was run on one thin section: Donley County #1 Sawyer, from depth 3226.7 feet. Of the elements sought, Fe, Mg, Ca, Na, Mn, Sr, and Ba all responded, at least occasionally, on calcite and dolomite, but could not be retrieved from anhydrite. Failure of anhydrite to respond is due to poor polish rather than any inherent problem with the equipment or low concentrations.

All analyses were run on the UT-BEG microprobe using standard techniques described in Bence and Albee (1968). Operating parameters were 15 kV, 10 nA, with a beam size of approximately 6 μm. Traverses across calcite crinoids and across crinoids replaced by dolomite showed only slight, non-systematic trace element variation.

The analyses given in the following section are considered reliable unless noted. Each point is labeled first with the thin section number (D 3226.7, which means Donley County

well; depth = 3226.7 feet) followed by a sequential number (1-42 which is the microprobe point number).

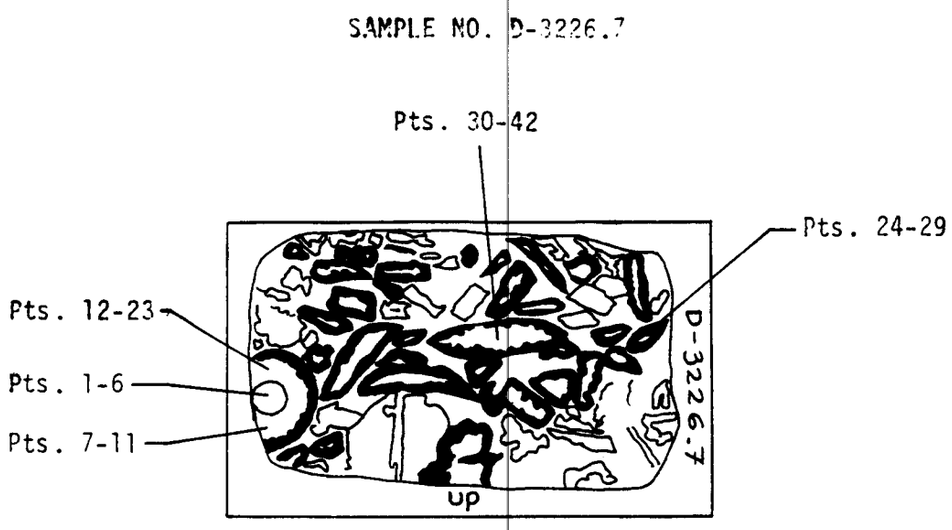
Points numbered 1-6 are from calcite from the center of a crinoid. Points 7-11 are dolomite crystals from the same crinoid sample, between the core and rim. Points 12-23 are calcite crystals from the rim of the same crinoid.

Points 24-29 are from remnants of a dolomite crystal which replaced a crinoid, and which was in turn replaced by chalcedony.

Points 30 through 42 represent a traverse across a single crystal of calcite of a crinoid.

A sketch showing location of microprobe points on the thin section is attached.

Figure 1.



Polished thin-section D-3226.7 showing locations of microprobe points. Sample probed July 16, 1985, by Jeffrey N. Rubin at the Microprobe laboratory of the Mineral Studies Laboratory of the Bureau of Economic Geology, The University of Texas at Austin.

Table 19. Microprobe points, sample D3226.7.

Point No. 1: Calcite; Crinoid A
X = 10904. Y = 1379.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	38.773	7.7044	CaO	54.251	0.316
Mg	0.754	0.2470	MgO	1.250	0.035
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.037	0.0053	MnO	0.048	0.033
Sr	0.034	0.0031	SrO	0.040	0.018
Ba	0.097	0.0056	BaO	0.108	0.044
C	12.091	20.0519	44.303		
O	48.214	60.0259	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 2: Calcite; Crinoid A
X = 10873. Y = 1431.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.012	0.0042	Na_2O	0.016	0.012
Ca	38.812	7.7020	CaO	54.305	0.316
Mg	0.699	0.2285	MgO	1.158	0.036
Fe	0.033	0.0047	FeO	0.043	0.035
Mn	0.020	0.0029	MnO	0.026	0.026
Sr	0.023	0.0021	SrO	0.027	0.018
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.125	20.0855	44.425		
O	48.277	60.0402	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 3: Calcite; Crinoid A; Core
X = 10845. Y = 1519.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.009	0.0030	Na_2O	0.011	0.011
Ca	39.050	7.7794	CaO	54.638	0.317
Mg	0.733	0.2408	MgO	1.216	0.035
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.077	0.0111	MnO	0.099	0.032
Sr	0.035	0.0032	SrO	0.041	0.018
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.007	19.9453	43.995		
O	48.090	59.9708	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 4: Calcite; Crinoid A; Core
X = 10850. Y = 1589.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.009	0.0029	Na_2O	0.011	0.011
Ca	38.560	7.6318	CaO	53.952	0.314
Mg	0.829	0.2704	MgO	1.374	0.037
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.014	0.0020	MnO	0.018	0.018
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.184	20.1410	44.645		
O	48.405	60.0687	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 5: Calcite; Crinoid A; Core
X = 10840. Y = 1648.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.009	0.0033	Na_2O	0.013	0.012
Ca	38.717	7.6801	CaO	54.172	0.315
Mg	0.814	0.2662	MgO	1.350	0.037
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.032	0.0046	MnO	0.041	0.036
Sr	0.010	0.0010	SrO	0.012	0.012
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.121	20.0689	44.412		
O	48.296	60.0324	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 6: Calcite; Crinoid A; Core
X = 10826. Y = 1721.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.010	0.0036	Na_2O	0.014	0.012
Ca	38.823	7.7005	CaO	54.321	0.316
Mg	0.596	0.1948	MgO	0.988	0.033
Fe	0.050	0.0071	FeO	0.064	0.035
Mn	0.008	0.0012	MnO	0.011	0.011
Sr	0.057	0.0052	SrO	0.067	0.019
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.155	20.1334	44.535		
O	48.301	60.0645	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 7: Dolomite; Crinoid A; Intermed
X = 10737. Y = 2162.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.147	0.0475	Na_2O	0.199	0.018
Ca	22.898	4.2314	CaO	32.038	0.218
Mg	11.968	3.6460	MgO	19.844	0.168
Fe	0.038	0.0050	FeO	0.048	0.034
Mn	0.025	0.0033	MnO	0.032	0.028
Sr	0.019	0.0016	SrO	0.022	0.019
Ba	0.020	0.0011	BaO	0.022	0.022
C	13.044	20.1200	47.796		
O	51.842	60.0303	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 8: Dolomite; Crinoid A; Intermed
X = 10696. Y = 2261.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.114	0.0369	Na_2O	0.154	0.017
Ca	23.290	4.3100	CaO	32.587	0.221
Mg	11.679	3.5632	MgO	19.365	0.165
Fe	0.036	0.0048	FeO	0.047	0.034
Mn	0.011	0.0015	MnO	0.014	0.014
Sr	0.031	0.0027	SrO	0.037	0.019
Ba	0.036	0.0019	BaO	0.040	0.040
C	13.034	20.1371	47.756		
O	51.768	60.0454	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 9: Dolomite; Crinoid A; Intermed
X = 10760. Y = 2354.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.035	0.0114	Na_2O	0.048	0.014
Ca	23.081	4.2771	CaO	32.294	0.219
Mg	11.666	3.5639	MgO	19.343	0.165
Fe	0.428	0.0569	FeO	0.550	0.056
Mn	0.072	0.0097	MnO	0.093	0.034
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.013	0.0007	BaO	0.014	0.014
C	13.007	20.1263	47.658		
O	51.699	60.0560	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 10: Dolomite; Crinoid A; Intermed
X = 10752. Y = 2367.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.045	0.0146	Na_2O	0.061	0.014
Ca	22.956	4.2286	CaO	32.120	0.218
Mg	11.755	3.5696	MgO	19.490	0.166
Fe	0.055	0.0072	FeO	0.070	0.034
Mn	0.005	0.0007	MnO	0.007	0.007
Sr	0.008	0.0007	SrO	0.009	0.009
Ba	0.000	0.0000	BaO	0.000	0.000
C	13.166	20.2758	48.242		
O	52.009	60.1288	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 11: Dolomite; Crinoid A; Intermed
X = 10742. Y = 2384.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.010	0.0032	Na_2O	0.014	0.013
Ca	23.092	4.2738	CaO	32.309	0.219
Mg	11.494	3.5071	MgO	19.059	0.163
Fe	0.480	0.0638	FeO	0.618	0.057
Mn	0.074	0.0100	MnO	0.095	0.032
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.018	0.0010	BaO	0.020	0.020
C	13.069	20.2136	47.885		
O	51.763	60.1048	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 12: Calcite; Crinoid A; Rim
X = 11381. Y = 4188.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.009	0.0029	Na_2O	0.012	0.012
Ca	38.473	7.5570	CaO	53.831	0.314
Mg	0.150	0.0485	MgO	0.248	0.020
Fe	0.038	0.0054	FeO	0.049	0.035
Mn	0.011	0.0016	MnO	0.014	0.014
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.048	0.0028	BaO	0.054	0.043
C	12.498	20.5771	45.793		
O	48.774	60.2867	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 13: Calcite; Crinoid A; Rim
X = 11381. Y = 4241.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	39.511	7.8588	CaO	55.283	0.320
Mg	0.216	0.0709	MgO	0.358	0.022
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.001	0.0001	MnO	0.001	0.001
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.106	20.1055	44.358		
O	48.166	60.0528	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 14: Calcite; Crinoid A; Rim
X = 11376. Y = 4293.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.032	0.0111	Na_2O	0.043	0.013
Ca	39.375	7.8387	CaO	55.093	0.319
Mg	0.323	0.1061	MgO	0.536	0.025
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.069	0.0040	BaO	0.077	0.045
C	12.077	20.0658	44.251		
O	48.123	60.0260	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 15: Calcite; Crinoid A; Rim
X = 11364. Y = 4401.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.020	0.0068	Na_2O	0.026	0.013
Ca	39.645	7.8929	CaO	55.471	0.321
Mg	0.079	0.0260	MgO	0.131	0.018
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.038	0.0056	MnO	0.049	0.032
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.096	20.1066	44.322		
O	48.121	60.0491	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 16: Calcite; Crinoid A; Rim
X = 11382. Y = 4467.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	39.913	7.9719	CaO	55.845	0.322
Mg	0.117	0.0386	MgO	0.194	0.020
Fe	0.010	0.0014	FeO	0.013	0.013
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	11.994	19.9822	43.948		
O	47.966	59.9911	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 17: Calcite; Crinoid A; Rim
X = 11377. Y = 4535.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.002	0.0005	Na_2O	0.002	0.002
Ca	40.066	8.0199	CaO	56.060	0.323
Mg	0.073	0.0242	MgO	0.122	0.017
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.010	0.0014	MnO	0.013	0.013
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.046	0.0027	BaO	0.052	0.047
C	11.941	19.9271	43.752		
O	47.862	59.9632	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 18: Calcite; Crinoid A; Rim
X = 11377. Y = 4645.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	40.024	8.0212	CaO	56.000	0.323
Mg	0.297	0.0980	MgO	0.492	0.025
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.003	0.0003	SrO	0.004	0.004
Ba	0.000	0.0000	BaO	0.000	0.000
C	11.873	19.8210	43.504		
O	47.803	59.9105	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 19: Calcite; Crinoid A; Rim
X = 11355. Y = 4730.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.036	0.0125	Na_2O	0.048	0.013
Ca	39.986	8.0131	CaO	55.947	0.323
Mg	0.234	0.0774	MgO	0.388	0.024
Fe	0.030	0.0043	FeO	0.039	0.032
Mn	0.019	0.0028	MnO	0.024	0.024
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.004	0.0003	BaO	0.005	0.005
C	11.885	19.8410	43.549		
O	47.806	59.9127	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 20: Calcite; Crinoid A; Rim
X = 11338. Y = 4805.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.018	0.0062	Na_2O	0.024	0.012
Ca	39.349	7.8134	CaO	55.057	0.319
Mg	0.160	0.0525	MgO	0.266	0.021
Fe	0.015	0.0021	FeO	0.019	0.019
Mn	0.044	0.0064	MnO	0.057	0.034
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.166	20.1825	44.577		
O	48.247	60.0874	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 21: Calcite; Crinoid A; Rim
X = 11359. Y = 4909.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.020	0.0071	Na_2O	0.027	0.013
Ca	39.951	7.9978	CaO	55.898	0.323
Mg	0.194	0.0641	MgO	0.322	0.022
Fe	0.003	0.0004	FeO	0.003	0.003
Mn	0.056	0.0082	MnO	0.072	0.035
Sr	0.001	0.0001	SrO	0.002	0.002
Ba	0.000	0.0000	BaO	0.000	0.000
C	11.920	19.8872	43.676		
O	47.855	59.9392	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 22: Calcite; Crinoid A; Rim
X = 11356. Y = 5039.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.016	0.0056	Na_2O	0.022	0.013
Ca	39.311	7.8436	CaO	55.004	0.319
Mg	0.647	0.2127	MgO	1.072	0.034
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.042	0.0038	SrO	0.050	0.020
Ba	0.000	0.0000	BaO	0.000	0.000
C	11.968	19.9044	43.853		
O	48.016	59.9487	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 23: Calcite; Crinoid A; Rim
X = 11382. Y = 5152.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.003	0.0010	Na_2O	0.004	0.004
Ca	38.923	7.7119	CaO	54.460	0.317
Mg	0.535	0.1748	MgO	0.888	0.031
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.185	20.1692	44.648		
O	48.353	60.0840	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 24: Dolomite; Crinoid B
X = 11857. Y = 34635.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	21.994	4.0488	CaO	30.774	0.212
Mg	12.316	3.7377	MgO	20.421	0.172
Fe	0.479	0.0633	FeO	0.616	0.059
Mn	0.020	0.0027	MnO	0.026	0.026
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.004	0.0002	BaO	0.005	0.005
C	13.143	20.2212	48.157		
O	52.042	60.1106	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 25: Dolomite; Crinoid B
X = 11727. Y = 34983.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.015	0.0047	Na_2O	0.020	0.011
Ca	21.854	4.0430	CaO	30.578	0.211
Mg	11.942	3.6422	MgO	19.801	0.168
Fe	1.144	0.1519	FeO	1.472	0.079
Mn	0.145	0.0196	MnO	0.188	0.037
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.042	0.0023	BaO	0.047	0.041
C	13.071	20.2072	47.895		
O	51.786	60.1006	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 26: Dolomite; Crinoid B
X = 11496. Y = 35407.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.003	0.0008	Na_2O	0.003	0.003
Ca	21.286	3.9191	CaO	29.782	0.208
Mg	11.954	3.6285	MgO	19.821	0.168
Fe	1.385	0.1830	FeO	1.782	0.084
Mn	0.113	0.0152	MnO	0.147	0.037
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	13.227	20.3815	48.465		
O	52.032	60.1903	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 27: Dolomite; Crinoid B
X = 11480. Y = 35433.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.012	0.0040	Na_2O	0.017	0.011
Ca	21.860	4.0343	CaO	30.587	0.212
Mg	12.505	3.8046	MgO	20.734	0.174
Fe	0.602	0.0797	FeO	0.774	0.062
Mn	0.061	0.0082	MnO	0.078	0.034
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	13.048	20.1060	47.810		
O	51.911	60.0505	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 28: Dolomite; Crinoid B
X = 11500. Y = 35452.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.006	0.0018	Na_2O	0.008	0.008
Ca	21.410	3.9258	CaO	29.956	0.209
Mg	12.198	3.6873	MgO	20.225	0.170
Fe	0.724	0.0953	FeO	0.932	0.064
Mn	0.066	0.0089	MnO	0.086	0.035
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.047	0.0025	BaO	0.053	0.041
C	13.302	20.4198	48.741		
O	52.246	60.2088	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 29: Dolomite; Crinoid B
X = 11486. Y = 35487.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.005	0.0016	Na_2O	0.007	0.007
Ca	21.418	3.9326	CaO	29.968	0.209
Mg	12.183	3.6876	MgO	20.200	0.170
Fe	0.824	0.1086	FeO	1.060	0.069
Mn	0.077	0.0104	MnO	0.100	0.033
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.050	0.0027	BaO	0.055	0.040
C	13.267	20.3868	48.611		
O	52.176	60.1924	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 30: Calcite; Crinoid C
X = 3419. Y = 24711.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.027	0.0094	Na_2O	0.037	0.012
Ca	38.729	7.6344	CaO	54.188	0.316
Mg	0.165	0.0535	MgO	0.273	0.020
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.004	0.0006	MnO	0.006	0.006
Sr	0.015	0.0013	SrO	0.017	0.017
Ba	0.069	0.0040	BaO	0.077	0.041
C	12.391	20.4515	45.401		
O	48.600	60.2198	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 31: Calcite; Crinoid C
X = 3561. Y = 24719.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.024	0.0082	Na_2O	0.032	0.014
Ca	39.232	7.8041	CaO	54.893	0.319
Mg	0.438	0.1436	MgO	0.726	0.028
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.024	0.0022	SrO	0.029	0.018
Ba	0.036	0.0021	BaO	0.040	0.040
C	12.085	20.0638	44.281		
O	48.161	60.0268	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 32: Calcite; Crinoid C
X = 3709. Y = 24728.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.007	0.0024	Na_2O	0.009	0.009
Ca	39.473	7.8457	CaO	55.230	0.320
Mg	0.127	0.0415	MgO	0.210	0.020
Fe	0.054	0.0076	FeO	0.069	0.036
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.140	20.1555	44.482		
O	48.200	60.0762	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 33: Calcite; Crinoid C
X = 3873. Y = 24753.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.015	0.0051	Na_2O	0.020	0.014
Ca	39.412	7.8325	CaO	55.144	0.320
Mg	0.225	0.0737	MgO	0.373	0.024
Fe	0.009	0.0013	FeO	0.012	0.012
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.002	0.0001	BaO	0.002	0.002
C	12.131	20.1335	44.449		
O	48.206	60.0635	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 34: Calcite; Crinoid C
X = 4051. Y = 24761.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.008	0.0027	Na_2O	0.011	0.011
Ca	38.969	7.7047	CaO	54.524	0.317
Mg	0.228	0.0744	MgO	0.379	0.024
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.023	0.0033	MnO	0.029	0.029
Sr	0.010	0.0009	SrO	0.012	0.012
Ba	0.019	0.0011	BaO	0.021	0.021
C	12.288	20.3214	45.023		
O	48.455	60.1590	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 35: Calcite; Crinoid C
X = 4240. Y = 24791.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.007	0.0026	Na_2O	0.010	0.010
Ca	39.177	7.7732	CaO	54.815	0.318
Mg	0.296	0.0968	MgO	0.491	0.026
Fe	0.022	0.0031	FeO	0.028	0.028
Mn	0.010	0.0014	MnO	0.013	0.013
Sr	0.029	0.0027	SrO	0.035	0.018
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.175	20.1819	44.609		
O	48.284	60.0893	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 36: Calcite; Crinoid C
X = 4417. Y = 24791.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	39.570	7.8701	CaO	55.365	0.321
Mg	0.083	0.0273	MgO	0.138	0.018
Fe	0.010	0.0014	FeO	0.013	0.013
Mn	0.030	0.0043	MnO	0.038	0.034
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.013	0.0008	BaO	0.014	0.014
C	12.126	20.1443	44.431		
O	48.168	60.0721	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 37: Calcite; Crinoid C
X = 4636. Y = 24788.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.011	0.0039	Na_2O	0.015	0.011
Ca	39.621	7.8896	CaO	55.437	0.321
Mg	0.136	0.0448	MgO	0.226	0.021
Fe	0.035	0.0050	FeO	0.045	0.031
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.084	20.0871	44.276		
O	48.112	60.0411	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 38: Calcite; Crinoid C
X = 4812. Y = 24788.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.020	0.0071	Na_2O	0.027	0.012
Ca	39.724	7.9161	CaO	55.581	0.321
Mg	0.113	0.0370	MgO	0.187	0.020
Fe	0.005	0.0007	FeO	0.006	0.006
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.063	20.0622	44.198		
O	48.075	60.0267	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 39: Calcite; Crinoid C
X = 5003. Y = 24793.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.001	0.0003	Na_2O	0.001	0.001
Ca	39.778	7.9215	CaO	55.656	0.322
Mg	0.016	0.0051	MgO	0.026	0.015
Fe	0.005	0.0007	FeO	0.007	0.007
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.093	20.1088	44.310		
O	48.107	60.0542	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 40: Calcite; Crinoid C
X = 5238. Y = 24786.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.033	0.0112	Na_2O	0.044	0.015
Ca	38.991	7.6979	CaO	54.556	0.317
Mg	0.099	0.0322	MgO	0.164	0.018
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.008	0.0011	MnO	0.010	0.010
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.343	20.3933	45.226		
O	48.526	60.1896	oxide-like spec.		
TOTAL	100.000			100.000	

Table 19 (cont.)

Point No. 41: Calcite; Crinoid C
X = 5419. Y = 24786.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.000	0.0000	Na_2O	0.000	0.000
Ca	38.963	7.6894	CaO	54.516	0.317
Mg	0.124	0.0404	MgO	0.206	0.019
Fe	0.000	0.0000	FeO	0.000	0.000
Mn	0.006	0.0008	MnO	0.007	0.007
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.011	0.0006	BaO	0.012	0.012
C	12.352	20.4045	45.258		
O	48.544	60.2022	oxide-like spec.		
TOTAL	100.000			100.000	

Point No. 42: Calcite; Crinoid C
X = 5524. Y = 24786.

Element	Wt. % Concentration	Normalized Atomic Concentration	Compound	Wt. % Concentration	1 Sigma error
Na	0.005	0.0018	Na_2O	0.007	0.007
Ca	38.336	7.5130	CaO	53.639	0.313
Mg	0.190	0.0615	MgO	0.316	0.023
Fe	0.029	0.0041	FeO	0.038	0.035
Mn	0.000	0.0000	MnO	0.000	0.000
Sr	0.000	0.0000	SrO	0.000	0.000
Ba	0.000	0.0000	BaO	0.000	0.000
C	12.555	20.6336	46.001		
O	48.884	60.3157	oxide-like spec.		
TOTAL	100.000			100.000	

PART VI

FLUID INCLUSION ANALYSES OF SPHALERITE

ANALYSES PREPARED BY

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Sphalerite was found in three of the four DOE wells that penetrated rocks of the Wolfcamp Formation. One of these samples, Donley County #1 Sawyer from 3942 feet depth, was suitable for fluid inclusion examination. All of the data are from two-phase inclusions concentrated along growth zones, and thus are considered to be primary inclusions.

Homogenization temperatures and freezing temperatures were gathered from doubly polished sections by J.R. Kyle, on heating and freezing stage equipment at The University of Texas at Austin. Preparation and analytical methods are discussed in Roedder (1984).

Fluid inclusion homogenization temperatures from 28 inclusions range from 50 to 74° C, averaging 60.5° C. This temperature is approximately 20 degrees warmer than would be predicted by the present-day geothermal gradient for this depth.

Freezing stage measurements from 23 inclusions--not necessarily the same inclusions measured for homogenization temperatures--expressed as equivalent weight percent NaCl, range from 20.8 to 21.8 equivalent weight percent. This is similar to the salinities of Wolfcamp brines which range from about 200,000 to 220,000 mg/l. This equivalent weight

percent range corresponds to initial melting temperatures between -26 and -28° C. Because they melt below the NaCl-H_2O eutectic of -20.8° C, other ions, most likely Ca and/or K, are likely to be present. Scanning the crystals under broad and narrow band fluorescence failed to detect any relevant hydrocarbon-filled inclusions.

Figure 2.

FLUID INCLUSION INVESTIGATION OF D3932 SPHALERITE

Statistics on D 3932

X	Y
# of points	26
Maximum	74
Minimum	50
Average	60.507692308
Median	58.5
Std. Deviation	6.2273540498
Corr. Coeff.	0

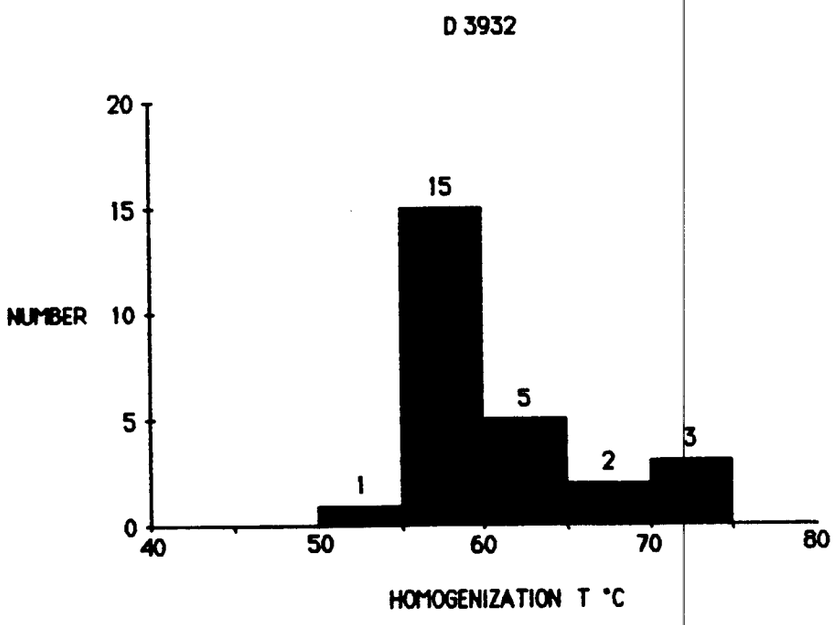

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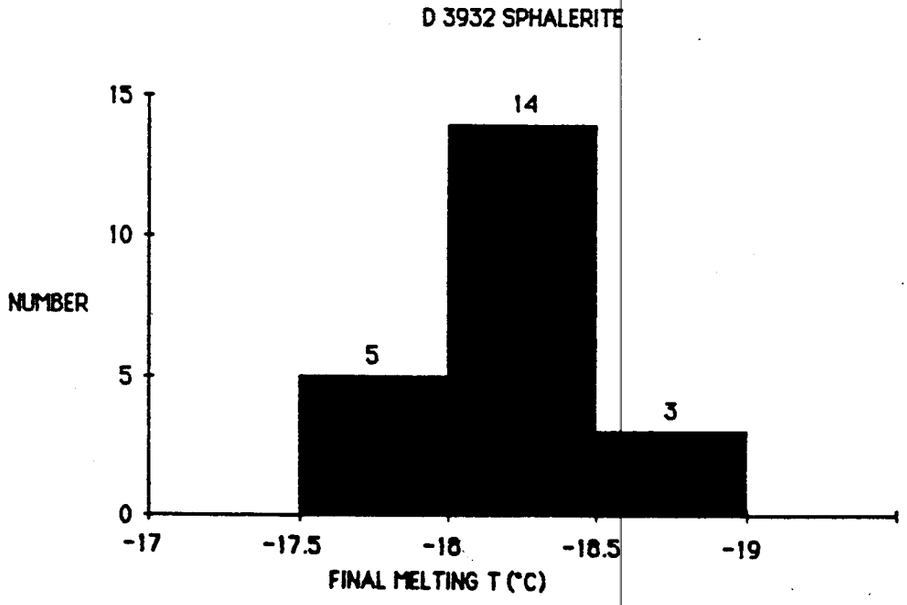
Figure 3.

Statistics on D 3932 SPHALERITE

X	Y
# of points	23
Maximum	-17.5
Minimum	-18.8
Average	-18.10869565
Median	-18.2
Std. Deviation	0.3654549387



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