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PHYSICAL AND CHEMICAL CHARACTERIZATION OF DEVONIAN GAS SHALE

QUARTERLY STATUS REPORT
(JANUARY 1 - MARCH 31, 1980)

PREPARED BY: R. E. ZIELINSKI,
PRINCIPAL INVESTIGATOR
AND
S. W. NANCE

MOUND FACILITY
Miamisburg, Ohio 45342

operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company

for the
U. S. DEPARTMENT OF ENERGY

Contract No. DE-AC04-76-DP00053

Monsanto

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EXECUTIVE SUMMARY

This quarterly contains a change in reporting format. The new format includes the reporting of all data by well rather than the type of analysis.

During this quarter, major elemental analysis was completed for 14 samples from the Ill-4 well, 51 samples from the KY-4 well, 33 samples from the OH-3 well, and 30 samples from the OH-4 well.

Minor elemental analysis was completed for 30 samples from the OH-4 well.

Elemental analysis of the Kerogens was completed for 46 samples of the KY-4 well. The average H/C and O/C values for these samples were 1.04 and 0.21, respectively. This would suggest that the kerogen was sourced from marine or intermediate type of organic matter. Analysis of 56 samples from the OH-4 well also suggests the kerogen source to be marine or intermediate. The 29 samples from the PA-3 well also suggests the same type of source material for the kerogen. For this well the average H/C and O/C values were 1.25 and 0.66, respectively.

Visual Kerogen Analysis of 128 samples from the OH-4 well indicates that the kerogen material was primarily herbaceous with some zones where woody-coaly material predominated. The Thermal Alteration Index (TAI) for this well varied from 1 to 2 on a downhole trend, indicating a slight maturity gradient but overall an immature kerogen. The Visual Kerogen Analysis of 118 samples from the PA-3 well again indicated that the kerogen material was primarily herbaceous with several woody-coaly intervals. The TAI gradient in this well was from 1+ to 2 again an indication of maturity increasing with depth but an overall assessment of an immature kerogen.

The Vitrinite Reflectance Analysis of 47 samples from the OH-4 well confirms the TAI results. The mean Ro value for these samples was 0.40 indicating a thermally immature source rock.

Material Balance Assays have been completed for samples from several of the wells. Seven samples from the KY-4 well were analyzed. These produced an average oil yield of 6.1 gallons per ton and a mean hydrocarbon gas yield of 139 SCF/ton of shale. The organically richest (4.4 wt %-TOC) sample of the PA-1 well was analyzed and provided and negligible oil yield (<0.5 gal/ton) and a hydrocarbon gas yield of 44 SCF/ton. Two samples from the PA-2 well were analyzed. These samples had 5 and 4.7 wt % TOC, respectively, and both provided negligible oil yield and hydrocarbon gas yields of only 7.9 and 6.5 SCF/ton, respectively. Three samples from the OH-3 well were analyzed. These samples had total organic carbon contents of: 3.2, 3.5, and 6.7 wt % and respectively yielded: 3.23, 2.39, and 3.26 gal/ton of oil and hydrocarbon gas of 77.7, 67.7 and 156.7 SCF/ton.

Pyrolysis-GC Analysis was performed on 35 samples from the PA-1 well and provided an average total hydrocarbon yield of 0.22 wt % and an average volatile yield of 1001 ppm. From the OH-4 well, 125 samples were analyzed and provided an average total hydrocarbon yield of 1.15 wt % and an average volatile yield of 1500 ppm. The 35 samples from the PA-3 well provided an average total hydrocarbon yield of 1.00 wt % and an average volatile yield of 1625 ppm. The high total hydrocarbon yields for both the OH-4 and PA-3 well samples seem to confirm the thermally immature nature of the source rocks from these two wells.

The lithologic description of the samples from the PA-3 well as well as the organic carbon determination have been completed.

The C_1-C_7 analyses of an additional 41 samples from the OH-4 well were completed. The average free gas content was 0.64 SCF/ft^3 of shale and the gas was relatively rich in methane. The average total gas content was 0.96 SCF/ft^3 of shale.

Bitumen or C_{15+} Analysis was performed on 41 samples from the OH-4 well. This analysis yielded an average concentration of total extractable material of 1998 ppm with a mean hydrocarbon to non-hydrocarbon material ratio of 2.53.

The bulk density analysis of the OH-4 samples was completed and the values are similar to those reported previously.

Dilatometry studies on samples from the OH-3 well were completed. The samples that were analyzed were chosen from the Chagrin member and the Lower Huron facies. Water still causes the greatest degree of swelling and exposure to kerosene results in the least degree of expansion. Samples from the Chagrin member expand less than those from the Lower Huron facie. The samples from the Lower Huron yielded similar results even though they had significantly different organic carbon contents.

Methane Permeability testing has been completed on samples from the PA-2, PA-3, OH-3 and OH-4 wells. Only three of the samples tested were unfractured and the permeability of these samples ranged from 5.3×10^{-8} to $<10^{-12}$ darcys. The permeability range for the fractured samples was from $>10^{-2}$ to 8.8×10^{-5} darcys.

Sorption studies were completed on samples from four zones of the OH-4 well. The studies completed during this quarter were those with 800, 400 and 200 psi pressures. The samples from the Dunkirk zone released 80-90% of their adsorbed gas within five hours. Samples from the Rhinestreet and Marcellus zones adsorbed less gas and released it at much slower rates. There appears to be no initial correlation of adsorption/desorption with TOC and bulk density.

LIST OF CONTRIBUTORS

The following have contributed input for this report:

J. D. Moteff

S. W. Nance

E. Stacy

R. E. Zielinski

I. INTRODUCTION

A change in the format of the Mound Facility EGSP reports begins with this issue. The geochemical characterization data is reported by well instead of by the type of analysis. For most well sections stratigraphic intervals are identified. The stratigraphic zones were picked from borehole logs. The logs and sample datums are discussed in the text. No concentrated effort was made to develop a rigid system of formation and member names. The well logs were generally tied to the nearest available USGS or state generated cross-sections, therefore, the interval names should only be used as a guide for determining stratigraphic position.

The general location of wells and corresponding well data used by Mound Facility in its EGSP study is indicated in Table 1 and Figure 1.

TABLE 1

Detailed description of EGSP well locations.

Appalachian Basin Wells

Mound Well	Well Name	Location State	Location County
PA-1	Minard Run Oil Co./ Minard Run Exploration #1	Pennsylvania	McKean
PA-2	C. E. Power Systems/ C. E. Power Systems #1	Pennsylvania	Allegheny
KY-4	Ashland Oil Co./ Skaggs-Kelley Unit #3-RS	Kentucky	Johnson
NY-1	National Fuel Gas Supply Corp./ #6213 (Jo) EGSP NY #1	New York	Allegany
KY-2	Columbia Gas Transmission Corp./ Columbia Gas #20,336	Kentucky	Martin
VA-1	Columbia Gas Transmission Corp./ Penn Va. Corp. Farm Well #20338	Virginia	Wise
WV-7	Mobay Chemical Corp./ H. Emch & A. Pyles Unit #1	West Virginia	Wetzel
WV-6	U. S. Dept. of Energy MERC #1	West Virginia	Monangalia
WV-5	Reel Drilling Co./ D/K Farm #3	West Virginia	Mason
11940	Consolidated Gas Supply Corp./ L. A. Bales #11940	West Virginia	Jackson
7239	Kentucky-West Virginia Gas Co./ Nicholas Combs #7239	Kentucky	Perry
OH-1	Canton Oil & Gas Co./ Glen-Gery #5-74S	Ohio	Carroll
OH-3	Thirlow Weed & Associates/ Louise Beckholt #1	Ohio	Knox
R-109	River Gas Company/ Florence L. House #R-109	Ohio	Washington
OH-4	Monsanto Research Corp./Bessermer and Lake Erie Railroad Co. #3	Ohio	Ashtabula
PA-3	Monsanto Research Corp. Pennsylvania DER/Presque Isle State Park #1	Pennsylvania	Erie

Illinois Basin Wells

IND-2	Indiana Geol. Survey/ Clark State Forest SDH-290 EGSP #2	Indiana	Clark
Ill-4	Rector & Stone Drilling Co./ Missouri Portland #1	Illinois	Hardin
I-1	Tri-Star Producing Co., Inc./ Lancaster #1-D	Illinois	Effingham
P-1	Energy Resource of Ind., Inc.,/ Phegley Farms, Inc. #1	Indiana	Sullivan
O-1	Orbit Gas Co./ Ray Clark #1	Kentucky	Christian

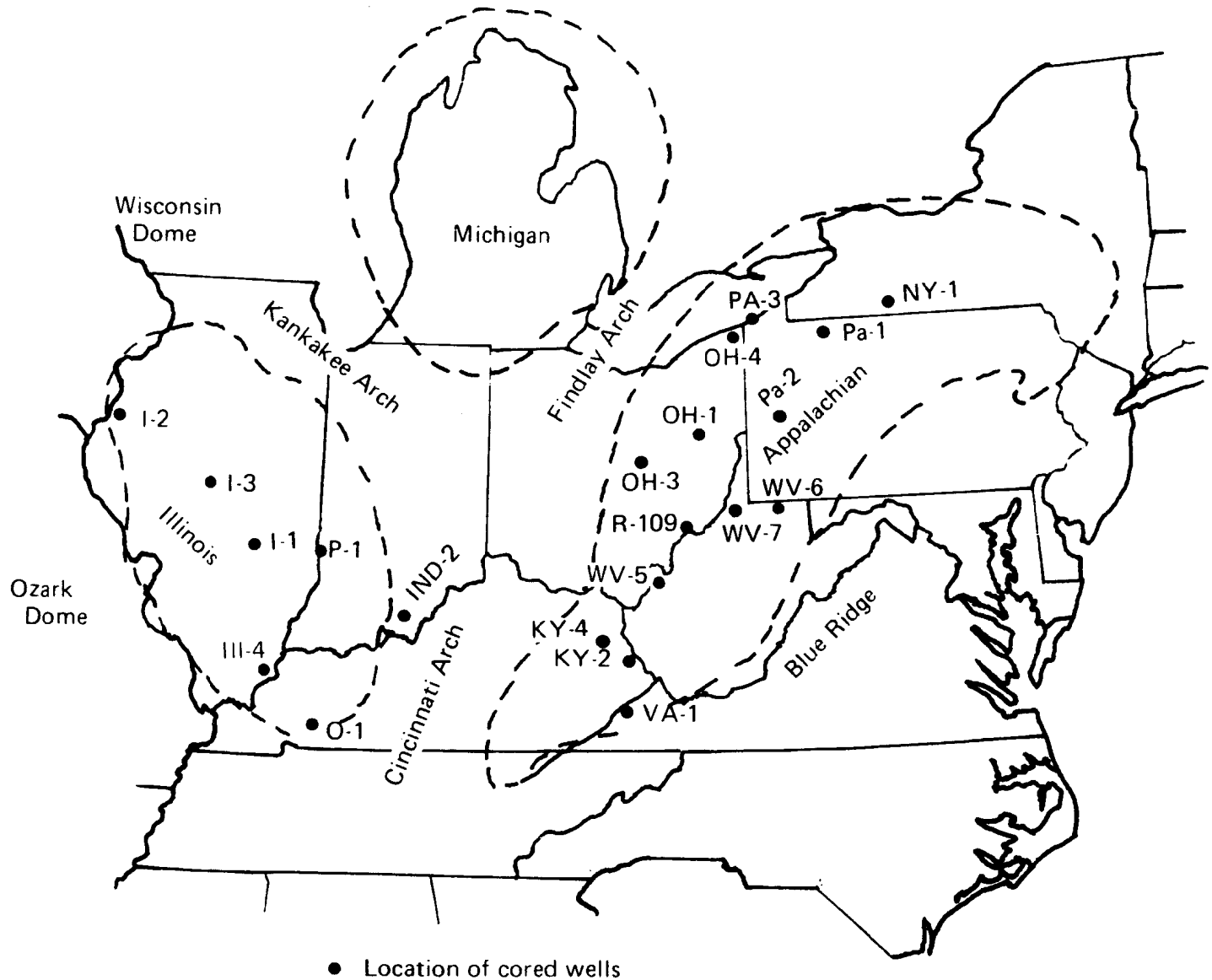

Figure 1
The distribution of cored wells in the Illinois and Appalachian Basins.

II. GEOCHEMISTRY

A. Ill-4 Well (Hardin County, Illinois)

1. Sample Identification and Depths

Table 2 contains the sample identification and corresponding sample depths from the Ill-4 well (Rector and Stone Drilling Company/Missouri Portland #1). Samples depths are datumed to the drilling datum. Drilling datum is ground level (578 ft).

2. Major Elemental Analysis

Table 3 indicated the concentration of the major elements (expressed as oxides) from the Ill-4 well samples.

B. KY-4 Well (Johnson County, Kentucky)

1. Sample Identification, Depths, and Stratigraphic Intervals

Table 4 contains the sample identification and corresponding depths for the samples from the KY-4 well (Ashland Oil Inc./ Skaggs-Kelly Unit #3-RS).

Table 5 identifies the stratigraphic intervals selected from the gamma-ray/density log. The sample and log depths are datumed from the Kelly Bushing (KB) which is at an elevation of 972 ft. Permanent datum is ground level (961 ft).

2. Major Elemental Analysis

Table 6 indicates the concentration of the major elements expressed in terms of the oxides for 51 samples from the KY-4 well.

3. Kerogen Elemental Composition

The three major factors which determine hydrocarbon potential are organic content, thermal maturation, and organic source. The latter two factors can be evaluated by elemental analysis of kerogen.(1)

Nonmarine environments tend to accumulate material rich in aromatics. This gives a relatively high O/C and low H/C (Curve C in Figure 2). The kerogen capable of producing oil is rich in aliphatic structures and, thus, has a higher H/C and lower O/C (Curve A, Figure 2). This type of kerogen is preferentially deposited in marine environments. Curve B in Figure 2 represents the evolution

TABLE 2

Shale Samples from the Ill-4 Well
located in Hardin County, Illinois

Mound Sample No.	Depth, Ft.
Ill-4-1	75.41/.78
Ill-4-2	95.47/.87
Ill-4-3	107.23/.58
Ill-4-4	107.59/.96
Ill-4-5	126.25/.65
Ill-4-6	142.15/.54
Ill-4-7	162.62/.98
Ill-4-8	172.43/.82
Ill-4-9	185.24/.62
Ill-4-10	204.44/.92
Ill-4-11	214.50/.92
Ill-4-12	232.07/.38
Ill-4-13	242/35/.69
Ill-4-14	252.60/.89

TABLE 3
MAJOR ELEMENTS IN WHOLE CORE
FOR ILL-4 WELL

Mound Sample Number	Al_2O_3(%)	Fe_2O_3(%)	CaO(%)	MgO(%)	TiO_2(%)	MnO(%)	Na_2O(%)	K_2O(%)	SiO_2(%)	P_2O_5(%)
Ill-4-1	11.8	3.20	0.87	0.45	.504	.010	3.7	4.0	65.7	N.D.
Ill-4-2	14.7	4.09	1.54	1.47	.752	.024	4.9	5.1	54.4	N.D.
Ill-4-4	17.0	5.52	1.42	1.39	.870	.014	1.4	7.6	56.6	N.D.
Ill-4-5	14.6	5.40	2.16	2.26	.840	.032	3.2	6.2	57.4	N.D.
Ill-4-6	14.6	4.39	4.02	2.89	.833	.027	4.4	5.4	55.1	N.D.
Ill-4-8	14.1	5.45	3.36	2.40	.748	.035	1.2	7.1	52.1	N.D.
Ill-4-9	15.8	5.29	1.04	1.94	.683	.017	3.7	5.3	60.4	N.D.
Ill-4-10	13.8	4.42	1.42	2.40	.723	.018	1.5	6.2	55.9	N.D.
Ill-4-11	14.4	4.68	2.50	2.81	.745	.021	2.8	5.3	55.5	N.D.
Ill-4-12	13.9	4.05	0.89	2.02	.603	.017	1.8	6.6	60.6	0.4
Ill-4-13	12.1	3.34	2.97	2.34	.525	.017	3.2	4.6	60.2	N.D.
Ill-4-14	9.7	3.39	6.47	3.71	.483	.024	2.7	4.5	56.4	N.D.

TABLE 4

Shale Samples from the KY-4 Well
located in Johnson County, Kentucky

Mound Sample No.	Depth, Ft.
KY-4-1	974.16/.68
KY-4-2	984.32/.61
KY-4-3	994.05/.36
KY-4-4	1004.38/.73
KY-4-5	1014.36/.64
KY-4-6	1024.23/.49
KY-4-7	1034.22/.53
KY-4-8	1044.52/.78
KY-4-9	1054.37/.62
KY-4-10	1064.31/.55
KY-4-11	1074.26/.51
KY-4-12	1091.10/.42
KY-4-13	1101.46/.67
KY-4-14	1121.14/.36
KY-4-15	1131.12/.36
KY-4-16	1148.12/.49
KY-4-17	1158.39/.63
KY-4-18	1168.43/.70
KY-4-19	1178.30/.52
KY-4-20	1188.17/.41
KY-4-21	1198.29/.62
KY-4-22	1206.35/.61
KY-4-23	1216.20/.46
KY-4-24	1226.40/.82
KY-4-25	1236.39/.63
KY-4-26	1246.27/.62
KY-4-27	1256.39/.58
KY-4-28	1265.28/.53
KY-4-29	1275.37/.58
KY-4-30	1285.53/.81
KY-4-31	1295.45/.72
KY-4-32	1305.18/.43
KY-4-33	1315.53/.81
KY-4-34	1324.12/.38
KY-4-35	1334.40/.62
KY-4-36	1344.30/.57
KY-4-37	1354.55/.81
KY-4-38	1364.31/.63
KY-4-39	1374.25/.50
KY-4-40	1384.30/.80

TABLE 4 (Continued)

Shale Samples from the KY-4 Well
located in Johnson County, Kentucky

Mound Sample No.	Depth, Ft.
KY-4-41	1394.39/.65
KY-4-42	1404.63/.90
KY-4-43	1414.44/.73
KY-4-44	1424.49/.72
KY-4-45	1441.08/.34
KY-4-46	1451.28/.55
KY-4-47	1461.32/.65
KY-4-48	1471.35/.62
KY-4-49	1481.15/.40
KY-4-50	1491.29/.54
KY-4-51	1500.19/.46

TABLE 5

The Stratigraphic Intervals of the KY-4 Well, Johnson County, Kentucky. (Datumed to KB. KB elevation is 972 ft.)

Stratigraphic Zone	Depth
Sunbury Shale	862-878
Bedford Shale	878-992
Cleveland Member	992-1085
Three Lick Bed	1085-1123
Upper Huron Member	1123-1188
Chagrin/Brallier	1188-1317
Lower Huron Member	1317-1417
Olentangy Shale	1417-1480

TABLE 6

MAJOR ELEMENTS IN WHOLE CORE

FOR KY-4 WELL

Mound Sample Number	Al_2O_3(%)	Fe_2O_3(%)	CaO(%)	MgO(%)	TiO_2(%)	MnO(%)	Na_2O(%)	K_2O(%)	SiO_2(%)	P_2O_5(%)
KY-4-1	9.0	12.7	1.45	1.83	.697	.118	0.6	2.5	59.5	N.D.
KY-4-2	20.4	7.19	0.36	1.36	.996	.045	0.5	4.2	48.9	0.3
KY-4-3	17.6	6.30	0.28	1.28	.943	.050	0.5	4.0	56.1	0.5
KY-4-4	15.9	4.34	0.13	1.02	.919	.011	0.6	3.8	60.2	N.D.
KY-4-5	15.6	5.21	0.14	1.12	.823	.011	0.6	3.9	59.1	0.5
KY-4-6	12.2	5.53	0.17	1.00	.726	.010	0.6	3.6	56.8	0.4
KY-4-7	12.9	6.28	0.26	1.03	.766	.010	0.7	3.6	62.6	N.D.
KY-4-8	11.0	3.57	0.89	0.89	.786	.010	0.8	3.1	67.5	N.D.
KY-4-9	13.8	3.50	0.18	1.08	.852	.011	0.7	3.7	64.8	N.D.
KY-4-10	13.4	3.74	0.18	0.98	.830	.010	0.7	3.6	61.6	N.D.
KY-4-11	15.1	6.04	0.13	1.00	.855	.011	0.8	3.8	59.6	N.D.
KY-4-12	15.9	5.25	0.11	1.14	.831	.012	0.7	4.1	57.0	N.D.
KY-4-13	12.4	3.79	0.84	1.08	.867	.015	0.8	3.4	62.2	N.D.
KY-4-14	17.9	9.44	0.23	1.31	.828	.015	0.6	4.4	54.7	N.D.
KY-4-15	18.7	4.26	0.18	1.56	.930	.014	0.7	4.5	62.6	N.D.
KY-4-16	13.1	4.52	1.06	1.14	.784	.020	0.7	3.4	53.7	0.4
KY-4-17	17.3	5.80	0.24	1.28	.887	.014	0.7	4.1	60.9	0.4
KY-4-18	16.6	6.20	0.41	1.31	.957	.018	0.8	4.1	62.9	0.4
KY-4-19	12.9	5.58	0.85	1.10	.796	.021	0.7	3.4	57.0	N.D.
KY-4-20	13.2	5.98	0.36	1.03	.775	.014	0.7	3.6	58.9	N.D.
KY-4-21	15.7	5.58	0.35	1.31	.812	.025	0.7	4.0	58.9	N.D.
KY-4-22	14.5	5.74	0.34	1.14	.778	.018	0.6	3.7	53.1	N.D.
KY-4-23	13.7	6.15	0.49	1.10	.788	.017	0.7	3.6	57.0	N.D.
KY-4-24	14.8	6.08	0.51	1.21	.773	.020	0.7	3.8	59.6	N.D.
KY-4-25	15.4	6.31	0.36	1.24	.775	.022	0.7	3.9	58.3	N.D.
KY-4-26	15.4	5.84	0.35	1.24	.741	.022	0.7	3.9	59.6	N.D.
KY-4-27	14.8	5.72	0.36	1.28	.737	.021	0.8	3.9	62.6	0.4
KY-4-28	15.7	6.71	0.35	1.31	.736	.021	0.8	4.1	58.3	N.D.
KY-4-29	16.3	6.21	0.35	1.38	.724	.023	0.8	4.2	55.7	0.4
KY-4-30	15.8	6.47	0.39	1.50	.721	.026	0.8	4.1	60.3	N.D.

TABLE 6 (Continued)

MAJOR ELEMENTS IN WHOLE CORE

FOR KY-4 WELL

Mound Sample Number	Al_2O_3(%)	Fe_2O_3(%)	CaO(%)	MgO(%)	TiO_2(%)	MnO(%)	Na_2O(%)	K_2O(%)	SiO_2(%)	P_2O_5(%)
KY-4-31	13.7	6.64	0.34	1.26	.726	.020	0.8	3.8	59.3	N.D.
KY-4-32	15.6	7.18	0.23	1.28	.783	.019	0.8	4.0	55.7	0.4
KY-4-33	13.6	10.8	1.75	1.73	.719	.044	0.7	3.6	48.5	N.D.
KY-4-34	15.6	7.63	0.34	1.28	.808	.019	0.7	3.9	55.7	0.4
KY-4-35	10.6	7.18	2.25	0.94	.685	.020	0.7	3.1	53.7	0.4
KY-4-36	11.5	7.02	1.75	1.45	.663	.027	0.7	3.3	56.3	N.D.
KY-4-37	12.7	5.88	0.91	1.00	.716	.018	0.8	3.7	59.3	0.4
KY-4-38	12.6	7.09	0.57	1.00	.728	.018	0.8	3.6	62.6	N.D.
KY-4-39	13.2	5.13	1.14	1.28	.731	.022	0.8	3.9	58.3	N.D.
KY-4-40	14.1	5.60	0.47	1.14	.733	.014	0.8	4.2	55.7	0.4
KY-4-41	13.4	5.84	0.34	1.10	.700	.014	0.8	4.0	53.1	0.4
KY-4-42	13.4	5.38	0.36	1.15	.686	.014	0.8	4.0	56.3	N.D.
KY-4-43	12.9	5.39	0.48	1.10	.664	.015	0.8	3.8	66.2	N.D.
KY-4-44	17.1	4.08	0.18	1.31	.805	.019	0.8	4.4	67.8	N.D.
KY-4-45	19.6	5.52	0.47	1.94	1.06	.029	0.6	4.5	66.2	N.D.
KY-4-46	18.0	7.40	0.37	1.63	.868	.020	0.6	4.2	55.0	N.D.
KY-4-47	17.0	5.73	2.65	2.75	.919	.054	0.6	4.1	56.3	N.D.
KY-4-48	17.0	8.37	0.44	1.52	.867	.019	0.6	4.0	53.1	N.D.
KY-4-49	18.9	6.46	0.51	1.94	.918	.031	0.6	4.6	59.3	N.D.
KY-4-50	18.5	5.49	2.86	3.06	.939	.054	0.6	4.8	56.3	N.D.
KY-4-51	17.9	5.28	2.18	2.73	.923	.046	0.6	4.5	58.9	N.D.

path of a kerogen with characteristics intermediate between the marine and nonmarine cases. Increasing thermal maturation initially eliminates oxygen from the kerogen, resulting in a decreased O/C ratio. Subsequently, hydrocarbons are generated and the ratio H/C declines. These effects are indicated by the arrow near Curve C (Figure 2).

The elemental composition of kerogen was determined for 46 samples from the KY-4 well. The atomic ratios H/C and O/C were computed for each sample (Table 7). The average H/C and O/C values were 1.04 and 0.21, respectively. The individual sample results were plotted on a H/C versus O/C diagram (Figure 2). The average H/C and O/C values were plotted for comparison with results from other Appalachian and Illinois Basin well results (Figure 3).

In general, the KY-4 samples are relatively hydrogen-rich. This suggests kerogen sourced from a marine or intermediate type organic matter.

4. Material Balance Assay Results

The material balance assay (MBA) results provide an indication of the shale total hydrocarbon potential. This analysis also indicates the types and characteristics of the shale fluids. Results are given for the oil, gas, and water yield, as well as the pH of the water, the gas composition, and the °API gravity of the oil.

For the assays, approximately 100 grams of well-riffled, representative 4-to-8 mesh material were heated and destructively distilled at a maximum temperature of 500°C. The assay is performed in a closed system and either helium or nitrogen is used as the flush gas. Oil and water are condensed in a centrifuge tube and non-condensable gases flow into an evacuated receiver. Following the pyrolysis process, the products are weighed and further analyzed.

Seven KY-4 samples were assayed. The carbon data for these samples were assayed. The carbon data for these samples is reported in Table 8. The average organic carbon content was 5.7 wt %. The product yields are described in Table 9. The average oil yield was 6.1 gal/ton with an °API-gravity of 23.1. The mean hydrocarbon gas yield was 139 ft^3/ton. The description of the gas conposition and component concentrations were given in the previous quarterly report.[2]

C. PA-1 Well (McKean County, Pennsylvania)

1. Sample Identification, Depths, and Stratigraphic Intervals

Table 10 contains the sample identification numbers and depths

TABLE 7

Kerogen Elemental Analysis for KY-4 Sample

MOUND SAMPLE NUMBER		WEIGHT PERCENT ASH FREE C	H	N	O	ASH	ATOMIC RATIO H/C	O/C
KY-4-	1	75.53	4.71	0.68	19.03	5.97	0.74	0.19
KY-4-	2	78.15	4.63	1.39	15.77	9.47	0.71	0.15
KY-4-	3	74.49	5.07	1.95	18.49	9.93	0.81	0.19
KY-4-	4	80.64	7.60	2.73	9.02	33.06	1.12	0.03
KY-4-	5	72.71	6.58	1.70	19.01	13.39	1.08	0.20
KY-4-	6	80.53	7.16	2.35	9.96	22.92	1.06	0.09
KY-4-	7	74.00	5.84	1.09	19.07	10.07	0.94	0.19
KY-4-	8	81.43	7.60	2.93	7.99	32.03	1.11	0.07
KY-4-	9	63.16	5.08	0.96	30.81	3.27	0.96	0.37
KY-4-	10	61.30	5.34	1.86	31.51	11.19	1.04	0.39
KY-4-	11	80.93	6.30	1.35	11.37	16.47	0.93	0.11
KY-4-	12	82.31	6.24	1.96	8.99	20.47	0.90	0.08
KY-4-	13	63.24	5.34	1.44	29.48	0.00	1.10	0.35
KY-4-	14	79.49	5.12	1.94	13.45	13.26	0.77	0.13
KY-4-	15	77.69	4.69	1.33	16.28	7.03	0.72	0.16
KY-4-	16	78.29	7.30	2.53	11.88	32.90	1.11	0.11
KY-4-	17	56.51	5.44	1.39	36.66	8.02	1.15	0.49
KY-4-	18	81.45	7.23	2.42	8.85	20.71	1.06	0.08
KY-4-	19	49.95	4.68	0.88	44.50	4.26	1.12	0.67
KY-4-	20	83.19	7.47	2.01	7.33	25.28	1.07	0.07
KY-4-	21	71.11	6.91	1.57	20.41	16.64	1.16	0.22
KY-4-	22	74.27	7.00	2.06	16.67	20.03	1.12	0.17
KY-4-	23	74.06	6.86	1.34	17.74	17.81	1.10	0.18
KY-4-	24	57.10	5.54	1.08	36.28	5.75	1.16	0.48
KY-4-	25	77.42	7.32	2.12	13.13	23.68	1.13	0.13
KY-4-	26	56.09	5.13	0.79	38.00	4.61	1.09	0.51
KY-4-	27	78.87	7.43	2.18	11.51	22.18	1.12	0.11
KY-4-	28	47.09	4.55	1.01	47.35	0.00	1.15	0.75
KY-4-	29	72.18	7.04	2.25	18.53	30.23	1.16	0.19
KY-4-	30	62.49	6.54	1.12	29.84	11.04	1.25	0.36
KY-4-	31	77.58	7.92	2.10	12.40	44.68	1.22	0.12
KY-4-	32	70.39	6.97	1.92	20.72	17.18	1.18	0.22
KY-4-	33	73.14	7.23	2.56	17.07	20.99	1.18	0.18
KY-4-	34	69.31	7.45	1.77	21.46	20.56	1.28	0.23
KY-4-	35	72.41	7.23	2.41	17.95	23.56	1.19	0.19
KY-4-	36	62.33	6.19	1.24	30.24	16.15	1.18	0.36
KY-4-	37	80.09	8.17	1.62	10.12	28.88	1.22	0.09
KY-4-	38	76.10	7.94	2.44	13.51	20.53	1.24	0.13
KY-4-	39	73.51	7.40	1.80	17.29	20.90	1.20	0.18
KY-4-	40	76.24	7.87	2.58	13.31	30.65	1.23	0.13
KY-4-	41	70.30	7.45	1.34	20.91	14.45	1.26	0.22
KY-4-	42	77.10	7.62	2.33	12.95	20.51	1.18	0.13
KY-4-	43	75.01	7.81	1.90	15.28	3.97	1.24	0.15
KY-4-	45	80.74	9.22	2.98	7.06	41.33	1.36	0.07
KY-4-	46	76.47	8.04	2.49	13.00	26.47	1.25	0.13
KY-4-	48	75.97	7.85	2.99	13.19	22.31	1.23	0.13

N=46 MEAN OF H/C= 1.04 O/C= 0.21

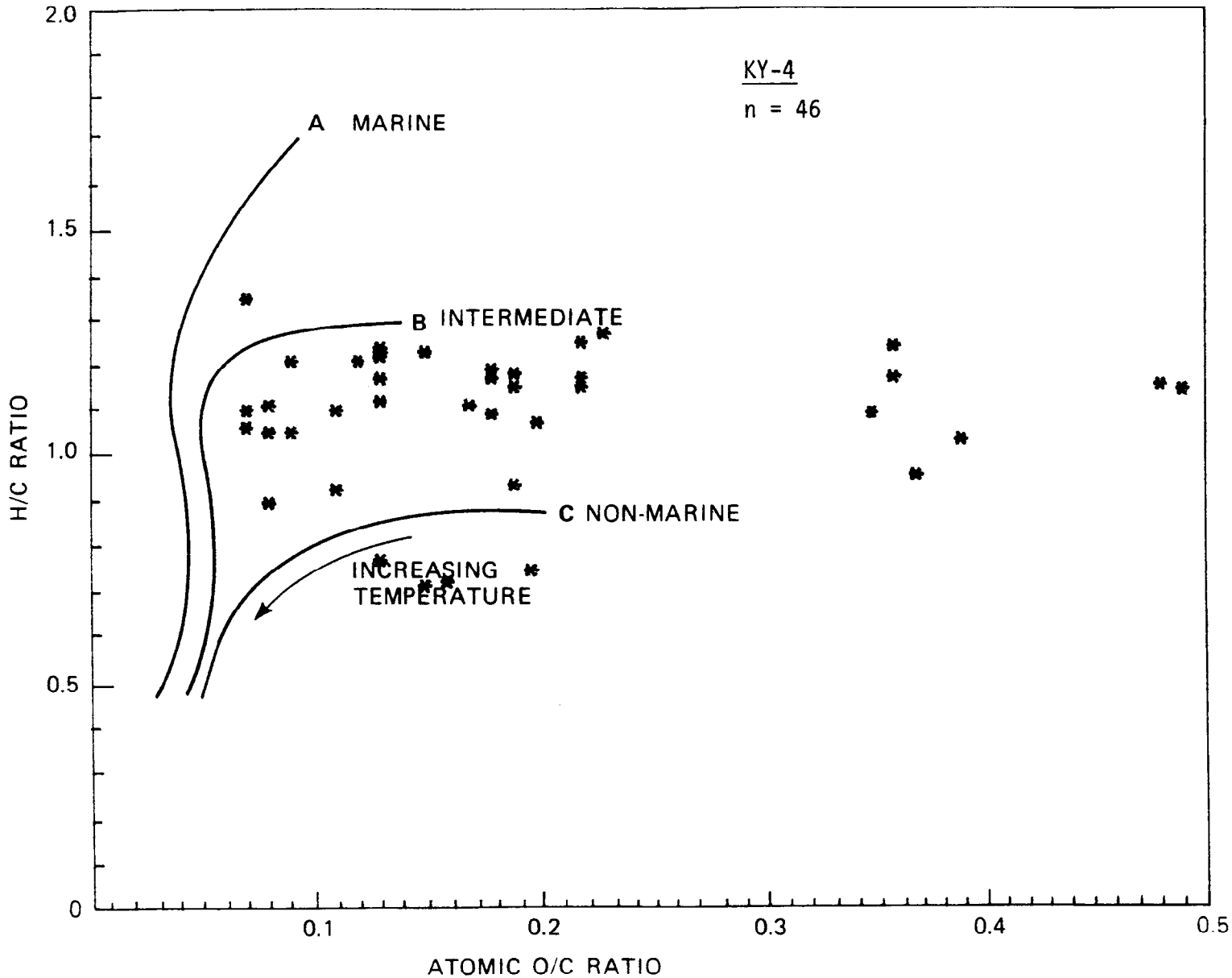

FIGURE 2
The atomic ratios hydrogen: carbon versus oxygen: carbon for kerogen samples from the KY-4 well.

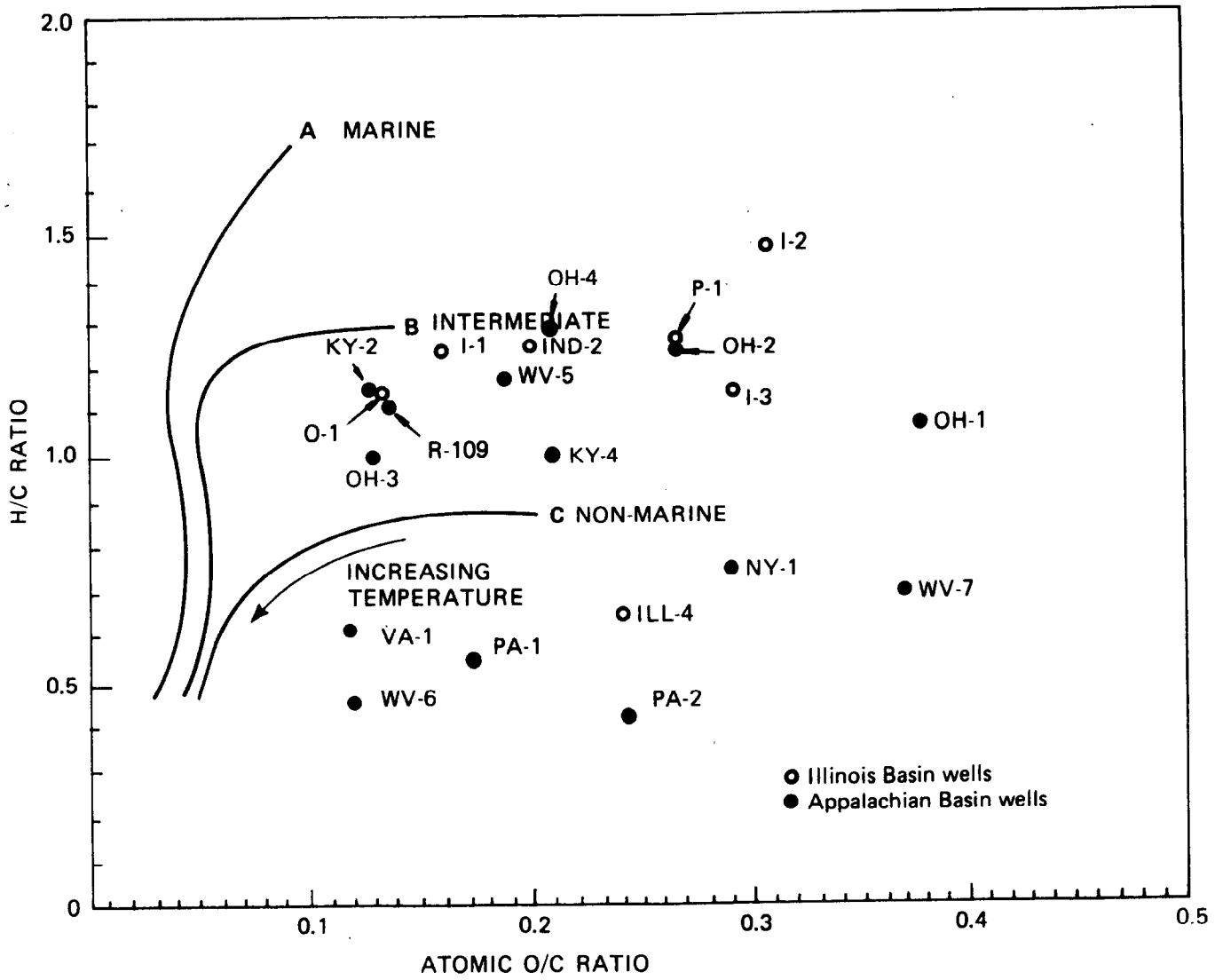

FIGURE 3

A comparison of the mean H/C versus O/C results for Upper Devonian Shale wells.

TABLE 8

Material Balance Assay Carbon and Ash Data
for KY-4 Well Samples

Mound Sample No.	KY-4-5	KY-4-7	KY-4-13	KY-4-32	KY-4-36	KY-4-37	KY-4-42
Pre-test:							
Total Carbon (%)	7.7	5.6	5.5	0.71	9.8	6.8	7.5
Organic Carbon (%)	7.4	5.5	5.3	0.31	8.0	6.2	6.9
Post test:							
Total Carbon (%)	3.9	3.3	3.6	0.65	6.3	4.0	4.2
Organic Carbon (%)	4.0	3.2	3.3	0.32	5.0	3.8	4.2
Carbon Transfer Ratio	-	-	-	-	-	-	-
Retorting Weight Loss (%)	6.37	5.61	5.11	2.50	7.17	6.11	6.33
Retorted Shale:							
Ash (%)	86.83	80.78	93.42	94.74	89.95	92.65	92.38
Ignition Loss (%)	13.17	19.22	6.58	5.26	10.05	7.35	7.62

TABLE 9

Material Balance Assay and Product Assay
for KY-4 Samples

Mound Sample No.	KY-4-5	KY-4-7	KY-4-13	KY-4-32	KY-4-36	KY-4-37	KY-4-42
Oil Yield (Gal/Ton)	8.37	5.75	5.28	<0.50	8.27	6.96	7.54
Specific Gravity (60°/60°)	.920	.909	.913	.917	.920	.913	.915
°API-Oil Gravity	22.3	24.2	23.5	22.8	22.3	23.3	23.1
Water Yield (Gal/Ton)	3.4	4.2	4.0	3.8	2.5	3.1	3.2
pH	9.4	9.4	9.3	9.2	8.9	9.4	9.5
Hydrocarbon Gas Yield (Ft^3/Ton)	171.8	120.1	126.0	7.4	189.9	158.2	200.0

from the PA-1 (Minard Run Oil Company/Minard Run Exploration #1).

Table 11 identifies the stratigraphic intervals selected from the gamma-ray/bulk density log. Sample and log depths are datumed from the Kelly Bushing which is 1271 ft or 11 ft above the permanent datum (ground level) of 1260 ft.

2. Gas Cannister Over-Pressure Gas Volumes

Core samples are placed in gas-tight cannisters at the well site and shipped to the laboratory for analysis of the gas volume and composition. The samples are allowed to off-gas for approximately six weeks (this is the conventional off-gassing method). The gas in the cannister headspace is bled-off until the cannister is at atmospheric pressure. This over-pressure gas volume is given in Table 12 for the 35, PA-1 samples.

The maximum over-pressure gas volume was 549 cm^3 at 4677 ft (PA-1-11). This sample was from the gray shale interval above the Burket member (black shale) of the Genesee Formation. The average over-pressure gas volume was $\sim$ 110 cm^3, assuming those cannisters with indications of a slight vacuum and slight pressure to be equal to an over-pressure gas volume of zero.

3. Material Balance Assay Analysis

Material Balance Assay was completed for sample PA-1-14 (Tables 13, 14, and 15). This organically rich (4.4 wt % TOC) had a negligible oil yield and a hydrocarbon gas yield of 44 ft^3/ton. The primary hydrocarbon gas was methane; nonhydrocarbon gas, carbon dioxide.

4. Pyrolysis-Gas Chromatographic Results

Pyrolysis techniques can be used to evaluate the naturally generated and total hydrocarbon potential of source rocks.[3]

The volatile hydrocarbon content (Peak I) is related to the gas content of the source rock, while the Peak II value indicates the remaining hydrocarbon producing potential. The ratio of Peak I/ Peak II and the maximum temperature of the hydrocarbons released can be used to indicate thermal maturity. As thermal maturity increases, more of the hydrocarbon potential (Peak II) is converted to volatile hydrocarbons (Peak I), thus increasing the ratio of Peak I/Peak II.

Some of the major advantages of pyrolytic analysis is the relatively simple and rapid analytical technique and the small sample size requirement.

TABLE 10

Shale Samples from the PA-1 Well
located in McKean County, Pennsylvania

Mound Sample No.	Depth, Ft.
PA-1-1	3483.32/.60
PA-1-2	3502.47/.73
PA-1-3	3522.50/.70
PA-1-4	4542.27/.53
PA-1-5	4562.21/.57
PA-1-6	4582.18/.47
PA-1-7	4600.33/.59
PA-1-8	4620.67/.92
PA-1-9	4640.63/.88
PA-1-10	4657.63/.85
PA-1-11	4677.27/.54
PA-1-12	4697.23/.50
PA-1-13	4717.13/.41
PA-1-14	4737.12/.36
PA-1-15	4757.12/.33
PA-1-16	4775.38/.58
PA-1-17	4795.42/.62
PA-1-18	4815.42/.68
PA-1-19	4835.35/.77
PA-1-20	4855.56/.80
PA-1-21	4875.42/.66
PA-1-22	4893.27/.46
PA-1-23	4913.23/.46
PA-1-24	4933.11/.39
PA-1-25	4951.31/.56
PA-1-26	4971.18/.57
PA-1-27	4991.40/.75
PA-1-28	5010.30/.61
PA-1-29	5030.23/.49
PA-1-30	5050.39/.66
PA-1-31	5069.38/.53
PA-1-32	5089.12/.33
PA-1-33	5100.47/.75
PA-1-34	5149.30/.59
PA-1-35	5169.48/.77

TABLE 11

The Stratigraphic Zones of the PA-1 Well, McKean County, Pennsylvania. Log datum is KB. KB is 1271 ft.

Stratigraphic Zone	Depth
West Falls Fm.	
(Base of) Rhinestreet Member	-4368
Sonyea Fm.	
Middlesex Member	4530-4612
Genesee Fm.	
Burket Member	4729-4762
Tully Ls.	4762-4766
Hamilton Grp.	
Mahantango Fm.	4766-4828
Driller's Tully	4828-4837
Mahantango Fm.	4837-5088
Marcellus	5088-5192
Onondaga Ls.	5192-

TABLE 12
Pressure/Vacuum in Container
for PA-1 Well

Mound Sample Number	Volume Displacement (cc of water)
PA-1-1	94
PA-1-2	0
PA-1-3	69
PA-1-4	Slight pressure
PA-1-5	153
PA-1-6	80
PA-1-7	139
PA-1-8	Slight pressure
PA-1-9	372
PA-1-10	40
PA-1-11	549
PA-1-12	2
PA-1-13	9
PA-1-14	Slight pressure
PA-1-15	Slight pressure
PA-1-16	31
PA-1-17	159
PA-1-18	2
PA-1-19	0
PA-1-20	180
PA-1-21	245
PA-1-22	0
PA-1-23	200
PA-1-24	Slight pressure
PA-1-25	385
PA-1-26	114
PA-1-27	264
PA-1-28	188
PA-1-29	385
PA-1-30	68
PA-1-31	6
PA-1-32	3
PA-1-33	21
PA-1-34	88
PA-1-35	0

TABLE 13

Material Balance Assay Carbon and Ash Data
for PA-1-14

Mound Sample No.	PA-1-14
Pre-test:	
Total Carbon (%)	4.6
Organic Carbon (%)	4.4
Post test:	
Total Carbon (%)	4.4
Organic Carbon (%)	4.4
Carbon Transfer Ratio	-
Retorting Weight Loss (%)	2.69
Retorted Shale:	
Ash (%)	92.65
Ignition Loss (%)	7.35

TABLE 14

Material Balance Assay and Product Assay
for the PA-1 Well

Mound Sample No.	PA-1-14
Oil Yield (Gal/Ton)	< 0.50
Specific Gravity (60°/60°)	-
°API-Oil Gravity	-
Water Yield (Gal/Ton)	4.0
pH	9.2
Hydrocarbon Gas Yield (Ft^3/Ton)	44.2

TABLE 15
MATERIAL BALANCE ASSAY FOR PA-1 SAMPLES

Mound Sample No.	PA-1-14
Hydrocarbons (cm^3/g)	
Methane	3.68
Ethane	0.65
Ethylene	0.17
Propane	0.26
Propylene	0.30
i-Butane	0.02
n-Butane	0.09
Butene-1	0.12
t-Butene-2	0.03
c-Butene-2	<0.01
i-Pentane	<0.01
n-Pentane	<0.01
Pentene-1	<0.01
Non-Hydrocarbons (cm^3/g)	
Hydrogen	<0.03
Hydrogen Sulfide	3.32
Carbon Monoxide	0.13
Carbon Dioxide	6.66

Thirty-five (35) PA-1 samples were analyzed by pyrolysis and gas chromatographic evaluation of the products (Table 16). The average total hydrocarbon yield, volatile yield, maximum Peak II temperature, and Peak I/Peak II values were 0.22 wt %, 1001 ppm, 463°C, and 0.83, respectively. The Peak I/Peak II value suggests a thermally mature shale, i.e., a significant conversion of potential to volatile hydrocarbons has taken place. These mean values are summarized in Table 17 for comparison with other Devonian shale well results.

D. PA-2 Well (Allegheny County, Pennsylvania)

1. Sample Identification, Depths, and Stratigraphic Intervals

Table 18 contains the identification and corresponding sample depths for the PA-2 well (C. E. Power Systems/C. E. Power Systems #1). Table 19 identifies the stratigraphic intervals selected from the bulk density/gamma/ray log. The sample and log datum is the Kelly Bushing (KB). KB is 769 or 10 ft above the permanent datum of ground level (759 ft).

2. Material Balance Assay Results

Two PA-2 samples were assayed. The organic carbon content for samples PA-2-6 and PA-2-22 were 5.0 and 4.7 wt %, respectively (Table 20). These samples had a negligible oil yield (<0.5 gal/ton) and a hydrocarbon gas yield of 7.9 and 6.5 ft^3/ton, respectively (Table 21). The gas composition and component concentrations were reported previously.[2]

E. OH-3 Well (Knox County, Ohio)

1. Sample Identification, Depths, and Stratigraphic Intervals

Table 22 contains the sample identification and corresponding sample depths for the OH-3 well (Thurlow Weed and Assoc./Louise Beckholtz #1). Table 23 identifies the stratigraphic intervals selected from the bulk density/gamma-ray log. These interval depths are measured for the log datum. The permanent log and drilling datum were not specified.

2. Major Elemental Analysis

The major element composition (expressed in terms of their oxides) was determined for 33 samples from the OH-3 well (Table 24).

TABLE 16
PYROLYSIS - GC ANALYSIS
FOR PA-1 WELL

Mound Sample Number	Total Hydrocarbon Yield (Wt %)	Total Hydrocarbon Content (PPM)	Maximum Temperature (°C)
PA-1-1	0.05	176	454
PA-1-2	0.01	44	428
PA-1-3	0.03	160	446
PA-1-4	0.41	1845	487
PA-1-5	0.27	1421	478
PA-1-6	0.38	1844	487
PA-1-7	0.44	1988	496
PA-1-8	0.06	251	439
PA-1-9	0.15	780	464
PA-1-10	0.12	536	458
PA-1-11	0.12	594	461
PA-1-12	0.40	1854	493
PA-1-13	0.23	1086	477
PA-1-14	0.64	3037	485
PA-1-15	1.30	5337	483
PA-1-16	0.19	999	471
PA-1-17	0.17	848	469
PA-1-18	0.11	613	445
PA-1-19	0.01	25	455
PA-1-20	0.03	128	446
PA-1-21	0.04	138	453
PA-1-22	0.06	267	452
PA-1-23	0.07	379	462
PA-1-24	0.06	260	439
PA-1-25	0.06	350	448
PA-1-26	0.33	1701	483
PA-1-27	0.03	105	453
PA-1-28	0.02	77	455
PA-1-29	0.06	261	448
PA-1-30	0.27	1302	470
PA-1-31	0.18	820	415
PA-1-32	0.54	2467	485
PA-1-33	0.23	983	465
PA-1-34	0.12	629	476
PA-1-35	0.34	1745	490

TABLE 17

Mean Values for the GC-Pyrolysis results for Upper Devonian Shales.

Well	Total Hydrocarbon Yield (wt %)	Volatile Hydrocarbon Content (ppm)	Peak I / Peak II	Peak II Maximum Temperature (°C)
Appalachian Basin Wells				
NY-1	0.13	479	0.58	459
WV-7	0.22	999	0.83	460
KY-4	1.89	2012	0.12	451
PA-2	0.02	75	0.60	462
OH-3	1.25	1351	0.12	452
OH-4	1.15	1500	0.16	458
PA-1	0.22	1001	0.83	463
PA-3	1.00	1625	0.19	458
Illinois Basin Wells				
IND-2	4.64	4238	0.10	450
Ill-4	0.22	607	0.38	443

TABLE 18

Shale Samples from the PA-2 Well
located in Allegheny County, Pennsylvania

Mound Sample No.	Depth, Ft.
PA-2-1	6962.16/.37
PA-2-2	6982.31/.60
PA-2-3	7002.36/.56
PA-2-4	7020.42/.62
PA-2-5	7040.31/.55
PA-2-6	7060.46/.70
PA-2-7	7079.19/.42
PA-2-8	7099.29/.56
PA-2-9	7119.39/.62
PA-2-10	7198.25/.47
PA-2-11	7218.12/.34
PA-2-12	7238.20/.42
PA-2-13	7258.33/.61
PA-2-14	7278.57/.78
PA-2-15	7298.46/.74
PA-2-16	7319.40/.65
PA-2-17	7339.44/.70
PA-2-18	7387.37/.55
PA-2-19	7402.31/.61
PA-2-20	7422.28/.54
PA-2-21	7442.22/.47
PA-2-22	7462.42/.64
PA-2-23	7482.44/.60

TABLE 19

The Stratigraphic Intervals of the PA-2 well, Alleghany County, Pennsylvania: (Datum is KB. KB elevation is 769 ft.).

Stratigraphic Zone	Depth
West Falls FM	
(Base of) Rhinestreet Member	- 6664
Sonyea FM	
Middlesex Member	6359 - 6927
Genesee FM	
Burket Member	7052 - 7082
Tully Limestone	7082 - 7142
Hamilton Group	
Mahantango FM	7142 - 7333
Marcellus	7333 - 7482 (est)
Onondaga	7482 (est) -

TABLE 20

Material Balance Assay Carbon and Ash Data
for PA-2 Well

Mound Sample No.	PA-2-6	PA-2-22
Pre-test:		
Total Carbon (%)	5.6	6.8
Organic Carbon (%)	5.0	4.7
Post test:		
Total Carbon (%)	5.8	7.6
Organic Carbon (%)	5.3	5.0
Carbon Transfer Ratio	-	-
Retorting Weight Loss (%)	1.48	1.45
Retorted Shale:		
Ash (%)	91.57	-
Ignition Loss (%)	8.43	-

TABLE 21

Material Balance Assay and Product Assay
for the PA-2 Well

Mound Sample No.	PA-2-6	PA-2-22
Oil Yield (Gal/Ton)	<0.50	<0.50
Specific Gravity (60°/60°)	-	-
°API-Oil Gravity	-	-
Water Yield (Gal/Ton)	2.2	2.0
pH	9.2	9.1
Hydrocarbon Gas Yield (Ft^3/Ton)	7.9	6.5

TABLE 22

Shale Samples from the OH-3 Well,
Knox County, Ohio

Mound Sample Number	Depth, Feet
OH-3-1	574.39/.81
OH-3-2	604.16/.36
OH-3-3	633.63/.94
OH-3-4	664.37/.61
OH-3-5	684.29/.55
OH-3-6	704.22/.58
OH-3-7	722.33/.59
OH-3-8	742.19/.42
OH-3-9	762.37/.56
OH-3-10	780.36/.60
OH-3-11	800.47/.72
OH-3-12	820.18/.49
OH-3-13	838.36/.72
OH-3-14	858.35/.64
OH-3-15	878.47/.68
OH-3-16	896.32/.61
OH-3-17	916.32/.52
OH-3-18	936.32/.61
OH-3-19	944.90/945.13
OH-3-20	960.85/961.14
OH-3-21	990.70/991.03
OH-3-22	1011.10/.24
OH-3-23	1031.39/.75
OH-3-24	1051.51/.76
OH-3-25	1074.40/.69
OH-3-26	1092.58/.86
OH-3-27	1112.58/.86
OH-3-28	1130.43/.71
OH-3-29	1150.17/.50
OH-3-30	1188.48/.73
OH-3-31	1208.18/.42
OH-3-32	1228.07/.41
OH-3-33	1247.32/.41
OH-3-34	

TABLE 23

The Stratigraphic Intervals of the OH-3 Well, Knox County, Ohio. (Datum is not available.)

Stratigraphic Units	Depth
Sunbury Shale	-392
Berea Sandstone	392-425
Bedford Shale	425-569
Cleveland	569-601
Chagrin	601-703
Huron Shale	703-1143
Upper Olentangy Shale	1143-1186
Lower Olentangy Shale	1186-1230
Onondaga Limestone	1230-

TABLE 24

MAJOR ELEMENTS IN WHOLE CORE
for the OH-3 Well

Mound Sample Number	Al_2O_3(%)	Fe_2O_3(%)	CaO(%)	MgO(%)	TiO_2(%)	MnO(%)	Na_2O(%)	K_2O(%)	SiO_2(%)	P_2O_5(%)
OH-3-1	19.5	10.1	0.49	1.69	.849	.147	0.2	4.0	51.3	N.D.
OH-3-2	14.0	5.07	0.15	1.38	.789	.017	0.5	3.2	62.0	N.D.
OH-3-3	18.0	9.81	0.97	2.18	.923	.088	0.2	4.5	56.1	N.D.
OH-3-4	16.6	7.02	0.27	1.41	.862	.030	0.8	3.9	65.8	N.D.
OH-3-5	22.7	6.38	0.12	1.82	1.05	.027	0.2	4.2	58.8	N.D.
OH-3-6	19.7	16.3	1.05	2.29	.897	.101	0.2	4.0	50.2	N.D.
OH-3-7	23.4	6.65	0.17	1.67	1.00	.024	0.3	4.8	56.9	N.D.
OH-3-8	22.7	6.35	0.20	1.63	.965	.037	0.2	5.4	58.8	N.D.
OH-3-9	18.9	6.20	0.13	1.58	.856	.018	0.3	4.7	58.3	N.D.
OH-3-10	17.2	5.74	0.21	1.56	.900	.019	0.6	3.3	61.5	N.D.
OH-3-11	18.0	6.20	0.25	1.58	.899	.023	0.5	3.7	62.6	N.D.
OH-3-12	18.9	6.52	0.20	1.67	.863	.025	0.3	3.3	61.0	N.D.
OH-3-13	20.2	6.43	0.36	1.78	.872	.046	0.3	4.0	61.5	N.D.
OH-3-14	17.5	6.20	0.52	1.45	.831	.029	0.3	3.3	65.3	N.D.
OH-3-15	15.5	5.47	0.31	1.27	.743	.019	0.6	3.0	68.0	N.D.
OH-3-16	17.2	5.81	0.27	1.38	.813	.022	0.3	3.9	62.3	N.D.
OH-3-17	13.5	5.69	0.49	1.34	.690	.026	1.2	3.4	65.3	N.D.
OH-3-18	15.6	5.63	0.28	1.34	.738	.027	0.8	3.9	62.6	N.D.
OH-3-19	16.1	7.00	1.01	1.74	.764	.044	N.D.	2.6	66.8	N.D.
OH-3-20	15.4	6.79	0.76	1.56	.692	.032	0.3	2.5	66.3	N.D.
OH-3-21	18.4	13.7	1.21	3.04	.747	.227	N.D.	3.0	51.2	N.D.
OH-3-22	15.7	7.87	0.28	1.34	.786	.025	N.D.	3.0	60.3	N.D.
OH-3-23	13.6	4.51	0.26	1.14	.671	.031	0.4	2.7	72.2	N.D.
OH-3-24	10.7	6.63	0.63	0.97	.620	.026	0.7	2.1	70.0	N.D.
OH-3-25	13.8	5.62	0.40	1.27	.769	.025	0.5	2.6	67.9	N.D.
OH-3-26	12.8	4.98	0.44	1.16	.697	.018	0.7	3.3	64.1	N.D.
OH-3-27	12.3	5.69	0.65	1.19	.729	.022	0.5	2.1	62.2	N.D.
OH-3-28	17.2	5.42	0.66	1.74	.856	.031	0.3	3.9	66.3	N.D.
OH-3-29	8.9	4.96	1.05	1.03	.548	.018	0.5	3.9	66.3	N.D.
OH-3-30	18.5	4.86	1.99	1.89	.917	.042	0.7	4.7	58.8	N.D.
OH-3-31	18.4	5.80	1.15	1.94	.986	.037	0.2	4.8	61.0	N.D.
OH-3-32	19.1	5.26	1.07	2.11	.906	.035	0.9	4.5	59.3	N.D.
OH-3-33	11.0	3.36	22.3	1.52	.383	.056	0.6	3.1	37.3	N.D.

3. Material Balance Assay Results

These samples from the OH-3 well were assayed. The organic carbon contents for samples OH-3-10, OH-3-16 and OH-3-26 were 3.5, 3.2, and 6.7 wt %, respectively (Table 25). The oil yields were 2.39, 3.23, and 3.26 gal/ton, respectively (Table 26). °API-oil gravities were not determined. The hydrocarbon gas yield was 67.7, 77.7, and 156.7 ft^3/ton, respectively. The hydrocarbon gas composition and component concentration were reported previously.[2]

F. OH-4 Well (Ashtabula County, Ohio)

1. Sample Identification, Depths, and Stratigraphic Intervals

Table 27 contains the identification and corresponding depths for the OH-4 well samples (Monsanto Research Corp./Bessemer and Lake Erie R.R. Co. #3). Table 28 indicates the stratigraphic intervals selected from the gamma-ray/bulk density log. Log and sample depths are measured from ground level which is at an elevation of 583 ft.

2. Gas Cannister Over-Pressure Gas Volumes

The over-pressure gas volume is given in Table 29 for 41 samples from the OH-4 well. For these samples the largest over-pressure gas volume was recorded for sample OH-4-113 (981 ft). This sample is an organically-rich (11.14 wt %) sample from the black shale member (Pipe Creek) of the Java Formation. If those samples which recorded a slight pressure or vacuum are assumed to have zero volume of over-pressure gas, then the average over-pressure gas volume for these 41 OH-4 samples is 2.0 cm^3.

3. C_1-C_7 Analysis

The hydrocarbon gases of these 41 samples were analyzed for composition and concentration (Table 30). The average C_1-C_4 gas concentration in the cannister headspace was 0.64 standard cubic feet of gas per cubic foot of shale (SCF/ft^3). This gas was relatively methane rich (gas wetness, C_1-C_4/C_2-C_4, = 20.1%). The total gas content (headspace gas plus macerated core sample gas averaged 0.96 SCF/ft^3 with an average gas wetness of 33.3%. The sample with the greatest headspace gas content was OH-4-80 at 1.66 SCF/ft^3. This sample comes from the top of the radioactive basal black shale (Dunkirk Member) of the Perrysburg Formation.

TABLE 25

Material Balance Assay Carbon and Ash Data
for OH-3 Well

Mound Sample No.	OH-3-10	OH-3-16	OH-3-26
Pre-test:			
Total Carbon (%)	3.7	3.2	6.9
Organic Carbon (%)	3.5	3.2	6.7
Post test:			
Total Carbon (%)	2.2	2.1	3.9
Organic Carbon (%)	2.2	2.1	3.8
Carbon Transfer Ratio	-	-	-
Retorting Weight Loss (%)	5.01	4.99	6.54
Retorted Shale:			
Ash (%)	94.40	93.36	94.00
Ignition Loss (%)	5.6	6.64	6.00

TABLE 26

Material Balance Assay and Product Assay
for the OH-3 Well

Mound Sample No.	OH-3-10	OH-3-16	OH-3-26
Oil Yield (Gal/Ton)	2.39	3.23	8.2
Specific Gravity (60°/60°)	.884	.886	.905
°API-Oil Gravity	-	-	-
Water Yield (Gal/Ton)	7.0	6.2	2.8
pH	9.1	9.4	9.4
Hydrocarbon Gas Yield (Ft^3/Ton)	67.7	77.7	156.7

Bessmer & Lake Erie Railroad Co.
and
Monsanto Research Corporation

Mound Sample No.	Depth (feet)	Comments
OH-4-1	509 (.72)	D/CCO
OH-4-2	510 (.44-.83)	C/CCO #1
OH-4-3	514 (.75)	D/CCO
OH-4-4	516 (.21-.53)	C/CCO*
OH-4-5	520 (.25-.43)	C/CCO #2
OH-4-6	520 (.43)	D/CCO
OH-4-7	525 (.95)	D/CCO
OH-4-8	527 (.1)	D/CCO
OH-4-9	529 (.47-.83)	C/CCO #3
OH-4-10	530 (.75)	D/CCO
OH-4-10-A	534 (.85)	**
OH-4-10-B	538 (.86)	**
OH-4-11	539 (.33-.59)	C/CCO #4
OH-4-12	541 (.39-.69)	C/CCO*
OH-4-13	541 (.95)	D/CCO
OH-4-14	546 (.15)	D/CCO
OH-4-15	549 (.36-.64)	C/CCO #5
OH-4-16	550 (.1)	D/CCO
OH-4-17	554 (.12)	D/CCO
OH-4-18	558 (.03)	D/CCO
OH-4-19	559 (.69-.92)	C/CCO #6
OH-4-20	563 (.12)	D/CCO
OH-4-21	564 (.47-.79)	C/CCO*
OH-4-21-A	565 (.91)	**
OH-4-22	566-571	D/CT
OH-4-23	571-581	D/CT
OH-4-24	581-591	D/CT
OH-4-25	591-601	D/CT
OH-4-26	601-611	D/CT
OH-4-27	611-621	D/CT
OH-4-28	621-631	D/CT
OH-4-29	631-641	D/CT
OH-4-30	641-651	D/CT no sample
OH-4-31	651-661	D/CT no sample
OH-4-32	661-671	D/CT no sample
OH-4-33	671-681	D/CT
OH-4-34	681-691	D/CT
OH-4-35	691-701	D/CT

C = Canned Samples
D = Bagged Dry Samples
PCO = Pressure
CCO = Conventional Core
CT = Cutting
* = presently being tested in field, not available for detailed analysis
** = presently being analyzed for TOC at Mound

TABLE 27 (Continued)
Bessemer & Lake Erie Railroad Co. and Monsanto Research Corporation

Mound Sample No.	Depth (feet)	Comments
OH-4-36	701-711	D/CT
OH-4-37	711-721	D/CT
OH-4-38	721-731	D/CT
OH-4-39	731-741	D/CT
OH-4-40	741-746	D/CT
OH-4-41	736	C/PCO pressure core chip
OH-4-42	747 (.35-.36)	D/CCO
OH-4-43	748	C/CCO #7
OH-4-44	748 (.55-.85)	C/CCO*
OH-4-45	750 (.55-.57)	D/CCO
OH-4-46	751 (.15-.44)	C/CCO*
OH-4-46-A	755 (.10)	**
OH-4-47	758 (.42-.64)	C/CCO #8
OH-4-48	759 (.27-.30)	D/CCO
OH-4-49	762 (.89-.91)	D/CCO
OH-4-49-A	767 (.56)	**
OH-4-50	768 (.30-.58)	C/CCO #9
OH-4-51	770 (.90-.91)	D/CCO
OH-4-51-A	773 (.58)	**
OH-4-52	777 (.10-.41)	C/CCO*
OH-4-53	778 (.51-.78)	C/CCO #10
OH-4-54	780 (.65-.66)	D/CCO
OH-4-55	784 (.14-.15)	D/CCO
OH-4-56	786 (.79-.81)	D/CCO
OH-4-57	789 (.10-.43)	C/CCO #11
OH-4-57-A	791 (.71)	**
OH-4-58	794	D/CCO
OH-4-58-A	798 (.64)	**
OH-4-59	799 (.05-.32)	C/CCO #12
OH-4-60	802 (.77-.79)	D/CCO
OH-4-61	807 (.45-.47)	D/CCO
OH-4-62	809 (.13-.43)	C/CCO #13
OH-4-63	811 (.50-.52)	D/CCO
OH-4-63-A	815 (.48)	**
OH-4-64	816 (.10-.44)	C/CCO*
OH-4-65	819 (.36-.54)	C/CCO #14
OH-4-66	823 (.21-.23)	D/CCO
OH-4-67	825 (.19-.47)	C/CCO*
OH-4-68	825 (.47-.87)	C/CCO*
OH-4-69	826	C/PCO-1-1
OH-4-69-A	826 (.30)	**
OH-4-70	827	C/PCO-1-2
OH-4-71	828	C/PCO-1-3
OH-4-72	829	C/PCO-1-4
OH-4-73	830	C/PCO-1-5
OH-4-74	831	C/PCO-1-6
OH-4-75	832	C/PCO-1-7

TABLE 27 (Continued)

Bessemer & Lake Erie Railroad Co. and Monsanto Research Corporation

Mound Sample No.	Depth (feet)	Comments
OH-4-76	833	C/PCO-1-8
OH-4-77	834	C/PCO-1-9
OH-4-78	835	C/PCO-1-10
OH-4-79	836 (.00-.35)	C/CCO*
OH-4-80	837 (.49-.75)	C/CCO #15
OH-4-81	838 (.52-.55)	D/CCO
OH-4-82	841 (.35-.37)	D/CCO
OH-4-83	843 (.19-.46)	C/CCO*
OH-4-84	846 (.15-.17)	D/CCO
OH-4-85	848 (.27-.61)	C/CCO #16
OH-4-85-A	850 (.33)	**
OH-4-86	853 (.79-.81)	D/CCO
OH-4-87	857 (.75-.77)	D/CCO
OH-4-88	858 (.36-.56)	C/CCO #17
OH-4-89	861 (.42-.77)	C/CCO*
OH-4-90	863 (.50-.52)	D/CCO
OH-4-91	868 (.49-.51)	D/CCO
OH-4-92	868 (.51-.75)	C/CCO #18
OH-4-93	872 (.22-.24)	D/CCO
OH-4-93-A	875 (.8)	**
OH-4-94	876-886	D/CT
OH-4-95	886-896	D/CT
OH-4-96	896-906	D/CT
OH-4-97	906-916	D/CT
OH-4-98	916-926	D/CT
OH-4-99	926-936	D/CT
OH-4-100	936-946	D/CT
OH-4-101	950 (.80-.82)	D/CCO
OH-4-102	951 (.25-.53)	C/CCO #19
OH-4-103	953 (.22-.51)	C/CCO*
OH-4-104	954 (.23-.26)	D/CCO
OH-4-105	957 (.64-.67)	D/CCO
OH-4-106	961 (.17-.45)	C/CCO #20
OH-4-107	962 (.35-.37)	D/CCO
OH-4-108	965 (.59-.62)	D/CCO
OH-4-108-A	969 (.26)	**
OH-4-109	971 (.42-.68)	C/CCO #21
OH-4-110	973 (.49-.53)	D/CCO
OH-4-111	977 (.60-.64)	D/CCO
OH-4-112	981 (.08-.47)	C/CCO*
OH-4-113	981 (.47-.76)	C/CCO #22
OH-4-114	981 (.76-.78)	D/CCO
OH-4-115	983 (.74-.78)	D/CCO
OH-4-116	986 (.16-.19)	D/CCO
OH-4-116-A	988 (.37)	**
OH-4-117	989-999	D/CT
OH-4-118	999-1009	D/CT
OH-4-119	1029-1039	D/CT
OH-4-120	1039-1054	D/CT

TABLE 27 (Continued)

Bessemer & Lake Erie Railroad Co. and Monsanto Research Corporation

Mound Sample No.	Depth (feet)	Comments
OH-4-121	1054-1059	D/CT
OH-4-122	1059-1069	D/CT
OH-4-123	1070 (.31-.33)	D/CCO
OH-4-124	1071 (.40-.66)	C/CCO #23
OH-4-125	1073 (.55-.58)	D/CCO
OH-4-126	1076 (.43-.77)	C/CCO*
OH-4-127	1077 (.65-.70)	D/CCO
OH-4-128	1081 (.14-.39)	C/CCO #24
OH-4-129	1081 (.39-.42)	D/CCO
OH-4-130	1085 (.38-.43)	D/CCO
OH-4-130-A	1089 (.17)	**
OH-4-131	1091 (.45-.71)	C/CCO #25
OH-4-132	1093 (.39-.42)	D/CCO
OH-4-133	1096 (.78-.81)	D/CCO
OH-4-134	1098 (.30-.60)	C/CCO*
OH-4-135	1100 (.58-.61)	D/CCO
OH-4-136	1101 (.23-.56)	C/CCO #26
OH-4-137	1104 (.67-.69)	D/CCO
OH-4-138	1107 (.82-.85)	D/CCO
OH-4-139	1109-1119	D/CT
OH-4-139-A	1119 (.30)	**
OH-4-140	1121 (.49-.74)	C/CCO #27
OH-4-141	1123 (.41-.43)	D/CCO
OH-4-142	1125 (.31-.58)	C/CCO*
OH-4-143	1127 (.86-.89)	D/CCO
OH-4-144	1131 (.28-.51)	C/CCO #28
OH-4-145	1131 (.51-.54)	D/CCO
OH-4-146	1134 (.68-.71)	D/CCO
OH-4-147	1137 (.37-.40)	D/CCO
OH-4-147-A	1140 (.22)	**
OH-4-148	1141 (.15-.49)	C/CCO*
OH-4-149	1141 (.49-.75)	C/CCO #29
OH-4-150	1143 (.65-.67)	D/CCO
OH-4-151	1147 (.21-.25)	D/CCO
OH-4-152	1151 (.16-.42)	C/CCO #30
OH-4-153	1153 (.42-.44)	D/CCO
OH-4-154	1155 (.43-.46)	D/CCO
OH-4-155	1158 (.77-.1.21)	C/CCO*
OH-4-156	1159 (.28-.31)	D/CCO
OH-4-157	1159	C/PCO-2-1
OH-4-158	1160	C/PCO-2-2
OH-4-159	1161	C/PCO-2-3
OH-4-160	1162	C/PCO-2-4
OH-4-161	1163	C/PCO-2-5
OH-4-162	1164	C/PCO-2-6
OH-4-162-A	1169 (.0.84)	**
OH-4-163	1169 (.15-.40)	C/CCO
OH-4-164	1171	C/CCO #31
OH-4-165	1174 (.22-.25)	D/CCO

TABLE 27 (Continued)

Bessemer & Lake Erie Railroad Co. and Monsanto Research Corporation

Mound Sample No.	Depth (feet)	Comments
OH-4-166	1178 (.47-.51)	D/CCO
OH-4-167	1181 (.26-.57)	C/CCO #32
OH-4-168	1181 (.74-.77)	D/CCO
OH-4-169	1184 (.36-.75)	C/CCO*
OH-4-170	1186 (.56-.59)	D/CCO
OH-4-171	1189 (.65-.68)	D/CCO
OH-4-172	1191 (.38-.61)	C/CCO #33
OH-4-172-A	1193 (.36)	**
OH-4-173	1197 (.34-.37)	D/CCO
OH-4-174	1199 (.07-.38)	C/CCO*
OH-4-175	1201 (.19-.40)	C/CCO #34
OH-4-176	1201 (.66-.69)	D/CCO
OH-4-177	1205 (.31-.34)	D/CCO
OH-4-178	1208 (.52-.55)	D/CCO
OH-4-179	1209-1219	D/CT
OH-4-180	1249-1259	D/CT
OH-4-181	1269-1289	D/CT
OH-4-182	1289-1309	D/CT
OH-4-183	1309 (.82-.92)	D/CCO
OH-4-184	1311 (.12-.40)	C/CCO #35
OH-4-184-A	1313 (.67)	**
OH-4-185	1315 (.43-.76)	C/CCO*
OH-4-186	1317 (.34-.38)	D/CCO
OH-4-187	1321 (.41-.44)	D/CCO
OH-4-188	1321 (.58-.82)	C/CCO #36
OH-4-189	1325 (.68-.71)	D/CCO
OH-4-190	1329 (.25-.27)	D/CCO
OH-4-191	1331 (.45-.70)	C/CCO #37
OH-4-192	1333 (.26-.30)	D/CCO
OH-4-192-A	1337 (.27)	**
OH-4-193	1340 (.39-.82)	C/CCO*
OH-4-194	1341 (.23-.26)	D/CCO
OH-4-195	1341 (.40-.65)	C/CCO #38
OH-4-196	1345 (.11-.15)	D/CCO
OH-4-197	1349 (.18-.20)	D/CCO
OH-4-198	1350 (.54-.56)	D/CCO
OH-4-199	1351 (.17-.50)	C/CCO #39
OH-4-200	1354 (.38-.40)	D/CCO
OH-4-201	1358 (.35-.68)	C/CCO*
OH-4-201-A	1359 (.27)	**
OH-4-202	1361 (.29-.58)	C/CCO #40
OH-4-203	1362 (.38-.41)	D/CCO
OH-4-204	1366 (.52-.55)	D/CCO
OH-4-205	1370 (.56-.60)	D/CCO
OH-4-206	1371 (.24-.58)	C/CCO #41
OH-4-207	1373 (.08-.42)	C/CCO*
OH-4-208	1374 (.29-.32)	D/CCO
OH-4-209	1379 (.12-.15)	D/CCO
OH-4-209-A	1383 (.54)	**

TABLE 28

The Stratigraphic Intervals of the OH-4 Well, Ashtabula County, Ohio. [Depths are from log datum which is ground level (583 ft).]

Stratigraphic Units	Depths
Perrysburg Fm.	
(Base of) Dunkirk	-863
Java Fm.	
Hanover	863-967
Pipe Creek	967-985
West Falls Fm.	
Angola	985-1140
Rhinestreet	1140-1202
Tully Ls.	1202-1222
Hamilton Grp.	
Mahantango Fm.	1222-1330
Marcellus	1330-1378
Onondaga Ls.	1378-

TABLE 29

Pressure/Vacuum in Container

for OH-4 Well samples.

Mound Sample Number	Volume Displacement, cm^3*
OH-4-002	14
OH-4-005	61
OH-4-009	0
OH-4-011	slight vacuum
OH-4-015	77
OH-4-019	34
OH-4-043	316
OH-4-047	0
OH-4-050	602
OH-4-053	193
OH-4-057	0
OH-4-059	259
OH-4-062	434
OH-4-065	231
OH-4-080	542
OH-4-085	299
OH-4-088	252
OH-4-092	slight vacuum
OH-4-102	142
OH-4-106	0
OH-4-109	slight vacuum
OH-4-113	818
OH-4-124	slight vacuum
OH-4-128	slight vacuum
OH-4-131	536
OH-4-136	0
OH-4-140	slight vacuum
OH-4-144	422
OH-4-149	459
OH-4-152	0
OH-4-164	148
OH-4-167	486
OH-4-172	slight pressure
OH-4-175	slight pressure
OH-4-184	141
OH-4-188	115
OH-4-191	450
OH-4-195	357
OH-4-199	786
OH-4-202	81
OH-4-206	slight vacuum

TABLE 30A

C_1-C_7 Hydrocarbon Analyses of Air Space for OH-4 Well

Mound Sample Number	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC4
OH-4-2	205771	20812	14247	556	5017	2655	246403	40631	16.0	0.11
OH-4-5	593544	70190	49042	2485	16819	883	732081	1 537	19.0	0.15
OH-4-9	92020	9339	6338	281	2180	1191	110157	18138	16.5	0.13
OH-4-11	44666	2155	932	20	205	66	47978	3312	6.9	0.10
OH-4-15	398985	43223	28312	1307	9346	4912	481174	82189	17.1	0.14
OH-4-19	345515	29749	17958	789	5750	2946	399761	54246	13.6	0.14
OH-4-43	1121380	235570	177256	7954	48543	18961	1590703	469323	29.5	0.16
OH-4-47	732777	129474	89464	4144	26194	12172	982052	249275	25.3	0.16
OH-4-50	866196	118941	69187	3119	18423	8522	1075866	209670	19.5	0.17
OH-4-53	477604	47333	26359	1228	8425	4950	560949	83345	14.9	0.15
OH-4-57	535031	81926	51603	2542	14292	7136	685395	150364	21.0	0.18
OH-4-59	546180	85443	55252	2780	15684	7632	705339	159159	22.6	0.18
OH-4-62	638008	91194	52937	2704	14235	6551	799078	161070	20.2	0.19
OH-4-65	1027824	114985	61515	2480	16956	6768	1223760	195936	16.0	0.14
OH-4-80	1216370	238260	156451	6417	38373	13076	1655871	439500	26.5	0.17
OH-4-85	511949	41841	18431	735	4785	2183	577742	65792	11.4	0.15
OH-4-88	699911	56033	23342	887	5064	2348	785237	85325	10.9	0.17
OH-4-92	55158	4256	1856	13	362	0	61645	6487	10.5	0.04
OH-4-102	589654	73605	31916	1511	6645	2043	703332	113678	16.2	0.23
OH-4-106	144399	16802	9063	452	2067	807	172784	28384	16.4	0.22
OH-4-109	47557	4387	2033	25	361	50	54363	6806	12.5	0.07
OH-4-113	1073671	129360	56979	94	12449	3427	1271554	198883	15.6	0.01
OH-4-124	48951	6229	4681	23	1274	2137	61158	12207	20.0	0.02
OH-4-128	59479	6223	3668	208	994	794	70581	11103	15.7	0.21
OH-4-131	164213	179865	346744	26693	136067	62358	853582	689368	80.8	0.20
OH-4-136	158302	27822	19886	1182	5623	3691	212815	54513	25.6	0.21
OH-4-140	132007	22597	15826	842	4549	3720	175821	43814	24.9	0.18
OH-4-144	804554	142916	72098	3139	17317	8303	1040024	235470	22.6	0.18
OH-4-149	795229	106804	48522	1879	12661	6809	965095	169866	17.6	0.15
OH-4-152	473146	81694	46777	2031	11972	8640	615620	142474	23.1	0.17
OH-4-164	470145	60260	29558	854	9124	5986	569941	99796	17.5	0.09
OH-4-167	826286	109324	49065	101	11566	5201	996342	170056	17.1	0.01
OH-4-172	621217	82195	38940	1432	10502	6696	754285	133068	17.6	0.14

TABLE 30A

C_1-C_7 Hydrocarbon Analyses of Air Space for OH-4 Well

Mound Sample Number	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/
OH-4-175	852004	149284	79470	85	20403	9141	101245	249241	22.6	0.[illegible]
OH-4-184	360637	61180	31685	1609	8239	6808	463349	102712	22.2	0.[illegible]
OH-4-188	544611	71792	33606	1495	8425	6023	659929	115318	17.5	0.[illegible]
OH-4-191	754858	114035	61376	2767	16707	11303	949742	194885	20.5	0.[illegible]
OH-4-195	661155	86365	36679	925	9210	3695	794333	133178	16.8	0.[illegible]
OH-4-199	720023	124552	68291	2823	16185	7232	931873	211850	22.7	0.[illegible]
OH-4-202	207024	27439	17248	917	5442	5578	258070	51046	19.8	0.[illegible]
OH-4-206	92301	12312	5986	10	1592	1460	112201	19900	17.7	0.[illegible]

TABLE 30B

C_1-C_7 Hydrocarbon Analyses of Cuttings Gas

Mound Sample Number	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC4
OH-4-2	193131	76567	125958	9596	52933	29225	458184	265053	57.9	0.18
OH-4-5	45813	44345	116671	10594	64345	41386	281767	235955	83.7	0.16
OH-4-9	920	1119	4184	460	4189	7065	10872	9952	91.5	0.11
OH-4-11	11095	1410	2802	364	2551	5150	18220	7126	39.1	0.14
OH-4-15	89444	71350	136614	10067	56059	28308	363534	274090	75.4	0.18
OH-4-19	259472	104339	163139	11892	66643	35905	605485	346013	57.2	0.18
OH-4-43	13034	49097	165091	13244	77076	39731	317542	304508	95.9	0.17
OH-4-47	1143	1254	7332	1316	8794	14096	19838	18695	94.2	0.15
OH-4-50	81294	89042	171656	13214	67360	30870	422563	341272	80.8	0.20
OH-4-53	4773	18221	69740	8088	46265	35981	147087	142313	96.8	0.17
OH-4-57	7379	19767	75034	9855	52584	42517	164620	157241	95.5	0.19
OH-4-59	4288	8603	55896	8977	48487	44514	126251	121963	96.6	0.19
OH-4-62	62214	59191	121234	11730	61673	39446	316041	253827	80.3	0.19
OH-4-65	236748	124903	170554	11580	58218	21620	602003	365255	60.7	0.20
OH-4-80	22615	70386	156105	11102	66296	29336	326504	303889	93.1	0.17
OH-4-85	495245	147966	136585	8781	33729	13315	822306	327062	39.8	0.26
OH-4-88	540190	153885	129886	7758	30478	12432	862197	322007	37.4	0.25
OH-4-92	1913	1810	4027	480	3063	4715	11292	9379	83.0	0.16
OH-4-102	1143	2023	8169	1287	5850	4609	18473	17330	93.8	0.22
OH-4-106	1857	6399	29254	4540	17719	13597	59768	59710	96.9	0.26
OH-4-109	1381	1768	3950	439	2588	4918	10125	8745	86.4	0.17
OH-4-113	227620	191164	189455	12029	35251	10672	655519	427899	65.3	0.34
OH-4-124	333	126	467	103	607	2086	1637	1304	79.7	0.17
OH-4-128	320	241	998	192	1262	2873	3012	2693	89.4	0.15
OH-4-131	116598	174279	245784	18509	72085	31150	627255	510657	81.4	0.26
OH-4-136	893	4157	24591	4333	21162	29673	55136	54243	98.4	0.20
OH-4-140	427	463	4725	1056	6122	15252	12792	12365	96.7	0.17
OH-4-144	36838	100555	209221	17797	82963	43474	447374	410536	91.8	0.21
OH-4-149	256446	152080	188681	12945	58708	29374	668859	412413	61.7	0.22
OH-4-152	2908	8481	27161	2731	19281	30020	60562	57654	95.1	0.14

TABLE 30B

C_1-C_7 Hydrocarbon Analyses of Cuttings Gas

Mound Sample Number	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/
OH-4-164	522776	148662	135806	6627	41288	18878	855119	332342	38.9	0
OH-4-167	386145	215111	188881	9439	40477	16067	840053	453908	54.0	0
OH-4-172	145366	98936	150811	10863	60577	42747	466552	321186	68.8	0
OH-4-175	286133	121897	134361	8528	41419	23517	592337	306204	51.7	0
OH-4-184	2015	3716	24896	4801	24458	47135	59886	57871	96.6	0
OH-4-188	68759	61063	105198	9566	47691	48623	292277	223518	76.5	0
OH-4-191	264784	86138	156900	13883	59951	41166	381656	316872	83.0	0
OH-4-195	255276	193330	195563	10197	42784	17231	697150	441873	63.4	0
OH-4-199	229664	159841	194843	12250	55360	27535	651957	422293	64.8	0
OH-4-202	46048	42509	85100	8596	41130	46688	223382	177334	79.4	0
OH-4-206	246088	110983	126490	8802	40517	25847	532881	286793	53.8	0

TABLE 30C

C_1-C_7 Hydrocarbon Analyses of Air Space and Cuttings Gas for OH-4 Well

Mound Sample Number	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC4
OH-4-2	398902	97379	140205	10152	57950	31880	704588	305686	43.4	0.18
OH-4-5	639357	114535	165713	13079	81164	42269	1013848	374491	36.9	0.16
OH-4-9	92940	10458	10522	741	6396	8256	121030	28090	23.2	0.12
OH-4-11	55761	3565	3734	834	2756	5216	66200	10439	15.8	0.14
OH-4-15	488429	114573	164926	11374	65405	33220	844707	356278	42.2	0.17
OH-4-19	604987	134088	181097	12681	72393	38851	1005246	400259	39.8	0.18
OH-4-43	1134414	284667	342347	21198	125619	58692	1908245	773831	40.6	0.17
OH-4-47	733920	130728	96796	5460	34988	26268	1001892	267972	26.8	0.16
OH-4-50	947490	207983	240843	16333	85783	39392	1498432	550492	36.8	0.19
OH-4-53	482377	65554	96099	9316	54690	40931	708036	225659	31.9	0.17
OH-4-57	542410	101693	126637	12397	66876	49653	850013	307603	36.2	0.19
OH-4-59	550468	94096	111148	11757	64171	52146	831590	281122	33.8	0.18
OH-4-62	700222	150385	174171	14434	75908	45997	1115120	414898	37.2	0.19
OH-4-65	1264572	239888	232069	14060	75174	28388	1825763	561191	30.7	0.19
OH-4-80	1238985	308646	217620	17519	83252	42412	1866022	627037	33.6	0.21
OH-4-85	1007194	189807	155016	9516	38514	15498	1400047	392853	28.1	0.25
OH-4-88	1240101	209918	153228	8645	35542	14780	1647434	407333	24.7	0.24
OH-4-92	57071	6066	5883	493	3425	4715	72938	15867	21.8	0.14
OH-4-102	590797	75628	40085	2798	12495	6652	721803	131006	18.2	0.22
OH-4-106	146256	23201	38317	4992	19786	14404	232552	86292	37.1	0.25
OH-4-109	48938	6155	5983	464	2949	4968	64489	15551	24.1	0.16
OH-4-113	1301291	320524	246434	12123	47700	14099	1928072	626781	32.5	0.25
OH-4-124	49284	6355	5148	126	1881	4223	62794	13510	21.5	0.07
OH-4-128	59799	6474	4666	400	2256	3667	73595	13796	18.8	0.18
OH-4-131	280811	354144	592528	45202	208152	93508	1480837	1200026	81.0	0.22
OH-4-136	159195	31979	44477	5515	26785	33364	267951	108756	40.6	0.21
OH-4-140	132434	23060	20551	1898	10671	18972	188614	56180	29.8	0.18
OH-4-144	841392	243471	281319	20936	100280	51777	1487398	646006	43.4	0.21
OH-4-149	1051675	2588884	237203	14824	71369	36183	1633955	582280	35.6	0.21
OH-4-152	476054	98175	73938	4762	31253	38660	676182	200128	29.6	0.15

TABLE 30C

C_1-C_7 Hydrocarbon Analyses of Air Space and Cuttings Gas for OH-4 Well

Mound Sample Number	Methane C1 PPM	Ethane C2 PPM	Propane C3 PPM	Isobutane iC4 PPM	Butane nC4 PPM	Total C5-C7 PPM	Total C1-C4 PPM	Total C2-C4 PPM	Gas Wetness %	iC4/nC
OH-4-164	992921	208882	165364	7481	50412	24864	1425060	432139	30.3	0.15
OH-4-167	1212431	324435	237946	9540	52043	21268	1836395	623964	34.0	0.18
OH-4-172	766583	181131	189751	12295	71079	49143	1220839	454256	37.2	0.17
OH-4-175	1138137	271181	213831	8613	61822	32658	1693584	555447	32.8	0.14
OH-4-184	362652	64896	56581	6410	32697	53943	523236	160584	30.7	0.20
OH-4-188	613370	132855	138804	11061	56116	54646	952206	338836	35.6	0.20
OH-4-191	719642	200173	218276	16650	76658	52469	1331399	511757	38.4	0.22
OH-4-195	916431	279695	232242	11122	51994	20926	1491484	575053	38.6	0.21
OH-4-199	949687	284393	263134	15073	71545	34767	1583832	634145	40.0	0.21
OH-4-202	253072	69948	102348	9513	46572	52266	481453	228381	47.4	0.20
OH-4-206	338389	123295	132476	8812	42109	27307	645081	306692	47.5	0.21

4. Major Elemental Analysis

The concentration of the major elements (expressed as wt % oxides) was determined for 30 samples from the OH-4 well (Table 31).

5. Minor Elemental Analysis

The uranium, thorium, vanadium, and nickel concentrations were also determined for these samples (Table 32). The sample organic carbon content[2] was compared to the uranium content and to the uranium to thorium ratio (Figures 4 and 5, respectively). The correlation coefficient for uranium case was 0.60; for the uranium: thorium case, 0.47. These were compared to similar results previously reported (Table 33).

6. Kerogen Elemental Analysis

The kerogen of fifty-six (56) samples from the OH-4 well were analyzed to determine elemental composition (Table 34). These results were plotted on a H/C versus O/C diagram (Figure 6). The H/C values suggest that kerogen is derived from marine (algal-amorphous) or an intermediate (herbaceous) source. There is a considerable spread in the O/C values. The thermal maturity as measured by vitrinite reflectance results (section F. 9) indicates that OH-4 organic material is immature.

7. Visual Kerogen Assessment

One of the primary factors in determining the oil and gas yield of source rocks is the source of the sedimentary organic material. The organic material can be generally classified as amorphous, algal, herbaceous (spores, pollen, cuticles, and membrane debris); and woody-coaly material (composed of structured and inertinite material, respectively). Algal, amorphous, organic material has the potential to yield significantly more oil and gas than woody-coaly material. Herbaceous material has an intermediate potential to produce hydrocarbons.[1,5]

Herbaceous material as well as woody-coaly material is primarily terresterially derived. The algal, amorphous material is sourced and deposited within a more marine environment.

The organic matter type can be assessed by visual inspection of acid and solvent insoluble organic matter (kerogen). The types of organic material are classified as algal-amorphous (A-A), herbaceous (H), and woody-coaly (W-C). The contents of these types

TABLE 31

MAJOR ELEMENTS IN WHOLE CORE
For OH-4 Well Samples

Mound Sample Number	Al_2O_3(%)	Fe_2O_3(%)	CaO(%)	MgO(%)	TiO_2(%)	MnO(%)	Na_2O(%)	K_2O(%)	SiO_2(%)	P_2O_5(%)
OH-4-002	14.5	5.92	.39	1.63	.886	.039	.9	2.8	67.2	<0.3
005	18.0	7.33	.24	1.97	.895	.035	.7	3.9	59.3	<0.3
009	17.7	12.3	.94	2.78	.872	.235	.5	4.0	51.7	<0.3
015	17.0	6.57	.31	1.89	.877	.036	.7	3.8	58.9	<0.3
019	15.6	6.13	.36	1.72	.837	.033	.8	3.3	59.0	<0.3
047	19.6	8.20	.19	1.90	.827	.038	.5	4.6	55.7	<0.3
050	15.9	6.63	.33	1.79	.842	.033	.6	3.8	60.9	<0.3
057	16.5	6.39	.41	1.88	.877	.039	.7	3.4	62.6	<0.3
059	17.7	7.42	.37	2.02	.879	.068	.6	4.0	60.8	<0.3
062	17.0	6.49	.23	1.85	.839	.030	.6	3.8	61.9	<0.3
080	14.8	6.17	.30	1.62	.889	.030	.7	3.2	61.9	<0.3
085	14.1	5.40	.26	1.60	.750	.024	.6	3.3	63.9	<0.3
088	13.4	5.76	.44	1.63	.727	.027	.6	3.2	61.0	<0.3
102	18.2	8.25	.55	2.36	.919	.039	.6	4.5	57.1	<0.3
106	18.7	6.74	.51	2.32	.918	.036	.7	4.2	61.1	<0.3
113	12.9	7.22	1.65	2.43	.674	.045	.5	3.2	46.6	<0.3
124	16.8	5.73	5.58	2.34	.804	.094	.6	3.9	56.6	<0.3
131	16.7	7.03	.30	1.97	.874	.030	.6	4.2	59.6	<0.3
140	17.6	5.78	2.97	2.41	.828	.056	.7	4.5	59.3	<0.3
149	15.7	5.84	.29	1.86	.816	.028	.6	4.0	61.9	<0.3
152	18.1	6.07	3.36	2.48	.769	.053	.6	4.5	56.8	<0.3
164	11.8	4.39	.32	1.20	.576	.014	.5	3.3	68.0	<0.3
172	16.4	4.64	.39	1.95	.693	.023	.6	4.6	63.2	<0.3
175	10.4	6.67	9.73	2.59	.488	.050	.4	2.9	46.3	<0.3
184	15.2	4.49	10.6	2.29	.604	.053	.5	3.8	48.5	<0.3
191	18.1	5.83	1.14	2.29	.745	.032	.5	4.3	57.9	<0.3
195	16.8	10.5	2.05	2.02	.594	.027	.4	4.0	47.4	<0.3
199	16.0	4.52	5.00	2.32	.664	.275	.5	4.4	52.5	<0.3
202	4.5	4.32	36.4	2.32	.180	.050	.1	1.7	15.7	<0.3
206	4.8	.96	35.2	2.27	.332	.031	<.1	1.9	21.2	<0.3

TABLE 32
U, V, Ni, and Th Composition of Whole Core

Mound Sample Number	Total Uranium (ppm)	Thorium (ppm)	Vanadium (ppm)	Nickel (ppm)
OH-4-002	6.7	10	110	44
005	7.5	12	140	71
009	4.2	12	130	35
015	5.3	12	150	73
019	8.0	12	140	69
047	13.0	88	140	47
050	7.5	18	120	54
057	6.9	12	130	50
059	6.2	13	160	64
062	7.4	12	120	59
080	11.0	16	110	51
085	18.0	14	130	66
088	14.0	10	110	85
102	6.2	12	180	126
106	5.0	12	180	62
113	11.0	10	110	73
124	5.0	10	100	40
131	14.0	12	130	132
140	2.9	11	120	46
149	18.0	10	190	124
152	5.1	10	160	52
164	24.0	9	200	122
172	9.6	9	250	81
175	11.0	8	760	185
184	2.6	13	140	60
191	8.8	9	260	119
195	18.0	20	220	272
199	4.6	10	160	73
202	2.1	2	50	39
R521-206	5.1	2	70	52

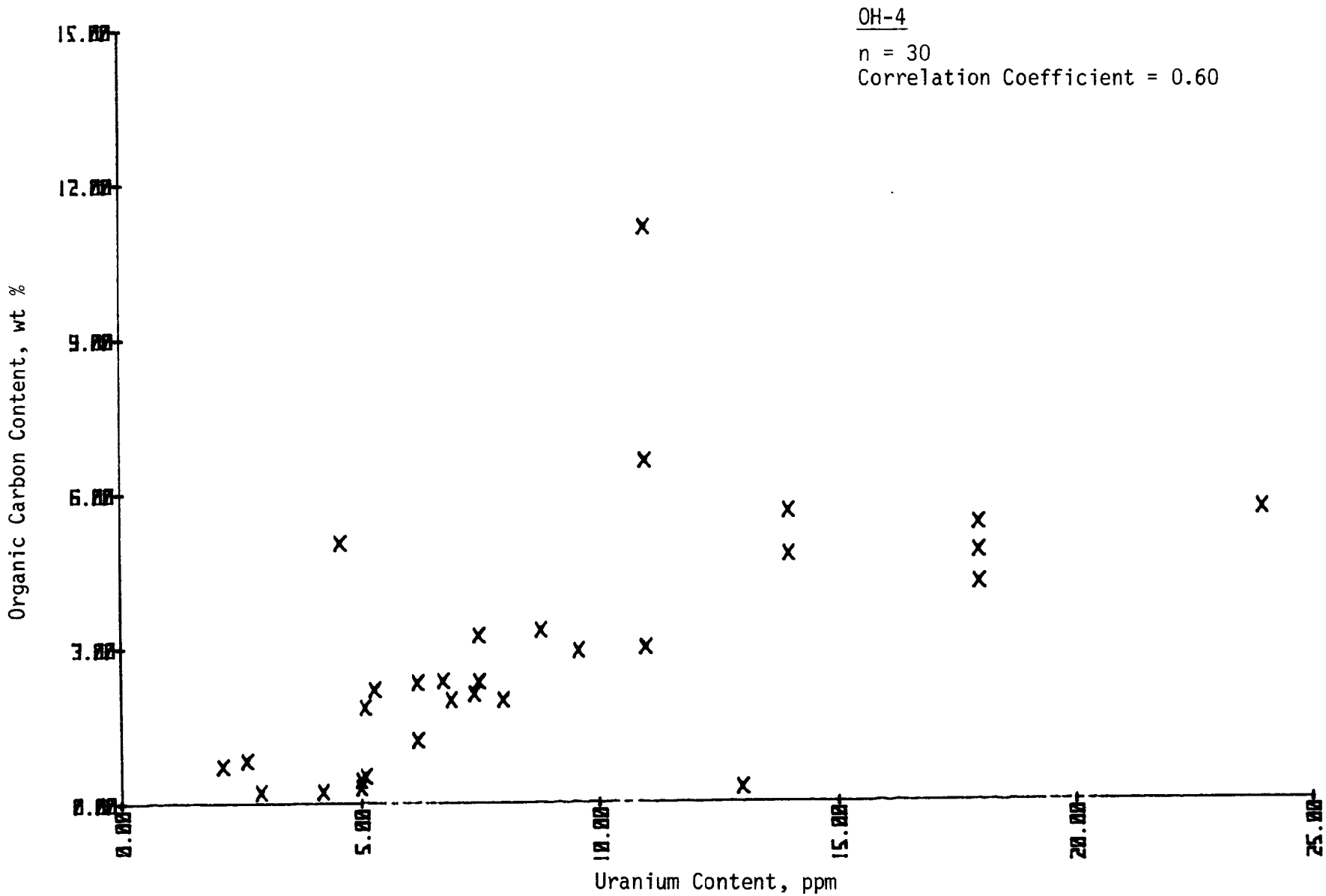

FIGURE 4
Uranium versus organic carbon content for OH-4 well samples.

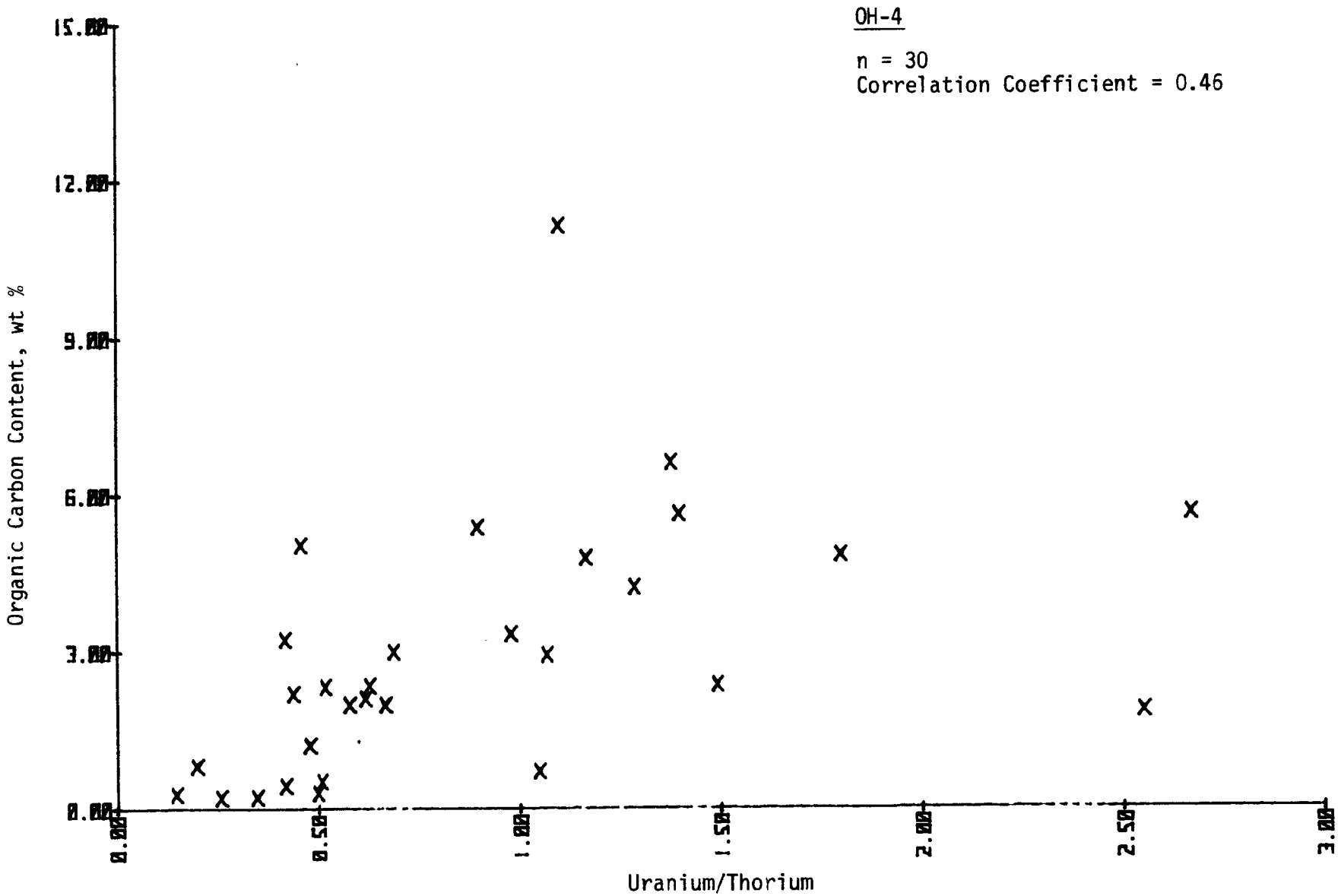

FIGURE 5
The ratio Uranium/Thorium versus organic carbon content for OH-4 well samples.

TABLE 33

Comparison of the relationships of uranium versus organic carbon content with the ratio uranium to thorium versus organic carbon content for Appalachian Basin Shale.

Well KY-2	U (versus organic carbon)	U/Th (versus organic carbon)	U Data	U/Th Data
Correlation Coefficient	0.81	0.86	16	16
Well WV-5				
Correlation Coefficient	0.68	0.73	68	53
Well VA-1				
Correlation Coefficient	0.98	0.99	6	6
Well WV-6				
Correlation Coefficient	0.62	0.94	33	29
Well WV-7				
Correlation Coefficient	0.46	0.51	45	45
Well NY-1				
Correlation Coefficient	0.22	0.38	161	161
Well OH-4				
Correlation Coefficient	0.60	0.46	30	30

TABLE 34

Kerogen Elemental Composition for OH-4 well samples.

MOUND SAMPLE NUMBER	WEIGHT PERCENT ASH FREE C	H	N	O	ASH	ATOMIC RATIO H/C	O/C
OH-4- 2	73.59	7.22	2.02	17.17	16.31	1.17	0.18
OH-4- 4	74.32	8.11	1.74	15.83	32.09	1.30	0.16
OH-4- 5	81.01	7.63	2.11	9.25	30.17	1.12	0.09
OH-4- 12	57.93	6.65	1.81	33.62	4.16	1.37	0.44
OH-4- 15	78.11	8.53	2.15	11.21	21.41	1.30	0.11
OH-4- 19	76.84	9.02	1.79	12.35	37.56	1.40	0.12
OH-4- 21	75.96	8.07	1.38	14.58	31.02	1.27	0.14
OH-4- 43	76.54	8.85	1.50	13.10	26.12	1.38	0.13
OH-4- 44	61.78	6.36	1.64	29.72	10.31	1.32	0.36
OH-4- 50	71.22	7.69	2.19	18.90	26.51	1.29	0.20
OH-4- 52	75.20	8.04	1.58	15.19	23.95	1.27	0.15
OH-4- 53	73.73	7.95	1.99	16.33	23.66	1.28	0.17
OH-4- 57	72.81	7.79	3.50	15.39	37.76	1.23	0.16
OH-4- 59	68.79	7.06	1.37	22.29	32.56	1.22	0.24
OH-4- 62	71.01	7.48	2.62	18.89	28.32	1.25	0.20
OH-4- 64	74.93	7.73	1.79	15.49	31.46	1.23	0.16
OH-4- 65	73.58	6.93	2.16	17.28	13.90	1.13	0.18
OH-4- 67	74.26	8.23	1.80	15.66	31.50	1.33	0.16
OH-4- 78	64.76	6.33	1.66	26.76	16.07	1.26	0.31
OH-4- 79	71.31	7.02	1.96	19.71	30.74	1.17	0.21
OH-4- 80	75.32	7.44	2.15	15.08	14.54	1.18	0.15
OH-4- 83	69.57	7.60	1.89	20.94	33.20	1.30	0.23
OH-4- 85	74.96	7.00	1.96	16.08	18.33	1.11	0.16
OH-4- 88	68.74	6.55	2.02	22.70	18.62	1.14	0.25
OH-4- 89	56.46	6.13	1.70	35.71	15.30	1.29	0.47
OH-4- 102	76.50	7.99	2.14	13.38	26.14	1.24	0.13
OH-4- 112	67.17	7.53	2.30	23.00	17.79	1.34	0.26
OH-4- 113	62.44	6.36	13.22	17.47	22.04	1.31	0.21
OH-4- 126	69.02	7.36	2.23	21.39	17.10	1.27	0.23
OH-4- 131	74.22	7.37	17.55	0.86	17.54	1.18	0.01
OH-4- 134	72.15	8.61	1.70	17.54	23.11	1.42	0.18
OH-4- 142	77.83	9.91	1.47	10.79	33.82	1.52	0.10
OH-4- 144	76.26	8.96	1.90	12.87	28.04	1.40	0.13
OH-4- 148	76.35	14.27	3.57	5.81	39.02	2.23	0.06
OH-4- 149	74.97	7.66	1.97	15.41	16.14	1.22	0.15
OH-4- 155	64.01	6.78	1.95	27.26	22.08	1.26	0.32
OH-4- 157	73.96	12.69	1.54	11.82	37.03	2.04	0.12
OH-4- 158	71.62	7.21	2.05	19.12	19.10	1.20	0.20
OH-4- 159	68.05	6.94	1.85	23.15	21.81	1.22	0.26
OH-4- 160	63.50	7.04	1.98	22.49	17.56	1.22	0.25
OH-4- 161	55.32	5.47	1.72	37.49	2.17	1.18	0.51
OH-4- 162	66.78	6.98	1.36	24.88	21.97	1.25	0.28
OH-4- 163	70.57	7.47	2.35	19.61	23.31	1.26	0.21
OH-4- 164	72.85	7.38	1.86	17.41	23.60	1.29	0.18
OH-4- 167	72.55	7.28	2.06	18.11	19.89	1.20	0.19

Kerogen Elemental Composition for OH-4 well samples.

MOUND SAMPLE NUMBER	WEIGHT PERCENT ASH FREE C	H	N	O	ASH	ATOMIC RATIO H/C	O/C
OH-4- 169	63.83	6.79	2.03	22.35	20.80	1.13	0.24
OH-4- 172	76.60	3.35	2.10	12.95	29.48	1.30	0.13
OH-4- 174	69.14	7.14	2.21	21.51	20.03	1.23	0.23
OH-4- 175	73.63	7.79	3.23	10.36	8.58	1.18	0.10
OH-4- 183	72.74	7.50	2.06	17.71	22.17	1.23	0.18
OH-4- 191	80.95	3.92	1.61	3.52	24.67	1.31	0.03
OH-4- 193	64.59	7.05	1.51	26.84	11.24	1.30	0.31
OH-4- 195	74.64	7.39	2.37	15.60	21.88	1.13	0.16
OH-4- 199	77.85	9.12	1.71	11.33	26.19	1.40	0.11
OH-4- 201	55.10	6.13	1.76	37.02	20.93	1.32	0.50
OH-4- 206	75.19	7.35	2.29	15.17	14.84	1.16	0.15

MEAN OF H/C= 1.29 O/C= 0.20

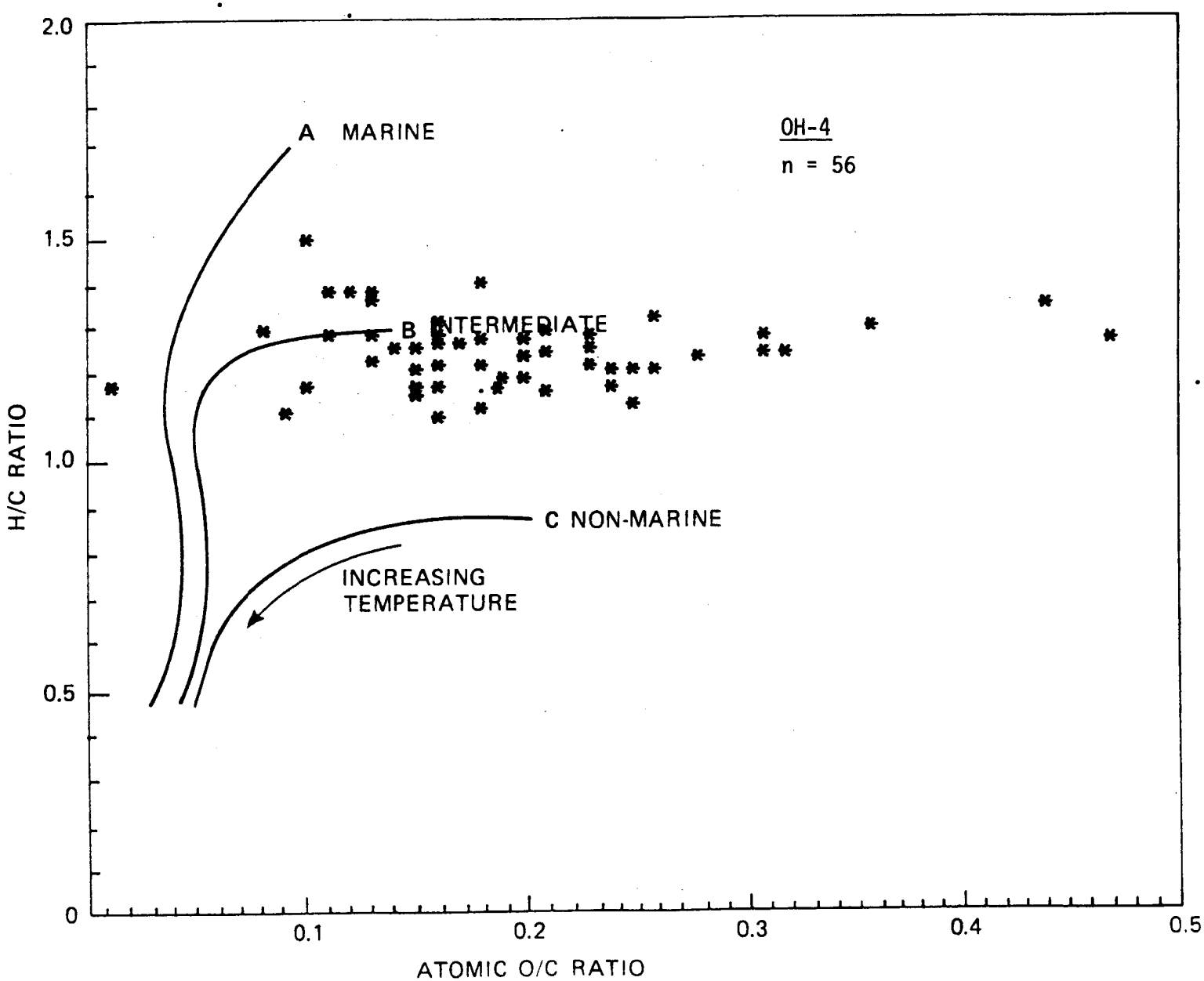

FIGURE 6
The comparison of the atomic ratio H/C and O/C for OH-4 well samples.

are rated as predominant, secondary, or trace. In some cases, the types are listed jointly; for example, H+W-C (herbaceous and woody-coaly).

Visual kerogen assessment of 128 samples from the OH-4 well was completed (Table 35). The primary kerogen type was most frequently herbaceous material. In some samples woody-coaly material was dominant. The kerogen type generally alternated between intervals of H, A-A, W-C, and intervals of W-C, H, -.

The A-A material was primarily amorphous sapropelic. The herbaceous kerogens primarily were comprised of cuticular-memberaneous debris, although degraded herbaceous material as well as spores and pollens were commonly present in lesser amounts. Woody structured debris, and to a lesser degree, coaly-inertinitic debris were the major components of the W-C kerogens.

The kerogen was in a good to excellent state of preservation and of a fine to medium grain size. The kerogen maturation (TAI) increased with depth from 1 to 1+ at 509 ft to 2 at 1379 ft. This corresponds to a change in kerogen coloration from a yellow to an orange-brown with increasing depth.

These OH-4 results are comparable to the visual kerogen assessment of the OH-4 sample reported in the previous quarterly.[2]

8. Vitrinite Reflectance Results

Thermal Maturation is one of the primary factors that determines the oil and gas yields of source rocks.

The maturation is a result of the burial temperature and duration of heating of the shale. Estimates of shale thermal maturity was made by vitrinite reflectance and kerogen coloration.

Vitrinite is a common constituent of sedimentary organic matter. The intensity of light reflected by vitrinite (vitrinite reflectance, R_0) increases with thermal maturity in an irreversible reaction.

Vitrinite reflectance measurements were made using 47 core and cutting samples from the OH-4 well (Table 36). Those samples containing indigenous vitrinite material were used to determine thermal maturity.[6] These samples are indicated by an asterisk '*'. The mean R_0 value for these samples is 0.40. The random mean reflectance values were effectively constant with depth for

TABLE 35
Kerogen Visal Assessment; Components of Kerogen
for OH-4 Well

Mound Sample Number	Predominant	Secondary	Trace
OH-4-1	W-C	H	-
OH-4-2	H	A-A	W-C
OH-4-3	H	W-C	-
OH-4-4	H	A-A	-
OH-4-5	H	A-A	-
OH-4-6	H	A-A	W-C
OH-4-7	H	A-A	W-C
OH-4-8	W-C	H	-
OH-4-9	H	W-C	A-A
OH-4-10	W-C	H	-
OH-4-11	H	A-A	W-C
OH-4-12	H	A-A	-
OH-4-13	H	A-A	W-C
OH-4-14	H	A-A	W-C
OH-4-15	H	A-A	W-C
OH-4-16	H	W-C	-
OH-4-17	H	A-A	W-C
OH-4-18	W-C	H	-
OH-4-19	H	A-A	W-C
OH-4-20	H	A-A	-
OH-4-21	H	W-C	A-A
OH-4-42	H	A-A	-
OH-4-43	H	A-A,W-C	-
OH-4-44	H	A-A	W-C
OH-4-45	H	A-A	W-C
OH-4-46	H	A-A	W-C
OH-4-47	H,W-C	--	-
OH-4-48	H	A-A,W-C	-
OH-4-49	W-C	H	-
OH-4-50	H	A-A	W-C
OH-4-51	H	W-C,A-A	-
OH-4-52	H	W-C	A-A
OH-4-53	H	A-A	W-C
OH-4-54	H	W-C	A-A
OH-4-55	W-C	H	A-A
OH-4-56	W-C	H	A-A
OH-4-57	H	A-A	A-A
OH-4-58	W-C,H	A-A	-
OH-4-59	H	A-A,W-C	-
OH-4-60	H	W-C,A-A	-
OH-4-61	W-C	H	-
OH-4-62	H	A-A	W-C
OH-4-63	H	W-C	A-A
OH-4-64	H	W-C ,A-A	-
OH-4-65	H	A-A,W-C	-

TABLE 35
Kerogen Visual Assessment; Components of Kerogen
for OH-4 Well

Mound Sample Number	Predominant	Secondary	Trace
OH-4-66	W-C	H	-
OH-4-67	H	W-C	A-A
OH-4-68	H	W-C	A-A
OH-4-69	H	W-C	A-A
OH-6-70	H	W-C	A-A
OH-4-71	H,W-C	A-A	-
OH-4-72	W-C	H	A-A
OH-4-73	W-C	H	A-A
OH-4-74	W-C,H	-	-
OH-4-75	H	W-C	-
OH-4-76	H	W-C	-
OH-4-77	H	W-C	-
OH-4-78	W-C	H	-
OH-4-79	H	A-A	W-C
OH-4-80	H	W-C	A-A
OH-4-81	H	A-A	-
OH-4-82	H	A-A	W-C
OH-4-83	H	A-A,W-C	-
OH-4-84	H	A-A	W-C
OH-4-85	H	A-A	W-C
OH-4-86	H	A-A	W-C
OH-4-87	H	A-A	W-C
OH-4-88	H	A-A	W-C
OH-4-89	H	A-A	-
OH-4-90	W-C	H	A-A
OH-4-91	W-C	H	-
OH-4-92	H	W-C	A-A
OH-4-93	W-C		-
OH-4-100	W-C	H	-
OH-4-102	H	W-C	A-A
OH-4-103	W-C	H	A-A
OH-4-104	W-C	H	A-A
OH-4-105	W-C	H	A-A
OH-4-106	W-C	H	A-A
OH-4-107	H	A-A	-
OH-4-108	W-C	H	-
OH-4-109	W-C	H	-
OH-4-110	W-C	H	-
OH-4-111	W-C	H	-
OH-4-112	H	A-A	W-C
OH-4-113	H	A-A	W-C
OH-4-114	H	A-A	W-C
OH-4-115	W-C	H	-
OH-4-116	H	W-C	A-A
OH-4-123	W-C	H	A-A
OH-4-124	H	W-C	A-A
OH-4-125	H	A-A	W-C

TABLE 35
Kerogen Visual Assessment; Components of Kerogen
for the OH-4 Well

Mound Sample Number	Predominant	Secondary	Trace
OH-4-126	H	A-A	W-C
OH-4-127	W-C	H	A-A
OH-4-128	W-C,H	--	A-A
OH-4-129	W-C	H	-
OH-4-131	H	A-A	-
OH-4-132	W-C	H	A-A
OH-4-133	W-C	H	-
OH-4-134	H	A-A	W-C
OH-4-135	W-C	H	A-A
OH-4-136	H	W-C,A-A	-
OH-4-138	W-C	H	A-A
OH-4-139	H	W-C	A-A
OH-4-140	H	W-C	A-A
OH-4-141	H	W-C	A-A
OH-4-142	H	A-A	-
OH-4-143	W-C	H	A-A
OH-4-144	H	A-A	W-C
OH-4-145	H	A-A	W-C
OH-4-146	H	W-C	A-A
OH-4-147	H	W-C	A-A
OH-4-148	H	A-A	-
OH-4-149	H	A-A	-
OH-4-150	H	W-C	A-A
OH-4-151	H	W-C	A-A
OH-4-152	H,W-C	--	A-A
OH-4-153	W-C	H	A-A
OH-4-154	H	A-A,W-C	-
OH-4-155	H	A-A	-
OH-4-156	H,W-C	A-A	-
OH-4-157	H	W-C	A-A
OH-4-158	H	A-A	-
OH-4-159	H	A-A	-
OH-4-160	H	A-A	-
OH-4-161	H	A-A	-
OH-4-162	H	W-C	A-A
OH-4-163	H	A-A	--
OH-4-164	H	A-A	--
OH-4-165	H	A-A	W-C
OH-4-166	H	A-A	W-C
OH-4-167	H	A-A	W-C
OH-4-168	H	A-A	W-C
OH-4-169	H	A-A	W-C
OH-4-170	H	A-A	W-C
OH-4-171	H	W-C	A-A
OH-4-172	H	A-A	W-C
OH-4-173	H	A-A	W-C
OH-4-174	H	A-A	-

TABLE 35
Kerogen Visual Assessment; Components of Kerogen
for the OH-4 Well

Mound Sample Number	Predominant	Secondary	Trace
OH-4-175	H	A-A	--
OH-4-176	H	A-A	--
OH-4-177	W-C	H	--
OH-4-178	W-C	H	A-A
OH-4-183	W-C	H	A-A
OH-4-184	H,W-C	--	A-A
OH-4-185	W-C	H	A-A
OH-4-186	H	W-C	A-A
OH-4-187	H	A-A	W-C
OH-4-188	H	W-C	A-A
OH-4-189	H	W-C	A-A
OH-4-190	H	A-A	--
OH-4-191	H	A-A	W-C
OH-4-192	H	W-C	A-A
OH-4-193	H	A-A	W-C
OH-4-194	H	A-A	--
OH-4-195	H	A-A	W-C
OH-4-196	H	A-A	W-C
OH-4-198	H	A-A	-
OH-4-199	H	A-A	W-C
OH-4-200	H	A-A	-
OH-4-201	H	A-A	W-C
OH-4-202	H	A-A	--
OH-4-203	H	A-A	--
OH-4-204	H	A-A	W-C
OH-4-205	H	A-A	W-C
OH-4-206	H	A-A	W-C
OH-4-207	H	A-A	W-C
OH-4-208	H	A-A	-
OH-4-209	H	A-A,W-C	-

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-002	510	CORE	(1)*	6	0.29	0.41	0.36
			(2)	11	0.48	0.74	0.59
OH-4-005	520	CORE	(1)*	3	0.27	0.33	0.30
			(2)	23	0.43	0.66	0.58
			(3)	1	2.07	2.07	2.07
OH-4-009	529	CORE	(1)*	4	0.28	0.42	0.34
			(2)	19	0.52	0.97	0.72
			(3)	30	1.05	1.63	1.36
			(4)	7	1.74	2.21	1.94
OH-4-011	539	CORE	(1)*	1	0.33	0.33	0.33
			(2)	2	0.93	1.10	1.02
			(3)	1	1.57	1.57	1.57
OH-4-015	549	CORE	(1)*	5	0.32	0.41	0.36
			(2)	9	0.50	0.81	0.63
OH-4-119	559	CORE	(1)*	10	0.32	0.40	0.36
			(2)	38	0.44	0.74	0.61
OH-4-023	581	CTG	(1)	21	0.48	0.69	0.61
			(2)	27	0.74	1.27	0.98
			(3)	12	1.37	2.03	1.62
OH-4-025	601	CTG	(1)*	7	0.33	0.37	0.35
			(2)	44	0.40	0.80	0.60
			(3)	9	1.03	1.57	1.28
OH-4-027	621	CTG	(1)	2	0.26	0.27	0.27
			(2)*	8	0.30	0.41	0.37
			(3)	39	0.43	0.84	0.59
			(4)	11	0.92	1.64	1.14

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-029	641	CTG	(1)*	14	0.26	0.43	0.37
			(2)	41	0.46	0.86	0.62
			(3)	5	1.09	1.35	1.22
OH-4-033	681	CTG	(1)	4	0.25	0.28	0.27
			(2)*	15	0.30	0.44	0.37
			(3)	37	0.46	0.91	0.64
			(4)	4	1.48	1.57	1.51
OH-4-035	701	CTG	(1)	12	0.27	0.34	0.30
			(2)*	11	0.38	0.47	0.48
			(3)	28	0.50	0.76	0.61
			(4)	9	0.84	1.83	1.17
OH-4-037	721	CTG	(1)*	12	0.31	0.45	0.40
			(2)	20	0.48	0.71	0.61
			(3)	5	1.07	1.79	1.42
OH-4-039	741	CTG	(1)*	11	0.29	0.49	0.39
			(2)	27	0.56	0.88	0.68
			(3)	3	1.26	1.46	1.36
OH-4-043	748	CORE	(1)*	17	0.30	0.44	0.36
			(2)	39	0.46	0.86	0.60
			(3)	4	1.33	1.55	1.43
OH-4-047	758	CORE	NO VITRINITE				
OH-4-050	768	CORE	(1)*	8	0.36	0.47	0.43
			(2)	20	0.49	0.64	0.55
			(3)	9	0.71	1.00	0.86
			(4)	5	1.17	1.40	1.26

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-053	778	CORE	(1)*	15	0.30	0.43	0.36
			(2)	27	0.46	0.82	0.64
			(3)	5	0.88	0.94	0.90
OH-4-057	789	CORE	(1)*	9	0.31	0.43	0.37
			(2)	35	0.46	0.88	0.67
			(3)	11	0.95	1.91	1.28
OH-4-059	799	CORE	(1)*	6	0.33	0.46	0.40
			(2)	40	0.50	0.75	0.62
			(3)	6	0.82	1.06	0.93
			(4)	8	1.48	1.97	1.68
OH-4-062	809	CORE	(1)*	8	0.30	0.45	0.36
			(2)	28	0.50	0.76	0.63
			(3)	10	0.77	1.77	1.05
OH-4-065	819	CORE	(1)*	7	0.34	0.44	0.38
			(2)	17	0.48	0.86	0.67
			(3)	1	1.28	1.28	1.28
OH-4-080	837	CORE	(1)*	4	0.30	0.45	0.36
			(2)	17	0.52	0.71	0.62
			(3)	4	1.23	2.17	1.76
OH-4-085	848	CORE	(1)*	11	0.30	0.42	0.38
			(2)	17	0.46	0.82	0.62
			(3)	5	0.96	1.12	1.06
			(4)	3	1.27	1.66	1.48
OH-4-088	858	CORE	(1)*	15	0.37	0.47	0.43
			(2)	16	0.50	0.75	0.57
			(3)	7	0.89	1.15	1.02
			(4)	2	1.39	1.79	1.59

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-092	868	CORE	(1)	1	0.75	0.75	0.75
			(2)	2	0.97	1.13	1.05
			(3)	1	1.47	1.47	1.47
OH-4-094	887	CTG	(1)	1	0.61	0.61	0.61
			(2)	3	0.88	0.96	0.93
			(3)	12	1.28	1.92	1.59
OH-4-096	906	CTG	(1)	1	0.30	0.30	0.30
			(2)*	6	0.43	0.47	0.45
			(3)	38	0.51	1.01	0.74
OH-4-098	926	CTG	(1)*	3	0.32	0.44	0.37
			(2)	10	0.48	0.58	0.54
			(3)	24	0.61	0.83	0.72
			(4)	23	0.89	1.95	1.15
OH-4-100	946	CTG	(1)	1	0.27	0.27	0.27
			(2)*	11	0.34	0.43	0.38
			(3)	10	0.50	0.65	0.58
			(4)	28	0.71	1.07	0.85
			(5)	10	1.18	1.75	1.41
OH-4-102	951	CORE	(1)*	12	0.34	0.46	0.41
			(2)	18	0.49	0.73	0.60
			(3)	27	0.80	1.09	0.97
			(4)	3	1.30	1.72	1.48
OH-4-106	961	CORE	(1)*	4	0.34	0.48	0.40
			(2)	13	0.58	0.88	0.73
			(3)	43	1.00	2.08	1.48

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-109	971	CORE	(1)	11	0.92	1.07	1.02
			(2)	9	1.13	1.28	1.19
			(3)	35	1.33	1.71	1.50
			(4)	5	1.76	2.11	1.89
OH-4-113	981	CORE	(1)*	10	0.36	0.44	0.39
			(2)	11	0.53	0.77	0.61
OH-4-118	1009	CTG	(1)*	1	0.37	0.37	0.37
			(2)	4	0.66	1.19	0.90
			(3)	2	1.67	2.04	1.86
OH-4-120	1054	CTG	(1)*	5	0.38	0.50	0.45
			(2)	22	0.55	0.75	0.65
			(3)	16	0.78	1.07	0.90
			(4)	11	1.21	1.47	1.33
			(5)	6	1.70	2.10	1.80
OH-4-122	1069	CTG	(1)*	2	0.37	0.43	0.40
			(2)	9	0.50	0.57	0.53
			(3)	24	0.59	0.75	0.67
			(4)	22	0.78	1.54	1.20
			(5)	3	1.71	1.87	1.77
OH-4-124	1071	CORE	(1)*	1	0.40	0.40	0.40
			(2)	8	0.90	1.21	1.08
OH-4-128	1081	CORE	NO VITRINITE				
OH-4-131	1091	CORE	(1)*	6	0.38	0.44	0.41
			(2)	2	0.50	0.51	0.51
			(3)	17	0.59	1.09	0.76
			(4)	1	1.38	1.38	1.38

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-136	1101	CORE	(1)*	2	0.40	0.40	0.41
			(2)	43	0.49	1.34	0.82
			(3)	15	1.34	2.15	1.68
OH-4-139	1119	CTG	(1)	1	0.33	0.33	0.33
			(2)	9	0.54	0.73	0.63
			(3)	3	0.94	1.03	0.99
OH-4-140	1121	CORE	NO VITRINITE				
OH-4-144	1131	CORE	(1)*	2	0.38	0.46	0.42
			(2)	8	0.59	0.76	0.66
			(3)	1	1.57	1.57	1.57
OH-4-149	1141	CORE	(1)*	4	0.36	0.49	0.44
			(2)	19	0.51	0.89	0.67
			(3)	1	1.32	1.32	1.32
OH-4-152	1151	CORE	(1)	6	0.62	0.68	0.65
			(2)	3	0.83	1.06	0.92
			(3)	5	1.40	2.02	1.61
OH-4-164	1171	CORE	(1)*	3	0.42	0.45	0.43
			(2)	6	0.54	0.79	0.64
			(3)	1	2.01	2.01	2.01
OH-4-167	1181	CORE	(1)*	10	0.37	0.47	0.44
			(2)	12	0.51	0.85	0.62
			(3)	8	1.24	1.97	1.58
OH-4-172	1191	CORE	(1)*	6	0.41	0.49	0.45
			(2)	8	0.52	0.69	0.60
			(3)	8	0.91	1.47	1.19

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-175	1201	CORE	(1)*	50	0.37	0.48	0.42
			(2)	8	0.50	0.59	0.53
			(3)	2	0.77	1.05	0.91
OH-4-179	1219	CTG	(1)	3	0.68	0.70	0.69
			(2)	3	0.98	1.01	1.00
			(3)	11	1.14	1.48	1.32
			(4)	10	1.65	1.97	1.83
OH-4-181	1289	CTG	(1)*	10	0.53	0.63	0.58
			(2)	12	0.68	0.92	0.77
			(3)	25	1.04	1.48	1.23
			(4)	13	1.49	1.81	1.69
OH-4-184	1311	CORE	(1)*	10	0.38	0.50	0.45
			(2)	7	0.53	0.58	0.56
			(3)	9	0.71	1.17	0.90
			(4)	34	1.36	2.29	1.82
OH-4-188	1321	CORE	(1)*	7	0.41	0.52	0.45
			(2)	10	0.57	0.67	0.61
			(3)	7	0.87	1.01	0.95
			(4)	8	1.18	2.10	1.66
OH-4-191	1331	CORE	(1)*	7	0.38	0.48	0.44
			(2)	40	0.53	1.77	0.80
			(3)	13	1.77	2.23	1.99
OH-4-195	1341	CORE	(1)*	9	0.39	0.50	0.45
			(2)	28	0.52	0.69	0.59
			(3)	6	0.73	1.14	0.89
			(4)	2	1.95	2.09	2.02

*Indigenous population

TABLE 36
Vitrinite Reflectance Summary
for EGSP OH-4 Well, Ashtabula County, Ohio

Sample Number	Depth (Feet)	Type of Sample	Population	Number of Readings	Minimum Reflectance (% Ro)	Maximum Reflectance (% Ro)	Average Mean Reflectance (% Ro)
OH-4-199	1351	CORE	(1)*	12	0.48	0.63	0.56
			(2)	3	0.67	0.94	0.81
			(3)	1	1.67	1.67	1.67
OH-4-202	1361	CORE	NO VITRINITE				
OH-4-206	1371	CORE	(1)*	3	0.45	0.50	0.48
			(2)	5	0.58	0.61	0.60
			(3)	4	0.64	1.07	0.79
			(4)	2	1.58	1.73	1.66

*Indigenous population

the '*' samples (Figure 7). The maturation gradient (change in R_o with depth) was 0.2 R_o/1000 ft.

The 0.40 R_o value indicates these sourcerocks are thermally immature.[5] The OH-4 results were compared to previously reported vitrinite reflectance results for other Illinois and Appalachian Basin wells (Table 37).

9. Bitumen (C_{15+} extract) Analysis

The C_{15+} soluble fraction (bitumen) of the organic matter provides information regarding the hydrocarbon producing potential, organic matter source, and thermal maturation of the shale. Migration of fluids has less effect on the bitumen content than it does on the gaseous hydrocarbon content. Therefore, there is less chance of mixed source rock products, sample handling procedures are less complex, and determination of source rock characteristics are more reliable than provided by evaluation of C_1-C_4 data.

The C_{15+} bitumen is chemically extracted from ground rock samples. This product is further extracted to yield asphaltenes (ASPH), nitrogen-sulfur-oxygen containing (NSO) compounds, paraffin-napthenes (P-N) and aromatics (AROM).

The carbon preference index (CPI) is influenced by the type and maturation of the organic matter. CPI's are calculated using two sets of data:

$$\text{C.P. Index A} = \frac{\dfrac{C_{21}+C_{23}+C_{25}+C_{27}}{C_{22}+C_{24}+C_{26}+C_{28}} + \dfrac{C_{21}+C_{23}+C_{25}+C_{27}}{C_{20}+C_{22}+C_{24}+C_{26}}}{2}$$

$$\text{C.P. Index B} = \frac{\dfrac{C_{25}+C_{27}+C_{29}+C_{31}}{C_{26}+C_{28}+C_{30}+C_{32}} + \dfrac{C_{25}+C_{27}+C_{29}+C_{31}}{C_{24}+C_{26}+C_{28}+C_{30}}}{2}$$

The bitumen from 41 OH-4 samples was analyzed (Table 38). The average concentration of the total extractable material was 1998 ppm. The mean ratio of hydrocarbon/non-hydrocarbon material was 2.53. For the non-hydrocarbons the average asphaltene/NSO value (nitrogen-sulfur-oxygen compounds) was 0.93. For the hydrocarbon fraction the ratio of paraffin-napthenes to aromatics value (PN/AROM) was 1.32. The paraffins were comprised of $\sim$ 23% isoprenoids and had carbon preference indicies (PI_A and CPI_B of 1.15 and 1.14, respectively (Table 39).

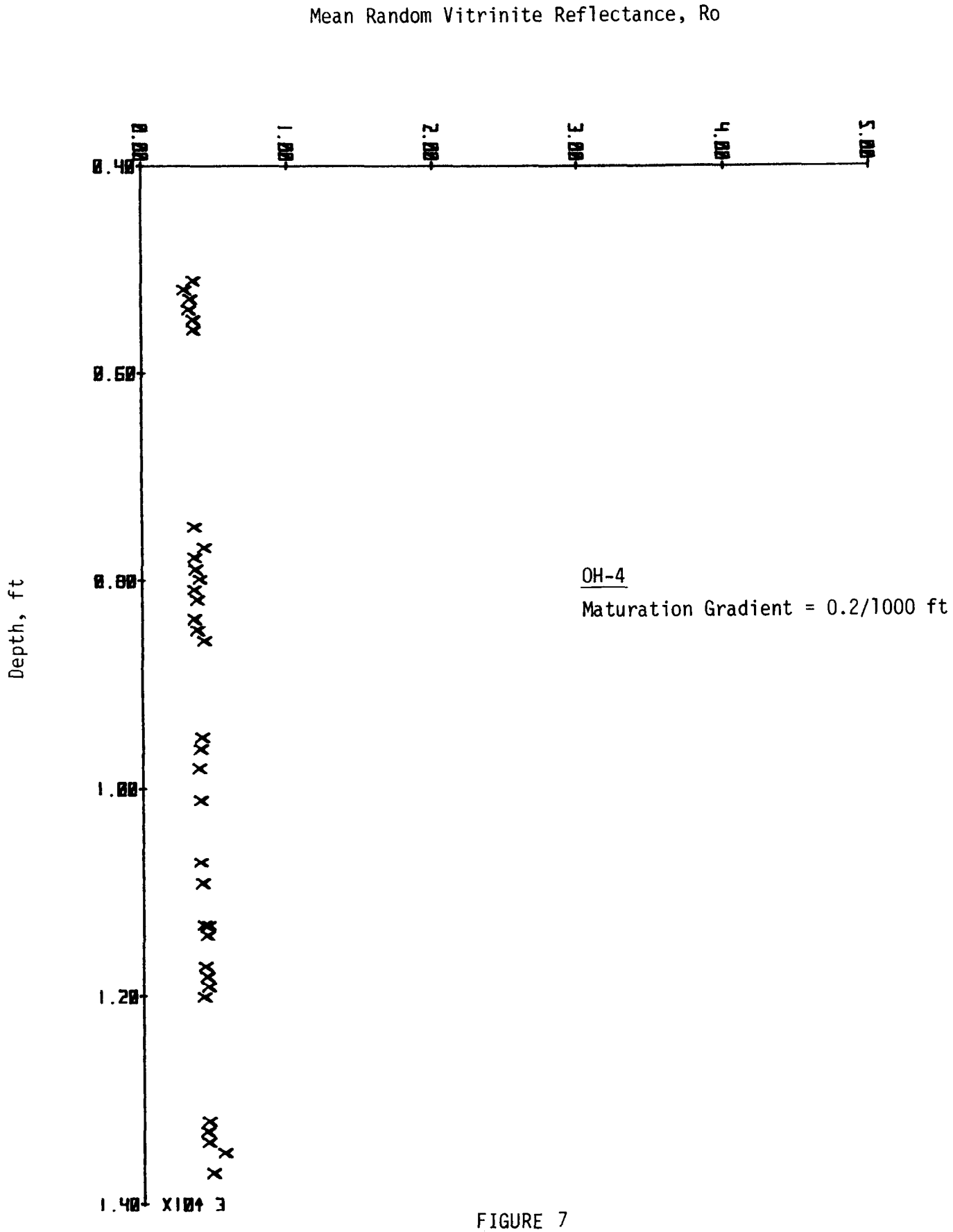

FIGURE 7

The maturation gradient for the OH-4 well as determined from vitrinite reflectance analysis of core samples.

TABLE 37

Maturation Results for Illinois and Appalachian Basin Shales

Appalachian Basin

Well	Predominant TAI	Mean Ro
VA-1	2+	1.02
KY-2	1+ to 3	0.52
WV-5	2- to 2+	0.64
WV-6	3+	2.19
KY-4	1+ to 2	0.57
R-109	2	0.58
PA-2	3 to 3+	2.48
OH-1	1+ to 2	0.71
OH-3	2	0.56
WV-7	3	1.58
NY-1	2- to 3	1.29
PA-1	3	1.12
OH-4	1 to 2	0.40
PA-3	1+ to 2	N.A.

Illinois Basin

Well		
O-1	2-	0.45
P-1*	2-	0.63
I-1	1+ to 2-	0.45
I-3	2 to 2+	0.46
I-2	1+	0.40
IND-2	1+	0.48
Ill-4	3 to 3+	1.44

*Core exposed for several weeks before canning.

TABLE 38

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for OH-4 Well

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (grams)	Total Extract (grams)	Precipitated Asphaltenes (grams)	N-C5 Soluble (grams)	Sulfur (grams)	Paraffins-Naphthenes (grams)	Aromatics (grams)	Eluted NSO'S (grams)	Noneluted NSO'S (grams)
OH-4-2		98.7	0.0685	0.0140	0.0545		0.0195	0.0209	0.0035	0.0106
OH-4-4		99.1	0.0181	0.0064	0.0117		0.0070	0.0036	0.0008	0.0003
OH-4-9		99.0	0.0092	0.0039	0.0053		--	--	--	--
OH-4-12		99.9	0.2113	0.0142	0.1971		0.0956	0.0577	0.0080	0.0358
OH-4-15		95.7	0.0983	0.0131	0.0852		0.0334	0.0346	0.0067	0.0104
OH-4-21		99.2	0.1631	0.0109	0.1522		0.0739	0.0498	0.0062	0.0224
OH-4-50		99.8	0.2321	0.0193	0.2128		0.0988	0.0872	0.0240	0.0028
OH-4-52		99.7	0.1794	0.0114	0.1680		0.0726	0.0516	0.0078	0.0360
OH-4-53		99.4	0.1454	0.0179	0.1275		0.0569	0.0594	0.0093	0.0019
OH-4-57		98.3	0.1092	0.0111	0.0981		0.0362	0.0388	0.0086	0.0145
OH-4-62		99.8	0.1079	0.0165	0.0914		0.0334	0.0340	0.0067	0.0173
OH-4-67		100.0	0.1160	0.0089	0.1071		0.0447	0.0401	0.0046	0.0177
OH-4-72		99.0	0.0135	0.0030	0.0105		0.0047	0.0042	0.0008	0.0008
OH-4-75		99.4	0.0172	0.0028	0.0144		0.0069	0.0042	0.0007	0.0026
OH-4-79		100.0	0.2486	0.0171	0.2315		0.1204	0.0628	0.0161	0.0322
OH-4-80		99.4	0.2127	0.0195	0.1932		0.0733	0.0752	0.0281	0.0166
OH-4-83		100.0	0.2571	0.0144	0.2427		0.1025	0.0655	0.0170	0.0578
OH-4-88		75.4	0.2548	0.0258	0.2290		0.0779	0.1018	0.0308	0.0185
OH-4-89		99.7	0.4726	0.0285	0.4441		0.1756	0.1556	0.0486	0.0643
OH-4-102		100.5	0.0566	0.0260	0.0306		0.0108	0.0147	0.0014	0.0037
OH-4-106		100.9	0.0158	0.0036	0.0122		0.0052	0.0057	0.0004	0.0009
OH-4-112		99.9	0.4293	0.0222	0.4071		0.1818	0.1397	0.0343	0.0514
OH-4-113		90.4	0.5014	0.0435	0.4579		0.1804	0.1577	0.0637	0.0561
OH-4-131		100.7	0.2613	0.0378	0.2235		0.0963	0.0709	0.0177	0.0385
OH-4-140		100.2	0.0107	0.0029	0.0078		--	--	--	--
OH-4-148		98.1	0.2493	0.0122	0.2371		0.1066	0.0772	0.0095	0.0438
OH-4-152		98.5	0.0188	0.0042	0.0146		0.0061	0.0038	0.0011	0.0036
OH-4-155		99.7	0.3175	0.0174	0.3001		0.1106	0.1250	0.0307	0.0338

TABLE 38

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography

B. Concentration of Extracted Materials in Rock

Mound Sample Number	Well Interval	Total Extract (ppm)	Hydrocarbons: Paraffin-Naphthene (ppm)	Hydrocarbons: Aromatic (ppm)	Hydrocarbons: Total (ppm)	Sulfur (ppm)	Nonhydrocarbons: Preciptd. Asphaltene (ppm)	Nonhydrocarbons: Eluted NSO's (ppm)	Nonhydrocarbons: Noneluted NSO's (ppm)	Nonhydrocarbons: Total (ppm)
OH-4-2		694	198	212	410		142	35	107	284
OH-4-4		183	71	36	107		65	8	3	76
OH-4-9		93	--	--	--		39	--	--	--
OH-4-12		2115	957	578	1535		142	80	358	580
OH-4-15		1027	349	362	711		137	70	109	316
OH-4-21		1644	745	502	1247		110	63	226	399
OH-4-50		2326	990	874	1864		193	240	28	461
OH-4-52		1799	728	518	1246		114	78	361	553
OH-4-53		1462	572	598	1170		180	94	19	293
OH-4-57		1111	368	395	763		113	87	148	348
OH-4-62		1081	335	341	676		165	67	173	405
OH-4-67		1160	447	401	848		89	46	117	312
OH-4-72		136	47	42	89		30	8	8	46
OH-4-75		173	69	42	111		28	7	26	61
OH-4-79		2486	1204	628	1832		171	161	322	654
OH-4-80		2140	737	757	1494		196	283	167	646
OH-4-83		2571	1025	655	1680		144	170	578	892
OH-4-88		3379	1033	1350	2383		342	408	245	995
OH-4-89		4740	1761	1561	3322		286	487	645	1418
OH-4-102		563	107	146	253		259	14	37	310
OH-4-106		157	52	56	108		36	4	9	49
OH-4-112		4297	1820	1398	3218		222	343	515	1080

TABLE 38

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography

B. Concentration of Extracted Materials in Rock

Mound Sample Number	Well Interval	Total Extract (ppm)	Hydrocarbons: Paraffin-Naphthene (ppm)	Hydrocarbons: Aromatic (ppm)	Hydrocarbons: Total (ppm)	Sulfur (ppm)	Nonhydrocarbons: Preciptd. Asphaltene (ppm)	Nonhydrocarbons: Eluted NSO's (ppm)	Nonhydrocarbons: Noneluted NSO's (ppm)	Nonhydrocarbons: Total (ppm)
OH-4-113		5546	1996	1744	3740		481	705	621	1807
OH-4-131		2595	956	704	1660		375	176	382	933
OH-4-140		107	--	--	--		29	--	--	--
OH-4-148		2541	1087	787	1874		124	97	446	667
OH-4-152		191	62	39	101		43	11	37	91
OH-4-155		3185	1109	1254	2363		175	308	339	822
OH-4-157		2491	1314	662	1976		126	309	340	775
OH-4-160		2957	1232	1025	2257		118	226	354	698
OH-4-164		4555	1811	1432	3243		272	450	590	1312
OH-4-174		2536	841	841	1682		233	139	483	855
OH-4-175		3342	1053	1116	2169		394	368	410	1172
OH-4-177		204	102	55	157		30	6	11	47
OH-4-184		612	231	146	377		117	20	98	235
OH-4-185		1284	755	338	1093		79	22	91	192
OH-4-193		4043	1797	1373	3170		224	249	400	873
OH-4-195		4526	1896	1400	3296		325	452	452	1229
OH-4-201		3159	1406	1104	2510		185	227	238	650
OH-4-206		1202	366	282	648		211	62	282	555
OH-4-207		1526	769	351	1120		136	14	256	406

TABLE 38 (Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromotography
for OH-4 Well

C. Composition of Extracts

Mound Sample Number	Well Interval	Hydrocarbons: Paraffin-Naphthene %	Hydrocarbons: Aromatic %	Hydrocarbons: PN/Arom	Sulfur %	Nonhydrocarbons: Eluted NSO's %	Nonhydrocarbons: Noneluted NSO's %	Nonhydrocarbons: Precipitd. Asphaltene %	Nonhydrocarbons: Asph/NSO	HC's %	HC/Non HC
OH-4-2		28.5	30.5	0.93		5.1	15.5	20.4	0.99	59.0	1.44
OH-4-4		38.7	19.9	1.94		4.4	1.7	35.4	5.80	58.6	1.42
OH-4-9		--	--	--		--	--	42.4	--	--	--
OH-4-12		45.2	27.3	1.66		3.8	16.9	6.7	0.32	72.5	2.64
OH-4-15		33.9	35.2	0.96		6.8	10.6	13.3	0.76	69.1	2.24
OH-4-21		45.3	30.5	1.49		3.8	13.7	6.7	0.38	75.8	3.13
OH-4-50		42.6	37.5	1.14		10.3	1.2	8.3	0.72	80.0	4.00
OH-4-52		40.5	28.8	1.41		4.3	20.1	6.4	0.26	69.3	2.26
OH-4-53		39.1	40.9	0.96		6.4	1.3	12.3	1.60	81.9	4.53
OH-4-57		33.1	35.5	0.93		7.9	13.3	10.2	0.48	68.6	2.18
OH-4-62		31.0	31.5	0.98		6.2	16.0	15.3	0.69	62.5	1.67
OH-4-67		38.5	34.6	1.11		4.0	15.3	7.7	0.40	73.1	2.72
OH-4-72		34.8	31.1	1.12		5.9	5.9	22.2	1.88	65.9	1.93
OH-4-75		40.1	24.4	1.64		4.1	15.1	16.3	0.85	64.5	1.82
OH-4-79		48.4	25.3	1.91		6.5	13.0	6.9	0.35	73.7	2.80
OH-4-80		34.5	35.4	0.98		13.2	7.8	9.2	0.44	69.9	2.32
OH-4-83		39.9	25.5	1.56		6.6	22.5	5.6	0.19	65.4	1.89
OH-4-88		30.6	40.0	0.77		12.1	7.3	10.1	0.52	70.6	2.40
OH-4-89		37.2	32.9	1.13		10.3	13.6	6.0	0.25	70.1	2.34
OH-4-102		19.1	26.0	0.73		2.5	6.5	45.9	6.56	45.1	0.82
OH-4-106		32.9	36.1	0.91		2.5	5.7	22.8	2.78	69.0	2.23
OH-4-112		42.3	32.5	1.30		8.0	12.0	5.2	0.26	74.8	2.97
OH-4-113		36.0	31.5	1.14		12.7	11.2	8.7	0.36	67.5	2.08
OH-4-131		36.9	27.1	1.36		6.8	14.7	14.5	0.67	64.0	1.78

TABLE 38 (Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromotography

C. Composition of Extracts

Mound Sample Number	Well Interval	Hydrocarbons: Paraffin-Naphthene %	Hydrocarbons: Aromatic %	Hydrocarbons: PN/Arom	Sulfur %	Nonhydrocarbons: Eluted NSO's %	Nonhydrocarbons: Noneluted NSO's %	Nonhydrocarbons: Precipitd. Asphaltene %	Asph/NSO	HC's %	HC/Non HC
OH-4-140		--	--	--		--	--	27.1	--	--	--
OH-4-148		42.8	31.0	1.38		3.8	17.6	4.9	0.23	73.8	2.82
OH-4-152		32.4	20.2	1.60		5.9	19.1	22.3	0.90	52.6	1.11
OH-4-155		34.8	39.4	0.88		9.7	10.6	5.5	0.27	74.2	2.88
OH-4-157		52.7	26.6	1.98		5.8	9.9	5.1	0.32	79.3	3.83
OH-4-160		41.7	34.7	1.20		7.7	12.0	4.0	0.20	76.4	3.24
OH-4-164		39.8	31.4	1.27		9.9	12.9	6.0	0.26	71.2	2.47
OH-4-174		33.2	33.2	1.00		5.5	19.0	9.2	0.38	66.4	1.98
OH-4-175		31.5	33.4	0.94		11.0	12.3	11.8	0.51	64.9	1.85
OH-4-177		50.0	27.0	1.85		2.9	5.4	14.7	1.77	77.0	3.35
OH-4-184		37.8	23.9	1.58		3.2	16.0	19.2	1.00	61.7	1.61
OH-4-185		58.8	26.3	2.24		1.7	7.1	6.2	0.70	85.1	5.71
OH-4-193		44.4	34.0	1.31		6.2	9.9	5.6	0.35	78.4	3.63
OH-4-195		41.9	30.9	1.36		10.0	10.0	7.2	0.36	72.8	2.68
OH-4-201		44.5	34.9	1.28		7.2	7.5	5.9	0.40	79.4	3.85
OH-4-206		30.4	23.4	1.30		5.2	23.4	17.6	0.62	53.8	1.16
OH-4-207		50.4	23.0	2.19		0.9	16.8	8.9	0.50	73.4	2.76

TABLE 39

Saturate Hydrocarbon Analyses

for OH-4 Well

Mound Sample Number	OH-4-2	OH-4-4	OH-4-12	OH-4-15	OH-4-21	OH-4-50
% Distribution						
nC_{15}	8.3	15.6	13.2	10.0	13.9	11.7
nC_{16}	8.7	14.9	10.7	9.5	11.3	9.9
nC_{17}	9.6	13.7	10.0	9.9	10.8	9.7
nC_{18}	7.5	9.7	7.4	7.9	8.1	7.7
nC_{19}	8.9	8.6	8.0	8.8	8.6	8.6
nC_{20}	6.0	6.0	6.0	6.5	6.3	6.3
nC_{21}	5.2	5.0	5.1	5.2	5.3	5.4
nC_{22}	3.3	3.6	3.2	3.6	3.7	3.8
nC_{23}	2.1	2.4	2.1	2.2	2.4	2.3
nC_{24}	1.2	1.6	1.3	1.2	1.5	1.2
nC_{25}	0.9	1.0	1.0	0.9	1.2	0.8
nC_{26}	0.6	0.7	0.6	0.6	0.8	0.5
nC_{27}	0.4	0.5	0.5	0.4	0.4	0.4
nC_{28}	0.2	0.2	0.2	0.2	0.2	0.2
nC_{29}	0.1	0.2	0.1	0.1	0.1	0.1
nC_{30}	--	0.1	0.1	0.1	0.1	0.1
nC_{31}	--	--	--	--	0.1	--
nC_{32}	--	--	--	--	--	--
iC_{18}	9.4	5.2	8.0	8.1	7.2	8.4
iC_{19}	18.4	7.4	16.0	17.2	12.2	15.4
iC_{20}	8.9	3.6	6.4	7.4	5.8	7.4
% Isoprenoid	36.7	16.2	30.4	32.7	25.2	31.2
CPI A	1.19	1.14	1.21	1.17	1.13	1.15
CPI B	1.21	1.26	1.25	1.15	1.16	1.07
Naphthene Ratio	1.37	1.37	1.36	1.34	1.26	1.53

TABLE 39 (Continued)
Saturate Hydrocarbon Analyses
for OH-4 Well

Mound Sample Number	OH-4-52	OH-4-53	OH-4-57	OH-4-62	OH-4-67	OH-4-72
% Distribution						
nC_{15}	11.9	12.4	8.0	9.9	8.3	14.9
nC_{16}	10.8	10.1	9.1	10.0	9.9	14.1
nC_{17}	10.8	9.9	10.4	10.6	10.6	11.7
nC_{18}	8.3	7.8	8.9	8.9	9.1	10.1
nC_{19}	8.8	8.4	9.9	9.2	9.3	9.5
nC_{20}	7.0	6.1	7.4	6.9	7.9	7.0
nC_{21}	6.2	5.2	6.4	5.7	7.0	5.9
nC_{22}	4.5	3.5	4.4	3.5	5.1	4.3
nC_{23}	2.8	3.6	2.8	2.3	3.4	3.1
nC_{24}	1.7	1.3	1.7	1.4	2.2	1.9
nC_{25}	1.2	0.8	1.1	0.9	1.5	1.3
nC_{26}	0.7	0.6	0.8	0.5	0.9	0.9
nC_{27}	0.5	0.3	0.6	0.4	0.6	0.7
nC_{28}	0.3	0.3	0.3	0.3	0.4	0.4
nC_{29}	--	0.1	0.3	0.1	0.2	0.2
nC_{30}	--	--	0.2	--	0.1	0.1
nC_{31}	--	--	0.1	--	0.1	0.1
nC_{32}	--	--	0.1	--	0.1	0.1
iC_{18}	6.9	8.4	7.3	8.2	5.9	4.3
iC_{19}	12.3	14.7	13.7	14.5	13.2	6.9
iC_{20}	5.3	6.6	6.5	7.0	4.2	2.4
% Isoprenoid	24.5	29.7	27.5	29.7	23.3	13.6
CPI A	1.13	1.31	1.13	1.19	1.11	1.12
CPI B	1.16	0.99	1.06	1.16	1.13	1.12
Naphthene Ratio	1.37	1.80	1.33	1.26	1.34	1.52

TABLE 39 (Continued)

Saturate Hydrocarbon Analyses
for OH-4 Well

Mound Sample Number	OH-4-75	OH-4-79	OH-4-80	OH-4-83	OH-4-88	OH-4-89
% Distribution						
nC_{15}	18.3	14.8	13.6	16.4	12.3	13.1
nC_{16}	13.9	12.1	12.6	13.1	10.7	10.2
nC_{17}	11.8	10.6	11.7	11.4	10.2	9.4
nC_{18}	9.5	8.4	9.0	8.4	8.0	7.4
nC_{19}	9.0	8.4	9.0	8.2	8.4	8.3
nC_{20}	6.7	6.4	6.8	5.7	6.1	6.1
nC_{21}	5.6	5.4	5.3	4.8	4.9	5.3
nC_{22}	3.9	3.9	3.5	3.3	3.4	3.7
nC_{23}	2.6	2.6	2.2	2.0	2.1	2.5
nC_{24}	1.5	1.5	1.1	1.2	1.1	1.5
nC_{25}	1.1	1.0	0.7	0.8	0.7	1.0
nC_{26}	0.7	0.7	0.3	0.5	0.5	0.6
nC_{27}	0.4	0.3	0.3	0.4	0.3	0.4
nC_{28}	0.3	0.2	0.1	0.1	0.2	0.2
nC_{29}	0.1	0.1	--	--	0.1	--
nC_{30}	0.1	0.1	--	--	--	--
nC_{31}	0.1	--	--	--	--	--
nC_{32}	--	--	--	--	--	--
iC_{18}	4.7	6.5	7.0	7.9	8.9	7.9
iC_{19}	7.3	12.2	11.9	11.1	15.8	15.6
iC_{20}	2.5	4.9	4.7	4.7	6.4	6.9
% Isoprenoid	14.5	23.6	23.6	23.7	31.1	30.4
CPI A	1.14	1.11	1.19	1.16	1.13	1.15
CPI B	1.10	0.98	1.45	1.33	1.08	1.18
Naphthene Ratio	1.58	1.93	1.89	1.61	1.50	1.39

TABLE 39 (Continued)

Saturate Hydrocarbon Analyses
for OH-4 Well

Mound Sample Number	OH-4-102	OH-4-106	OH-4-112	OH-4-113	OH-4-131	OH-4-148
% Distribution						
nC_{15}	5.2	0.1	16.7	16.8	13.7	15.0
nC_{16}	10.2	1.7	12.7	12.7	12.2	12.4
nC_{17}	13.3	9.4	10.7	10.7	11.4	11.6
nC_{18}	13.1	15.3	8.2	8.2	9.3	9.2
nC_{19}	12.6	17.6	8.2	8.1	9.1	9.0
nC_{20}	9.9	14.1	6.4	6.2	6.8	7.0
nC_{21}	7.0	11.8	5.4	5.3	5.8	5.9
nC_{22}	4.9	7.2	3.8	3.5	3.6	4.0
nC_{23}	2.9	5.1	2.7	2.2	2.3	2.4
nC_{24}	1.7	2.6	1.7	1.4	1.3	1.5
nC_{25}	0.8	1.6	1.2	0.9	0.8	1.0
nC_{26}	0.6	0.1	0.9	0.6	0.6	0.7
nC_{27}	0.4	0.6	0.5	0.4	0.3	0.4
nC_{28}	0.3	0.4	0.3	0.2	0.1	0.2
nC_{29}	0.1	0.2	0.1	0.2	0.1	0.1
nC_{30}	0.1	0.1	0.1	0.1	0.1	0.1
nC_{31}	0.1	0.1	0.1	0.1	0.0	--
nC_{32}	0.1	0.1	--	0.1	--	--
iC_{18}	4.2	1.6	5.8	6.4	6.7	5.8
iC_{19}	10.1	5.9	9.9	10.7	11.4	9.3
iC_{20}	2.6	3.6	4.8	5.3	4.4	4.2
% Isoprenoid	16.9	11.1	20.5	22.4	22.5	19.3
CPI A	1.07	1.24	1.11	1.15	1.18	1.13
CPI B	0.93	1.12	1.05	1.11	1.01	1.05
Naphthene Ratio	1.26	1.12	1.55	2.04	1.31	1.39

TABLE 39 (Continued)

Saturate Hydrocarbon Analyses
for OH-4 Well

Mound Sample Number	OH-4-152	OH-4-155	OH-4-157	OH-4-160	OH-4-164	OH-4-174
% Distribution						
nC_{15}	0.2	16.1	19.2	19.4	15.8	15.6
nC_{16}	2.2	12.5	14.6	14.4	12.8	12.8
nC_{17}	9.5	11.1	12.2	12.2	11.7	11.5
nC_{18}	13.2	8.8	8.8	8.9	8.6	8.8
nC_{19}	15.6	8.7	8.2	8.4	8.5	8.8
nC_{20}	12.8	6.7	5.9	6.1	5.9	6.5
nC_{21}	11.7	5.7	5.1	4.7	4.8	5.2
nC_{22}	7.2	4.0	3.4	3.1	3.0	3.5
nC_{23}	4.8	2.7	2.2	1.8	1.7	2.3
nC_{24}	2.8	1.7	1.4	1.0	0.9	1.3
nC_{25}	1.8	1.1	1.0	0.6	0.7	1.0
nC_{26}	0.9	0.8	0.6	0.5	0.3	0.5
nC_{27}	0.6	0.4	0.2	0.1	0.1	0.2
nC_{28}	0.2	0.2	0.1	0.1	0.1	0.2
nC_{29}	0.2	0.1	0.1	--	--	0.1
nC_{30}	0.1	--	--	--	--	--
nC_{31}	0.1	--	--	--	--	--
nC_{32}	--	--	--	--	--	--
iC_{18}	3.7	6.1	6.0	6.5	8.4	7.1
iC_{19}	7.5	8.8	7.4	7.9	11.1	9.6
iC_{20}	5.0	4.5	3.6	4.0	5.5	4.7
% Isoprenoid	16.2	19.4	17.0	18.4	25.0	21.4
CPI A	1.26	1.11	1.15	1.06	1.21	1.16
CPI B	1.43	1.10	1.24	0.80	1.26	1.25
Naphthene Ratio	0.92	1.29	1.67	1.51	1.26	1.62

TABLE 39 (Continued)
Saturate Hydrocarbon Analyses
for OH-4 Well

Mound Sample Number	OH-4-175	OH-4-177	OH-4-184	OH-4-185	OH-4-193	OH-4-195
% Distribution						
nC_{15}	14.9	13.8	5.3	13.2	11.8	13.8
nC_{16}	12.7	12.9	7.4	11.7	10.2	11.7
nC_{17}	11.5	12.4	9.6	11.0	10.0	11.0
nC_{18}	8.9	10.0	8.5	8.8	8.1	8.5
nC_{19}	8.8	10.1	9.5	9.4	9.0	9.1
nC_{20}	6.3	7.7	7.3	7.0	6.9	6.7
nC_{21}	4.9	6.9	6.5	5.9	6.1	5.2
nC_{22}	2.8	5.0	5.3	4.2	4.3	3.3
nC_{23}	1.6	3.6	4.3	2.9	3.0	2.0
nC_{24}	0.9	2.4	3.1	2.0	1.9	1.2
nC_{25}	0.6	1.7	2.5	1.4	1.4	0.8
nC_{26}	0.3	1.1	1.9	0.9	0.9	0.5
nC_{27}	0.1	0.7	1.4	0.7	0.7	0.3
nC_{28}	0.1	0.5	0.9	0.4	0.4	0.2
nC_{29}	--	0.4	0.7	0.3	0.3	0.1
nC_{30}	--	0.2	0.3	0.2	0.2	0.1
nC_{31}	--	0.1	0.2	0.1	0.1	0.1
nC_{32}	--	--	0.1	--	0.0	0.0
iC_{18}	8.3	3.5	6.3	5.6	6.7	7.1
iC_{19}	11.8	5.1	11.4	8.5	10.4	10.7
iC_{20}	5.4	1.8	7.8	5.9	7.6	7.6
% Isoprenoid	25.5	10.4	25.5	20.0	24.7	25.4
CPI A	1.23	1.11	1.08	1.11	1.15	1.14
CPI B	1.32	1.15	1.14	1.19	1.01	1.11
Naphthene Ratio	1.50	1.09	1.02	1.39	1.02	1.33

TABLE 39 (Continued)

Saturate Hydrocarbon Analyses
for OH-4 Well

Mound Sample Number	OH-4-201	OH-4-206	OH-4-207
% Distribution			
nC_{15}	12.3	12.1	11.4
nC_{16}	10.7	11.2	10.6
nC_{17}	10.1	11.1	10.5
nC_{18}	8.2	9.1	9.0
nC_{19}	9.1	9.6	9.6
nC_{20}	7.2	7.4	7.9
nC_{21}	6.5	5.9	6.9
nC_{22}	4.7	4.1	5.1
nC_{23}	3.5	2.7	3.4
nC_{24}	2.4	1.5	2.3
nC_{25}	1.6	1.1	1.7
nC_{26}	1.0	0.7	1.2
nC_{27}	0.7	0.5	0.8
nC_{28}	0.5	0.3	0.6
nC_{29}	0.3	0.2	0.3
nC_{30}	0.1	0.1	0.2
nC_{31}	0.1	0.1	0.1
nC_{32}	--	0.0	--
iC_{18}	5.8	6.1	5.0
iC_{19}	8.9	9.4	7.8
iC_{20}	6.4	6.9	5.6
% Isoprenoid	21.1	22.4	18.4
CPI A	1.12	1.14	1.08
CPI B	1.18	1.16	1.06
Naphthene Ratio	1.20	1.18	1.03

10. Pyrolysis-Gas Chromatographic Results

One hundred and twenty-five (125) samples from the OH-4 well were analyzed by this pyrolytic method (Table 40). The average values for the total hydrocarbon yield, volatile hydrocarbon content, and Peak II maximum temperature were 1.15 wt %, 1500 ppm, and 458°C. The mean Peak I/Peak II value was 0.16. These results were combined with the results from previously analyzed OH-4 samples [2] and compared to other Devonian shale well data (Table 17). The maximum total hydrocarbon yield (9.23 wt %) and volatile hydrocarbon content (7062 ppm) were obtained for sample OH-4-112. This sample is at a drillers depth of 981 ft in the Pipe Creek member of the Java Formation.

11. Bulk Density Analysis

Bulk density was determined for 87 samples from the OH-4 well (Table 41). The average bulk density was 2.62 g/cm^3. This value is similar to previously reported mean well values.[2] The most dense sample of this set was OH-4-87 (857 ft) with a bulk density of 2.97 g/cm^3. This is from the Dunkirk member of the Perrysburg Formation. Major elemental analysis data is not currently available for this sample. The high density value from a massive black shale unit suggests this particular sample may have contained a high proportion of pyrite. The least dense (2.37 g/cm^3) sample was OH-4-203 (1362 ft). This sample was recovered from the Marcellus facies of the Hamilton Group.

There is a general linear relationship between sample organic carbon content and bulk density.[2] The bulk density values were compared to the organic carbon contents of these OH-4 samples (Figure 8). There is a good linear relationship between these variables (correlation coefficient = -0.79, 87 samples).

G. PA-3 Well (Erie County, Pennsylvania)

1. Sample Identification, Depths and Stratigraphic Intervals

Table 42 contains the sample identification and corresponding depths for the samples from the PA-3 well (MRC and Pennsylvania DER/Presque Isle State Park #1). Table 43 identifies stratigraphic intervals selected from the gamma-ray/bulk density log. The sample and log depths are measured from the Kelly Bushing (578 ft) four feet above permanent datum (ground level, 574 ft).

TABLE 40

Pyrolysis - GC Analysis for OH-4 samples

Mound Sample Number	Total Hydrocarbon Yield (Wt %)	Volatile Hydrocarbon Content (ppm)	Peak II Maximum Temperature (°C)
OH-4-001	.03	73	453
OH-4-002	1.08	1688	454
OH-4-004	.68	777	455
OH-4-005	1.07	1376	453
OH-4-006	.40	555	458
OH-4-008	.03	56	458
OH-4-009	.04	76	448
OH-4-011	.01	33	449
OH-4-012	.81	1233	454
OH-4-014	.93	1097	460
OH-4-015	.99	973	457
OH-4-017	.85	1219	460
OH-4-019	.84	1096	454
OH-4-020	1.02	1670	463
OH-4-021	.17	262	464
OH-4-043	1.30	1636	456
OH-4-044	1.10	1339	477
OH-4-045	1.46	2008	463
OH-4-046	1.06	1463	467
OH-4-047	.06;.05	117;107	441;442
OH-4-049	.08	252	456
OH-4-050	1.43	1918	455
OH-4-052	.53	898	466
OH-4-053	.87	1221	454
OH-4-054	.68	1230	453
OH-4-056	.98	1601	452
OH-4-057	.82	1098	451
OH-4-059	.42	582	451
OH-4-060	1.07	1758	455
OH-4-062	.89	1143	452
OH-4-063	.95	1390	453
OH-4-064	.84	1372	468
OH-4-065	1.11	1478	451
OH-4-067	.59	865	467
OH-4-068	.07	134	468
OH-4-069	.06	120	464
OH-4-070	.09	160	464
OH-4-071	.06	92	465
OH-4-072	.08	184	440
OH-4-073	.08	174	450
OH-4-074	.08	153	449
OH-4-075	.05	87	449

TABLE 40 (Continued)

Pyrolysis - GC Analysis for OH-4 samples

Mound Sample Number	Total Hydrocarbon Yield (Wt %)	Volatile Hydrocarbon Content (ppm)	Peak II Maximum Temperature (°C)
OH-4-076	.04	92	452
OH-4-077	.06	127	454
OH-4-078	.02	59	445
OH-4-079	1.65	2156	460
OH-4-080	1.44	1487	454
OH-4-081	1.35	2274	456
OH-4-083	1.46	1954	460
OH-4-084	2.40	2891	456
OH-4-085	1.81	2172	452
OH-4-087	1.82	2817	458
OH-4-088	2.46	2736	454
OH-4-089	4.31	5200	465
OH-4-091	.01	36	438
OH-4-092	.02	38	448
OH-4-101	.02	50	448
OH-4-102	.81	454	454
OH-4-103	.03	53	450
OH-4-105	.01	37	443
OH-5-106	.06	88	450
OH-4-108	.09	188	457
OH-4-109	.02	50	448
OH-4-111	.09	197	456
OH-4-112	9.23	7062	467
OH-4-113	7.75	5950	459
OH-4-115	.24	802	457
OH-4-123	.11	224	464
OH-4-124	.03	54	449
OH-4-126	3.07	3277	467
OH-4-127	.06	121	457
OH-4-128	.02	38	454
OH-4-130	.05	124	454
OH-4-131	2.08	2333	455
OH-4-133	.03	134	460
OH-4-134	2.26	2595	468
OH-4-136	.07	140	455
OH-4-137	.43	802	455
OH-4-140	.04	77	461
OH-4-141	.23	366	453
OH-4-142	2.58	2676	468
OH-4-144	1.19	1359	470
OH-4-145	1.81	1869	458
OH-4-147	.12	209	455
OH-4-148	1.46	2059	470
OH-4-149	2.20	2485	476

TABLE 40 (Continued)

Pyrolysis - GC Analysis for OH-4 samples

Mound Sample Number	Total Hydrocarbon Yield (Wt %)	Volatile Hydrocarbon Content (ppm)	Peak II Maximum Temperature (°C)
OH-4-151	.57	786	452
OH-4-152	.10	177	465
OH-4-154	.45	863	462
OH-4-155	2.33	3414	467
OH-4-157	.53	1384	467
OH-4-158	3.75	5143	471
OH-4-159	3.30	4538	462
OH-4-160	3.12	4062	461
OH-4-161	2.66	4166	467
OH-4-162	1.00	2686	448
OH-4-163	3.26	4996	452
OH-4-164	2.72	3630	465
OH-4-165	2.38	4212	466
OH-4-167	2.52	3667	465
OH-4-168	1.85	3341	463
OH-4-169	1.63	2640	454
OH-4-171	1.08	2292	466
OH-4-172	1.32	1792	469
OH-4-174	3.10	4397	453
OH-4-175	2.78;2.63	3391;3161	475;472
OH-4-176	3.03	4578	462
OH-4-178	.17	440	464
OH-4-184	.22	303	476
OH-4-185	.70	1735	455
OH-4-186	.47	1023	463
OH-4-188	.68	1236	478
OH-4-189	.57	1158	472
OH-4-191	1.44	2461	455
OH-4-192	.67	1451	466
OH-4-193	1.40	2317	459
OH-4-195	1.98	3215	452
OH-4-196	3.53	4832	468
OH-4-199	2.52	2906	458
OH-4-200	1.88	3607	458
OH-4-201	2.29	3333	463
OH-4-202	.27	613	449
OH-4-204	.56	1032	463
OH-4-206	.80	963	458
OH-4-207	.34	813	466
OH-4-209	.24	466	461

TABLE 41

Density of Core Sample
for OH-4 Well

Mound Sample Number	Density (g/cm^3)
OH-4-001	2.72
OH-4-003	2.71
OH-4-006	2.70
OH-4-007	2.64
OH-4-008	2.68
OH-4-010	2.66
OH-4-013	2.55
OH-4-014	2.58
OH-4-016	2.67
OH-4-017	2.61
OH-4-018	2.69
OH-4-020	2.58
OH-4-042	2.49
OH-4-045	2.53
OH-4-048	2.62
OH-4-049	2.68
OH-4-051	2.58
OH-4-054	2.64
OH-4-055	2.60
OH-4-056	2.52
OH-4-058	2.66
OH-4-060	2.60
OH-4-061	2.70
OH-4-063	2.61
OH-4-066	2.66
OH-4-081	2.59
OH-4-082	2.51
OH-4-084	2.50
OH-4-086	2.52
OH-4-087	2.97
OH-4-090	2.72
OH-4-091	2.67
OH-4-093	2.68
OH-4-101	2.68
OH-4-104	2.67
OH-4-105	2.68
OH-4-107	2.50
OH-4-108	2.67
OH-4-110	2.66
OH-4-111	2.67
OH-4-114	2.24
OH-4-115	2.67
OH-4-116	2.70
OH-4-123	2.68

TABLE 41 (Continued)

Density of Core Sample
for OH-4 Well

Mound Sample Number	Density (g/cm^3)
OH-4-125	2.78
OH-4-127	2.73
OH-4-129	2.73
OH-4-130	2.69
OH-4-132	2.72
OH-4-133	2.71
OH-4-135	2.69
OH-4-137	2.67
OH-4-138	2.71
OH-4-141	2.67
OH-4-143	2.66
OH-4-145	2.55
OH-4-146	2.67
OH-4-147	2.71
OH-4-150	2.69
OH-4-151	2.64
OH-4-153	2.70
OH-4-154	2.67
OH-4-156	2.66
OH-4-165	2.45
OH-4-166	2.55
OH-4-168	2.51
OH-4-170	2.63
OH-4-171	2.56
OH-4-173	2.45
OH-4-176	2.45
OH-4-177	2.68
OH-4-178	2.65
OH-4-183	2.62
OH-4-186	2.62
OH-4-187	2.61
OH-4-189	2.61
OH-4-190	2.55
OH-4-192	2.58
OH-4-194	2.41
OH-4-196	2.41
OH-4-198	2.43
OH-4-200	2.52
OH-4-203	2.37
OH-4-204	2.61
OH-4-205	2.65
OH-4-208	2.56
OH-4-209	2.65

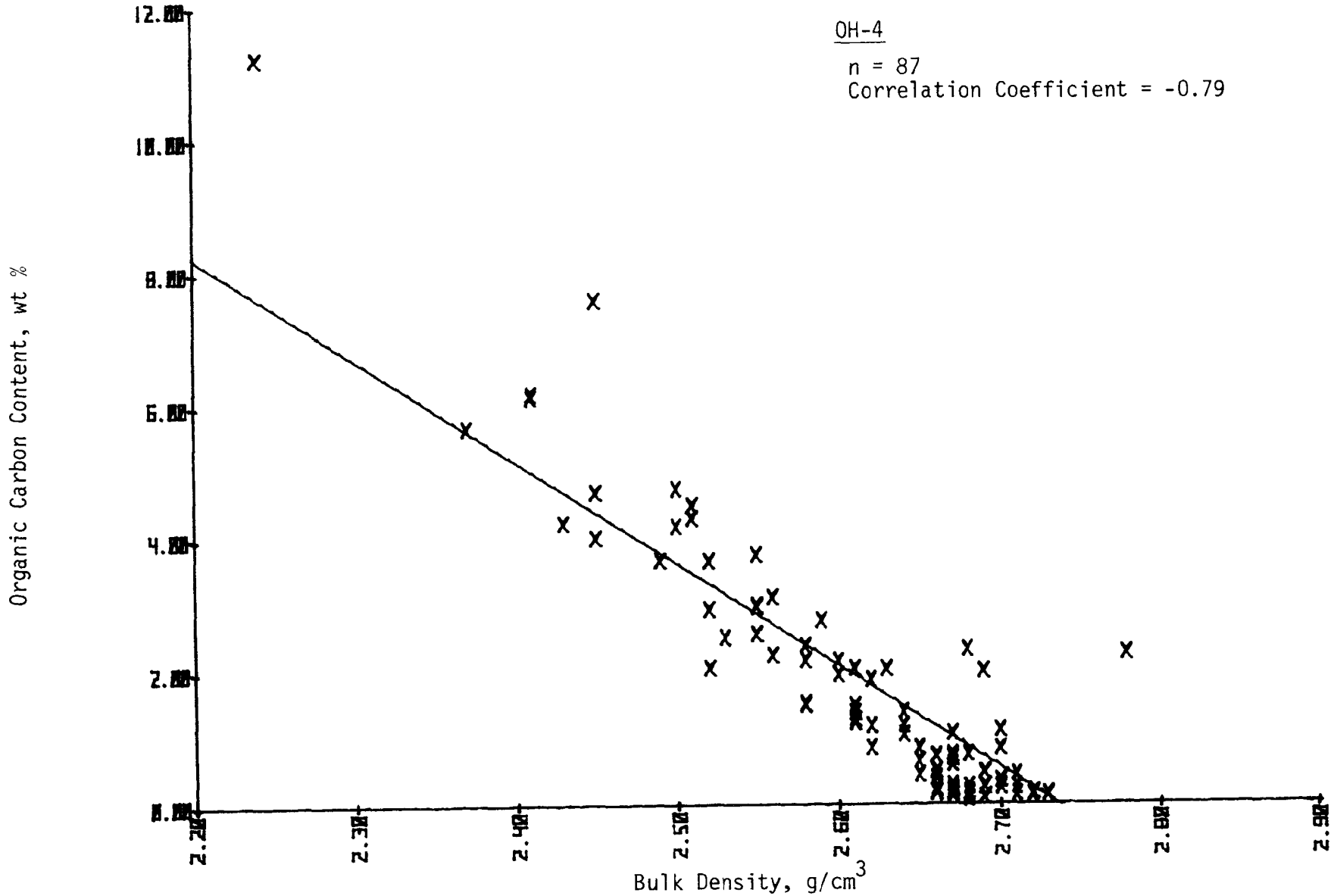

FIGURE 8
Bulk Density versus organic carbon content for OH-4 well samples.

TABLE 42
Samples from the PA-3 Well,
Erie County, Pennsylvania

Mound Sample No.	Depth (ft)	Sample Identification
PA-3-1	375 (.0-.5)	C/PCO* 1-11
PA-3-2	375 (.5-1.5)	C/PCO* 1-10
PA-3-3	376 (.5-1.5)	C/PCO* 1-9
PA-3-4	377 (.5-1.5)	C/PCO* 1-8
PA-3-5	378 (.5-1.5)	C/PCO* 1-7
PA-3-6	379 (.5-1.5)	C/PCO* 1-6
PA-3-7	380 (.5-1.5)	C/PCO* 1-5
PA-3-8	381 (.5-1.5)	C/PCO* 1-4
PA-3-9	382 (.5-1.5)	C/PCO* 1-3
PA-3-10	383 (.5-1.5)	C/PCO* 1-2
PA-3-11	384 (.5-1.0)	C/PCO* 1-1
PA-3-12	385 (.00-.31)	C/CCO*
PA-3-13	386 (.73-.76)	D/CCO
PA-3-14	387 (.55-.82)	C/CCO B
PA-3-15	390 (.18-.22)	D/CCO**
PA-3-16	394 (.70-.74)	D/CCO
PA-3-17	397 (.22-.48)	C/CCO B
PA-3-18	398 (.70-.73)	D/CCO
PA-3-19	401 (.33-.72)	C/CCO*
PA-3-20	403 (.17-.22)	D/CCO**
PA-3-21	407 (.32-.57)	C/CCO B
PA-3-22	407 (.80-.84)	D/CCO
PA-3-23	411 (.15-.32)	D/CCO
PA-3-24	415 (.28-.32)	D/CCO**
PA-3-25	417 (.21-.49)	C/CCO B
PA-3-26	419 (.45-.48)	D/CCO
PA-3-27	420 (.19-.54)	C/CCO*
PA-3-28	423 (.58-.63)	D/CCO
PA-3-29	541 (.72-.75)	D/CCO
PA-3-30	542 (.40-.65)	C/CCO B
PA-3-31	545 (.20-.52)	C/CCO*
PA-3-32	546 (.50-.55)	D/CCO**
PA-3-33	550 (.23-.28)	D/CCO
PA-3-34	552 (.25-.56)	C/CCO B
PA-3-35	554 (.76-.80)	D/CCO
PA-3-36	558 (.47-.50)	D/CCO**
PA-3-37	563 (.60-.80)	D/CCO**
PA-3-38	565 (.66-.70)	D/CCO
PA-3-39	567 (.24-.62)	C/CCO
PA-3-40	570 (.76-.82)	D/CCO**
PA-3-41	572 (.52-.73)	C/CCO B
PA-3-42	574 (.64-.69)	D/CCO
PA-3-43	579 (.10-.15)	D/CCO
PA-3-44	580 (.82-.87)	D/CCO**
PA-3-45	582 (.33-.63)	C/CCO B

TABLE 42 (Continued)
Samples from the PA-3 Well,
Erie County, Pennsylvania

Mound Sample No.	Depth (ft)	Sample Identification
PA-3-46	584 (.77-.82)	D/CCO
PA-3-47	588 (.54-.57)	D/CCO
PA-3-48	592 (.32-.63)	C/CCO B
PA-3-49	592 (.63-.66)	D/CCO**
PA-3-50	596 (.55-.60)	D/CCO
PA-3-51	600 (.19-.23)	D/CCO
PA-3-52	601 (.18-.67)	C/CCO*
PA-3-53	602 (.40-.73)	C/CCO B
PA-3-54	604 (.88-.92)	D/CCO**
PA-3-55	608 (.32-.39)	D/CCO
PA-3-56	611 (.46-.50)	D/CCO
PA-3-57	612 (.42-.73)	C/CCO B
PA-3-58	613 (.20-.62)	C/CCO*
PA-3-59	615 (.39-.44)	D/CCO**
PA-3-60	620 (.23-.28)	D/CCO
PA-3-61	621 (.90-.93)	D/CCO**
PA-3-62	622 (.41-.71)	C/CCO B
PA-3-63	625 (.36-.42)	D/CCO
PA-3-64	627 (.31-.73)	C/CCO*
PA-3-65	629 (.51-.57)	D/CCO
PA-3-66	633 (.29-.56)	C/CCO B
PA-3-67	633 (.56-.61)	D/CCO**
PA-3-68	637 (.30-.34)	D/CCO
PA-3-69	641 (.19-.27)	D/CCO
PA-3-70	642 (.58-.85)	C/CCO B
PA-3-71	645 (.35-.40)	D/CCO**
PA-3-72	648 (.77-.86)	D/CCO
PA-3-73	652 (.38-.69)	C/CCO B
PA-3-74	653 (.13-.19)	D/CCO
PA-3-75	655 (.49-.92)	C/CCO*
PA-3-76	656 (.82-.92)	D/CCO**
PA-3-77	660 (.21-.26)	D/CCO
PA-3-78	720 (.32-.40)	D/CCO
PA-3-79	722 (.10-.39)	C/CCO B
PA-3-80	724 (.52-.55)	D/CCO**
PA-3-81	728 (.50-.55)	D/CCO
PA-3-82	732 (.30-.57)	C/CCO B
PA-3-83	732 (.57-.63)	D/CCO
PA-3-84	734 (.20-.58)	C/CCO*
PA-3-85	736 (.32-.38)	D/CCO**

TABLE 42 (Continued)

Samples from the PA-3 Well,
Erie County, Pennsylvania

Mound Sample No.	Depth (ft)	Sample Identification
PA-3-86	740 (.48-.52)	D/CCO
PA-3-87	742 (.28-.52)	C/CCO B
PA-3-88	744 (.38-.44)	D/CCO
PA-3-89	748 (.56-.60)	D/CCO**
PA-3-90	752 (.40-.59)	C/CCO B
PA-3-91	752 (.59-.65)	D/CCO
PA-3-92	754 (.07-.47)	C/CCO*
PA-3-93	756 (.12-.17)	D/CCO
PA-3-94	760 (.53-.58)	D/CCO**
PA-3-95	930 (.76-.80)	D/CCO
PA-3-96	932 (.43-.70)	C/CCO B
PA-3-97	934 (.67-.72)	D/CCO**
PA-3-98	940 (.35-.40)	D/CCO
PA-3-99	941 (.48-.88)	C/CCO*
PA-3-100	942 (.52-.82)	C/CCO B
PA-3-101	944 (.32-.39)	D/CCO
PA-3-102	948 (.15-.23)	D/CCO**
PA-3-103	952 (.45-.50)	D/CCO
PA-3-104	952 (.50-.79)	C/CCO B
PA-3-105	956 (.47-.53)	D/CCO
PA-3-106	958 (.45-.86)	C/CCO*
PA-3-107	960 (.39-.43)	D/CCO**
PA-3-108	962 (.44-.69)	C/CCO B
PA-3-109	964 (.71-.76)	D/CCO
PA-3-110	968 (.09-.16)	D/CCO
PA-3-111	969 (.58-.63)	D/CCO**
PA-3-112	970 (.67-.71)	D/CCO
PA-3-113	972 (.29-.60)	C/CCO*
PA-3-114	972 (.60-.83)	C/CCO B
PA-3-115	974 (.32-.45)	D/CCO
PA-3-116	978 (.58-.64)	D/CCO**
PA-3-117	982 (.11-.42)	C/CCO B
PA-3-118	982 (.42-.48)	D/CCO
PA-3-119	986 (.18-.25)	D/CCO
PA-3-120	990 (.14-.19)	D/CCO**
PA-3-121	992 (.19-.40)	C/CCO B
PA-3-122	994 (.50-.55)	D/CCO
PA-3-123	997 (.18-.60)	C/CCO*
PA-3-124	998 (.14-.20)	D/CCO
PA-3-125	1002 (.23-.30)	D/CCO**

TABLE 42 (Continued)
Samples from the PA-3 Well,
Erie County, Pennsylvania

Mound Sample No.	Depth (ft)	Sample Identification
PA-3-126	1002 (.30-.58)	C/CCO B
PA-3-127	1006 (.37-.43)	D/CCO
PA-3-128	1009 (.78-.83)	D/CCO
PA-3-129	1012 (.36-.66)	C/CCO B
PA-3-130	1012 (.66-.72)	D/CCO**
PA-3-131	1013 (.35-.75)	C/CCO*
PA-3-132	1015 (.56-.66)	D/CCO
PA-3-132A	1016 (.12-.54)	C/CCO*
PA-3-132B	1016 (.12-.54)	C/CCO B
PA-3-133	1019 (.57-.62)	D/CCO
PA-3-134	1022 (.44-.65)	C/CCO B
PA-3-135	1024 (.09-.15)	D/CCO**
PA-3-136	1028 (.12-.21)	D/CCO
PA-3-137	1032 (.20-.47)	C/CCO B
PA-3-138	1032 (.47-.56)	D/CCO
PA-3-139	1036 (.22-.29)	D/CCO**
PA-3-140	1036 (.47-.90)	C/CCO*
PA-3-141	1040 (.80-.86)	D/CCO
PA-3-142	1042 (.28-.58)	C/CCO B
PA-3-143	1044 (.07-.13)	D/CCO
PA-3-144	1048 (.47-.60)	D/CCO**
PA-3-145	1177 (.60-.66)	D/CCO**
PA-3-146	1178 (.31-.62)	C/CCO B
PA-3-147	1180 (.28-.61)	C/CCO*
PA-3-148	1181 (.15-.22)	D/CCO
PA-3-149	1185 (.25-.32)	D/CCO
PA-3-150	1188 (.36-.62)	C/CCO B
PA-3-151	1189 (.20-.28)	D/CCO**
PA-3-152	1193 (.81-.89)	D/CCO
PA-3-153	1197 (.52-.58)	D/CCO
PA-3-154	1198 (.29-.71)	C/CCO B
PA-3-155	1201 (.14-.22)	D/CCO**
PA-3-156	1203 (.34-.74)	C/CCO
PA-3-157	1205 (.45-.53)	D/CCO
PA-3-158	1208 (.31-.58)	C/CCO B
PA-3-159	1210 (.29-.37)	D/CCO
PA-3-160	1214 (.65-.72)	D/CCO**
PA-3-161	1217 (.15-.19)	D/CCO
PA-3-162	1218 (.49-.77)	C/CCO B
PA-3-163	1220 (.13-.54)	C/CCO*
PA-3-164	1221 (.16-.21)	D/CCO
PA-3-165	1225 (.30-.37)	D/CCO**

TABLE 42 (Continued)

Samples from the PA-3 Well,
Erie County, Pennsylvania

Mound Sample No.	Depth (ft)	Sample Identification
PA-3-166	1228 (.61-.87)	C/CCO B
PA-3-167	1229 (.28-.35)	D/CCO
PA-3-168	1233 (.66-.72)	D/CCO
PA-3-169	1237 (.55-.61)	D/CCO**
PA-3-170	1238 (.34-.67)	C/CCO B
PA-3-171	1241 (.67-.73)	D/CCO
PA-3-172	1245 (.30-.37)	D/CCO
PA-3-173	1245 (.37-.76)	C/CCO*
PA-3-174	1246 (.88-.96)	D/CCO**
PA-3-175	1248 (.28-.34)	D/CCO**
PA-3-176	1248 (.34-.91)	C/CCO B
PA-3-177	1253 (.56-.63)	D/CCO
PA-3-178	1259 (.26-.33)	D/CCO
PA-3-179	1264 (.67-.77)	D/CCO**
PA-3-180	1272 (.29-.35)	D/CCO

C	Canned Sample
D	Bagged, Dry Sample
PCO	Pressure Core
CCO	Conventional Core (B+Battelle Sample)
CT	Cuttings
*	Sample for Methane Desorption
**	Presently being analyzed for TOC at Mound

TABLE 43

The Stratigraphic Invervals of the PA-3 Well Erie County, Pennsylvania. [Depths are from log datum which is KB (578 ft).]

Stratigraphic Units	Depth
Perrysburg Fm	
(Base of) Dunkirk	-638
West Falls Fm.	
Hanover	638-723
Pipe Creek	723-758
West Falls Fm.	
Angola	758-950
Rhinestreet	950-1038
Tully Ls.	1038-1114
Hamilton Grp.	
Mahantango Fm.	1114-1231
Marcellus	1231-1250
Onondaga Ls.	1250-

2. Lithological Descriptions

The lithological descriptions were completed for eight PA-3 well samples. These samples were medium dark gray to brownish black, non-to-slightly calcareous, tabular, moderately hard, 100% shales. These descriptions were added to the similar PA-3 results previously reported.[2] The eight samples are indicated by '*' values in Table 44.

3. Organic Carbon Content Values

The total organic carbon content (TOC) was determined for 42 samples from the PA-3 well. These results ('*' values) were combined with previously reported TOC data (Table 45) . The average TOC of the new data set is 2.22 wt %. PA-3-170 was the most organically rich sample of the new data. This sample occurs at a depth of 1238 ft in the Marcellus facies of the Hamilton Group. The combined TOC data is plotted versus depth in Figure 9.

4. Pyrolysis-Gas Chromatographic Analysis

Thirty-five (35) samples from the PA-3 well were analyzed by this technique (Table 46). The average values for total hydrocarbon content, volatile hydrocarbon content, and Peak II maximum temperature were 1.00 wt %, 1625 ppm, and 458°C. The Peak I/Peak II value was 0.19. These average values were compared to similar previously reported data (Table 17). The PA-3 results indicate a high total hydrocarbon potential, thermally immature source rock.

5. Kerogen Elemental Analysis

The kerogen elemental composition was determined for 29 samples from the PA-3 well (Table 47).

These samples had average atomic H/C and O/C values of 1.25 and 0.66, respectively. It should be noted that the ash content of these samples was relatively high. For samples with an ash content of approximately 40 wt % or greater, the C, H, N analytical results can be unreliable. The average ash content of these samples was approximately 35 wt % and was as high as 78 wt % for sample PA-3-173. The H/C and O/C values for the individual samples were not plotted because of the considerable scatter in the O/C data. It is probable that this scatter is a result of the high ash contents.

A survey of the H/C results indicates that the kerogen from these samples is relatively hydrogen rich. This suggests that, in general, the kerogen was sourced from intermediate (herbaceous) and/or marine (algal-amorphous) type organic debris.

TABLE 44

Gross Lithological Description for PA-3 Well

(*Data added to previous quarterly.)

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-009 *	382'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium dark gray.	N4
PA-3-013	386'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-014	387'	100% Shale, noncalcareous, slightly anhydritic, slightly micromicaceous, moderately hard, tabular, dark olive gray.	5Y3/1
PA-3-016	394'	100% Shale, noncalcareous, slightly micromicaceous, slightly carbonaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-017	397'	100% Shale, noncalcareous, very slightly anhydritic, slightly micromicaceous, few Tasmanites visible, moderately hard, tabular, olive black.	5Y4/1
PA-3-018	398'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-021	407'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium dark gray.	N4
PA-3-022	407'	100% Shale, noncalcareous, slightly anhydritic, very slightly micromicaceous, tabular, moderately hard, medium dark gray.	N4
PA-3-023	411'	100% Shale, noncalcareous, slightly anhydritic, tabular, moderately hard, olive black.	5Y2/1
PA-3-025	417'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium dark gray to dark gray.	N4 to N3
PA-3-026	419'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-028	423'	100% Shale, noncalcareous, slightly micromicaceous, very slightly anhydritic, very slightly carbonaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-029	541'	100% Shale, noncalcareous, slightly anhydritic, very slightly carbonaceous, Tasmanites visible, tabular, moderately hard, medium gray.	N4
PA-3-030	542'	100% Shale, noncalcareous, slightly anhydritic, many Tasmanites visible, moderately hard, tabular, brownish black.	5YR2/1
PA-3-031*	545'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-033	550'	100% Shale, noncalcareous, slightly anhydritic, very slightly carbonaceous, Tasmanites visible, tabular, moderately hard, medium gray.	N4
PA-3-034	552'	100% Shale, noncalcareous, slightly anhydritic, abundant Tasmanites visible, moderately hard, tabular, brownish black.	5YR2/1
PA-3-035	554'	100% Shale, noncalcareous, slightly anhydritic, very slightly carbonaceous, Tasmanites visible, tabular, moderately hard, medium gray.	N4
PA-3-037	563'	100% Shale, noncalcareous, slightly anhydritic, massive, moderately hard, medium gray.	N5
PA-3-038	565'	100% Shale, noncalcareous, slightly anhydritic, very slightly micromicaceous, tabular, moderately hard, medium dark gray.	N4

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-041	572'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium gray.	N5
PA-3-042	574'	100% Shale, noncalcareous, very slightly anhydritic, very slightly carbonaceous, very slightly micromicaceous, tabular, moderately hard, medium gray.	N4
PA-3-043	579'	100% Shale, noncalcareous, slightly anhydritic, very slightly micromicaceous, tabular, moderately hard, medium gray.	N4
PA-3-045	582'	100% Shale, very slightly calcareous, anhydritic, moderately hard, tabular, medium gray.	N5
PA-3-046	584'	100% Shale, noncalcareous, slightly micromicaceous, tabular, moderately hard, olive black.	5Y2/1
PA-3-047	588'	100% Shale, noncalcareous, anhydritic, very slightly micromicaceous, tabular, moderately hard, medium dark gray.	N4
PA-3-048	592'	100% Shale, noncalcareous, slightly anhydritic, abundant Tasmanites visible, moderately hard, tabular, olive black.	5Y2/1
PA-3-050	596'	100% Shale, noncalcareous, slightly micromicaceous, tabular, moderately hard, olive black.	5Y2/1
PA-3-051	600'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-053	602'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium gray.	N5

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-055	608'	100% Shale, noncalcareous, slightly anhydritic, extreme abundance of visible Tasmanites, tabular, moderately hard, brownish gray.	5YR4/1
PA-3-056	611'	100% Shale, noncalcareous, slightly anhydritic, tabular, moderately hard, brownish gray.	5YR4/1
PA-3-057	612'	100% Shale, noncalcareous, slightly anhydritic, very slightly micromicaceous, few Tasmanites visible, moderately hard, tabular, dark brownish gray.	5YR3/1
PA-3-060	620'	100% Shale, noncalcareous, slightly micromicaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-062	622'	100% Shale, noncalcareous, slightly micromicaceous, very slightly anhydritic, moderately hard, tabular, brownish black.	5YR2/1
PA-3-063	625'	100% Shale, noncalcareous, slightly micromicaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-064*	627'	100% Shale, noncalcareous, very slightly micromicaceous, tabular, moderately hard, dark brownish gray.	5YR3/1
PA-3-065	629'	100% Shale, noncalcareous, slightly micromicaceous, very slightly anhydritic, tabular, moderately hard, medium dark gray.	N4
PA-3-066	633'	100% Shale, noncalcareous, slightly micromicaceous, moderately hard, tabular, brownish black.	5YR2/1
PA-3-068	637'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium to medium dark gray.	N5 to N4

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-069	641'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium to medium dark gray.	N5 to N4
PA-3-070	642'	100% Shale, very slightly calcareous, anhydritic, moderately hard, tabular, medium gray.	N5
PA-3-072	648'	100% Shale, slightly calcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-073	652'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium gray.	N5
PA-3-074	653'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-077	660'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-078	720'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-079	722'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-081	728'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-082	732'	100% Shale, noncalcareous, very slightly anhydritic, moderately hard, tabular, brownish black.	5YR2/1
PA-3-083	732'	100% Shale, noncalcareous, slightly anhydritic, tabular, moderately hard, brownish black.	5YR2/1

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-086	740'	100% Shale, very slightly calcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-087	742'	100% Shale, very slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-088	744'	100% Shale, very slightly calcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-090	752'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-091	752'	100% Shale, noncalcareous, carbonaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-092*		100% Shale, noncalcareous, slightly micromicaceous, very slightly carbonaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-093	756'	100% Shale, slightly calcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-095	930'	100% Shale, slightly calcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-096	932'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-098	940'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-100	942'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-101	944'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N4

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-103	952'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-104	952'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-105	956'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-106*	958'	100% Shale, noncalcareous, slightly micromicaceous, tabular, moderately hard, medium dark gray.	N4
PA-3-108	962'	100% Shale, noncalcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-109	964'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-110	968'	100% Shale, noncalcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-112	970'	100% Shale, slightly calcareous, anhydritic, tabular, moderately hard, medium gray.	N5
PA-3-114	972'	100% Shale, noncalcareous, slightly anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-115	974'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-117	982'	100% Shale, noncalcareous, slightly carbonaceous, moderately hard, tabular, brownish black.	5YR2/1

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-118	982'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-119	986'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-121	992'	100% Shale, noncalcareous, slightly carbonaceous, moderately hard, tabular, brownish black.	5YR2/1
PA-3-122	994'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-124	998'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-126	1002'	100% Shale, noncalcareous, slightly carbonaceous, Tasmanites visible, moderately hard, tabular, brownish black.	5YR2/1
PA-3-127	1006'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, abundant visible Tasmanites, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-128	1009'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, abundant visible Tasmanites, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-129	1012'	100% Shale, noncalcareous, slightly anhydritic, very slightly carbonaceous, moderately hard, tabular, dark brownish gray.	5Y3/1

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-131*	1013'	100% Shale, noncalcareous, very slightly carbonaceous, tabular, moderately hard, brownish black.	5YR2/1
PA-3-132	1015'	100% Shale, noncalcareous, slightly carbonaceous, very slightly micromicaceous, abundant visible Tasmanites, tabular to massive, moderately hard, brownish black.	5YR2/1
PA-3-132B	1016'	100% Shale, noncalcareous, very slightly anhydritic, very slightly carbonaceous, moderately hard, tabular, brownish black.	5YR2/1
PA-3-133	1019'	100% Shale, noncalcareous, very slightly micromicaceous, very slightly carbonaceous, tabular, moderately hard, medium gray.	N4
PA-3-136	1028'	100% Shale, noncalcareous, slightly anhydritic, very slightly micromicaceous, tabular, moderately hard, brownish gray.	5YR2/1
PA-3-137	1032'	100% Shale, noncalcareous, slightly anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-138	1032'	100% Shale, noncalcareous, slightly anhydritic, very slightly micromicaceous, tabular, moderately hard, brownish gray.	5YR4/1
PA-3-141	1040'	100% Shale, calcareous, slightly anhydritic, tabular, moderately hard, brownish black.	5YR2/1
PA-3-142	1042'	100% Micrite, slightly argillaceous, hard, massive, brownish gray.	5YR4/1
PA-3-143	1044'	100% Micrite, slightly argillaceous, massive, hard, brownish gray.	5YR4/1

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-146	1178'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-147 *	1180'	100% Shale, slightly calcareous, anhydritic, tabular to massive, moderately hard, medium dark gray.	N4
PA-3-148	1181'	100% Shale, calcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-149	1185'	100% Shale, calcareous, anhydritic, tabular, moderately hard, medium gray.	N4
PA-3-150	1188'	100% Shale, very slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-152	1193'	100% Shale, slightly calcareous, anhydritic, tabular, medium hard, medium gray.	N4
PA-3-153	1197'	100% Shale, slightly calcareous, anhydritic, tabular, medium hard, medium gray.	N4
PA-3-154	1198'	100% Shale, very slightly calcareous, anhydritic, moderately hard, conchoidal, medium dark gray.	N4
PA-3-157	1205'	100% Shale, slightly calcareous, anhydritic, tabular, medium hard, medium gray.	N4
PA-3-158	1208'	100% Shale, very slightly calcareous, anhydritic, moderately hard, conchoidal to tabular, medium dark gray.	N4
PA-3-159	1210'	100% Shale, slightly calcareous, anhydritic, tabular, medium hard, medium gray.	N4
PA-3-161	1217'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4

TABLE 44 (Continued)

Gross Lithological Description
for PA-3 Well

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code
PA-3-162	1218'	100% Shale, very slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-164	1221'	100% Shale, slightly calcareous, anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-166	1228'	100% Shale, noncalcareous, slightly anhydritic, moderately hard, tabular, medium dark gray.	N4
PA-3-167	1229'	100% Shale, noncalcareous, tabular, moderately hard, tabular, dark gray.	N3
PA-3-168	1233'	100% Shale, noncalcareous, slightly carbonaceous, moderately hard, tabular, brownish black.	5YR2/1
PA-3-170	1238'	100% Shale, noncalcareous, slightly carbonaceous, moderately hard, tabular, grayish black.	N2
PA-3-171	1241'	100% Shale, noncalcareous, slightly carbonaceous, moderately hard, tabular, brownish black.	5YR2/1
PA-3-172	1245'	100% Shale, very calcareous, tabular, moderately hard, medium gray.	N4
PA-3-173*	1245'	100% Shale, slightly calcareous, anhydritic, fossiliferous, tabular, moderately hard, medium dark gray.	N4
PA-3-176	1248'	100% Biomicrite, slightly argillaceous, very hard, massive, medium gray.	N5
PA-3-177	1253'	100% Micrite, slightly argillaceous, massive, hard, medium gray.	N4
PA-3-178	1259'	100% Micrite, massive, hard, light olive gray.	5Y6/1
PA-3-180	1272	100% Biomicrite, massive, hard, very light gray.	N8

TABLE 45

Total Organic Carbon for PA-3 Well

Mound Sample Number	Total Organic Carbon, wt %
PA-3-009*	0.24/0.24
PA-3-013	1.41
PA-3-014*	2.35
PA-3-016	4.00
PA-3-017*	3.40
PA-3-018	0.40/0.39
PA-3-021*	0.25
PA-3-022	0.93/0.95
PA-3-023	1.81
PA-3-025*	0.61
PA-3-026	0.98
PA-3-028	3.05
PA-3-029	1.70
PA-3-030*	1.97
PA-3-031*	2.15
PA-3-033	2.90
PA-3-034*	3.43
PA-3-035	3.94
PA-3-037	1.66
PA-3-038	2.35
PA-3-041*	0.18
PA-3-042	4.93/4.98
PA-3-043	1.39
PA-3-045*	0.22
PA-3-046	3.65
PA-3-047	2.73
PA-3-048*	2.45/2.39
PA-3-050	5.78
PA-3-051	1.18
PA-3-053*	0.12
PA-3-055	2.69
PA-3-056	2.43
PA-3-057*	1.64
PA-3-060	3.82
PA-3-062*	3.18
PA-3-063	4.83
PA-3-064*	3.11
PA-3-065	3.18
PA-3-066*	4.38
PA-3-068	1.46
PA-3-069	0.25
PA-3-070*	0.09
PA-3-072	0.14
PA-3-073*	0.56
PA-3-074	0.18

TABLE 45 (Continued)

Total Organic Carbon for PA-3 Well

Mound Sample Number	Total Organic Carbon, wt %
PA-3-077	0.13
PA-3-078	0.38
PA-3-079*	0.12
PA-3-081	0.38/0.42
PA-3-082*	4.98
PA-3-083	1.05
PA-3-086	0.18
PA-3-087*	0.26
PA-3-088	0.31
PA-3-090*	0.68
PA-3-091	4.74
PA-3-092*	6.98
PA-3-093	0.26
PA-3-095	0.41
PA-3-096*	0.19/0.24
PA-3-098	0.37
PA-3-100*	0.29
PA-3-101	0.42
PA-3-103	0.71
PA-3-104*	0.66
PA-3-105	0.29
PA-3-106*	3.62
PA-3-108*	0.18
PA-3-109	0.27/0.32
PA-3-110	0.31
PA-3-112	0.46
PA-3-114*	1.06
PA-3-115	4.84
PA-3-117*	4.26
PA-3-118	4.59
PA-3-119	6.25
PA-3-121*	4.24
PA-3-122	4.20
PA-3-124	4.98
PA-3-126*	6.09
PA-3-127	4.43
PA-3-128	3.28
PA-3-129*	2.50
PA-3-131*	5.01
PA-3-132	7.38
PA-3-132B*	5.37
PA-3-133	5.78/5.70
PA-3-136	1.70
PA-3-137*	2.03
PA-3-138	1.45

TABLE 45 (Continued)

Total Organic Carbon for PA-3 Well

Mound Sample Number	Total Organic Carbon, wt %
PA-3-141	2.85
PA-3-142*	0.12/0.14
PA-3-143	0.26
PA-3-146*	0.45
PA-3-147*	0.53
PA-3-148	0.43
PA-3-149	0.42
PA-3-150*	0.42
PA-3-152	0.43
PA-3-153	0.56
PA-3-154*	0.46
PA-3-157	0.59
PA-3-158*	0.43
PA-3-159	0.52
PA-3-161	0.66/0.66
PA-3-162*	0.66
PA-3-164	0.86
PA-3-166*	1.94
PA-3-167	2.44
PA-3-168	6.34
PA-3-170*	7.88
PA-3-171	8.66
PA-3-172	1.65
PA-3-173*	2.06
PA-3-176*	0.22
PA-3-177	0.48
PA-3-178	0.18
PA-3-180	0.07

*Data added to previous quarterly.

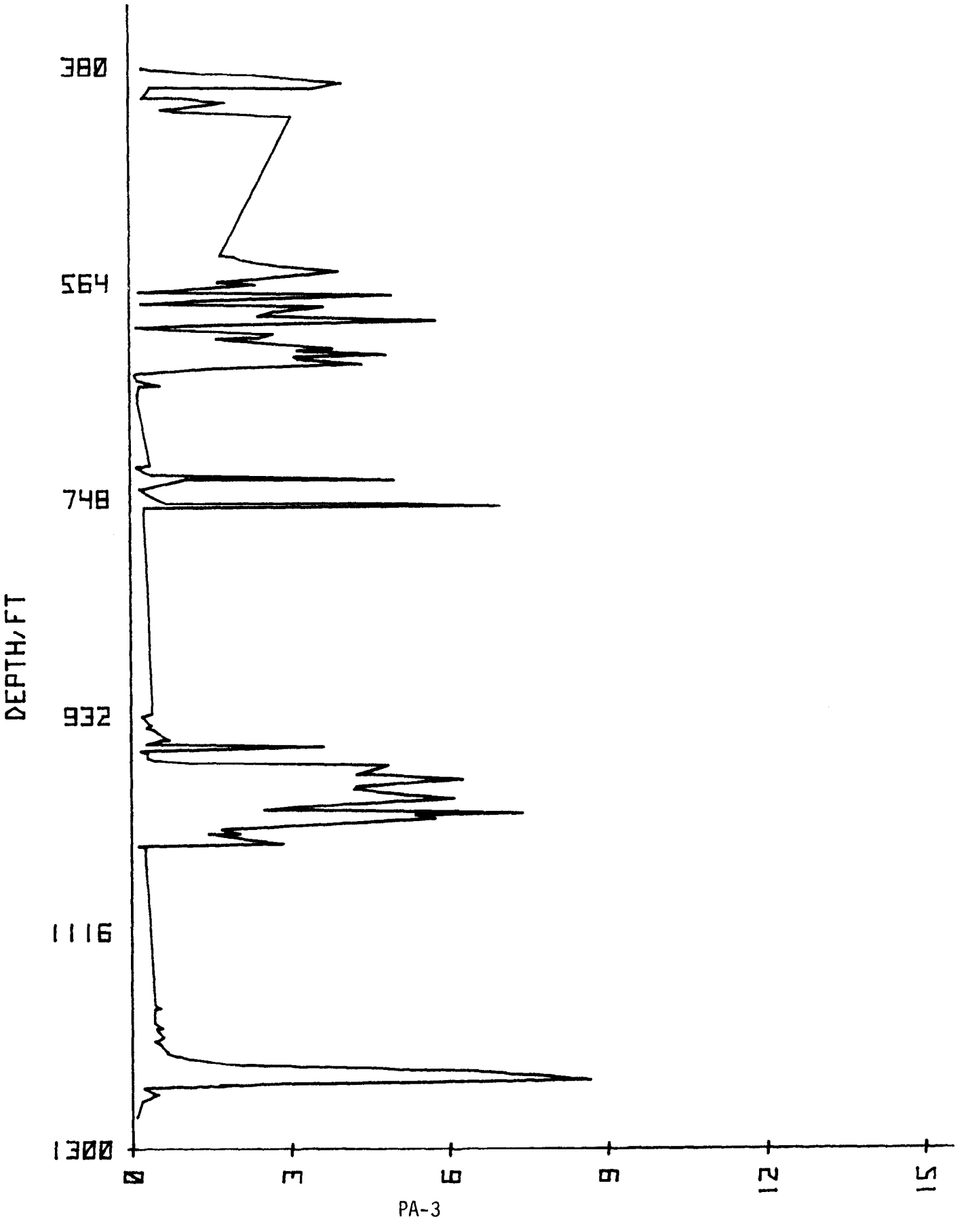

FIGURE 9
Organic carbon content versus depth for PA-3 samples.

TABLE 46
Pyrolysis - GC Analysis for PA-3 Well Samples.

Mound Sample Number	Total Hydrocarbon Yield (Wt %)	Volatile Hydrocarbon Content (ppm)	Peak II Maximum Temperature (°C)
PA-3-013	0.22	350	453
PA-3-018	0.06	145	446
PA-3-023	0.61	928	454
PA-3-028	0.96	1,471	456
PA-3-033	1.55	2,181	456
PA-3-037	0.75	1,389	467
PA-3-042	1.79	2,593	466
PA-3-046	1.28	2,684	462
PA-3-050	2.54	4,114	460
PA-3-055	1.37	1,995	464
PA-3-060	1.89	3,316	465
PA-3-065	1.46	2,551	466
PA-3-069	0.10	298	453
PA-3-074	0.12	382	454
PA-3-078	0.11	227	460
PA-3-083	1.74; 1.73	1,713; 1,958	454; 441
PA-3-088	0.15	294	449
PA-3-093	0.07	328	420
PA-3-098	0.29	694	453
PA-3-103	0.36	680	461
PA-3-109	0.15	337	454
PA-3-112	0.24	720	455
PA-3-118	2.29	3,955	454
PA-3-122	1.93	3,962	465
PA-3-127	1.97	3,502	463
PA-3-132	3.77	4,706	480
PA-3-136	0.70	1,462	470
PA-3-141	1.14	1,272	475
PA-3-148	0.07	164	469
PA-3-152	0.07	145	460
PA-3-157	0.16	278	469
PA-3-161	0.19	367	455
PA-3-167	0.97	1,882	453
PA-3-171	3.62	4,564	456
PA-3 -178	0.22; 0.21	1,212; 1,291	448; 432

TABLE 47

Kerogen Composition for the
for the PA-3 samples.

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
PA-3-009	75.24	5.12	1.22	18.42	39.88	0.82	0.18
PA-3-014	37.82	4.01	1.07	57.10	38.74	1.27	1.77
PA-3-017	48.64	4.79	0.96	45.61	29.20	1.18	0.70
PA-3-021	56.68	4.59	1.38	37.35	27.98	0.97	0.49
PA-3-030	45.20	5.32	0.37	49.11	39.68	1.41	0.81
PA-3-031	76.13	8.78	1.96	13.63	27.78	1.31	0.13
PA-3-034	36.47	4.20	0.38	58.95	43.77	1.38	1.21
PA-3-048	42.66	5.08	0.46	51.80	44.29	1.43	0.91
PA-3-057	43.16	4.71	1.69	50.44	38.73	1.31	0.88
PA-3-062	41.20	4.21	1.67	52.92	42.29	1.23	0.96
PA-3-064	83.37	9.34	1.29	6.00	24.42	1.34	0.05
PA-3-066	52.21	5.04	1.37	41.38	27.96	1.16	0.59
PA-3-073	47.14	5.50	0.78	46.58	29.45	1.40	0.74
PA-3-079	48.84	3.21	2.87	45.08	21.40	0.79	0.69
PA-3-082	50.94	5.99	1.02	42.05	26.57	1.41	0.62
PA-3-090	61.81	4.63	1.16	32.40	20.99	0.90	0.39
PA-3-092	81.51	9.15	2.29	7.05	21.65	1.35	0.06
PA-3-104	28.90	3.50	0.74	66.86	59.01	1.45	1.73
PA-3-106	83.51	10.18	1.12	5.19	24.23	1.46	0.05
PA-3-114	32.64	4.19	0.62	62.55	46.21	1.54	1.44
PA-3-117	49.55	5.03	1.03	44.39	30.40	1.22	0.67
PA-3-121	46.64	4.70	0.99	47.67	39.37	1.21	0.77
PA-3-126	48.18	4.88	1.35	45.59	28.98	1.22	0.71
PA-3-131	82.01	8.91	1.06	8.02	27.65	1.30	0.07
PA-3-132B	53.85	4.88	1.27	40.00	28.76	1.09	0.56
PA-3-137	49.24	4.91	1.17	44.68	29.96	1.20	0.68
PA-3-162	47.18	4.61	0.66	47.55	46.28	1.16	0.77
PA-3-170	59.17	6.61	1.08	33.14	32.02	1.33	0.42
PA-3-173	75.18	9.68	4.60	10.54	77.93	1.54	0.11

6. Visual Kerogen Assessment

The visual kerogen analysis of 118, PA-3 samples was completed (383 to 1272 ft) (Table 48). The TAI increased from 1+ to 2 with depth. This corresponds to a coloration change of yellow to yellow-orange to orange-brown with increasing depth. In general, the kerogen particle size ranged from finely disseminated to medium grained and was in an excellent to good state of preservation. The sample kerogen was primarily herbaceous, with the secondary kerogen type alternating between woody-coaly and algal-amorphous. Several intervals in the well contained a kerogen type where woody-coaly material was predominant (e.g., 653 to 751 ft and 1178 to 1218 ft).

III. DILATOMETRY RESULTS

Select samples from the OH-3 well were tested to determine the degree of shale expansion as a function of varying interactive fluids and confining pressures. The samples were selected from the Ohio Shale interval; one from the Chagrin member (OH-3-3 at 633 ft), and two from the Lower Huron facies (OH-3-23 at 1031 ft and OH-3-27 at 1112 ft). The organic carbon contents of samples OH-3-3, OH-3-23, and OH-3-27 were 0.27, 0.43, and 7.63 wt %, respectively.

The radial expansion of the sample was measured parallel to the bedding planes. These samples ($\sim$ 0.75 inches in length and $\sim$ 0.25 inches in diameter) were exposed to four different fluids and four different confining pressures for each fluid. The fluids were H_2O, 2% KCl, 2% KCl + H_2CO_3 and kerosene. The confining pressures were 14.7, 500, 1000, and 1500 psi.

The study results are indicated in Table 49 and Figures 10 and 23. The results are reported for each four fluids at a given confining pressure. In some cases it was necessary to plot these results on two graphs because of the range of % expansion for the different fluids.

The following contains some general observations concerning the test results: 1) the sample expansion decreased with increasing confining pressure; 2) the shale samples expanded significantly more when treated with H_2O then 2% KCl and 2% KCl plus H_2CO_3. The samples expanded the least when treated with kerosene; and 3) the samples from the Chagrin member expanded less than either of the Huron member samples. These latter samples had similar test results even though they contained significantly different total organic carbon contents.

IV. SORPTION STUDIES

Methane sorption testing is one method of determining the potential gas

TABLE 48
Kerogen Visual Assessment; Components of Kerogen
for PA-3 Well

Mound Sample Number	Predominant	Secondary	Trace
PA-3-9	H	W-C	A-A
PA-3-13	H	W-C	A-A
PA-3-14	H	W-C	A-A
PA-3-16	H	A-A	W-C
PA-3-17	H	A-A,W-C	-
PA-3-18	H	W-C	-
PA-3-21	H	W-C	-
PA-3-22	H	W-C	A-A
PA-3-23	H	W-C	A-A
PA-3-25	H	W-C	A-A
PA-3-26	H	W-C	A-A
PA-3-28	H	W-C	A-A
PA-3-29	H	A-A	W-C
PA-3-30	H	W-C,A-A	-
PA-3-31	H	A-A	W-C
PA-3-33	H	A-A	W-C
PA-3-34	H	A-A	W-C
PA-3-35	H	A-A	W-C
PA-3-37	H	A-A	W-C
PA-3-38	H	A-A	W-C
PA-3-41	H,W-C	A-A	-
PA-3-42	H	A-A	-
PA-3-43	H	A-A,W-C	-
PA-3-45	H	W-C	A-A
PA-3-46	H	W-C	A-A
PA-3-47	H	A-A	W-C
PA-3-48	H	A-A	-
PA-3-50	H	A-A	-
PA-3-51	H	W-C	A-A
PA-3-53	H	W-C	A-A
PA-3-55	H	A-A	W-C
PA-3-56	H	A-A	-
PA-3-57	H	A-A	W-C
PA-3-60	H	A-A	-
PA-3-62	H	A-A	-
PA-3-63	H	A-A	-
PA-3-64	H	A-A	W-C
PA-3-65	H	A-A	W-C
PA-3-66	H	A-A	W-C
PA-3-68	H	A-A	-
PA-3-69	H	W-C	A-A
PA-3-70	H	W-C	A-A
PA-3-72	H	W-C	A-A
PA-3-73	H	A-A	W-C
PA-3-74	H	W-C	-

TABLE 48 (Continued)
Kerogen Visual Assessment; Components of Kerogen
for PA-3 Well

Mound Sample Number	Predominant	Secondary	Trace
PA-3-77	W-C	H	-
PA-3-78	W-C	H	A-A
PA-3-79	Reworked material?		
PA-3-81	W-C	H	A-A
PA-3-82	H	A-A	W-C
PA-3-83	H	A-A,W-C	-
PA-3-86	W-C	H	-
PA-3-87	W-C	H	A-A
PA-3-88	W-C	H	A-A
PA-3-90	W-C	H	A-A
PA-3-91	H	A-A	W-C
PA-3-92	H	A-A	-
PA-3-93	H	W-C	A-A
PA-3-95	H	W-C,A-A	-
PA-3-96	H	W-C,A-A	-
PA-3-98	H	W-C	A-A
PA-3-100	H	A-A	W-C
PA-3-101	H	W-C	A-A
PA-3-103	H	A-A	W-C
PA-3-104	H	W-C	A-A
PA-3-105	H	W-C	A-A
PA-3-106	H	A-A	W-C
PA-3-108	H	W-C	A-A
PA-3-109	H,W-C	A-A	-
PA-3-110	H,W-C	A-A	-
PA-3-112	H	W-C	A-A
PA-3-114	H	W-C	A-A
PA-3-115	H	A-A	-
PA-3-117	H	A-A	-
PA-3-118	H	A-A	-
PA-3-119	H	A-A	-
PA-3-121	H	W-C	A-A
PA-3-122	H	A-A	-
PA-3-124	H	A-A	W-C
PA-3-126	H	A-A	W-C
PA-3-127	H	A-A	W-C
PA-3-128	H	A-A,W-C	-
PA-3-129	H	W-C	A-A
PA-3-131	H	A-A	W-C
PA-3-132	H	A-A,W-C	-
PA-3-132B	H	A-A	W-C
PA-3-133	H	A-A	W-C
PA-3-136	H	W-C	A-A
PA-3-137	H	W-C	A-A
PA-3-138	H	W-C	A-A

TABLE 48 (Continued)
Kerogen Visual Assessment; Components of Kerogen
for PA-3 Well

Mound Sample Number	Predominant	Secondary	Trace
PA-3-141	H	A-A	-
PA-3-142	H	A-A,W-C	-
PA-3-143	H	A-A	W-C
PA-3-146	W-C	H	A-A
PA-3-147	W-C	H	A-A
PA-3-148	W-C	H	A-A
PA-3-149	W-C	H	A-A
PA-3-150	W-C	H	A-A
PA-3-152	W-C	H	A-A
PA-3-153	W-C	H	A-A
PA-3-154	W-C	H	A-A
PA-3-157	W-C	H	A-A
PA-3-158	W-C	H	A-A
PA-3-159	H	W-C	A-A
PA-3-161	H	W-C	A-A
PA-3-162	W-C	H	A-A
PA-3-164	H	W-C,A-A	-
PA-3-166	H	A-A	W-C
PA-3-167	H	A-A	W-C
PA-3-168	H	A-A	W-C
PA-3-170	H	A-A	-
PA-3-171	H	A-A	-
PA-3-172	H	W-C	A-A
PA-3-173	H	W-C,A-A	-
PA-3-176	H	A-A	W-C
PA-3-177	H	A-A	W-C
PA-3-178	H	A-A	W-C
PA-3-180	W-C	H	-

TABLE 49
Dilatometry Results For OH-3
% Expansion Radial Direction

Fluid	Pressure (psia)	OH-3-3	OH-3-23	OH-3-27
H_2O	Atmospheric	0.0085	0.022	0.024
	500	0.0075	0.018	0.023
	1000	0.0083	0.018	0.016
	1500	0.0043	0.0082	0.014
H_2O + 2% KCl	Atmospheric	0.0023	0.0065	0.0026
	500	0.0021	0.0032	0.0028
	1000	0.0019	0.0015	0.0024
	1500	0.0005	0.0041	0.0008
H_2CO_3 + 2% KCl	Atmospheric	0.0024	0.0066	0.0022
	500	0.0019	0.0037	0.0037
	1000	0.0019	0.0031	0.0027
	1500	0.0004	0.0022	0.0006
Kerosene	Atmospheric	0.0008	0.0016	0.0005
	500	*	*	*
	1000	*	*	*
	1500	*	0.0010	*

*Sample Range 1×10^{-5} to 7×10^{-6}

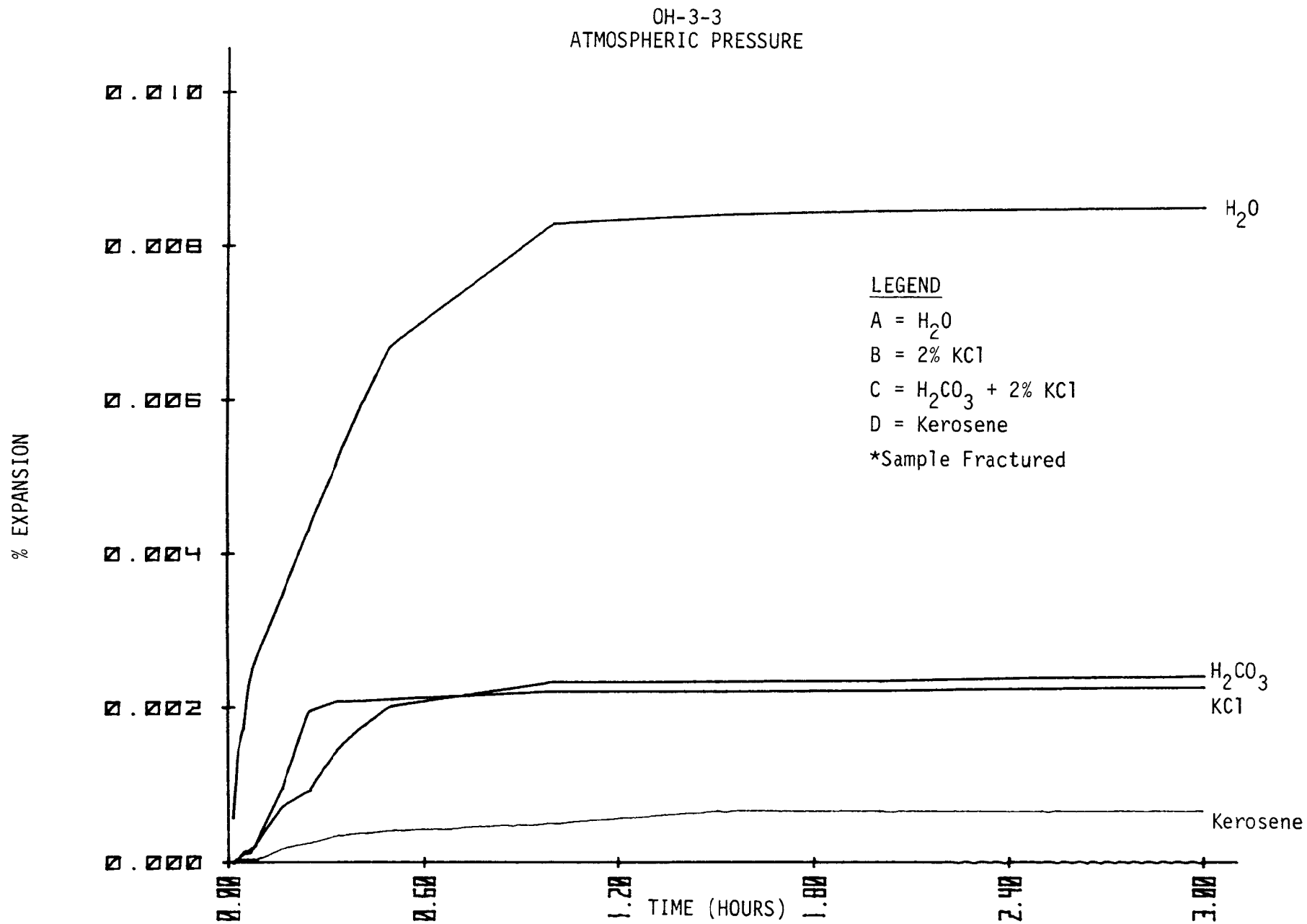

FIGURE 10
Expansion of the OH-3-3 sample at Atmospheric Pressure

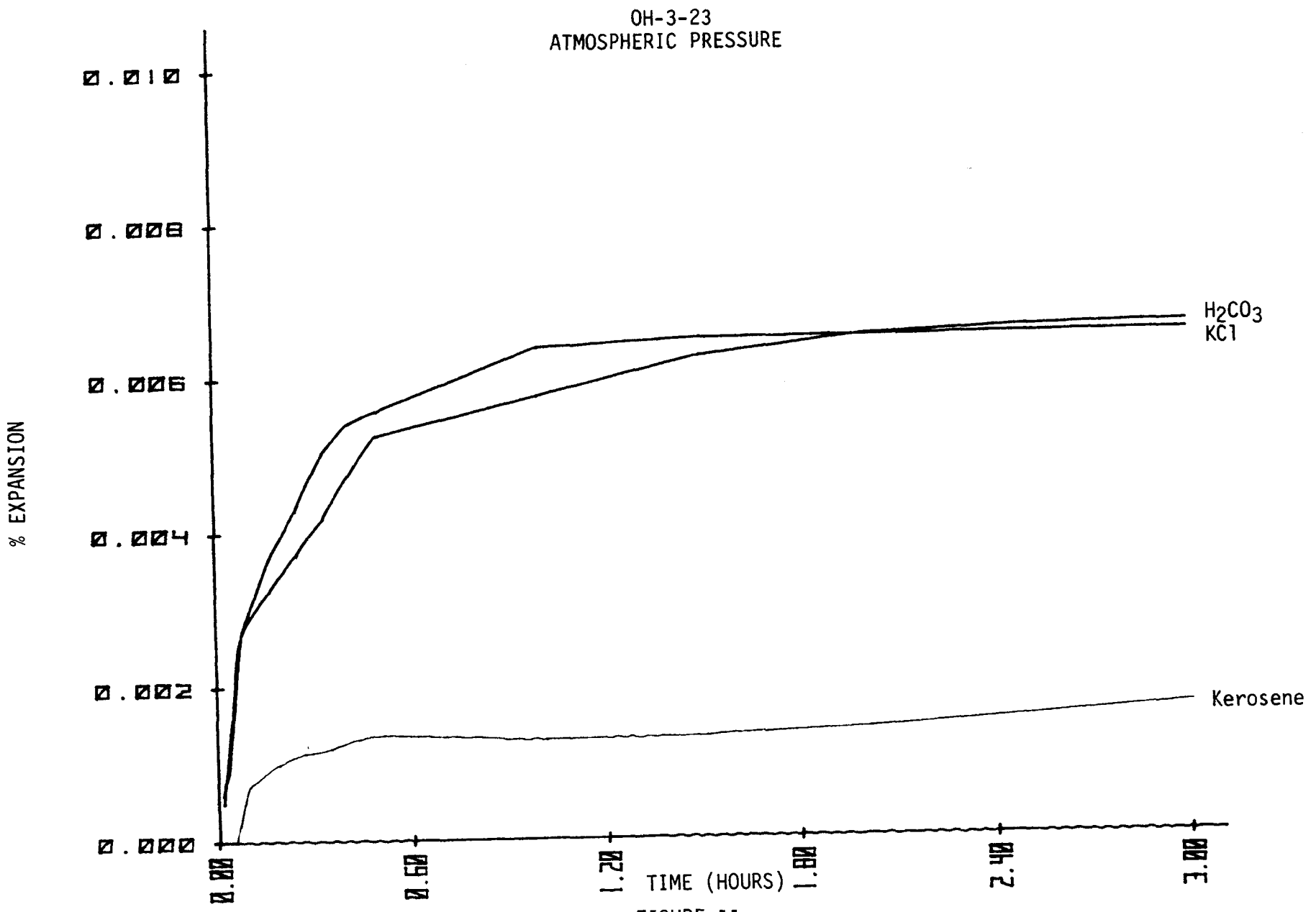

FIGURE 11
Expansion of the OH-3-23 sample at Atmospheric Pressure

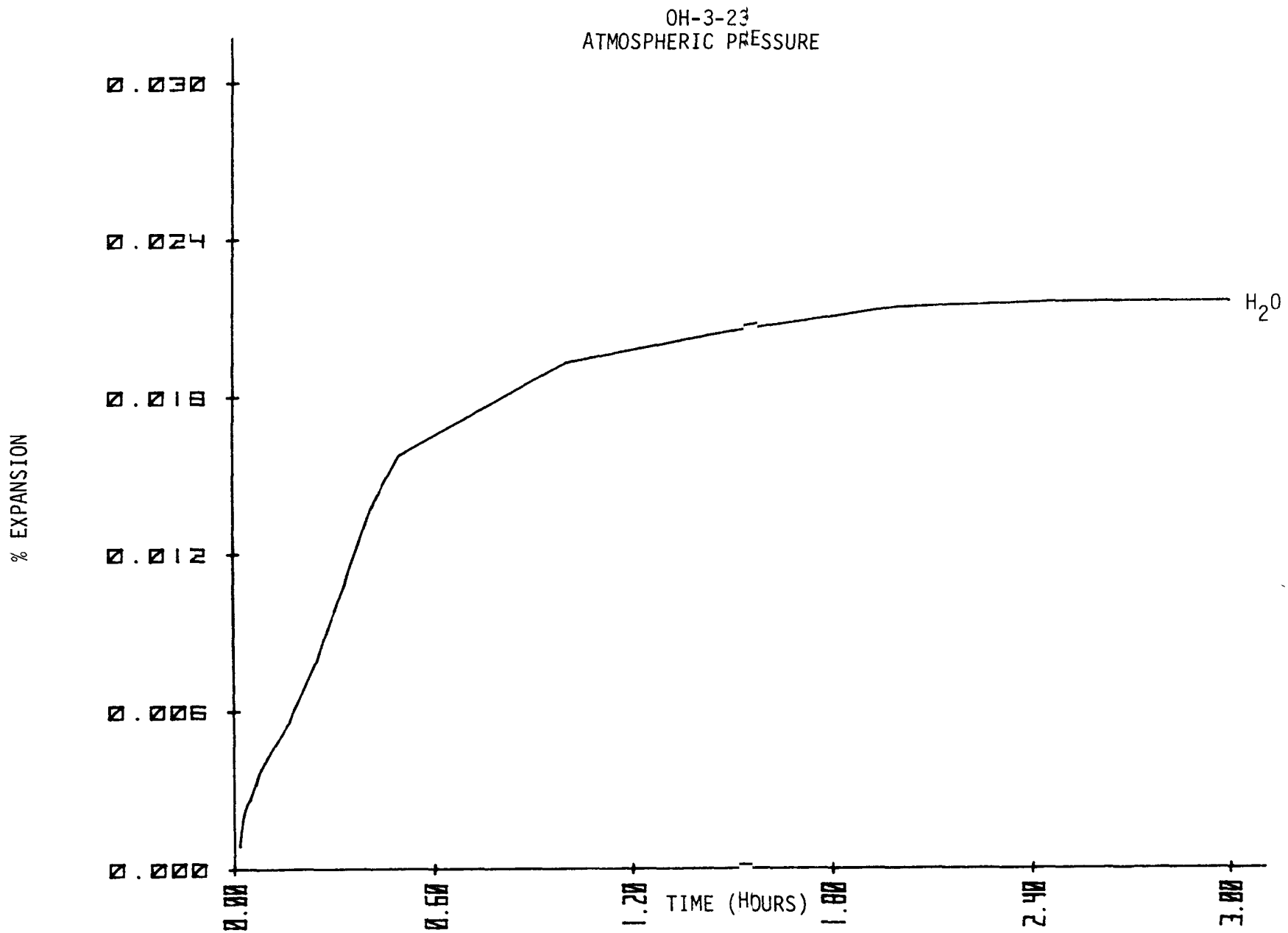

FIGURE 12
Expansion of the OH-3-23 sample at Atmospheric Pressure

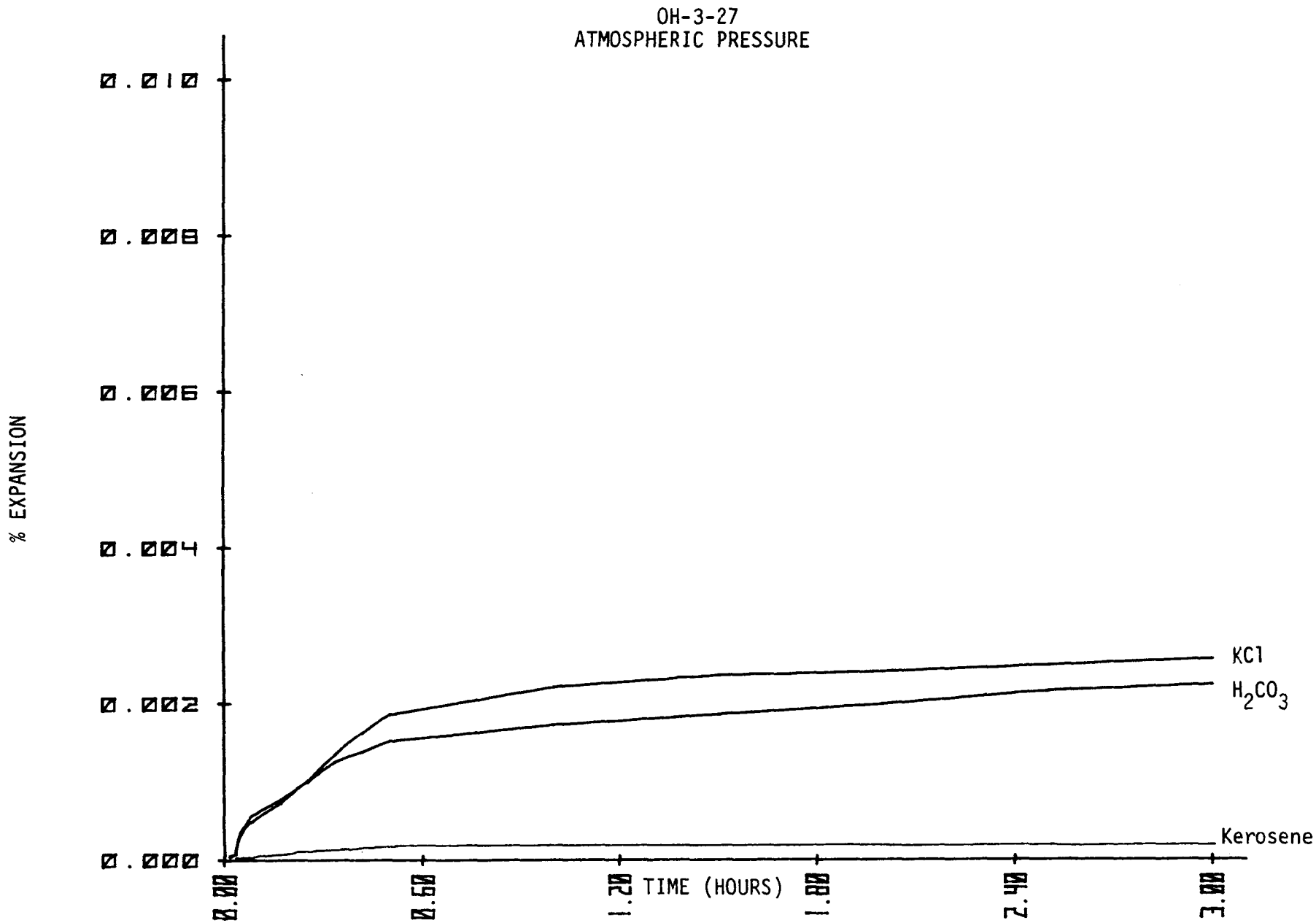

FIGURE 13

Expansion of the OH-3-27 sample at Atmospheric Pressure

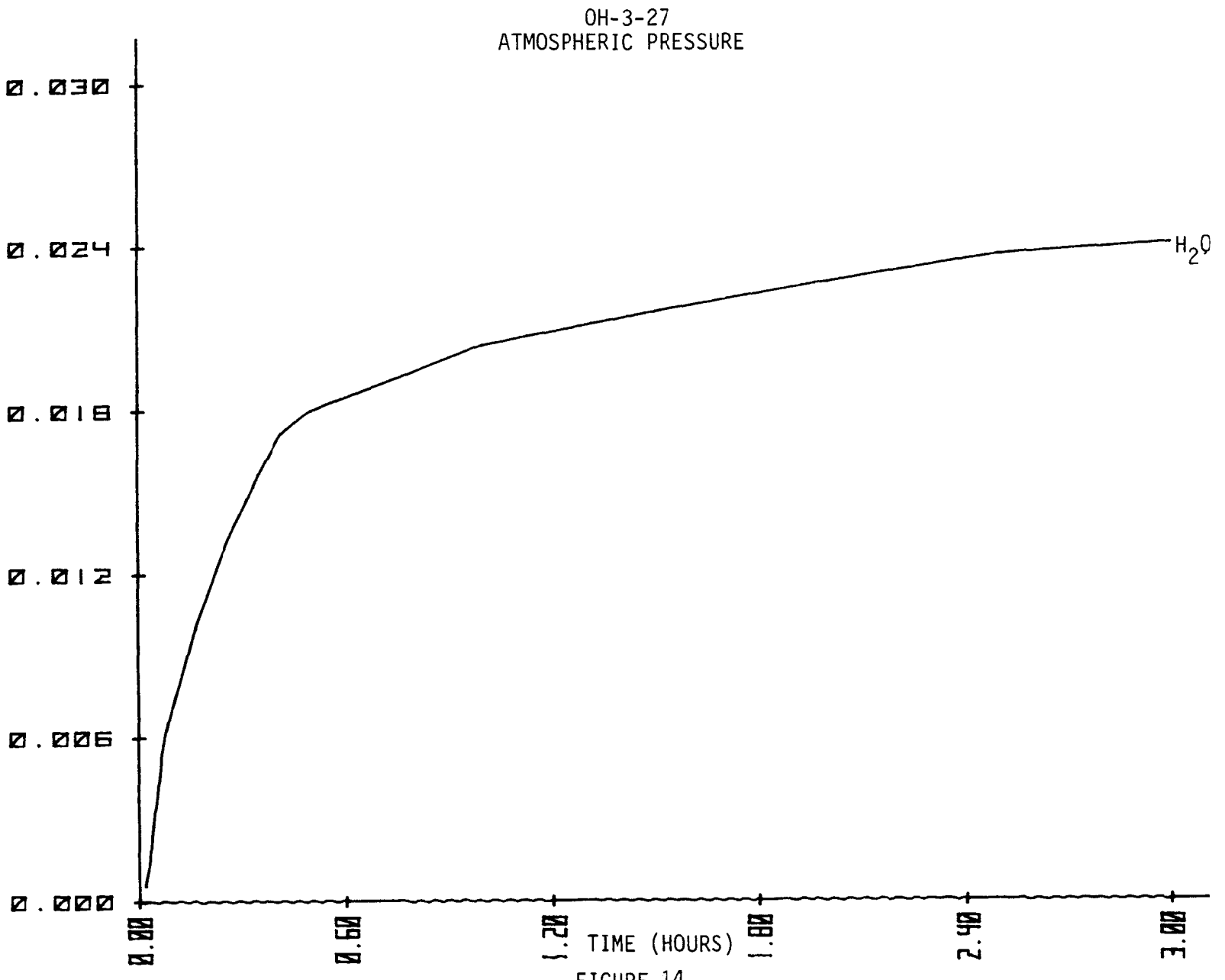

FIGURE 14
Expansion of the OH-3-27 sample at Atmospheric Pressure

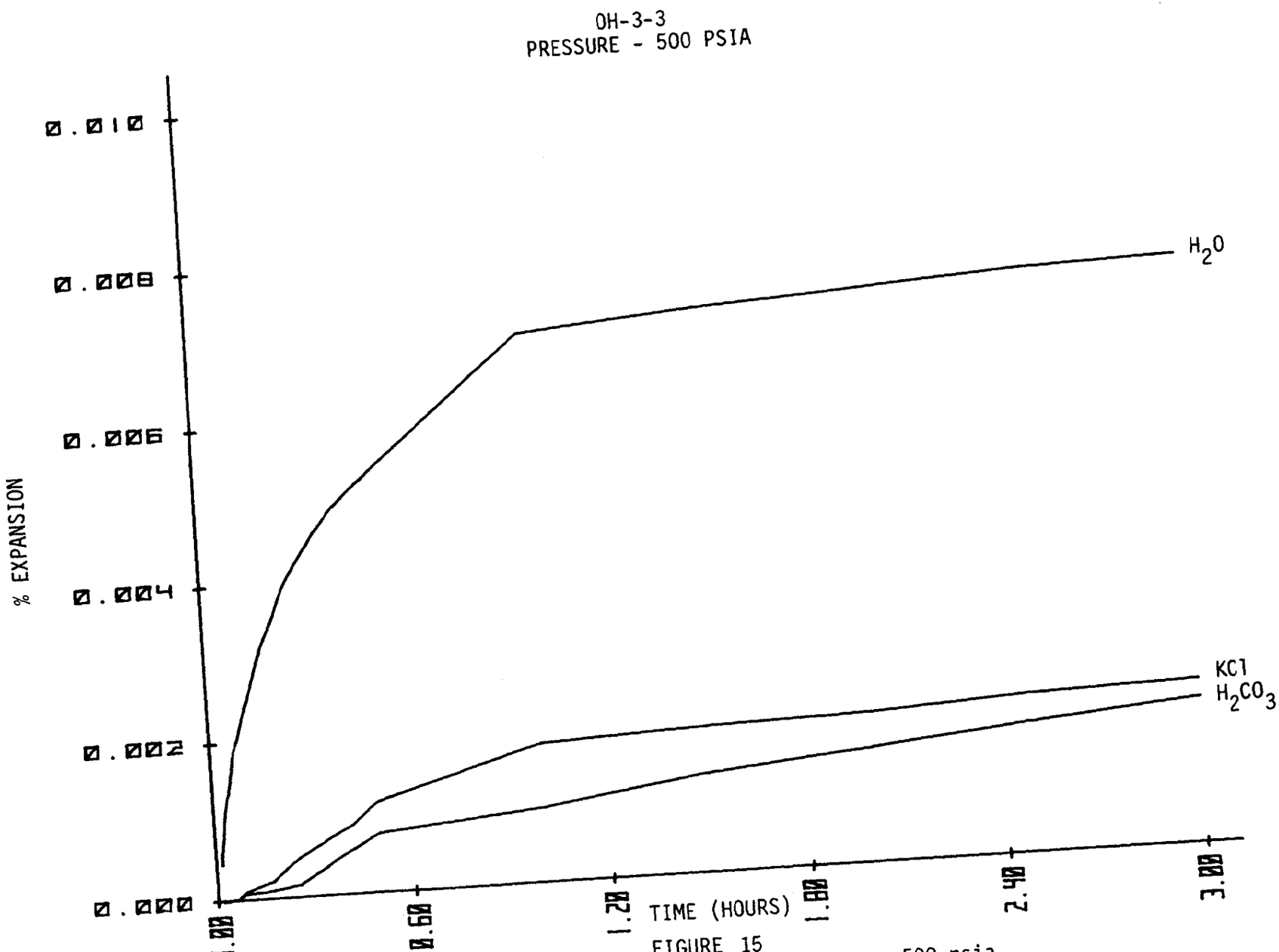

FIGURE 15
Expansion of the OH-3-3 sample at Pressure - 500 psia.

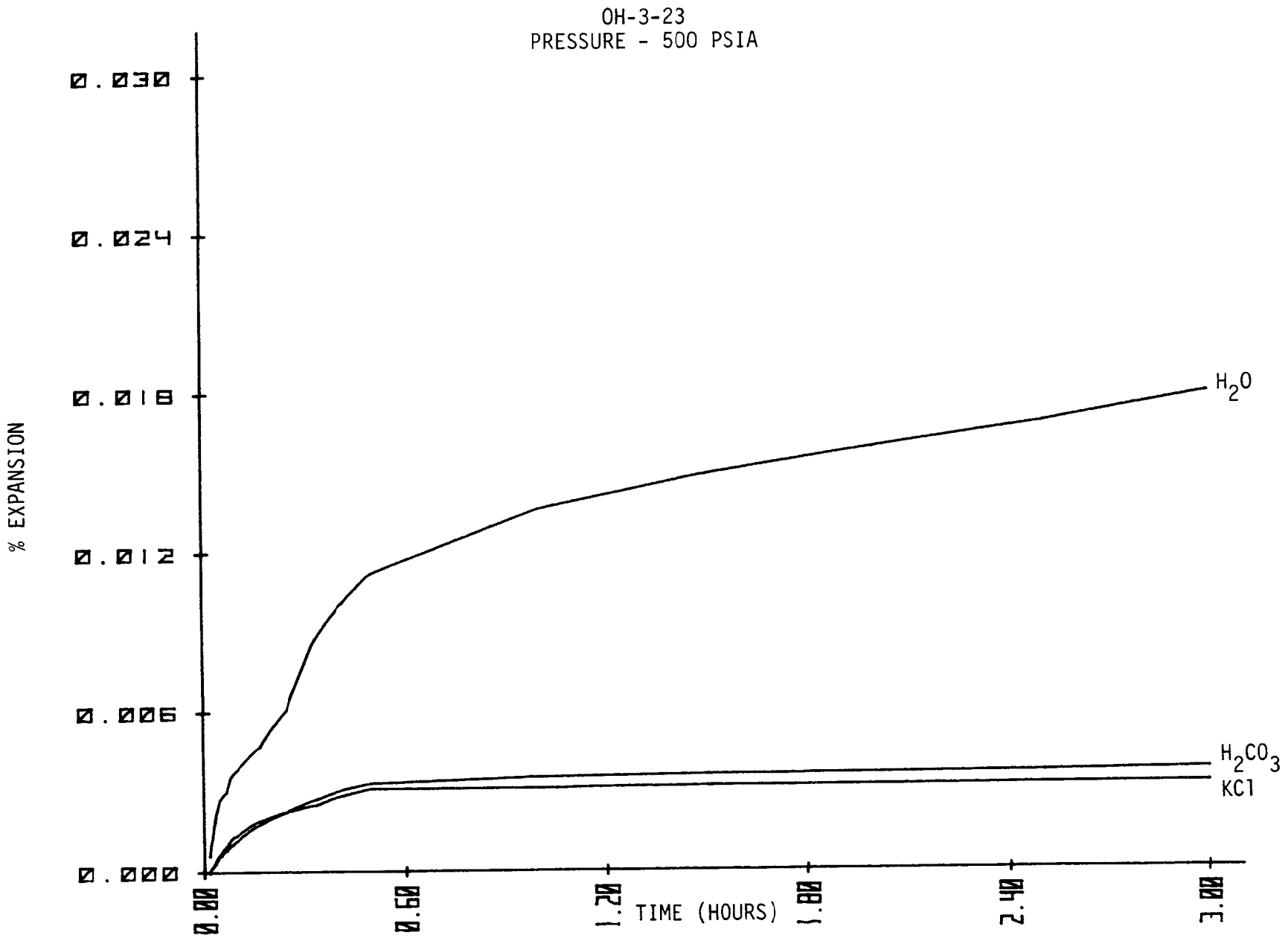

FIGURE 16

Expansion of the OH-3-23 sample at Pressure - 500 psia.

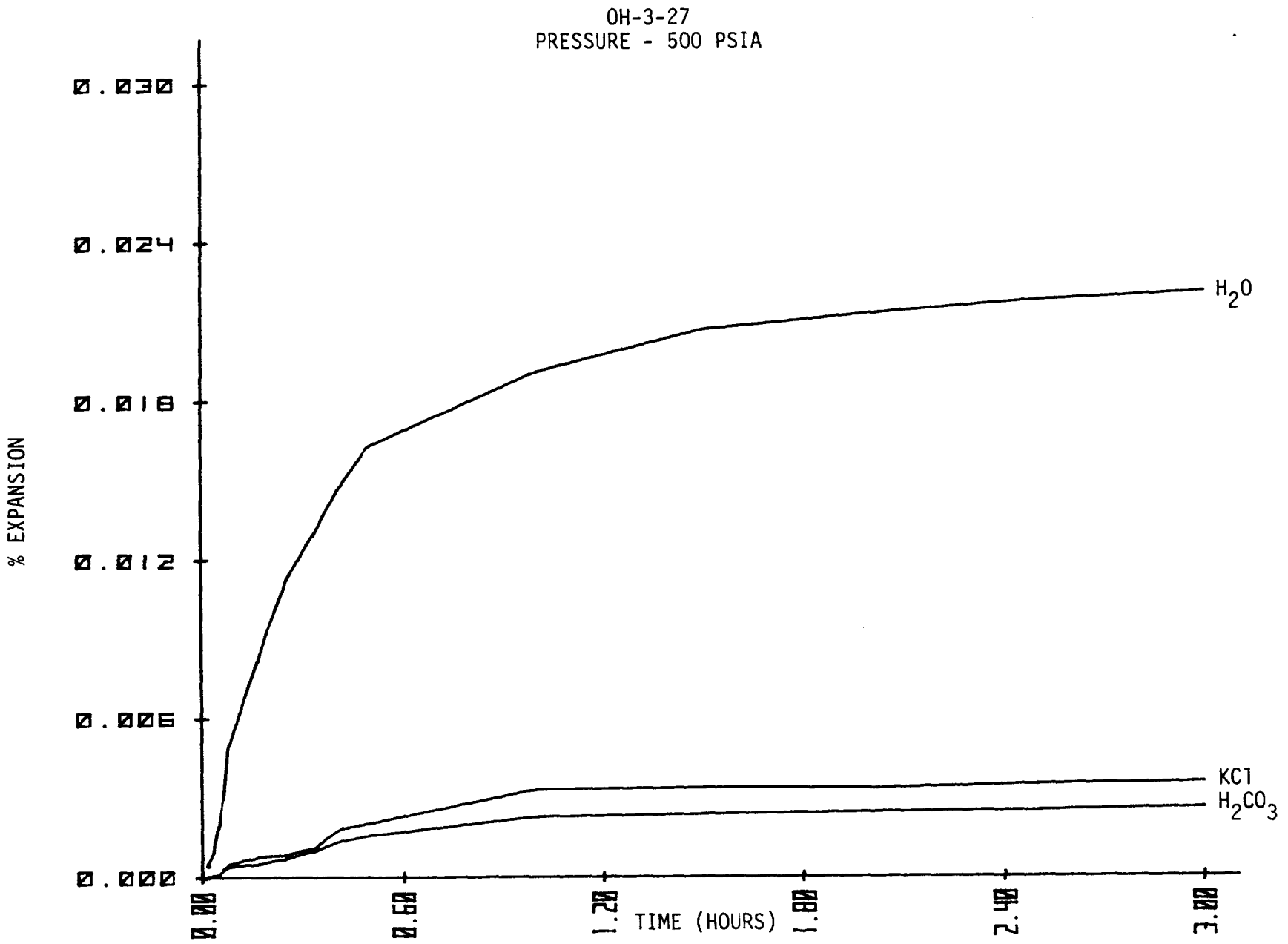

FIGURE 17
Expansion of the OH-3-27 sample at Pressure - 500 psia.

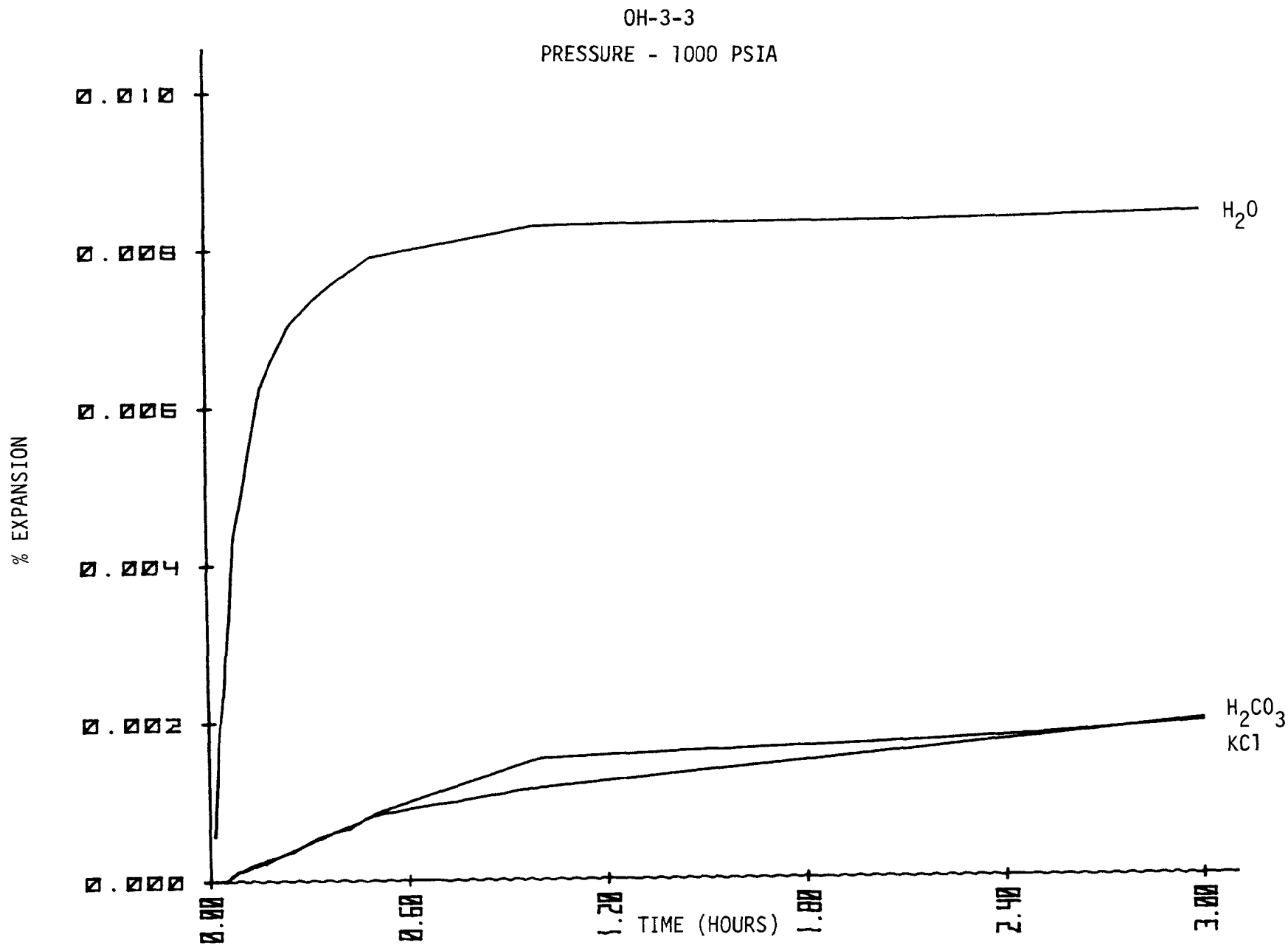

FIGURE 18
Expansion of the OH-3-3 sample at Pressure - 1000 psia.

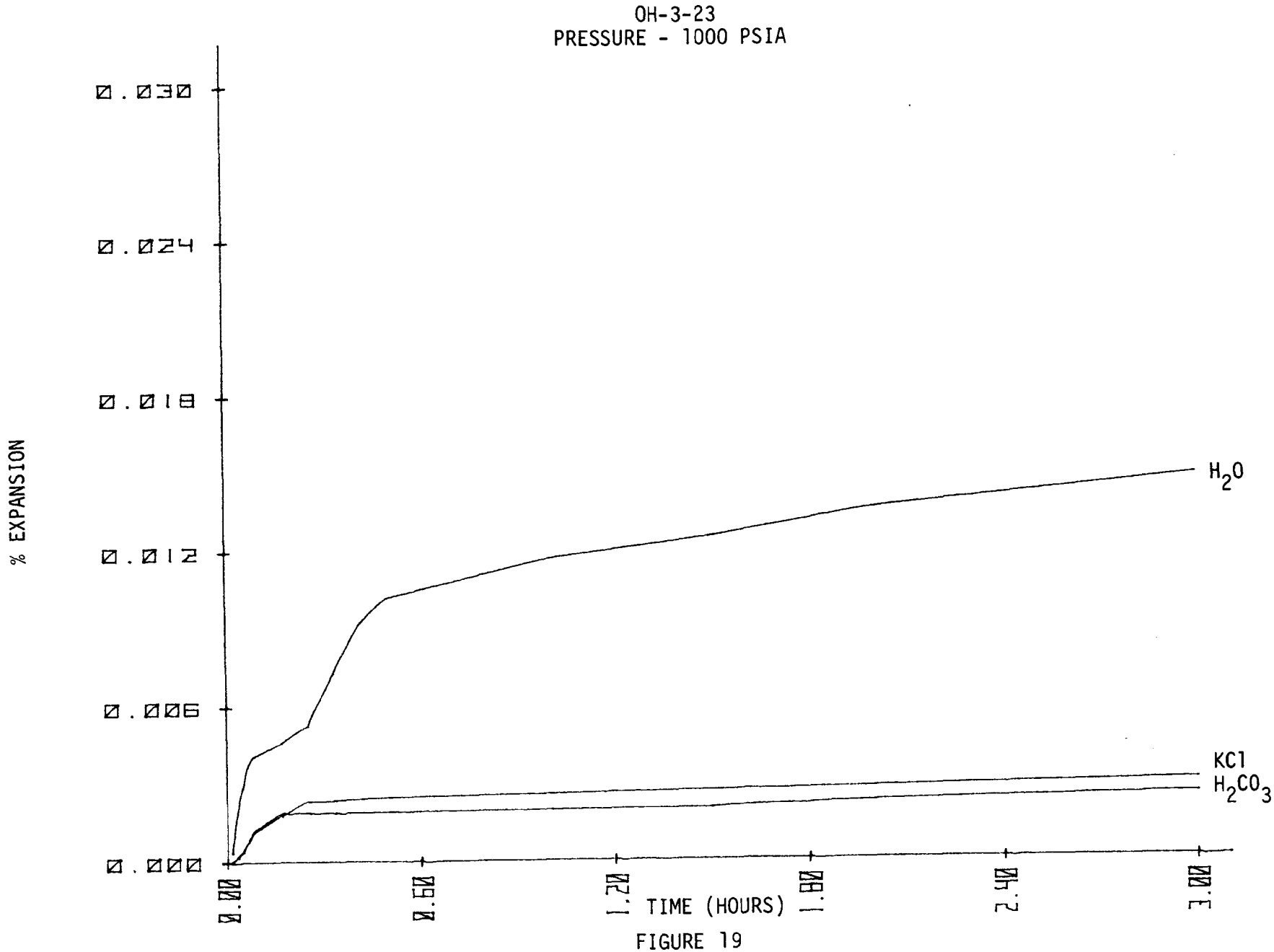

FIGURE 19
Expansion of the OH-3-23 sample at Pressure - 1000 psia.

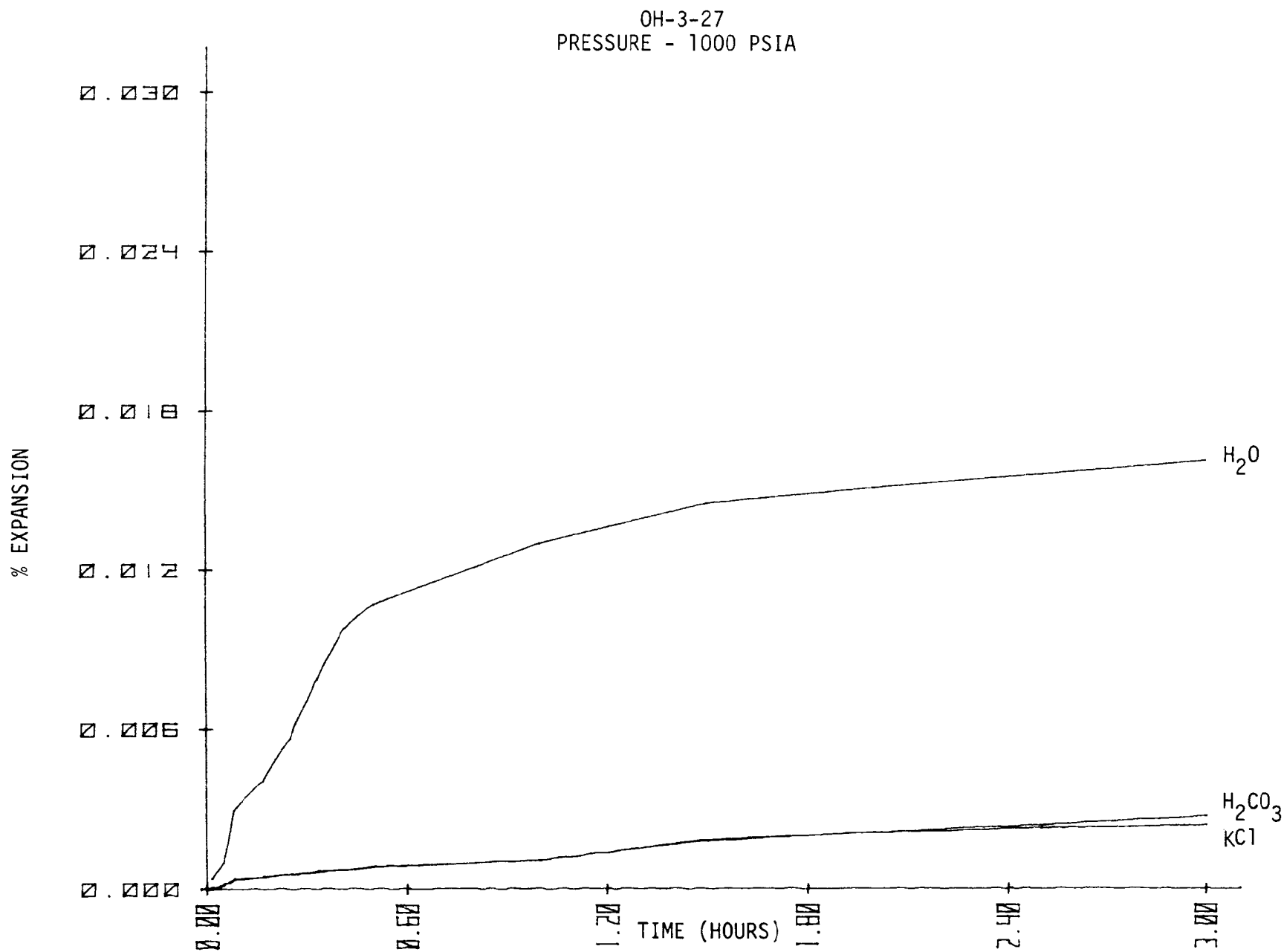

FIGURE 20
Expansion of the OH-3-27 sample at Pressure - 1000 psia.

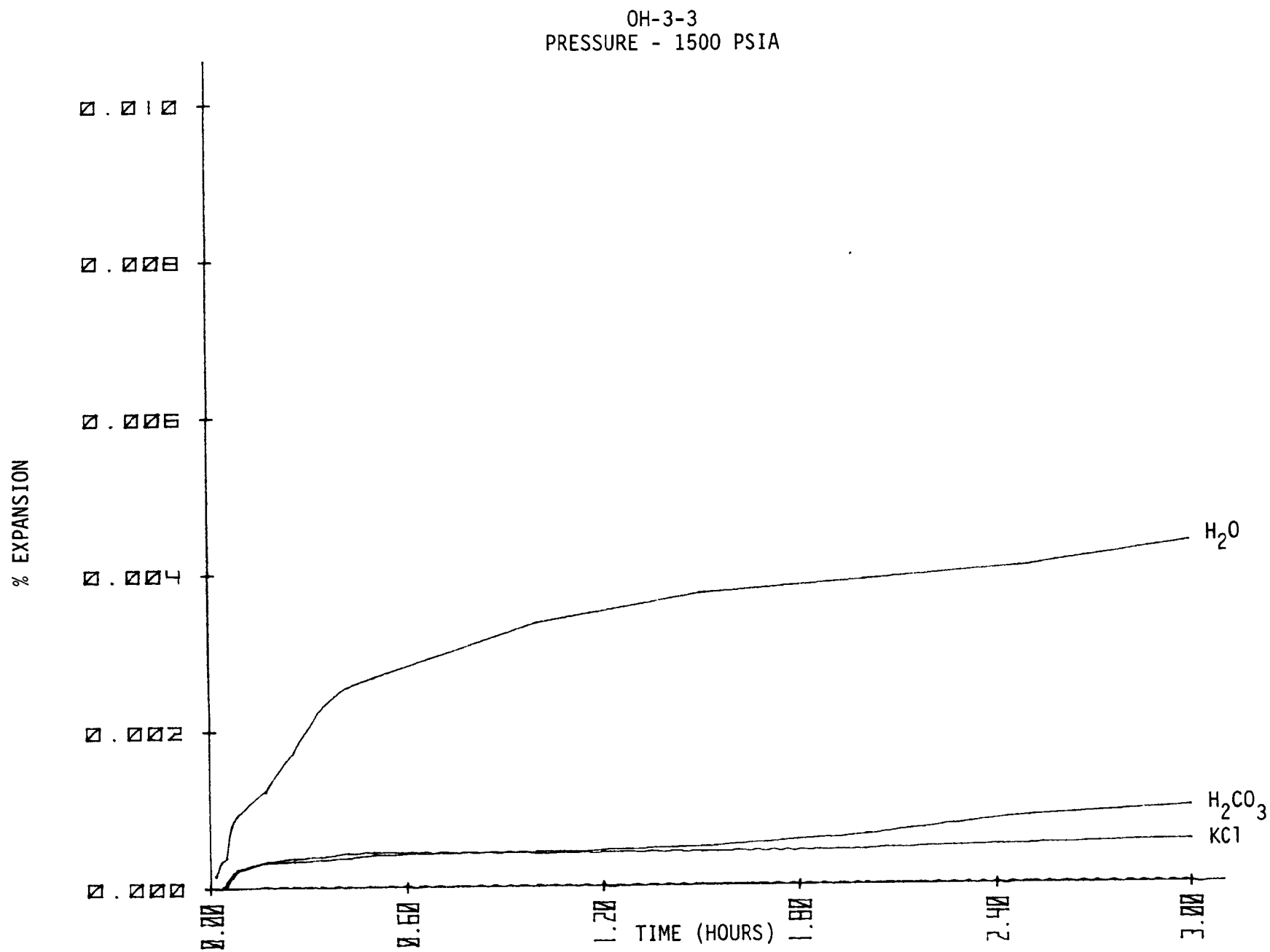

FIGURE 21

Expansion of the OH-3-3 sample at Pressure - 1500 psia.

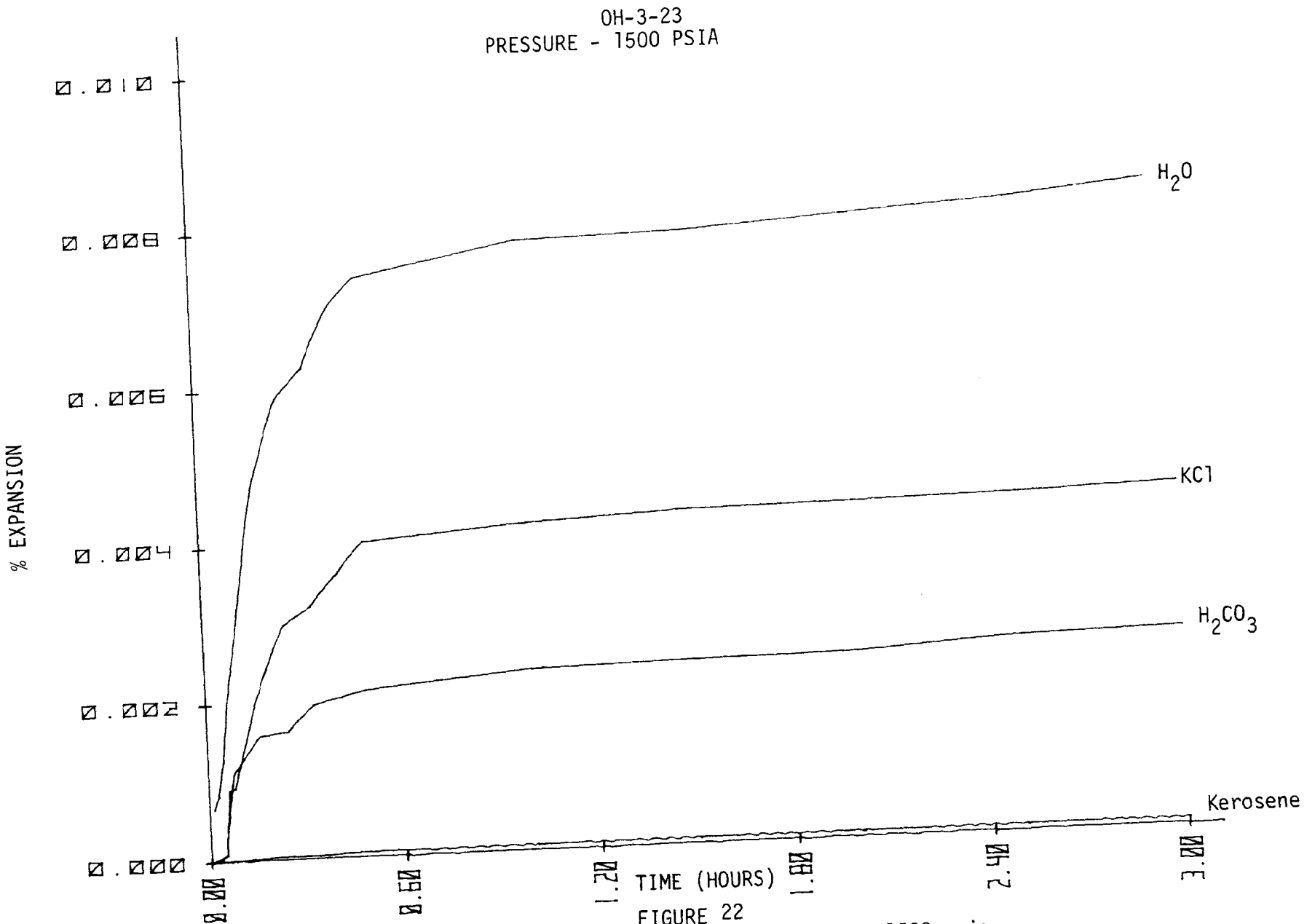

FIGURE 22
Expansion of the OH-3-23 sample at Pressure - 1500 psia.

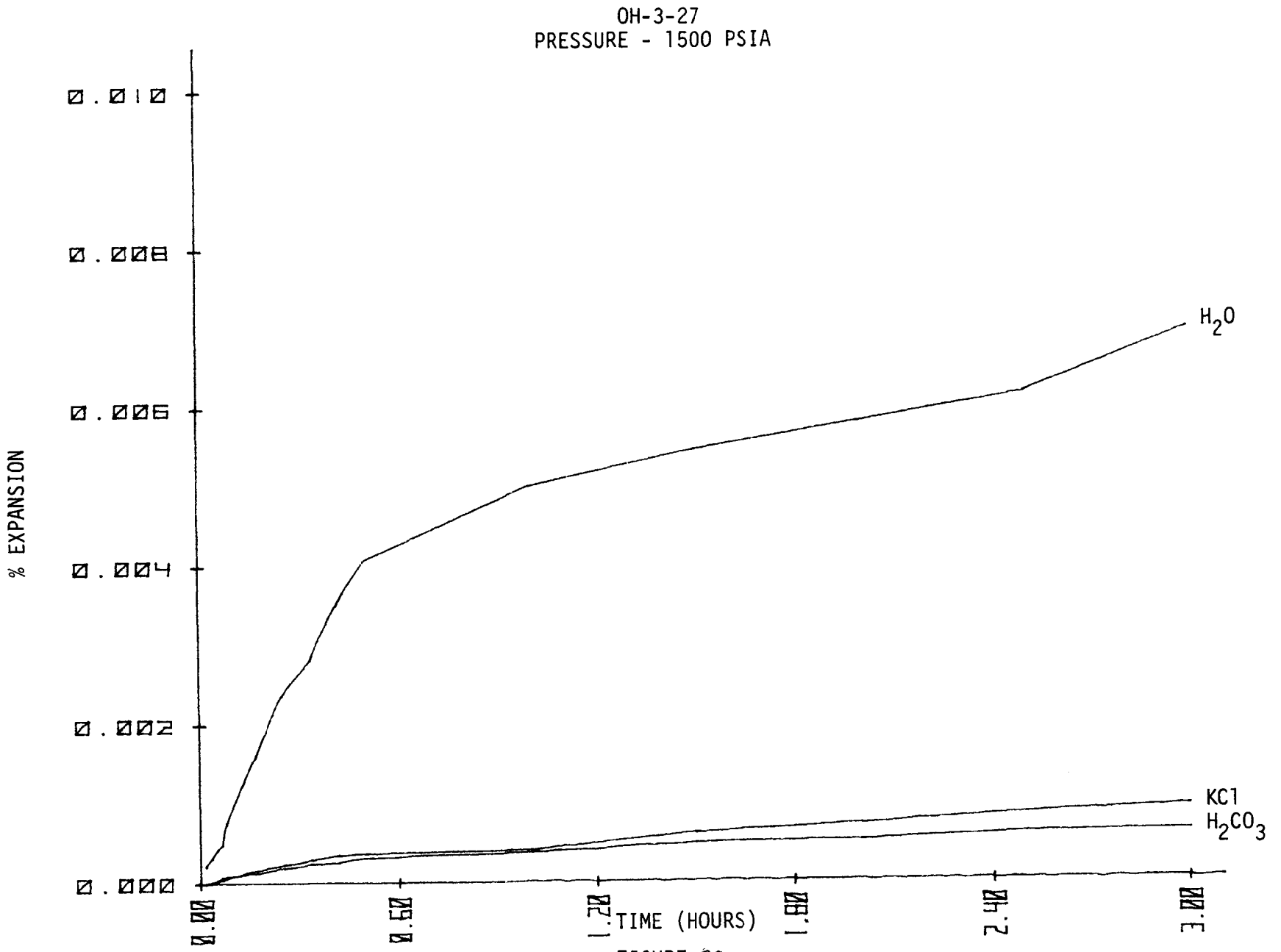

FIGURE 23
Expansion of the OH-3-27 sample at Pressure - 1500 psia.

volume and flow rate in Devonian shales. Since the voids in shale include micropores, macropores, and fractures, it is expected that gas volume and flow data will vary between individual samples from the same stratigraphic interval. The data in this report is based on sorption tests performed on samples from four (4) stratigraphic zones. The sample selections were from the upper Dunkirk, basal Dunkirk, Rhinestreet, and Marcellus intervals. The sample selection was then based on organic carbon content and density (Table 50).

The sorption testing of these samples were completed through four pressure phases. The results of the twelve hundred (1200) psia tests were published in a previous quarterly.[2] The eight hundred (800), four hundred (400), and two hundred (200) psia sample pressurization (adsorption) and the atmospheric pressure desorption results are expressed in the rate versus time plots, Figures 24, 25, and 26. Cumulative gas release totals, calculated from sample weight versus release rate and corrected to atmospheric pressure are given in Tables 51, 52, and 53. The volume of desorbed methane is summarized for each sample at the four pressures in Table 54.

The Dunkirk samples released eightly to ninety percent (80-90%) of the adsorbed gas within five hours of pressure release. The Rhinestreet and Marcellus samples adsorbed less gas during pressurization and released the gas at a much slower rate. Test results suggest that there is no direct relationship of gas volume potential and flow rates with organic carbon content or bulk density.

V. METHANE PERMEABILITY STUDIES

Methane permeability for samples from the PA-2 and PA-3 wells, along with additional samples from OH-3 and OH-4 were measured parallel to the bedding planes. Only three of these 18 samples were not fractured. These three samples had values ranging from 5.3×10^{-8} to $<10^{-12}$ darcys. A summary of all permeability values for tested Devonian shale is given in Table 55. A few values ('**') in this table have been changed slightly from the previous quarterly[2] to correct for a minor error in calculation. Figure 27 indicates the range of permeability values for the unfractured values obtained from each well. Figures 28 and 29 are updated distributions of unfractured and fractured permeability values of Devonian shales.

TABLE 50
Physicochemical characteristics of the OH-4 samples used for sorption testing.

	OH-4-15	OH-4-43	OH-4-164	OH-4-199
Density (gm/cm^3)	2.69	2.56	2.33	2.50
Organic Carbon (wt %)	2.20	2.57	5.63	5.04
Sample Weight (gm)	304.1	218.5	355.8	254.0

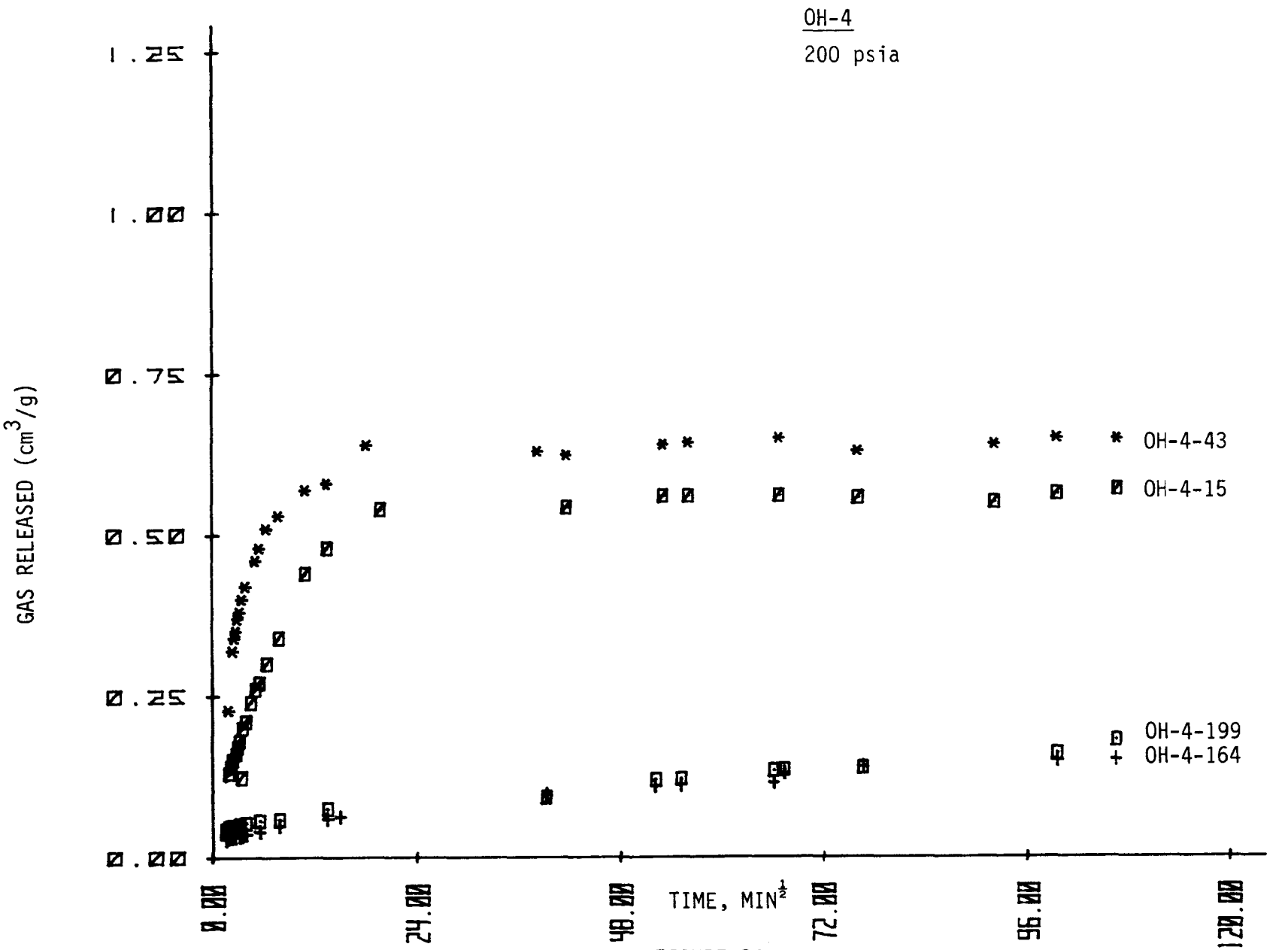

FIGURE 24
The concentration of gas desorbed as a function of time for the OH-4 samples at 200 psia.

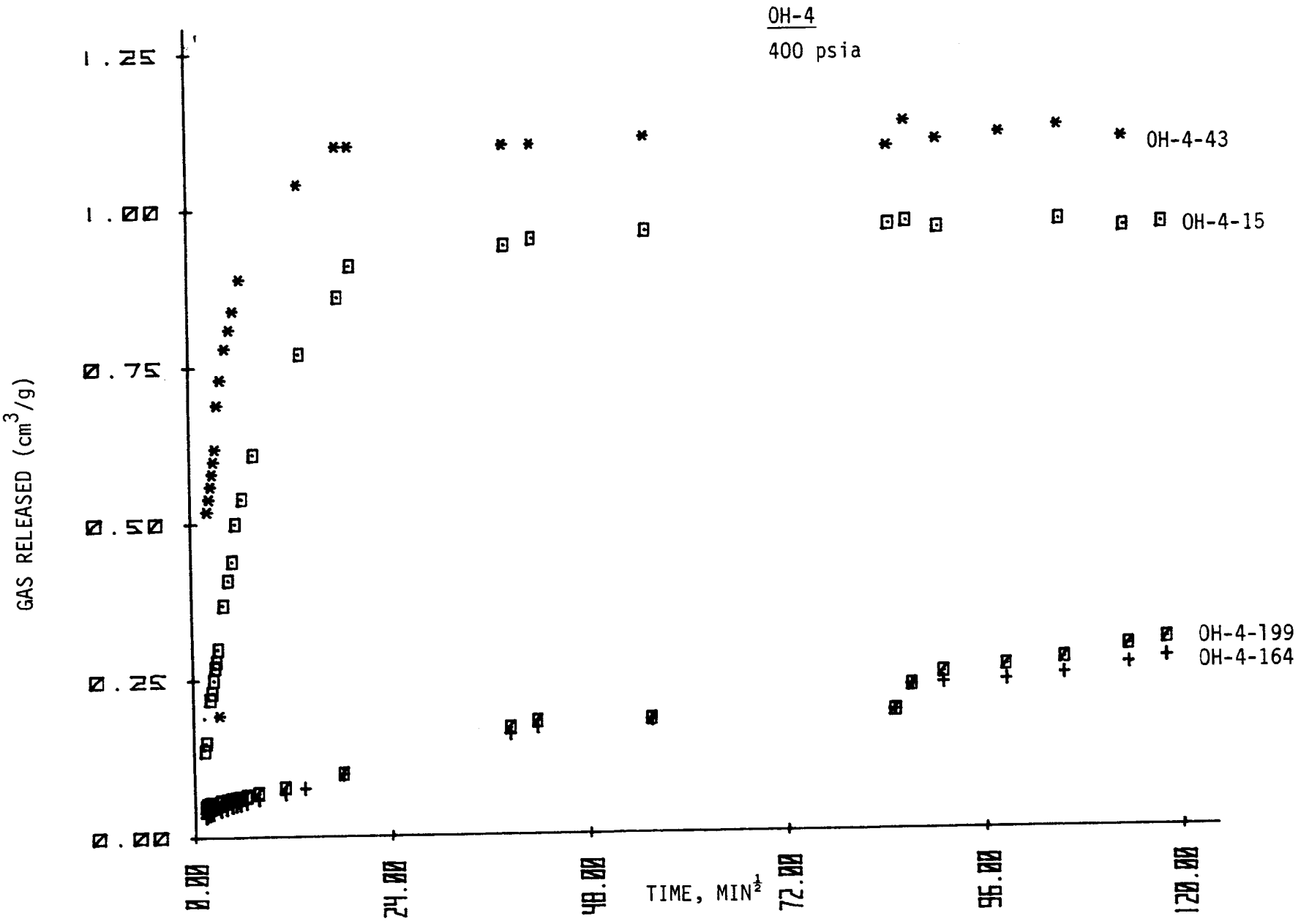

FIGURE 25
The concentration of gas desorbed as a function of time for OH-4 samples at 400 psia.

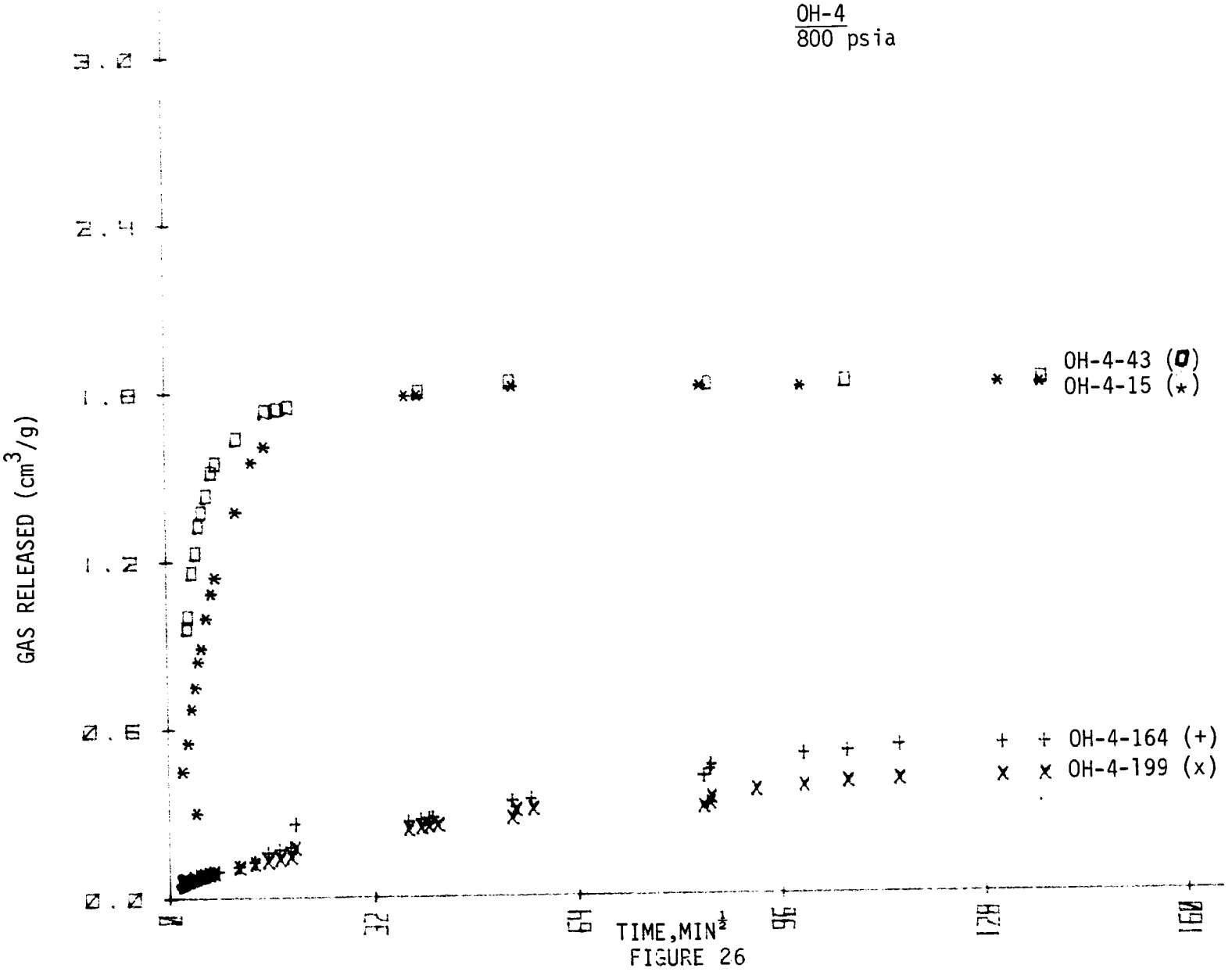

FIGURE 26

The concentration of gas desorbed as a function of time for the OH-4 samples at 800 psia.

TABLE 51
200 psia Sorption Test, Time and Volume (cm^3/g)
Data for OH-4 Samples

Time ($min^{\frac{1}{2}}$)	Volume (cm^3/g) OH-4-15	OH-4-43	OH-4-164	OH-4-199
1.41	-	-	-	-
1.58	0.12	-	0.0306	0.046
1.87	0.13	0.23	0.0309	0.047
2.12	0.14	-	0.0312	0.048
2.35	0.15	0.32	0.0315	0.049
2.55	-	0.34	0.032	-
2.74	0.16	0.35	-	-
2.92	0.17	0.37	-	-
3.16	0.18	0.38	0.034	0.051
3.46	0.20	0.40	0.035	-
3.87	0.21	0.42	0.036	0.053
4.47	0.24	-	-	-
5.00	0.26	0.46	-	-
5.48	0.27	0.48	0.040	0.057
6.32	0.30	0.51	-	-
7.75	0.34	0.53	0.049	0.059
10.95	0.44	0.57	-	-
13.42	0.48	0.58	0.060	0.076
15.00	-	-	0.063	-
18.17	-	0.64	-	-
19.75	0.54	-	-	-
38.34	-	0.63	-	-
39.31	-	-	0.097	0.093
41.71	0.543	0.63	-	-
52.11	-	-	0.11	0.12
53.10	0.56	0.64	-	-
55.18	-	-	0.112	0.121
56.12	0.56	0.64	-	-
66.07	-	-	0.115	0.134
66.86	0.56	0.65	-	-
67.42	-	-	0.13	0.135
76.09	0.56	0.63	-	-
76.58	-	-	0.14	0.138
92.14	0.55	0.64	-	-
99.57	-	-	0.149	0.16
99.65	0.56	0.65	-	-
106.56	-	-	0.15	0.18
106.77	0.57	0.65	-	-

TABLE 52
400 psia Sorption Test, Time and Volume Data
for OH-4 Samples

	Volume (cm^3/g)			
Time ($min^{\frac{1}{2}}$)	OH-4-15	OH-4-43	OH-4-164	OH-4-199
1.41	0.14	0.19	0.035	0.051
1.58	0.15	-	0.035	0.052
1.87	-	-	0.037	0.053
2.12	0.22	0.52	0.038	0.054
2.35	0.23	0.54	-	-
2.55	0.25	0.56	-	-
2.74	0.27	0.58	-	-
2.92	0.28	0.60	-	-
3.16	0.30	0.62	0.043	0.057
3.46	-	0.69	-	-
3.87	0.37	0.73	0.046	0.059
4.47	0.41	0.78	0.049	0.061
5.00	0.44	0.81	0.051	0.062
5.48	0.50	0.84	0.052	0.063
6.32	0.54	0.89	0.055	0.066
7.75	0.61	-	0.060	0.070
10.95	0.71	-	0.069	0.078
13.42	0.77	1.04	0.077	-
18.17	0.86	1.10	0.099	0.099
19.75	0.91	1.10	-	-
38.34	0.94	1.10	0.16	0.17
41.71	0.95	1.10	0.17	0.18
55.59	0.96	1.10	0.18	0.182
85.03	0.96	1.10	0.19	0.19
87.12	0.97	1.10	0.23	0.23
90.99	0.96	1.10	0.233	0.25
98.59	0.96	1.10	0.236	0.26
105.64	0.96	1.10	0.245	0.27
113.58	0.96	1.10	0.26	0.29
118.24	0.96	1.10	0.27	0.30

TABLE 53
800 psia Sorption Time ($min^{\frac{1}{2}}$) and
Volume (cm^3/g) Data for the OH-4 Samples.

Time ($min^{\frac{1}{2}}$)	Volume (cm^3/g) OH-4-15	OH-4-43	OH-4-164	OH-4-199
1.73	-	-	0.045	0.058
1.87	-	-	.046	-
2.00	0.295	-	.047	.060
2.12	-	-	.048	-
2.24	-	-	.049	.062
2.35	0.452	-	.050	.063
2.55	-	-	.052	.064
2.65	-	-	.053	.065
2.92	-	-	.056	.066
3.00	-	0.971	.057	-
3.16	0.552	1.010	.059	.067
3.87	0.675	1.169	.063	.072
4.47	0.751	1.240	.068	.077
5.00	0.843	1.338	.073	.080
5.48	0.890	1.385	.078	.082
6.32	0.997	1.444	.084	.086
7.07	1.086	1.528	.089	.090
7.75	1.143	1.559	.093	.093
10.95	1.377	1.647	.111	.109
13.42	1.554	-	.126	.121
15.49	1.610	1.744	.159	.130
17.32	-	1.750	.169	.138
18.97	-	1.757	.177	.145
19.75	-	-	.262	.176
37.55	1.787	-	.268	.241
39.50	1.789	1.807	.274	.247
40.62	-	-	.279	.251
41.35	-	-	.282	-
42.07	-	-	.301	.255
53.94	-	1.839	.338	.278
54.50	1.816	-	-	.307
56.92	-	-	.344	-
57.18	-	-	-	.310
83.96	1.811	-	.420	.311
85.03	-	1.824	.444	.323
85.21	-	-	.459	.343
92.14	-	-	.474	.370
99.64	1.807	-	.496	.381
106.63	-	1.829	.505	.396
114.50	-	-	.524	.403
130.80	1.816	-	.527	.410
137.37	1.811	1.831	.528	.412

TABLE 54
Summary of sorption test result
for OH-4 samples.

Pressure	Gas Concentration (cm^3 of gas per gm of shale)			
	OH-4-15	OH-4-43	OH-4-164	OH-4-199
@ 1200 psia	1.84	2.82	0.64	0.64
@ 800 psia	1.81	1.83	0.53	0.41
@ 400 psia	0.96	1.10	0.27	0.30
@ 200 psia	0.57	0.65	0.15	0.18

TABLE 55
Summary of Current Devonian Shale
Permeability Values

Sample	Permeability (darcys)
WV-5-22	$<10^{-12}$
WV-5-25	1.6×10^{-12}
WV-5-7	1.3×10^{-10}
*WV-5-52	7.4×10^{-9}
WV-5-46	7.8×10^{-7}
*WV-5-47	3.2×10^{-5}
*WV-5-44	6.5×10^{-5}
IND-2-10	2.5×10^{-9}
IND-2-11	6.1×10^{-9}
IND-2-16	1.6×10^{-8}
IND-2-9	9.5×10^{-5}
*IND-2-5	1.7×10^{-4}
*IND-2-12	1.9×10^{-3}
WV-7-37	$<10^{-12}$
*WV-7-14	1.3×10^{-5}
*WV-7-1	1.6×10^{-5}
*WV-7-7	2.1×10^{-4}
*WV-7-24	2.2×10^{-4}
*WV-7-22	7.2×10^{-4}
*WV-7-30	7.7×10^{-4}
NY-1-41	1.1×10^{-8}
NY-1-88	2.1×10^{-8}
NY-1-67	1.7×10^{-6}
*NY-1-113	6.3×10^{-4}
NY-1-111	6.8×10^{-4}
*NY-1-142	1.6×10^{-3}
*NY-1-124	4.6×10^{-3}
*NY-1-146	5.8×10^{-3}
*NY-1-138	1.4×10^{-2}
KY-2-64	$<10^{-12}$
KY-2-65	8.6×10^{-10}
KY-2-41	1.0×10^{-9}
KY-2-52	4.3×10^{-9}
KY-2-39	6.1×10^{-9}
*KY-2-12	1.4×10^{-2}
*KY-2-3	$>10^{-2}$
*KY-2-14	$>10^{-2}$

TABLE 55 (Continued)
Summary of Current Devonian Shale
Permeability Values

Sample	Permeability (darcys)
KY-4-2	7.4×10^{-10}
KY-4-47	1.9×10^{-7}
*KY-4-31	2.6×10^{-5}
*KY-4-41	5.6×10^{-4}
*KY-4-38	1.3×10^{-3}
*KY-4-24	1.2×10^{-2}
	$>10^{-2}$
OH-3-23	1.3×10^{-8}
OH-3-25	1.8×10^{-7}
*OH-3-17	2.2×10^{-3}
*OH-3-28	4.1×10^{-3}**
OH-4-199	$<10^{-12}$
OH-4-43	2.0×10^{-6}
*OH-4-109	2.8×10^{-5}
*OH-4-15	3.3×10^{-5}
*OH-4-164	1.0×10^{-3}
*PA-1-21	9.8×10^{-6}
*PA-1-11	8.8×10^{-5}**
*PA-1-28	1.3×10^{-4}**
*PA-1-9	2.1×10^{-4}**
*PA-1-23	8.4×10^{-4}**
*PA-1-17	8.1×10^{-4}**
*PA-2-7	5.8×10^{-5}
*PA-2-8	8.8×10^{-5}
*PA-2-9	7.4×10^{-4}
*PA-2-14	$>10^{-2}$
*PA-2-16	$>10^{-2}$
OH-3-24	$<10^{-12}$
OH-3-27	7.5×10^{-8}
*OH-3-4	6.3×10^{-4}
*OH-3-15	9.6×10^{-4}
*OH-3-29	$>10^{-2}$

TABLE 55 (Continued)
Summary of Current Devonian Shale
Permeability Values

Sample	Permeability (darcys)
*OH-4-80	3.8×10^{-5}
*OH-4-167	1.3×10^{-3}
*OH-4-195	1.6×10^{-3}
PA-3-70	5.3×10^{-8}
*PA-3-121	2.3×10^{-4}
*PA-3-108	6.0×10^{-4}
*PA-3-82	4.5×10^{-3}
*PA-3-17	$>10^{-2}$

*Samples contain visually or microscopically identifiable fractures.
**Updated from previous quarterly report.

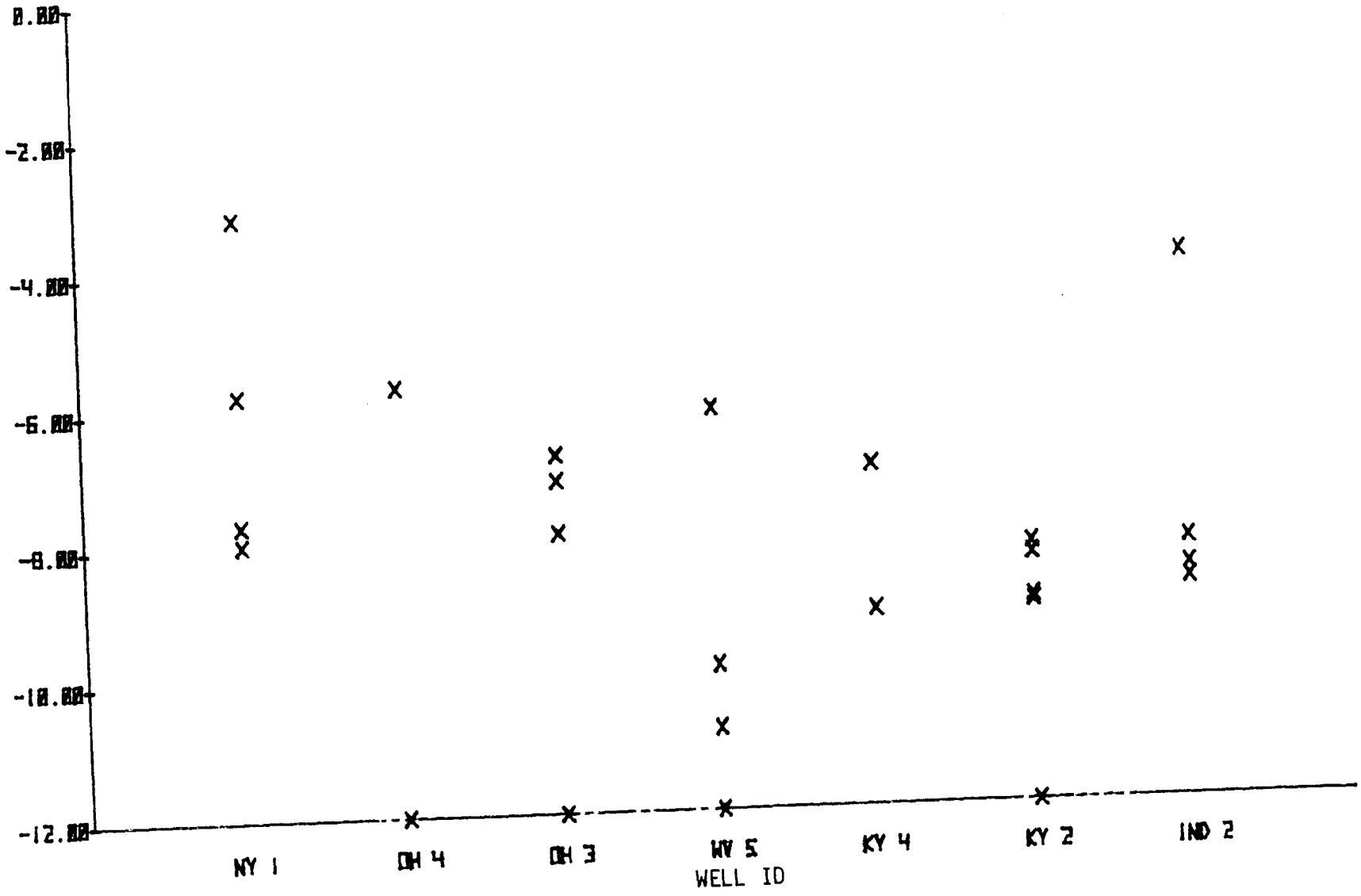

FIGURE 27
Range of Permeability Values for Unfractured Samples Per Well.

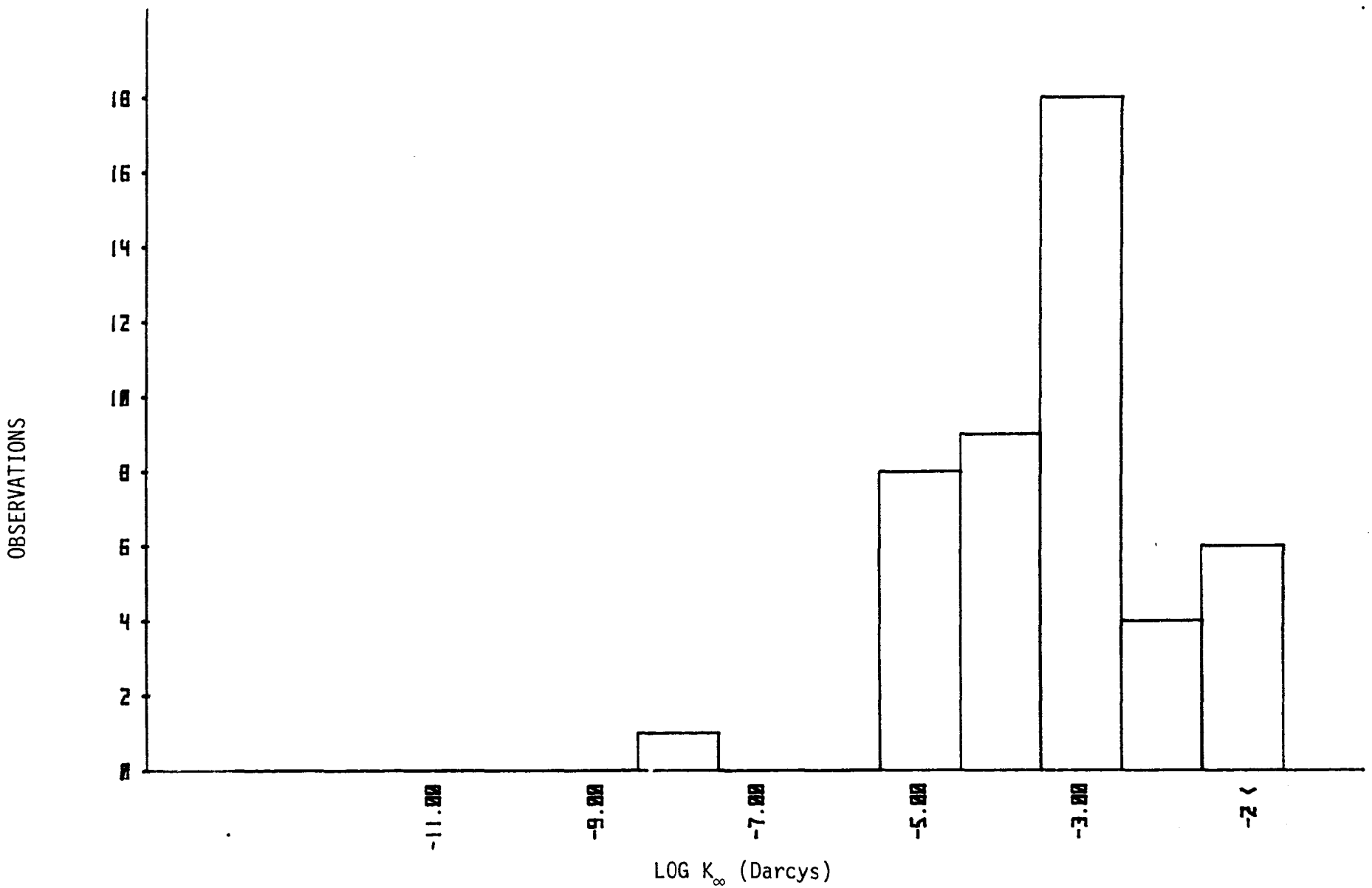

FIGURE 28
Distribution of Permeability Values for Fractured Samples

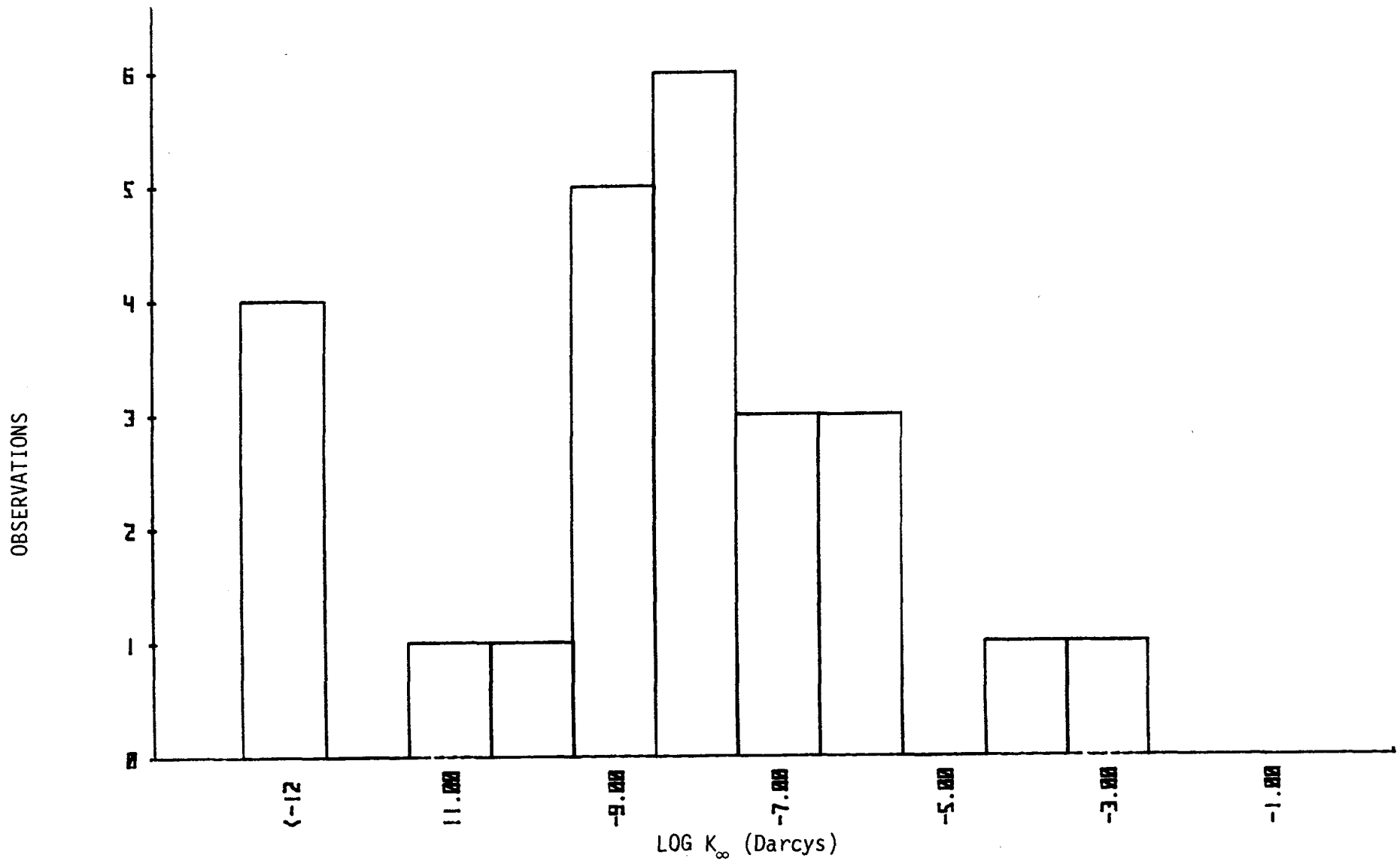

FIGURE 29
Distribution of Permeability Values for Unfractured Samples

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