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MLM-EGSP-TPR-Q-006

PHYSICAL AND CHEMICAL CHARACTERIZATION OF DEVONIAN GAS SHALE

QUARTERLY STATUS REPORT (APRIL 1 - JUNE 30, 1978)

PREPARED BY: R. E. ZIELINSKI
PRINCIPAL INVESTIGATOR

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

Monsanto

MOUND FACILITY
Miamisburg, Ohio

operated by
MONSANTO RESEARCH CORPORATION
a subsidiary of Monsanto Company

for the
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Contract No. EY-76-C-04-0053

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STATUS SUMMARY

Biostratigraphic analysis of samples from wells R-109, OH-1, and WV-5 have been completed. The samples from the R-109 well are Upper Devonian, Famennian or Frasnian Stages. The samples from the OH-1 and WV-5 wells range from the Middle Devonian, Givetian Stage to the Upper Devonian, Famennian Stage.

The depositional environment of the R-109 well is non-marine with a restricted marine transition in the middle of the well. A regressive pattern of marine overlain successively by restricted marine and non-marine was observed in the OH-1 well. The basal sections of the WV-5 well are dominated by restricted marine deposition with a greater influence of non-marine sediments at the shallower depths.

Organic carbon results for the WV-5 well indicate a mean value of 1.33 weight percent. The actual data indicate significant and abrupt changes in organic carbon content within the well. Overall, the values range from 0.02 to 6.74 weight percent. The bottom 50 foot interval is the most organically rich with a mean value of 3.93 weight percent.

Lithology of the WV-5 samples, in general indicates that the samples are 100% shale, noncalcareous and fissile with occurrences of dolomite, micas and pyrite.

The vitrinite reflectance results for the WV-5 well show a large degree of scatter with depth. The mean R_o value is 0.64 and is consistent with previously reported data.

Detailed kerogen analysis has been completed on samples from the OH-1 and R-109 wells. The organic matter from both well locations appears to be of an intermediate nature, with the material from the R-109 well being the more mature.

Visual kerogen analyses of the WV-5 samples have been completed. The results indicate increasing TAI values with increasing depth. This indication of a thermal maturation gradient is supported by the vitrinite reflectance results.

Mineralogical analyses have been completed on samples from the O-1, P-1, I-1, I-2, I-3, KY-2, VA-1, R-109, OH-1 and WV-5 wells. These analyses included mineral phase identification, phase concentration, particle size distribution and the fabric of preferred mineral orientation. The mineralogy was determined by x-ray and optical techniques.

The dominant mineral phase of the Illinois Basin samples was clay. The clays, predominantly illite, accounted for normally a minimum of 50% and up to 80% of the shales. The presence of quartz is ubiquitous, ranging from 10 to 40% of the samples. The occurrence of pyrite is also common but does not exceed 12%.

In the Appalachian Basin samples, clays again dominate with illite generally accounting for 50 to 90% of the clay minerals present. The quartz content of the samples from the southern portion of the basin is less than that found in the Illinois Basin samples. Pyrite is again present but variable up to 20%.

The elemental analyses of the samples from the WV-5 well were also completed. These data again tend to indicate that the elemental concentrations are related to depositional environment and organic content.

The ash free weight percent values of carbon, nitrogen, oxygen and hydrogen were determined for the samples from the WV-5 and WV-6 wells. The carbon content is related to the degree of thermal maturation.

Detailed hydrocarbon analyses have been completed on the WV-5 well samples.

Material Balance Assays have also been completed on the available samples from the WV-5 well. Mean values for the oil yield (gal/ton), ^{o}API-gravity, and hydrocarbon gas yield (ft^3/ton) are 2.78, 27.3, and 55.5, respectively.

The C_1-C_4 analysis of the WV-6 well samples has been completed. The test results indicate a mean gas content which is significantly greater than the results obtained for wells KY-2 and VA-1. A significant portion of the lighter hydrocarbons were effused to the sample container's air space.

Permeation of helium through samples from the WV-5 well is being determined. These values are being tempered with x-ray analyses of the samples. The modified hydrostatic pressure test manifold and the methane test apparatus are in the final stages of assembly and tests using this equipment should begin shortly. Select samples are still being exposed to various moisture environments prior to permeation testing.

Scanning electron microscopy is in progress on the samples from the WV-5 well. Current results indicate heavy concentrations of pyrite at various depths. In samples WV-5-3 and WV-5-36, gypsum crystals commonly occurred with the pyrite.

Geophysical efforts this quarter included the writing of a computer program (SYNLOG) to calculate a synthetic log; the computation of synthetic seismograms for data taken in the Pricetown area; interpretation of the three dimensional seismic records for the Cottageville Field. Two structure maps were made from the three dimensional seismic data, one at the top of the Onondaga limestone and the other at the top of the basement.

Sensitivity analysis using seven parameter statistical models derived from Clinton Sands gas flow data indicates that treatment volumes larger than those used would not have been productive. For low flow wells (those producing less than 100,000 MCF over a 60 month period) the models predicted that a 2-3 fold increase in treatment volume would have produced only a minimal increase in flow. Similar analysis for high flow (>100,000 MCF) wells suggests that larger treatment volumes could improve the flow.

Pairwise analysis of data from wells within preselected longitude and latitude windows indicate that there is little communication between the 328 wells analyzed. If close wells are connected or coupled, it would be expected that the higher flow of one well would tend to decrease the flow of a close adjacent well. These results indicate that this is not occurring.

Oriented core samples from the WV-5 well - 2700 to 3100 foot interval - were analyzed to determine Shore hardness, splitting tensile strength, and Young's modulus. Generally, results indicate no relationship of the test values and depth. However, Shore hardness values decrease irregularly with increasing depth. This suggests that "maturation" with increasing depth is not the primary factor in determining the mechanical properties of these shales. Random maximum tensile strength direction was observed from the results of point load testing.

Several large blocks of shale were acquired for stimulation testing and modeling purposes.

LIST OF CONTRIBUTORS

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A. SAMPLE DESCRIPTION

Tables 1 through 12 identify the specific samples discussed in this study and their respective depths. Select samples were also analyzed from the OH-2 well, Logan County, Ohio.

B. STRATIGRAPHY AND BIOFACIES

Biostratigraphic studies were completed on samples from Appalachian Basin wells R-109, OH-1 and WV-5. Biofacies results from the Appalachian Basin wells VA-1 and KY-2 as well as the Illinois Basin wells I-2, I-3, P-1 and O-1 have been reported elsewhere.[1,2]

The samples from R-109 are Late Devonian, in age (Table 13). The deepest cored sample, R-109-8 was deposited during the Frasnian Stage. The deposition of the younger sediment at R-109-7 and R-109-5 occurred during the transition between the Frasnian and Famennian stages. Biofacies established that the deposition of sample R-109-3 and younger sediments took place during the Famennian stage.

Deposition of shales within the cored intervals represents a longer depositional period at Appalachian well sites OH-1 and WV-5. Shales from both wells were deposited from the Middle Devonian Givetian Stage to the Upper Devonian Famennian Stage (Table 14 and 15).

Depositional environment is selected on the basis of whether the dominate palynomorphs are marine, restricted marine, or non-marine. The results for R-109 (Table 16) indicate a non-marine environment at R-109-8 changing abruptly to restricted marine (R-109-7 and R-109-5) and more gradually reverting to non-marine deposition in the shallower samples. The 114 ft. Devonian section at OH-1 indicates a regressive pattern of marine overlain successively by restricted marine and non-marine (Table 17). Well WV-5 is located in the southern regions of the Devonian version of the Appalachian Basin. A marine depositional environment was never dominant. The shales from the basal section of this well suggests restricted marine deposition with a greater influence of non-marine sediments subsequent to the deposition of sample WV-5-19 (Table 18).

TABLE 1

Shale Samples from the KY-2 Well
Located in Martin County, Kentucky

Mound Sample No.	MERC Sample No.	Depth, Ft.
KY-2-1	C-336-2444-A	2443.25/.35
KY-2-2	C-336-2444-B	2443.35/.60
KY-2-3	C-336-2474-A	2474.20/.53
KY-2-4	C-336-2474-B	2474.53/.85
KY-2-5	C-336-2504-A	2503.35/.55
KY-2-6	C-336-2504-B	2503.55/.80
KY-2-7	C-336-2534-A	2535.08/.33
KY-2-8	C-336-2534-B	2535.33/.60
KY-2-9	C-336-2555-A	2555.50/.75
KY-2-10	C-336-2555-B	2555.75/.90
KY-2-11	C-336-2597-A	2597.25/.56
KY-2-12	C-336-2597-B	2597.56/.85
KY-2-13	C-336-2627-A	2627.22/.60
KY-2-14	C-336-2627-B	2627.60/.85
KY-2-15	C-336-2657-A	2657.30/.67
KY-2-16	C-336-2657-B	2657.67/.85
KY-2-17	C-336-2687-A	2687.37/.57
KY-2-18	C-336-2687-B	2687.57/.88
KY-2-19	C-336-2715-A	2715.03/.29
KY-2-20	C-336-2715-B	2715.29/.66
KY-2-21	C-336-2745-A	2745.16/.58
KY-2-22	C-336-2745-B	2745.58/.69
KY-2-23	C-336-2773-A	2773.45/.60
KY-2-24	C-336-2773-B	2773.60/.85
KY-2-25	C-336-2803-A	2803.40/.58
KY-2-26	C-336-2803-B	2803.58/.69
KY-2-27	C-336-2833-A	2833.31/.50
KY-2-28	C-336-2833-B	2833.50/.65
KY-2-29	C-336-2861-A	2861.45/.71
KY-2-30	C-336-2861-B	2861.71/.88
KY-2-31	C-336-2890-A	2890.20/.40
KY-2-32	C-336-2890-B	2890.40/.65
KY-2-33	C-336-2921-A	2921.32/.50
KY-2-34	C-336-2921-B	2921.50/.70
KY-2-35	C-336-2947-A	2947.43/.71
KY-2-36	C-336-2947-B	2947.71/.92
KY-2-37	C-336-2977-A	2977.40/.60

Table 1 (Cont'd.)

Shale Samples from the KY-2 Well
Located in Martin County, Kentucky

Mound Sample No.	MERC Sample No.	Depth, Ft.
KY-2-38	C-336-2977-B	2977.60/.83
KY-2-39	C-336-3005-A	3005.03/.31
KY-2-40	C-336-3005-B	3005.31/.67
KY-2-41	C-336-3035-A	3035.43/.65
KY-2-42	C-336-3035-B	3035.65/.95
KY-2-43	C-336-3054-A	3054.10/.40
KY-2-44	C-336-3054-B	3054.55/.90
KY-2-45	C-336-3085-A	3085.20/.40
KY-2-46	C-336-3085-B	3085.40/.60
KY-2-47	C-336-3113-A	3113.40/.67
KY-2-48	C-336-3113-B	3113.67/.91
KY-2-49	C-336-3143-A	3143.22/.39
KY-2-50	C-336-3143-B	3143.39/.63
KY-2-51	C-336-3171-A	3171.18/.50
KY-2-52	C-336-3171-B	3171.50/.73
KY-2-53	C-336-3201-A	3201.03/.25
KY-2-54	C-336-3201-B	3201.25/.52
KY-2-55	C-336-3230-A	3230.27/.50
KY-2-56	C-336-3230-B	3230.50/.64
KY-2-57	C-336-3260-A	3260.26/.46
KY-2-58	C-336-3260-B	3260.46/.68
KY-2-59	C-336-3288-A	3288.10/.23
KY-2-60	C-336-3288-B	3288.23/.50
KY-2-61	C-336-3328-A	3328.30/.56
KY-2-62	C-336-3328-B	3328.56/.86
KY-2-63	C-336-3358-A	3358.05/.56
KY-2-64	C-336-3358-B	3358.56/.76
KY-2-65	C-336-3386-A	3386.10/.35
KY-2-66	C-336-3386-B	3386.35/.70

TABLE 2

Shale Samples from the I-1 Well
Located in Effingham County, Illinois

Mound Sample No	MERC Sample No.	Depth, Ft.
I-1-1	I-1-3023-A	3023*
I-1-4	I-1-3044-B	3044.25/.60
I-1-6	I-1-3057-B	3057.30/.65
I-1-8	I-1-3075-B	3075.31/.50
I-1-9	I-1-3099-A	3099.30/.51

*Not accurately defined.

TABLE 3

Shale Samples from the O-1 Well
Located in Christian County, Kentucky

Mound Sample No.	MERC Sample No.	Depth, Ft.
O-1-1	O-1-2184	2183.71/2184.08
O-1-3	O-1-2261	2261.02/.50
O-1-4	O-1-2292	2292.47/.91
O-1-5	O-1-2317	2317.21/.64

TABLE 4

Shale Samples from the P-1 Well
Located in Sullivan County, Indiana

Mound Sample	MERC Sample No.	Depth, Ft.
P-1-1	P1-2142	2492.33/.83
P-1-2	P1-2521	2521.08/.33
P-1-3	P1-2549	2549.25/.67

TABLE 5

Shale Samples from the VA-1 Well
Located in Wise County, Virginia

Mound Sample No.	MERC Sample No.	Depth, Ft.
VA-1-1	C-338-4885-A	4885.13/.40
VA-1-2	C-338-4885-B	4885.40/.75
VA-1-3	C-338-4915-A	4915.10/.37
VA-1-4	C-338-4915-B	4915.37/.68
VA-1-5	C-338-4945-A	4945.20/.43
VA-1-6	C-338-4945-B	4945.43/.77
VA-1-7	C-338-4969-A	4969.20/.35
VA-1-8	C-338-4969-B	4969.35/.50
VA-1-9	C-338-4969-C	4969.50/.70
VA-1-10	C-338-4975-A	4975.10/.32
VA-1-11	C-338-4975-B	4975.32/.54
VA-1-12	C-338-5229-A	5229.20/.35
VA-1-13	C-338-5229-B	5229.35/.65
VA-1-14	C-338-5259-A	5259.10/.25
VA-1-15	C-338-5259-B	5259.25/.65
VA-1-16	C-338-5289-A	5289.10/.46
VA-1-17	C-338-5289-B	5289.46/.60
VA-1-18	C-338-5319-A	5319.37/.56
VA-1-19	C-338-5319-B	5319.56/.70
VA-1-20	C-338-5348-A	5348.30/.62
VA-1-21	C-338-5348-B	5348.62/.80
VA-1-22	C-338-5379-A	5379.08/.33
VA-1-23	C-338-5379-B	5379.33/.57
VA-1-24	C-338-5393-A	5393.20/.50
VA-1-25	C-338-5393-B	5393.50/.65
VA-1-26	C-338-5393-C	5393.65/.90
VA-1-27	C-338-5409-A	5409.07/.37
VA-1-28	C-338-5409-B	5409.37/.55
VA-1-29	C-338-5439-A	5439.15/.40
VA-1-30	C-338-5439-B	5439.40/.67
VA-1-31	C-338-5469-A	5469.20/.53
VA-1-32	C-338-5469-B	5469.53/.80

TABLE 6

Shale Samples from the I-2 Well
Located in Henderson County, Illinois

Mound Sample No.	MERC Sample No.	Depth, Ft.
I-2-A*	N1-RAR#1 (120' Above Core Point)	190/200
I-2-1	N1-RAR#1-1-A	334.25/.50
I-2-2	N1-RAR#1-1-B	334.50/.75
I-2-3	N1-RAR#1-2-A	364.10/.32
I-2-4	N1-RAR#1-2-B	364.32/.55
I-2-5	N1-RAR#1-3-A	394.15/.36
I-2-6	N1-RAR#1-3-B	394.36/.60
I-2-7	N1-RAR#1-4-A	425.33/.52
I-2-8	N1-RAR#1-4-B	425.52/.90
I-2-9	N1-RAR#1-5-A	454.14/.40
I-2-10	N1-RAR#1-5-B	454.40/.65
I-2-11	N1-RAR#1-6-A	481.15/.32
I-2-12	N1-RAR#1-6-B	481.32/.53
I-2-13	N1-RAR#1-7-A	508.26/.48
I-2-14	N1-RAR#1-7-B	508.48/.70
I-2-15	N1-RAR#1-9-A	538.29/.45
I-2-16	N1-RAR#1-9-B	538.45/.67
I-2-17	N1-RAR#1-10-A	568.40/.60
I-2-18	N1-RAR#1-10-B	568.60/.80
I-2-19	N1-RAR#1-11-A	598.15/.30
I-2-20	N1-RAR#1-11-B	598.30/.55
I-2-B*	N1-RAR#1 (120' Below Core Point)	730/740

*Cuttings.

TABLE 7

Shale Samples from the I-3 Well
Located in Tazewell County, Illinois

Mound Sample No.	MERC Sample No.	Depth, Ft.
I-3-A*	N2-MAK#1 (120' Above Core Point)	770/780
I-3-1	N2-MAK#1-1-A	940.10/.33
I-3-2	N2-MAK#1-1-B	940.10/.33
I-3-3	N2-MAK#1-1-C	940.33/.75
I-3-4	N2-MAK#1-2-B	969.04/.27
I-3-5	N2-MAK#1-2-C	969.27/.71
I-3-6	N2-MAK#1-3-A	995.08/.27
I-3-7	N2-MAK#1-3-B	995.15/.31
I-3-8	N2-MAK#1-3-C	995.31/.85
I-3-9	N2-MAK#1-4-B	1018.22/.43
I-3-10	N2-MAK#1-4-C	1018.43/.90
I-3-11	N2-MAK#1-5-A	1048.19/.39
I-3-12	N2-MAK#1-5-B	1048.19/.39
I-3-13	N2-MAK#1-5-C	1048.39/.79
I-3-14	N2-MAK#1-6-B	1078.25/.45
I-3-15	N2-MAK#1-6-C	1078.45/.83
I-3-16	N2-MAK#1-7-A	1108.12/.35
I-3-17	N2-MAK#1-7-B	1108.12/.35
I-3-18	N2-MAK#1-7-C	1108.35/.77
I-3-19	N2-MAK#1-8-B	1138.01/.17
I-3-20	N2-MAK#1-8-C	1138.17/.60
I-3-B*	N2-MAK#1 (120' Below Core Point)	1270/1280

*Cuttings.

TABLE 8

Shale Samples from the R-109 Well
Located in Washington County, Ohio

Mound Sample Number	Depth (ft.)
R-109-1	3490.80/3491.10
R-109-2	3518.60/3519.00
R-109-3	3549.30/.60
R-109-4	3579.50/3580.00
R-109-5	3609.70/3610.10
R-109-6	3639/3640
R-109-7	3669/3670
R-109-8	3702/3706.50

TABLE 9

Shale Samples from the OH-1 Well
Located in Carroll County, Ohio

Mound Sample Number	Depth (ft.)
OH-1-1	2082.20/.60
OH-1-2	2110.00/.50
OH-1-3	2140.10/.30
OH-1-4	2169.10/.60
OH-1-5	2198.30/.70
OH-1-6	3080.40/.80
OH-1-7	3110.90/3111.00
OH-1-8	3137.50/.70
OH-1-9	3171.00/.40
OH-1-10	3196.00/.30

TABLE 10

Shale Samples from the Swift-1-28 Well (Antrim Basin)

Mound Sample No.	Depth, Ft.
S-1-28-1	1410
S-1-28-2	1420
S-1-28-3	1430
S-1-28-4	1440
S-1-28-5	1450
S-1-28-6	1460
S-1-28-7	1470
S-1-28-8	1480
S-1-28-9	1490
S-1-28-10	1500
S-1-28-11	1510
S-1-28-12	1520
S-1-28-13	1530
S-1-28-14	1540
S-1-28-15	1550
S-1-28-16	1560
S-1-28-17	1570
S-1-28-18	1580

TABLE 11

Shale Samples from the WV-5 Well
Mason County, West Virginia

Mound Sample Number	Depth (ft.)
WV-5-1	2705.18/.60
WV-5-2	2715.20/.60
WV-5-3	2725.20/.60
WV-5-4	2735.60/.95
WV-5-5	2745.01/.30
WV-5-6	2758.13/.42
WV-5-7	2768.33/.70
WV-5-8	2778.25/.58
WV-5-9	2788.45/.83
WV-5-10	2798.40/.80
WV-5-11	2808.13/.45
WV-5-12	2816.23/.52
WV-5-13	2826.20/.63
WV-5-14	2846.23/.58
WV-5-15	2856.24/.65
WV-5-16	2866.03/.38
WV-5-17	2874.10/.38
WV-5-18	2884.20/.50
WV-5-19	2894.22/.64
WV-5-20	2904.20/.60
WV-5-21	2914.22/.60
WV-5-22	2932.09/.43
WV-5-23	2942.28/.61
WV-5-24	2952.36/.73
WV-5-25	2962.17/.55
WV-5-26	2972.09/.44
WV-5-27	2982.30/.75
WV-5-28	2990.27/.65
WV-5-29	3000.39/.83
WV-5-30	3010.35/.75
WV-5-31	3020.30/.60
WV-5-32	3030.51/.82
WV-5-33	3040.25/.75
WV-5-34	3049.30/.57
WV-5-35	3059.22/.56

TABLE 11 (continued)

Shale Samples from the WV-5 Well
Mason County, West Virginia

Mound Sample Number	Depth (ft.)
WV-5-36	3069.35/.70
WV-5-37	3079.28/.70
WV-5-38	3089.10/.45
WV-5-39	3099.11/.41
WV-5-40	3107.27/.61
WV-5-41	3117.30/.70
WV-5-42	3127.15/.48
WV-5-43	3137.47/.78
WV-5-44	3145.48/.75
WV-5-45	3157.55/.85
WV-5-46	3166.14/.55
WV-5-47	3176.12/.56
WV-5-48	3186.30/.80
WV-5-49	3196.30/.73
WV-5-50	3206.42/.81
WV-5-51	3216.10/.58
WV-5-52	3225.13/.50
WV-5-53	3235.46/.84
WV-5-54	3245.18/.49
WV-5-55	3257.50/.80
WV-5-56	3267.38/.69
WV-5-57	3277.33/.75
WV-5-58	3287.35/.68
WV-5-59	3297.50/.78
WV-5-60	3308.36/.78
WV-5-61	3316.25/.56
WV-5-62	3325.35/.75
WV-5-63	3336.22/.68
WV-5-64	3346.18/.50
WV-5-65	3356.42/.68
WV-5-66	3366.35/.59
WV-5-67	3374.35/.70
WV-5-68	3384.40/.76

TABLE 12

Samples for the WV-6 Well
Monongalia County, West Virginia

Mound Sample No.	Depth (Ft.)
Ml-C-1	2000-2010
Ml-C-9	2230-2240
Ml-C-18	2500-2510
Ml-C-27	2770-2780
Ml-C-35	3010-3020
Ml-C-43	3250-3260
Ml-C-51	3490-3500
Ml-C-60	3760-3770
Ml-C-68	3990-4000
Ml-C-76	4230-4240
Ml-C-85	4510-4520
Ml-C-93	4750-4760
Ml-C-101	4990-5000
Ml-C-109	5230-5240
Ml-C-118	5510-5520
Ml-C-126	5750-5760
Ml-C-134	5990-6000
Ml-C-141	6200-6210
Ml-C-143	6260-6270
Ml-C-148	6410-6420
Ml-C-149	6440-6450
Ml-C-151	6500-6510
Ml-C-152	6530-6540
Ml-C-153	6560-6570
Ml-C-155	6650-6660
Ml-C-156	6680-6690
Ml-C-157	6710-6720
Ml-C-158	6740-6750
Ml-C-159	6770-6780
Ml-C-160	6800-6810
Ml-C-161	6830-6840
Ml-C-163	6890-6900
Ml-C-165	6900-6910
Ml-C-168	6930-6940
Ml-C-169	6940-6950
Ml-C-171	6960-6970
Ml-C-174	6990-7000
Ml-C-179	7015-7020

TABLE 12 (Continued)

Samples for the WV-6 Well
Monongalia County, West Virginia

Mound Sample No.	Depth (Ft.)
M1-C-182	7030-7035
M1-C-185	7045-7050
M1-C-188	7060-7065
M1-C-191	7075-7080
M1-C-193	7090-7095
M1-C-195	7100-7110
M1-C-199	7125-7130
M1-C-202	7140-7145
M1-C-206	7155-7160
WV-6-1	7197.30/.68
WV-6-2	7207.11/.48
WV-6-3	7217.50/.95
WV-6-4	7227.35/.90
WV-6-5	7239.48/.81
WV-6-6	7249.50/.87
WV-6-7	7259.51/.83
WV-6-8	7269.30/.60
WV-6-9	7279.20/.63
WV-6-10	7289.10/.47
WV-6-11	7298.28/.70
WV-6-12	7308.21/.61
WV-6-13	7318.30/.72
WV-6-14	7328.09/.48
WV-6-15	7338.10/.30
WV-6-16	7338.10/.30
WV-6-17	7338.30/.55
WV-6-18	7338.55/.85
WV-6-19	7348.07/.35
WV-6-20	7356.40/.76
WV-6-21	7366.36/.80
WV-6-22	7376.07/.25
WV-6-23	7376.07/.25
WV-6-24	7376.25/.42
WV-6-25	7376.45/.70
WV-6-26	7392.55/.89
WV-6-27	7403.33/.79
WV-6-28	7413.49/.90

TABLE 12 (Continued)

Samples for the WV-6 Well
Monongalia County, West Virginia

Mound Sample No.	Depth (Ft.)
WV-6-29	7423.10/.36
WV-6-30	7433.22/.55
WV-6-31	7443.12/.57
WV-6-32	7451.28/.75
WV-6-33	7461.06/.50
WV-6-34	7471.53/.88
WV-6-35	7481.05/.25
WV-6-36	7481.05/.25
WV-6-37	7481.25/.41
WV-6-38	7481.41/.67
WV-6-39	7491.40/.72
WV-6-40	7501.16/.49

TABLE 13

Age

for the R-109 Well, Washington County, Ohio

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE	SECOND CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE
R-109-1	3491'	D	U	Fa	Spores: Hymenoxonotriletes sp., Knoxisporites literatus, ets, Actritarchs: Elektoriskos dolos	D	-	-	Spores have a Devonian aspect
R-109-2	3519'	D	U	Fa	Spores: Knoxisporites literatus, H. famenniensis, Acritarchs: Elektoriskos dolos	D	-	-	Spores have a Devonian aspect
R-109-3	3549'	D	U	Fa	Acritarchs: Veryhachium spp., solisphaeridium spinoglobosum Veryhachium trispinosum type A				
R-109-5	3610'	D	U	Fa or Fr	Stratigraphic location between samples of Frasnian and Famennian age				
R-109-7	3679'	D	U	Fa or Fr	Stratigraphic location between samples of Frasnian and Famennian age				

Key
- D - Devonian
- U - Upper
- Fa - Famennian
- Fr - Frasnian

TABLE 13 (Continued)
Age
for the R-109 Well, Washington County, Ohio

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE	SECOND CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE
R-109-8	3702'	D	U	Fr	Spores: cf. <u>Rhabdosporites langi</u>, <u>Ancyrospora</u> spp. Acritarchs: <u>Cymetiosphaera peifferi</u>	D	-	-	Spores have a Devonian aspect

Key
D - Devonian
U - Upper
Fr- Frasnian

TABLE 14
Age
for the OH-1 Well, Carroll County, Ohio

		FIRST CYCLE PALYNOMORPHS				SECOND CYCLE PALYNOMORPHS			
Mound No.	Depth	SYSTEM	SERIES	STAGE	RATIONALE	SYSTEM	SERIES	STAGE	RATIONALE
OH-1-1	2082'	D	U	Fa	Spores: Presence of *Convolutispora* sp. spores with grapnel-like processes. Acritarchs: *Unellium ampullium Elektoriskos dolos*, *Gorgonisphaeridium elongatum*.	D	L-M	-	Spores: *Dibolisporites* sp. (as seen in Canadian)
OH-1-5	2198'	D	U or M	-	Stratigraphic position between samples of Upper and Middle Devonian Age.				
OH-1-6	3080'	D	U or M	-	Stratigraphic position between samples of Upper and Middle Devonian Age	D			Large size of *Tasmanites* indicative of Devonian
OH-1-10	3196'	D	M	Gi	Acritarchs: *Navifusa bacillum Diexallophasis remotum*, *Polyedryxium diabolicum*, *P. decorum* etc.	D	M		A few dark spores have a Middle Devonian Aspect, and much of the woody material appears (by TAI) to be reworked.

Key
D - Devonian
U - Upper
Fa - Famennian
M - Middle
Gi - Givetian
L - Lower

TABLE 15
Age
WV-5 Well

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE	SECOND CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE
WV-5-1	2705'	D	U	Fa	Acritarchs: <u>Navifusa procera</u>, a granulate <u>Veryhachium sp</u>. <u>Gorgonisphaeridium absitum</u>. Spores: <u>Ancyrospora capillata</u>, <u>Verrucosisporites</u> cf. V. <u>bullatus</u> "<u>Dicrospora Multi-furcata</u>				
WV-5-4	2735'	D	U	Fa	Stratigraphic location within Fammennian-aged strata.				
WV-5-7	2768'	D	U	Fa	Stratigraphic location within Famennian-aged strata.				
WV-5-10	2798'	D	U	Fa	Acritarchs: Navifusa procera, numerous <u>Veryhachium trispinosum spp</u>.				
WV-5-13	2826'	D	U	Fa	Acritarchs: <u>Senziella incurvata</u>, <u>Gorgonisphaeridium absitum</u> Spores: "<u>Dicrospora</u>" <u>Multi-furcata</u>				

Key
D Devonian
U Upper
Fa Famennian

TABLE 15 (Continued)
Age
WV-5 Well

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE	SECOND CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE
WV-5-16	2866'	D	U	Fa	Acritarchs: Navifusa procera q. absitum. Spores: V. cf. V. bullatus				
WV-5-19	2894'	D	U	Fa	Acritarchs: Duvernaysphaera tesselata. Spores: Dimultifurcata				
WV-5-22	2932'	D	U	Fa	Stratigraphic location between strata known to be Frasnian and strata known to be Famennian				
WV-5-25	2962'	D	U	Fa-Fr	Stratigraphic location between strata known to be Frasnian and strata known to be Famennian				
WV-5-28	2990'	D	U	Fr	Chitinozoan: two n. sp., Anyochitina cf. A. capillata				
WV-5-31	3020'	D	U	Fr	Stratigraphic location				

Key
D Devonian
U Upper
Fa Famennian
Fr Frasnian

TABLE 15 (Continued)
Age
WV-5 Well

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE	SECOND CYCLE PALYNOMORPHS: SYSTEM	SERIES	STAGE	RATIONALE
WV-5-34	3049'	D	U	Fr	Acritarchs: Maharanites sp. Cymatiosphaera prifferi Cy. parvicarina, Diexallophasis remotum.				
WV-5-37	3079'	D	U	Fr	Stratigraphic Location				
WV-5-40	3107'	D	U	Fr	Stratigraphic Location	D	?		Large amounts of woody material at a higher maturity than indigenous material imply reworked older Devonian (possibly Middle to Upper Silurian Source
WV-5-43	3137'	D	U	Fr	Acritarchs: Multiplicisphaeridium ramusculosum, g. ampullum, Cy. peifferi				
WV-5-46	3157'	D	U	Fr	Acritarchs: g. pleurispinosum Mu. ramusculosum, Cy. peifferi, Elektoriskos colos.	D	?		

Key
D - Devonian
U - Upper
Fr- Frasnian

TABLE 15 (Continued)
Age
WV-5 Well

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS SYSTEM	SERIES	STAGE	RATIONALE	SECOND CYCLE PALYNOMORPHS SYSTEM	SERIES	STAGE	RATIONALE
WV-5-49	3186'	D	U	Fr	Spore: Calamospora atavata Acritarchs: Tunisphaeridium sp. Multiplicisphaeridium sprucegrovensis, Cy. labyrinthica, Mu. rammusculosum.				
WV-5-52	3216'	D	U	Fr	Acritarchs: Diex. remotum Mu. ramusculosum, Exochoderma asketum, Cy. peifferi.				
WV-5-55	3245'	D	U	Fr	Acritarchs: Quisquiletes buckhornensis, Mu. sprucegrovensis, Elektoriskos dolos.				

Key
D - Devonian
U - Upper
Fr- Frasnian

TABLE 15(Continued)
Age
WV-5 Well

Mound No.	Depth	FIRST CYCLE PALYNOMORPHS				SECOND CYCLE PALYNOMORPHS			
		SYSTEM	SERIES	STAGE	RATIONALE	SYSTEM	SERIES	STAGE	RATIONALE
WV-5-58	3277'	D	U	Fr	Acritarchs: Dateriocradus sp. Pterospermella n. sp. Mu. sprucegrovensis. Cymatiosphaera spp.				
WV-5-62	3308'	D	M	Gi	Acritarchs: Navifusa bacillum, Crameria pharaonis, Duvernaysphaera angelae				
WV-5-65	3336'	D	M	Gi	Acritarchs: N. bacillum; Stratigraphic location				
WV-5-67	3356'	D	M	Gi	Chitinozoans: Desmochitina parkerae, Huegisphaera glabra. Acritarchs: Multiplicisphaeri- dium Ramispinosum, Estiatera sp. N. bacillum, Polyedryxium decorium				

KEY
- D Devonian
- U Upper
- M Middle
- Fr Frasnian
- Gi Givetian

TABLE 15 (Continued)
Age

WV-5 Well

		FIRST CYCLE PALYNOMORPHS				SECOND CYCLE PALYNOMORPHS			
Mound No.	Depth	SYSTEM	SERIES	STAGE	RATIONALE	SYSTEM	SERIES	STAGE	RATIONALE
WV-5-70	3384'	D	M	Gi	Chitinozoans: <u>Desmochitina</u> <u>parkerae</u> <u>Ancyrochitina</u> <u>cornigera</u> <u>Ancyrochitna</u> cf. <u>A</u>. <u>devonica</u> Acritarchs: <u>Palacanthus</u> <u>ledanosii</u>, <u>Estiatera</u> sp. N. <u>bacillum</u>, <u>Polyedryxium</u> <u>decorum</u>, <u>Duvernaysphaera</u> <u>angelae</u>.				

Key
D - Devonian
M - Middle
Gi- Givetian

TABLE 16

Depositional Environment an istribution of Palynomorphs for the R-109 Well, Washington County, Ohio

			FIRST CYCLE PALYNOMORPHS											SECOND CYCLE PALYNOMORPHS		
			NONMARINE						RESTRICTED MARINE	MARINE						
MOUND NO.	DEPTH	NUMBER OF COUNTS	VASCULAR PLANT DEBRIS	MEGASPORES	SPORES WITH GRAPNEL PROCESSES	SACCATE POLLEN & SPORES	SPORES IN TETRADS	OTHER POLLEN AND SPORES	TASMANITES	LEIOSPHERES & SPHAEROMORPHS	ACRITARCHS	CHITINOZOANS	SCOLECODONTS	POLLEN AND SPORES	TASMANITES	ACHRITARCHS, CHITINOZOANS, SCOLECODONTS
R-109-1	3491'	300	46	0	t	3	t	27	10	9	4	0	t	1	0	0
R-109-2	3519'	300	49	0	t	2	0	21	4	12	12	0	0	t	0	0
R-109-3	3549'	300	22	0	t	2	0	16	37	16	5	0	0	0	2	0
R-109-5	3610'	200	1	0	0	0	0	t	98	0	1	0	0	0	t	0
R-109-7	3670'	200	5	0	t	1	0	2	86	4	2	0	0	0	0	0
R-109-8	3702'	300	56	t	1	1	t	22	1	3	15	0	t	t	t	t

t = trace (less than 1%)

TABLE 17

Depositional Environme and Distribution of Palynomorphs for the OH-1 Well, Carroll County, Ohio

			FIRST CYCLE PALYNOMORPHS											SECOND CYCLE PALYNOMORPHS		
			NONMARINE						RESTRICTED MARINE		MARINE					
Mound No.	Depth	NUMBER OF COUNTS	VASCULAR PLANT DEBRIS (1)	MEGASPORES	SPORES WITH GRAPNEL PROCESSES	SACCATE & ZONATE-POLLEN & SPORES	SPORES IN TETRADS	OTHER POLLEN AND SPORES	TASMANITES	LEIOSPHERES & SPHAEROMORPHS	ACITTRARCHS	CHITINOZOAMS (2)	SCOLECODONTS	POLLEN AND SPORES	TASMANITES	ACRITARCHS, CHITINOZOANS SCOLECODONTS
OH-1-1	2082'	300	40	t	t	1	0	21	2	11	25	0	t	t	0	0
OH-1-5	2198'	300	13	0	t	t	0	1	72	14	0	0	0	0	0	0
OH-1-6	3080'	200	3	0	0	0	0	.5	75	4	-	0	0	t	17.5	0
OH-1-10	3196'	300	22	0	0	0	0	1	2	29	42	3(2)	t	t(1)	0	0

t = trace (less than 1%)

(1) Much of the vascular plant debris (in First Cycle Palynomorphs) may be reworked.

(2) Fragments (>20um) and whole bodies

TABLE 18

Depositional Environment and Distribution of Palynomorphs

WV-5 [illegible] 1

			FIRST CYCLE PALYNOMORPHS												SECOND CYCLE PALYNOMORPHS	
			NONMARINE						RESTRICTED MARINE	MARINE						
MOUND NO.	DEPTH	NUMBER OF COUNTS	VASCULAR PLANT DEBRIS	MEGASPORES	SPORES WITH GRAPNEL PROCESSES	SACCATE & ZONATE POLLEN & SPORES	SPORES IN TETRADS	OTHER POLLEN AND SPORES	TASMANITES	LEIOSPHERES & SPHAEROMORPHS	ACRITARCHS	CHITINOZOANS	SCOLECODONTS	POLLEN AND SPORES	TASMANITES	ACHRITARCHS, CHITINOZOANS, SCOLECODONTS
WV-5-1	2705'	300	29	t	1	2	t	33	1	9	24	0	t	t	0	0
WV-5-4	2735'	200	6	0	0	0	0	t	91	3	0	0	0	0	0	0
WV-5-7	2768'	200	15	0	0	0	0	t	76	9	0	0	0	0	0	0
WV-5-10	2798'	300	13	0	t	t	t	t	81	6	t	0	t	0	0	0
WV-5-13	2826'	300	28	t	1	2	0	36	2	17	14	0	0	t	0	0
WV-5-16	2866'	300	34		t	4	t	30	2	23	7	0	0	t	0	0
WV-5-19	2894'	300	36	t	1	3	t	35	1	18	5	0	0	1	0	t
WV-5-22	2932'	200	1	0	0	0	0	0	97	2	0	0	0	0	0	0
WV-5-25	2962'	200	5	0	0	t	0	0	85	10	0	0	0	0	0	0
WV-5-28	2990'	200	2	0	0	t	t	0	88	6	0	3	1	0	0	0
WV-5-31	3020'	200	1	0	0	0	0	0	93	6	0	0	1	0	0	0
WV-5-34	3049'	300	5	0	t	t	0	14	17	48	16	t	t	0	0	0
WV-5-37	3079'	300	7	0	0	1	0	8	51	31	2	0	t	0	0	0
WV-5-40	3107'	300	7					t	7	10	3			70	3	1

TAB 8(Continued)

Depositional Environment and Distribution of Palynomorphs

WV-5 Well

			FIRST CYCLE PALYNOMORPHS											SECOND CYCLE PALYNOMORPHS		
			NONMARINE							RESTRICTED MARINE	MARINE					
MOUND NO.	DEPTH	NUMBER OF COUNTS	VASCULAR PLANT DEBRIS	MEGASPORES	SPORES WITH GRAPNEL PROCESSES	SACCATE & ZONATE POLLEN & SPORES	SPORES IN TETRADS	OTHER POLLEN AND SPORES	TASMANITES	LEIOSPHERES & SPHAEROMORPHS	ACRITARCHS	CHITINOZOANS	SCOLECODONTS	POLLEN AND SPORES	TASMANITES	ACHRITARCHS, CHITINOZOANS, SCOLECODONTS
WV-5-43	3137'	300	4	0	0	t	t	3	3	16	7			67		
WV-5-46	3157'	300	21		t	t	0	5	6	11	9	0	0	t	48	t
WV-5-49	3186'	300	27	t	t	1	t	10	2	19	32	0	t	t	8	?
WV-5-52	3216'	300	5	t	t	t	0	6	60	18	11	t	t	t	t	0
WV-5-55	3245'	300	31		t	t	0	6	9	27	22	0	0	t	4	
WV-5-58	3277'	300	10	t	t	4	0	7	67	10	2	0	0	t	t	
WV-5-62	3308'	300	15	0	t	t	0	4	52	25	2	0	0	t	tg	
WV-5-65	3336'	200	11	0	0	0	0	t	80	8	1	0	0	0		0
WV-5-67	3356'	300	4	0	0	0	0	t	61	27	7	t	t	0	t	0
WV-5-70	3384'	300	8	0	0	t	0	1	33	40	18	t	t	0	0	0

C. ORGANIC CARBON CONTENT RESULTS

The mean organic carbon content in weight percent for wells OH-2 and WV-5 is 0.71 and 1.33, respectively (Tables 19 and 20). This can be compared with the results from other Appalachian wells analyzed in the Devonian Shale study. Mean organic carbon content (in weight percent) for wells VA-1, KY-2, R-109 and OH-1 are 1.96, 2.04, 1.35, and 1.86, respectively.[5] Only one sample was analyzed from well OH-2. The results from WV-5 indicate significant and abrupt changes in the organic carbon content of the well profile. For example, samples WV-5-58, WV-5-59 and WV-5-60 have values of 0.54, 5.05 and 0.61, respectively. Thus the variation in the organic content of these thinly bedded shales is below the resolution of the 10 ft. sampling interval. The organic carbon content ranges from 0.02 to 6.74. The bottom 50 ft. of well WV-5 is organically rich. This interval has a mean value of 3.93, or nearly three times the well profile mean organic carbon content.

D. LITHOLOGIC DESCRIPTION

The lithology of the Devonian shales from wells OH-2 and WV-5 (Tables 19 and 20) is consistent with previously reported results. In general, samples are nearly 100% shale, non-calcareous, and fissile. Minor amounts of dolomite, micas, and pyrite are common.

E. VITRINITE REFLECTANCE ANALYSIS

Vitrinite reflectance results for OH-2 were limited to a single sample with only three readings (Table 21). The R_o value was 0.57. The well profile for WV-5 had a mean R_o value of 0.64 (Table 22). Over 60 samples were analyzed. The values vary with depth, however, an estimate can be made of the geothermal gradient at this site. These results are discussed in detail in a paper in preparation.

The mean R_o values for wells VA-1, KY-2, WV-5, R-109 and OH-1 are 1.02, 0.52, 0.64, 0.58, and 0.71, respectively. The results from WV-5 indicate a thermal maturation similar to that of KY-2, R-109, and OH-1. This is consistent with previous observations that VA-1, located in the southern regions of the Appalachian Basin, has experienced a different depositional setting and diagenetic history than the remaining sampled

TABLE 19

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-1		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	.18
WV-5-2		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	.17
WV-5-3		100% Shale, noncalcareous, slightly silty, slightly carbonaceous, micro-micaceous, fissile, hard, dark gray.	N3	2.16
WV-5-4		100% Shale, noncalcareous, slightly silty, slightly carbonaceous, micro-micaceous, fissile, hard, dark gray.	N3	1.84
WV-5-5		100% Shale, noncalcareous, slightly silty, gypsiferous, pyritic, blocky to fissile, hard, medium dark gray.	N4	.19; .22R
WV-5-6		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, dark gray to dusky yellowish brown.	N3 to 10YR 2/2	1.18

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-7		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, dark gray to dusky yellowish brown.	N3 to 10YR 2/2	.82
WV-5-8		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, dark gray to dusky yellowish brown.	N3 to 10YR 2/2	.46
WV-5-9		100% Shale, noncalcareous, slightly gypsiferous, fissile, moderately hard, medium dark gray.	N4	.14
WV-5-10		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, micro-micaceous, blocky to fissile, hard, medium dark gray.	N4	.31
WV-5-11		100% Shale, noncalcareous, gypsiferous, pyritic, fissile, hard, medium dark gray.	N4	.15
WV-5-12		100% Shale, noncalcareous, gypsiferous, pyritic, fissile, hard, medium dark gray.	N4	.17

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-13		100% Shale, noncalcareous, slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.10
WV-5-14		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, blocky, hard, medium dark gray to dark greenish gray.	N4 to 5GY 4/1	.10
WV-5-15		100% Shale, noncalcareous, gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.19 ;16R
WV-5-16		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, blocky to fissile, medium dark gray.	N4	.13
WV-5-17		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, moderately hard, dusky yellowish brown.	10YR 2/2	1.64
WV-5-18		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, slightly carbonaceous, fissile, hard, dusky yellowish brown.	10YR 2/2	1.85

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
~~WV-5~~-19		100% Shale, noncalcareous, slightly silty, gypsiferous, fissile, hard, medium dark gray.	N4	.13
WV-5-20		100% Shale, noncalcareous, slightly silty, gypsiferous, fissile, hard, medium dark gray.	N4	.12
WV-5-21		100% Shale, noncalcareous, slightly silty, fissile, hard, brownish black.	5YR 2/1	2.23
WV-5-22		100% Shale, noncalcareous, slightly silty, fissile, hard, dusky yellowish brown.	10YR 2/2	1.83
WV-5-23		100% Shale, noncalcareous, slightly silty, fissile, hard, dusky yellowish brown.	10YR 2/2	1.46
WV-5-24		100% Shale, noncalcareous, slightly gypsiferous, abundance of <u>Tasmanites</u> present, fissile, hard, dark gray to dusky yellowish brown.	N3 to 10YR 2/2	2.13

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-25		100% Shale, noncalcareous, silty, fissile, hard, brownish black.	5YR 2/1	1.82
WV-5-26		100% Shale, noncalcareous, silty, slightly gypsiferous, _Tasmanites_ present, fissile, hard, dusky yellowish brown.	10YR 2/2	2.30
WV-5-27		100% Shale, noncalcareous, slightly silty, gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.14; .15R
WV-5-28		100% Shale, noncalcareous, slightly silty, gypsiferous, blocky to fissile, hard, medium dark gray.	N4	1.47
WV-5-29		100% Shale, noncalcareous, silty, slightly gypsiferous, blocky to fissile, hard, brownish black.	5YR 2/1	1.06
WV-5-30		100% Shale, noncalcareous, silty, slightly gypsiferous, blocky to fissile, hard, brownish black.	5YR 2/1	.45

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-31		100% Shale, noncalcareous, silty, slightly gypsiferous, blocky to fissile, hard, brownish black. _Tasmanites_ associated.	5YR 2/1	2.96
WV-5-32		100% Shale, noncalcareous, silty, slightly gypsiferous, indurated, very hard, brownish black.	5YR 2/1	3.38
WV-5-33		100% Shale, noncalcareous, slightly silty, gypsiferous, blocky, hard, greenish gray.	5GY 5/1	.02
WV-5-34		100% Shale, noncalcareous, slightly silty, gypsiferous, blocky, hard, greenish gray.	5GY 5/1	.04
WV-5-35		100% Shale, noncalcareous, slightly silty, gypsiferous, blocky, hard, greenish gray.	5GY 5/1	.27
WV-5-36		100% Shale, noncalcareous, slightly silty, gypsiferous, fissile, hard, medium dark gray. Trace _Tasmanites_.	N4	.46

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-37		100% Shale, noncalcareous, slightly silty, gypsiferous, fissile, hard, medium dark gray. Trace *Tasmanites*.	N4	.11
WV-5-38		100% Shale, slightly dolomitic, slightly silty, slightly gypsiferous, blocky, hard, medium dark gray.	N4	.10; 08R
WV-5-39		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.50
WV-5-40		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.12
WV-5-41		100% Shale, noncalcareous, slightly gypsiferous, fissile, moderately hard, medium dark gray.	N4	.26
WV-5-42		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	2.29

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-43		100% Shale, slightly dolomitic, slightly silty, slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	2.72
WV-5-45		100% Shale, noncalcareous, gypsiferous, pyritic, blocky to fissile, hard, greenish gray.	5GY 5/1	.23; .25R
WV-5-46		100% Shale, noncalcareous, gypsiferous, fissile, hard, medium dark gray.	N4	.27
WV-5-47		100% Shale, very slightly dolomitic, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	1.31
WV-5-48		100% Shale, noncalcareous, slightly silty, gypsiferous, fissile, hard, medium dark gray.	N4	.04
WV-5-49		100% Shale, very slightly dolomitic, slightly silty, gypsiferous, fissile, hard, medium dark gray.	N4	.64

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-50		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	.51
WV-5-51		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	.67
WV-5-52		100% Shale, noncalcareous, slightly silty, slightly gypsiferous, fissile, hard, medium dark gray.	N4	.39
WV-5-53		100% Shale, very slightly dolomitic, very slightly silty, gypsiferous, blocky to fissile, moderately hard, medium gray.	N5	1.89
WV-5-54		100% Shale, noncalcareous, slightly silty, very slightly gypsiferous, very slightly carbonaceous, blocky to fissile, hard, brownish black.	5YR 2/1	5.49

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
~~WV-5~~-55		100% Shale, noncalcareous, very slightly silty, gypsiferous, blocky to fissile, moderately hard, medium dark gray.	N4	.27
WV-5-56		100% Shale, noncalcareous, very slightly silty, gypsiferous, blocky to fissile, moderately hard, medium dark gray.	N4	.42
WV-5-57		100% Shale, noncalcareous, very slightly silty, gypsiferous, blocky to fissile, moderately hard, medium dark gray.	N4	1.62
WV-5-58		100% Shale, noncalcareous, very slightly silty, gypsiferous, blocky to fissile, moderately hard, medium dark gray.	N4	.54
WV-5-59		100% Shale, noncalcareous, very slightly silty, very slightly gypsiferous, blocky to fissile, hard, brownish black.	5YR 2/1	5.05
WV-5-60		100% Shale, very slightly dolomitic, very slightly silty, slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.61

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-62		100% Shale, very slightly dolomitic, very slightly silty, slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	.48
WV-5-63		100% Shale, noncalcareous, silty, very slightly gypsiferous, blocky to fissile, hard, medium dark gray.	N4	5.70
WV-5-64		100% Shale, noncalcareous, very slightly silty, slightly gypsiferous, blocky to fissile, moderately hard, dark gray.	N3	.57
WV-5-65		100% Shale, noncalcareous, slightly silty, very slightly gypsiferous, blocky to fissile, hard, brownish black.	5YR 2/1	4.74
WV-5-66		100% Shale, noncalcareous, slightly silty, very slightly gypsiferous, blocky to fissile, hard, dark gray.	N3	6.17
WV-5-67		100% Shale, noncalcareous, slightly silty, very slightly gypsiferous, blocky to fissile, hard, dark gray.	N3	2.37

TABLE 19 (Continued)

Organic Carbon Analyses and Gross Lithological Description
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
WV-5-68		100% Shale, noncalcareous, slightly silty, very slightly gypsiferous, blocky to fissile, hard, dark gray.	N3	1.41; 1.37R
WV-5-69		100% Shale, dolomitic, slightly silty, very fossiliferous, fissile, hard, brownish black.	5YR 2/1	6.74
WV-5-70		100% Shale, noncalcareous, very slightly silty, slightly gypsiferous, blocky to fissile, moderately hard, medium dark gray.	N4	2.15

TABLE 20

Organic Carbon Analyses and Gross Lithological Description
for the OH-2 Well, Logan County, Ohio

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
OH-2-X		100% Shale, very calcareous grading to dolomitic, very slightly gypsiferous, blocky, very hard, dark gray.	N3	.71

TABLE 21

Vitrinite Reflectance Summary
for the OH-2 Well, Logan County, Ohio

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
OH-2-X	-	3	.42	.71	.57

TABLE 22

Vitrinite Reflectance Summary
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-1	2705'	50	.42	.98	.63
	(population 1)	30	.42	.63	.53
	(population 2)	20	.65	.98	.77
WV-5-2	2715'	15	.54	.99	.73
	(population 1)	2	.54	.58	.56
	(population 2)	13	.66	.99	.76
WV-5-3	2725'	56	.26	.81	.49
	(population 1)	30	.26	.49	.38
	(population 2)	26	.52	.81	.61
WV-5-4	2735'	42	.26	.74	.52
	(population 1)	14	.26	.47	.41
	(population 2)	28	.50	.74	.57
WV-5-5	2745'	14	.39	.71	.60
	(population 1)	4	.39	.52	.47
	(population 2)	10	.55	.71	.66
WV-5-6	2758'	17	.35	.85	.60
	(population 1)	14	.35	.62	.56
	(population 2)	3	.73	.85	.79

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-7	2768'	7	.44	.68	.53
	(population 1)	6	.44	.59	.51
	(population 2)	1	.68	.68	.68
WV-5-8	2778'	53	.34	.81	.60
	(population 1)	8	.34	.47	.42
	(population 2)	45	.50	.81	.63
WV-5-9	2788'	24	.49	.70	.59
WV-5-10	2798'	71	.38	.90	.64
	(population 1)	15	.38	.52	.47
	(population 2)	56	.56	.90	.68
WV-5-11	2808'	20	.43	.76	.56
	(population 1)	17	.43	.61	.53
	(population 2)	3	.70	.76	.73
WV-5-12	2816'	38	.37	.85	.51
	(population 1)	14	.37	.58	.49
	(population 2)	24	.60	.85	.68
WV-5-13	2826'	23	.44	.97	.74
	(population 1)	3	.44	.58	.51
	(population 2)	20	.63	.97	.77

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-14	2846'	12	.39	1.04	.72
	(population 1)	3	.39	.49	.43
	(population 2)	9	.66	1.04	.82
WV-5-15	2856'	17	.52	.82	.63
	(population 1)	13	.52	.65	.59
	(population 2)	4	.70	.82	.75
WV-5-16	2866'	37	.40	1.02	.66
	(population 1)	24	.40	.68	.54
	(population 2)	13	.70	1.02	.88
WV-5-17	2874'	40	.28	.86	.63
	(population 1)	15	.28	.57	.47
	(population 2)	25	.62	.86	.73
WV-5-18	2884'	54	.33	.81	.57
	(population 1)	38	.33	.63	.52
	(population 2)	16	.65	.81	.70
WV-5-19	2894'	27	.41	.91	.60
	(population 1)	8	.41	.52	.47
	(population 2)	19	.55	.91	.66

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-20	2904'	5	.35	.78	.51
	(population 1)	4	.35	.58	.44
	(population 2)	1	.78	.78	.78
WV-5-21	2914'	34	.30	.84	.53
	(population 1)	19	.30	.56	.43
	(population 2)	15	.60	.84	.66
WV-5-22	2932'	50	.28	.88	.57
	(population 1)	37	.28	.63	.51
	(population 2)	13	.68	.88	.76
WV-5-23	2942'	57	.38	.91	.58
	(population 1)	42	.38	.63	.52
	(population 2)	15	.65	.91	.73
WV-5-24	2952'	55	.28	.78	.56
	(population 1)	16	.28	.52	.46
	(population 2)	39	.53	.78	.60
WV-5-25	2962'	16	.28	.68	.49
	(population 1)	9	.28	.54	.37
	(population 2)	7	.60	.68	.64

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-26	2972'	29	.33	.76	.55
	(population 1)	13	.33	.54	.46
	(population 2)	16	.57	.76	.64
WV-5-27	2982'	25	.34	.92	.57
	(population 1)	13	.34	.54	.46
	(population 2)	12	.59	.92	.70
WV-5-28	2990'	20	.33	.72	.54
	(population 1)	12	.33	.57	.45
	(population 2)	8	.63	.72	.67
WV-5-29	3000'	52	.27	.89	.62
	(population 1)	11	.27	.45	.36
	(population 2)	41	.54	.89	.69
WV-5-30	3010'	49	.34	.90	.58
	(population 1)	18	.34	.53	.43
	(population 2)	31	.55	.90	.67
WV-5-31	3020'	51	.26	.75	.47
	(population 1)	35	.26	.52	.40
	(population 2)	16	.55	.75	.62
WV-5-32	3030'	85	.26	.82	.49
	(population 1)	59	.26	.52	.42
	(population 2)	26	.55	.82	.64

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-33	3040'	No Vitrinite	-	-	-
WV-5-34	3049'	No Vitrinite	-	-	-
WV-5-35	3059'	6	.47	.85	.67
	(population 1)	3	.47	.58	.51
	(population 2)	3	.81	.85	.83
WV-5-36	3069'	70	.30	.86	.62
	(population 1)	23	.30	.54	.44
	(population 2)	47	.60	.86	.71
WV-5-37	3079'	31	.33	.95	.63
	(population 1)	9	.33	.53	.41
	(population 2)	22	.56	.95	.71
WV-5-38	3089'	No Vitrinite			
WV-5-39	3099'	31	.35	.89	.56
	(population 1)	19	.35	.58	.47
	(population 2)	12	.60	.89	.69
WV-5-40	3107'	7	.58	1.13	.91
	(population 1)	2	.58	.64	.61
	(population 2)	5	.86	1.13	1.03

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-41	3117'	8	.67	1.06	.94
WV-5-42	3127'	59	.30	.88	.64
	(population 1)	19	.30	.57	.48
	(population 2)	40	.60	.88	.72
WV-5-43	3137'	16	.50	1.15	.90
	(population 1)	4	.50	.63	.58
	(population 2)	12	.79	1.15	1.01
WV-5-45	3145'	6	.52	1.02	.79
	(population 1)	1	.52	.52	.52
	(population 2)	5	.76	1.02	.84
WV-5-46	3157'	5	.40	1.03	.76
	(population 1)	2	.40	.65	.53
	(population 2)	3	.78	1.03	.92
WV-5-47	3166'	No Vitrinite	-	-	-
WV-5-48	3176'	7	.62	1.04	.90
	(population 1)	1	.62	.62	.62
	(population 2)	6	.82	1.04	.95
WV-5-49	3186'	No Vitrinite	-	-	-

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-50	3196'	31	.33	1.06	.68
	(population 1)	19	.33	.69	.57
	(population 2)	12	.70	1.06	.85
WV-5-51	3206'	44	.37	1.05	.70
	(population 1)	20	.37	.64	.50
	(population 2)	24	.71	1.05	.87
WV-5-52	3216'	19	.37	1.06	.62
	(population 1)	16	.37	.69	.55
	(population 2)	3	.92	1.06	.98
WV-5-53	3225'	8	.42	1.22	.79
	(population 1)	4	.42	.71	.54
	(population 2)	4	.83	1.22	1.04
WV-5-54	3235'	36	.55	.84	.71
WV-5-55	3245'	No Vitrinite	-	-	-
WV-5-56	3257'	12	.45	.89	.70
	(population 1)	7	.45	.68	.60
	(population 2)	5	.78	.89	.84
WV-5-57	3267'	22	.42	1.14	.70
	(population 1)	10	.42	.65	.51
	(population 2)	12	.71	1.14	.86

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-58	3277'	25	.39	.90	.73
	(population 1)	10	.39	.70	.62
	(population 2)	15	.75	.90	.81
WV-5-59	3287'	36	.48	.93	.68
	(population 1)	25	.48	.71	.62
	(population 2)	11	.75	.93	.84
WV-5-60	3297'	13	.49	.90	.80
	(population 1)	1	.49	.49	.49
	(population 2)	12	.72	.90	.83
WV-5-62	3308'	7	.44	.91	.64
	(population 1)	4	.44	.61	.51
	(population 2)	3	.75	.91	.81
WV-5-63	3316'	53	.44	.86	.61
	(population 1)	49	.44	.72	.59
	(population 2)	4	.75	.86	.80
WV-5-64	3225'	23	.44	.89	.73
	(population 1)	8	.44	.69	.60
	(population 2)	15	.75	.89	.80
WV-5-65	3336'	18	.47	.75	.58
	(population 1)	17	.47	.62	.57
	(population 2)	1	.75	.75	.75

TABLE 22 (Continued)

Vitrinite Reflectance Summary
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Depth (feet)	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
WV-5-66	3346'	15	.48	.91	.63
	(population 1)	13	.48	.71	.60
	(population 2)	2	.80	.91	.86
WV-5-67	3356'	16	.53	.73	.63
WV-5-68	3366'	49	.45	.90	.69
	(population 1)	47	.45	.82	.68
	(population 2)	2	.88	.90	.89
WV-5-69	3374'	69	.42	.92	.65
	(population 1)	66	.42	.83	.64
	(population 2)	3	.85	.92	.89
WV-5-70	3384'	13	.40	.70	.54

Appalachian wells.[5] Well OH-2 lies in the region of the Cincinnati Arch and is nearly due west of well OH-1. Any comparison of the R_o value from OH-2 with previous results from other studies would be questionable because of the lack of vitrinite at the OH-2 site.

F. KEROGEN: ELEMENTAL ANALYSIS

The three major factors which determine hydrocarbon potential are organic content, thermal maturation, and organic source. The latter two factors can be evaluated by the elemental analysis of kerogen.[6] Curve A in Figure 1 represents the thermal evolution path of marine organic sediments; C, non-marine. Curve B is organic sediment of an intermediate type. Elemental kerogen analysis is given for OH-1 and R-109 in Tables 23 and 24, respectively. Mean values for the H/C and O/C ratios from wells OH-1 and R-109 are plotted in Figure 1. The organic matter from both locations appears to be of the intermediate type. R-109 shale also appears more mature than OH-1 shale. This is probably the result of the greater depth of the R-109 shales (3500-3700 ft.) compared to OH-1 shales (200-3100-ft.). Previously reported mean vitrinite reflectance values for well OH-1, and R-109 were given as 0.71 and 0.58, respectively.[5] This apparent inconsistency may be due to the lack of vitrinite at R-109 limiting the accuracy of R_o values for samples from this well.

G. KEROGEN: VISUAL ASSESSMENT

The kerogen from 68 samples from the 2705 to 3325 foot interval of well WV-5, was visually analyzed to determine TAI (thermal alteration index) values (Figure 2). TAI values increase with increasing depth. This suggests a significant geothermal gradient exists at this well site. This conclusion is supported by the vitrinite reflectance results from these shales.

The organic matter was preserved in good to excellent condition. The particle size of this material varied from fine to coarse throughout the well profiles with no depth related trend. Visual assessment of the source of the organic material also suggest no depth related trend. The organic matter type varied abruptly from amorphous to woody. The presence of minor coaly debris is ubiquitous.

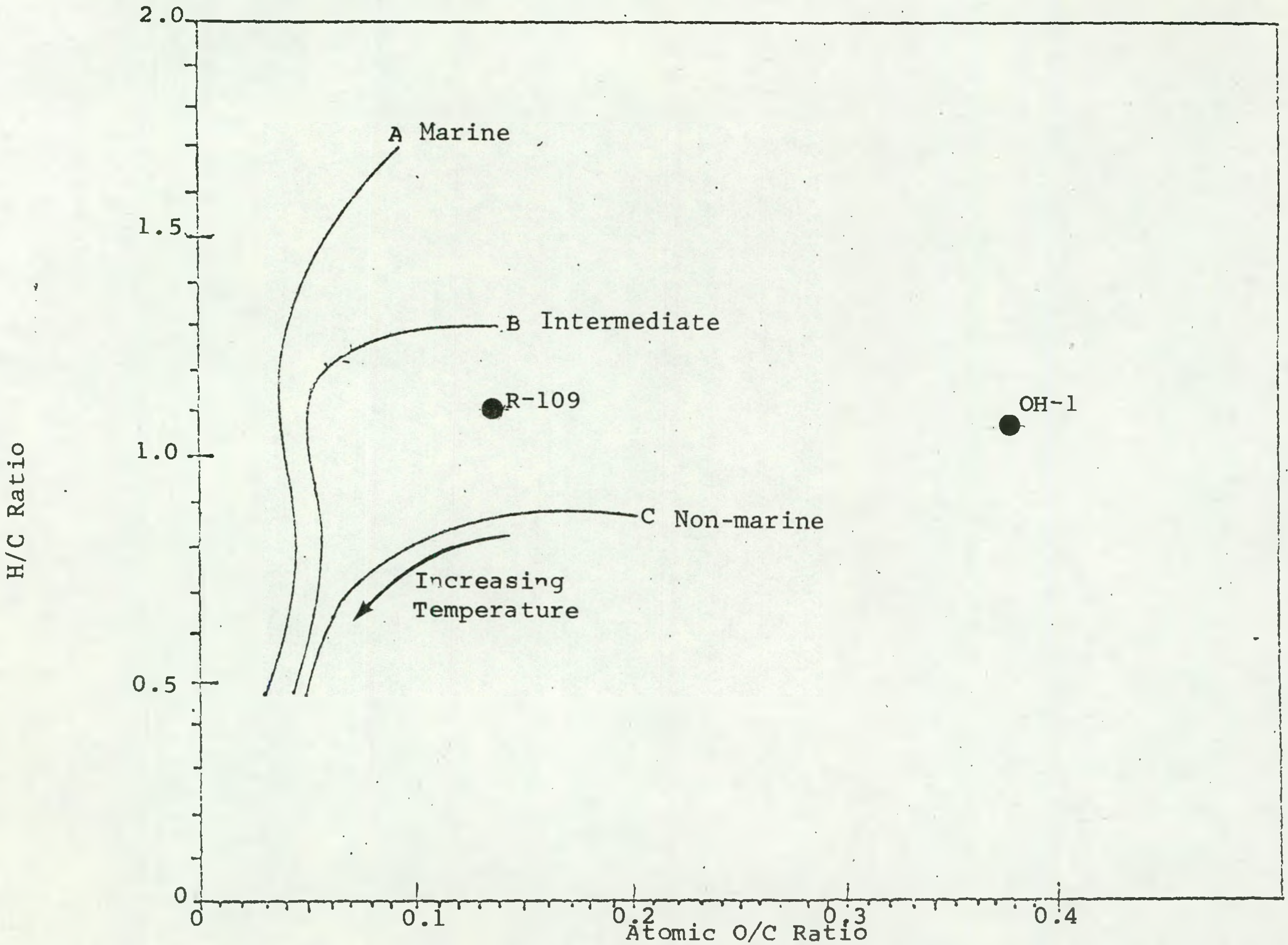


Figure 1 - Atomic ratio results (adapted from Tissot et al.[6]).

TABLE 23

Kerogen Composition
for the OH-1 Well, Carroll County, Ohio

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
OH-1-3	41.25	3.27	1.10	54.38	15.59	.94	.99
OH-1-5	68.02	6.68	2.39	22.91	23.36	1.17	.25
OH-1-6	72.85	7.08	1.82	18.25	17.26	1.16	.19
OH-1-7	79.83	7.19	2.47	10.51	18.94	1.07	.10

TABLE 24

Kerogen Composition
for the R-109 Well, Washington County, Ohio

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
R-109-4	77.28	6.51	1.87	14.33	13.01	1.00	.14
R-109-5	75.69	6.90	1.78	15.63	13.89	1.09	.16
R-109-7	77.92	7.82	1.37	12.89	16.23	1.20	.12

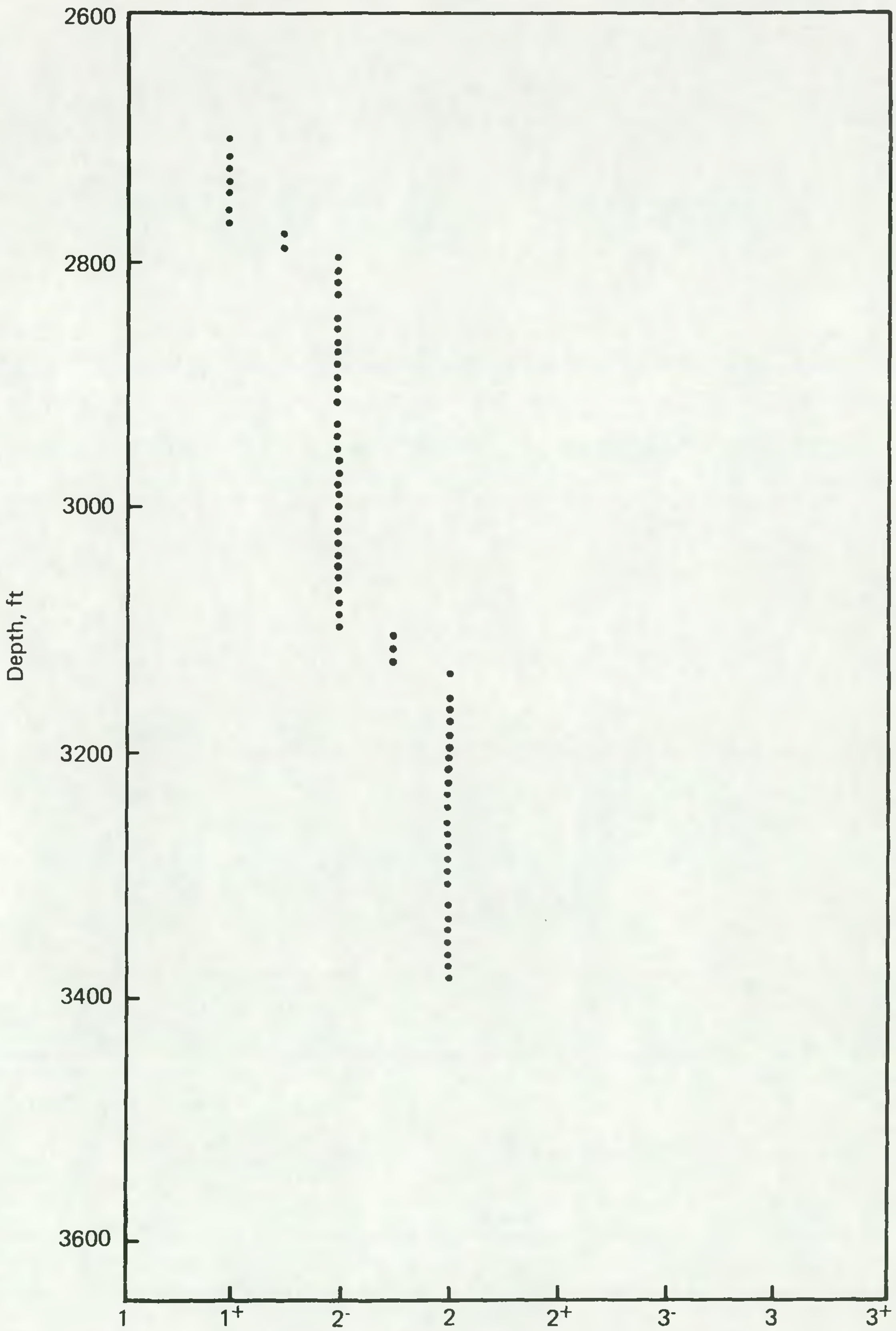


Figure 2

Dominant Stage of Thermal Alteration Index

for Shale Samples from WV-5 , Mason County, West Virginia

H. MINERALOGICAL RESULTS

Samples from wells O-1, P-1, I-2, I-3, and I-1 from the Illinois Basin and wells VA-1, KY-2, WV-5, R-109, OH-1, and OH-2, from the Appalachian Basin were selectively analyzed by x-ray and optical methods to determine mineral phase concentration, and clay mineralogy (Tables 25-54). For samples from the Illinois Basin the dominant mineral phase of these shales is clay. The clays, predominately illite, ranged from 50% to 80% of the shales. The presence of quartz is ubiquitous, ranging from 10% to 40% of the samples. The occurrence of pyrite is also common but does not exceed 12%. The optical methods indicate that organic content as well as dolomite are occasionally significant phases. For example, the organic phase is over 30% in samples from wells O-1 and I-1. Dolomite appears only to be important at well I-2. Three samples from this site had dolomite concentrations ranging from 25% to 50%. The lack of an adequate number of samples from each well, does not allow valid evaluation of the mineralogical properties versus depth.

The results for Appalachian Basin samples indicate the expected dominance of clay minerals. Illite generally accounts for 50% to 90% of the clay minerals present. Since kaolinite occurs in only minor amounts, chlorites and mixed layer clays account for the remaining fraction. The optical mineralogy results from VA-1, KY-2, and WV-5, demonstrate that the quartz content of the shales in the southern Appalachian Basin (10 to 20%) is less than the Illinois Basin shales (10% to 40%). Pyrite is commonly present but the contents are variable, exceeding 20% in some cases. Dolomite and calcite are minor constituents with isolated exceptions. For example, the single sample from well OH-2 contained 62.5% calcite as determined by final inspection. Organic content was less than 20% in VA-1 and KY-2, averaging 7.2 and 5.0, respectively. The range of organic content in WV-5 was $\sim$0% to 40% with a mean value of 10.5%. Results were not available for the optical mineralogical assessment of organic content for shale samples from OH-1, and R-109. Mean organic carbon content, determined by geochemical methods, for wells VA-1, KY-2, and WV-5 are 1.96, 2.04, and 1.33, respectively (values in weight percent). Thus estimating organic carbon content based on the visual appearance of the sample may be misleading.

TABLE 25

Point Count of Mineral Phases
for the O-1 Well, Christian County, Kentucky

Mound Sample Number	O-1-3
Percent Distribution (%)	
Clay Mineral	30.5
Muscovite	1
Quartz	16
Feldspar	
Calcite	
Dolomite	7
Siderite	
Pyrite	7.5
Chert	
Organic	38

TABLE 26

Identification of Mineral Phases by Optical Mineralogy for the O-1 Well, Christian County, Kentucky

Mound Sample Number	O-1-1	O-1-4
Clay Mineral	A	A
Muscovite	A	F
Quartz	A	A
Feldspar		
Calcite		
Dolomite	A	A
Siderite		
Pyrite	A	A
Chert		F
Organic	A	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 27

X-ray Identification of Mineral Phases
for the O-1 Well, Christian County, Kentucky

Mound Sample Number	O-1-1	O-1-4
Percent Distribution (%)		
Clay (10Å)	23	19
Clay (7Å)	0	0
Quartz (4.27Å)	33	38
Potassium Feldspar (4.24Å)	0	0
Sodium Feldspar (4.20Å)	13	15
Calcite (3.03Å)	0	0
Dolomite (2.89Å)	10	23
Siderite (2.79Å)	0	0
Pyrite (2.72Å)	20	4

TABLE 28

Point Count of Mineral Phases
for the P-1 Well, Sullivan County, Indiana

Mound Sample Number	P-1-1
Percent Distribution (%)	
Clay Mineral	83
Muscovite	
Quartz	11.5
Feldspar	
Calcite	
Dolomite	3
Siderite	
Pyrite	
Chert	
Organic	4

TABLE 29

Identification of Mineral Phases by Optical Mineralogy
for the P-1 Well, Sullivan County, Indiana

Mound Sample Number	P-1-1
Clay Mineral	D
Muscovite	S
Quartz	F
Feldspar	
Calcite	
Dolomite	R
Siderite	
Pyrite	R
Chert	S
Organic	S

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 30

X-ray Identification of Mineral Phases
for the P-1 Well, Sullivan County, Indiana

Mound Sample Number	P-1-1
Percent Distribution (%)	
Clay (10Å)	26
Clay (7Å)	29
Quartz (4.27Å)	26
Potassium Feldspar (4.24Å)	0
Sodium Feldspar (4.20Å)	18
Calcite (3.03Å)	0
Dolomite (2.89Å)	0
Siderite (2.79Å)	0
Pyrite (2.72Å)	0

TABLE 31

Point Count of Mineral Phases
for the I-2 Well, Henderson County, Illinois

Mound Sample Number	I-2-1	I-2-10	I-2-18
Percent Distribution (%)			
Clay Mineral	54	25.5	53
Muscovite			
Quartz	11.5	5	10
Feldspar			
Calcite			
Dolomite	32.5	54.5	26
Siderite			
Pyrite	0.5	11.5	2.5
Chert			
Organic	1.5	3	8.5

TABLE 32

Identification of Mineral Phases by Optical Mineralogy
for the I-2 Well, Henderson County, Illinois

Mound Sample Number	I-2-1	I-2-6	I-2-10	I-2-14	I-2-18
Percent Distribution (%)					
Clay Mineral	D	D	A	D	A
Muscovite					
Quartz	A	F	F	A	A
Feldspar					
Calcite					
Dolomite	A	A	A		A
Siderite					
Pyrite	F	F	A	F	F
Chert				S	
Organic	S	S	A	R	F

D-Dominant (50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (1%)

TABLE 33

X-ray Identification of Mineral Phases
for the I-2 Well, Henderson County, Illinois

Mound Sample Number	I-2-1	I-2-6	I-2-10	I-2-14	I-2-18
Percent Distribution (%)					
Clay (10Å)	14	15	22	30	28
Clay (7Å)	7	12	14	20	14
Quartz (4.27Å)	36	21	27	33	28
Potassium Feldspar (4.24Å)	7	21	14	7	6
Sodium Feldspar (4.20Å)	0	0	0	10	6
Calcite (3.03Å)	0	0	0	0	0
Dolomite (2.89Å)	29	29	24	0	19
Siderite (2.79Å)	0	0	0	0	0
Pyrite (2.72Å)	7	3	0	0	0

TABLE 34

X-ray Identification of Mineral Phases
for the I-3 Well, Tazewell County, Illinois

Mound Sample Number	I-3-4	I-3-14	I-3-17
Percent Distribution (%)			
Clay (10Å)	19	21	25
Clay (7Å)	13	14	14
Quartz (4.27Å)	29	36	36
Potassium Feldspar (4.24Å)	6	14	7
Sodium Feldspar (4.20Å)	0	0	7
Calcite (3.03Å)	0	0	0
Dolomite (2.89Å)	32	7	4
Siderite (2.79Å)	0	0	0
Pyrite (2.72Å)	0	7	7

TABLE 35

Point Count of Mineral Phases
for the I-1 Well, Effingham County, Illinois

Mound Sample Number	I-1-1	I-1-9
Percent Distribution (%)		
Clay Mineral	44	52
Muscovite		0.5
Quartz	16	5.5
Feldspar		
Calcite		
Dolomite		1
Siderite		
Pyrite	7	5.5
Chert		
Organic	33	35.5

TABLE 36

Identification of Mineral Phases by Optical Mineralogy for the I-1 Well, Effingham County, Illinois

Mound Sample Number	I-1-1	I-1-6	I-1-9
Clay Mineral	D	D	D
Muscovite			R
Quartz	A	A	F
Feldspar			
Calcite			
Dolomite		A	S
Siderite			
Pyrite	A	A	A
Chert		F	
Organic	A	A	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 37

X-ray Identification of Mineral Phases
for the I-1 Well, Effingham County, Illinois

Mound Sample Number	I-1-1	I-1-6	I-1-9
Percent Distribution (%)			
Clay (10Å)	27	16	31
Clay (7Å)	13	5	17
Quartz (4.27Å)	33	53	28
Potassium Feldspar (4.24Å)	0	5	0
Sodium Feldspar (4.20Å)	10	5	13
Calcite (3.03Å)	0	0	0
Dolomite (2.89Å)	0	11	6
Siderite (2.79Å)	0	0	0
Pyrite (2.72Å)	17	5	6

TABLE 38

Point Count of Mineral Phases
for the VA-1 Well, Wise County, Virginia

Mound Sample Number	VA-1-6	VA-1-17	VA-1-32
Percent Distribution (%)			
Clay Mineral	90	62	53
Muscovite	0.5	1.5	2
Quartz	4	14.5	12.5
Feldspar			
Calcite			
Dolomite			
Siderite		2	1.5
Pyrite	2.5	15.5	15
Chert			
Organic	3	4.5	14

TABLE 39

Identification of Mineral Phases by Optical Mineralogy
for the VA-1 Well, Wise County, Virginia

Mound Sample Number	VA-1-2	VA-1-6	VA-1-13	VA-1-17	VA-1-27	VA-1-32
Clay Mineral	D	D		D	D	D
Muscovite	F	R		R		S
Quartz	A	S	F	A	F	A
Feldspar						
Calcite	F					
Dolomite						
Siderite			D	S	S	S
Pyrite		S		A	A	A
Chert						
Organic	A	S	S	A	S	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 40

X-ray Identification of Mineral Phases
for the VA-1 Well, Wise County, Virginia

Mound Sample Number	VA-1-2	VA-1-6	VA-1-13	VA-1-17	VA-1-27	VA-1-32
Percent Distribution (%)						
Clay (10Å)	19	48	8	28	22	20
Clay (7Å)	5	10	8	16	13	10
Quartz (4.27Å)	48	24	8	31	43	50
Potassium Feldspar (4.24Å)	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	19	10	0	9	13	5
Calcite (3.03Å)	0	0	0	0	0	0
Dolomite (2.89Å)	5	0	0	0	0	0
Siderite (2.79Å)	0	5	77	3	4	5
Pyrite (2.72Å)	5	5	0	13	4	10

TABLE 41

Point Count of Mineral Phases
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-13	KY-2-18	KY-2-25	KY-2-27	KY-2-38	KY-2-50
Percent Distribution (%)						
Clay Mineral	19	41.5	88	52.5	71.5	59.5
Muscovite	6.5	1.5	1.5	8	2	5.5
Quartz	59	27.5	6	14	13	11.5
Feldspar						
Calcite	14	0.5				23.5
Dolomite				24		
Siderite						
Pyrite		11	1		6	
Chert						
Organic	1	17.5	3.5	1.5	7.5	

TABLE 41 (Continued)

Point Count of Mineral Phases
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-58	KY-2-66
Percent Distribution (%)		
Clay Mineral	87.5	52
Muscovite	1.5	
Quartz	9.5	20.5
Feldspar		
Calcite		
Dolomite		8.5
Siderite	1.5	
Pyrite		10
Chert		
Organic		9

TABLE 42

Identification of Mineral Phases by Optical Mineralogy
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-13	KY-2-18	KY-2-21	KY-2-25	KY-2-27	KY-2-29	KY-2-34
Clay Mineral	F	D	D	D	D	D	D
Muscovite	F	F	F	F	A		F
Quartz	D	A	A	F	A	F	A
Feldspar							
Calcite	A	R					S
Dolomite							
Siderite							
Pyrite	R	A	A	F	S	A	A
Chert							
Organic	F	A	A	F	F	A	A

D - Dominant (>50 %) A - Abundant (50-10%) F - Frequent (10-3%) S - Scarce (3-1%) R - Rare (<1 %)

TABLE 42 (Continued)

Identification of Mineral Phases By Optical Mineralogy
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-38	KY-2-42	KY-2-50	KY-2-54	KY-2-58	KY-2-62	KY-2-66
Clay Mineral	D	D	D	D	D	D	A
Muscovite	S	A	A	F	F	S	
Quartz	A	A	A	F	S	S	A
Feldspar							
Calcite	S	S	R	A			
Dolomite							F
Siderite					F		
Pyrite	A	F		A		F	A
Chert							
Organic	F	A	S	A	S	F	A

D - Dominant (>50%) A - Abundant (50-10%) F - Frequent (10-3%) S - Scarce (3-1%) R - Rare (<1 %)

TABLE 43

X-ray Identification of Mineral Phases
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-2	KY-2-6	KY-2-11	KY-2-13	KY-2-18	KY-2-21	KY-2-25	KY-2-27	KY-2-29
Percent Distribution (%)									
Clay (10A)	21	12	24	21	23	26	25	24	28
Clay (7A)	11	6	10	11	14	11	13	12	14
Quartz (4.27A)	53	59	48	53	45	37	31	40	34
Potassium Feldspar (4.24A)	0	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20A)	11	12	10	11	0	11	9	8	7
Calcite (3.03A)	0	0	0	0	0	0	0	0	0
Dolomite (2.89A)	0	6	0	5	0	4	0	12	0
Siderite (2.79A)	0	0	0	0	0	0	0	4	0
Pyrite (2.72A)	5	6	10	0	9	11	22	0	17

TABLE 43 (Continued)

X-ray Identification of Mineral Phases
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-34	KY-2-38	KY-2-42	KY-2-50	KY-2-54	KY-2-58	KY-2-62	KY-2-66
Percent Distribution (%)								
Clay (10A)	23	27	22	22	26	24	31	30
Clay (7A)	12	12	15	16	12	17	25	4
Quartz (4.27A)	38	38	37	31	29	34	31	43
Potassium Feldspar (4.24A)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20A)	12	12	7	9	9	10	13	9
Calcite (3.03A)	0	0	0	9	0	0	0	0
Dolomite (2.89A)	0	0	0	6	0	0	0	9
Siderite (2.79A)	0	0	0	6	0	14	0	0
Pyrite (2.72A)	15	12	19	0	24	0	0	4

TABLE 44

Point Count of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-2	WV-5-4	WV-5-6	WV-5-8	WV-5-10	WV-5-12	WV-5-14	WV-5-16
Percent Distribution (%)								
Clay Mineral	53.5	41.5	24	76.5	60.5	50	65.5	83
Muscovite		1	2.5	0.5	2		0.5	1.5
Quartz	14.5	15.5	35	6	18	21	18	8.5
Feldspar								
Calcite	1	0.5		0.5			12	
Dolomite								
Siderite			7					
Pyrite	18	22.5	13.5	9.5	10	13.5	3.5	2.5
Chert								
Organic	13	19	18	7	9.5	15.5	0.5	4.5

TABLE 44 (Continued)

Point Count of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-18	WV-5-20	WV-5-22	WV-5-24	WV-5-26	WV-5-28	WV-5-30	WV-5-32
Percent Distribution (%)								
Clay Mineral	62.5	73	19.5	53.5	51	38	80	34.5
Muscovite		1	2		0.5	0.5	0.5	1
Quartz	12.5	10.5	26	6	12	22.5	7.5	20.5
Feldspar						0.5		
Calcite			6			1		
Dolomite		6						
Siderite								
Pyrite	10.5	6.5	20	10	11.5		11.5	5.5
Chert			0.5					0.5
Organic	14.5	3	26.5	30.5	25	37.5		38

TABLE 44 (Continued)

Point Count of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-34	WV-5-36	WV-5-38	WV-5-40	WV-5-42	WV-5-45	WV-5-47	WV-5-49
Percent Distribution (%)								
Clay Mineral	71	66	54.5	89	71.5	78	86.5	83.5
Muscovite	2.5	1.5	0.5	1	1		0.5	0.5
Quartz	23,5	22.5	6.5	8	14	12	9	4
Feldspar								
Calcite	1		38	1		0.5	3	4.5
Dolomite								
Siderite								
Pyrite		2.5	0.5	1	6.5	9		6
Chert								
Organic	2	7.5			7	0.5	1	1

TABLE 44 (Continued)

Point Count of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-51	WV-5-53	WV-5-55	WV-5-57	WV-5-59	WV-5-62	WV-5-64	WV-5-66
Percent Distribution (%)								
Clay Mineral	65.5	78	91.5	85	46	86	81.5	51
Muscovite	3		1	2.5				
Quartz	28	18	7.5	8.5	14.5	6	11	3.5
Feldspar								
Calcite	1.5	0.5				0.5	2	0.5
Dolomite								
Siderite								
Pyrite	1	3		3.5	9	7	5	14.5
Chert								
Organic	1	0.5		0.5	30.5	0.5	1.5	30.5

TABLE 44 (Continued)

Point Count of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-68	WV-5-70
Percent Distribution (%)		
Clay Mineral	67	84.5
Muscovite		0.5
Quartz	10.5	0.5
Feldspar		
Calcite	1.5	
Dolomite		
Siderite		
Pyrite	12	12
Chert		
Organic	9	2.5

TABLE 45

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-1	WV-5-2	WV-5-3	WV-5-4	WV-5-5	WV-5-6	WV-5-7	WV-5-8	WV-5-9
Clay Mineral	D	D	D	D	D	A	A	D	D
Muscovite		R		R		S	S	S	
Quartz	F	A	A	A	S	A	A	F	R
Feldspar									
Calcite	S		R	R			R	R	
Dolomite									
Siderite	S					F			
Pyrite	A	A	A	A	A	A	A	A	S
Chert			R			R	S	R	
Organic	A	A	A	A	S	A	A	F	S

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-10	WV-5-11	WV-5-12	WV-5-13	WV-5-14	WV-5-15	WV-5-16	WV-5-17
Clay Mineral	D	D	D	D	D	D	D	A
Muscovite	S				R		R	S
Quartz	A	S	A	S	A	S	F	A
Feldspar								
Calcite					A	F		
Dolomite								
Siderite								
Pyrite	A	F-S	A	F	S	F	S	A
Chert								S
Organic	A	F-S	A	S	R	S	F	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-18	WV-5-19	WV-5-20	WV-5-21	WV-5-22	WV-5-23	WV-5-24	WV-5-25
Clay Mineral	D	D	D	A	A	D	A	D
Muscovite			S	S	S	S		S
Quartz	A	F	F	A	A	A	F	A
Feldspar		R						
Calcite					F			S
Dolomite			F					
Siderite								
Pyrite	A	A	F	A	A	A	A	A
Chert					R	R		R
Organic	A	F	S	A	A	A	A	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-26	WV-5-27	WV-5-28	WV-5-29	WV-5-30	WV-5-31	WV-5-32	WV-5-33
Clay Mineral	A	D	A	D	D	A	A	A
Muscovite	R	S	R		R	S	R	S
Quartz	F	F	A	A	F	A	A	A
Feldspar			R					
Calcite		S	R			S		A
Dolomite				S				
Siderite								
Pyrite	A	A	A	A	A	A	F	S
Chert							R	
Organic	A	R	A	A		A	A	S

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-34	WV-5-35	WV-5-36	WV-5-37	WV-5-38	WV-5-39	WV-5-40	WV-5-41
Clay Mineral	D	D	D	D	D	D	D	D
Muscovite	S	S	S	S	R	F	S	S
Quartz	A	A	A	A	F	A	F	A
Feldspar								
Calcite	S				A	F	S	
Dolomite								
Siderite								
Pyrite	S	F	A	A	F	S	S	S
Chert								
Organic	S	S	A	F	S	S	S	S

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-42	WV-5-43	WV-5-45	WV-5-46	WV-5-47	WV-5-48	WV-5-49	WV-5-50
Clay Mineral	D	D	D	D	D	D	D	D
Muscovite	S		S	S	S	S	R	S
Quartz	F	F	F	A	F	A	S	A
Feldspar								
Calcite		A	S	S	S	S	S	F
Dolomite								
Siderite								
Pyrite	A	A	A	S	S	F	F	F
Chert							R	
Organic	F	F	S	S	S	S	S	S

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-51	WV-5-52	WV-5-53	WV-5-54	WV-5-55	WV-5-56	WV-5-57	WV-5-58
Clay Mineral	D	D	D	A	D	D	D	D
Muscovite	S	S	S	S	S	S	S	S
Quartz	A	A	A	A	F	F	F	F
Feldspar								
Calcite	S	S	S	S				S
Dolomite								
Siderite								
Pyrite	S	F	F	A	F	S	A	A
Chert								
Organic	S	S	S	A	S	S	S	F

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5 59	WV-5-60	WV-5-62	WV-5-63	WV-5-64	WV-5-65	WV-5-66	WV-5-67
Clay Mineral	A	D	D	D	D	A	A	A
Muscovite	S	S	R	R	R	S	S	S
Quartz	F	F	S	F	F	F	S	S
Feldspar								
Calcite	S	S	F		S	F	S	S
Dolomite								
Siderite								
Pyrite	A	A	A		A	A	A	A
Chert					R	F		S
Organic	A	F	F	A	F	A	A	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 45 (Continued)

Identification of Mineral Phases by Optical Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-68	WV-5-69	WV-5-70
Clay Mineral	D	A	D
Muscovite	S		R
Quartz	F	F	R
Feldspar			
Calcite	F	A	
Dolomite			
Siderite			
Pyrite	A	A	A
Chert		S	
Organic	A	A	F

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 46

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-1	WV-5-2	WV-5-3	WV-5-4	WV-5-5	WV-5-6	WV-5-7	WV-5-8
Percent Distribution (%)								
Clay (10Å)	24	30	23	24	15	23	23	33
Clay (7Å)	16	17	14	12	12	15	14	20
Quartz (4.27Å) (*)	27(16)	33(13)	45(24)	40(14)	19(9)	38(16)	45(23)	33(10)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	5	3	5	4	0	8	5	0
Calcite (3.03Å)	0	0	0	0	0	0	0	0
Dolomite (2.89Å)	0	0	0	0	0	0	0	0
Siderite (2.79Å)	0	0	0	0	0	4	0	0
Pyrite (2.72Å)	19	10	5	12	38	12	9	3
Mixed Layer Clay (~11Å)	8	7	9	8	8	0	5	10

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-9	WV-5-10	WV-5-11	WV-5-12	WV-5-13	WV-5-14	WV-5-15	WV-5-16
Percent Distribution (%)								
Clay (10Å)	37	30	38	25	37	19	32	33
Clay (7Å)	22	19	23	17	22	11	18	17
Quartz (4.27Å) (*)	22(10)	37(13)	35(16)	42(16)	33(12)	37(17)	45(22)	33(13)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	0	0	0	4	4	7	0	7
Calcite (3.03Å)	0	0	0	0	0	11	0	0
Dolomite (2.89Å)	0	0	0	0	0	11	0	0
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	4	11	4	12	0	0	0	0
Mixed Layer Clay (~11Å)	15	4	0	4	7	4	5	10

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-17	WV-5-18	WV-5-19	WV-5-20	WV-5-21	WV-5-22	WV-5-23	WV-5-24
Percent Distribution (%)								
Clay (10Å)	30	30	29	29	21	21	25	27
Clay (7Å)	17	15	26	14	8	11	14	12
Quartz (4.27Å) (*)	33(17)	30(11)	32(16)	36(17)	42(19)	36(15)	36(20)	38(13)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	0	6	0	7	4	4	7	0
Calcite (3.03Å)	0	0	0	0	0	4	0	4
Dolomite (2.89Å)	0	0	0	4	0	7	0	4
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	10	9	3	4	17	11	11	7
Mixed Layer Clay (∿11Å)	10	9	10	7	8	7	7	7

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-25	WV-5-26	WV-5-27	WV-5-28	WV-5-29	WV-5-30	WV-5-31	WV-5-32
Percent Distribution (%)								
Clay (10Å)	28	27	31	24	29	31	27	26
Clay (7Å)	12	12	19	16	14	15	14	9
Quartz (4.27Å) (*)	40 (15)	38 (18)	38 (15)	40 (20)	36 (13)	38 (17)	45 (15)	43 (22)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	4	4	4	4	0	0	0	4
Calcite (3.03Å)	0	0	0	0	0	0	0	0
Dolomite (2.89Å)	0	0	0	0	4	0	0	0
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	8	7	0	12	11	8	9	9
Mixed Layer Clay (∿11Å)	8	12	7	4	7	8	5	9

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-33	WV-5-34	WV-5-35	WV-5-36	WV-5-37	WV-5-38	WV-5-39	WV-5-40
Percent Distribution (%)								
Clay (10Å)	27	29	29	24	30	22	31	32
Clay (7Å)	15	17	21	20	19	16	21	21
Quartz (4.27Å) (*)	38(18)	42(20)	36(17)	40(22)	37(13)	22(16)	34(14)	36(16)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	13	4	4	8	0	7	0	0
Calcite (3.03Å)	4	0	0	0	0	22	7	4
Dolomite (2.89Å)	0	0	0	0	0	2	0	0
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	0	0	4	4	7	2	0	0
Mixed Layer Clay (∿11Å)	4	8	7	4	7	7	7	7

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-41	WV-5-42	WV-5-43	WV-5-45	WV-5-46	WV-5-47	WV-5-48	WV-5-49
Percent Distribution (%)								
Clay (10Å)	34	30	26	30	34	30	34	27
Clay (7Å)	24	17	12	18	24	23	24	23
Quartz (4.27Å) (*)	34(13)	33(18)	29(12)	30(14)	34(14)	33(17)	34(15)	33(19)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	3	0	0	0	0	0	7	3
Calcite (3.03Å)	3	0	24	9	3	7	3	7
Dolomite (2.89Å)	0	0	3	0	0	0	0	0
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	0	10	3	6	0	0	0	0
Mixed Layer Clay (~11Å)	0	10	3	6	3	0	0	10

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-50	WV-5-51	WV-5-52	WV-5-53	WV-5-54	WV-5-55	WV-5-56	WV-5-57
Percent Distribution (%)								
Clay (10Å)	36	27	31	30	32	36	36	27
Clay (7Å)	18	19	22	19	16	21	21	21
Quartz (4.27Å) (*)	36(13)	38(21)	31(13)	37(15)	26(8)	9(12)	29(11)	30(15)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	0	4	6	4	3	4	7	0
Calcite (3.03Å)	4	0	3	4	0	0	0	6
Dolomite (2.89Å)	4	0	0	0	0	0	0	0
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	0	4	0	4	16	4	0	6
Mixed Layer Clay (~11Å)	4	7	6	4	6	4	7	9

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-58	WV-5-59	WV-5-60	WV-5-62	WV-5-63	WV-5-64	WV-5-65	WV-5-66
Percent Distribution (%)								
Clay (10Å)	32	30	36	26	33	38	32	28
Clay (7Å)	19	15	21	18	17	19	5	7
Quartz (4.27Å) (*)	26(9)	37(20)	25(10)	29(18)	33(11)	38(17)	45(15)	34(17)
Potassium Feldspar (4.24Å)	0	0	0	0	0	0	0	0
Sodium Feldspar (4.20Å)	3	4	4	0	0	0	0	0
Calcite (3.03Å)	10	0	7	15	0	0	0	0
Dolomite (2.89Å)	0	0	4	0	0	0	0	0
Siderite (2.79Å)	0	0	0	0	0	0	0	0
Pyrite (2.72Å)	6	7	4	6	10	4	9	17
Mixed Layer Clay (~11Å)	3	7	0	6	7	0	9	14

*Peak height in tenths of inch

TABLE 46 (Continued)

X-ray Identification of Mineral Phases
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-67	WV-5-68	WV-5-69	WV-5-70
Percent Distribution (%)				
Clay (10Å)	30	23	13	29
Clay (7Å)	7	12	9	13
Quartz (4.27Å) (*)	37(12)	38(22)	17(9)	32(13)
Potassium Feldspar (4.24Å)	0	0	0	0
Sodium Feldspar (4.20Å)	0	0	0	0
Calcite (3.03Å)	0	8	43	13
Dolomite (2.89Å)	0	4	4	0
Siderite (2.79Å)	0	0	0	0
Pyrite (2.72Å)	19	12	9	6
Mixed Layer Clay (~11Å)	7	4	4	6

*Peak height in tenths of inch

TABLE 47

Clay Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-1	WV-5-4	WV-5-7	WV-5-10	WV-5-13	WV-5-16	WV-5-19	WV-5-22
Percent Distribution								
Montmorillonite	0	0	0	0	0	0	0	0
Illite	71	54	68	71	73	73	82	63
Mixed-Layer	14	35	20	14	15	15	8	26
Kaolinite	3	3	0	5	4	5	3	5
Chlorite	12	8	12	10	8	7	7	6
Crystallinity (mm)	1.4	1.8	1.7	1.7	1.6	2.6	1.7	1.5
Sharpness Ratio	5.5	3.5	5.3	4.4	5.3	4.3	3.9	4.9
10Å Peak Height (mm)	93	46	58	83	105	56	90	44

TABLE 47 (Continued)

Clay Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-25	WV-5-28	WV-5-31	WV-5-34	WV-5-37	WV-5-40	WV-5-43	WV-5-46
Percent Distribution								
Montmorillonite	0	0	0	0	0	0	0	0
Illite	59	57	75	69	75	57	61	66
Mixed-Layer	33	29	15	17	10	32	31	22
Kaolinite	3	5	3	4	5	2	0	0
Chlorite	5	9	7	10	10	9	8	12
Crystallinity (mm)	1.5	1.8	1.4	2.0	1.7	1.5	1.8	1.4
Sharpness Ratio	5.4	3.9	4.3	3.2	4.4	4.3	4.5	4.7
10Å Peak Height (mm)	54	54	60	130	127	104	95	104

TABLE 47 (Continued)

Clay Mineralogy
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-47	WV-5-52	WV-5-55	WV-5-58	WV-5-62	WV-5-65	WV-5-67	WV-5-70
Percent Distribution								
Montmorillonite	0	0	0	0	0	0	0	0
Illite	61	68	61	70	71	75	73	66
Mixed-Layer	25	20	28	19	16	16	18	23
Kaolinite	0	0	0	0	0	0	0	0
Chlorite	14	12	11	11	13	9	9	11
Crystallinity (mm)	1.5	1.5	1.7	1.7	1.4	1.5	1.5	1.8
Sharpness Ratio	5.3	4.6	4.9	3.5	6.0	4.5	4.2	4.9
10Å Peak Height (mm)	117	117	142	106	127	45	46	69

TABLE 48

X-ray Identification of Mineral Phases
for the R-109 Well, Washington County, Ohio

Mound Sample Number	R-109-1	R-109-2	R-109-3	R-109-5	R-109-8
Percent Distribution (%)					
Clay (10Å)	30	23	27	26	28
Clay (7Å)	23	15	18	15	17
Quartz (4.27Å)	33	38	30	37	34
Potassium Feldspar (4.24Å)	0	0	0	0	0
Sodium Feldspar (4.20Å)	7	12	12	11	10
Calcite (3.03Å)	0	7	0	0	0
Dolomite (2.89Å)	7	4	6	0	7
Siderite (2.79Å)	0	0	0	0	0
Pyrite (2.72Å)	0	0	6	11	3

TABLE 49

Clay Mineralogy
for the R-109 Well, Washington County, Ohio

Mound Sample Number	R-109-1	R-109-2	R-109-3	R-109-5	R-109-8
Percent Distribution					
Montmorillonite	0	0	0	0	0
Illite	56	58	65	74	56
Mixed-Layer	33	30	24	13	33
Kaolinite	0	0	0	0	0
Chlorite	11	12	11	13	11
Crystallinity (mm)	1.6	1.2	1.7	1.8	1.7
Sharpness Ratio	4.3	5.4	5.6	5.7	4.1
10Å Peak Height (mm)	68	108	79	51	94

TABLE 50

X-ray Identification of Mineral Phases
for the OH-1 Well, Carroll County, Ohio

Mound Sample Number	OH-1-1	OH-1-5	OH-1-6	OH-1-10
Percent Distribution (%)				
Clay (10Å)	29	25	22	19
Clay (7Å)	26	13	9	12
Quartz (4.27Å)	26	32	43	23
Potassium Feldspar (4.24Å)	0	0	0	0
Sodium Feldspar (4.20Å)	11	10	13	4
Calcite (3.03Å)	0	0	0	38
Dolomite (2.89Å)	6	6	0	0
Siderite (2.79Å)	0	0	0	0
Pyrite (2.72Å)	3	13	13	4

TABLE 51

Clay Mineralogy
for the OH-1 Well, Carroll County, Ohio

Mound Sample Number	OH-1-1	OH-1-5	OH-1-6	OH-1-10
Percent Distribution				
Montmorillonite	0	0	0	0
Illite	74	85	89	50
Mixed-Layer	10	0	0	34
Kaolinite	0	0	0	0
Chlorite	16	15	11	16
Crystallinity (mm)	1.3	1.9	1.1	2.0
Sharpness Ratio	6.1	4.0	4.2	3.1
10Å Peak Height (mm)	116	48	67	93

TABLE 52

Point Count of Mineral Phases
for the OH-2 Well, Logan County, Ohio

Mound Sample No.	OH-2-X
Percent Distribution (%)	
Clay Mineral	
Muscovite	
Quartz	
Feldspar	
Calcite	62.5
Dolomite	
Siderite	
Pyrite	2.5
Chert	
Organic	35

TABLE 53

Identification of Mineral Phases by Optical Mineralogy
for the OH-2 Well, Logan County, Ohio

Mound Sample No.	OH-2-X
Clay Mineral	
Muscovite	
Quartz	
Feldspar	
Calcite	D
Dolomite	
Siderite	
Pyrite	
Chert	
Organic	A

D-Dominant (>50%) A-Abundant (50-10%) F-Frequent (10-3%) S-Scarce (3-1%) R-Rare (<1%)

TABLE 54

X-ray Identification of Mineral Phases
for the OH-2 Well, Logan County, Ohio

Mound Sample No.	OH-2-X
Percent Distribution (%)	
Clay (10Å)	7
Clay (7Å)	1
Quartz (4.27Å) (*)	7(6)
Potassium Feldspar (4.24Å)	0
Sodium Feldspar (4.20Å)	0
Calcite (3.03Å)	73
Dolomite (2.89Å)	7
Siderite (2.79Å)	0
Pyrite (2.72Å)	1
Mixed Layer Clay (~11Å)	2

*Peak height in tenths of inch

I. SEDIMENTATION STUDIES

Samples from the Illinois and Appalachian Basin wells were also analyzed to determine particle size distribution, expressed as 'ϕ' (Table 55), and the degree of preferred orientation of the shale minerals. This information will be useful for interpreting sedimentation rates and the environment of deposition. The following comments are based on a general preliminary investigation of the results.

Selected samples from Illinois Basin wells O-1, P-1, I-1, and I-2 were analyzed for particle size distribution (Tables 56-59). Median ϕ ranged from 6.7 to 9.0. No trends were apparent.

Appalachian Basin shales from VA-1 and KY-2 also exhibited a high degree of variability in the particle size distribution (Tables 60-61). However, median ϕ values were relatively less at the KY-2 well site. KY-2 samples indicate significant changes in particle size distribution with depth.

Shale samples from Appalachian Basin wells VA-1, KY-2, WV-5 and OH-2 as well as Illinois Basin wells O-1, P-1, I-1 and I-2 provided data for preferred orientation studies (Table 62-69). Most samples have 60% to 95% of the clay minerals and organic materials parallel to bedding. An exception is well I-1 which has a very high degree of preferred orientation (greater than 95%) throughout the well profile. Also, the clay minerals and organic material from approximately a 180 ft. section of WV-5 (samples WV-5-33 to WV-5-51) had a fair to poor degree of parallel bedding.

J. ELEMENTAL ANALYSIS

The major and minor element concentrations of shale samples from WV-5 and OH-2 are reported in Tables 70 and 73. Results for selected samples from O-1, P-1, I-1, I-2, I-3, VA-1, and KY-2 were reported previously.[1] These data indicate that major and minor element concentrations are related to the depositional environment and organic content. Preliminary results using thorium to uranium ratios, demonstrate a good correlation between these ratios and organic content. Even better predications of organic carbon content were achieved by using Th/U coupled with V/Ni data. The Th/U ratio method

TABLE 55

Size Grade Scales

Udden-Wentworth	"ϕ" Values
Very Fine Sand ——0.0625mm——	4
Coarse Silt ——0.0313mm——	5
Medium Silt ——0.0156mm——	6
Fine Silt ——0.0078mm——	7
Very Fine Silt ——0.0039mm——	8
Coarse Clay ——0.0020mm——	9
Medium Clay ——0.0010mm——	10
Fine Clay ——0.0005mm——	11

TABLE 56

Particle Size Distribution
for the O-1 Well, Christian County, Kentucky

Mound Sample Number	O-1-4
Cumulative Weight Percent Coarser Than ϕ (%)	
4ϕ	80.3
5ϕ	85.6
6ϕ	91.6
7ϕ	
8ϕ	
9ϕ	
10ϕ	
11ϕ	
Median ϕ	

TABLE 57

Particle Size Distribution
for the P-1 Well, Sullivan County, Indiana

Mound Sample Number	P-1-1
Cumulative Weight Percent Coarser Than (%)	
4 ϕ	0.6
5 ϕ	0.8
6 ϕ	2.7
7 ϕ	10.1
8 ϕ	34.0
9 ϕ	52.7
10 ϕ	83.3
11 ϕ	89.6
Median ϕ	8.8

TABLE 58

Particle Size Distribution
for the I-1 Well, Effingham County, Illinois

Mound Sample Number	I-1-1	I-1-9
Cumulative Weight Percent Coarser Than (%)		
4 ϕ	38.2	64.1
5 ϕ	39.6	67.6
6 ϕ	44.7	70.0
7 ϕ	53.0	72.5
8 ϕ	68.5	74.0
9 ϕ	73.7	76.0
10 ϕ	84.9	76.5
11 ϕ	89.7	77.1
Median ϕ	6.7	

TABLE 59

Particle Size Distribution
for the I-2 Well, Henderson County, Illinois

Mound Sample Number	I-2-1	I-2-10	I-2-18
Cumulative Weight Percent Coarser Than (%)			
4 ϕ	1.0	4.5	6.6
5 ϕ	0.5	9.2	7.8
6 ϕ	8.2	12.3	15.2
7 ϕ	20.0	27.8	32.9
8 ϕ	40.1	45.0	51.2
9 ϕ	49.6	56.4	60.7
10 ϕ	60.6	68.3	72.1
11 ϕ	70.9	77.2	77.5
Median ϕ	9.0	8.5	7.9

TABLE 60

Particle Size Distribution
for the VA-1 Well, Wise County, Virginia

Mound Sample Number	VA-1-6	VA-1-13	VA-1-32
Cumulative Weight Percent Coarser Than (%)			
4 ϕ	3.9	1.0	2.4
5 ϕ	9.3	1.3	2.1
6 ϕ	24.5	6.8	12.2
7 ϕ	45.9	25.0	29.7
8 ϕ	58.4	45.3	50.2
9 ϕ	65.7	60.8	61.7
10 ϕ	70.7	73.7	78.0
11 ϕ	75.0	84.7	85.0
Median ϕ	7.3	8.3	8.0

TABLE 61

Particle Size Distribution
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-11	KY-2-18	KY-2-25	KY-2-27	KY-2-38
Cumulative Weight Percent Coarser Than (%)					
4 ϕ	35.0	8.6	54.2	40.2	6.2
5 ϕ	43.5	15.9	59.8	47.0	5.7
6 ϕ	56.5	31.2	63.5	56.7	16.9
7 ϕ	70.3	52.1	71.3	69.3	36.2
8 ϕ	79.1	67.6	79.3	78.3	55.8
9 ϕ	84.8	76.3	84.8	84.0	63.8
10 ϕ	90.9	88.5	90.5	90.2	76.7
11 ϕ	95.3	93.9	93.9	93.0	85.4
Median ϕ	5.5	6.9		5.3	7.7

TABLE 62

Preferred Orientation of Minerals
for the VA-1 Well, Wise County, Virginia

Mound Sample Number	VA-1-2	VA-1-6	VA-1-13	VA-1-17	VA-1-27	VA-1-32
Orientation Parallel to Bedding						
Excellent						
Good	X	X		X	X	X
Fair						
Poor						
Random			X			

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	>95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	<30%

TABLE 63

Preferred Orientation of Minerals
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-13	KY-2-18	KY-2-21	KY-2-25	KY-2-27	KY-2-29	KY-2-34	KY-2-38	KY-2-42
Orientation Parallel to Bedding									
Excellent									
Good		X	X			X	X	X	X
Fair	X				X				
Poor									
Random				X					

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	>95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% 60 30%
Random:	<30%

TABLE 63 (Continued)

Preferred Orientation of Minerals
for the KY-2 Well, Martin County, Kentucky

Mound Sample Number	KY-2-50	KY-2-54	KY-2-58	KY-2-62	KY-2-66
Orientation Parallel to Bedding					
Excellent		X		X	
Good					
Fair	X		X		X
Poor					
Random					

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	>95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	<30%

TABLE 64

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-1	WV-5-2	WV-5-3	WV-5-4	WV-5-5	WV-5-6	WV-5-7	WV-5-8
Orientation Parallel to Bedding								
Excellent								
Good	X	X	X	X	X			
Fair						X	X	X
Poor								
Random								

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-9	WV-5-10	WV-5-11	WV-5-12	WV-5-13	WV-5-14	WV-5-15
Orientation Parallel to Bedding							
Excellent							X
Good	X	X	X	X	X		
Fair						X	
Poor							
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-16	WV-5-17	WV-5-18	WV-5-19	WV-5-20	WV-5-21	WV-5-22
Orientation Parallel to Bedding							
Excellent	X						
Good			X	X		X	
Fair		X			X		X
Poor							
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-23	WV-5-24	WV-5-25	WV-5-26	WV-5-27	WV-5-28	WV-5-29
Orientation Parallel to Bedding							
Excellent							
Good	X		X			X	X
Fair		X		X	X		
Poor							
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-30	WV-5-31	WV-5-32	WV-5-33	WV-5-34	WV-5-35	WV-5-36
Orientation Parallel to Bedding							
Excellent							
Good	X	X	X				
Fair					X		X
Poor				X		X	
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-37	WV-5-38	WV-5-39	WV-5-40	WV-5-41	WV-5-42	WV-5-43
Orientation Parallel to Bedding							
Excellent							
Good							
Fair	X			X		X	
Poor		X	X		X		X
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-45	WV-5-46	WV-5-47	WV-5-48	WV-5-49	WV-5-50	WV-5-51
Orientation Parallel to Bedding							
Excellent							
Good							
Fair				X	X		
Poor	X	X	X			X	X
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64(Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-52	WV-5-53	WV-5-54	WV-5-55	WV-5-56	WV-5-57	WV-5-58
Orientation Parallel to Bedding							
Excellent							
Good			X				X
Fair	X	X		X	X	X	
Poor							
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-59	WV-5-60	WV-5-62	WV-5-63	WV-5-64	WV-5-65	WV-5-66
Orientation Parallel to Bedding							
Excellent							
Good	X		X	X	X	X	X
Fair		X					
Poor							
Random							

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 64 (Continued)

Preferred Orientation of Minerals
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-67	WV-5-68	WV-5-69	WV-5-70
Orientation Parallel to Bedding				
Excellent				
Good	X		X	X
Fair		X		
Poor				
Random				

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 65

Preferred Orientation of Minerals
for the OH-2 Well, Logan County, Ohio

Mound Sample No.	OH-2-X
Orientation Parallel to Bedding	
Excellent	
Good	
Fair	
Poor	
Random	X

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 66

Preferred Orientation of Minerals
for the O-1 Well, Christian County, Kentucky

Mound Sample Number	O-1-1	O-1-4
Orientation Parallel to Bedding		
Excellent		
Good	X	X
Fair		
Poor		
Random		

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	30%

TABLE 67

Preferred Orientation of Minerals
for the P-1 Well, Sullivan County, Indiana

Mound Sample Number	P-1-1
Orientation Parallel to Bedding	
Excellent	
Good	X
Fair	
Poor	
Random	

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	>95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	<30%

TABLE 68

Preferred Orientation of Minerals
for the I-1 Well, Effingham County, Illinois

Mound Sample Number	I-1-1	I-1-6	I-1-9
Orientation Parallel to Bedding			
Excellent	X	X	X
Good			
Fair			
Poor			
Random			

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	>95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	<30%

TABLE 69

Preferred Orientation of Minerals
for the I-2 Well, Henderson County, Illinois

Mound Sample Number	I-2-1	I-2-6	I-2-10	I-2-14	I-2-18
Orientation Parallel to Bedding					
Excellent					
Good	X	X	X	X	
Fair					
Poor					
Random					X

Percent Clay Minerals and Organic Material Parallel to Bedding

Excellent:	>95%
Good:	95% to 80%
Fair:	80% to 60%
Poor:	60% to 30%
Random:	<30%

TABLE 70

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason Sounty, West Virginia

Mound Sample No.	WV-5-1	WV-5-2	WV-5-3	WV-5-4	WV-5-5	WV-5-6	WV-5-7	WV-5-8
Major Oxides (Wt. %)								
SiO_2	56.2	55.1	62.6	58.9	56.7	58.3	62.1	60.5
Al_2O_3	20.8	19.4	12.6	14.7	17.8	15.9	15.7	20.0
Fe_2O_3	7.24	8.74	6.50	7.47	9.77	9.80	7.10	6.76
MgO	2.23	2.09	1.50	1.76	1.81	1.83	1.77	2.05
CaO	.252	.274	.268	.376	.154	.453	.233	.208
Na_2O	.410	.364	.456	.362	.446	.519	.515	.514
K_2O	4.48	4.21	2.64	3.19	3.97	3.40	3.49	4.30
TiO_2	.881	.925	.710	.696	.870	.806	.740	.993
P_2O_5	.06	.09	.01	N.D.	.09	.07	.03	.06
MnO	.0860	.0321	.0248	.0302	.0270	.286	.148	.0382
Major Elements (Wt. %)								
S	.80	2.52	2.28	2.52	3.76	1.88	1.60	1.20

TABLE 70 (Continued)

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-9	WV-5-10	WV-5-11	WV-5-12	WV-5-13	WV-5-14	WV-5-15	WV-5-16
Major Oxides (Wt. %)								
SiO_2	58.9	60.5	69.0	50.2	62.1	57.8	58.9	62.0
Al_2O_3	21.9	18.9	14.8	18.7	17.8	14.9	20.2	19.6
Fe_2O_3	6.17	7.73	4.36	13.1	10.2	5.40	6.00	5.10
MgO	2.07	1.63	1.48	1.80	2.26	2.24	1.98	1.82
CaO	.207	.154	.190	.137	.891	3.05	.725	.170
Na_2O	.369	.497	.652	.392	.463	.502	.419	.536
K_2O	4.78	3.95	3.04	4.15	3.82	3.26	4.34	4.25
TiO_2	1.03	1.00	.851	.924	.844	.861	.933	1.01
P_2O_5	.03	.04	.08	.03	.07	N.D.	.03	.06
MnO	.0505	.0304	.0244	.0375	.225	.0751	.0819	.0311
Major Elements (Wt. %)								
S	.44	2.24	.48	5.96	.16	.44	.68	.48

TABLE 70 (Continued)

Chemical Composition
Major Oxides and Elements
for WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-17	WV-5-18	WV-5-19	WV-5-20	WV-5-21	WV-5-22	WV-5-23	WV-5-24
Major Oxides (Wt. %)								
SiO_2	57.8	60.5	62.1	60.5	64.7	60.5	59.9	57.2
Al_2O_3	18.9	16.8	19.6	20.4	13.3	13.4	15.2	16.5
Fe_2O_3	7.48	5.79	5.73	5.78	5.41	7.20	5.68	6.52
MgO	1.83	1.79	1.74	2.07	1.47	1.80	1.67	1.69
CaO	.132	.308	.296	.507	.311	1.57	.268	.247
Na_2O	.430	.464	.481	.484	.527	.521	.437	.515
K_2O	4.01	3.79	4.36	4.45	2.96	2.89	3.39	3.73
TiO_2	.795	.728	.957	.964	.633	.731	.696	.691
P_2O_5	N.D.	.05	.06	.10	.03	N.D.	N.D.	.04
MnO	.0522	.0259	.0922	.0593	.0217	.0428	.0248	.116
Major Elements (Wt. %)								
S	1.96	1.48	.56	.20	1.68	2.44	1.48	1.48

TABLE 70 (Continued)

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-25	WV-5-26	WV-5-27	WV-5-28	WV-5-29	WV-5-30	WV-5-31	WV-5-32
Major Oxides (Wt. %)								
SiO_2	58.9	59.3	59.9	56.2	56.2	55.6	54.6	58.9
Al_2O_3	14.7	14.6	15.4	16.7	15.5	14.0	13.8	12.2
Fe_2O_3	7.60	6.27	6.38	8.07	8.17	8.51	6.87	5.99
MgO	1.66	1.71	1.93	1.87	1.60	1.60	1.49	1.28
CaO	.449	.661	1.90	.783	.278	.702	238	239
Na_2O	.489	.475	.382	.415	.455	.474	.343	.311
K_2O	3.35	3.22	3.40	3.64	3.41	3.14	3.06	2.65
TiO_2	.700	.681	.752	.793	.681	.719	.657	.604
P_2O_5	N.D.	.02	N.D.	N.D.	N.D.	.01	N.D.	N.D.
MnO	.272	.0311	.229	.298	.281	.0527	.225	.209
Major Elements (Wt. %)								
S	1.72	1.92	.60	1.44	2.16	3.68	1.72	1.44

TABLE 70(Continued)

Chemical Composition
Major Oxides and Elements
for WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-33	WV-5-34	WV-5-35	WV-5-36	WV-5-37	WV-5-38	WV-5-39	WV-5-40
Major Oxides (Wt. %)								
SiO_2	59.9	61.0	56.7	59.1	61.5	50.5	55.6	55.3
Al_2O_3	17.0	18.3	18.2	16.9	15.4	15.9	15.1	18.7
Fe_2O_3	4.67	4.96	7.24	6.97	7.53	5.76	10.2	6.46
MgO	1.87	1.97	1.98	1.86	1.68	1.98	1.83	2.09
CaO	1.03	.323	.380	.255	.245	6.79	.844	1.09
Na_2O	.470	.321	.466	.605	.534	.325	.470	.375
K_2O	3.58	3.83	3.85	3.61	3.20	3.54	3.00	4.18
TiO_2	.887	.940	.937	.820	.793	.753	.785	.860
P_2O_5	.04	N.D.	N.D.	.02	.02	.10	.06	.05
MnO	.0454	.0554	.156	.201	.0320	.142	.0522	.110
Major Elements (Wt. %)								
S	.12	.04	1.08	.92	2.36	.12	3.60	.06

TABLE 70(Continued)

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-41	WV-5-42	WV-5-43	WV-5-45	WV-5-46	WV-5-47	WV-5-48	WV-5-49
Major Oxides (Wt. %)								
SiO_2	55.3	57.3	49.8	54.2	58.0	57.3	60.1	57.3
Al_2O_3	19.8	17.7	14.8	15.0	17.9	17.6	17.1	17.1
Fe_2O_3	6.54	7.46	8.54	9.90	6.14	6.52	5.77	6.90
MgO	2.4	1.95	1.76	1.88	2.18	2.21	1.97	2.24
CaO	.64	.352	5.35	1.66	1.28	1.66	.750	1.90
Na_2O	.501	.634	.438	.582	.540	.558	.667	.504
K_2O	4.50	3.98	3.52	3.43	4.27	4.08	3.87	3.85
TiO_2	.923	.812	.631	.750	.853	.877	.892	.828
P_2O_5	.05	.03	N.D.	.04	.07	.09	.07	.09
MnO	.0915	.0283	.0724	.0489	.0627	.114	.114	.157
Major Elements (Wt. %)								
S	.04	1.04	3.16	3.52	.08	.04	.08	.04

TABLE 70(Continued)

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-50	WV-5-51	WV-5-52	WV-5-53	WV-5-54	WV-5-55	WV-5-56	WV-5-57
Major Oxides (Wt. %)								
SiO_2	57.3	59.1	59.4	56.7	51.1	59.5	60.9	56.1
Al_2O_3	16.1	17.1	14.6	16.4	15.6	18.0	17.6	15.4
Fe_2O_3	9.02	7.64	6.51	8.24	8.40	6.75	6.22	8.01
MgO	1.76	1.96	2.01	2.01	1.90	2.13	2.03	1.96
CaO	.632	.379	2.11	1.26	.354	.545	.938	1.36
Na_2O	.586	.586	.669	.625	.498	.571	.480	.412
K_2O	3.63	3.95	3.42	3.81	3.67	4.40	4.26	3.64
TiO_2	.820	.861	.863	.801	.743	.750	.770	.646
P_2O_5	.04	.07	.06	.03	N.D.	.04	.30	.06
MnO	.361	.177	.240	.199	.0842	.155	.174	.159
Major Elements (Wt. %)								
S	1.36	1.16	.16	1.44	2.36	.08	.08	1.40

TABLE 70 (Continued)

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-58	WV-5-59	WV-5-60	WV-5-62	WV-5-63	WV-5-64	WV-5-65	WV-5-66
Major Oxides (Wt. %)								
SiO_2	54.7	58.5	54.5	51.3	57.1	55.4	56.8	58.9
Al_2O_3	17.4	15.6	17.5	16.5	16.2	18.4	12.5	13.8
Fe_2O_3	7.68	7.34	7.03	8.69	7.99	7.14	4.53	7.40
MgO	2.00	1.81	2.10	2.00	1.86	1.92	1.32	1.39
CaO	1.60	.350	2.10	1.90	.732	.679	.549	.651
Na_2O	.474	.617	.408		.480	.539	.353	.344
K_2O	4.15	3.66	4.15		3.88	4.38	2.89	3.36
TiO_2	.709	.669	.684		.613	.671	.484	.492
P_2O_5	.02	.05	.04		.05	.04	.04	.04
MnO	.162	.167	.129		.196	.130	.0741	.168
Major Elements (Wt. %)								
S	1.48	1.64	1.24		1.96		1.40	2.60

TABLE 70 (Continued)

Chemical Composition
Major Oxides and Elements
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-67	WV-5-68	WV-5-69	WV-5-70
Major Oxides (Wt. %)				
SiO_2	60.6	56.8	40.4	55.1
Al_2O_3	13.8	13.7	11.7	16.6
Fe_2O_3	5.72	9.33	5.78	5.59
MgO	1.41	1.63	1.49	1.76
CaO	.310	1.39	9.66	1.72
Na_2O	.361	.360	.199	.453
K_2O	3.51	3.52	3.26	4.09
TiO_2	.530	.540	.494	.579
P_2O_5	.04	.04	.12	.10
MnO	.0902	.475	.145	.105
Major Elements (Wt. %)				
S	2.20	1.12	2.24	1.48

TABLE 71

Chemical Composition
Major Oxides and Elements
for the OH-2 Well, Logan County, Ohio

Mound Sample No.	OH-2-X
Major Oxides (Wt. %)	
SiO_2	31.1
Al_2O_3	7.34
Fe_2O_3	3.41
MgO	1.80
CaO	21.8
Na_2O	.114
K_2O	1.83
TiO_2	.379
P_2O_5	.11
MnO	.0971
Major Elements (Wt. %)	
S	.68

TABLE 72

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-1	WV-5-2	WV-5-3	WV-5-4	WV-5-5	WV-5-6	WV-5-7
Minor and Trace Elements (PPM)							
Be	2.6	2.6	1.8	2.2	2.3	3.3	3.3
B							
Sc	15	15	10	10	15	15	15
V	155	171	120	132	137	143	136
Cr	125	95.9	78.7	77.4	81.3	282	175
Co	16	26	20	19	24	29	24
Ni	47	52	50	46	40	127	85
Cu	24.1	29.7	31.3	31.0	22.6	59.1	41.7
Zn	61	134	212	52	73	98	75
Ga	20	15	10	15	20	10	15
Ge	20	20	20	20	20	20	20
As	9	4	4	5	4	8	5
Se	5	5	5	5	5	5	5
Rb	200	180	140	130	190	180	170
Sr	110	143	73.3	76.7	160	107	93.3
Zr	118	121	102	100	113	122	110
Mo	N.D.	N.D.	39	39	N.D.	56	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	5	5	3	4	3	5	8
Sb	1	1	1	1	1	1	1
Cs	22	22	12	16	26	24	20
Ba	637	487	507	355	406	437	518
La	50	50	100	50	100	100	100
Ce	160	160	160	160	160	160	160
Hf	40	40	40	40	40	40	40
Ta	65	65	65	65	65	65	65
W	4	4	4	4	4	8	8
Au	.02	.02	.02	.02	.02	.02	.02
Pb	N.D.	20	N.D.	N.D.	N.D.	20	25
Th	6	8	N.D.	N.D.	7	N.D.	N.D.
U	3.2	6.0	10	9.2	4.0	13	7.4
Cl	140	140	140	280	430	210	140
F	760	656	584	640	608	640	34

TABLE 72 (Continued)

Elemental Composition
for the WV-5 Well, Mason County; West Virginia

Mound Sample No.	WV-5-8	WV-5-9	WV-5-10	WV-5-11	WV-5-12	WV-5-13	WV-5-1
Minor and Trace Elements (PPM)							
Be	2.6	2.6	2.4	1.7	2.6	2.4	1.9
B							
Sc	20	15	20	15	15	15	15
V	160	168	149	104	165	141	116
Cr	96.3	100	90.1	83.7	97.8	141	86.5
Co	21	17	26	12	34	22	13
Ni	43	38	49	25	67	49	35
Cu	24.3	27.3	26.2	18.9	34.5	36.2	21.5
Zn	94	51	78	65	922	97	73
Ga	20	20	20	15	20	15	10
Ge	20	20	20	20	20	20	20
As	6	5	4	6	40	13	3
Se	5	5	5	5	5	5	5
Rb	200	210	190	160	190	180	170
Sr	207	277	200	110	263	180	160
Zr	131	133	137	119	123	112	130
Mo	N.D.	N.D.	N.D.	N.D.	39	N.D.	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	3	3	8	1	5	3	1
Sb	1	1	1	1	1	1	1
Cs	24	26	22	16	36	24	18
Ba	673	706	510	498	441	607	464
La	100	70	50	70	100	50	70
Ce	160	160	160	160	160	160	160
Hf	40	40	40	40	40	40	40
Ta	65	65	65	65	65	65	65
W	8	4	4	4	4	4	4
Au	.02	.02	.02	.02	.02	.02	.02
Pb	20	N.D.	N.D.	N.D.	10	N.D.	N.D.
Th	12	13	12	N.D.	14	10	8
U	8.2	3.6	4.8	2.8	12	2.6	4.0
Cl	780	990	140	430	690	430	780
F	572	728	736	680	692	848	640

TABLE 72 (Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-15	WV-5-16	WV-5-17	WV-5-18	WV-5-19	WV-5-20
Minor and Trace Elements (PPM)						
Be	2.4	2.4	2.4	2.7	2.5	2.8
B						
Sc	15	20	20	10	15	20
V	166	5	172	161	161	164
Cr	118	92.0	109	88.3	137	103
Co	17	22	29	26	27	21
Ni	47	37	97	82	55	31
Cu	30.7	27.1	34.2	41.6	34.0	24.5
Zn	50	59	74	163	98	75
Ga	20	20	20	10	15	20
Ge	<20	<20	<20	<20	<20	<20
As	6	5	4	3	8	7
Se	<5	<5	<5	5	5	<5
Rb	200	210	210	200	230	240
Sr	220	230	153	116	226	199
Zr	123	132	114	112	132	132
Mo	N.D.	N.D.	5	85	N.D.	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	5	1	4	3	8	3
Sb	<1	<1	<1	<1	<1	<1
Cs	26	22	26	30	36	34
Ba	705	684	563	427	654	654
La	100	100	100	100	100	50
Ce	<160	<160	<160	<160	<160	<160
Hf	<40	<40	<40	<40	<40	<40
Ta	<65	<65	<65	<65	<65	<65
W	4	4	12	4	8	4
Au	<.02	<.02	<.02	<.02	<.02	<.02
Pb	N.D.	N.D.	25	15	N.D.	N.D.
Th	8	10	N.D.	10	15	16
U	5.2	6.4	6.8	9.2	6.4	4.6
Cl	780	280	140	710	990	710
F	668	240	612	740	704	304

TABLE 72(Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-21	WV-5-22	WV-5-23	WV-5-24	WV-5-25	WV-5-26	WV-5-27	WV-5-28
Minor and Trace Elements (PPM)								
Be	2.0	2.2	2.3	2.3	2.3	2.3	2.3	2.2
B								
Sc	10	10	10	10	10	10	15	10
V	126	122	138	151	145	135	113	132
Cr	76.8	84.5	86.3	156	261	87.1	212	284
Co	31	35	32	25	29	29	20	28
Ni	46	74	61	75	104	76	82	124
Cu	37.0	46.4	45.8	48.0	66.2	47.5	31.6	53.2
Zn	36	59	89	123	105	78	60	81
Ga	10	10	10	10	10	15	10	10
Ge	<20	<20	<20	<20	<20	<20	<20	<20
As	5	8	4	3	3	4	2	6
Se	5	5	5	5	<5	<5	<5	<5
Rb	170	170	210	210	190	190	170	170
Sr	78.9	92.2	98.9	106	85.5	85.6	139	136
Zr	95	121	104	105	108	106	128	114
Mo	51	99	51	51	50	50	11	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	10	9	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	3	3	5	5	3	4	5	3
Sb	<1	<1	<1	<1	<1	<1	<1	<1
Cs	26	26	30	32	34	28	20	32
Ba	390	299	477	458	439	236	531	576
La	70	70	50	50	50	70	70	50
Ce	<160	<160	<160	<160	<160	<160	<160	I.S.
Hf	<40	<40	<40	<40	<40	<40	<40	I.S.
Ta	<65	<65	<65	<65	<65	<65	<65	I.S.
W	4	4	4	4	4	8	4	4
Au	<.02	<.02	<.02	<.02	<.02	<.02	<.02	<.02
Pb	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Th	7	8	7	7	N.D.	N.D.	8	N.D.
U	12	15	11	11	.9	12	3.2	6.6
Cl	1300	1600	2100	280	990	1600	1900	990
F	608	584	600	648	732	728	672	640

TABLE 72 (Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-29	WV-5-30	WV-5-31	WV-5-32	WV-5-33	WV-5-34	WV-5-35	WV-5-36
Minor and Trace Elements (PPM)								
Be	2.3	2.0	2.3	2.3	2.2	2.5	2.4	2.3
B								
Sc	10	10	15	15	20	20	15	20
V	139	108	134	157	131	133	141	151
Cr	207	92.7	167	216	91.6	104	183	213
Co	37	37	27	20	16	17	32	26
Ni	107	62	96	104	32	38	83	85
Cu	69.4	40.7	68.1	72.3	24.4	8.9	27.2	65.7
Zn	86	74	126	100	59	66	70	61
Ga	15	10	10	10	15	15	10	10
Ge	<20	<20	<20	<20	<20	<20	<20	<20
As	4	5	4	3	1	2	5	6
Se	<5	<5	<5	5	<5	<5	<5	5
Rb	190	160	160	140	170	200	200	170
Sr	106	106	82.2	72.2	166	186	182	137
Zr	109	113	100	96	132	141	135	123
Mo	85	32	103	190	N.D.	N.D.	N.D.	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	9	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	8	4	3	1	1	1	3	3
Sb	<1	<1	<1	<1	1	1	1	1
Cs	28	28	24	22	24	26	38	44
Ba	546	456	528	457	611	771	707	635
La	50	50	70	70	70	100	70	50
Ce	<160	<160	<160	<160	160	160	160	160
Hf	<40	<40	<40	<40	40	40	40	40
Ta	<65	<65	<65	<65	65	65	65	65
W	4	4	8	8	4	4	8	4
Au	<.02	<.02	<.02	<.02	.02	.02	.02	.02
Pb	N.D.	N.D.	N.D.	25	N.D.	N.D.	10	25
Th	7	N.D.	N.D.	N.D.	8	9	7	13
U	17	3.0	13	24.5	.5	1.2	1.5	3.0
Cl	1600	1600	700	210	710	280	210	210
F	632	520	552	456	608	632	640	620

TABLE 72(Continued)

Elemental Composition
for the WV-5 Wells, Mason County, West Virginia

Mound Sample No.	WV-5-37	WV-5-38	WV-5-39	WV-5-40	WV-5-41	WV-5-42	WV-5-43	WV-5-45
Minor and Trace Elements (PPM)								
Be	2.2	2.2	2.0	2.5	2.7	2.5	2.3	2.2
B								
Sc	20	20	15	20	15	15	15	15
V	133	134	141	157	170	188	119	119
Cr	94.6	87.2	89.7	142	135	97.7	77.9	80.5
Co	26	14	65	17	24	44	18	18
Ni	60	40	96	59	51	75	48	36
Cu	71.5	48.5	15.1	30.9	75.0	46.1	41.6	19.6
Zn	52	58	60	68	68	53	71	51
Ga	15	10	10	15	15	15	20	10
Ge	<20	<20	<20	<20	<20	<20	<20	<20
As	11	3	30	3	6	23	30	10
Se	<5	<5	<5	<5	<5	<5	<5	<5
Rb	160	160	170	220	220	210	190	170
Sr	137	163	113	163	177	137	197	183
Zr	127	107	124	123	133	123	93	109
Mo	68	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	4	10	8	8	8	1	5	4
Sb	1	1	1	1	<1	<1	<1	<1
Cs	52	28	54	54	56	56	54	56
Ba	552	452	535	653	703	732	537	866
La	50	70	50	70	70	50	50	50
Ce	160	160	160	160	<160	<160	<160	<160
Hf	40	40	40	40	<40	<40	<40	<40
Ta	65	65	65	65	<65	<65	<65	<65
W	4	4	4	4	4	4	4	4
Au	.02	.02	.02	.02	<.02	<.02	<.02	<.02
Pb	40	N.D.	N.D.	N.D.	N.D.	25	N.D.	N.D.
Th	8	12	7	13	16	13	10	9
U	3.2	1.9	8.4	8.6	2.6	8.1	5.8	2.8
Cl	210	140	210	<70	430	640	70	70
F	540	632	464	560	680	648	620	492

TABLE 72(Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-46	WV-5-47	WV-5-48	WV-5-49	WV-5-50	WV-5-51
Minor and Trace Elements (PPM)						
Be	2.4	2.3	2.3	2.2	2.2	2.3
B						
Sc	20	15	20	15	15	20
V	142	141	125	135	115	140
Cr	106	135	153	166	349	207
Co	17	20	21	15	56	34
Ni	42	54	54	60	153	90
Cu	65.8	30.5	18.9	36.1	38.0	25.5
Zn	69	61	57	70	61	57
Ga	20	10	10	15	15	10
Ge	<20	<20	<20	<20	<20	<20
As	6	3	4	3	13	14
Se	<5	5	<5	5	5	5
Rb	200	200	170	190	190	190
Sr	170	170	190	143	210	183
Zr	120	125	129	115	129	131
Mo	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	5	3	1	4	5	3
Sb	<1	<1	<1	<1	<1	<1
Cs	25	40	52	42	56	56
Ba	708	573	608	530	633	720
La	50	50	50	50	20	50
Ce	<160	<160	<160	<160	<160	<160
Hf	<40	<40	<40	<40	<40	<40
Ta	<65	<65	<65	<65	<65	<65
W	4	4	4	4	4	4
Au	<.02	<.02	<.02	<.02	<.02	<.02
Pb	N.D.	N.D.	N.D.	N.D.	35	25
Th	16	14	13	10	12	13
U	1.5	1.8	3.0	2.4	4.8	3.0
Cl	<70	570	570	500	430	360
F	640	640	496	480	800	496

TABLE 72 (Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-52	WV-5-53	WV-5-54	WV-5-55	WV-5-56	WV-5-57
Minor and Trace Elements (PPM)						
Be	2.2	2.4	2.6	2.4	2.4	2.2
B						
Sc	20	15	10	20	15	15
V	114	145	183	146	148	134
Cr	225	208	124	179	153	175
Co	14	19	65	21	14	17
Ni	81	53	181	54	58	52
Cu	55.7	38.9	57.2	54.2	54.1	41.2
Zn	56	57	63	61	55	47
Ga	10	10	10	15	10	10
Ge	<20	<20	<20	<20	<20	<20
As	4	4	1	5	2	2
Se	5	5	<5	5	<5	5
Rb	180	190	170	190	190	150
Sr	137	133	117	146	149	112
Zr	124	118	118	112	116	99
Mo	N.D.	N.D.	172	N.D.	N.D.	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	1	8	3	3	3	5
Sb	<1	<1	<1	<1	<1	<1
Cs	50	54	56	42	44	52
Ba	496	685	449	577	584	488
La	20	50	50	50	50	50
Ce	<160	<160	<160	<160	<160	<160
Hf	<40	<40	<40	<40	<40	<40
Ta	<65	<65	<65	<65	<65	<65
W	4	4	4	4	4	4
Au	.02	.02	.02	.02	.02	.02
Pb	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Th	11	10	11	12	15	11
U	2.4	4.2	12	2.4	4.6	5.2
Cl	210	280	850	780	430	570
F	412	528	620	680	1000	592

TABLE 72(Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-58	WV-5-59	WV-5-60	WV-5-62	WV-5-63	WV-5-64
Minor and Trace Elements (PPM)						
Be	2.5	2.4	2.4	2.3	2.5	2.9
B						
Sc	20	15	20	15	15	20
V	171	248	164	167	280	200
Cr	180	187	142	172	233	171
Co	22	27	18	28	23	24
Ni	70	132	53	81	119	58
Cu	48.1	83.1	37.6	48.2	63.5	46.5
Zn	42	352	71	46	109	48
Ga	15	10	20	10	10	20
Ge	<20	<20	<20	<20	<20	<20
As	2	4	3	3	2	6
Se	<5	5	<5	<5	<5	<5
Rb	170	170	170	160	180	180
Sr	172	98.9	156	139	98.9	149
Zr	109	106	101	94	93	105
Mo	6	79	N.D.	N.D.	9	9
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Sn	8	3	5	8	5	1
Sb	<1	<1	<1	<1	<1	<1
Cs	48	54	54	38	58	40
Ba	668	584	596	605	575	908
La	50	30	20	50	20	30
Ce	<160	<160	<160	<160	<160	<160
Hf	<40	<40	<40	<40	<40	<40
Ta	<65	<65	<65	<65	<65	<65
W	4	4	4	4	4	4
Au	<.02	<.02	<.02	<.02	<.02	<.02
Pb	15	17	N.D.	N.D.	10	N.D.
Th	11	12	10	7	12	12
U	5.2	16	4.0	3.2	8.0	3.4
Cl	280	210	360	360	640	140
F	640	600	612	688	496	632

TABLE 72 (Continued)

Elemental Composition
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-65	WV-5-66	WV-5-67	WV-5-68	WV-5-69	WV-5-70
Minor and Trace Elements (PPM)						
Be	2.3	2.4	2.5	2.2	2.6	1.9
B						
Sc	10	15	15	15	15	15
V	264	254	374	244	471	145
Cr	110	213	152	443	201	161
Co	12	17	27	23	16	12
Ni	119	117	88	200	279	85
Cu	56.0	64.7	63.6	84.9	498	31.5
Zn	57	228	1090	45	43	26
Ga	10	10	10	10	<10	15
Ge	<20	<20	20	20	20	20
As	2	4	5	20	6	3
Se	5	5	<5	<5	5	<5
Rb	150	160	180	150	150	190
Sr	82.2	85.5	106	106	229	98.9
Zr	92	80	87	86	78	91
Mo	148	9	10	6	84	N.D.
Ag	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	N.D.	N.D.	8	N.D.	N.D.	N.D.
Sn	1	1	1	4	10	5
Sb	1	1	<1	<1	<1	<1
Cs	48	44	54	44	50	52
Ba	541	513	589	456	334	538
La	50	20	20	20	20	20
Ce	160	160	<160	<160	<160	<160
Hf	40	40	<40	<40	<40	<40
Ta	65	65	<65	<65	<65	<65
W	4	4	4	4	4	4
Au	.02	.02	<.02	<.02	<.02	<.02
Pb	N.D.	15	15	30	N.D.	N.D.
Th	7	N.D.	8	N.D.	N.D.	6
U	11	12	12	4.2	7.4	3.6
Cl	210	360	<70	<70	<70	360
F	688	920	1060	1080	912	920

TABLE 73

Elemental Composition
for the OH-2 Well, Logan County, Ohio

Mound Sample No.	OH-2-X
Minor and Trace Elements (PPM)	
Be	1.0
B	
Sc	<10
V	58.7
Cr	65.7
Co	7
Ni	36
Cu	12.9
Zn	28
Ga	<10
Ge	20
As	3
Se	<5
Rb	80
Sr	416
Zr	51
Mo	N.D.
Ag	N.D.
Cd	N.D.
Sn	1
Sb	<1
Cs	44
Ba	240
La	50
Ce	<160
Hf	<40
Ta	<65
W	4
Au	.02
Pb	N.D.
Th	N.D.
U	1.3
Cl	360
F	420

may offer a technique for evaluation of formation organic content by remote methods. This could be accomplished with gamma spectral logging (a common logging method) to detect the relatively abundant naturally radioactive uranium and thorium. Remote sensing of the V and Ni content of shale formations by neutron logging may enable an even more quantitative method for determining hydrocarbon producing potential of the shales through remote sensing.

The ash free weight percent of C, N, O, and H for samples from WV-6, WV-5, and OH-2 are given in Tables 74, 75, and 76, respectively. The relative carbon content is related to the degree of thermal maturation. Increasing maturation gives a greater relative carbon content. Preliminary studies have also established that of these four primary components of organic matter, hydrogen content is the most important factor in developing hydrocarbon producing potential. Preliminary interpretations are currently limited by the lack of whole rock C, H, N, and O results.

K. DETAILED HYDROCARBON ANALYSIS

Samples from well WV-5 were analyzed to determine the composition and the concentrations of the C_4-C_7, C_{15+}, and the saturate hydrocarbon fractions of the organic material (Tables 77-82). Similarly C_{15+} and saturate hydrocarbon results for OH-2 are found in Tables 83-87. Extensive data for these fractions from samples in both Appalachian and Illinois Basin wells have been reported previously(1,3,4,7). These data are important in computing hydrocarbon content, shale maturation, hydrocarbon yields, and specific physical and chemical characteristics of hydrocarbon yield. Some of these aspects have been discussed in previous reports. The detailed hydrocarbon data are being used in several current investigations, results from the studies are at a preliminary stage and will be discussed in subsequent reports.

L. MATERIAL BALANCE ASSAY RESULTS

The MBA hydrocarbon oil and gas yields of selected samples from wells WV-5 and WV-6 are reported in Tables 88 through 93. The yield of the non-hydrocarbon gases is equivalent or exceeds that of the hydrocarbon gases. For WV-5, H_2S is the principal

TABLE 74

Whole Rock Composition
for the WV-6 Well, Monongalia County, West Virginia

Mound Sample No.	Weight Percent Carbon	Hydrogen	Nitrogen	Ash
WV-6-1	5.01	.33	.09	80.24
WV-6-2	2.63	.44	.16	88.55
WV-6-3	2.51	.45	.12	88.24
WV-6 4	1.10	.47	14	93.68
WV-6-5	.99	.49	.15	92.74
WV-6-6	1.96	.59	.17	91.77
WV-6-7	1.34	.46	13	86.71
WV-6-8	1.22	.57	.18	91.85
WV-6-9	2.02	.63	.19	91.04
WV-6-10	1.04	.54	.18	88.55
WV-6-11	1.77	.63	.18	91.77
WV-6-12	1.38	.58	.19	91.44
WV-6-13	1.37	.63	.19	90.39
WV-6-14	1.15	.67	.18	91.92
WV-6-15	1.96	.58	.18	95.62
WV-6-18	1.92	.63	.16	90.13
WV-6-19	2.74	60	.21	90.14
WV-6-20	3.05	73	.20	88.85
WV-6-21	3.02	.54	.22	88.25
WV-6-23	2.66	.59	.24	91.59
WV-6-24	3.91	.60	.25	88.86
WV-6-26	4.01	.57	.25	87.02
WV-6-27	4.18	.62	.28	86.54
WV-6-28	4.41	.72	.31	86.06
WV-6-29	2.99	61	.28	90.22
WV-6-30	3.04	.59	.28	90.23
WV-6-31	7.50	.69	.41	83.60
WV-6-32	8.25	62	.33	83.22
WV-6-33	9.99	69	.37	80.75
WV-6-34	7.12	53	.26	84.49
WV-6-35	8.85	.65	.43	81.88
WV-6-38	6.93	58	.28	84.40
WV-6-39	13.44	.70	.47	78.13
WV-6-40	9.60	.34	.19	78.00

TABLE 75

Whole Rock Composition Samples
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Weight Percent (Ash Free)				Weight Percent	Atomic	Atomic
	C	H	N	O	Ash	H/C	O/C
WV-5-1	16.8	8.2	2.0	72.9	92.2	5.86	3.25
WV-5-2	25.3	6.4	1.5	66.8	91.0	3.04	1.98
WV-5-3	37.5	9.3	2.5	50.7	92.4	2.98	1.01
WV-5-4	40.3	8.6	2.1	49.1	89.2	2.56	0.91
WV-5-5	5.4	10.4	2.2	82.1	94.4	23.11	11.40
WV-5-6	34.0	7.9	2.3	55.8	90.4	2.79	1.23
WV-5-7	32.8	8.3	1.9	57.1	91.5	3.04	1.31
WV-5-8	9.7	10.3	2.0	78.0	93.8	12.74	6.03
WV-5-9	7.8	9.1	1.9	81.2	93.0	14.00	7.81
WV-5-10	11.7	7.9	1.7	78.7	92.8	8.10	5.04
WV-5-11	4.2	10.4	2.4	83.0	94.2	29.71	14.82
WV-5-12	3.4	8.8	2.8	84.9	92.0	31.06	18.73
WV-5-13	18.8	4.8	1.1	75.4	89.0	3.06	3.01
WV-5-14	15.3	5.3	1.9	77.5	93.0	4.16	3.80

TABLE 75(Continued)

Whole Rock Composition Samples
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
WV-5-15	4.7	9.5	2.1	83.7	93.9	24.26	13.36
WV-5-16	5.1	9.3	3.0	82.6	93.7	21.88	12.15
WV-5-17	34.3	8.9	2.7	54.2	90.1	3.11	1.19
WV-5-18	36.3	8.6	2.6	52.6	89.1	2.84	1.09
WV-5-19	5.5	8.9	2.3	83.4	94.1	19.42	11.37
WV-5-20	4.1	9.6	2.0	84.2	93.9	28.10	15.40
WV-5-21	45.8	7.7	2.0	44.5	88.5	2.02	0.73
WV-5-22	43.5	7.5	2.0	47.0	89.4	2.07	0.81
WV-5-23	36.6	9.7	2.0	51.7	91.9	3.18	1.06
WV-5-24	41.9	9.2	1.6	47.3	89.5	2.63	0.85
WV-5-25	45.8	8.3	3.4	42.6	89.9	2.17	0.70
WV-5-26	24.0	8.1	1.8	66.1	92.6	4.05	2.07
WV-5-27	7.7	9.2	3.1	80.0	94.2	14.34	7.79
WV-5 28	41.3	7.6	1.8	49.3	88.7	2.21	0.90

TABLE 75 (Continued)

Whole Rock Composition Samples
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
WV-5-29	43.8	8.1	2.0	46.1	88.6	2.22	0.79
WV-5-30	9.6	7.5	3.9	79.0	93.5	9.38	6.17
WV-5-31	34.6	8.7	2.5	54.3	91.0	3.02	1.18
WV-5-32	52.3	8.1	2.5	37.2	87.0	1.86	0.53
WV-5-33	7.3	9.1	3.2	80.4	95.0	14.96	8.26
WV-5-34	3.3	9.4	3.3	84.0	94.7	34.18	19.09
WV-5-35	4.0	9.0	2.1	85.0	94.4	27.00	15.94
WV-5-36	13.7	9.2	2.6	74.5	93.8	8.06	4.08
WV-5-37	11.3	6.9	2.2	79.6	91.6	7.33	5.28
WV-5-38	7.7	9.2	1.5	81.5	94.2	14.34	7.94
WV-5-39	11.2	6.4	1.2	81.2	93.6	6.86	5.44
WV-5-40	7.0	9.0	2.9	81.1	93.8	15.43	8.69
WV-5-41	5.2	10.4	2.1	82.3	94.3	24.00	11.87
WV-5-42	20.0	8.5	1.9	69.7	91.6	5.10	2.61

TABLE 75 (Continued)

Whole Rock Composition Samples
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
WV-5-43	19.8	5.9	2.2	72.2	92.2	3.58	2.73
WV-5-45	6.2	5.9	1.1	86.8	92.6	11.42	10.50
WV-5-46	7.8	8.4	2.2	81.6	93.8	12.92	7.85
WV-5-47	7.7	8.7	3.0	80.7	94.1	13.56	7.86
WV-5-48	5.9	8.8	2.1	83.3	94.7	17.90	10.59
WV-5-49	8.6	8.2	2.3	80.9	93.7	11.44	7.06
WV-5-50	15.6	8.6	1.7	74.1	93.7	6.62	3.56
WV-5-51	6.9	9.4	1.8	81.9	94.7	16.35	8.90
WV-5-52	11.5	9.9	2.4	76.3	94.1	10.33	4.98
WV-5-53	38.5	8.4	2.4	50.5	90.1	2.62	0.98
WV-5-54	43.6	8.2	1.8	46.5	86.8	2.26	0.80
WV-5-55	4.3	10.1	3.0	82.6	94.5	28.19	14.41
WV-5-56	4.7	9.6	1.8	83.9	94.5	24.51	13.39
WV-5-57	11.3	7.1	1.3	80.4	93.6	7.54	5.34

TABLE 75 (Continued)

Whole Rock Composition Samples
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
WV-5-58	13.4	7.1	1.8	77.7	92.1	6.36	4.35
WV-5-59	48.2	8.3	1.8	41.7	88.0	2.07	0.65
WV-5-60	15.4	7.3	2.0	75.4	92.9	5.69	3.67
WV-5-62	17.1	8.0	2.1	72.9	93.3	5.61	3.20
WV-5-63	24.0	8.2	1.6	66.0	92.4	4.10	2.06
WV-5-64	8.8	7.4	1.8	82.1	93.0	10.09	7.00
WV-5-65	50.1	8.5	1.9	39.6	87.8	20.70	6.03
WV-5-66	24.2	6.7	2.4	66.7	91.2	3.32	2.07
WV-5-67	20.0	8.2	2.2	69.6	93.5	4.92	2.61
WV-5-68	21.7	6.2	1.4	70.7	92.0	3.43	2.44
WV-5-69	54.2	5.6	1.9	38.2	75.5	1.24	0.53
WV-5-70	18.2	7.8	1.9	72.1	93.1	5.14	2.97

TABLE 76

Whole Rock Composition Sample
for the OH-2 Well, Logan County, Ohio

Mound Sample Number	Weight Percent (Ash Free) C	H	N	O	Weight Percent Ash	Atomic H/C	Atomic O/C
OH-2-X	28.9	2.6	1.3	67.3	85.1	1.08	1.75

TABLE 77

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-1	WV-5-2	WV-5-3	WV-5-4	WV-5-5	WV-5-6	WV-5-7	WV-5-8	WV-5-9	WV-5-10
Isobutane	4.2	3.5	12.2	13.0	4.7	12.4	10.8	8.1	2.8	7.2
n-Butane	14.2	16.7	23.3	23.4	19.8	24.4	21.2	23.1	16.6	20.0
Isopentane	13.9	15.8	18.5	18.2	13.6	18.5	17.4	15.6	11.9	16.9
n-Pentane	15.1	16.0	18.1	18.9	15.5	18.7	18.3	18.6	15.2	18.7
2, 2-Dimethylbutane	0.1	0.1	0.3	0.2	0.1	0.2	0.2	0.2	0.2	0.2
Cyclopentane	1.0	0.8	1.8	1.8	1.1	1.5	1.6	1.2	0.9	1.1
2, 3-Dimethylbutane	0.6	0.6	0.4	0.4	0.5	0.4	0.5	0.5	0.6	0.6
2-Methylpentane	7.2	7.5	4.0	3.9	6.3	4.2	5.1	5.3	6.5	6.0
3-Methylpentane	4.8	4.9	2.7	2.7	4.1	2.7	3.3	3.5	4.3	3.8
n-Hexane	8.3	8.1	4.0	4.0	7.2	4.2	5.4	6.0	8.9	6.7
Methylcyclopentane	5.8	5.2	4.7	4.5	5.3	3.9	4.8	4.5	5.4	4.4
2, 2-Dimethylpentane	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.1
Benzene	0.6	0.6	0.2	0.2	0.0	0.1	0.4	0.4	0.5	0.1
2, 4-Dimethylpentane	0.0	0.0	0.2	0.2	0.5	0.2	0.0	0.0	0.0	0.3
2, 2, 3-Trimethylbutane	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cyclohexane	1.8	1.5	1.5	1.5	1.7	1.4	1.6	1.6	2.0	1.5
3, 3-Dimethylpentane	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1, 1-Dimethylcyclopentane	0.8	0.7	0.4	0.3	0.7	0.3	0.4	0.5	0.7	0.5
2-Methylhexane	3.2	3.0	0.9	0.8	2.8	0.9	1.2	1.6	3.4	1.8
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1, cis-3-Dimethylcyclopentane	1.9	1.6	0.8	0.7	1.6	0.6	0.8	0.9	1.8	1.0
3-Methylhexane	3.4	3.1	0.9	0.8	3.1	0.9	1.1	1.5	3.5	1.8
1 trans-3-Dimethylcyclopentane	1.7	1.3	0.7	0.6	1.1	0.6	0.7	0.8	1.5	0.8
1 trans-2-Dimethylcyclopentane	2.9	2.3	1.3	1.1	2.5	1.0	1.2	1.3	2.5	1.4
3-Ethylpentane	0.5	0.3	0.2	0.1	0.4	0.2	0.2	0.2	0.5	0.2
n-Heptane	3.6	2.9	0.9	0.8	3.2	0.9	1.3	1.8	4.9	2.1
1, cis-Dimethylcyclopentane	0.6	0.4	0.3	0.3	0.6	0.3	0.3	0.3	0.7	0.3
Methylcyclohexane	3.4	2.8	1.5	1.3	2.9	1.3	1.7	2.0	4.3	2.1
Toluene	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.2	0.1	0.2
C_4-C_7 Hydrocarbons cm^3/g	23964.9	33659.8	68106.8	60691.6	61000.3	57545.6	68151.3	42488.8	29399.9	4[illegible]703.9
2-methylpentane/3-methylpentane	1.49	1.54	1.44	1.47	1.51	1.53	1.52	1.52	1.51	1.58
isopentane/n-pentane	0.92	0.99	1.02	0.97	0.88	0.99	0.95	0.84	0.78	0.90
cyclohexane/methylcyclopentane	0.31	0.30	0.33	0.35	0.34	0.36	0.35	0.36	0.38	0.36
methylcyclopentane/methylcyclohexane	1.72	1.82	2.99	3.28	1.79	2.93	2.74	2.19	1.25	0.02

TABLE 77(Continued)

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-11	WV-5-12	WV-5-13	WV-5-14	WV-5-15	WV-5-16	WV-5-17	WV-5-18	WV-5-19	WV-5-20
Isobutane	4.0	4.7	3.9	7.7	2.7	6.0	13.5	14.8	4.6	4.2
n-Butane	17.8	18.6	13.1	15.8	14.4	22.4	23.3	26.5	17.6	15.4
Isopentane	13.4	14.6	12.3	10.7	11.9	14.7	17.9	18.4	12.9	12.5
n-Pentane	16.4	17.6	15.1	14.1	15.8	18.5	19.0	19.1	16.5	16.1
2, 2-Dimethylbutane	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Cyclopentane	0.7	0.8	0.7	0.6	0.7	0.9	1.6	1.4	0.8	0.8
2, 3-Dimethylbutane	0.6	0.6	0.7	0.6	0.5	0.4	0.6	0.6	0.3	0.3
2-Methylpentane	7.1	6.8	7.4	6.9	7.3	6.4	4.1	3.4	6.9	7.3
3-Methylpentane	4.5	4.3	4.7	4.3	4.7	4.1	2.7	2.2	4.4	4.7
n-Hexane	9.0	8.7	10.6	9.9	10.3	8.4	4.6	3.7	8.8	9.3
Methylcyclopentane	4.3	4.9	4.8	4.0	4.9	0.1	3.8	3.1	4.7	5.0
2, 2-Dimethylpentane	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0
Benzene	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0
2, 4-Dimethylpentane	0.5	0.4	0.5	0.5	0.5	0.3	0.2	0.2	0.4	0.5
2, 2, 3-Trimethylbutane	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1
Cyclohexane	1.5	1.6	1.8	1.6	2.0	1.7	1.5	1.2	1.6	1.6
3, 3-Dimethylpentane	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1, 1-Dimethylcyclopentane	0.7	0.6	0.7	0.7	0.8	0.6	0.3	0.3	0.8	0.8
2-Methylhexane	3.1	2.6	3.8	3.6	3.5	2.3	0.8	0.7	3.0	3.2
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1, cis-3-Dimethylcyclopentane	1.5	1.3	1.7	1.6	1.7	1.2	0.6	0.5	1.7	1.8
3-Methylhexane	3.0	2.5	3.7	3.5	3.4	3.2	0.7	0.6	3.0	3.3
1 trans-3-Dimethylcyclopentane	1.3	1.1	1.4	1.3	1.5	0.0	0.5	0.4	1.4	1.5
1 trans-2-Dimethylcyclopentane	2.1	1.8	2.3	2.2	2.4	1.6	0.8	0.7	2.3	2.6
3-Ethylpentane	0.4	0.3	0.4	0.4	0.4	0.2	0.1	0.1	0.3	0.5
n-Heptane	3.8	3.1	5.3	5.3	5.0	3.0	1.0	0.7	3.7	4.1
1, cis-Dimethylcyclopentane	0.5	0.4	0.5	0.5	0.6	0.4	0.2	0.1	0.5	0.6
Methylcyclohexane	3.1	2.7	3.9	3.7	4.4	2.7	1.5	1.0	3.1	3.1
Toluene	0.1	0.0	0.1	0.1	0.2	0.1	0.3	0.1	0.1	0.1
C_4-C_7 Hydrocarbons cm^3/g	36168.7	33758.6	10050.1	22664.3	25558.9	29522.9	38620.8	38077.2	39599.7	34564.2
2-methylpentane/3-methylpentane	1.57	1.57	1.58	1.60	1.56	1.58	1.54	1.52	1.54	1.53
isopentane/n-pentane	0.82	0.83	0.82	0.76	0.75	0.80	0.94	0.96	0.78	0.77
cyclohexane/methylcyclopentane	0.35	0.36	0.39	0.39	0.41	9.79	0.41	0.38	0.34	0.31
methylcyclopentane/methylcyclohexane	1.37	1.69	1.21	1.10	1.11	0.06	2.53	3.08	1.51	1.62

TABLE 77 (Continued)

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-21	WV-5-22	WV-5-23	WV-5-24	WV-5-25	WV-5-26	WV-5-27	WV-5-28	WV-5-29	WV-5-30
Isobutane	14.6	13.3	10.0	12.1	12.4	11.5	4.2	10.5	12.2	6.8
n-Butane	29.7	25.0	18.5	33.9	27.0	28.4	20.9	35.6	38.7	27.2
Isopentane	16.9	16.7	14.5	15.6	15.0	14.1	9.3	12.9	12.9	12.1
n-Pentane	18.0	18.6	16.8	19.3	18.0	18.2	17.0	16.7	16.2	17.3
2, 2-Dimethylbutane	0.1	0.1	0.2	0.2	0.2	0.2	0.6	0.4	0.3	0.3
Cyclopentane	1.5	1.9	2.2	1.5	1.6	1.8	1.0	1.2	1.2	1.1
2, 3-Dimethylbutane	0.3	0.3	0.5	0.3	0.3	0.3	0.6	0.4	0.3	0.5
2-Methylpentane	3.0	3.7	5.3	3.4	3.1	3.4	6.7	3.4	3.0	5.4
3-Methylpentane	2.1	2.5	3.6	2.2	2.7	2.4	4.2	2.3	2.0	3.4
n-Hexane	3.3	4.3	6.8	3.7	4.8	4.4	9.6	4.0	3.4	7.0
Methylcyclopentane	3.5	4.3	6.4	2.9	4.4	4.6	4.6	3.5	2.9	4.6
2, 2-Dimethylpentane	0.0	0.0	0.1	0.1	0.1	0.1	0.3	0.2	0.1	0.2
Benzene	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2, 4-Dimethylpentane	0.1	0.2	0.2	0.2	0.6	0.6	0.5	0.6	0.5	0.5
2, 2, 3-Trimethylbutane	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Cyclohexane	1.1	1.5	2.3	0.9	1.6	1.8	1.6	1.4	1.1	1.7
3, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.2	0.1	0.1
1, 1-Dimethylcyclopentane	0.3	0.3	0.5	0.2	0.3	0.3	0.5	0.3	0.2	0.4
2-Methylhexane	0.6	0.8	1.4	0.5	0.8	0.8	2.2	0.8	0.7	1.4
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1, cis-3-Dimethylcyclopentane	0.6	0.7	1.1	0.4	0.6	0.7	1.1	0.6	0.4	0.8
3-Methylhexane	0.6	0.8	1.4	0.5	0.8	0.8	2.5	0.8	0.6	1.4
1 trans-3-Dimethylcyclopentane	0.5	0.6	1.0	0.3	0.5	0.6	0.9	0.5	0.4	0.7
1 trans-2-Dimethylcyclopentane	0.8	1.0	1.7	0.6	1.1	1.2	2.1	0.8	0.7	1.4
3-Ethylpentane	0.1	0.1	0.2	0.1	0.3	0.2	0.8	0.2	0.2	0.5
n-Heptane	0.7	1.0	1.8	0.6	1.2	1.0	4.5	1.0	0.7	2.1
1, cis-Dimethylcyclopentane	0.2	0.3	0.4	0.1	0.3	0.3	0.6	0.3	0.1	0.4
Methylcyclohexane	1.0	1.4	2.5	0.7	1.5	1.6	2.9	1.2	0.8	2.2
Toluene	0.2	0.3	0.3	0.0	0.5	0.6	0.8	0.2	0.3	0.4
C_4-C_7 Hydrocarbons cm^3/g	32457.3	97423.8	71154.5	32586.3	122138.3	126376.1	150888.6	164613.4	167481.6	174435.3
2-methylpentane/3-methylpentane	1.44	1.48	1.49	1.56	1.13	1.42	1.57	1.50	1.50	1.57
isopentane/n-pentane	0.94	0.90	0.86	0.81	0.84	0.77	0.55	0.77	0.80	0.70
cyclohexane/methylcyclopentane	0.33	0.36	0.37	0.31	0.38	0.40	0.35	0.40	0.38	0.37
methylcyclopentane/methylcyclohexane	3.35	3.07	2.54	4.15	2.94	2.84	1.61	2.82	3.28	2.11

TABLE 77(Continued)

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-31	WV-5-32	WV-5-33	WV-5-34	WV-5-35	WV-5-36	WV-5-37	WV-5-38	WV-5-39	WV-5-40
Isobutane	9.5	13.9	3.2	2.9	4.1	10.5	5.7	4.5	11.6	5.1
n-Butane	39.8	42.0	15.7	13.6	20.4	24.6	26.7	25.2	49.6	31.0
Isopentane	10.7	10.8	9.4	9.1	9.8	13.6	10.0	8.3	9.3	9.0
n-Pentane	15.1	14.0	14.7	14.5	16.5	19.5	15.9	13.9	12.2	15.9
2, 2-Dimethylbutane	0.3	0.3	0.2	0.5	0.2	0.2	0.2	0.2	0.2	0.2
Cyclopentane	1.5	1.5	0.6	0.7	0.9	1.2	0.9	1.2	1.2	1.1
2, 3-Dimethylbutane	0.4	0.3	0.6	0.7	0.6	0.5	0.6	0.5	0.3	0.6
2-Methylpentane	2.9	2.2	7.0	6.8	5.6	4.5	5.0	4.2	1.7	4.0
3-Methylpentane	2.1	1.6	4.5	4.4	3.6	2.8	3.0	2.8	1.2	2.6
n-Hexane	3.8	2.8	10.4	10.4	9.2	6.5	8.5	7.8	2.4	7.0
Methylcyclopentane	3.6	3.0	4.0	4.1	4.1	3.8	3.8	4.8	2.2	4.1
2, 2-Dimethylpentane	0.2	0.2	0.3	0.4	0.3	0.1	0.2	0.2	0.1	0.2
Benzene	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.7	0.3
2, 4-Dimethylpentane	0.8	0.9	0.6	0.7	0.6	0.2	0.4	0.5	0.0	0.4
2, 2, 3-Trimethylbutane	0.0	0.0	0.1	0.3	0.1	0.1	0.1	0.1	0.0	0.1
Cyclohexane	1.6	1.3	1.5	1.7	1.7	1.7	1.9	2.8	1.3	2.4
3, 3-Dimethylpentane	0.1	0.1	0.2	0.3	0.2	0.1	0.1	0.2	0.2	0.3
1, 1-Dimethylcyclopentane	0.4	0.3	0.8	0.9	0.8	0.4	0.5	0.7	0.3	0.6
2-Methylhexane	0.9	0.6	4.3	4.3	3.1	1.4	2.5	2.6	0.5	1.6
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1, cis-3-Dimethylcyclopentane	0.6	0.4	1.8	1.9	1.5	0.8	1.0	1.3	0.3	0.9
3-Methylhexane	0.7	0.5	5.4	5.5	3.9	1.3	2.2	2.3	0.3	1.3
1 trans-3-Dimethylcyclopentane	0.6	0.4	0.0	0.0	0.0	0.6	0.9	1.2	0.3	0.8
1 trans-2-Dimethylcyclopentane	1.0	0.7	2.8	3.0	2.3	1.1	1.4	2.0	0.5	1.4
3-Ethylpentane	0.3	0.2	0.8	0.7	0.6	0.2	0.3	0.4	0.1	0.3
n-Heptane	1.1	0.7	5.8	6.0	4.6	2.0	4.3	5.1	0.8	2.9
1, cis-Dimethylcyclopentane	0.4	0.2	0.7	1.0	1.0	0.3	0.4	0.7	0.3	0.5
Methylcyclohexane	1.5	0.9	3.3	4.0	3.4	1.9	3.0	4.9	1.1	3.6
Toluene	0.3	0.4	1.3	1.6	1.1	0.2	0.3	1.3	1.0	1.8
C_4-C_7 Hydrocarbons cm^3/g	128696.2	144459.5	56082.9	19569.6	10944.7	65652.7	24903.1	2813.8	3662.6	2856.0
2-methylpentane/3-methylpentane	1.39	1.39	1.56	1.52	1.56	1.60	1.62	1.48	1.40	1.51
isopentane/n-pentane	0.71	0.77	0.64	0.63	0.59	0.70	0.63	0.60	0.76	0.57
cyclohexane/methylcyclopentane	0.45	0.45	0.37	0.42	0.41	0.46	0.51	0.59	0.63	0.58
methylcyclopentane/methylcyclohexane	2.45	3.21	1.23	1.03	1.21	1.94	1.24	0.97	1.91	1.14

TABLE 77 (Continued)

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-41	WV-5-42	WV-5-43	WV-5-45	WV-5-46	WV-5-47	WV-5-48	WV-5-49	WV-5-50	WV-5-51
Isobutane	5.4	11.2	18.7	2.7	4.0	4.6	10.8	5.0	9.2	4.3
n-Butane	26.7	20.3	33.3	9.9	20.0	20.2	25.0	26.1	32.3	21.4
Isopentane	8.8	14.6	12.7	8.1	7.5	7.3	15.7	9.2	12.7	12.9
n-Pentane	12.7	18.3	15.3	12.4	13.5	10.2	20.7	15.0	17.7	19.4
2, 2-Dimethylbutane	0.5	0.2	0.2	0.2	0.1	0.7	0.2	0.3	0.2	0.2
Cyclopentane	1.7	1.7	1.4	0.5	1.0	1.6	1.3	1.3	1.3	0.9
2, 3-Dimethylbutane	1.3	0.6	0.4	0.8	0.6	1.0	0.6	0.7	0.5	0.7
2-Methylpentane	5.9	4.6	2.5	7.1	4.8	3.8	3.9	4.2	3.6	5.7
3-Methylpentane	3.7	2.8	1.6	4.2	3.1	2.7	2.4	2.9	2.2	3.4
n-Hexane	8.6	6.9	3.2	11.8	9.6	5.5	5.5	7.4	5.4	9.1
Methylcyclopentane	4.3	4.4	2.5	4.0	4.4	3.9	3.5	4.3	3.6	4.3
2, 2-Dimethylpentane	0.5	0.1	0.1	0.2	0.2	0.6	0.1	0.4	0.1	0.2
Benzene	0.0	0.3	0.6	0.5	0.3	0.7	0.3	0.5	0.2	0.4
2, 4-Dimethylpentane	1.4	0.2	0.0	0.0	0.5	0.8	0.2	0.5	0.2	0.0
2, 2, 3-Trimethylbutane	0.0	0.0	0.1	0.1	0.2	0.5	0.1	0.2	0.1	0.1
Cyclohexane	2.6	2.5	1.5	2.0	2.6	2.7	2.0	2.9	2.2	2.3
3, 3-Dimethylpentane	0.2	0.0	0.1	0.1	0.2	0.6	0.1	0.6	0.1	0.2
1, 1-Dimethylcyclopentane	0.8	0.4	0.3	1.0	0.9	1.6	0.4	0.9	0.4	0.6
2-Methylhexane	2.4	1.3	0.6	4.6	3.2	3.5	0.8	2.2	0.9	1.9
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1, cis-3-Dimethylcyclopentane	1.2	0.9	0.5	2.4	1.9	2.5	0.5	1.4	0.5	0.9
3-Methylhexane	2.0	1.1	0.5	4.3	2.9	2.4	0.7	1.7	0.7	1.5
1 trans-3-Dimethylcyclopentane	1.2	0.8	0.4	2.1	1.7	1.8	0.4	1.0	0.4	0.8
1 trans-2-Dimethylcyclopentane	1.8	1.3	0.8	3.7	3.0	3.7	0.8	1.9	0.8	1.3
3-Ethylpentane	0.4	0.1	0.1	0.4	0.5	1.2	0.1	0.5	0.1	0.3
n-Heptane	2.9	2.0	0.9	9.4	6.8	6.1	1.3	3.3	1.4	3.2
1, cis-Dimethylcyclopentane	0.4	0.3	0.3	0.7	0.9	2.1	0.3	0.3	0.3	0.5
Methylcyclohexane	2.5	2.4	1.2	5.1	5.2	5.5	1.7	4.2	2.2	3.2
Toluene	0.2	0.4	0.5	1.8	0.5	2.0	0.5	1.4	0.5	0.5
C_4-C_7 Hydrocarbons cm^3/g	3488.9	65029.6	37907.5	74304.5	15950.7	1181.5	19504.1	2191.9	19310.9	13134.1
2-methylpentane/3-methylpentane	1.56	1.63	1.57	1.68	1.54	1.40	1.62	1.44	1.58	1.67
isopentane/n-pentane	0.70	0.80	0.83	0.66	0.56	0.72	0.76	0.61	0.72	0.67
cyclohexane/methylcyclopentane	0.60	0.58	0.58	0.51	0.60	0.69	0.58	0.68	0.60	0.55
methylcyclopentane/methylcyclohexane	1.71	1.81	2.02	0.79	0.85	0.82	2.02	1.01	1.64	1.32

TABLE 77 (Continued)

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-52	WV-5-53	WV-5-54	WV-5-55	WV-5-56	WV-5-57	WV-5-58	WV-5-59	WV-5-60	WV-5-62
Isobutane	6.0	14.0	11.1	0.9	1.2	12.0	2.9	13.1	3.7	3.5
n-Butane	17.0	23.1	18.9	6.3	6.1	21.7	13.5	23.1	17.5	14.2
Isopentane	13.3	16.3	14.8	4.9	8.8	15.4	9.1	15.5	9.7	11.4
n-Pentane	17.9	18.4	16.9	9.2	13.3	19.5	13.2	18.1	14.5	16.5
2, 2-Dimethylbutane	0.2	0.2	0.2	0.3	5.7	4.3	6.5	0.3	2.3	0.1
Cyclopentane	0.8	1.9	2.2	0.9	0.6	1.4	0.8	2.2	1.0	0.8
2, 3-Dimethylbutane	0.7	0.5	0.6	0.5	0.8	0.5	0.6	0.4	0.6	0.6
2-Methylpentane	6.4	3.8	4.9	5.4	8.0	4.1	6.5	3.6	6.5	7.3
3-Methylpentane	3.7	2.3	3.1	3.4	4.8	2.5	4.0	2.3	4.1	4.6
n-Hexane	10.3	5.2	6.8	11.6	12.4	4.8	9.9	4.8	9.7	10.9
Methylcyclopentane	4.1	4.0	5.5	5.6	4.9	3.6	4.7	5.3	5.1	5.3
2, 2-Dimethylpentane	0.2	0.1	0.1	0.2	0.2	0.1	0.2	0.0	0.2	0.1
Benzene	0.4	0.7	0.6	0.4	0.0	0.3	0.1	0.5	0.1	0.0
2, 4-Dimethylpentane	0.0	0.0	0.2	0.5	0.6	0.2	0.4	0.0	0.4	0.4
2, 2, 3-Trimethylbutane	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0
Cyclohexane	2.0	2.1	2.8	3.2	2.1	1.4	1.7	2.1	1.8	1.6
3, 3-Dimethylpentane	0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.0	0.1	0.1
1, 1-Dimethylcyclopentane	0.5	0.3	0.5	1.1	1.0	0.4	0.9	0.4	0.9	0.7
2-Methylhexane	2.5	0.8	1.2	5.6	4.7	1.1	3.6	0.8	3.1	3.4
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1, cis-3-Dimethylcyclopentane	1.1	0.5	0.8	2.6	2.1	0.7	2.0	0.8	1.9	1.8
3-Methylhexane	2.1	0.7	1.1	5.3	6.0	1.0	3.5	0.8	3.0	3.5
1 trans-3-Dimethylcyclopentane	0.9	0.5	0.7	2.3	0.0	0.6	1.7	0.7	1.7	1.5
1 trans-2-Dimethylcyclopentane	1.5	0.8	1.2	3.6	2.8	0.9	2.8	1.2	2.7	2.5
3-Ethylpentane	0.2	0.1	0.1	0.5	0.5	0.1	0.4	0.1	0.4	0.3
n-Heptane	4.4	1.3	1.7	12.5	7.3	1.4	6.1	1.2	4.6	5.2
1, cis-Dimethylcyclopentane	0.4	0.2	0.3	1.1	0.8	0.3	0.6	0.3	0.6	0.5
Methylcyclohexane	3.1	1.7	2.6	9.5	5.0	1.4	3.9	1.8	3.7	2.9
Toluene	0.2	0.7	0.9	2.3	0.2	0.3	0.1	0.5	0.2	0.1
C_4-C_7 Hydrocarbons cm^3/g	25389.7	68826.4	388409.7	14697.2	37837.9	70851.7	53544.8	132504.2	74115.3	14[illegible]378.7
2-methylpentane/3-methylpentane	1.71	1.64	1.59	1.57	1.66	1.61	1.61	1.51	1.56	1.59
isopentane/n-pentane	0.74	0.89	0.87	0.54	0.66	0.79	0.69	0.86	0.68	0.69
cyclohexane/methylcyclopentane	0.49	0.54	0.52	0.57	0.43	0.39	0.38	0.40	0.35	0.31
methylcyclopentane/methylcyclohexane	1.32	2.26	2.10	0.60	0.99	2.48	1.21	2.88	1.38	1.81

TABLE 77 (Continued)

Detailed C_4-C_7 Hydrocarbon Analyses
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-63	WV-5-64	WV-5-65	WV-5-66	WV-5-67	WV-5-68	WV-5-69	WV-5-70
Isobutane	11.8	1.1	9.4	9.9	1.6	6.7	8.7	2.9
n-Butane	21.4	6.0	24.6	18.2	8.3	14.2	36.9	16.3
Isopentane	15.5	6.9	13.7	15.2	4.2	11.9	10.3	8.0
n-Pentane	18.1	12.1	19.5	16.0	8.3	15.3	16.0	14.4
2, 2-Dimethylbutane	0.1	0.2	0.2	0.1	0.6	0.2	0.1	0.1
Cyclopentane	2.2	0.5	2.2	2.7	1.7	1.7	2.2	1.4
2, 3-Dimethylbutane	0.4	0.6	0.4	0.5	0.5	0.6	0.3	0.5
2-Methylpentane	4.6	7.9	4.4	4.9	3.9	1.7	3.0	5.4
3-Methylpentane	3.0	5.1	2.9	3.4	3.0	5.1	2.1	3.8
n-Hexane	5.8	13.2	5.6	6.8	7.9	10.9	4.3	9.7
Methylcyclopentane	5.1	5.3	5.0	6.8	7.4	7.3	5.0	7.3
2, 2-Dimethylpentane	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.2
Benzene	0.5	0.7	0.2	0.4	0.0	0.0	0.0	0.0
2, 4-Dimethylpentane	0.0	0.0	0.2	0.1	2.1	0.4	0.5	0.4
2, 2, 3-Trimethylbutane	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1
Cyclohexane	1.8	1.8	1.8	2.6	4.1	2.5	1.9	3.2
3, 3-Dimethylpentane	0.1	0.2	0.1	0.0	0.3	0.1	0.0	0.2
1, 1-Dimethylcyclopentane	0.4	1.1	0.1	0.5	1.6	1.0	0.4	1.2
2-Methylhexane	1.1	5.5	1.2	1.3	2.7	2.7	0.8	2.2
2, 3-Dimethylpentane	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.6
1, cis-3-Dimethylcyclopentane	0.8	2.8	0.9	1.0	3.1	2.2	0.8	2.3
3-Methylhexane	1.0	5.8	1.1	2.3	3.8	2.8	0.8	2.7
1 trans-3-Dimethylcyclopentane	0.7	2.1	0.7	0.0	2.8	1.5	0.8	1.8
1 trans-2-Dimethylcyclopentane	1.2	4.1	1.3	1.9	4.8	3.0	1.3	3.4
3-Ethylpentane	0.2	0.7	0.2	0.2	0.9	0.3	0.1	0.5
n-Heptane	1.5	8.9	1.6	1.8	8.1	3.7	1.2	5.2
1, cis-Dimethylcyclopentane	0.4	1.0	0.4	0.5	2.0	0.6	0.3	1.0
Methylcyclohexane	1.6	4.8	1.7	2.3	8.2	3.2	1.6	4.9
Toluene	0.5	1.5	0.4	0.6	6.7	0.2	0.5	0.3
C_4-C_7 Hydrocarbons cm^3/g	161176.3	33787.8	202755.9	102235.9	9743.1	208033.1	50511.9	51778.1
2-methylpentane/3-methylpentane	1.55	1.54	1.51	1.46	1.29	0.34	1.39	1.41
isopentane/n-pentane	0.86	0.57	0.71	0.95	0.51	0.78	0.64	0.56
cyclohexane/methylcyclopentane	0.36	0.35	0.38	0.38	0.55	0.35	0.39	0.43
methylcyclopentane/methylcyclohexane	3.13	1.10	2.92	2.94	0.90	2.29	3.01	1.49

TABLE 78

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (Grams)	Total Extract (Gram)	Precipitated Asphaltenes (Grams)	N-C5 Soluble (Grams)	Sulfur (Grams)	Paraffins-Naphthenes (Grams)	Aromatics (Grams)	Eluted NSO'S (Grams)	Noneluted NSO's (Grams)
WV-5-1		62.0	0.0187	0.0111	0.0076	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-2		89.7	0.1490	0.0215	0.1275	N.D.	0.0368	0.0494	0.0269	0.0144
WV-5-3		86.1	0.3536	0.0432	0.3104	N.D.	0.0988	0.1143	0.0598	0.0375
WV-5-4		84.1	0.4077	0.0664	0.3413	N.D.	0.1079	0.1231	0.0695	0.0408
WV-5-5		86.7	0.0504	0.0054	0.0450	N.D.	0.0136	0.0143	0.0062	0.0109
WV-5-6		92.7	0.2582	0.0229	0.2353	N.D.	0.0677	0.0879	0.0543	0.0254
WV-5-7		84.6	0.1985	0.0188	0.1797	N.D.	0.0646	0.0712	0.0308	0.0131
WV-5-8		92.7	0.0970	0.0458	0.0512	N.D.	0.0145	0.0211	0.0117	0.0039
WV-5-9		92.2	0.0174	0.0063	0.0111	N.D.	0.0040	0.0051	0.0020	0.0000
WV-5-10		90.5	0.0896	0.0068	0.0828	N.D.	0.0273	0.0320	0.0149	0.0086
WV-5-11		91.0	0.0198	0.0049	0.0149	N.D.	0.0050	0.0064	0.0035	0.0000
WV-5-12		86.1	0.1064	0.0115	0.0949	N.D.	0.0362	0.0373	0.0150	0.0064
WV-5-13		90.4	0.0147	0.0040	0.0107	N.D.	0.0036	0.0042	0.0029	0.0000
WV-5-14		80.2	0.0227	0.0037	0.0190	N.D.	0.0038	0.0051	0.0038	0.0063
WV-5-15		89.4	0.0220	0.0047	0.0173	N.D.	0.0070	0.0067	0.0028	0.0008
WV-5-16		90.8	0.0364	0.0063	0.0301	N.D.	0.0110	0.0129	0.0046	0.0016
WV-5-17		88.3	0.2113	0.0121	0.1992	N.D.	0.0846	0.0763	0.0368	0.0015
WV-5-18		83.6	0.2532	0.0187	0.2345	N.D.	0.0743	0.0803	0.0491	0.0308
WV-5-19		84.5	0.0310	0.0049	0.0261	N.D.	0.0059	0.0075	0.0045	0.0082
WV-5-20		84.3	0.0260	0.0061	0.0199	N.D.	0.0069	0.0083	0.0043	0.0004

TABLE 78(Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (Grams)	Total Extract (Gram)	Precipitated Asphaltenes (Grams)	N-C5 Soluble (Grams)	Sulfur (Grams)	Paraffins-Naphthenes (Grams)	Aromatics (Grams)	Eluted NSO'S (Grams)	Noneluted NSO's (Grams)
WV-5-21		93.8	0.3388	0.0259	0.3129	N.D.	0.1025	0.1347	0.0609	0.0148
WV-5-22		86.6	0.2985	0.0222	0.2763	N.D.	0.0833	0.1124	0.0579	0.0227
WV-5-23		96.1	0.2305	0.0166	0.2139	N.D.	0.0931	0.0888	0.0320	0.0000
WV-5-24		56.4	0.2523	0.0176	0.2347	N.D.	0.0995	0.0928	0,0321	0.0103
WV-5-25		86.1	0.3213	0.0230	0.2983	N.D.	0.1190	0.1038	0.0489	0.0266
WV-5-26		90.7	0.2837	0.0233	0.2604	N.D.	0.1004	0.1093	0.0389	0.0118
WV-5-27		80.1	0.0274	0.0074	0.0200	N.D.	0.0076	0.0086	0.0027	0.0011
WV-5-28		84.2	0.1369	0.0141	0.1228	N.D.	0.0441	0.0511	0.0185	0.0091
WV-5-29		61.5	0.2214	0.0217	0.1997	N.D.	0.0572	0.0755	0.0367	0.0303
WV-5-30		86.3	0.2084	0.0235	0.1849	N.D.	0.0653	0.0830	0.0259	0.0107
WV-5-31		82.6	0.2673	0.0269	0.2404	N.D.	0.0740	0.1029	0.0451	0.0184
WV-5-32		79.8	0.2799	0.0416	0.2383	N.D.	0.0847	0.0915	0.0307	0.0314
WV-5-33		88.5	0.0088	0.0049	0.0039	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-34		83.6	0.0131	0.0026	0.0105	N.D.	0.0012	0.0012	0.0016	0.0065
WV-5-35		87.5	0.0090	0.0034	0.0056	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-36		82.5	0,0418	0.0040	0.0378	N.D.	0.0114	0.0126	0.0094	0.0044
WV-5-37		81.1	0.0546	0.0072	0.0474	N.D.	0.0195	0.0160	0.0072	0.0047
WV-5-38		87.4	0.0101	0.0040	0.0061	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-39		88.1	0.0209	0.0043	0.0166	N.D.	0.0028	0.0054	0.0031	0.0053
WV-5-40		86.0	0.0046	0.0024	0.0022	N.D.	N.D.	N.D.	N.D.	N.D.

TABLE 78(Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (Grams)	Total Extract (Gram)	Precipitated Asphaltenes (Grams)	N-C5 Soluble (Grams)	Sulfur (Grams)	Paraffins-Naphthenes (Grams)	Aromatics (Grams)	Eluted NSO'S (Grams)	Noneluted NSO's (Grams)
WV-5-41		92.4	0.0056	0.0030	0.0026	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-42		90.4	0.0745	0.0061	0.0684	N.D.	0.0290	0.0246	0.0085	0.0063
WV-5-43		92.0	0.0130	0.0037	0.0093	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-45		91.9	0.0934	0.0051	0.0883	N.D.	0.0446	0.0283	0.0093	0.0061
WV-5-46		91.7	0.0157	0.0039	0.0118	N.D.	0.0035	0.0031	0.0013	0.0039
WV-5-47		92.5	0.0057	0.0026	0.0031	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-48		92.8	0.0051	0.0027	0.0024	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-49		91.0	0.0046	0.0023	0.0023	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-50		92.3	0.0231	0.0051	0.0180	N.D.	0.0069	0.0077	0.0030	0.0004
WV-5-51		88.0	0.0130	0.0038	0.0092	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-52		85.1	0.0082	0.0028	0.0054	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-53		86.8	0.0076	0.0022	0.0054	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-54		96.4	0.3062	0.0207	0.2855	N.D.	0.1026	0.1266	0.0471	0.0092
WV-5-55		83.1	0.0047	0.0022	0.0025	N.D.	N.D.	N.D.	N.D.	N.D.
WV-5-56		78.2	0.0243	0.0038	0.0205	N.D.	0.0072	0.0065	0.0028	0.0040
WV-5-57		93.7	0.0177	0.0033	0.0144	N.D.	0.0048	0.0065	0.0022	0.0009
WV-5-58		94.3	0.0527	0.0048	0.0479	N.D.	0.0142	0.0160	0.0071	0.0106
WV-5-59		86.9	0.2784	0.0120	0.2664	N.D.	0.1007	0.0945	0.0437	0.0275
WV-5-60		85.4	0.0555	0.0052	0.0503	N.D.	0.0163	0.0159	0.0076	0.0105
WV-5-62		80.3	0.0365	0.0034	0.0331	N.D.	0.0099	0.0100	0.0053	0.0079

TABLE 78(Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (Grams)	Total Extract (Gram)	Precipitated Asphaltenes (Grams)	N-C5 Soluble (Grams)	Sulfur (Grams)	Paraffins-Naphthenes (Grams)	Aromatics (Grams)	Eluted NSO'S (Grams)	Noneluted NSO's (Grams)
WV-5-63		65.6	0.1465	0.0052	0.1413	N.D.	0.0592	0.0543	0.0228	0.0050
WV-5-64		90.9	0.0521	0.0059	0.0462	N.D.	0.0154	0.0189	9,9972	0.0047
WV-5-65		75.7	0.3407	0.0185	0.3222	N.D.	0.1229	0.1305	0.0540	0.0148
WV-5-66		80.3	0.2814	0.0173	0.2641	N.D.	0.1057	0.0980	0.0449	0.0155
WV-5-67		70.4	0.3066	0.0171	0.2895	N.D.	0.0982	0.1117	0.0496	0.0300
WV-5-68		75.6	0.1692	0.0111	0.1581	N.D.	0.0631	0.0605	0.0219	0.0126
WV-5-69		75.3	0.2688	0.0444	0.2244	N.D.	0.0496	0.0946	0.0583	0.0219
WV-5-70		80.5	0.1198	0.0070	0.1128	N.D.	0.0433	0.0418	0.0141	0.0136

TABLE 79

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography for the WV-5 Well, Mason County, West Virginia

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)
WV-5-1		302	-	-	-	-	179	-	-	-
WV-5-2		1661	410	551	961	-	240	300	161	700
WV-5-3		4107	1148	1328	2475	-	502	695	436	1632
WV-5-4		4848	1283	1464	2747	-	790	826	485	2101
WV-5-5		581	157	165	322	-	62	72	126	260
WV-5-6		2785	730	948	1679	-	247	586	274	1107
WV-5-7		2346	764	842	1605	-	222	364	155	741
WV-5-8		1046	156	228	384	-	494	126	42	662
WV-5-9		189	43	55	99	-	68	22	0	90
WV-5-10		990	302	354	655	-	75	165	95	335
WV-5-11		218	55	70	125	-	54	38	0	92
WV-5-12		1236	420	433	854	-	134	174	74	382
WV-5-13		163	40	46	86	-	44	32	0	76
WV-5-14		283	47	64	111	-	46	47	79	172
WV-5-15		246	78	75	153	-	53	31	9	93
WV-5-16		401	121	142	263	-	69	51	18	138
WV-5-17		2393	958	864	1822	-	137	417	17	571
WV-5-18		3029	889	961	1849	-	224	587	368	1179
WV-5-19		367	70	89	159	-	58	53	97	208
WV-5-20		308	82	98	180	-	72	51	5	128
WV-5-21		3612	1093	1436	2529	-	276	649	158	1083

TABLE 79 (Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

B. Concentration of Extracted Materials in Rock

Mound Sample Number	Well Interval	Total Extract (ppm)	---------Hydrocarbons--------- Paraffin-Naphthene (ppm)	Aromatic (ppm)	Total (ppm)	Sulfur (ppm)	-------------Nonhydrocarbons------------- Preciptd. Asphaltene (ppm)	Eluted NSO's (ppm)	Noneluted NSO's (ppm)	Total (ppm)
WV-5-22		3447	962	1298	2260	-	256	669	262	1187
WV-5-23		2399	969	924	1893	-	173	333	0	506
WV-5-24		4473	1764	1645	3410	-	312	569	183	1064
WV-5-25		3732	1382	1206	2588	-	267	568	309	1144
WV-5-26		3128	1107	1205	2312	-	257	429	130	816
WV-5-27		342	95	107	202	-	92	34	14	140
WV-5-28		1626	524	607	1131	-	167	220	108	495
WV-5-29		3600	930	1228	2158	-	353	597	493	1442
WV-5-30		2415	757	962	1718	-	272	300	124	696
WV-5-31		3236	896	1246	2142	-	326	546	223	1094
WV-5-32		3508	1061	1147	2208	-	521	385	393	1299
WV-5-33		99	-	-	-	-	55	-	-	-
WV-5-34		157	14	14	29	-	31	19	78	128
WV-5-35		103	-	-	-	-	39	-	-	-
WV-5-36		507	138	153	291	-	48	114	53	216
WV-5-37		673	240	197	438	-	89	89	58	236
WV-5-38		116	-	-	-	-	46	-	-	-
WV-5-39		237	32	61	93	-	49	35	60	144
WV-5-40		53	-	-	-	-	28	-	-	-
WV-5-41		61	-	-	-	-	32	-	-	-
WV-5-42		824	321	272	593	-	67	94	70	231

TABLE 79 (Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

B. Concentration of Extracted Materials in Rock

			---------Hydrocarbons---------				------------Nonhydrocarbons------------			
Mound Sample Number	Well Interval	Total Extract (ppm)	Paraffin-Naphthene (ppm)	Aromatic (ppm)	Total (ppm)	Sulfur (ppm)	Preciptd. Asphaltene (ppm)	Eluted NSO's (ppm)	Noneluted NSO's (ppm)	Total (ppm)
WV-5-43		141	-	-	-	-	40	-	-	-
WV-5-45		1016	485	308	793	-	55	101	66	223
WV-5-46		171	38	34	72	-	43	14	43	99
WV-5-47		62	-	-	-	-	28	-	-	-
WV-5-48		55	-	-	-	-	29	-	-	-
WV-5-49		51	-	-	-	-	25	-	-	-
WV-5-50		250	75	83	158	-	55	33	4	92
WV-5-51		148	-	-	-	-	43	-	-	-
WV-5-52		96	-	-	-	-	33	-	-	-
WV-5-53		88	-	-	-	-	25	-	-	-
WV-5-54		3176	1064	1313	2378	-	215	489	95	799
WV-5-55		57	-	-	-	-	26	-	-	-
WV-5-56		311	92	83	175	-	49	36	51	136
WV-5-57		189	51	69	121	-	35	23	10	68
WV-5-58		559	151	170	320	-	51	75	112	239
WV-5-59		3204	1159	1087	2246	-	138	503	316	957
WV-5-60		650	191	186	377	-	61	89	123	273
WV-5-62		455	123	125	248	-	42	66	98	207
WV-5-63		2233	902	828	1730	-	79	348	76	503
WV-5-64		573	169	208	377	-	65	79	52	196
WV-5-65		4501	1624	1724	3347	-	244	713	196	1153

TABLE 79(Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography for the WV-5 Well, Mason County, West Virginia

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)
WV-5-66		3504	1316	1220	2537	-	215	559	193	968
WV-5-67		4355	1395	1587	2982	-	243	705	426	1374
WV-5-68		2238	835	800	1635	-	147	290	167	603
WV-5-69		3570	659	1256	1915	-	590	774	291	1655
WV-5-70		1488	538	519	1057	-	87	175	169	431

TABLE 80

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography for the WV-5 Well, Mason County, West Virginia

C. Composition of Extracts

Mound Sample Number	Well Interval	Hydrocarbons: Paraffin-Naphthene %	Hydrocarbons: Aromatic %	PN/Arom	Sulfur %	Nonhydrocarbons: Eluted NSO'S %	Nonhydrocarbons: Noneluted NSO'S %	Nonhydrocarbons: Precipitd. Asphaltene %	Asph/NSO	HC'S %	HC/Non HC
WV-5-1		-	-	-	-	-	-	59.4	-	-	-
WV-5-2		24.7	33.2	0.74	-	18.1	9.7	14.4	0.52	57.9	1.37
WV-5-3		27.9	32.3	0.86	-	16.9	10.6	12.2	0.44	60.3	1.52
WV-5-4		26.5	30.2	0.88	-	17.0	10.0	16.3	0.60	56.7	1.31
WV-5-5		27.0	28.4	0.95	-	12.3	21.6	10.7	0.32	55.4	1.24
WV-5-6		26.2	34.0	0.77	-	21.0	9.8	8.9	0.29	60.3	1.52
WV-5-7		32.5	35.9	0.91	-	15.5	6.6	9.5	0.43	68.4	2.17
WV-5-8		14.9	21.8	0.69	-	12.1	4.0	47.2	2.94	36.7	0.58
WV-5-9		23.0	29.3	0.78	-	11.5	0.0	36.2	3.15	52.3	1.10
WV-5-10		30.5	35.7	0.85	-	16.6	9.6	7.6	0.29	66.2	1.96
WV-5-11		25.3	32.3	0.78	-	17.7	0.0	24.7	1.40	57.6	1.36
WV-5-12		34.0	35.1	0.97	-	14.1	6.0	10.8	0.54	69.1	2.23
WV-5-13		24.5	28.6	0.86	-	19.7	0.0	27.2	1.38	53.1	1.13
WV-5-14		16.7	22.5	0.75	-	16.7	27.8	16.3	0.37	39.2	0.64
WV-5-15		31.8	30.5	1.04	-	12.7	3.6	21.4	1.31	62.3	1.65
WV-5-16		30.2	35.4	0.85	-	12.6	4.4	17.3	1.02	65.7	1.91
WV-5-17		40.0	36.1	1.11	-	17.4	0.7	5.7	0.32	76.1	3.19
WV-5-18		29.3	31.7	0.93	-	19.4	12.2	7.4	0.23	61.1	1.57
WV-5-19		19.3	24.2	0.79	-	14.5	26.5	15.8	0.39	43.2	0.76
WV-5-20		26.5	31.9	0.83	-	16.5	1.5	23.5	1.30	58.5	1.41

TABLE 80(Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

C. Composition of Extracts

Mound Sample Number	Well Interval	Hydrocarbons: Paraffin-Naphthene %	Hydrocarbons: Aromatic %	PN/Arom	Sulfur %	Nonhydrocarbons: Eluted NSO'S %	Nonhydrocarbons: Noneluted NSO'S %	Nonhydrocarbons: Precipitd. Asphaltene %	Asph/NSO	HC'S %	HC/Non HC
WV-5-21		30.3	39.8	0.76	-	18.0	4.4	7.6	0.34	70.0	2.33
WV-5-22		27.9	37.7	0.74	-	19.4	7.6	7.4	0.28	65.6	1.90
WV-5-23		40.4	38.5	1.05	-	13.9	0.0	7.2	0.52	78.9	3.74
WV-5-24		39.4	36.8	1.07	-	12.7	4.1	7.0	0.42	76.2	3.21
WV-5-25		37.0	32.3	1.15	-	15.2	8.3	7.2	0.30	69.3	2.26
WV-5-26		35.4	38.5	0.92	-	13.7	4.2	8.2	0.46	73.9	2.83
WV-5-27		27.7	31.4	0.88	-	9.9	4.0	27.0	1.95	59.1	1.45
WV-5-28		32.2	37.3	0.86	-	13.5	6.6	10.3	0.51	69.5	2.28
WV-5-29		25.8	34.1	0.76	-	16.6	13.7	9.8	0.32	59.9	1.50
WV-5-30		31.3	39.8	0.79	-	12.4	5.1	11.3	0.64	71.2	2.47
WV-5-31		27.7	38.5	0.72	-	16.9	6.9	10.1	0.42	66.2	1.96
WV-5-32		30.3	32.7	0.93	-	11.0	11.2	14.9	0.67	63.0	1.70
WV-5-33		-	-	-	-	-	-	55.7	-	-	-
WV-5-34		9.2	9.2	1.00	-	12.2	49.6	19.8	0.32	18.3	0.22
WV-5-35		-	-	-	-	-	-	37.8	-	-	-
WV-5-36		27.3	30.1	0.90	-	22.5	10.5	9.6	0.29	57.4	1.35
WV-5-37		35.7	29.3	1.22	-	13.2	8.6	13.2	0.61	65.0	1.86
WV-5-38		-	-	-	-	-	-	39.6	-	-	-
WV-5-39		13.4	25.8	0.52	-	14.8	25.4	20.6	0.51	39.2	0.65
WV-5-40		-	-	-	-	-	-	52.2	-	-	-

TABLE 80 (Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

C. Composition of Extracts

Mound Sample Number	Well Interval	Hydrocarbons: Paraffin-Naphthene %	Aromatic %	PN/Arom	Sulfur %	Nonhydrocarbons: Eluted NSO'S %	Noneluted NSO'S %	Precipitd. Asphaltene %	Asph/NSO	HC'S %	HC/Non HC
WV-5-41		-	-	-	-	-	-	53.6	-	-	-
WV-5-42		38.9	33.0	1.18	-	11.4	8.5	8.2	0.41	71.9	2.56
WV-5-43		-	-	-	-	-	-	28.5	-	-	-
WV-5-45		47.8	30.3	1.58	-	10.0	6.5	5.5	0.33	78.1	3.56
WV-5-46		22.3	19.7	1.13	-	8.3	24.8	24.8	0.75	42.0	0.73
WV-5-47		-	-	-	-	-	-	45.6	-	-	-
WV-5-48		-	-	-	-	-	-	52.9	-	-	-
WV-5-49		-	-	-	-	-	-	50.0	-	-	-
WV-5-50		29.9	33.3	0.90	-	13.0	1.7	22.1	1.50	63.2	1.72
WV-5-51		-	-	-	-	-	-	29.2	-	-	-
WV-5-52		-	-	-	-	-	-	34.1	-	-	-
WV-5-53		-	-	-	-	-	-	28.9	-	-	-
WV-5-54		33.5	41.3	0.81	-	15.4	3.0	6.8	0.37	74.9	2.98
WV-5-55		-	-	-	-	-	-	46.8	-	-	-
WV-5-56		29.6	26.7	1.11	-	11.5	16.5	15.6	0.56	56.4	1.29
WV-5-57		27.1	36.7	0.74	-	12.4	5.1	18.6	1.06	63.8	1.77
WV-5-58		26.9	30.4	0.89	-	13.5	20.1	9.1	0.27	57.3	1.34
WV-5-59		36.2	33.9	1.07	-	15.7	9.9	4.3	0.17	70.1	2.35
WV-5-60		29.4	28.6	1.03	-	13.7	18.9	9.4	0.29	58.0	1.38
WV-5-62		27.1	27.4	0.99	-	14.5	21.6	9.3	0.26	54.5	1.20

TABLE 80(Continued)

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the WV-5 Well, Mason County, West Virginia

C. Composition of Extracts

		Hydrocarbons				Nonhydrocarbons					
Mound Sample Number	Well Interval	Paraffin-Naphthene %	Aromatic %	PN/Arom	Sulfur %	Eluted NSO'S %	Noneluted NSO'S %	Precipitd. Asphaltene %	Asph/NSO	HC'S %	HC/Non HC
WV-5-63		40.4	37.1	1.09	-	15.6	3.4	3.5	0.19	77.5	3.44
WV-5-64		29.6	36.3	0.81	-	13.8	9.0	11.3	0.50	65.8	1.92
WV-5-65		36.1	38.3	0.94	-	15.8	4.3	5.4	0.27	74.4	2.90
WV-5-66		37.6	34.8	1.08	-	16.0	5.5	6.1	0.29	72.4	2.62
WV-5-67		32.0	36.4	0.88	-	16.2	9.8	5.6	0.21	68.5	2.17
WV-5-68		37.3	35.8	1.04	-	12.9	7.4	6.6	0.32	73.0	2.71
WV-5-69		18.5	35.2	0.52	-	21.7	8.1	16.5	0.55	53.6	1.16
WV-5-70		36.1	34.9	1.04	-	11.8	11.4	5.8	0.25	71.0	2.45

TABLE 81

Saturate Hydrocarbon Analyses

Summary of Paraffin-Naphthene Distribution
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	% Paraffin	% Isoprenoid	% Naphthene	C-P Index A	C-P Index B	ip19/ip20
WV-5-1		5.2	0.5	94.3	1.13	-	0.50
WV-5-2		10.1	2.3	87.6	1.09	1.19	1.43
WV-5-3		9.7	2.2	88.1	1.08	1.17	1.24
WV-5-4		10.3	2.3	87.4	1.04	1.05	1.21
WV-5-5		8.6	2.3	89.1	1.12	-	1.58
WV-5-6		9.1	1.9	89.0	1.08	-	1.11
WV-5-7		11.1	1.9	87.0	1.08	-	1.14
WV-5-8		6.3	1.0	92.7	1.09	-	1.03
WV-5-9		8.5	0.8	90.7	1.11	-	0.93
WV-5-10		13.9	2.6	83.5	1.10	1.22	1.62
WV-5-11		7.7	1.0	91.3	1.13	-	1.43
WV-5-12		14.8	2.6	82.7	1.10	1.20	1.69
WV-5-13		7.8	0.8	91.4	1.08	-	1.36
WV-5-14		4.3	0.5	95.3	1.13	-	0.77
WV-5-15		9.0	1.0	90.0	1.05	-	1.19
WV-5-16		5.6	0.6	93.7	1.12	-	1.30
WV-5-17		17.0	2.8	80.2	1.05	1.12	1.69
WV-5-18		17.9	2.6	79.5	0.98	1.03	1.67
WV-5-19		7.8	1.2	91.0	1.16	-	1.26
WV-5-20		8.6	1.1	90.4	1.08	-	1.29
WV-5-21		14.5	3.1	82.4	1.10	1.20	1.80
WV-5-22		11.3	2.3	86.4	1.08	-	1.62
WV-5-23		13.8	2.2	83.9	1.10	1.17	1.73
WV-5-24		13.1	2.7	84.3	1.09	1.15	1.62
WV-5-25		14.4	2.7	82.9	1.05	1.09	1.61

TABLE 81(Continued)

Saturate Hydrocarbon Analyses

Summary of Paraffin-Naphthene Distribution
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	% Paraffin	% Isoprenoid	% Naphthene	C-P Index A	C-P Index B	ip19/ip20
WV-5-26		10.9	2.1	87.0	1.04	1.04	1.59
WV-5-27		2.9	0.4	96.6	-	-	1.29
WV-5-28		11.6	2.0	86.4	1.07	1.17	1.51
WV-5-29		8.5	1.9	89.6	1.03	1.06	1.34
WV-5-30		14.4	3.2	82.3	1.08	1.14	1.48
WV-5-31		11.1	2.1	86.7	1.09	1.15	1.35
WV-5-32		14.0	2.5	83.5	1.11	-	1.80
WV-5-33		3.4	0.0	96.6	1.06	-	1.00
WV-5-34		2.5	0.1	97.5	1.05	-	0.33
WV-5-35		8.8	0.7	90.5	1.07	-	0.68
WV-5-36		11.2	1.7	87.1	1.22	-	1.50
WV-5-37		10.9	1.8	87.3	1.10	-	1.49
WV-5-38		7.2	0.5	92.4	1.05	1.20	0.57
WV-5-39		12.7	0.9	86.4	1.08	-	0.95
WV-5-40		4.1	0.1	95.8	0.99	1.11	2.00
WV-5-41		3.9	0.1	96.1	0.98	1.13	0.80
WV-5-42		16.9	2.8	80.3	1.15	-	2.77
WV-5-43		6.2	0.6	93.1	1.15	-	0.81
WV-5-45		17.3	5.2	77.6	1.14	1.20	1.79
WV-5-46		8.5	0.4	91.1	1.12	1.22	0.27
WV-5-47		7.2	0.2	92.6	1.04	1.11	0.42
WV-5-48		5.9	0.1	94.1	1.03	1.20	1.33
WV-5-49		4.1	0.1	95.8	0.99	1.14	0.67
WV-5-50		23.2	2.2	74.6	1.09	1.22	1.83
WV-5-51		15.1	0.3	84.6	1.13	1.28	1.10

TABLE 81 (Continued)

Saturate Hydrocarbon Analyses

Summary of Paraffin-Naphthene Distribution
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	% Paraffin	% Isoprenoid	% Naphthene	C-P Index A	C-P Index B	ip19/ip20
WV-5-52		11.1	1.7	87.2	1.08	1.24	0.85
WV-5-53		5.4	0.5	94.2	1.13	-	0.60
WV-5-54		14.8	2.1	83.0	1.11	1.19	1.69
WV-5-55		5.8	0.1	94.1	1.08	1.21	0.67
WV-5-56		3.7	0.6	95.6	-	-	0.92
WV-5-57		4.8	0.6	94.6	1.17	-	1.00
WV-5-58		9.2	1.4	89.4	1.15	-	1.41
WV-5-59		10.8	1.5	87.7	1.04	-	1.18
WV-5-60		10.6	1.6	87.8	1.19	-	1.45
WV-5-62		11.6	1.3	87.1	1.12	-	1.38
WV-5-63		8.6	1.2	90.2	1.09	-	1.12
WV-5-64		10.3	1.4	88.3	1.20	-	1.38
WV-5-65		11.1	1.8	87.1	1.04	1.10	1.15
WV-5-66		12.6	2.0	85.3	1.04	1.06	1.12
WV-5-67		8.8	1.5	89.7	1.06	1.10	1.15
WV-5-68		18.0	2.7	79.3	1.03	1.06	1.33
WV-5-69		14.2	1.8	83.9	1.04	1.15	1.28
WV-5-70		18.5	2.7	78.8	0.97	0.92	0.64

TABLE 82

Saturate Hydrocarbon Analyses

Normalized Paraffin Distribution

for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	% nC15	% nC16	% nC17	% ip19	% nC18	% ip20	% nC19	% nC20	% nC21	% nC22	% nC23	% nC24	% nC25	% nC26	% nC27	% nC28	% nC29	% nC30	% nC31	% nC32	% nC33	% nC34	% nC35
WV-5-1		0.7	0.9	6.8	2.7	13.6	5.4	16.7	14.9	12.2	9.3	6.8	4.1	2.7	1.4	0.9	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-2		4.6	7.4	10.6	11.0	10.0	7.7	9.6	8.5	7.3	5.9	4.6	3.4	3.1	2.1	1.8	1.1	0.5	0.4	0.4	0.2	0.0	0.0	0.0
WV-5-3		3.6	6.3	10.4	10.4	10.1	8.4	9.6	8.3	7.3	6.1	5.1	3.8	3.3	2.3	1.8	1.2	0.9	0.5	0.5	0.2	0.0	0.0	0.0
WV-5-4		2.2	5.1	8.5	9.8	9.3	8.1	9.7	8.8	7.8	6.6	5.7	4.5	3.6	2.9	2.3	1.7	1.1	0.8	0.6	0.3	0.1	0.0	0.0
WV-5-5		0.3	5.4	12.4	13.0	12.6	8.3	11.7	9.7	8.0	6.0	4.6	2.9	2.1	1.2	0.7	0.4	0.3	0.2	0.1	0.0	0.0	0.0	0.0
WV-5-6		0.3	4.0	9.0	9.2	10.7	8.3	11.2	9.7	8.5	7.2	5.9	4.2	3.9	2.7	2.0	1.4	0.9	0.6	0.3	0.0	0.0	0.0	0.0
WV-5-7		0.5	3.4	8.0	7.8	10.0	6.8	10.9	10.0	9.3	7.9	6.8	5.1	4.3	3.2	2.5	1.8	1.2	0.6	0.2	0.0	0.0	0.0	0.0
WV-5-8		0.3	3.0	8.5	6.6	12.3	6.4	12.9	11.5	9.4	7.7	6.3	4.3	3.7	2.4	1.9	1.2	0.9	0.3	0.3	0.0	0.0	0.0	0.0
WV-5-9		0.2	2.7	9.1	4.3	12.7	4.6	13.8	12.5	10.9	8.8	7.1	4.8	3.5	2.1	1.4	0.6	0.5	0.2	0.2	0.0	0.0	0.0	0.0
WV-5-10		3.7	8.7	12.4	9.7	10.6	6.0	9.5	8.0	7.0	5.7	4.7	3.6	3.2	2.1	1.8	1.2	1.0	0.6	0.4	0.2	0.0	0.0	0.0
WV-5-11		1.2	6.1	12.0	6.8	13.0	4.7	12.5	10.5	9.1	7.3	5.7	3.9	3.0	1.7	1.4	0.7	0.3	0.2	0.0	0.0	0.0	0.0	0.0
WV-5-12		4.1	8.1	11.6	9.3	10.3	5.5	9.5	8.3	7.3	5.9	5.1	3.8	3.4	2.4	2.0	1.3	1.0	0.6	0.4	0.2	0.0	0.0	0.0
WV-5-13		0.3	3.3	8.7	5.2	11.1	3.8	11.9	11.6	10.7	9.0	7.3	5.5	4.4	2.7	2.0	1.2	0.8	0.3	0.3	0.0	0.0	0.0	0.0
WV-5-14		0.2	2.2	9.3	4.2	13.5	5.4	14.0	13.0	10.6	8.6	6.9	4.4	3.4	1.5	1.2	0.7	0.5	0.2	0.0	0.0	0.0	0.0	0.0
WV-5-15		0.3	4.5	11.9	5.5	12.6	4.6	11.9	10.8	9.2	8.6	7.1	4.6	3.6	2.2	1.0	0.6	0.4	0.3	0.1	0.0	0.0	0.0	0.0
WV-5-16		10.7	16.5	15.0	5.8	12.2	4.5	9.7	7.4	5.6	4.5	3.1	1.7	1.6	0.6	0.4	0.4	0.2	0.2	0.0	0.0	0.0	0.0	0.0
WV-5-17		5.7	8.5	10.0	8.9	9.6	5.2	9.2	8.0	7.2	6.1	5.1	4.1	3.5	2.7	2.2	1.5	1.1	0.7	0.5	0.2	0.0	0.0	0.0
WV-5-18		5.3	8.3	10.0	7.9	9.4	4.8	9.2	8.2	7.5	6.3	5.5	5.5	3.5	2.7	2.0	1.5	1.1	0.7	0.5	0.2	0.1	0.0	0.0
WV-5-19		0.4	3.9	11.9	7.2	14.5	5.8	14.3	12.3	10.0	7.2	5.2	3.2	2.2	0.9	0.6	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-20		3.0	11.1	16.0	6.3	14.1	4.9	12.7	10.0	7.4	5.6	3.9	2.4	1.3	0.7	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-21		7.9	10.2	11.7	11.3	10.0	6.3	8.9	7.6	6.5	5.2	4.3	2.9	2.6	1.7	1.2	0.7	0.4	0.3	0.3	0.1	0.0	0.0	0.0
WV-5-22		3.9	9.1	12.9	10.6	11.2	6.5	9.9	8.5	7.0	5.5	4.4	3.2	2.7	1.7	1.2	0.8	0.4	0.2	0.2	0.0	0.0	0.0	0.0
WV-5-23		8.3	11.2	12.3	8.8	10.3	5.1	9.1	7.9	6.8	5.4	4.5	3.1	2.5	1.7	1.2	0.7	0.5	0.2	0.2	0.1	0.0	0.0	0.0
WV-5-24		8.4	10.1	11.1	10.5	9.4	6.5	8.4	7.5	6.5	5.3	4.6	3.3	2.8	1.9	1.3	0.9	0.6	0.4	0.3	0.2	0.0	0.0	0.0
WV-5-25		6.7	9.2	11.0	9.7	9.6	6.1	9.2	8.0	7.0	6.0	4.9	3.6	2.9	2.2	1.4	0.9	0.7	0.4	0.3	0.2	0.0	0.0	0.0
WV-5-26		5.5	9.3	12.4	9.8	10.9	6.2	9.9	8.4	6.9	5.7	4.5	3.2	2.4	1.8	1.1	0.9	0.5	0.3	0.2	0.1	0.0	0.0	0.0
WV-5-27		1.3	12.1	17.8	7.4	13.8	5.7	11.8	9.8	7.1	5.7	3.4	1.7	1.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-28		1.2	5.3	10.4	9.0	11.0	6.0	10.6	9.0	7.9	6.6	5.5	4.4	3.9	2.8	2.3	1.6	1.1	0.5	0.4	0.1	0.1	0.0	0.0
WV-5-29		0.7	4.7	10.6	10.6	11.1	7.8	10.5	9.3	7.9	6.9	5.5	4.2	3.3	2.5	1.6	1.1	0.6	0.5	0.4	0.2	0.0	0.0	0.0
WV-5-30		0.8	4.6	9.0	10.9	9.6	7.4	9.5	8.7	8.1	7.2	6.1	4.6	4.5	3.2	2.3	1.5	0.8	0.5	0.4	0.2	0.1	0.0	0.0
WV-5-31		0.5	4.9	10.3	9.2	11.5	6.8	11.1	9.8	8.5	7.0	5.7	4.1	3.7	2.5	1.7	1.1	0.5	0.4	0.3	0.1	0.0	0.0	0.0
WV-5-32		9.4	12.8	13.3	9.7	10.9	5.4	9.6	8.0	6.5	4.0	3.6	2.4	1.7	0.8	0.5	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
WV-5-33		2.0	1.3	1.0	0.7	3.7	0.7	8.6	12.3	12.6	13.3	11.3	8.6	7.6	5.3	4.7	2.7	2.3	1.0	0.3	0.0	0.0	0.0	0.0
WV-5-34		0.7	0.3	1.7	0.7	7.2	2.1	12.8	15.9	12.4	13.4	10.7	6.9	5.9	3.4	3.1	1.0	1.0	0.3	0.3	0.0	0.0	0.0	0.0
WV-5-35		0.3	0.8	6.0	2.9	11.9	4.3	14.6	14.2	12.2	10.4	7.7	5.1	3.7	2.3	1.5	0.8	0.6	0.3	0.2	0.0	0.0	0.0	0.0
WV-5-36		1.2	6.1	14.9	7.9	16.2	5.3	14.6	11.8	8.7	5.6	3.7	2.0	1.4	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-37		1.6	8.0	14.4	8.6	13.7	5.7	12.3	10.5	8.2	6.0	4.4	2.7	1.8	1.0	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0
WV-5-38		0.3	0.5	3.8	2.2	9.4	3.8	13.0	14.2	12.6	11.5	8.6	5.8	5.4	3.8	2.0	1.2	0.9	0.4	0.5	0.1	0.0	0.0	0.0
WV-5-39		0.5	0.7	4.6	3.3	11.2	3.4	15.1	14.6	12.8	10.8	8.0	5.4	4.1	2.6	1.4	0.6	0.4	0.2	0.2	0.0	0.0	0.0	0.0
WV-5-40		1.2	1.2	1.5	1.0	3.0	0.5	5.7	9.9	9.6	12.6	11.3	8.9	9.6	8.9	5.7	3.2	2.7	1.7	1.5	0.5	0.0	0.0	0.0

TABLE 52 (Continued)

Saturate Hydrocarbon Analyses

Normalized Paraffin Distribution
for the WV-5 Well, Mason County, West Virginia

Mound Sample Number	Well Interval	% nC15	% nC16	% nC17	% ip19	% nC18	% ip20	% nC19	% nC20	% nC21	% nC22	% nC23	% nC24	% nC25	% nC26	% nC27	% nC28	% nC29	% nC30	% nC31	% nC32	% nC33	% nC34	% nC35
WV-5-41		1.3	1.1	1.3	0.9	4.7	1.1	8.2	14.9	12.1	13.6	10.6	6.9	7.1	6.7	4.1	1.9	1.5	0.9	1.1	0.2	0.0	0.0	0.0
WV-5-42		10.7	16.6	18.1	10.6	13.2	3.8	9.7	6.8	4.6	2.6	1.5	0.9	0.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-43		0.5	3.9	10.3	4.2	13.2	5.1	14.0	12.7	10.9	8.0	6.3	4.2	3.0	1.6	1.1	0.5	0.3	0.2	0.2	0.0	0.0	0.0	0.0
WV-5-45		4.7	8.9	12.7	14.8	11.0	8.3	9.5	8.1	6.5	4.6	3.7	2.4	1.8	1.1	0.8	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0
WV-5-46		0.3	0.3	1.0	0.9	5.5	3.2	13.1	17.0	16.1	13.2	10.3	6.5	4.9	3.2	2.0	1.0	0.7	0.3	0.3	0.1	0.0	0.0	0.0
WV-5-47		0.3	0.3	0.9	0.7	4.3	1.8	9.4	12.8	13.2	13.1	11.8	9.0	7.4	5.4	3.5	2.5	1.8	0.9	0.7	0.3	0.0	0.0	0.0
WV-5-48		0.4	0.4	0.7	0.7	4.3	0.6	9.8	13.7	13.0	13.4	10.8	8.2	7.6	5.9	4.1	2.2	2.0	0.9	0.9	0.4	0.0	0.0	0.0
WV-5-49		0.5	0.8	1.0	0.5	4.4	0.8	9.8	15.8	13.2	14.2	10.3	6.7	6.7	5.4	3.4	2.1	1.8	1.0	1.0	0.5	0.0	0.0	0.0
WV-5-50		0.9	5.3	10.1	5.6	12.5	3.1	13.4	12.2	10.6	8.4	6.2	4.1	3.0	1.8	1.1	0.7	0.5	0.2	0.2	0.1	0.0	0.0	0.0
WV-5-51		0.6	0.7	1.9	1.1	5.9	1.0	12.5	16.4	16.8	13.7	10.5	6.8	5.0	2.9	1.9	1.0	0.7	0.3	0.3	0.1	0.0	0.0	0.0
WV-5-52		0.1	1.0	9.7	6.1	16.2	7.1	14.0	10.7	8.5	7.3	6.1	4.0	3.7	2.4	1.2	0.6	0.6	0.3	0.3	0.2	0.0	0.0	0.0
WV-5-53		0.2	1.9	8.7	3.1	13.8	5.1	14.1	12.7	10.7	8.5	7.1	4.9	3.9	2.4	1.7	0.5	0.5	0.2	0.2	0.0	0.0	0.0	0.0
WV-5-54		1.4	5.6	10.8	7.8	11.5	4.6	11.3	10.2	9.0	7.0	5.7	4.1	3.5	2.4	2.0	1.2	0.9	0.4	0.3	0.2	0.0	0.0	0.0
WV-5-55		1.1	1.1	1.9	0.9	6.0	1.3	11.3	14.3	13.8	13.4	11.1	6.8	6.4	4.9	2.6	1.1	1.1	0.4	0.6	0.2	0.0	0.0	0.0
WV-5-56		0.8	5.4	13.3	6.8	16.8	7.5	14.9	12.2	8.7	5.8	3.7	2.1	1.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-57		2.3	6.0	11.8	5.4	14.7	5.4	14.1	12.0	9.5	6.8	5.0	3.1	2.3	0.8	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-58		2.6	9.3	14.9	7.6	12.1	5.4	12.0	9.8	8.2	5.7	4.4	2.9	2.3	1.5	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
WV-5-59		1.3	6.3	11.7	6.7	13.5	5.7	12.7	10.8	8.6	6.8	5.0	3.6	2.6	1.9	1.1	0.8	0.5	0.3	0.3	0.0	0.0	0.0	0.0
WV-5-60		1.4	8.9	16.6	7.7	15.5	5.3	13.7	10.5	8.0	5.1	3.3	1.9	1.1	0.5	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV-5-62		0.6	3.6	10.2	6.0	13.7	4.3	13.9	12.1	10.4	8.1	6.3	4.1	3.1	1.8	1.0	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0
WV-5-63		1.8	7.3	11.8	6.4	12.8	5.7	11.8	10.1	8.7	6.6	5.4	3.7	2.8	1.9	1.1	0.9	0.7	0.3	0.2	0.0	0.0	0.0	0.0
WV-5-64		2.0	8.1	14.1	7.1	12.9	5.1	11.8	9.8	8.9	6.2	5.0	3.2	2.7	1.3	0.9	0.5	0.2	0.1	0.1	0.0	0.0	0.0	0.0
WV-5-55		3.7	8.9	12.9	7.3	11.6	6.3	10.3	8.7	7.2	5.9	4.8	3.7	2.9	2.1	1.3	1.0	0.7	0.4	0.3	0.1	0.0	0.0	0.0
WV-5-66		2.5	7.4	11.6	7.4	11.3	6.6	10.4	9.3	7.9	6.6	5.5	4.0	3.2	2.4	1.5	1.1	0.6	0.3	0.2	0.2	0.0	0.0	0.0
WV-5-67		2.8	7.9	12.3	7.8	12.3	6.8	11.0	9.0	7.3	5.7	4.6	3.5	2.9	2.2	1.4	0.9	0.6	0.4	0.3	0.1	0.1	0.0	0.0
WV-5-68		3.4	8.1	11.5	7.4	10.7	5.5	9.8	8.9	7.8	6.5	5.2	4.1	3.4	2.7	1.8	1.3	0.9	0.6	0.4	0.2	0.0	0.0	0.0
WV-5-69		1.9	6.6	10.5	6.4	11.4	5.1	11.1	9.9	8.4	6.8	5.7	4.4	3.2	2.7	2.1	1.3	1.3	0.4	0.3	0.2	0.0	0.0	0.0
WV-5-70		1.2	5.3	9.7	4.9	10.6	7.7	10.1	9.6	8.1	7.2	5.7	4.5	3.6	3.1	2.3	2.4	1.5	1.3	0.7	0.4	0.0	0.0	0.0

TABLE 83

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the OH-2 Well, Logan County, Ohio

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (Grams)	Total Extract (Gram)	Precipitated Asphaltenes (Grams)	N-C5 Soluble (Grams)	Sulfur (Grams)	Paraffins-Naphthenes (Grams)	Aromatics (Grams)	Eluted NSO'S (Grams)	Noneluted NSO's (Grams)
OH-2-X		80.3	0.1545	0.0115	0.1430	N.D.	0.0591	0.0528	0.0233	0.0078

TABLE 84

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the OH-2 Well, Logan County, Ohio

B. Concentration of Extracted Materials in Rock

			Hydrocarbons				Nonhydrocarbons			
Mound Sample Number	Well Interval	Total Extract (ppm)	Paraffin-Naphthene (ppm)	Aromatic (ppm)	Total (ppm)	Sulfur (ppm)	Preciptd. Asphaltene (ppm)	Eluted NSO's (ppm)	Noneluted NSO's (ppm)	Total (ppm)
OH-2-X		1924	736	658	1394	-	143	290	97	531

TABLE 85

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography
for the OH-2 Well, Logan County, Ohio

C. Composition of Extracts

		Hydrocarbons				Nonhydrocarbons					
Mound Sample Number	Well Interval	Paraffin-Naphthene %	Aromatic %	PN/Arom	Sulfur %	Eluted NSO'S %	Noneluted NSO'S %	Precipitd. Asphaltene %	Asph/NSO	HC'S %	HC/Non HC
OH-2-X		38.3	34.2	1.12	-	15.1	5.0	7.4	0.37	72.4	2.63

TABLE 86

Saturate Hydrocarbon Analyses

Summary of Paraffin-Naphthene Distribution
for the OH-2 Well, Logan County, Ohio

Mound Sample Number	Well Interval	% Paraffin	% Isoprenoid	% Naphthene	C-P Index A	C-P Index B	ip19/ip20
OH-2-X		14.7	2.2	83.1	1.04	1.09	1.06

TABLE 87

Saturate Hydrocarbon Analyses

Normalized Paraffin Distribution
for the OH-2 Well, Logan, Ohio

Mound Sample Number	Well Interval	% nC15	% nC16	% nC17	% ip19	% nC18	% ip20	% nC19	% nC20	% nC21	% nC22	% nC23	% nC24	% nC25	% nC26	% nC27	% nC28	% nC29	% nC30	% nC31	% nC32	% nC33	% nC34	% nC35
OH-2-X		1.4	5.0	9.8	6.7	10.3	6.3	10.8	8.5	7.4	6.2	5.4	4.5	4.0	3.3	2.7	2.1	1.8	1.4	1.2	0.6	0.4	0.2	0.1

TABLE 88

Material Balance Assay Product Assay
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-3	WV-5-4	WV-5-10	WV-5-19	WV-5-21	WV-5-22	WV-5-24	WV-5-25
Oil Yield (Gal./Ton)	4.1	4.8	0.5	0.5	6.2	6.4	1.8	4.8
Specific Gravity ($60^{o}/60^{o}$)	.889	.892	-	-	.891	.900	-	.884
^{o}API-Oil Gravity	27.7	27.1	-	-	27.3	25.7	-	28.6
Water Yield (Gal./Ton)	2.7	4.2	3.5	4.3	3.0	2.8	3.5	3.2
pH	9.3	9.3	9.1	9.3	9.2	9.3	9.3	9.3
Hydrocarbon Gas Yield (Ft /Ton)	75.1	102.9	11.9	7.0	109.3	117.5	40.4	90.8

TABLE 38(Continued)

Material Balance Assay Product Assay
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-26	WV-5-27	WV-5-28	WV-5-29	WV-5-30	WV-5-33	WV-5-35	WV-5-36
Oil Yield (Gal./Ton)	4.3	0.5	3.0	5.0	0.5	1.1	0.5	0.5
Specific Gravity ($60^{o}/60^{o}$)	.891	-	.885	.897	-	-	-	-
^{o}API-Oil Gravity	27.3	-	28.4	26.2	-	-	-	-
Water Yield (Gal./Ton)	2.9	3.2	3.6	3.4	3.0	2.8	3.6	3.7
pH	9.3	9.1	9.5	9.4	9.3	9.3	9.2	9.3
Hydrocarbon Gas Yield (Ft /Ton)	72.7	3	77.4	110.8	5.0	2.0	2.0	7.2

TABLE 89

Material Balance Assay Gaseous Yield
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-3	WV-5-4	WV-5-10	WV-5-19	WV-5-21	WV-5-22	WV-5-24	WV-5-25
Hydrocarbons (cm^3/g)	2.344	3.212	<0.370	<0.220	3.413	3.669	1.262	2.834
Methane	1.244	1.739	0.244	0.145	1.781	1.940	0.640	1.470
Ethane	0.413	0.533	0.029	0.008	0.588	0.619	<0.226	0.491
Ethylene	0.060	0.081	<0.003	<0.004	0.086	0.105	0.003	0.066
Propane	0.250	0.335	0.045	0.019	0.358	0.373	0.149	0.302
Propylene	0.099	0.139	0.023	0.012	0.142	0.161	0.053	0.115
i-Butane	0.025	0.035	<0.003	<0.004	0.038	0.036	0.023	0.037
n-Butane	0.111	0.156	<0.003	<0.004	0.187	0.176	0.078	0.163
Butene-1	0.044	0.060	<0.003	<0.004	0.062	0.072	0.022	0.046
t-Butene-2	0.016	0.023	<0.003	<0.004	0.024	0.025	0.008	0.019
c-Butene-2	0.008	0.012	<0.003	<0.004	0.014	0.015	<0.004	0.012
i-Pentane	0.032	0.042	<0.003	<0.004	0.043	0.041	0.021	0.033
n-Pentane	0.038	0.054	<0.003	<0.004	0.073	0.076	0.030	0.061
Pentene-1	0.003	0.004	<0.003	<0.004	0.014	0.030	0.005	0.019
Non-Hydrocarbons (cm^3/g)								
Hydrogen	1.435	1.985	<0.256	<0.306	2.082	2.106	0.733	1.510
Hydrogen Sulfide	3.035	4.898	1.100	0.304	2.743	2.139	1.348	2.100
Carbon Monoxide	0.038	0.067	<0.006	<0.008	0.089	0.110	<0.007	0.061
Carbon Dioxide	0.979	1.246	0.278	0.654	1.298	1.992	0.699	1.185

TABLE 89(Continued)

Material Balance Assay Gaseous Yield
for the WV-5- Well, Mason County, West Virginia

Mound Sample No.	WV-5-26	WV-5-27	WV-5-28	WV-5-29	WV-5-30	WV-5-33	WV-5-35	WV-5-36
Hydrocarbons (cm^3/g)	2.269	<0.090	2.416	3.458	<0.2	<0.004	<0.04	<0.22
Methane	1.095	0.051	1.254	1.758	0.094	0.005	0.006	0.128
Ethane	0.416	0.005	0.419	0.606	0.015	0.005	0.006	<0.022
Ethylene	0.046	<0.003	0.043	0.077	0.002	<0.003	<0.003	0.003
Propane	0.277	<0.003	0.263	0.393	0.017	0.003	<0.003	0.025
Propylene	0.086	0.007	0.082	0.129	0.013	0.003	<0.003	<0.019
i-Butane	0.035	<0.003	0.036	0.041	<0.002	0.003	<0.003	<0.003
n-Butane	0.152	<0.003	0.141	0.214	<0.002	0.003	<0.003	<0.003
Butene-1	0.036	<0.003	0.036	0.058	<0.002	0.003	<0.003	0.006
t-Butene-2	0.015	<0.003	0.014	0.022	<0.002	0.003	<0.003	<0.003
c-Butene-2	0.007	<0.003	0.008	0.014	<0.002	0.003	<0.003	<0.003
i-Pentane	0.031	<0.003	0.035	0.040	<0.002	0.003	<0.003	<0.003
n-Pentane	0.057	<0.003	0.061	0.081	<0.002	0.003	<0.003	<0.003
Pentene-1	0.016	<0.003	0.062	0.024	<0.002	0.003	0.003	<0.003
Non-Hydrocarbons (cm^3/g)								
Hydrogen	1.228	<0.211	1.494	1.965	<0.17	<0.216	<0.218	<0.23
Hydrogen Sulfide	1.666	<0.009	2.812	2.694	0.537	0.221	0.274	1.090
Carbon Monoxide	0.039	<0.005	0.036	0.064	0.004	<0.005	<0.006	<0.006
Carbon Dioxide	0.931	1.632	0.907	0.835	0.894	0.598	0.888	0.423

TABLE 89(Continued)

Material Balance Assay Gaseous Yield
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-37	WV-5-44	WV-5-46	WV-5-47	WV-5-48	WV-5-49	WV-5-50
Hydrocarbons (cm^3/g)	0.158	1.484	<0.004	<0.07	<0.04	0.415	<0.05
Methane	0.081	0.619	<0.005	0.032	<0.005	0.199	<0.006
Ethane	0.006	0.273	0.005	0.006	<0.005	0.082	<0.006
Ethylene	0.021	0.062	<0.003	<0.003	<0.003	<0.003	<0.003
Propane	0.015	0.160	<0.003	<0.004	<0.003	0.046	<0.003
Propylene	<0.003	0.115	<0.003	<0.003	<0.003	0.027	<0.003
i-Butane	<0.003	0.016	<0.003	<0.003	<0.003	<0.003	<0.003
n-Butane	<0.004	0.090	<0.003	<0.003	<0.003	0.024	<0.003
Butene-1	<0.003	0.050	<0.003	<0.003	<0.003	0.011	<0.003
t-Butene-2	<0.003	0.018	<0.003	<0.003	<0.003	0.005	<0.003
c-Butene-2	<0.003	0.012	<0.003	<0.003	<0.003	<0.003	<0.003
i-Pentane	<0.003	0.013	<0.003	<0.003	<0.003	<0.003	<0.003
n-Pentane	<0.003	0.041	<0.003	<0.003	<0.003	<0.004	<0.003
Pentene-1	<0.003	0.015	<0.003	<0.003	<0.003	0.005	<0.003
Non-Hydrocarbons (cm^3/g)							
Hydrogen	<0.217	1.315	<0.214	<0.233	<0.214	0.352	<0.253
Hydrogen Sulfide	0.817	3.013	0.214	0.273	<0.008	1.304	0.266
Carbon Monoxide	<0.006	0.050	<0.003	<0.003	<0.003	<0.005	<0.003
Carbon Dioxide	0.732	0.865	2.432	1.173	1.667	0.745	1.507

TABLE 89 (Continued)

Material Balance Assay Gaseous Yield
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-60
Hydrocarbons (cm^3/g)	0.192
Methane	0.090
Ethane	0.029
Ethylene	<0.003
Propane	0.021
Propylene	0.011
i-Butane	<0.003
n-Butane	0.016
Butene-1	<0.003
t-Butene-2	<0.003
c-Butene-2	<0.003
i-Pentane	<0.003
n-Pentane	<0.003
Pentene-1	<0.003
Non-Hydrocarbons (cm^3/g)	
Hydrogen	<0.250
Hydrogen Sulfide	0.688
Carbon Monoxide	<0.003
Carbon Dioxide	1.757

TABLE 90

Material Balance Assay Carbon and Ash Data
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-3	WV-5-4	WV-5-10	WV-5-19	WV-5-21	WV-5-22	WV-5-24	WV-5-25	WV-5-26	WV-5-27
Pre-test:										
Total Carbon (%)	4.19	5.18	0.80	0.51	5.70	6.13	1.94	4.23	3.13	0.52
Organic Carbon(%)	3.71	4.96	0.80	0.50	5.43	5.24	1.87	4.12	3.03	0.17
Post-test:										
Total Carbon (%)	2.4	3.0	0.80	0.46	3.5	3.7	1.4	2.8	2.1	0.40
Organic Carbon(%)	2.0	2.70	0.60	0.38	3.30	3.10	1.00	2.40	1.70	0.19
Carbon Transfer Ratio	46.09	45.56	25.00	24.00	39.23	40.84	46.52	41.75	43.89	---
Retorting Weight Loss(%)	3.94	5.37	2.07	2.21	5.05	5.20	3.04	4.41	3.39	1.43
Retorted Shale:										
Ash (%)	94.81	93.72	95.43	95.99	93.60	93.95	95.91	94.54	95.12	95.51
Ignition Loss(%)	5.19	6.28	4.57	4.01	6.40	6.05	4.09	5.46	4.88	4.49

TABLE 90 (Continued)

Material Balance Assay Carbon and Ash Data
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	WV-5-28	WV-5-29	WV-5-30	WV-5-33	WV-5-35	WV-5-36
Pre-test:						
Total Carbon (%)	3.45	4.86	0.63	0.23	0.26	0.53
Organic Carbon(%)	3.29	4.70	0.35	0.12	0.12	0.45
Post-test:						
Total Carbon (%)	2.6	3.2	0.38	0.20	0.24	0.42
Organic Carbon(%)	2.1	2.8	0.34	0.12	0.17	0.36
Carbon Transfer Ratio	36.17	40.43	28.57	---	---	20.66
Retorting Weight Loss(%)	3.46	4.24	1.85	1.86	2.04	2.30
Retorted Shale:						
Ash (%)	93.99	93.49	96.16	97.07	96.62	96.35
Ignition Loss(%)	6.01	6.51	3.84	2.93	3.38	3.65

TABLE 91

Material Balance Assay Product Assay
for the WV-6 Well, Monongalia County, West Virginia

Mound Sample No.	WV-6-16	WV-6-21	WV-6-36
Oil Yield (Gal/Ton)	<0.5	<0.5	<0.5
Specific Gravity ($60^o/60^o$)	---	---	---
^{o}API-Oil Gravity	---	---	---
Water Yield (Gal/Ton)	2.6	5.4	3.9
pH	9.0	9.2	9.0
Hydrocarbon Gas Hield Ft^3/Ton)	<3.0	<3.0	9.2

TABLE 92.

Material Balance Assay Gaseous Yield
for the WV-6 Well, Monongalia County, West Virginia

Mound Sample No.	WV-6-16	WV-6-21	WV-6-36
Hydrocarbons (cm^3/g)	<0.06	<0.08	0.286
Methane	<0.008	0.049	0.227
Ethane	<0.008	<0.005	<0.006
Ethylene	<0.004	<0.003	<0.003
Propane	<0.004	<0.003	0.021
Propylene	<0.004	<0.003	<0.003
i-Butane	<0.004	<0.003	<0.003
n-Butane	<0.004	<0.003	<0.003
Butene-1	<0.004	<0.003	<0.003
t-Butene-2	<0.004	<0.003	<0.003
c-Butene-2	<0.004	<0.003	<0.003
i-Pentane	<0.004	<0.003	<0.003
n-Pentane	<0.004	<0.003	<0.003
Pentene-1	<0.004	<0.003	<0.003
Non-Hydrocarbons (cm^3/g)			
Hydrogen	<0.296	<0.214	<0.250
Hydrogen Sulfide	0.240	0.426	2.124
Carbon Monoxide	<0.008	<0.005	<0.006
Carbon Dioxide	1.211	1.198	2.128

TABLE 93

Material Balance Assay Carbon
and Ash Data for the WV-6 Well, Monongalia County,
West Virginia

Mound Sample No.	WV-6-16	WV-6-21	WV-6-36
Pre-test:			
Total Carbon (%)	1.8	2.8	8.0
Organic Carbon(%)	1.2	2.7	7.7
Post-test:			
Total Carbon (%)	1.8	2.8	7.4
Organic Carbon(%)	1.1	2.8	7.1
Carbon Transfer Ratio	8.33	---	7.79
Retorting Weight Loss(%)	---	---	---
Retorted Shale:			
Ash (%)	93.89	92.71	88.10
Ignition Loss(%)	6.11	7.29	11.90

component of the non-hydrocarbon fraction; H_2 and CO_2, secondary; and CO relatively insignificant. For WV-6 samples CO_2 is dominant; H_2S, secondary. Methane is the most abundant hydrocarbon, commonly accounting for more than 50% of the total gaseous hydrocarbon yield. Mean values for the oil yield (gal/ton, ^{o}API-gravity, and hydrocarbon gas yield (ft^3/ton), for shale from WV-5 are 2.78, 27.3 and 55.5, respectively. Similar results for WV-6 for the oil yield and gas yield were <0.5 (gal/ton) and 5.1 (ft^3/ton), respectively. Comparative results for oil yields (gal/ton) from Appalachian Basin wells VA-1, KY-2, R-109, and OH-1 are 0.5, 1.63, 1.17, and 1.73, respectively. Even though oil yields of WV-5 are greater than those from previously tested Appalachian Basin wells, it is still substantially less than the yield of tested Illinois Basin shale samples. These were greater than 9.0 gal/ton. Similarly the WV-5 mean hydrocarbon gas yield, 55 ft^3/ton, is larger than the values from other Appalachian Basin wells. For example, the previously calculated high mean hydrocarbon gas yield among these basin wells tested was 35 ft^3/ton reported for R-109.

M. C_1-C_7 RESULTS

Light hydrocarbon analysis of 34 WV-6 samples taken at ∿10 ft. intervals indicates high gas content (Table 94, 95, and 96). Mean C_1-C_7 content of the core container air space was about 22,000 ppm. This is nearly 50% greater than comparative results from VA-1 and KY-2. The predominate gases are C_1 and C_7. The mean gas wetness for the shale plus container air space is 25.2%. Gas analysis core samples averaged a gas wetness of 58.4%. This is evidence of the rapid offgassing of primarily methane. Thus, the shale core only has 43% of the gas wetness of the core plus container. These are similar to results from Appalachian wells KY-2 and WV-5, in which the core gas wetness was 61% and 45%, respectively, of the core plus container gas wetness. Results were different for shale from VA-1 (core gas wetness only 19%). These are consistent with the results of many other chemical tests which has established the contrast between sediments from the VA-1 well location and the region occupied by the other tested wells.

The average C_5-C_7 concentration was very low. The results for the shale sample analysis indicate 35 out of 38 samples had an insignificant C_5-C_7 content.

TABLE 94

C_1-C_7 Hydrocarbon Analyses of Shale Core for the WV-6 Well, Monongalia County, West Virginia

Mound Sample Identification	Depth Interval	Methane C_1 PPM	Ethane C_2 PPM	Propane C_3 PPM	Isobutane iC_4 PPM	Butane nC_4 PPM	Total C_5-C_7 PPM	Total C_1-C_4 PPM	Total C_2-C_4 PPM	Wetness %	iC_4/nC_4
WV-6-1		111087.0	34757.8	3654.3	81.4	133.0	33.8	149713.7	38626.7	25.8	0.61
WV-6-2		9695.1	6421.1	546.1	0.0	2.5	0.0	16664.9	6969.8	41.8	0.00
WV-6-3		10163.0	4855.1	547.4	10.9	17.7	0.0	15594.3	5431.3	34.8	0.62
WV-6-4		8971.5	5052.1	829.1	7.7	18.5	0.0	14879.1	5907.6	39.7	0.42
WV-6-5		11888.6	14632.6	997.5	7.9	17.4	0.0	27544.2	15655.5	56.8	0.46
WV-6-6		12184.8	13109.2	745.7	8.7	17.4	0.0	26066.1	13881.2	53.3	0.50
WV-6-7		7575.7	6149.7	567.8	12.4	22.8	0.0	14328.6	6752.8	47.1	0.54
WV-6-8		7767.0	10718.3	640.5	7.9	15.7	0.0	19149.5	11382.5	59.4	0.50
WV-6-9		5752.5	7708.7	567.2	7.5	12.5	0.0	14048.6	8296.0	59.1	0.60
WV-6-10		9.27.4	10949.8	641.0	4.6	7.9	0.0	20703.9	11603.5	56.0	0.59
WV-6-11		4970.1	5819.9	637.6	15.1	22.3	0.0	11465.3	6495.1	56.7	0.68
WV-6-12		6530.9	11651.6	634.0	6.9	15.0	0.0	18838.6	12307.7	65.3	0.46
WV-6-13		8854.1	9409.5	509.1	6.1	12.8	0.0	18791.7	9937.6	52.9	0.48
WV-6-14		5367.5	6200.4	448.0	2.1	6.2	0.0	12024.4	6656.8	55.4	0.35
WV-6-15		4208.9	2945.5	559.3	9.6	16.1	0.0	7739.6	3530.7	45.6	0.60
WV-6-18		8946.6	11225.1	693.7	6.5	11.1	0.0	20883.2	11936.5	57.2	0.59
WV-6-19		6416.6	15729.7	1054.5	13.2	24.3	0.0	23238.6	16821.9	72.4	0.54
WV-6-20		25144.9	27844.2	1093.4	10.9	22.6	0.0	54116.3	28971.4	53.5	0.48
WV-6-21		5823.7	10830.4	766.9	11.3	24.5	0.0	17457.0	11633.3	66.6	0.46
WV-6-23		4196.7	6395.7	929.1	8.7	16.9	0.0	11547.2	7350.5	63.7	0.52
WV-6-24		5227.1	10703.6	743.2	8.1	15.4	0.0	16697.6	11470.5	68.7	0.53
WV-6-26		15080.6	18825.8	1567.0	23.0	37.2	3.0	35533.7	20453.1	57.6	0.62
WV-6-27		26405.4	24146.5	1037.7	4.6	12.1	0.0	51606.4	25201.0	48.8	0.38
WV-6-28		20802.6	27582.3	1078.0	12.2	22.3	0.0	49515.5	28694.8	58.0	0.55
WV-6-29		13068.5	17212.9	1015.1	6.0	13.1	0.0	31315.9	18247.3	58.3	0.46
WV-6-30		7308.6	9657.5	752.6	3.9	10,6	0.0	17733.5	10424.8	58.8	0.37
WV-6-31		2798.8	12081.9	1096.9	13.3	21.8	0.0	16012.9	13214.1	82.5	0.61
WV-6-32		28660.6	34585.9	1175.6	16.8	32.7	0.0	64471.9	35811.2	55.5	0.51
WV-6-33		3232.5	20475.1	1167.3	12.7	22.5	0.0	24910.2	21677.7	87.0	0.56
WV-6-34		3136.9	6458.1	720.1	10.4	19.0	0.0	10344.7	7207.7	69.7	0.55
WV-6-35		5809.6	24907.7	1173.8	14.5	28.1	0.0	31933.9	26124.2	81.8	0.52
WV-6-38		3463.5	4846.4	562.7	10.0	18.6	4.1	8901.2	5437.7	61.1	0.54
WV-6-39		7067.1	32688.1	1167.0	12.8	21.8	0.0	40956.9	33889.8	82.7	0.59
WV-6-40		31684.4	32648.9	1281.7	16.0	28.2	0.0	65659.3	33974.9	51.7	0.57

TABLE 95

C_1-C_7 Hydrocarbon Analyses of Air Space for the WV-6 Well, Monongalia County, West Virginia

Mound Sample Identification	Depth Interval	Methane C_1 PPM	Ethane C_2 PPM	Propane C_3 PPM	Isobutane iC_4 PPM	Butane nC_4 PPM	Total C_5-C_7 PPM	Total C_1-C_4 PPM	Total C_2-C_4 PPM	Wetness %	iC_4/nC_4
WV-6-1		276078.0	25532.9	902.9	22.5	73.9	0.0	302610.4	26532.4	8.8	0.30
WV-6-2		178646.7	31328.3	1118.4	22.5	53.7	6.2	211169.8	32523.1	15.4	0.42
WV-6-3		177529.7	25682.6	901.4	20.1	43.1	0.0	204177.0	26647.3	13.1	0.47
WV-6-4		145168.0	27666.5	1256.5	12.1	28.5	0.0	174131.9	28963.8	16.6	0.43
WV-6-5		220596.8	43200.7	1485.7	18.8	42.2	0.0	265344.4	44747.5	16.9	0.45
WV-6-6		192767.3	32705.9	1082.9	19.0	47.9	0.0	226623.2	33855.9	14.9	0.40
WV-6-7		223485.9	41021.1	1609.6	41.6	97.4	18.0	266255.8	42769.9	16.1	0.43
WV-6-8		187025.3	37457.8	1278.6	32.5	56.8	2.4	225851.3	38825.9	17.2	0.57
WV-6-9		134030.6	24683.9	790.5	20.2	32.3	0.9	159557.8	25527.1	16.0	0.63
WV-6-10		124913.5	32098.8	1358.6	57.6	86.6	13.9	158515.2	33601.7	21.2	0.67
WV-6-11		196624.0	2245.1	739.4	16.9	40.1	0.9	219665.6	23041.6	10.5	0.42
WV-6-12		180547.9	24189.2	793.3	14.4	40.6	0.0	205585.7	25037.7	12.2	0.36
WV-6-13		189366.0	19698.9	712.3	19.5	52.8	7.5	209849.7	20483.6	9.8	0.37
WV-6-14		205547.9	28464.8	914.5	15.0	37.5	0.0	234979.8	29431.9	12.5	0.40
WV-6-15		195257.8	84737.1	5349.7	115.6	237.3	23.0	285697.8	90440.0	31.7	0.49
WV-6-18		202416.7	35301.1	1510.7	36.9	90.3	13.4	239355.9	36939.1	15.4	0.41
WV-6-19		110116.9	48897.6	1963.3	45.6	75.4	2.0	161099.1	50982.2	31.6	0.61
WV-6-20		37379.2	5064.9	1358.7	21.9	51.6	0.0	43876.5	6497.2	14.8	0.42
WV-6-21		27260.5	3747.3	866.8	13.5	27.9	0.0	31916.1	4655.6	14.6	0.48
WV-6-23		334045.1	1550614.4	44.9	104.8	294.7	0.0	1885104.1	1551059.0	82.3	0.36
WV-6-24		262004.2	105687.4	2986.5	27.2	44.1	0.0	370749.7	108745.4	29.3	0.62
WV-6-26		276159.1	58860.4	1542.7	15.3	23.0	0.0	336600.7	60441.6	18.0	0.67
WV-6-27		261174.0	30385.8	851.6	20.6	54.2	2.1	292486.5	31312.4	10.7	0.38
WV-6-28		294419.3	37708.0	993.7	38.3	126.7	0.0	333286.2	38866.9	11.7	0.30
WV-6-29		420046.2	71531.8	2112.5	35.3	64.0	0.0	493789.9	73743.7	14.9	0.55
WV-6-30		304996.3	52578.1	1527.3	33.7	66.7	0.0	359202.2	54205.9	15.1	0.51
WV-6-31		92738.2	41652.8	1025.8	0.0	15.9	0.0	135432.9	42694.6	31.5	0.00
WV-6-32		246377.9	33146.9	739.3	0.0	20.8	0.0	280285.1	33907.1	12.1	0.00
WV-6-33		51470.0	39604.0	1012.0	15.7	31.3	0.0	92133.2	40663.2	44.1	0.50
WV-6-34		148360.9	78755.4	2037.1	28.3	50.2	0.0	229232.1	80871.1	35.3	0.56
WV-6-35		285216.3	183304.8	5611.1	0.0	99.7	0.0	474232.1	189015.7	39.9	0.00
WV-6-38		125300.7	21344.1	575.5	0.0	0.0	0.0	147220.4	21919.7	14.9	-
WV-6-39		235437.6	50341.7	1043.2	0.0	0.0	0.0	286822.5	51384.9	17.9	-
WV-6-40		267234.9	41504.7	927.5	0.0	30.8	0.0	309698.1	42463.1	13.7	0.00

TABLE 96

C_1-C_7 Hydrocarbon Analyses of Shale Core and Air Space
for the WV-6 Well, Monongalia County, West Virginia

Mound Sample Identification	Depth Interval	Methane C_1 PPM	Ethane C_2 PPM	Propane C_3 PPM	Isobutane iC_4 PPM	Butane nC_4 PPM	Total C_5-C_7 PPM	Total C_1-C_4 PPM	Total C_2-C_4 PPM	Wetness %	iC_4/nC_4
WV-6-1		387165.0	60290.8	4557.2	103.9	206.9	33.8	452324.1	65159.1	14.4	0.50
WV-6-2		188341.8	37749.4	1664.6	22.5	56.3	6.2	227834.8	39492.9	17.3	0.40
WV-6-3		187692.8	30537.7	1448.8	31.1	60.8	0.0	219771.4	32078.6	14.6	0.51
WV-6-4		154139.6	32718.7	2085.7	19.9	47.0	0.0	189011.0	34871.4	18.4	0.42
WV-6-5		232485.5	57833.3	2483.2	26.8	59.7	0.0	292888.6	60403.1	20.6	0.45
WV-6-6		204952.1	45815.2	1828.7	27.7	65.4	0.0	252689.3	47737.1	18.9	0.42
WV-6-7		231061.7	47170.9	2177.5	54.0	120.3	18.0	280584.4	49522.7	17.6	0.45
WV-6-8		194792.4	48176.2	1919.2	40.4	72.5	2.4	245000.9	50208.4	20.5	0.56
WV-6-9		139783.2	32392.6	1357.7	27.8	44.9	0.9	173606.5	33823.2	19.5	0.62
WV-6-10		134040.9	43048.6	1999.7	62.2	94.5	13.4	179246.2	45205.2	25.2	0.66
WV-6-11		201594.2	28065.1	1377.0	32.0	62.4	0.9	231130.9	29536.7	12.8	0.51
WV-6-12		187078.8	35840.9	1427.4	21.4	55.7	0.0	224424.3	37345.5	16.6	0.38
WV-6-13		198220.1	29108.4	1221.4	25.6	65.7	7.5	228641.4	30421.2	13.3	0.39
WV-6-14		210915.5	34665.3	1362.5	17.1	43.7	0.0	247004.3	36088.8	14.6	0.39
WV-6-15		199466.8	87682.7	5909.1	125.3	253.4	23.0	293437.5	93970.7	32.0	0.49
WV-6-18		211363.3	46526.3	2204.4	43.4	101.4	13.4	260239.1	48875.7	18.8	0.43
WV-6-19		116533.6	64627.4	3017.9	58.9	99.8	2.0	184337.8	67804.1	36.8	0.59
WV-6-20		62524.1	32909.2	2452.2	32.8	74.3	0.0	97992.9	35468.7	36.2	0.44
WV-6-21		33084.2	14577.8	1633.7	24.8	52.5	0.0	49373.2	16288.9	33.0	0.47
WV-6-23		338241.8	1557010.1	974.0	113.6	311.7	0.0	1896651.4	1558409.5	82.2	0.36
WV-6-24		267231.3	116391.1	3729.7	35.4	59.6	0.0	387447.3	120215.9	31.0	0.59
WV-6-26		291239.7	77686.2	3109.8	38.3	60.2	3.0	372134.4	80894.7	21.7	0.64
WV-6-27		287579.5	54532.3	1889.4	25.2	66.3	2.1	344092.9	56513.4	16.4	0.38
WV-6-28		315239.9	65290.4	2071.7	50.5	149.1	0.0	382801.7	67561.8	17.6	0.34
WV-6-29		433114.8	88744.8	3127.6	41.3	77.1	0.0	525105.9	91991.1	17.5	0.54
WV-6-30		312304.9	62235.7	2279.9	37.7	77.3	0.0	376935.8	64630.8	17.1	0.49
WV-6-31		95537.0	53734.8	2122.8	13.3	37.7	0.0	151445.9	55908.8	36.9	0.35
WV-6-32		275038.5	67732.8	1915.0	16.8	53.6	0.0	344757.0	69718.4	20.2	0.31
WV-6-33		54702.5	60079.1	2179.3	28.4	53.9	0.0	117043.5	62340.9	53.3	0.53
WV-6-34		151497.9	85213.5	2757.2	38.7	69.3	0.0	239576.9	88078.9	36.8	0.56
WV-6-35		291026.0	208212.6	6784.9	14.5	127.8	0.0	506166.0	215139.9	42.5	0.11
WV-6-38		128764.2	26190.6	1138.2	10.0	18.6	4.1	156121.7	27357.4	17.5	0.54
WV-6-39		242504.7	83029.8	2210.2	12.8	21.8	0.0	327779.5	85274.8	26.0	0.59
WV-6-40		298919.4	74153.7	2209.2	16.0	59.0	0.0	375357.5	76438.1	20.4	0.27

N. PERMEATION STUDIES

The permeation of helium was measured through four samples of shale from Mason County, West Virginia. Measurements were made both parallel and perpendicular to the bedding planes. Gas flow in all but one of the parallel samples (WV-5-46) was high enough to be measured by a flow meter. Gas flow in WV-5-46 and all perpendicular samples had to be measured on a mass spectrometer. Table 95 contains the results.

The permeability values (not corrected for slip flow) are determined by Darcy's Law:

$$\text{Permeability} = \frac{qP\,L\,\mu}{A}\,\frac{2}{(P_a^2-P_b^2)}$$

q = flow rate	μ = viscosity of Helium
p = pressure at which flow rate is measured	A = surface area
L = Length	P_a = pressure at high end
	P_b = pressure at low end

Permeability values are dependent on sample condition. Each sample is x-rayed and its surface area visually inspected. Mineral lenses and inclusions, internal and surface cracking, areas of high and low density have been seen in the samples. These factors affect permeability. For example, Sample WV-5-46 showed no sign of imperfections and had a permeability of 2.3×10^{-8}d; whereas WV-5-49 had a number of cracks visible on both the high and low pressure surfaces and had a permeability of 2.8 d. These effects should be lessened by testing subsequent samples under hydrostatic pressure.

The effect of moisture on permeability is under investigation. Sample fractions from WV-5-50 are being exposed to environments of 65%, 85% and 100% relative humidities.

The equipment for the methane permeation study is being assembled. A combination of flowmeter, pressure monitored standard volumes, and mass spectrometer have been selected based on the magnitude of the permeability.

TABLE 97

Permeation of Helium Through Shale, Mason County, West Virginia

Mound Sample No.		Permeability (darcys)	High Press (psi)	Low Press (psi)	Sample Condition X-Ray	Sample Condition Surface
WV-5-46	$\parallel$ E/W	1.3×10^{-7}	19.6	vacuum	area of slight high density	crack
	$\parallel$ N/S	1.8×10^{-8}	18.2	vacuum	"	N.D.
WV-5-47	$\perp$	2.7×10^{-10}	2.0	"	one area of high density	N.D.
	$\parallel$ N/S	6.3×10^{-2}	27	atmospheric	N.D.	cracks
WV-5-48	$\perp$	2.8×10^{-8}	212	vacuum	1 large lens between planes	N.D.
	$\parallel$	4.1×10^{-1}	14-18	atmospheric	crack and large density area	cracks
WV-5-49	$\perp$	1.6×10^{-7}	18	vacuum	small low density area and high density area	N.D.
	$\parallel$ N/S	2.8	14	atmospheric	N.D.	number of cracks

N.D. - No Defects Noted .

O. SCANNING ELECTRON MICROSCOPY STUDIES (SEM)

A preliminary examination by SEM of select samples from the WV-5 well core indicates heavy concentrations of iron sulfide (FeS_2) at various depths. The characteristic framboidal ("raspberry-like") structure was evident in each of the samples (Figure 3, Figure 4). Dispersed clusters of euhedral crystals (Figure 5, Figure 6) were observed in light gray banded zones in WV-5-3 and WV-5-36 (Figure 7). Similar banded zones were also observed in other WV-5 core samples. However, better analytical results were favored by the distinct delineation between the sedimentary minerals and the band width of the pyrite deposits found in the WV-5-3 and WV-5-36 core samples.

Pyrite, one of the most common iron sulfide minerals, is a potential indicator of the depositional environments. Experimental work suggests that pyrite deposition occurs in a sedimentary basin with restricted physical and chemical parameters. The establishment of a mechanism and rate of pyrite formation has not been fully developed, although several possible explanations were previously described(1). In all cases it was suggested that the sulfide was derived by the reduction of sulfate present in sea water, although in some instances a small quantity of sulfur is thought to be obtained from organic matter.

In samples WV-5-3 and WV-5-36, Gypsum crystals ($CaSO_4$) commonly occurred with the pyrite (FeS_2). The high concentration of free sulfur aided in the precipitation of these crystals, probably contemporaneous with the pyrite formation. The size and shape of these crystals (Figure 8, Figure 9) indicates an unrestricted and lengthy rate of growth.

The overall calcium content of these two particular samples was greater than that observed in other WV-5 samples.

P. RESULTS OF GEOPHYSICAL STUDIES

Geophysical studies resulted in: 1) the writing of a computer program (SYNLOG); 2) making synthetic seismograms; and 3) interpreting the three dimensional seismic records from the Cottageville Field.

Figure 3

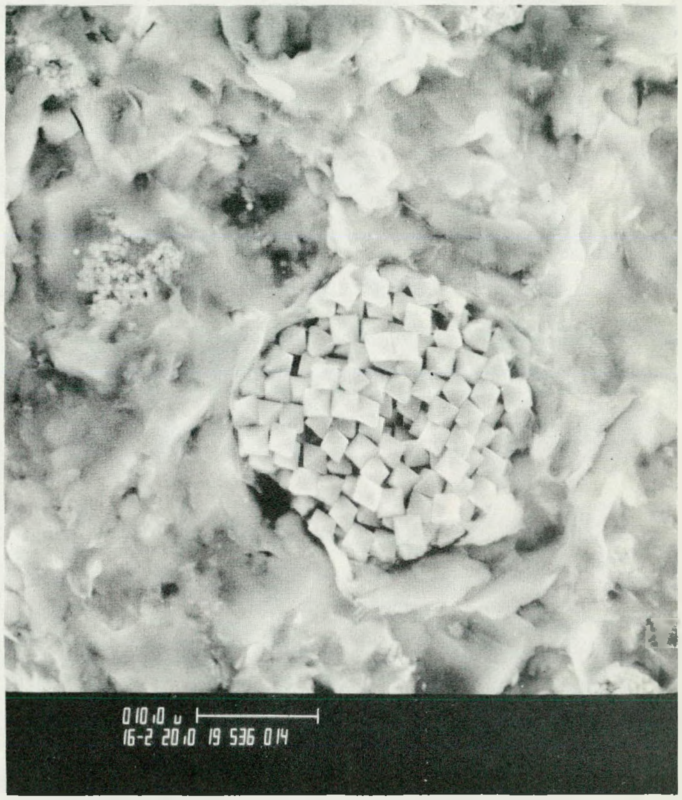


Figure 4

Framboid formations on the fractured surface of the core from WV-5-36. The incomplete formation, Figure 4, as evidenced by the random orientation of the euhedral FeS_2 crystals, indicates the crystallization occurred in an environment different than of the tightly packed formations in Figure 3.

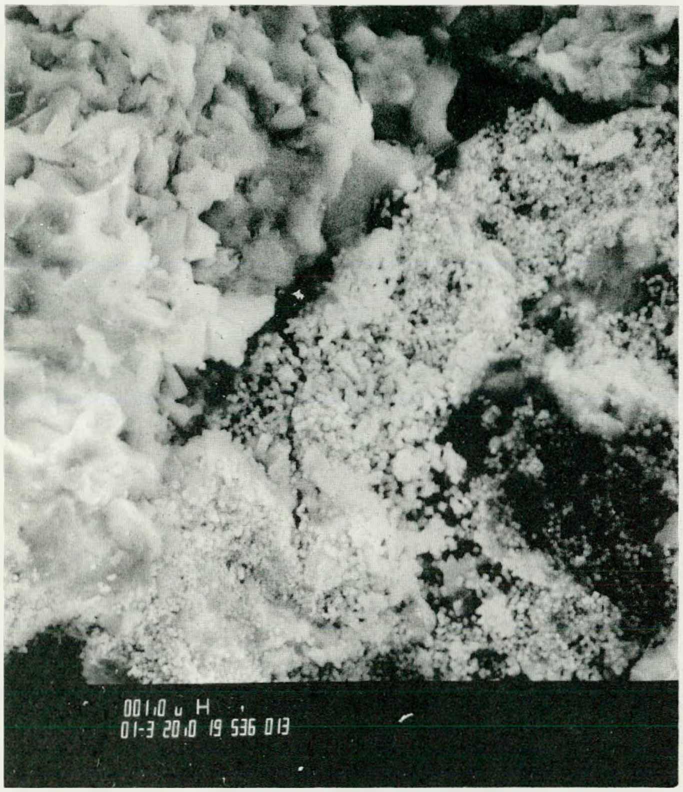


Figure 5

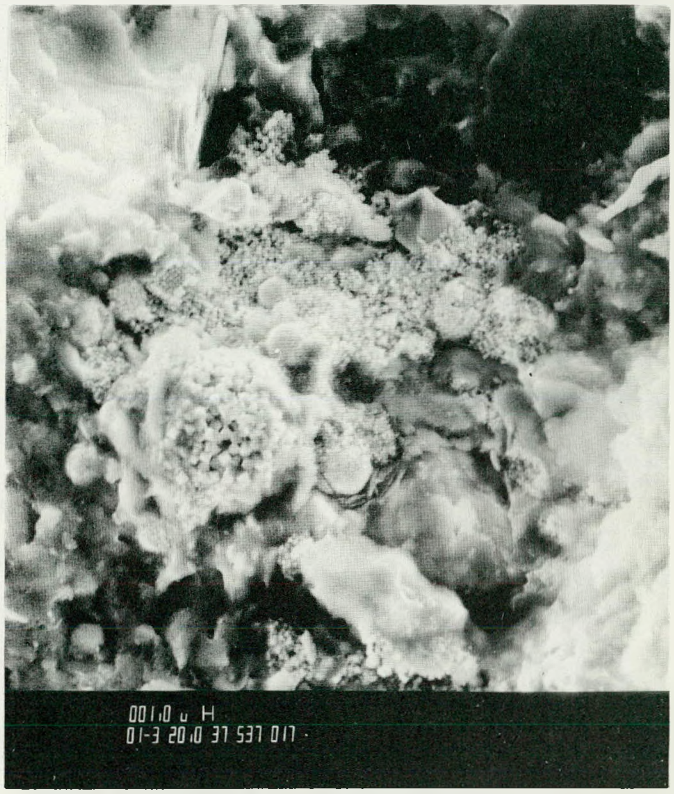


Figure 6

Heavy concentrations of FeS_2 in the light-grey banded zones were easily indentified. Loosely packed and randomly oriented, these heavy concentrations reduced the bonding strength of the shale matrix.

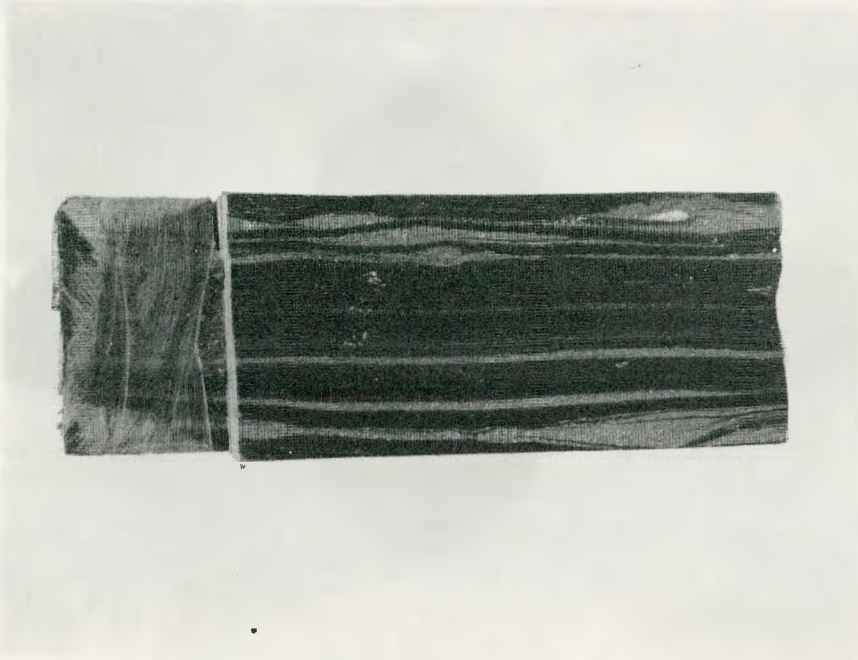


Figure 7

Light grey bands of pyrite deposited in the bedding planes of WV-5-3.

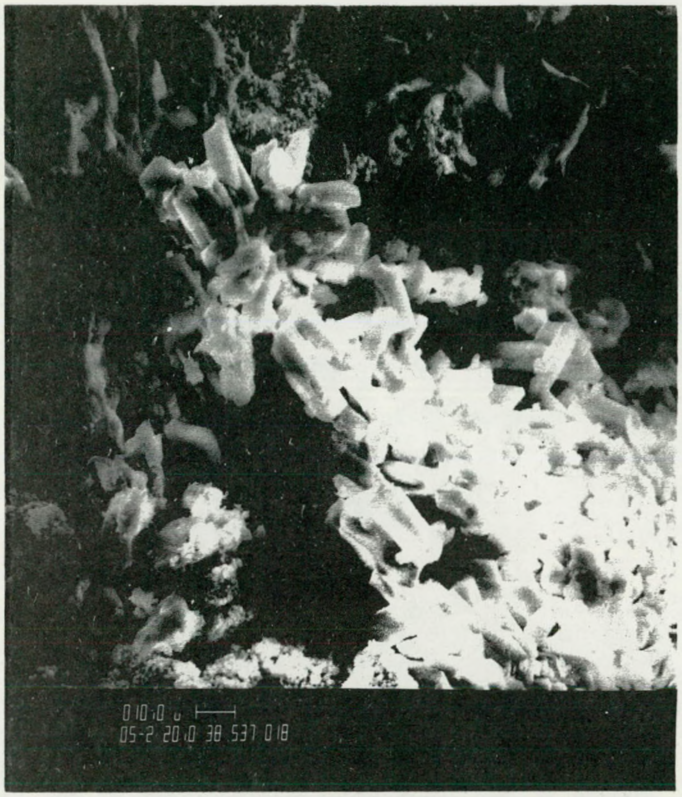


Figure 8

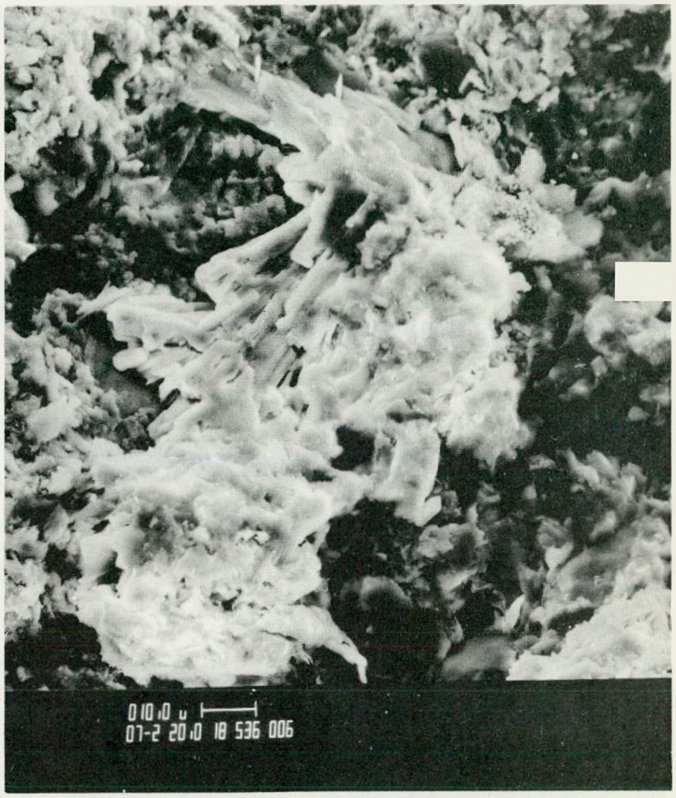


Figure 9

Well developed gypsum crystals embedded in pyrite.

SYNLOG produces a record of the reflection coefficients (synthetic log) which are calculated from an input of a seismic trace (Figure 10) and the estimated pulse shape from that trace (Figure 11). Both the seismic trace and the estimated pulse are transformed into the complex frequency domain. The pulse is then divided into the seismic trace. The result is transformed back into the time domain to produce the synthetic log (Figure 12).

The synthetic seismograms were computed for data taken from the Pricetown area. The data consisted of 852 sonic velocities taken at two foot intervals from a digitized sonic log from the Dallison #1 well. No density information was given so a constant density of a 2.4 g/cm^3 was assumed for calculating the reflection coefficients. The reflection coefficients (R.C.) were calculated by the equation:

$$\mathrm{R.C.} = \frac{\rho_1 \nu_1 - \rho_2 \nu_2}{\rho_1 \nu_1 \quad \rho_2 \nu_2}$$

where,

ρ_1 = density for layer one

ρ_2 = density for layer two

ν_1 = velocity for layer one

ν_2 = velocity for layer two

After the reflection coefficients were calculated, they were spaced by adding the appropriate number of zeroes between the values to approximate the sampling interval used for the seismic pulse. The sampling interval in this case was 0.0899 milliseconds.

The estimated pulse was constructed by summing cosine waves at the frequencies desired and converting the result to minimum phase. The estimated pulse (Figure 13) was then convolved with the reflection coefficients to form the synthetic seismogram. An example of the synthetic seismograms is shown in Figure 14. The pulse used in this example contains frequencies which range to 31-494 Hz.

The three dimensional seismic coverage at the Cottageville Field consists of 77 seismic lines with 169 shot points each. Two structure maps were made from these data, one at the top

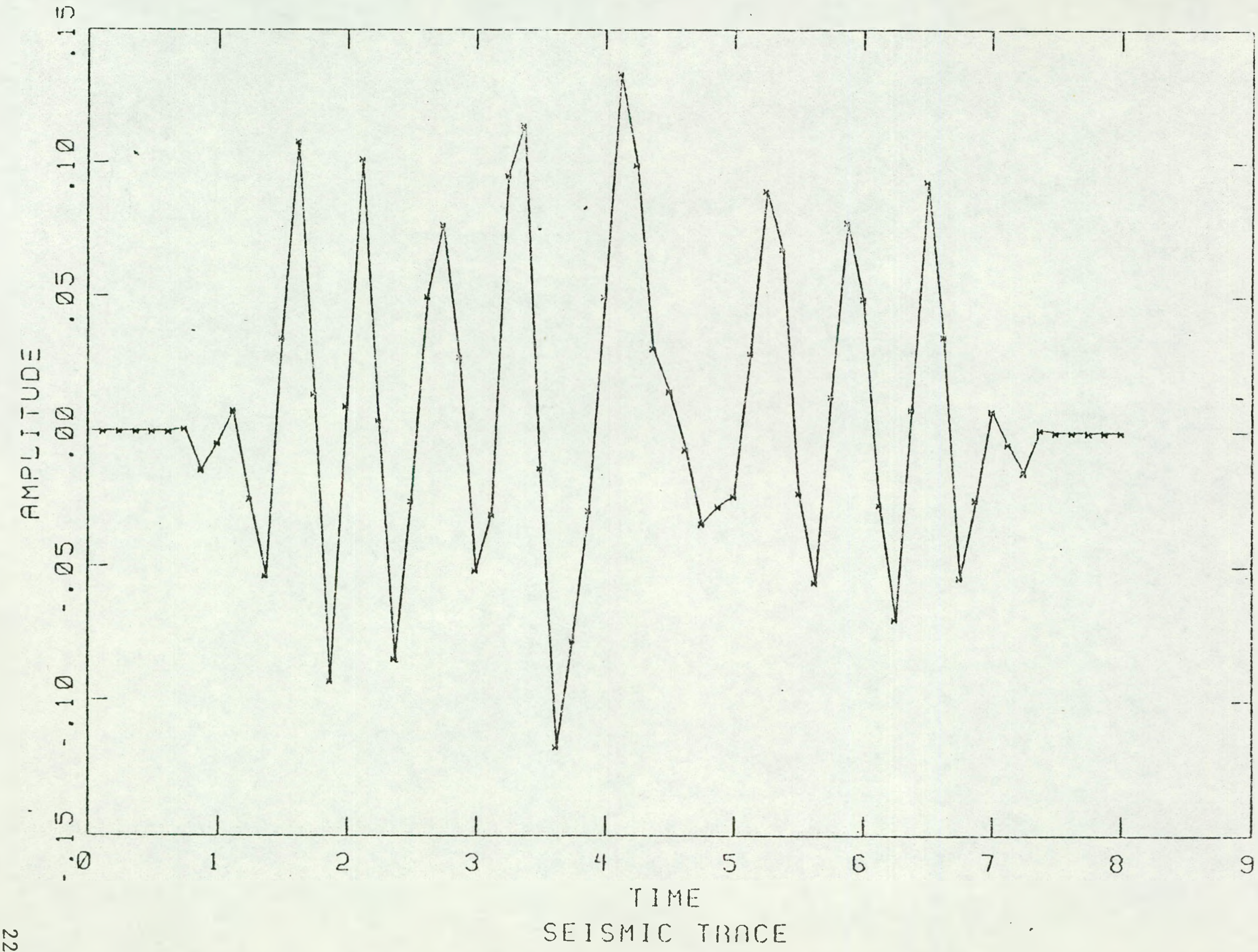


Figure10 - Seismic trace used in SYNLOG

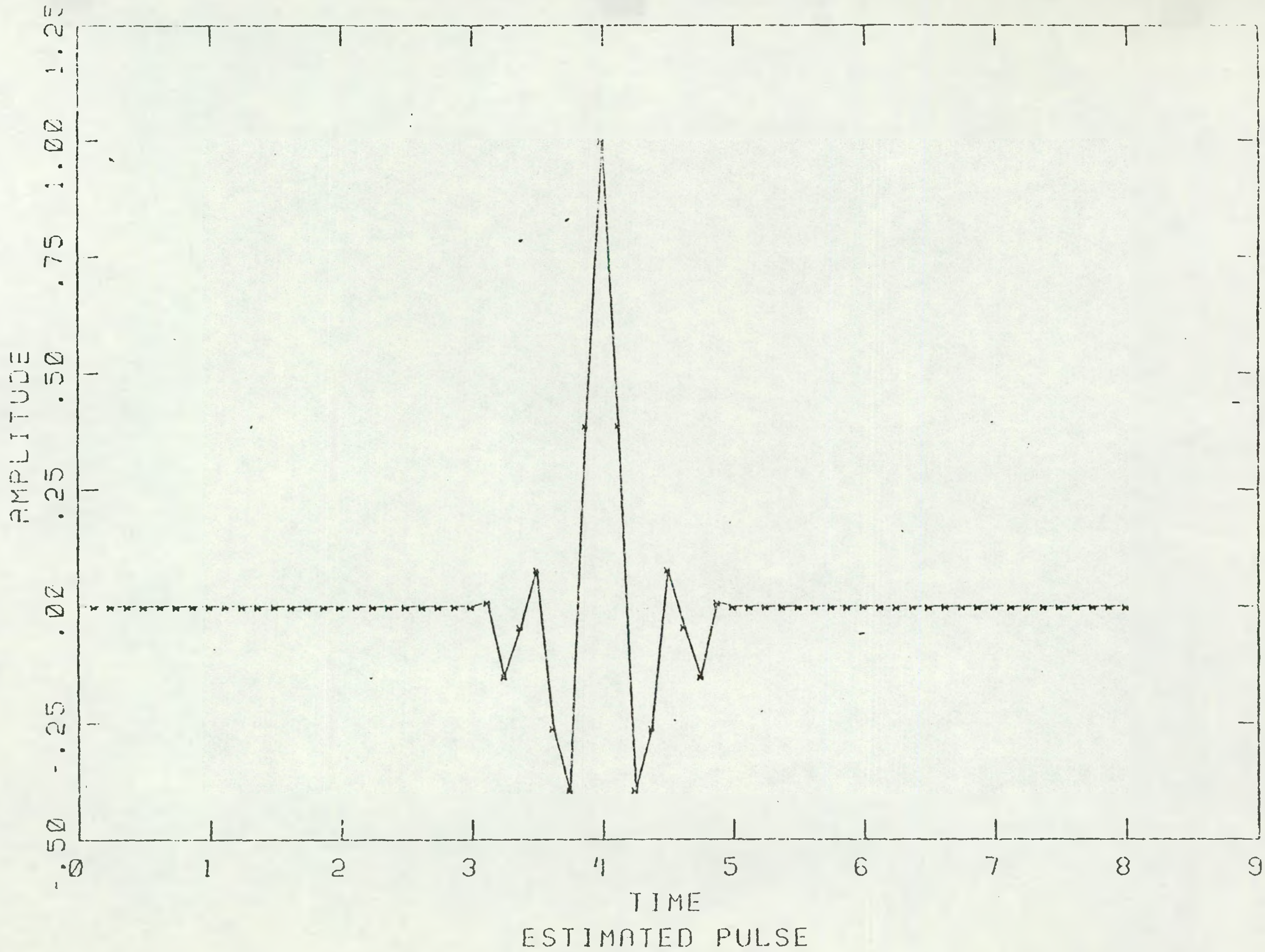
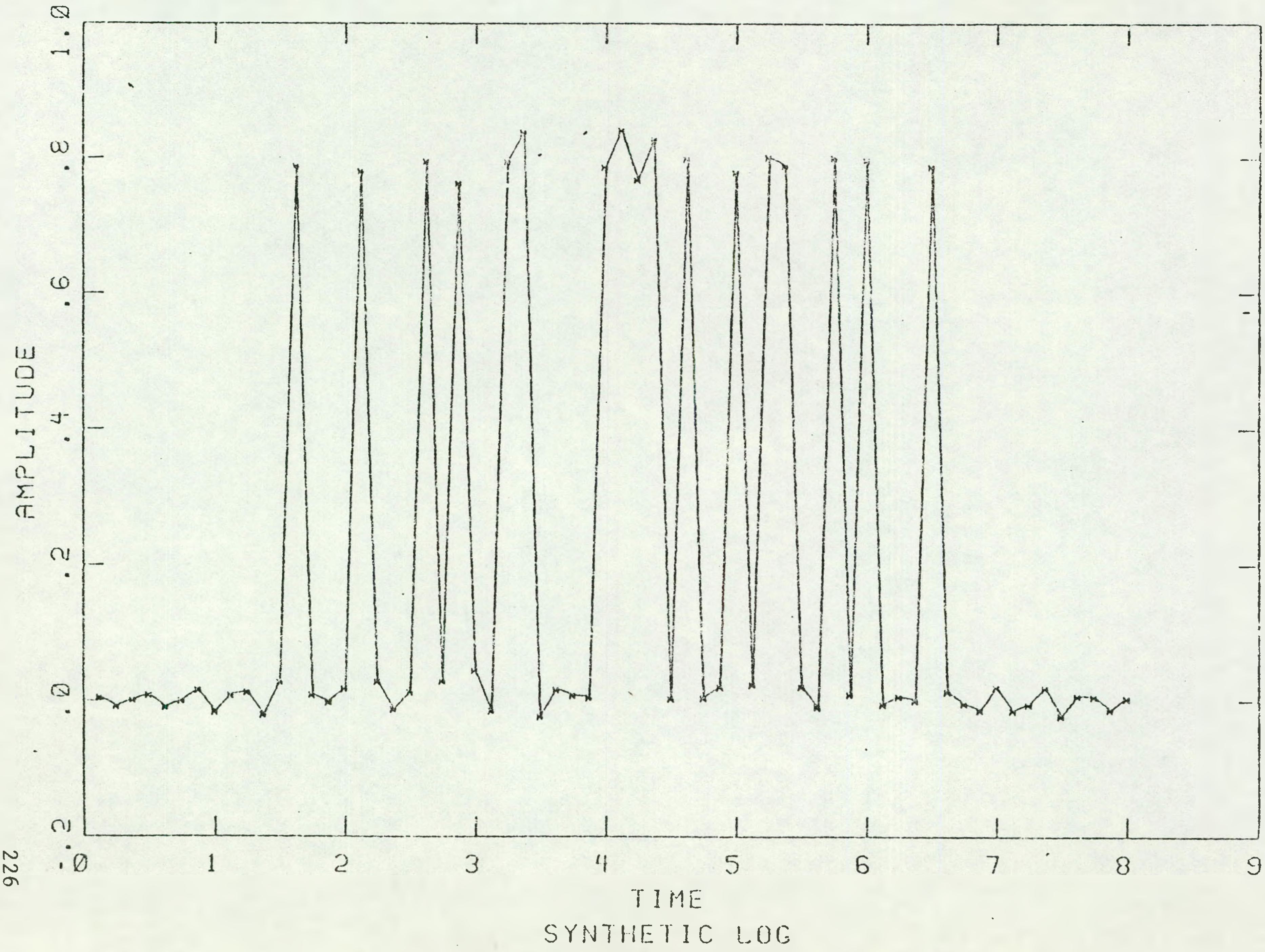


Figure 1i-Estimated pulse used in SYNLOG

Figure 12- Experimental Synthetic Log



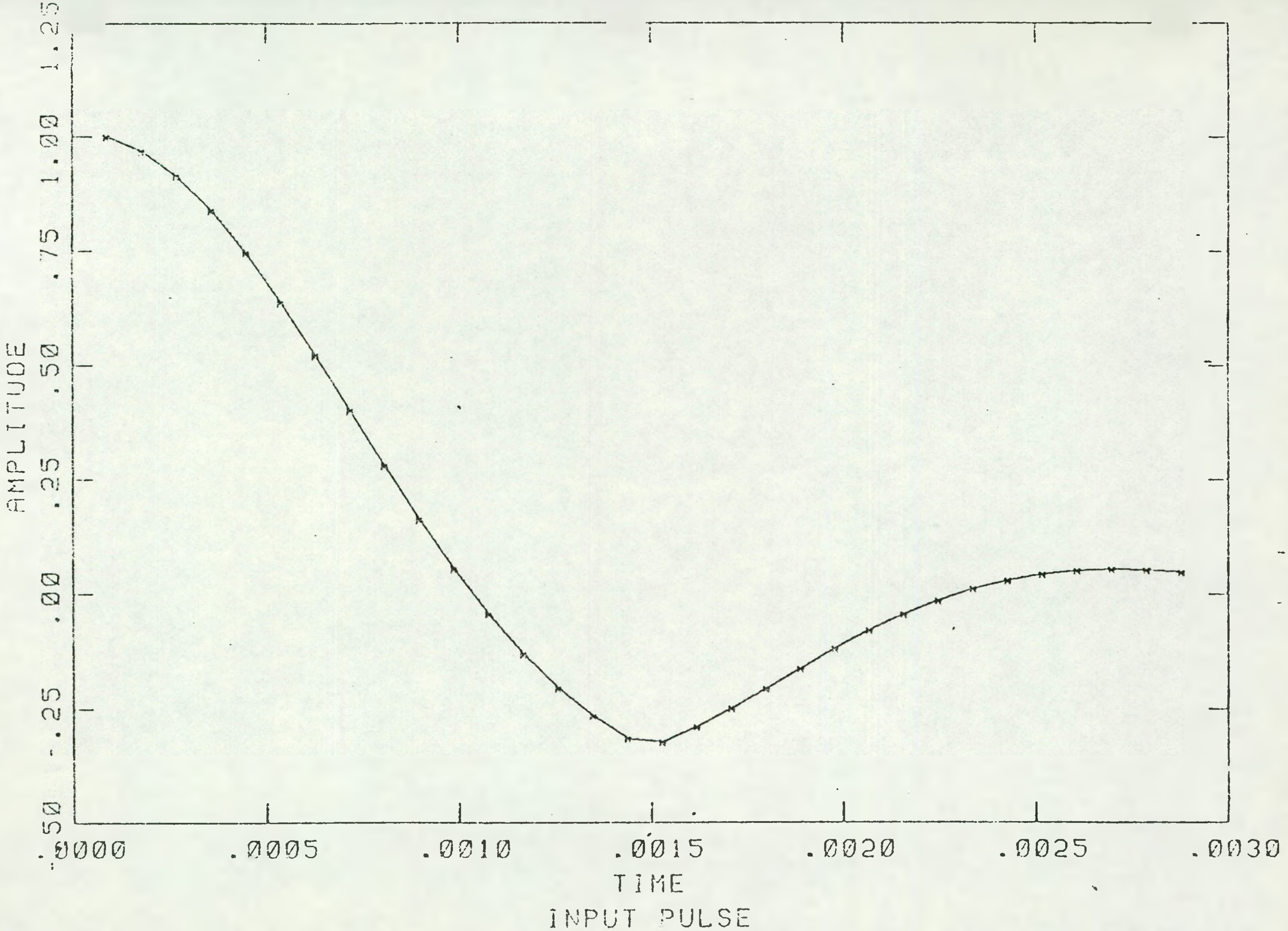


Figure 13- Input pulse used in making synthetic seismogram

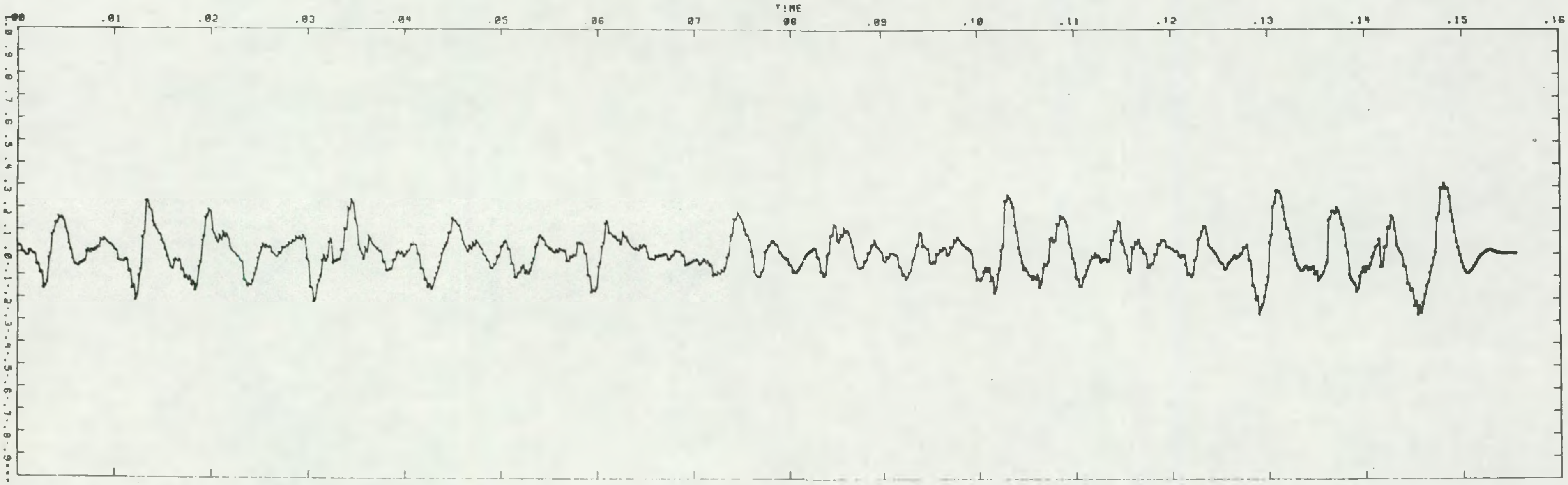


Figure 14 - Synthetic Seismogram

of the Onondaga limestone and the other at the top of the basement. The structure maps were made by picking a time value on the appropriate reflection every tenth shot point on every line and then contouring the values.

The map on the Onondaga (Figure 15) shows a gentle dip to the southeast. The only major feature on the map consists of an anticlinal area in the upper right quadrant of the map.

The basement structure map (Figure 16) also shows a regional dip to the southeast, but it has considerably more structure than the Onondaga structure map. While having several anticlinal and synclinal features, the dominant feature on the basement structure map is a steeply dipping monocline which cuts across the middle of the map.

This study tests the concept that the fractures in the Devonian shales are related to basement structures.[8,9]. The basement structural map was divided into five structural regions; regional dip (A), flat lying (B), synclinal (C), anticlinal (D) and steeply dipping (E). These are shown in Figure 17. Production data, as a measure of fracture porosity, from the area above each structural region were compared to see if any area was significantly more productive than the others thus showing a correlation between the deep structure and the fracturing.

Thirty-seven wells were used in the study, which includes every well with production data which was drilled in the area covered by the structural map. The majority of the wells were drilled by Consolidated Gas Company and the remaining by either Cities Service or Columbia Gas. No distinction was made between stimulated and unstimulated wells. Only production from wells drilled before July 1 was considered as first-year production. The wells are spotted on the map in Figure 17.

The results from the study are shown on Table 98. The production from the shales over the steeply dipping region is much greater than over any of the other structural regions. While occupying only 15.0% of the test area, 32.4% of the wells were drilled there, and these accounted for 41.4% of the total annual production from the test area. This is 10% more than the total annual production found over the synclinal region which occupies almost 5% more of the test area and 19% more than the total annual production over the flat lying region.

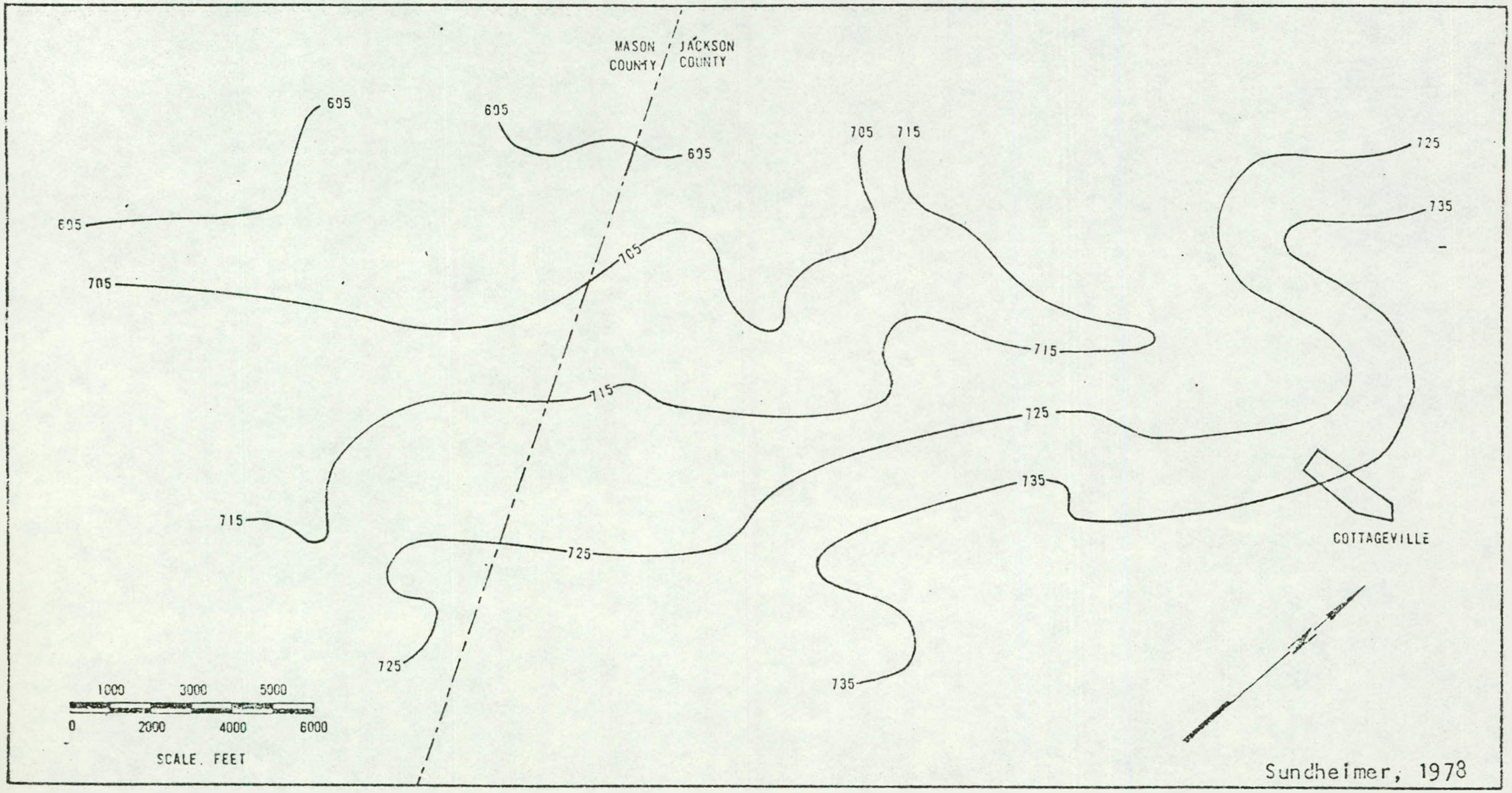


Figure 15– Isotime Structural Contours on Top of the Onondago. Contour Interval = 10 milliseconds.

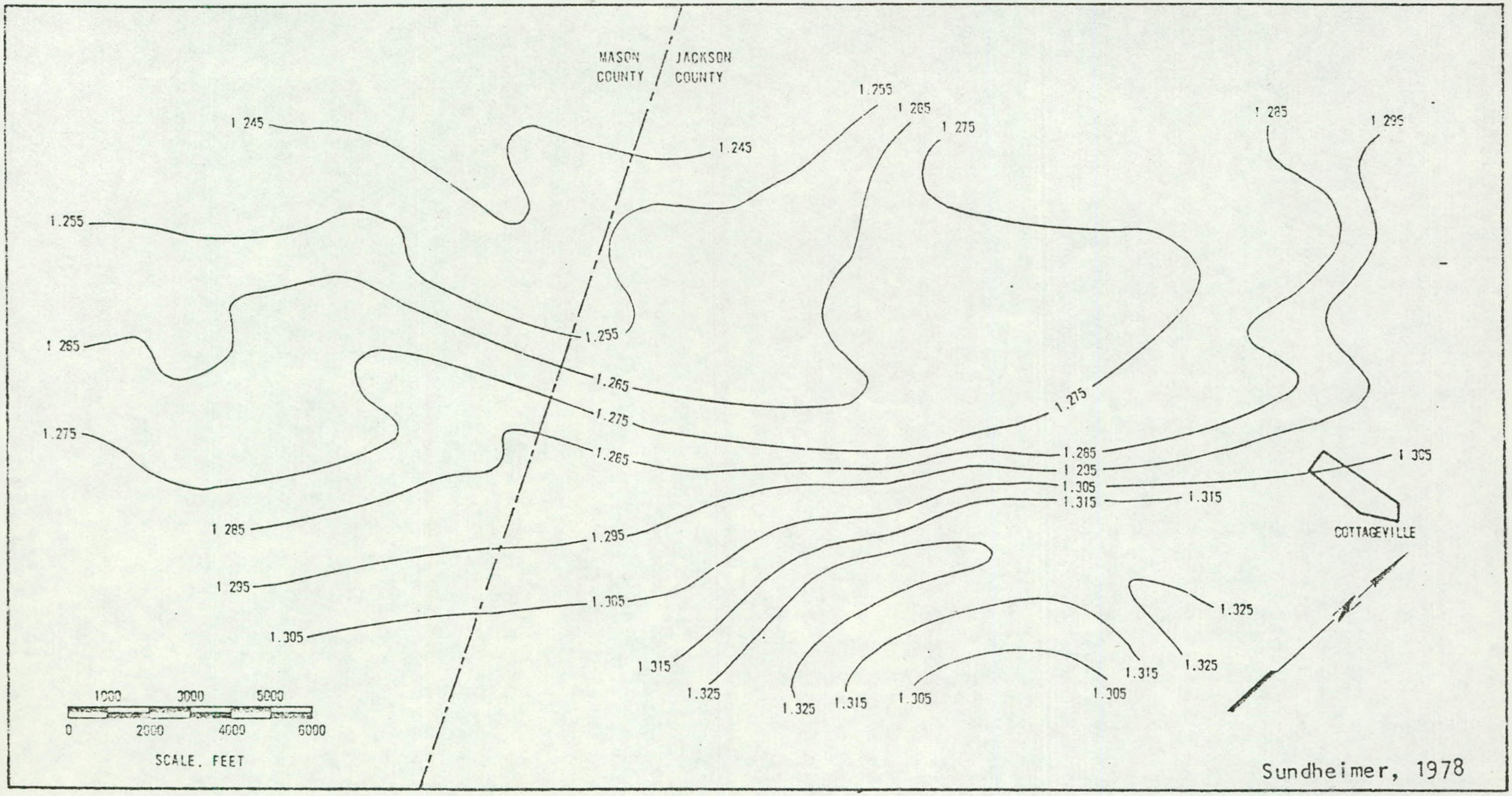


Figure 16 - Isotime Structural Contours on Top of the Basement. Contour Interval = 0.010 seconds.

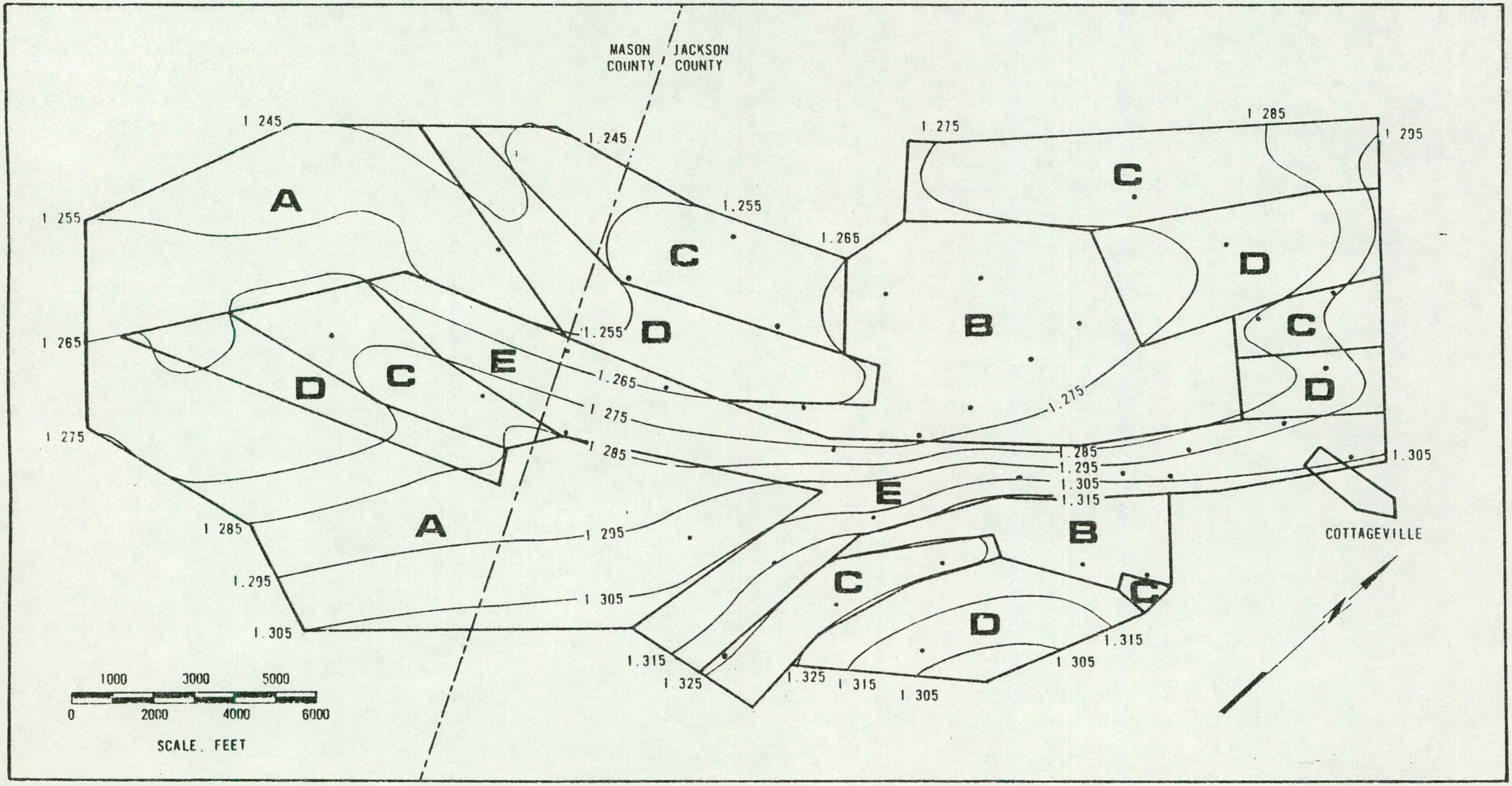


Figure 18- Isotime Structural Contours on Top of the Basement divided into Five Structural Regions.
Contour Interval = 0.010 seconds. Wells = (·).

TABLE 98 – Production Data from the Areas over Five Structural Regions

Structural Region	# of map area	# of wells drilled in the area (% of total)	First year production (% of total)	First and second year production (% of total)	First five years of production (% of total)	Total annual production (% of total)
Regional dip	30.1%	2 (5.4%)	30,478 MCF (3.1%)	50,232 MCF (2.8%)	61,562 MCF (1.9%)	90,467 MCF (1.2%)
Flat Lying	15.3%	9 (24.3%)	211,950 (21.5%)	371,777 (20.3%)	677,498 (21.3%)	1,634,167 (22.1%)
Synclinal	19.7%	11 (29.7%)	243,912 (24.8%)	500,808 (27.3%)	933,903 (29.4%)	2,281,229 (30.8%)
Anticlinal	19.8%	3 (8.1%)	28,990 (3.0%)	54,072 (3.0%)	108,639 (3.4%)	332,990 (4.5%)
Steeply Dipping	15.0%	12 (32.4%)	469,099 (47.7%)	856,049 (46.7%)	1,397,038 (44.0%)	3,059,629 (41.4%)
Totals	99.9%	37 (99.9%)	984,429 (100.1%)	1,833,029 (100.1%)	3,178,640 (100.0%)	7,398,482 (100.0%)

These results support the theory that basement structure and fractures in the Devonian shale are related. The exact nature of this relationship is as yet unclear and will be the subject of future work.

Q. STATISTICAL ANALYSIS RESULTS

Seven parameter statistical models derived from Clinton Sands flow data (328 wells) were used to compute fits to the flow data accumulated over a 60 month period. The sensitivities of the models to changes in the independent parameters, primarily volume, are indicated. These data were obtained from data first partitioned according to longitude and latitude, and then further partitioned according to flow magnitude, as given previously[1,4]. Thus, the data clusters (CL1, CL2, CL3):

CL1	41.0 < LONG < 41.2
	81.15 < LAT < 81.35
CL2	40.1 < LONG < 40.5
	81.30 < LAT < 81.55
CL3	LONG < 4012
	LAT > 81.45

were then further classified according to whether or not the cummulative flow (Y4) for a 60 month period was greater than 100,000 MCF. By this convention the high flow and low flow data for CL1 are designed as HICL1 and LOCL1, respectively. The labels and models for these clusters are given in Table 99. Definitions of the independent variables (X's) are listed in Table 100.

A comparison between the computed values and the observed values of various wells for LOCL1 is tabulated in Table 101. The wells in this cluster as well as those in the other clusters were selected to cover the range of values for both the cumulative flow and the independent parameters, particularly the volume parameters.

Inspection of Table 101 indicates that for LOCL1 the fit is good. There are exceptions, for example, well No. 27. The sensitivity of the predicted value to volume related parameters

TABLE 99

Labels and Models Used for the Clinton Sands Gas Flow Study

Label	Model
HICL1	$Y_4 = {}^{-}20572 + 54.3X_{15} + 67.9X_{16} - 22X_{17} - 49.7X_{18} + 560177X_{25} + 195.4X_{29} - 424103X_{31}$
LOCL1	$Y_4 = -490388 + 305X_3 + 83X_6 + 141X_7 + 812X_{14} - 5.7X_{15} + 1.31X_{18} - 14.5X_{20}$
HICL2	$Y_4 = -265411 + 201X_7 - 479094X_{13} - 2458X_{14} + 8.1X_{16} - 1.08X_{17} - 2.92X_{18} + 246051X_{25}$
LOCL2	$Y_4 = 37074 - 1197X_4 + 53.6X_7 + 803X_{14} + 1.82X_{15} - 22.6X_{20} + 15595X_{25} + 125X_{29}$
HICL3	$Y_4 = -3454870 + 304X_6 - 303X_7 - 1053X_{11} + 7322X_{14} - 9.4X_{15} - 3.5X_{18} + 5669926X_{31}$
LOCL3	$Y_4 = 132739 - 573X_3 + 19X_{11} - 48217X_{13} + 1480X_{14} + 0.8X_{18} + 237X_{29} - 185736X_{31}$

TABLE 100

List of Independent Variables and Their Physical Significance for the Clinton Sands Gas Flow Study: Twenty Variable Set

Variable	Physical Significance
Y_1	Open Flow, MDFD
Y_4	Accumulated Production of Well For 60 Months
X_3	Gross Sand, Ft.
X_4	Net Sand, Ft.
X_5	Porosity, %
X_6	Depth to the Perforation: "Depth of the Well"
X_7	Rock Pressure, psi
X_{10}	Breakdown Pressure, psi
X_{11}	Average Treating Pressure During FRAC Operation
X_{12}	Instant Shut-In Pressure
X_{13}	Perforation Size
X_{14}	Number of Perforations
X_{15}	Pad Volume, Gal.
X_{16}	Treatment Volume, Gal.
X_{17}	Total Water Volume, Gal.
X_{18}	Total Sand, Lbs.
X_{21}	Vertical Stress: $1.15X_6$
X_{24}	X_4/X_3
X_{25}	X_{18}/X_{16}
X_{29}	X_4/X_5
X_{30}	$X_{11}+0.43X_6$
X_{31}	X_{30}/X_6

TABLE 101

Comparison between Computed and Observed Values of Selected Wells for LOCL1: Seven Parameter Model

Well No.	Observed	Computed
3	94081	90129
7	74240	84117
10	93453	77596
12	79950	73798
15	87042	73187
21	99847	73499
23	59851	53254
	59851	87969*
27	26483	60645

*Based on X_{18} = 50,000; value for FRAC operation was 23,500

(X_{15}, X_{18}) was tested by increasing or decreasing the field test values by 100% or more. For example, a 100% increase in the total sand (X_{18}) for well No. 23 yielded a computed value of approximately 88,000 MCF which is still below the economic cut-off of 100,000 MCF used in this study. Similarly an approximate two-fold change in the pad volume (X_{15}) for wells No. 3 increased the computed value from ∿90,000 MCF to 100,000 MCF, a marginal improvement. Generally this analysis suggests that the FRAC treatments used were appropriate for these low flow wells and that a two-fold or greater increase in the modeled volume parameters would not have been productive.

The results of a comparable analysis for HICL1 is indicated in Table 102. Again the fit is reasonable. But in contrast to the LOCL1 model, the model for HICL1 reflects a greater sensitivity to changes in the volume parameters. For well No. 1 an increase in the treatment volume (X_{16}) of 7% gives an increase of 27% in the computed flow. Similarly a change of 14% in the total sand (X_{18}) yields an increase of 61% in the computed flow. A resolution on interaction of the volume parameters is currently being tested with a seven parameter non-linear model. In general, however, this analysis suggests that a controlled balance among the volume parameters could improve the flow for high flow wells in CL1.

Generally, initial analysis for the other clusters suggest there are regional differences.

The flow data also were examined statistically for indicators of well communication. In this ananlysis an appropriate independent variable X_i and dependent variable Y_j were selected for each data point. Then all such points were examined and the differences

$$X_i^{(2)}-X_i^{(1)} \quad \text{and} \quad Y_j^{(2)}-Y_j^{(1)}$$

were calculated. If these two differences are of the same sign, then the results are considered to be in a consistent direction; otherwise, they are in an inconsistent direction. Next for all pairs of points which are within a window (Δ) in longitude and latitude, the number of consistent and inconsistent pairs are counted.

TABLE 102

Comparison between Computed and Observed Values of Selected Wells for HICL1: Seven Parameter Model

Well No.	Observed	Computed
1	183961	252058
	183961	319958*
	183961	406128**
2	333309	202412
4	217784	327659
17	486178	421154
22	457757	350283
30	111272	146081
68	173061	112993
71	140780	189705

*Based on X_{16} = 15,400; value for FRAC operation was 14,400

**Based on X_{18} = 18,900; value for FRAC operation was 22,000

For any randomly selected pair, if X_i is positively correlated with Y_j, then it would be expected that more consistent pairs will be obtained than inconsistent pairs. However, the test hypothesis is that the closer the wells, the more likely are the results to be consistent. This is indicated by the computation.

If close wells were connected or coupled, then higher flow of one well would tend to decrease the flow of a nearby well. The results indicate that this is not occurring because as Δ decreases, the percent of consistent pairs increase. A sample data summary is given in Table 103.

R. MECHANICAL TESTING RESULTS

WV-5 oriented core samples, from ∿2700 ft. to 3100 ft., were analyzed to determine Shore Hardness, Young modulus, splitting tensile strength and elongation during mechanical testing (Table 104).

Generally, results indicate no consistent relationship of the test values and depth. Point load testing results indicate a random maximum tensile strength direction (Table 105). Shore Hardness values decrease irregularly with increasing depth. This suggests that the increased "maturation" with increased depth is not the primary factor in determining the mechanical properties of these shales.

S. SHALE BLOCK FRACTURE ANALYSIS

A shale fracture analysis study is being initiated. Multi-ton "blocks" of the Devonian age Ohio Shale (Chagrin Member) have been acquired. Lithologic and natural fracture characteristics will be determined prior to induced fracturing. This thin bedded medium blue-gray noncarbonaceous shale exhibits fissile weathering which produces a rubble of polygonal chips. This shale member is correlative with other potential gas producing shales of the Appalachian Basin. In the area of sample collection the wedge-shaped Chagrin Member is up to 1200 feet thick, thickening from west to east. The Chagrin Member is underlain by the Huron Shale Member and is unconformably overlain by the Cleveland Shale Member. These three shale members comprise the Ohio Shale of Northeastern Ohio.

TABLE 103

Summary Table Indicating that Communication Among Adjacent Wells is Minimal.

Window (Δ)	Variables	Consistent Direction	Inconsistent Direction	% Consistent
0.005	X_4, Y_4	23	13	63.9
0.010	X_4, Y_4	180	155	53.7
0.007	X_4, Y_1	100	66	60.2
0.009	X_4, Y_1	155	115	57.4
0.010	X_4, Y_1	188	147	56.1
0.012	X_4, Y_1	266	214	55.4
0.015	X_4, Y_1	395	316	55.6

TABLE 104

Physical Properties of Core Samples, WV-5 Well,
Mason County, West Virginia

Mound Sample No.	Depth (ft.)	Shore Hardness S_h	Splitting Tensile σ (MPa)	Young's Modulus Y (MPa) (X10)	Elongation (cm)	Density ρ (g/cm^3)	Gas Released Mole/cm^2/sec (X10^{-12})
WV-5-3	2725.5	22.95	2.797	6.040	0.0508	2.59	0.2705
WV-5-4	2735.5	15.20	2.644	3.056	0.0949	2.53	4.011
WV-5-22	2932.5	19.10	3.305	6.861	0.0528	2.51	3.510
WV-5-27	2982.5	14.65	2.522	6.407	0.0432	2.59	11.510
WV-5-29	3000.5	17.00	3.136	7.405	0 0464	2.44	7.298
WV-5-33 (1)	3040.5	16.60	2.086	6.145	0.0351	2.63	6.902
WV-5-35 (2)	3059.5	14.80	1.116	4.651	0.0488	2.64	9.791
WV-5-36	3069.5	13.75	2.848	7.053	0.0443	2.59	11.480
WV-5-42 (3)	3127.5	13.20	1.811	4.768	0.0417	2.47	--

(1) Some blockiness in line of break caused a lower than expected splitting tensile value.
(2) Mineral lense in sample probably caused high loading in area and premature failure.
(3) Blockiness of material exposed by mechanical testing resulted in low splitting tensile value.

TABLE 105

Determination of Maximum Tensile Strength Direction
by Point-load Testing of Samples
for the WV-5 Well, Mason County, West Virginia

Mound Sample No.	Depth	Maximum Tensile Direction
WV-5-3	2725.5	---
WV-5-4	2735.5	NE $\sim 45^{\circ}$ from North
WV-5-7	2768.5	NE $\sim 45^{\circ}$ from North
WV-5-19	2894.5	---
WV-5-21	2914.5	E $\sim 90^{\circ}$ from North
WV-5-22	2932.5	ENE $\sim 75^{\circ}$ from North
WV-5-24	2952.5	NNE $\sim 15^{\circ}$ from North
WV-5-27	2982.5	---
WV-5-29	3000.5	NNW $\sim 15^{\circ}$ from North
WV-5-33	3040.5	---
WV-5-35	3059.5	ESE $\sim 120^{\circ}$ from North
WV-5-36	3069.5	E $\sim 90^{\circ}$ from North
WV-5-42	3127.5	NNW $\sim 45^{\circ}$ from North

Prior to fracture, microscopic and macroscopic lithologic analyses and fracture analysis will be conducted. Coring of the blocks will provide virtually fresh rock specimens for x-ray, sonic wave, tensile stress and fractographic analyses. Rock fracture will be monitored simultaneously with the foam fracturing process. Multiple fracturing of each block will provide information as to the proppant impregnation, fracture extension and permeability increase. After fracture has been completed, fractographic analyses of various cored samples will be completed to determine the relationship of natural stress to the fracture pattern developed.

T. ADDITIONAL DATA

Test results for the density of the shale from the WV-6 well are given in Table 106. The results are generally within the range of density values for previously reported results (1,3,4).

At the well sites, representative shale samples are selected from the cores and placed in air-tight containers. These samples are then shipped to the laboratory where the containers are gas-tapped. The pressure of these gas filled containers for WV-6 are given in Table 107.

TABLE 106

Density of Core Samples
for the WV-6 Well, Monongalia County, West Virginia

Mound Sample No.	Density (g/cm^3)
WV-6-1	2.74
WV-6-2	2.71
WV-6-3	2.70
WV-6-4	2.70
WV-6-5	2.69
WV-6-6	2.66
WV-6-7	2.71
WV-6-8	2.72
WV-6-9	2.68
WV-6-10	2.71
WV-6-11	2.69
WV-6-12	2.70
WV-6-13	2.71
WV-6-14	2.70
WV-6-15	2.61
WV-6-18	2.67
WV-6-19	2.59
WV-6-20	2.61
WV-6-21	2.60
WV-6-23	2.62
WV-6-24	2.56
WV-6-26	2.68
WV-6-27	2.61
WV-6-28	2.61
WV-6-29	2.55
WV-6-30	2.59
WV-6-31	2.50
WV-6-32	2.54
WV-6-33	2.43
WV-6-34	2.50
WV-6-35	2.44
WV-6-38	2.49
WV-6-39	2.36
WV-6-40	2.67

TABLE 107

Pressure/Vacuum in Containers
Containing the WV-6 Well, Monongalia County,
West Virginia

Mound Sample No.	Pressure (lb/in^2)	Vacuum (in,Hg)
WV-6-1	1.5	
WV-6-2	Atmospheric	
WV-6-3	0.5	
WV-6-4		2.0
WV-6-5	1.0	
WV-6-6	1.5	
WV-6-7	0.5	
WV-6-8	0.5	
WV-6-9	1.0	
WV-6-10	Atmospheric	
WV-6-11	1.0	
WV-1-12	1.5	
WV-6-13	2.0	
WV-6-14	2.0	
WV-6-15		2.5
WV-6-18	Atmospheric	
WV-6-19		1.5
WV-6-20	5.5	
WV-6-21	Atmospheric	
WV-6 23		2.5
WV-6-24		1.5
WV 6-26	2.0	
WV-6-27	8.5	
WV-6-28	7.0	
WV-6-29	2.0	
WV-6-30	2.5	
WV-6-31		0.5
WV-6-32	6.5	
WV-6-33	Atmospheric	
WV-6-34		0.5
WV-6-35		2.3
WV-6-38		1.8
WV-6-39	1.0	
WV-6-40	1.5	

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