48-2

VA -1

SUMMARY REPORT

COLUMBIA GAS

WELL #20338

VOLUME 1

Komar

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TABLE OF CONTENTS

Section

1.0 Summary. 1

2.0 Well Siting. 2

3.0 Drilling/Casing, Coring, Logging, and Cementing Operations. 6

4.0 Core Data 8

5.0 Stimulation Operations 11

- Treatment of First Interval
- Treatment of Second Interval

6.0 Present Wall Status 24

7.0 Summary of Results and Conclusions . . 25

Appendix A - Core Descriptions and Offgas Determinations by Columbia Gas and Transmission Co 26

Appendix B - Chemical and Physical Analysis by Battelle Laboratories 52

Appendix C - Chemical and Physical Analysis by Juniata Co11ege. 83

Appendix 0 - Chemical, Physical and Mechanical Tests and Analysis by Mound Facility . .107

Appendix E - Fracture Fluids Studies by Chenevert and Associates, Inc . . .152

Appendix F - Geologic Description and Analysis by West Virginia University 165

Appendix G - Disposition of Core Samples from Wise County, Virginia 175

Appendix H - Physical and Chemical Properties and Lithologic Description of Core Samples by METC. 178

Appendix I - Scope of Work. 281

Appendix J - We11 Costs 288

LIST OF FIGURES

Figures

2.1 Location of Columbia Well #20338 3

2.2 Location Map for Proposed Well #20338. 4

2.3 Pine Mountain Thrust Area . . . 5

3.1 Columbia Gas Well #20338 . . . 7

4.1 Comparison of Gamma Ray Gas Content, Carbon Content and Porosity 9

LIST OF TABLES

Tabl es

4.1 Summary of Reservoir Data Well #20338. 10

5.1 Reservoir Information 13

5.2 Treating Log - Well #20338 - - - - - - - - - - - - - - . .14-18

5.3 First Interval Treating Summary of Well #20338 - - - - . . •19

5.4 Second Interval Treating Summary for Well #20338 . . .20

5.5 Monthly Status of the Well After Stimulation, from December, 1977 to October, 1978 - - - - - - - - - - - - - - - - - - . .21

1.0 SUMMARY

This' report compiles the site selection criteria, drilTing, coring, logging, casing, cementing and stimul ati on operations of Well #20338, in Wise County, VA. The well was drilled by Columbia Gas Transmission Company under contract EF-76-C-05-5303.

Selection of the well site was based on use of remote sensing imagery and skylab techniques. The well was drilled during April, 1977 to a total depth of 5740 ft. to the top of Corniferous limestone. A total of 380 ft. of 3½ inch oriented Devonian Shale core was retrieved from two intervals, 4870 - 5020 ft. and 5210 - 5455 ft. The coring operation was performed by Christiansen Diamond Services, Inc. Cores were later sent to several laboratories for the study of physical, chemical and mechanical properties. Documentation of the tests and analysis performed by these facilities are in the Appendices.

The well was logged with a series of wet and dry hole logs. Two zones, based on log and core analysis were selected for a cryogenic type of stimulation treatment. Zone 1 was treated with 84,020 gallons of fluids (CO_2 + H_2O) with 270,000 lbs. of sand and Zone 2 was treated with 130,620 gallons of fluids (CO_2 + H_2O) with 295,000 lbs. of sand.

Prior to stimulation and treatment, no measurable gas was produced from either interval. After treatments and clean up, the Zone 1 open flow was measured at 54 - 107 MCF of gas per day and in Zone 2 the open flow was measured to a maximum of 40 MCF of gas per day.

The well is presently shut-in. No gas production has been recorded from the well to date.

2.0 WELL SITING

Well Site 20338 .is located in the northwestern portion of Wise County, VA as shown in Figure 2.1. The well is located on one of two distinct NW-SE trending lineaments mapped from analysis of LANDSAT imagery (Figure 2.2). This particular lineament is called the Powell River Lineament and the other is the Guest River-Critical Fork Lineament. The features originate at, and appear to be genetically related to, the N-S trending Buck Knob Anticline. Subsurface mapping has not, as yet, indicated what these features might be; however, all shallow and surface features in this portion of Wise County are related to shallow decollement faulting in the Devonian Shale as shown in Figure 2.3. The decollement zone contains gas which generally flows at a rate of 300 to 1000 Mcfd. Likewise, Skylab imagery indicated fracture lineation zones in the site area of well #20338. The Powell River lineations and the Guest River-Critical Fork lineations are labelled A-A' and B-8' respectively on Figure 2.2. Field measurements of dip directions and angles are listed below:

Dip Direction	Pip Average	Percent of Total Data
N. E.	80^0	38
S.E.	81^0	28
S.W.	83^0	17
N.W.	80^0	14

Structurally, the well is located in a synclinal low, bounded on the east by the thrust faulted Buck Knob Anticline and on the west by Rogers Ridge fault. The thickness of shale appears to be related to the existing geologic structure and ranges.1000 feet to 1100 feet thick.

Two wells have been previously drilled by Columbia Gas Transmission in Wise County, VA. Well 20055-T was stimulated in the Middle Brown Unit of Devonian Shale. It had an open flow of 112 Mcfd with a 48-hour rock pressure of 870 Ibs, This Unit contains the decollement fault. The second well 20056-T was shot with 13,500 lbs. of 80% gelatin through the total Devonian Shale, Berea, Weir and Injun horizons. It open flowed at 490 Mcfd on a 6-hour test with a 72 hour rock pressure of 900 lbs. Well 20338 is 22,000 feet NE of well 20056-T and 11,000 feet SW of well 20055-T. Well 20056 is too far south of well 20338 to be shown on the location map (Figure 2.2).

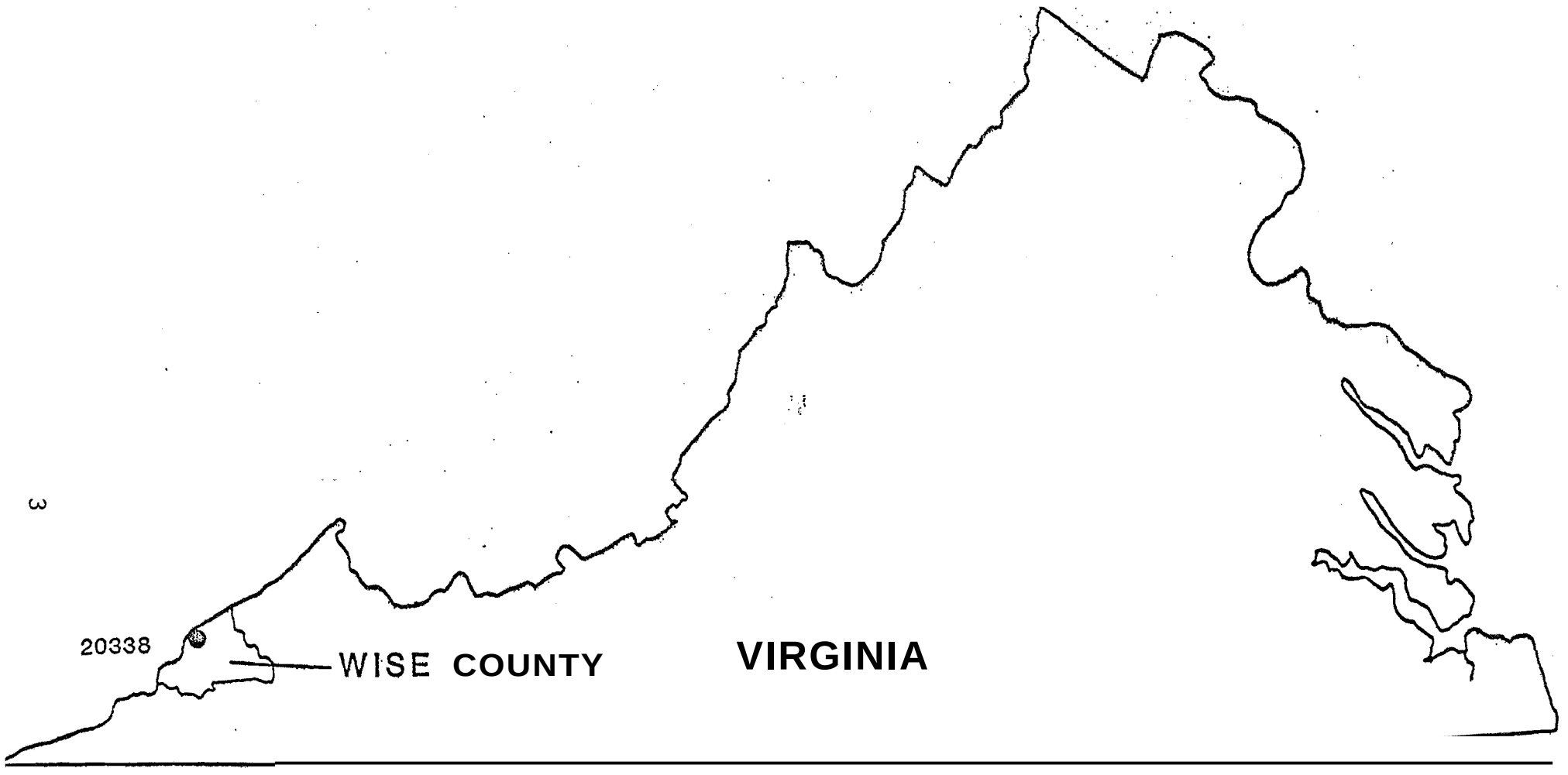


FIGURE 2.1 LOCATION OF COLUMBIA WELL NO. 20338 ,WISE COUNTY,VIRGINIA

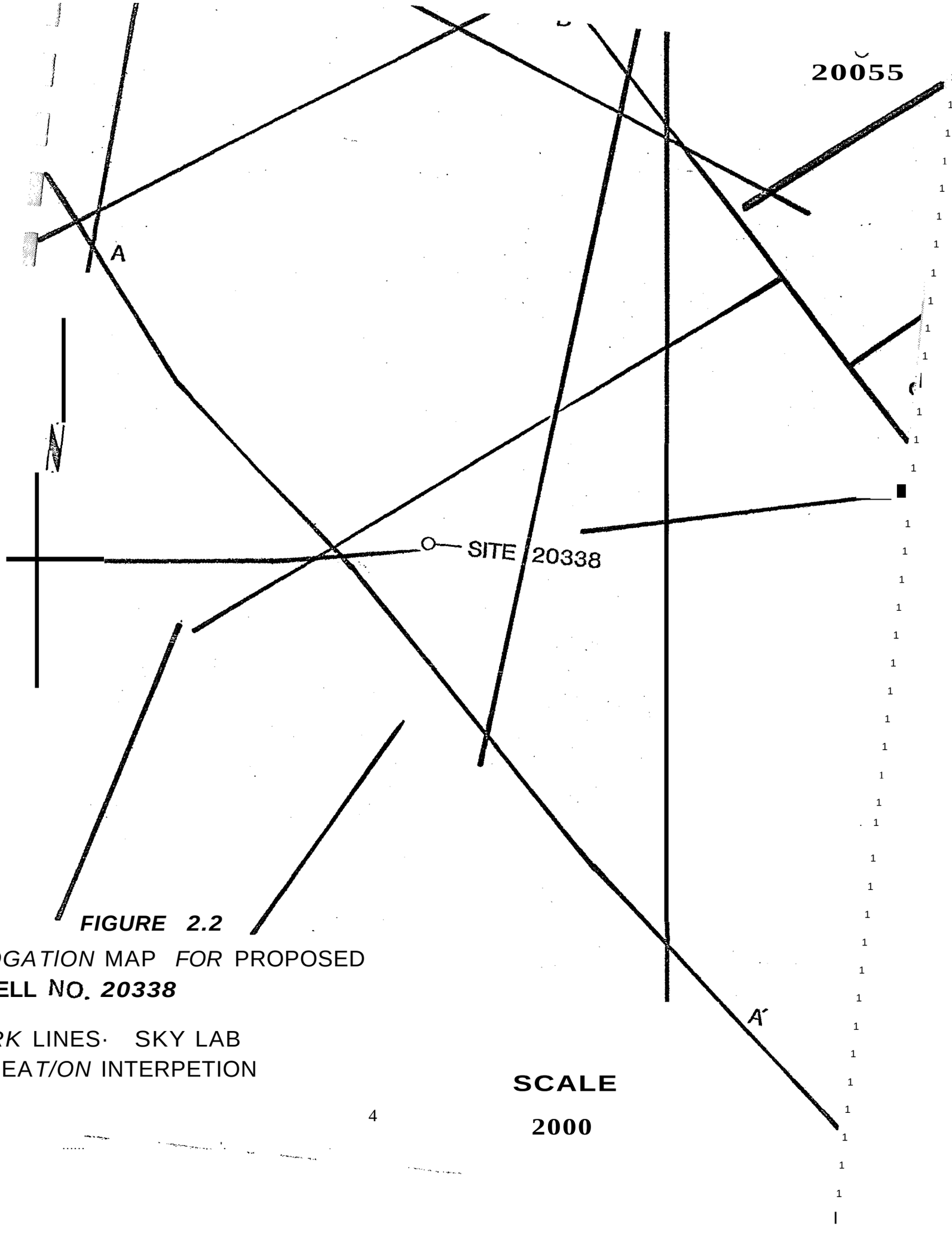
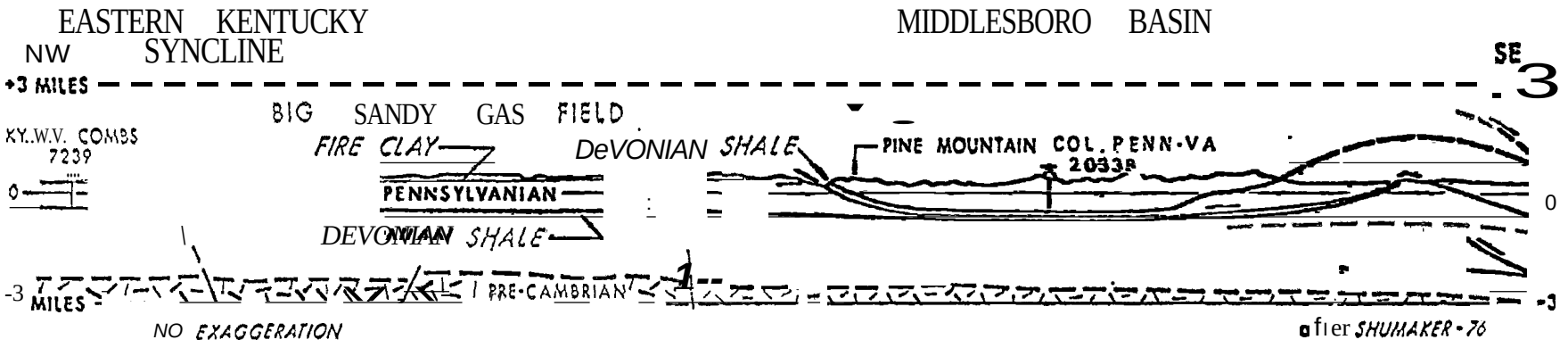


FIGURE 2.2

LOCATION MAP FOR PROPOSED
WELL NO. 20338

DARK LINES· SKY LAB
LINEATION INTERPETION



PINE N\OUNTAIN THRUST AREA

Figure 2.3 This cross section through the Pine Mountain thrust shews the location of the Wise County #20338 (Virginia' well.

3.0 DRILLING/CASING, CORING, LOGGING, AND CEMENTING OPERATIONS

Drilling operations were started on March 28, 1977 and were completed in April, 1977. The well was drilled with air to a depth of 5740 ft. A 15-inch bit was used to drill down to 992 feet and 11 3/4-inch casing was set through 992 ft. A 10 5/8-inch bit was then used to drill to a depth of 3765 ft., and 8 5/8-inch casing was set at 3765 ft. A 7 7/8-inch drill bit was used to drill to the final depth of 5740 ft. A 4 1/2-inch production string was set to the total depth. Figure 3.1 presents a profile of the well.

Coring Operation

A total of 380 ft. of 3 1/2-inch oriented core was retrieved from two Devonian Shale intervals at 4870 - 5020 and 5210 - 5455 ft. A total of eleven runs were made to extract the core. The minimum and maximum length of the core per run was 10 - 60 ft. respectively. Core samples were sent to Battelle, Mound, Juniata College, and Columbia Gas for various analyses. A list of sample distribution by depth and contractor is presented in Table 1, Appendix G. After completing the coring operation and drilling to total depth, the well was logged.

Logging Operation

The following suite of wet and dry hole logs were run:

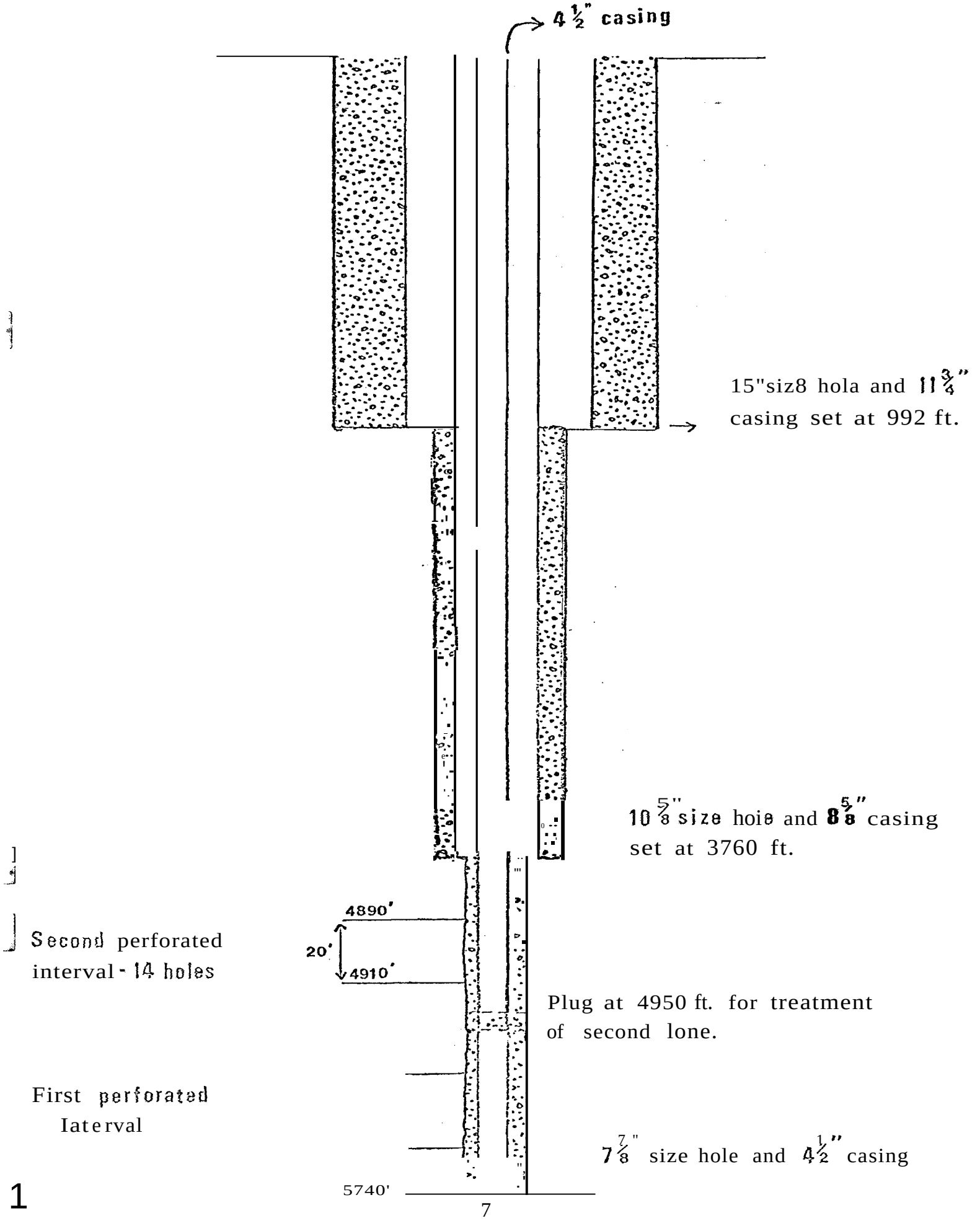
1. Epithermal Neutron Porosity
2. Temperature
3. Gamma Ray Sibilation Survey & Temperature
4. Density Borehole Compensated

The copies of the logs are not attached, but can be obtained for review in the EGSP Open File repositories.

Cementing Operation

Data on cementing is not available.

Figure 6. I uurumma Gas Well No. 20338



4.0 CORE DATA

A comparison of gamma ray lithology, gas content, carbQn content and porosity for three wells including #20338 is presented in Figure 4.1. High offgas values have been observed in zones indicating high carbon content, with corresponding lower values of gas release when carbon content is low.

In addition to chemical analysis, Battelle and Columbia Gas also determined the bulk denisty, porostty, and off-gassing values of the core samples. A summary of these values at various depths is presented in Table 4.1. Appendices A, B, C and D present the results of core analyses carried out by Columbia Gas, Battelle, Juniata College and Mound Facility, respectively.

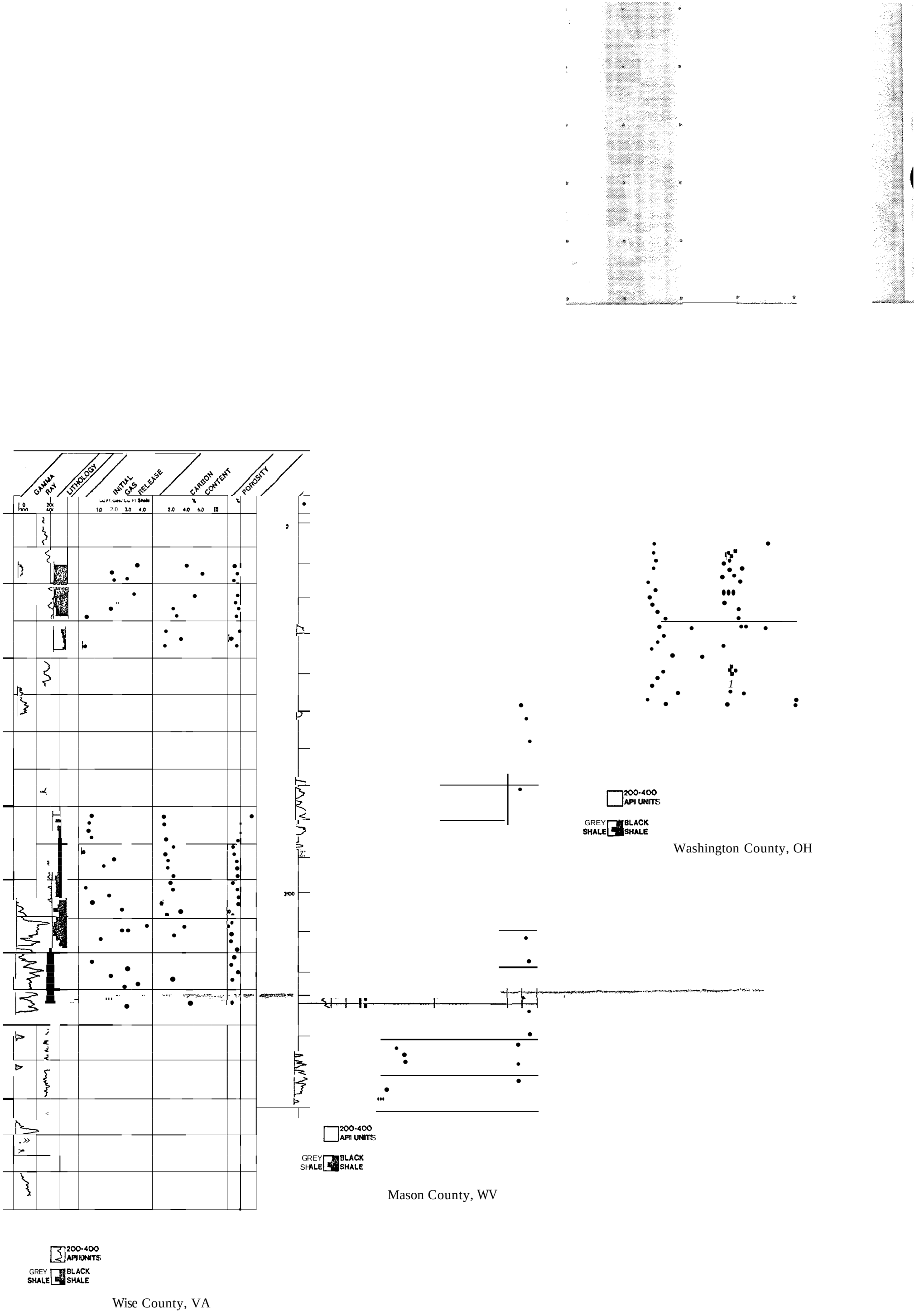


Figure 4.1 Comparison of Gamma Ray, Lithology, Gas Content, Carbon Content and Porosity for WIse County, VA, Mason County, WV, and Washington County, OH, Wells.

Table 4.1 SUMMARY OF RESERVOIR DATA

WELL # 20338

CORED & PERFORATED INTERVALS	DEPTH (feet)	OFF GAS * cu, ft. gas! cu. ft. shale	PERME_ A81l1TY	DE PTH (feet)	BULK DENSITY ** glee	TOTAL POROSITY %
4870	4871	.51		4872	2.610	1.U43
	4881	.26		4882	2.484	8.002
	4890	•39		4892	2.555	3.914
4890	4891	.28		4982	2.490	3.126
	4901	.44		4912	2.523	"5.552
	4911	.45		4922	2.615	4.473
	4921	.31		4930	2.625	2.089
4910	4931	.24		4940	2.618	1.513
	4941	.02		4950	2.694	4.938
	4951	.13		4960	2.844	2.760
	4961	.00		4970	2.824	.757
	4971	.00		4980	2.722	1.608
	4981	.03		5212	2.808	5.267
	5211	.12		5222	2.745	2.833
	5221	.IU		5232	2.696	5.203
5230	5231	.07		5242	2.895	2.729
	5241	.10		5253	2.726	3.889
	5251	.13		5263	2.776	2.406
	5261	.U3		5273	2.694	3.782
	5271	.30		5283	2.713	? 086
	5281	.20		5293	2.662	2.142
	5291	.0037	NA	5303	2.667	2.188
	5302	.390		5312	2.666	2.154
	5311	.05		5322	2.679	7.959
	5321	.26		5332	2.761	7.396
	5331	.10		5342	2.672	.398
	5341	.36		5347	2.756	2.597
	5350	.32		5357	2.733	3.335
	5361	.0037		5362	2.568	1.280
	5363	.620		5372	2.590	.723
	" 5366	.38		5382	2.622	6.078
	5371	.44		5394	2.724	2.515
	5380	.18		5404	2.627	5.006
	5401	.63		5414	2.551	.691
	5411	.09		5424	2.590	6.353
	5421	.44		5434	2.695	1.467
	5431	.28		5444	2.548	.721 "
	5441	.53		5447	2.590	2.039
	5445	.38		5457	2.650	.642
	5451	.56		5467	2.567	1.874
5450	5461	.24				
	5471	.41				
	5688	.01				
5480						

FROM COLUMBIA GAS OFF-GAS ANALYSIS

** FROM BATTELLE LABS

NA-NOT AVAILABLE

5.0 STIMULATION OPERATIONS

Two zones were selected for treatment in well #20338. The interval for the first zone was from 5450 ft. to 5480 ft. (30 ft.) and for the second zone was from 4890 ft. to 4910 ft. (20 ft.). The zones were selected on the following basis:

- Presence of high organic content
- Relatively high concentration of gas based on analysis of logs and core samples

A Cryogenic type of treatment was selected for stimulation of both zones. The advantages of Cryogenic treatments are the following:

- Large volumes of proppant can be carried at low injection rates.
- Lower rates are used to enhance the fracture length.
- High concentrations of proppant can be carried to hold the fracture open.
- Treatment contains energy assist fluids for better well clean-up.

Treatment of the first interval {Zones ,5450":'5480 ft

The first interval was pe.rforated between 5450 ft. and 5480 ft. On September 13,1977, after perforation, the interval was treated with 15% NE acid and 4000 gal. of water to establish breakdown pressure and injection rate. After this pre-treatment the well was tested and no measurable flow of gas was observed. On September 14, 1977 the well was treated with a Cryogenic type of stimulation treatment. After stimulation and subsequent cleaning the open flow fluctuated between 54-107 MCFD.

Stimulation design for the interval consisted of 100,000 gallons of fluids (65,000 gallons of gelled water and 35,000 gallons of liquid CO_2) and 270,000 lbs of sand (45,000 lbs of 100 mesh sand and 225,000 lbs of 20/40 mesh sand). These volumes of fluids and proppant were designed to generate a theoretical fracture profile as follows:

Fracture Created Length, Feet	Fracture Width, Inches	Proppant Length, Feet	Proppant Height, Feet
1,651.6	0.414	985.3	123.4

The basic reservoir information used to generate this profile is presented in Table 5.1.

The interval was treated by Haliburton Service Co. on September 14, 1977. Table 5.2 presents a log of the treating schedule during the fracturing. A total of 84,020 gallons of fluid were injected including 23,500 gallons of CO_2. The procedure used to treat the interval was to initiallY pump CO_2 through the system for twenty minutes to lower the temperature of the system in order to keep the CO_2 in liquid form. The well was treated for a total of three hours at a average injection rate of 30.2 BPM and treating pressure between 1910 and 2100 psi. A summary of the treatment of the first interval and changes in volume from the original design is presented in Table 5.3.

Following the treatment, clean-up operations began. Within two days 50 percent of the fluids injected were recovered. After sixteen days, using swabbing operations 81 percent of the fluids were recovered. Following cleanup and testing for the wells open flow potential, Zone 1 was isolated in preparation for treatment of Zone 2.

Treatment of the Second Interval (Zone 2, 4890-4910 ft.)

The second interval was also stimulated with a Cryogenic technique on November 29, 1977. A bridge plug was set at 4950 ft. to isolate Zone 2.

Zone 2 was perforated between 4890 to 4910 ft. (20 ft.). After perforation the zone was treated with 15% NE acid and 4000 gallons of water on November 27, 1977 to establish formation breakdown and injection rate. No measurable gas was produced before stimulation. After stimulation open flow from Zone 2 was measured at -40 Mcfd.

The treating pressure averaged between 1560 to 2650 psi at an average injection rate of 26.9 BPM. The total amount of fluid injected including water, and CO_2 was 130,620 gallons. A total of 295,000 1bs. of 100 and 20/40 mesh sand was used.

A brief summary of the treatment for the second tnterval is given in Table 5.4. The injection rates recorded at various pressures by Halliburton are presented in the attachment.

TABLE 5.1

RESERVOIR INFORMATION

Formation:	Devonian Shale	
Proposed Interval:	Depth	Feet
	4,890--4,910	20
	5,450--5,480	30
BHTP:	1,800 Psi	
Permeability:	0.01 md	
Porosity:	2--6 percent	
Gross Thlckness:	810 feet	
Net Thickness:	50 feet	
Treating Pipe Size:	4.5 inch 'casing,	
Youngts Modulus of Elasticity:	2.9--5.2 E6	
Bottom Hole Temperature:	115^0 F	
Damage Ratio:	1.0	
Drainage Radius:	1,320 feet	
Well Spacing:	160 acres	
Reservoir Fluid Pressure:	500 Psi	
Net Fracture Height:	30 feet	
Gross Fracture Height:	150 feet	

TABLE 3.2

Treating Log-Well #20338

me	Volume (Gallons}	Sand Type and Cone.	Rate (BPM)	Frac " Pressure {PSIG}	Annulus Pressure (PSIG)	Remarks
:01				5,000	"60	Testing lines
:04:18		Gel1 ed pre-pad			60	' Start Pumping
: 5	290	Gell edpre-pad		2,010	60	
: 6	1,440	Gelled pre-pad	27.4	1,980	60	
:07	2,700	Ge11ed pre-pad	30.0	1,810	60	
: 8	3,970	Ge11 ed pre-pad	30.2	1,800	60	
: 9	5,240	Gelled pre-pad	30.2	1,830	60	
:10	6,500	Gelled pre-pad	30.0	1,835	60	
:11	7,780	Gelled pre-pad	30.5	1,830	60	
: 2	9,060	Gelled pre-pad	30.5	1,850	60	
:13	10,330	Ge11ed pre-pad	30.2	1,860	60	
:14	11,610	Gelled pre-pad	30.5	1,870	60	
: 5	12,900	Gelled pre-pad	30.7	1,885	60	
: 6	14,170	Gelled pre-pad	30.2	1,895	20	
:17	15,460	Ge11ed pre-pad	30.7	1,900	60	
: 8	16,740	Gelled pre-pad	30.5	1,900	60	
: 9	18,020	Ge11ed pre-pad	30.5	1,920	60	
:20	19,320	Gelled pre-pad	31.0	1,930	60	
0:36	20,000	Gelled pad with CO_2	24.3	1,290'	60	Starting pad with C
:21	20,340	Gell ed pad with CO_2	24.3	1,250	60	line vibrating
2	21,200	Gelled pad with CO_2	20.5	1,620	60	
:23	22,020	Gell ed pad with CO_2	19.5	1,840	60	
:24	22,530	Gelled pad with CO_2	19.3	1,920	60	
25	23,640	Gell ed pad with CO_2	19.3	1,980	70	
1:26	24,460	Gell ed pad with CO_2	19.5	1,990	10	Pad'with C02 on bot
27	25,300	Gell ed pad with CO_2	20.0	1,990	65	
28	26,190	Gelled pad with CO_2	21.2	2,000	10	--
1:30	27,810	Gelled pad with CO_2	19.3	2,010	60	--
31	28,620	Gell ed pad with CO_2	19.3	2,040	60	
1:32	29,470	Gell ed pad with CO_2	20.2	1,950	60	
33	30,280	Ge11ed pad with CO_2	19.3	1,945	60	
34	31,120	Gel1 ed pad with CO_2	20.0	1,930	60	
1:35	31,960	Ge11ed pad with CO_2	20.0	1,500	60	Cut CO_2 Off-union
35:20	32,210	Gell ed pad with CO_2	18.0		60	Shut-down
j59:29				1,290	60	Resume pumping wit
:00	32,680	Gelled pad \'lith CO_2		1,540	70	

Treating Log-Well #20338 (Cont'd)

Time	Volume (Gallons)	Sand Type and Cone.	Rate (BPM)	Frac Pressure (PSIG)	Annulus Pressure (PSIG)	Remarks
2:17	47,820	Flush w/gel	29.5	2,100	60	
2:17:42	48,650	Flush w/gel			70	Shut down ,to repair leak, .
2.31:28		Gelled water				Resume pumping' '.
2:32	49,010	Gelled water		1,400	70	
2:33	49,840	Gelled water	19.8	1,840	70	
2:34	50,650	Flush w/gel	19.3	1,470	70	Cut' C02-Flush 50,25 gallons-swing leak; again
2:35	51,500	Flush w/gel	20.2	1,420	70	--
2:36	52,370	Flush w/ge1	20.7	1,415	70	
2:37	53,460	Flush w/gel	26.0	2,070	70	450 sks of 100 mest
2:37:36	54,190	Flush w/gel	30.0		70	Shut-down to repail
3:09:43		Gelled water with 2 ppg 20/40 mesh			70	Resume pumping wit1 ppg 20/40 - cuttin rate of C02 and wat down
3:10	54,330	Gelled wat.er with 2 ppg 20/40 mesh	12.1	990	70	
3:11	54,880	Gelled water with 2 ppg 20/40 mesh	13.1	1,330	70	
3:12	55,430	Gelled water with 2 ppq 20/40 mesh	13.1	1,425	80	
3:13	56,000	Gell ed water- '-'lith. 2 ppg 20/40 mesh	13.6	1,435	80	
3:14	56,560	Gelled water with 2 ppg 20/40 mesh	13.3	1,435	80	
3:15	57,130	Gell ed water with 2 ppg 20/40 mesh	13.6	1,435	80	
3:15:49	57,590	Gelled water with 3 ppg 20/40 mesh	13.6	1,445	70	
:J16	57,700	Gel1 ed water with 3 ppg 20/40 mesh	13.6	1,435	70	
3:17	58,270	Gelled water with 3 .Ppg 20/40 mesh	13.6	1,445	70	Gelled water with ppg 20/40 mesh on bottom
3:18	58,830	Gelled water with 3 ppg 20/40 mesh	13.3	1,465	70	
3:19	59,400	Gell ed water with 3 ppg 20/40 mesh	13.6	1,470	70	
3:20	59,970	Gelled water with 3 ppg 20/40 mesh	13.6	1,475	70	--
13:21	60,530	Gelled water with 3 ppg 20/40 mesh	13.3	1,485	70	--
13:21:38	60,890	Gelled water with 4 ppg 20/40 mesh	13.6	1,495	75	
13:22	61,100	Gelled water with 4 ppg 20/40 mesh	13.6	1,485	70	--
13:24	62,240	Gelled water with 4 ppg 20/40 mesh	13.6	1,450	70	Gelled water" with ppg, 20/40 mesh on bottom.

Treating log-Well #20338 (Cont'd)

	Volume (Gallons)	Sand Type and Cone.	Rate (BPM)	Frac Pressure (PSIG)	Annulus Pressure (PSIG)	Remarks
:51	77,550	Gelled water with 2 ppg 20/40 mesh	13.3	2,075	80	
:52	78,100	Gelled water with 2 ppg 20/40 mesh	13.1	2,360	80	
	78,740	Gelled water with 4 ppg 20/40 mesh	15.2	2,890	70	
:54	79,420	Flush w/gel	16.2	3,560	10	Cut sand-Cut CO_2 @ 79,000 gallons
.55	80,230	Flush w/KCl water	19.3	2,965	80	
:56	81,030	Flush w/KCl water	19.1	3,160	80	
57	81,820	Flush wlKCl water	18.8	3,1120	10	
58	82,620	Flush wIKel water	19.1	2,800	70	
:59	83,500	Flush wIKel water	21.0	2,775	70	
59:34	84,020	Flush wIKel water			70	Cut engines-check valve sheet

nped fluid to keep valve open to obtain ISIP 1,290
900 (5 min.)
830 (10 min.)
790 (15 min.)

used approximately 1015 tons of C02 = 23,500 gallons

Table 5.3

First Interval Treatment Summary for Well # 20338

Treatment Parameter	Design	Actual
Well Number	20338	20338
County, State	Wise, VA.	Wise,. Va.
Interval Number	1	1
Perforated Interval (ft.)	5450-5480	5450-5480
Treatment date		Sept. 14, 1977
Treatment Type	Cryogenic	Cryogenic
Treatment Size (gal.)	97500	84,020
Liquid Carbon-Dioxide (gal.)	35000	23,500
Water (gallons) gelled	65000	60,520
Sand Volume (lbs.) (450 Sks 100 mesh +2250 Sks 20/40 mesh)	270000	
Concentration (ppg)		
Average Pumping rate (BPM)		30.2
Maximum Pumping Rate (BPM)	30.0	30.2
Breakdown Pressure (PSig)	-----	
Minimum Injection Pressure (PSig)	-----	1900
Maximum Injection Pressure (PSig)	-----	2100
Instaneous Shut-in Pressure (Psi)	-----	1290

Tab 1e -5.4

Second Interval Treatment Summary for Well # 20338

Treatment Parameter	Desi gn	Actual
We 11 Number	20338	.20338
County, State	Wise, VA.	Wi se, VA.
Interval Number	2	2
Perforated Interval (ft.)	4890-4910	4890-4910
Treatment Date		Nov. 29, 1917
Treatment Type	Cryogeni c	Cryogeni c
Treatment Size (ga1.)	NA	130620
Sand Volume (lbs) (45000 Ibs. of 100 mesh + 250,000 Ibs. of 20/40 mesh)		295,000 Ibs.
.Concentration (ppg)	NA	NA
Average Pumping Rate		26.9 BPM
Maximum Pumping Rate	NA	
Breakdown Pressure (PSig)		
Minimum Injection Pressure (PSig)		1100
Maximum Injection Pressure (PSig)		2650
Instaneous Shut-in Pressure		1160

Table 5.5

Monthly Status of The Well After Stimulation, from December, 1977 to October, 1978.

January, 1978	Frac Water was being swabbed from the Second Zone. While swabbing a· tool was lost in the well. Fishing operation was being conducted to clean the well out.
February, 1978	No change from January, 1978 except that on Feb. 28, 1978, the swab carne free.
March, 1978	Bridge plug separating the two zones has been drilled out. Well is shut-in to for an open flow test from-t.he combined zones.
April , 1978	Well was still making water, with a gas open flow rate. of 215 mcfd gauged from both zones.
May, 1978	Well is being prepared for a post-frac reservoir test.
June, 1978	Final open flow from both zones was 233 mcfd with a rock pressure of 480 psi. The well is still being prepared for post-frac reservoir test.
July, 1978	No change from June, 1978
August, 1978	No change from June, 1978

Table 5.5
-Continued-

September, 1978	No change from June, 1978
October, 1978	Still no information is reported on post-frac reservoir tests.

6.0 PRESENT WELL STATUS

The well has not-been put into production as of October 1978. The monthly status of the well is summarized in Table 5.5

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7.0 SUMMARY OF RESULTS AND CONCLUSIONS

1. Stimulation with cryogenic fluids increased open from 0 to 40 Mcfd and 0-54/107 Mcfd from Zone 2 and 1 respectively.
2. Clean-up period for fracturing fluids in Zone 1 was relatively short with 81% fluid recovery in sixteen days.
3. The well has not been put into production; therefore, no long term production data are available to indicate production enhancement due to treatment.
4. Short term production tests were delayed due to mechanical problems. However, since no pre-frac well tests were done, improvement due to stimulation will be difficult to quantify.
5. The average offgassing values for the cored interval were 1.76 cu. ft. gas/ cu. ft. shale.
6. Total porosity values based on core analysis by Battelle Labs ranged between 0.35 to 8 percent.

APPENDIX A

CORE DESCRIPTIONS AND OFFGAS DETERMINATIONS

BY

COLUMBIA GAS TRANSMISSION CO.

This appendix presents the analysis performed by Columbia Gas. A total of forty-one samples obtained by Columbia Gas are listed in Table 1.1. The lithologic description of the core is presented in Table 1.2.

The results of measurements of offgassing and average gas content of the Devonian Shale are shown in Tables 1.3 and 1.4.

List of Tables

Tables		Page
1.1	Depths of the Core Samples from Wise County, VA	29
1.2	Lithologic Description of Core Shale Intervals	30-48
1.3	Offgas Values, Well #20338	49
1.4	Average Gas Contents of the Devonian Shale	50
1.5	Statistical Values of Trapped Gas and Gas from Bergen Breakdown	51

Tab1e 1. 1 Depth of The Core Samples' from Wise Co., Virginia Well # 20338

1- 4871.00-4871.40'
2. 4881.00-4881.40
3. 4891.00-4891.40
4. 4901.00-4901.40
5. 4911.00-4911.40
6. 4921.00-4921.40
7. 4930.60-4931.00
8. 4931.00-4931.40
9. 4941.00-4941.40
10. 4951.00-4951.40
11. 4961.00-4961.40
12. 4971.00-4971.40
13. 4981.00-4981.40
14. 5211.00-5211.40
15. 5221.00-5221.40
16. 5231.00-5231.40
17. 5241.00-5241.40
18. 5251.00-5251.40
19. 5261 .00-5261 .40
20. 5271.00-5271.40
21. 5286.20-5286.60
22. 5291.00-5291.40
23. 5302.00-5302.40
24. 5311.00-5311.40
25. 5321.00-5321.40
26. 5331.00-5331.40
27. 5341.00-5341.40
28. 5345.30-5345.70
29. 5350.00-5350.40
30. 5361.00-5361.40
31. 5371 .00-5371 .40
32. 5380.00-5380.40
33. 5401.00-5401.40
34. 5411.00-5411.40
35. 5421.00-5421.40
36. 5431 .00-5431 .40
37. 5441.00-5441.40
38. 5451.00-5451.40
39. 5461.00-5461.40
40. 5471.00-5471.40
41. 5688.20-5688.50

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Table 1.20escription of Cored Shale Intervals
from Well Number 20,338, Wise Co., Va.

Run #1 (4870'-4928.6)

From	To	lithologic Description
4810	4928	Entire run represented by black shale·

from	To	Fractures
4885.2	4885.7	Slickensided, near vertical, parted
4894.2	4894.2	Slickensided horizorrtal plane
4896.2	4897.6	70° inclined, mineralized·
4905.7	4905.7	Slickensided, horizontal plane
4910.5	4910.5	Slickensided, horizontal plane
4914.0	4914.5	3 vertical mineralized fractures, horizontal slickensided surface
4918.0	4918.0	3 near horizontal mineralized fractures, with a slickensided surface

From	To	Other Features
4871.5	4871 .7	3 anhydrite-carbonate layers
4872.3	4872.3	Anhydrite-carbonate layer, with 2 pyrite blebs
4872.5	4873.3	3 anhydrite-carbonate layers
4873.5	4874.2	Numerous pyrite blebs
4875.4	4875.6	3 anhydrite-carbonate layers
4876.9	4877.1	3 anhydrite-carbonate layers
4877.8	4877.8	Anhydrite-carbonate layer
4878.2	4878.5	Numerous anhydrite-carbonate lc··ers
4879.4	4879.4	2 anhydrite-carbonate layers
4882.2	4882.2	2 anhydrite-carbonate layers
4882.6	4882.7	2 anhydrite-carbonate layers
4884.2	4884.3	2 anhydrite-carbonate layers
4884.8	4885.7	Several anhydrite-carbonate layers
4888.8	4888.8	Anhydrite-carbonate layer
4891.4	4891.4	Anhydrite-carbonate layer
4892.6	4892.6	Anhydrite-carbonate layer -
4892.9	4892.9	Anhydrite-carbonate layer
4893.0	4893.0	Anhydrite-carbonate layer
4893.7	4893.7	Pyrite filled layer
4894.6'·	4894.8	Numerous anhydrite-carbonate layers
4897.0	4897:2	Numerous anhydrite-carbonate layers
4900.0	4900.0	Anhydrite-carbonate layer
4900.4	4900.4	Anhydrite-carbonate layer
4901.3	4901.3	Anhydrite-carbonate layer
4901.5	4901.5	Anhydrite-carbonate layer
4903.1	4903.1	Anhydrite-carbonate layer with large pyrite bleb
4903.3	. 4904.3	4 anhydritc-carbonate 1ayers
4904.5	4904.5	Anhydrite-carbonate layer with Tarqe pyrite bleb
4904.7	4904.7	Anhydrite-carbonate layer .
4905.0	4905.0	Anhydrite-carbonate layer with 2 pyrite blebs
4905.5	4905.9	3 anhyddte-carbonate layers
4907.0	4907.2	Several anhydrite-carbonate layers

Run #1 (Cont.) (4908.7-4928.0)

From	To	Other Features
4908.7	4908.8	Anhydrite-carbonate layer with apparent fossil fragments
4911.0	4911.0	2 pyrite layers
4911.2	4911.5	2 anhydrite layers with 1 pyrite layer
4914.6	4914.6	Anhydrite-carbonate and pyrite layer
4919.0	4919.2	3 anhydrite-carbonate layers
4919.3	4919.3	Large pyrite bleb
4919.4	4928.0	Numerous anhydrite-carbonate layers

Gas bleeding throughout entire core

Run #2 (4928.6 - 4985.5)

From	To	"lithologic Description
4928.6	4943.6	Black shale
4943.6	4945.1	Black shale with dark gray laminae
4945.1	4945.9	Medium dark gray share
4945.9	4946.9	Medium dark gray and dark gray shale, banded and laminated
4946.9	4948.1	Dark gray shale with medium gray silty shale laminae
4948.1	4948.3	Medium dark gray shale "
4948.3	4948.5	Medium dark gray shale \·/ith medium gray silty shale laminated in bedding or loading feature
4948.5	4950.2	Medium dark gray shale and dark gray bands laminae
4950.2	4951 .1	Medium dark gray and black liminated shale with numerous silt laminae and loading feature pyrite blebs
4951.1	4951.8	Medium gray shale with medium dark to dark gray bands, loading features
4951.8	4955.3	Medium gray shale with dark gray and medium dark gray bands, silt laminae
4955.3	4955.8	Dark gray shale with medium dark gray liminae, with numerous siltstone
4955.8	4956.6	Medium gray shale with dark gray band
4956.6	4956.9	Medium gray silt shale
4956.9	4957.7	Medium gray shale with 2.5' dark and medium gray shale and silty laminae
4957.7	4958.5	Medium gray shale to black shale, silty laminaes showing loading features
4958.5	4958.9	Medium gray shale
4958.9	4960.7	Medium dark gray shale with medium gray black shale, light gray laminae
4960.7	4961.9	Medium gray shale with medium dark gray laminae and some light gray laminae
4961.9	4962.5	Medium dark gray shale
4962.5	4953.4	Medium gray with occasional medium dark gray laminae
4963.4	4963.6	light gray shale with slightly silty band
4963.6	4963.9	Medium gray shale
4963.9	4964.4	light gray to medium gray shale with light gray silty laminae
4964.4	4964.9	Medium gray shale with a .15' light gray shale band
4964.9	4965.3	light gray shale and medium gray shale cross bedded.
4965.3	4969.7	Medium gray shale with occasional light gray shale laminae
4969,7	4970.1	Medium gray shale
4970.1	4971.3	light gray silty shale with medium dark gray laminae crossbedded
4971.3	4971.8	Medium gray shale
4971.8	4972.4	light gray silty shale with medium gray laminae crossbedding
4972.4	4973.0	Medium gray shale with light gray laminated bands
4973.0	4980.8	Medium gray shale with sparse medium dark gray shale laminae and some light gray laminae
4980.8	4982.0	Medium gray with numerous medium dark gray bands, some light gray silty laminae .:ith loading features
4982.0	4982.5	Medium gray shale

Run #2 (Cont.) (4982.5 - 4985.5)

From	To	lithologic Description
4982.5	4982.9	Black and medium gray shale laminae with light gray shale laminae
4982.9	4984.4	Medium gray shale with two .05 black shale bands
4984.4	4985.5	Medium dark gray and black laminated shale"with light gray shale laminae

From	To	Fractures·
4930.0	4930·	Slickensided, horizontal plane" parted
4931.5	4931.5	Slickensided, horizontal plane, parted
4934.4	4934.4	Slickensided, horizontal plane, parted·
4934.8	4934.8	Slickensided, horizontal plane, parted
4934.8	4935:2	4 near vertical, parted
4935.2	4935.2	Slickensided, horizontal plane, parted
4935.4	4935.4	Horizontal plane, mineralized
4935.7	4935.7	Slickensided, horizontal plane. parted
4937.7	4937.7	Slickensided, horizontal plane, parted
4939.5	4939.5	Slickensided, horizontal plane, parted
4940.0	4940.0	Slickensided, horizontal plane, parted
4941.7	4941 .7	Slickensided, horizontal plane, parted
4942.2	4942.7	3 slickensided, horizontal planes, parted
4943.8	4945.0	3· slickensided, horizontal planes, parted
4946.3	4947.7	3 slickensided, horizontal planes, parted
4950.6	4950.6	Slickensided, horizontal plane, parted
4951.5	4961.5	Slickensided, horizontal plane, parted
4972.6	4972.6	Slickensided, horizontal plane, parted
4973.0	4973.7	2 60^0 inclined, slickensided, parted
4974.3	4974.3	Slickensided, horizontal plane, parted
4977.0	4977.4	4 slickensided) horizontal planes, parted
4978.4	4978.4	Slickensided, horizontal plane, parted
4980.5	4980.5	Slickensided, horizontal plane, parted
4981.7	4981.7	Slickensided, horizontal planejoar-ted
4984.2	4985.5	3 slickensided, horizontal planes, parted

From	To	Other Features
4929.0	4929.0	2 anhydrite - carbonate layers
4929.8	4930.0	3 anhydrite - carbonate layers
4931.2	4932.0	7 anhydrite - carbonate layers
4.932.8	4932.8	Pyrite filled layer
4933.2	4935.3	6 anhydrite - carbonate layers
4937.2	4937.2	large pyrite bleb
4938.5	4939.5	Numerous anhydrite - carbonate layers
4940.0	4940.3	3 anhydrite - carbonate layers
4943.7	4944.9	4 anhydrite - carbonate layers
4949.0	4950.6	5 pyrite blebs
4952.2	4955.0	Several pyrite blebs and layers
4960.2	4960.5	large pyrite bleb with several filled layers

Run #2 (Cont.) (4982.5 - 4985.5)

From	To	lithologic Description
4982.5	4982.9	Black and medium gray shale laminae with light gray shale laminae
4982.9	4984.4	Medium gray shale with two .05 black shale bands
4984.4	4985.5	Medium dark gray and black laminated shale with light gray shale laminae

From	To	fractures
4930.0	4930	Slickensided, horizontal plane, parted
4931.5	4931.5	Slickensided, horizontal plane, parted
4934.4	4934.4	Slickensided, horizontal plane, parted
4934.8	4934.8	Slickensided, horizontal plane, parted
4934.8	4935:2	4 near vertical, parted
4935.2	.4935.2	Slickensided, horizontal plane, parted
4935.4	4935.4	Horizontal plane, mineralized
4935.7	4935.7	Slickensided, horizontal plane, parted'
4937.7	4937.7	Slickensided, horizontal plane, parted
4939.5	4939.5	Slickensided, horizontal plane, parted
4940.0	4940.0	Slickensided, horizontal plane, parted
4941.7	4941.7	Slickensided, horizontal plane, parted
4942.2	4942.7	3 slickensided, horizontal planes parted
4943.8	4945.0	3 slickensided, horizontal planes: parted
4946.3	4947.7	3 s'liccensided, horIzonta'l planes, par-ted
4950.6	4950.6	Slickensided, horizontal plane, parted
4961.5	4961.5	Slickensided, horizontal plane, parted
4972.6	4972.6	Slickensided, horizontal plane, parted
4973.0	4973.7	2 60° inclined, slickensided) parted
4974.3	4974.3	Slickensided, horizontal pfane, parted
4977.0	4977.4	4 slickensided, horizontal planes, parted
4978.4	4978.4	Slickensided, horizontal plane, parted
4980.5	4980.5	Slickensided, horizontal plane, parted
4981..7	4981.7	Slickensided, horizontal plane, parted
4984.2	4985.5	3 slickensided, horizontal planes, parted

from	To	Other Features
4929.0	4929.0	2 anhydrite - carbonate layers
4929.8	4930.0	3 anhydrite - carbonate layers
4931..2	4932.0	7 anhydrite - carbonate layers
4932.8	4932.8	Pyrite filled layer
4933.2	4935.3	6 anhydrite - carbonate layers
4937.2	4937.2	large pyrite bleb
4938.5	4939.5	Numerous anhydrite - carbonate layers
4940.0	4940.3	3 anhydrite - carbonate layers
4943.7	4944.9	4 anhydrite - carbonate layers
4949.0	4950.6	5 pyrite blebs
4952.2	4955.0	Several pyrite blebs and layers
4960.2	4960.5	Large pyrite bleb with several filled layers

Run #2 (Cont.) (4962.2 - 4982.7)

From	To	Other Features
4962.2	4962.4	Several pyrite blebs and filled layers
4964.0	4964.0	2 pyrite filled layers
4965.0	4965.4	2 slightly anhydrite - carbonate layers
4982.7	4982.7	2 pyrite blebs

Slicken sides in all directions but mostly horizontal for entire length of core.

Run #3 (5210 - 52201

From	To	lithologic Description
5210	5220	Entire core cross-bedded medium dark gray shale with black shale bands and some silty laminae

From	To	Fractures
5211.4	5215.0	Slickensided, vertical, parted
5212.6	5212.6	Slickensided, horizontal plane, parted
5212.6	5214.2	Slickensided) near vertical. parted
5213.0	5213.0	Slickensided, horizontal plane) parted
5215.0	5215.8	50^0 inclined) slickensided) parted
5216.0	5217.7	70^0 inclined) slickensided, parted
5218.0	5218.0	Slickensided plane) parted
5219.1	5219.8	80° inclined) parted

from	To	Other Features
5210.0	5210.8	Numerous anhydrite - carbonate. layers
5213.6	5214.0	5 anhydrite - carbonate layers
5215.1	5217.6	5 anhydrite - carbonate layers
5218.6	5218.8	3 anhydrite - carbonate layers

Run #4 (5220 - 5251)

From	To	lithologic Description
5220.0	5236.0	Medium dark gray shale with some black shale bands and laminae. Occasional silty streaks.
5236.0	5236.3	light gray silty *zone*
5236.3	5237.0	Medium dark gray shale with black shale bands
5237.0	5237.3	light gray silty zone
5237.3	5249.2	Medium dark gray shale with black shale bands
5249.2	5251.0	Primarily black shale with some black shale bands

From	To	Fractures
5222.0	5223.0	Vertical, parted
5222.4	5222.4	Slickensided, horizontal plane, parted
5223.8	5224.4	45° inclined, slickensided, parted
5245.6	5246.4	Near Vertical, parted
5246.2	5246.2	Slickensided, horizontal plane, parted
5247.0	5248.5	Vertical, parted
5249.2	5250.°2	Vertical, parted

From	To	Other Features
5247.2	5247.2	Pyrite bleb
5247.7	5247.7	Pyrite bleb
5248.4	5248.4	Pyrite bleb
5248.9	5248.9	Pyrite-bleb

Run #5 (5251 - 5310)

from	To	lithologic Description
5251.0	5255.4	Black shale with medium dark gray and dark gray shale laminae and bands, numerous anhydrite stringe
5255.4	5258.2	Dark gray shale and bt ack-shal e layers with some worm burrows
5258.2	5260.7	Black shale and dark gray laminated shale
5260.7	5264.4	Medium dark gray shale with black shale bands and laminae, pyritized Worm burrows near top
5264.4	5267.8	Black shale with medium dark gray shale bands and laminae
5267.8	5268.7	Bl ack shal e
5268.7	5272.2	Black shale with medium dark gray shale bands and laminae
5272.2	5273.4	Medium dark gray shale
5273.4	5278.9	Black shale with medium dark gray shale bands and laminae
5278.9	5280.5	Mostly medium dark gray shale with some dark gray a. black shale bands and laminae
5280.5	5286.9	Black shale with dark gray shale bands and laminae, a few anhydrite seams
5286.9	5287.7	Medium dark gray shale with one .1' black shale banI
5287.7	5292.3	Black shale with dark gray shale bands and laminae
5292.3	5292.7	Medium dark gray shale
5292.7	5310.0	Black shale with dark gray shale laminae and bands

From	To	Fractures
5253.3	5253.3	Slickensided, horizontal plane, parted
5263.5	5263.5	51ickensided, horizontal plane, parted
5266.4	5266.4	Slickensided) horiz onta'I plane, parted
5268.8	5268.8	Slickensided» horizontal plane, parted
5270.0	5270.0	Slickensided, horizontal plane, parted
5274.6	5274.6	Slickensided, horizontal pl ane, parted
5275.2	5275.2	Slickensided» horizontal plane, parted
5285.2	5286.0	Near vertical to 70° incline
5292.1	5292.1	Slickensided, horizontal plane) parted
5305.0	5307.0	Vertical, irregular surface) parted
5307.5	5308.4	Vertical, irregular surface, parted

From	To	Other Features
5251.0	5254.8	Numerous anhydrite stringers
5258.3	5258.5	3 anhydrite - carbonate layers
52'64.4	5264.4	Anhydrite - carbonate layer
5265.2	5266.0	5 anhydrite - carbonate layers
5267.3	5267.3	Anhydrite - carbonate layer
5268.5	5268.5	Anhydrite - carbonate layer.
5271.7	5271.7	Anhydrite - carbonate layer
5272.8	5272.8	Anhydrite - carbonate layer

Run #5 (Cont.) 5274.7 - 5307.8)

From	To	Other Features .
5274.7	5274.7	Anhydrite - carbonate layer
5276.0	5277.0	Numerous anhydrite - carbonate layers
5277.3	5277.3	Anhydrite - carbonate layer
5218.0	5278.0	Anhydrite - carbonate layer
5278.4	5278.4	Anhydrite - carbonate layer
5279.0	5279.2	2 anhydrite - carbonate layers
5282.8	5282.8	Anhydrite - carbonate layer
5234.7	5284.7	Anhydrite - carbonate layer
5235.0	5285.2	2 anhydrite - carbonate layers'
5235.4	5285.4	2 anhydrite - carbonate layers
5292.8	5292.8	Anhydrite - carbonate layer
5299.1	5299.4	2 anhydrite - carbonate layers
5299.8	5299.9	Several thin anhydrite - carbonate layers
5301.6	5301.6	Anhydrite - carbonate layer
5303.8	5303.8	Anhydrite - carbonate layer
5305.0	5305.0	Anhydrite - carbonate layer
5307.8	5307.8	Anhydrite - carbonate layer

Gas leaking along most of core. .

Run #6 (5310 - 5345)

	To	Lithologic Description
5310.0	5313.8	Black Shale
5313.8	5314.0	Medium dark gray shale
5314.0	5314.3	Black shale
5314.3	5314.5	Medium dark gray shale
5314.5	5318.2"	Black shale
5318.2	5318.5	Medium dark gray shale
5318.5	5325.7	Black shale
5325.7	5327.7	Medium dark gray shale with black shale bands
5327.7	5329.0	Black shale with one band of medium dark to light gray shale .2' long
5329.0	5332.9	Medium dark gray shale with 2 black shale bands. One calcareous band at top and a few pyrite worm burrows
5332.9	5335.0	Black shale
5335.0	5337.5	Medium dark gray shale with 3 black shale bands .1' to .2' in width
5337.5	5339.0	Black shale
5339.0	5339.5	Medium dark gray shale
5339.5	5341.1	Black shale
5341.1	5341.3	Medium dark gray band
5341.3	5345.0	Black shale

	To	.fractures
5311.5	5312.6	9 slickensided, horizontal plane
5314.2	5314.2	'Horizontal plane
5319.2	5319.2	Slickensided> horizontal plane> parted
5320.0	5320.0	'Slickensided) horizontal plane, parted
5321.3	5321.3	2 slickensided, horizontal planes, parted
5322.4	5322.4	Slickensided, horizontal plane, parted
5334.2	5334.2	Slickensided, horizontal plane> parted
5336.0	5336.0	Slickensided> horizontal plane, parted
5336.9	5337.4	3 slickensided, horizontal planes, parted
5338.0	5338.4	4 slickensided, horizontal planes, parted
5339.6	5339.6	Slickensided, horizontal plane, parted
5340.3	5340.3	Slickensided, horizontal plane, parted
5341.3	5341.3	Slickensided, horizontal plane, ,parted

From		Other Feattires
5310.8	5310.8	Anhydrite'- carbonate layer
5311.5"	5312.4	4 anhydrite - carbonate layers
5313.0	5313.0	Anhydrite - carbonate layer
5318.2	5318.2	Anhydrite - carbonate Teyer-
5319.9	5319.9	Anhydrite - carbonate layer
5321.5	5321.5	Anhydrite - carbonate layer
5322.8,	5322.8	Anhydrite - carbonate layer
5329.9	5329.9	Pyrite bleb
5330.3	5330.3	Pyrite bleb
5330.8	5330.8	Pyrite bleb

Run #6 (Cont.) (5331.4 - 5337.0)

From	To	Other Features
5331.4	5331.4	Pyrite bleb
5332.4	5332.4	Pyrite bleb
5335.6	5335.6	Pyrite bleb
5336-.1	5336.1	Pyrite bleb
5337.0	5337.0	Pyrite bleb

Considerable gas bleeding along core•

Run #7 (5345 - 5360)

	To	lithologic Description
5345.0	5345.9	Black shale
5345.9	5347.9	Half black shale and half dark gray shale
5347.9	5351.0	Black shale
5351.0	5351.3	Medium dark gray shale
5351.3	5354.0	Black shale
5354.0	5354.5	Medium dark gray shale
5354.5	5354.9	Black shale
5354.9	5355.2	Medium dark gray shale
5355.2	5357.3	Black shale
5357.3	5357.5	Medium dark gray shale
5357.5	5360.0	Black shale

From	To	Fractures
5352.2	5352.3	2 slickensided, horizontal planes, parted
5352.5	5352.8	3 slickensided, horizontal planes, parted
5354.0	5354.0	Slickensided, horizontal plane) parted
5354.5	5354.5	Slickensided, horizontal plane) parted
5354.7	5354.7	Slickensided, horizontal plane, parted
5355.0	5355.8	7 slickensided) horizontal planes) parted
5356.2	5356.2	Slickensided. horizontal plane, parted
5356.4	5356.4	Slickensided, horizontal plane) parted
5357.7	-5357.7	Slickensided, horizontal plane, parted
5358.2	5358.2	Slickensided) horizontal plane) parted
5359.1	53°60.0	"9 slickensided) horizontal planes) parted

Slickensides at 20° from horizontal

From	To	Other Features
5346.9	5346.9	Anhydrite - carbonate layer
5351.4	5351.4	Anhydrite - carbonate layer
5352.7	5352.7	2 anhydrite - carbonate layers
5354.2	5354.2	Anhydrite - carbonate layer
5354.7	5354.7	Anhydrite - carbonate layer
5355.8	5355.8	Anhydrite - carbonate layer
5356.2	5356.2	2 anhydrite - carbonate layers

Run #8 (5360 - 5392)

from	To	lithologic Description
5360.0	5380.9	Black shale
5380.9	5382.3	Medium gray shale
5382.3	5383.1	Black shale
5333.1	5383.7	Medium dark gray shale
5383.7	5384.2	Black shale
5384.2	5384.6	Dark gray shale
5384.6	5385.3	Black shale
5385.3	5385.8	Dark gray shale
5385.8	5388.0	Black shale
5388.0	5388.2	Medium dark gray shale
5338.2	5389.6	Black shale
5389.6	5392.0	Medium gray shale

From	To	Fractures
5360.4	5360.6	3 slickensided, horizontal planes) parted
5361.4	5361.4	Slickensided, horizontal plane, parted
5361.8	5361.8	Slickensided, horizontal plane, parted
5362.5	5362.5	Slickensided, horizontal plane. parted
5363.1	5363.1	Slickensided, horizontal plane, parted
5367.6	5357.6	Slickensided) horizontal plane, parted
5358.0	5368.0	Slickensided, horizontal plane, parted
S370.8	5370.8	Slickensided, he-rizontal plane, parted
5371.2	5371.2	Slickensided, horizontal plane, parted
5373.3	5373.8	3 slickensided, horizontal planes, parted
5375.4	5375.6	2 slickensided, horizontal planes, parted
5.376.0	5378.0	12 slickensided, horizontal planes, parted
5378.5	5378.5	Slickensided, horizontal plane, parted
5379.0	5379.0	Slickensided, horizontal plane, parted
5379.3	5379.3	Slickensided, horizontal plane, parted
5379.6	5379.6	Slickensided, horizontal plane, parted
5380.9	5380.9	Slickensided, horizontal plane, parted
5381.4	5381.4	Slickensided, horizontal plane, parted
5381.8	5381.8	Slickensided, horizontal plane, parted
5382.0	5382.0	Slickensided, horizontal plane, parted
5383.3	5383.3	Slickensided, horizontal pfane, parted
5384.1-	5384.1	Slickensided, horizontal plane, parted
5384.5	5384.5	Slickensided, horizontal plane, parted
5384.7	5384.7	Slickensided, horizontal plane, parted
5387.0	5387.0	Slickensided, horizontal plane. parted
5388.0	5388.0	Slickensided, horizontal plane, parted
5383.2	5388.2	Slickensided, horizontal plane, parted
5389.1	5390.1	6 slickensided, horizontal planes, parted

From	To	Other Features
5362.9	5362.9	Anhydrite - carbonate layer
5380.6	5380.6	Large pyrite bleb
5386.6	5386.6	Pyrite bleb-

Run #8 (Cont.) (5388.5 - 5389.6)

From	To	Other features
5388.5	5388.5	Pyrite layer
5389.0	5389.0	Pyrite layer
5389.6	5389.6	Pyrite layer

Gas bleeding profusely through entire core.

lithologic Description

Medium gray shale with numerous 45° filled hairline fractures
Medium dark gray shale with worm burrows . near base
Black shale
Medium dark gray shale and black shale with worm burrow
Black shale with some very dark gray shale
Medium dark gray shale with some black shale bands and laminae
Black shale with medium dark gray shale bands
Medium dark gray shale with 3 b'lacksha'[ebands approximately .25' - .41' wide
Black shale with a few dark gray shale laminae
Medium dark gray shale with one .3' wide black shale band with some worm burrows
Black shale
Medium dark gray shale band
Black shale with olive black shale layers

Black shale with olive black shale bands
01 ive black shale \11 th dark gray shale and black shale bands
B1 ack shal e
B'lack shale with dark gray shale bands
Black shale
Black shale and dark gray shale
Black shale
Black shale and dark gray shale with worm burrows
Black shale
Dark gray shale and black shale with worm burrows
Black shale
Dark gray shale and balck shale with worm burrows
Black shale

Fractures

18 slickensided fractures, at]0° parted
5 slickensided, horizcntal planes, parted
Slickensided, horizontal plane, parted
3 slickensided, horizontal planes) parted
4 slickensided, horizontal planes) parted
Slickensided, horizontal plane, parted
Slickensided, horizontal plane, parted
Near vertical
Near vertical
Slickensided, horizontal plane, parted
Slickensided) horizontal plane) parted
3 slickensided) horizontal-planes, parted
Slickensided) horizontal plane, parted

Run #9 (Cont.) (5411.3 - 5444.4)

From	To	Fractures
5411.3	5411.3	Slickensided, horizontal plane, parted
5414.5	5414.5	Slickensided, horizontal plane, parted
5416.4	5416.4	Slickensided. horizontal plane, parted
5416.9	5416.9	Slickensided. horizontal plane, parted
5417.3	5417.3	Slickensided. horizontal plane, parted
5417.4	5418.0	Near vertical
5428.0	5428.9	Near vertical
5432.6	5432.8	2 slickensided. horizontal planes, parted
5433.9	5434.0	2 slickensided. horizontal planes, parted
5434.4	5434.4	Slickensided. horizontal plane, parted
5434.7	5434.7	Slickensided, horizontal plane, parted
5435.0	5435.1	2 slickensided, horizontal planes, parted
5435.3	5435.5	3 slickensided, horizontal planes, parted.
5435.7	5435.7	Slickensided. horizontal plane, parted
5435.9	5435.9	Slickensided, horizontal plane, parted
5436.1	5436.5	5 slickensided. horizontal planes, parted
5436.7	5437.4	5 slickensided. horizontal planes) parted
5437.8	5437.8	Slickensided) horizontal plane, parted
5438.0	5438.0	Slickensided. horizontal plane, parted
5438.9	5438.9	Slickensided. horizontal plane, parted
5439.4	5439.4	Slickensided, horizontal plane, parted
5442.0	5442.0	Slickensided. horizontal plane, parted
5442.5	5442.5	Slickensided, horizontal plane) parted
5444.4	5444.4	Slickensided, horizontal plane, parted

From	To	Other Features
5398.0	5398.0	2 pyrite blebs
5399.0	5399.0	Large pyrite bleb
5400.0	5400.0	Pyrite bleb
5406.4	5406.4	Anhydrite - carbonate layer
5417.4	5417.5	large pyrite bleb
5418.3	5418.3	Pyrite bleb
5419.0	5419.0	Large pyrite bleb
5420.0	5420.0	Vertical black kerogen layer
5420.1	5420.1	Pyrite bleb
5421.5	.5421.5	Pyrite bleb
5423.4	5423.4	Pyrite bleb
5426.2	5426.2	Pyrite bleb
5428.3	5428.3	Pyrite bleb
5432.7	5432.7	Pyrite 1ayer
5438.2	5438.2	2 pyrite blebs
5438.4	5438.4	Pyrite bleb

Run #10 (5445 - 5475)

	To	lithologic Description
5445.0	5447.3	Medium dark gray shale and dark gray shale laminated and banded» some worm burrows
5447.3	5449.1	Black shale
5449.1	5449.7	Dark gray shale
5449.7	5450.0	Black shale
5450.0	5450.6	Medium dark gray shale
5450.6	5452.8	Black shale
5452.8	5455.4	Medium dark gray shale and dark gray shale with. 2 black shale bands» loading features and worm burro!
5455.4	5456.0	Black shale
5456.0	5456.2	Medium gray shale with some worm burrows
5456.2	5461.9	Black shale
5461.9	5463.3	Medium dark gray shale and dark gray shale with loading features and a .4' black shale band
5463.3	5475.0	Black shale

	To	Fractures
5449.3	5449.9	60°)inclined
5452.0	5453.0	85°, nearly vertical
5453.6	5453.6	Slickensided, horizontal plane, parted
5453.7	5454.6	Nearly vertical
5454.1	5454.1	Slickensided, horizontal plane, parted
5454.3	5454.3	Slickensided, horizontal plane, parted
5456.5	5456.5	Slickensided, horizontal plane, parted
5464.3	5464.3	Slickensided, horizontal plane, parted
5469.9	5469.9	Slickensided, horizontal plane» parted
5469.9	5470.8	Nearly vertical

	To	Other Features
5450.6	5450.6	Pyrite bleb
5458.7	5458.7	Pyrite bleb
5460.6	5460.7	large. pyrite bleb
5461.1	5461.1	Pyrite bleb
5464.9	5464.9	Pyrite bleb
5468.3	5458.3	Pyrite bleb
5470.8	5470.8	Pyrite bleb
5475.0	5475.0	Pyrite bleb
5475.4	5475.5	Kerogen 1ayer

Run #11 (5684 - 5689)

From	To	lithologic Description
5684.0	5689.0	light gray shale to black fossiliferous limestone

From	To	Other Features
5684.0	5689.0	Brachio pods and possible horn coral

Point flo.	Depth (Feet)	Off Gas Cu.Ft. Gas Cu.Ft. Shale	Trapped Gas Cu.Ft. Gas Cu.Ft. Shale	Kerogen Derived Gas Cu.Ft. Gas Cu.Ft. Shale
1	4871	.51	.470	.820
2	4881	.26	.460	.530
3	4890	.39	.000	.000
4	4891	.28	.210	.640
5	4901	.44	1.190	3.260
6	"4911	.45	1.440	2.180
7	4921	.31	.650	1.010
8	4931.	.24	.270	.950
9	4941	.02	.470	.560
10	4951	.13	.020	.100
11	4961	.00	.050	.110
12	4971	.00	.020	.120
13	4981	.03	.070	.060
14	5211	.12	.520	.280
15	5221	.10	.040	.130
16	5231	.07	.110	.490
17	5241	.10	.280	.390
18	5251	.13	.100	.120
19	5261	.03	.050	.030
20	5271	.30		
21	5281	.20	.260	.930
22	5291	.0037	.550	1.550
23	5302	.390	.180	.090
24	5311	.05	.410	1.110
25	5321	.26	.620	.810
26	5331	.10	.002	.050
27	5341	.36	.510	1.170
28	5350	.32	.070	.470
29	5361	.0037	.080	.120
30	5363	:620		
31	5366	.38		
32	5371	.44	1.060	.790
33	5380	.18	.120	.440
34	5401	.63	.930	1.270
35	5411	.09	.230	.600
36	5421	.44	.750	1.820
37	5431	.28	.060	.050
38	5441	.53		
39	5445	.38		
40	5451	.56	.750	.910
41	5461	.24	.530	2.430
42	5471	.41	.31.0	.800
43	5688	.01	.040	.090

Table 1.4

Average Gas Contents of the Devonian Shale
(in cubic feet of gas per cubic foot of shale)

Average Gas Content (Cubic Feet of Gas/Cub-jc Feat .of Shal e)	Well 20403	U-n 2"0402	Well 20336	Uell 20338
Overall	.26	.37	.22	1.76
Zone I				2.54*
Upper Gray	.03	.01	.18	.25
Zone II	.09	not done	.00*	not done
Middle Gray	.12	.24	.10	1.00
Zone III	.35*	.45*	.59*	2.58*
Lower Gray	.29	not done	.13	not done
Zone IV	.97*	1.04*	.35*	not done
Medium Gray	.10	.10	.10	.37
Dark Gray	.24	.39	.10	.61
Black	.70	.63	.41	2.14

* - denotes sections with generally high natural gamma radiation.

TABLE 5.1

STATISTICAL VALUES OF TRAPPED GAS AND GAS FROM BERGEN BREAKDOWN

	20402	20403	20336	20338
TRAPPED GAS:				
Average Black Shale	4.39	4.82	3.26	.47
Average Gray Shale	2.75	1.05	.64	_12
Overall Average	3.65	1.82	1.69	_38
Gas from Bergen Breakdown:				
Average Black Shale	18_93	14.57	10.39	.87
Average Gray Shale	11.60	4.49	1.59	.30
Overall Average	14.96	6.56	5.13	.74

APPENDIX B

CHEMICAL AND PHYSICAL ANALYSIS

BY

BATTELLE LABORATORIES

This appendix presents the chemical and physical analysis performed on cores obtained from Columbia gas well #20338 by Battelle Labs at various depths as shown on Table 2.1.

The chemical analysis includes the gas composition and its relationship with depth as function of changing pressures. The physical analysis includes the determination of porosity, bulk density, surface area and core volume at various pressures. Lithologic descriptions of the samples obtained from the well is presented in Table 2.2.

The Battelle reference number for the core is C-338.

List of Tables

Tables

2.1 Depths of Core-Samples from Wise County, VA, Well #20338 56

2.2 Core Barrel Run Information 57-58

2.3 Initial Gas Release Data 59

2.4 Statistical Analysis of Offgas Data . . .60

2.5 Chemical Characterization Data 61-63

2.6 Summary of Physical Characterization Data. . . 64

2.7 Statistical Analysis of Physical Characterization Data . . .65

2.8 Porosity Data for Sample C338-4872 - Table 9 66-67

List of Figures

Figures		Page
2. I	Gas content as a function of sample depth . .	68
2.2	Ranking of wells accordi ng to gas contents.	69
2.3	Carbon content as a function of sample depth.	70
2.4	Hydrogen content as a function of sample depth.	71
2.5	HIc Atomic Ratio as a function of sample depth.	72
2.6	Ranking of wells accordi ng to carbon contents .	73
2.7	Rank ing of wells according to hydrogen contents	74
2.8	Ranking of wells according to HIe atomic rat ios	75
2.9	Gas content as a function of carbon content .	76
2.10	Gas content as a function of hydrogen content	77
2. II	Gas content as a function of bulk density content	78
2. 12	Carbon content as a funct ion of bu'lk densi ty.	79
2. 13	Hydrogen content as a function of bulk density.	80
2. 14	Pore volume as a function of pressure for sample (338-4872).	81
2.15	Pore size distribution for sample C338-4872	82

Table 2.1 . Depths of Core Samples from Wise County, Virginia, Well No. 20338

1. 4872.40 - 4872.80
2. 4892.58 - 4892.25
3. 4902.25 - 4902.55
4. 4912.40 - 4912.70
5. 4922.45 - 4922.78
6. 4930.10 - 4930.42
7. 4940.42 - 4940.72
8. 4950.23 - 4950.54
9. 4960.30 - 4960.62
10. 4970.12 - 4970.70
11. 4980.60 - 4980.90
12. 5212.50 - 5212.89
13. 5223.10 - 5212.89
14. 5232.15 - 5242.70
15. 5242.38 - 5242.70
16. 5253.45 - 5253.76
17. 5263.50 - 5263.92
18. 5273.50 - 5273.87
19. 5283.38 - 5283.75
20. 5293.50 - 5293.85
21. 5303.30 - 5303.80
22. 5312.61 - 5312.84
23. 5322.10 - 5322.45
24. 5331.40 - 5331.72
25. 5342.09 - 5342.45
26. 5347.30 - 5347.78
27. 5357.20 - 5357.65
28. 5362.22 -5362.50
29. 5372.40 - 5372.70
30. 5382.27 - 5382.55
31. 5394.15 - 5394.60
32. 5404.09 - 5404.38
33. 5414.30 - 5404.57
34. 5424.55 - 5424.90
35. 5434.32 - 5434.69
36. 5444.31 - 5444.58
37. 5447.30 - 5447.60
38. 5457.33 - 5457.60
39. 5467.40 - 5467.77

TABLE 2.2 WELL DATA FOR C-338

LOCATION: WISE COUNTY, VA

ALTITUDE: 2395 FEET

COORDINATES: 37.00 (DEGREES.MINUTES) LATITUDE
82.41 (DEGREES.MINUTES) LONGITUDE

CORING BEGAN AT 4870 FEET AND STOPPED AT 5475 FEET, IT TOOK 11 BARRELS TO COMPLETE.

SAMPLES WERE RETURNED TO BATTELLE ON 5/3/77.

THERE WERE 40 SAMPLES COLLECTED FOR BATTELLE AND 41 SAMPLES COLLECTED FOR THERS.

RUN INFORMATION FROM WELL C-338

RUN NO. 1 CORING BEGAN AT 4870 FEET AND CORING STOPPED AT 4920 FEET THE AVERAGE CORING RATE IS 7.33 FEET PER MINUTE, THE SAMPLES WERE ON SURFACE IN 4.00 HOURS.

RUN NO. 2 CORING BEGAN AT 4920 FEET AND CORING STOPPED AT 4986 FEET, THE AVERAGE CORING RATE IS 15.05 FEET PER MINUTE, THE SAMPLES WERE ON SURFACE IN 3.62 HOURS.

RUN NO 5

RUN NO. 6 CORING BEGAN AT 5340 FEET AND CORING STOPPED AT 5345 FEET THE AVERAGE CORING RATE IS 8.26 FEET PER MINUTE, THE SAMPLES WERE ON SURFACE IN 3.18 HOURS.

Table 22 RUN INFORMATION FROM WELL CONTINUED C-338 (Continued)

RUN NO. 7	CORING BEGAN AT 5345 FEET AND CORING STOPPED AT 5360 FEET. THE AVERAGE CORING RATE IS 8.00 FEET PER MINUTE. THE SAMPLES WERE ON SURFACE IN 3.28 HOURS.
RUN NO. 8	CORING BEGAN AT 5360 FEET AND CORING STOPPED AT 5392 FEET. THE AVERAGE CORING RATE IS 10.25 FEET PER MINUTE. THE SAMPLES WERE ON SURFACE IN 3.43 HOURS.
RUN NO. 9	CORING BEGAN AT 5392 FEET AND CORING STOPPED AT 5445 FEET. THE AVERAGE CORING RATE IS 4.56 FEET PER MINUTE. THE SAMPLES WERE ON SURFACE IN 4.33 HOURS.
RUN NO. 10	CORING BEGAN AT 5445 FEET AND CORING STOPPED AT 5475 FEET. THE AVERAGE CORING RATE IS 9.21 FEET PER MINUTE. THE SAMPLES WERE ON SURFACE IN 2.50 HOURS.
RUN NO. 11	CORING BEGAN AT 5684 FEET AND CORING STOPPED AT 5690 FEET. THE AVERAGE CORING RATE IS 46.15 FEET PER MINUTE. THE SAMPLES WERE ON SURFACE IN 3.08 HOURS.

Table 2.3 INITIAL GAS RELEASE DATA: WELL C-338

SAMPLE ID	PRESSURE BRR	FREE VOLUME C	CORE VOLUME CC	OPEN POROSITY PCT.	GAS COMPOSITION, VOLUME PERCENT TOTAL METHANE	ETHANE	PROPANE	BUTANE	PENTANE	HYDROC.	NITROGEN	OXYGEN	CARBON DIOXIDE	GAS RELEASED/ UNIT VOLUME OF SHALE	SEQ NO
C338-4872.	2100.	820.	630.	1.04	64.00	6.74	.84	.24	0.00	71.82	26.55	.55	1.04	2.59	1
C338-4882.	2015.	928.	522.	1.69	61.70	6.30	.74	.15	0.00	68.89	27.20	3.80	11	3 ?5	2
C338-4892.	1907.	849.	601.	.84	64.5U	6.70	.86	.08	C.Oe	72.14	25.10	2.80	.03	2.56	3
C338-4902.	1450.	923.	527.	1.73	63.40	7.63	.95	0.00	0.00	71.98	26.10	1.93	.41	2.40	4
C338-4912.	2170.	881.	569.	1.77	65.90	6.99	.84	.10	0.00	73.83	25.10	.89	.22	3.27	5
C338-4922.	1795.	846.	604.	1.40	58.60	5.99	.74	.33	0.00	65.66	31.30	2.35	.71	2.17	6
C338-4930.	1460.	882.	568.	2.09	51.00	3.99	.53	0.00	0.00	55.52	37.3C	&.70	.49	1.66	7
C338-4940.	1613.	900.	550.	1.51	52.20	5.57	.68	0.00	0.00	58.45	35.22	5.36	.98	2.03	8
C338-4950.	1220.	892.	558.	1.58	44.10	4.41	.59	.11	0.00	49.21	44.60	2.23	3.91	1.26	9
C338-4960.	1000	860.	590.	2.29	41.81	3.87	.53	0.00	0.00	46.21	47.30	2.79	3.69	.89	10
C338-4970.	710.	931.	519.	.53	2.73	0.00	0.00	0.00	0.00	2.73	76.79	19.99	.51	.05	11
C338-4980.	760.	913.	537.	1.61	10.80	10.76	.11	0.00	0.00	27.&7	63.50	.63	8.30	.47	12
C33B-5212.	1050.	855.	595.	5.27	36.70	3.33	3.77	0.00	0.00	45.80	53.24	1.27	3.0&	.91	13
C338-5222.	1075.	823.	627.	2.83	39.66	3.87	.38	0.00	0.00	43.91	52.28	1.06	?.75	.82	14
C338-5232.	1975.	512.	938.	2.77	65.23	4.15	.30	O.OU	0.00	69.68	29.02	.41	.8B	.99	15
C338-5242.	1475	888.	562.	2.13	58.01	4.62	.38	0.00	0.00	63.01	34.?0	1.21	1.58	1.93	16
C338-5253.	1558.	876.	574.	1.15	55.40	8.00	.65	0.00	0.00	64.05	34.28	.41	1.23	2.00	17
C338-5263.	1640.	695.	755.	1.31	57.21	5.27	.61	0.00	0.00	63.09	35.45	.48	.99	1.25	18
CJ38-5273.	750.	1450.	C.	2.06	58.12	8.25	1.10	0.00	0.00	67.47	30.80	.42	1.25	R	19
C338-5283.	800.	744.	706.	2.09	67.81	9.0?	.84	0.00	0.00	77.72	20.81	.34	.67	.86	20
C338-5293.	925.	769.	681.	2.14	71.81	9.30	.86	0.00	0.00	81.97	17.22	.26	.55	T.13	21
C338-5303.	?900.	493.	957.	1.18	77.50	4.78	.44	0.00	0.00	82.72	16.70	.33	.26	1.6?	?2
C336-5312.	1250.	1067.	383.	2.15	47.39	6.37	.54	0.00	0.00	54.30	42.62	.60	2.51	2.49	23
C338-5322.	177·.	82&.62	1.	2.55	51.?1	5.25	.43	.09	0.00	67.47	31.10	.43	.98	2.08	24
C338-5332.	870.	912.	538.	2.37	21.60	1.50	.07	0.00	0.00	23.17	63.60	11.90	1.35	.45	2S
C338-5342.	1225.	797.	653.	.40	72.10	6.80	.61	0.00	0.00	79.51	19.80	.59	.13	1.56	26
C338-5347.	1740.	645.	805.	1.16	60.00	4.56	.43	.09	0.00	65.08	32.80	.98	1.21	1.19	27
C338-5357.	1150.	712.	738.	.98	70.50	6.15	.51	0.00	0.00	77.16	21.30	.34	1.29	1.13	28
C330-53&2.	1150.	899.	551	28	73.90	7.91	.63	.06	o.UO	82.50	16.70	.33	.53	2.03	29
C338-5372.	975.	812.	638.	.72	78.30	8.50	.70	0.00	0.00	87.50	11.30	.57	.22	1.43	30
CJ3e-5382.	1OCO.	906.	544.	.73	66.60	6.70	.&1	0.00	0.00	73.91	23.10	2.80	.20	1.62	31
C338-5394.	1075.	722.	728.	2.11	35.69	2.92	.46	0.00	0.00	39.03	53.19	6.37	1.41	.55	32
C338-5404.	850.	1010.	440.	1.43	51.03	6.35	.75	.07	0.00	58.20	36.55	4.96	.29	1.49	33
C338-5414.	1490.	972.	470.	.89	62.90	6.10	.47	0.00	0.00	69.47	26.47	4.01	.78	2.77	34
C338-5424.	2600.	807.	643.	2.36	69.05	5.71	.41	0.00	0.00	75.97	21.55	2.38	.09	3.26	35
C338-5434.	1125.	796.	654.	1.11	55.20	5.80	.68	0.00	0.00	61.68	34.50	3.60	.20	1.11	36
C330-5444.	1125.	950.	500.	.72	71.30	7.50	.55	0.00	0.00	79.35	18.80	1.67	.08	2.23	37
C338-5447.	2337.	803.	647.	.74	68.90	6.34	.40	0.00	0.00	75.64	23.40	.46	.48	2.89	38
C338-5457.	975.	915.	535.	.64	56.30	5.10	.36	0.00	0.00	61.76	32.00	6.20	.08	1.36	39
C338-5467.	107s.	767.	683.	1.09	80.40	7 50	.55	0.00	0.00	88.45	11.10	.46	.41	1.41	40

Table 2.4 SYATYSYICAL ANALYSES OF OFF GAS DATA

WELL C338

	MEAN	STANDARD DEVIATION	VARIENCE	COFFFYCYENY OF DEVIATION	95 PCT. CONFIDENCE INYERVAL LOWER LIMIT	UPPER LIMIT	NO OF SAMPLES
ETHANE, PERCENT	6.066	2.61	6.80	.43	5.233	6.900	40
PROPANE, PERCENI	.647	.56	.31	.86	.470	.825	40
BUTANE, PERCENT	.033	.07	.01	2.16	.010	.056	40
PENTANE, PFRCENT	0.000	0.00	0.00	Y	0.000	0.000	40
TOTAL HYDROCARBONS, POT	63.590	18.01	324.41	.28	57.835	69.346	40
NITROGEN, PERCENT	32.748	14.75	217.48	.45	28.036	37.461	40
OXYGEN, PERCENT Y	2.623	3.73	13.91	1.42	1.431	3.815	40
CARBON DIOXIDE, PERCENT	1.146	1.51	2.29	1.32	.663	1.630	40
GAS VOLUME/SHALE VOLUME	1.166	1.06	1.12	.91	~~-4.590~~ 7 .90	1.504	40

Table 2.5 CHEMICAL CHARACTERIZATION DATA, 12/77

SAMPLE ID	TOTAL, PERCENT CARBON	HYDROGEN	NITROGEN	LOW TEMPERATURE ASH, % 200 C	100 C	CARD CODE	SEQ NO.
C338-4872	4.0	.4	.1			5	1
C338-4882.	6.2	.6	.2			5	2
C338-4912	5.2	.5	.2			5	3
C338-4930.	2.3	.4	.1			5	7
C338-4940.	2.8	.8	.1			5	8
C338-4950.	3.1	.4	.1			5	9
C338-4960.	1.3	.4	.1			5	10
C338-4970.	3.4	.3	.1			5	11
C338-4980.	1.2	.5	.1			5	12
C338-5212.	1.t					5	13
C338-5222.	1.2	.5	.1			5	14
C338-5242.	1.4	.5	.1			5	16
C338-5253.	2.5	.5	.1			5	17
C338-5263.	1.3	.5	.1			5	18
C338-5273.	1.7	.5	.1			5	19
C338-5283.	1.7	.5	.1			5	20
C338-5293.	2.5	.5	.1			5	21
C338-5303.	2.1	.5	.1			5	22
C338-5312.	2.5	.5	.1			5	23
C338-5332.	1.0	.5	.1			5	25
C338-5342	3.5	.6	.2			5	26

Table 2.5 CHEMICAL CHARACTERIZATION DATA, 12/77 (Continued)

SAMPLE ID	TOTAL, PERCENT CARBON	HYDROGEN	NITROGEN	LOW TEMPERATURE ASH, % 200 C	100 C	CARD CODE	SEQ. NO.
C338-5347.	1.1	.5	.1			5	27
C338-5382.	4.0	.5	.2			5	31
C338-5394.	2.6	.4	.1			5	32
C338-5434.	2.4	.5	.1			5	36
C338-5447.	5.1	.6	.2			5	39
C338-5467.	4.8	.6	.2			5	40
5111-85	-R	-R	-R	-R	-R	***	***
Avg.	2.7	0.5					

TABLE 2.5 CHEHICAL CHARACTERIZATION DATA (Continued)

Sample ID	Carbon	Hydrogen	Nitrogen
C-338-4892	4.7	0.5	0.1
C-338-4922	3.2	0.4	0.1
C-338-5232	0.8	0.5	0.1
C-338-5322	1.8	0.5	0.2
C-338-5357	1.9	0.4	0.1
C-338-5362	6.2	0.6	0.2
C-338-5372	4.7	0.5	0.2
C-338-5404	3.8	0.5	0.2
C-338-5414	5.3	0.6	0.2
C-338-5424	5.0	0.5	0.2
C-338-5444	6.2	0.6	0.2

Table 2.6 SUMMARY OF PHYSICAL CHARACTERIZATION DATA FOR WELL C-338

	BULK DENSTY Glee	OPEN POROSTY PCT	CLOSED POROSTY PCT	TOTAL POROSTY PCT	SURFACE AREA M2/G	SEQ
C338-4812.	2.610	1.043	0.000	1.043	11.520	1
C338-4882.	2.484	1.689	6.313	8.002	11.940	2
C338-4892.	2.555	.844	3.071	3.914	8.350	3
C338-4902.	2.490	1.732	1.394	3.126	13.190	4
C338-4912.	2.523	1.773	3.780	5.552	8.900	5
C338-4922.	2.615	1.396	3.077	4.473	8.980	6
C338-4930.	2.625	2.089	0.000	2.089	6.160	7
C338-4940.	2.618	1.513	0.000	1.513	9.420	8
C338-4950.	2.694	1.578	3.360	4.938	5.930	9
C338-4960.	2.844	2.286	.474	2.760	3.130	10
C338-4970.	2.824	.530	.227	.757	2.530	11
C338-4980.	2.722	1.608	0.000	1.608	2.230	12
C338-5212.	2.808	5.267	0.000	5.267	3.330	13
C338-5222.	2.745	2.833	0.000	2.833	4.280	14
C338-5232.	2.696	2.774	2.432	5.203	3.520	15
C338-5242.	2.595	2.134	.595	2.729	4.540	16
C338-5253.	2.726	1.153	2.736	3.889	7.310	17
C338-5263.	2.776	1.307	1.099	2.406	3.230	18
C338-5273.	2.694	2.058	1.724	3.782	2.530	19
C338-5283.	2.713	2.086	0.000	2.086	5.540	20
C338-5293.	2.662	2.142	0.000	2.142	5.560	21
C338-5303.	2.667	1.182	1.006	2.188	4.800	22
C338-5312.	2.666	2.154	0.000	2.154	8.310	23
C338-5322.	2.679	2.553	5.407	7.959	6.560	24
C338-5332.	2.761	2.365	5.031	7.396	2.760	25
C338-5342.	2.672	.398	0.000	.398	7.740	26
C338-5347.	2.756	1.159	1.438	2.597	7.180	27
C338-5357.	2.733	.979	2.357	3.335	11.200	28
C338-5362.	2.568	.278	1.005	1.280	14.020	29
C338-5372.	2.590	.723	0.000	.723	16.690	30
C338-5382.	2.622	.732	5.346	6.078	11.900	31
C338-5394.	2.724	2.113	.403	2.515	3.890	32
C338-5404.	2.627	1.428	3.577	5.006	3.730	33
C338-5414.	2.551	.891	0.000	.891	21.520	34
C338-5424.	2.590	2.361	3.993	6.353	18.040	35
C338-5434.	2.695	1.113	.354	1.467	3.160	36
C338-5444.	2.548	.721	0.000	.721	24.010	37
C338-5447.	2.590	.741	1.298	2.039	15.760	38
C338-5457.	2.658	.642	0.000	.642	18.310	39
C338-5467.	2.567	1.094	.779	1.874	12.970	40

Table 2.7 STATISTICAL ANALYSES OF PHYSICAL CHARACTERIZATION DATA

WELL C-33a

	MEAN	STANDARD DEVIATION	VARIENCE	COEFFICIENT OF DEVIATION	95 PCT. CONFIDENCE INTERVAL LOWER LIMIT	UPPER LIMIT	NO OF SAMPLES
BULK DENSITY, G/CC	2.664	.10	.01	.04	2.634	2.695	40
APPARENT DENSITY, G/CC	2.708	.11	.01	.04	2.673	2.743	40
TRUE DENSITY, G/CC	2.693	.14	.02	.05	2.648	2.739	40
OPEN POROSITY, PCT	1.586	.91	.82	.57	1.297	1.876	40
CLOSED POROSITY, PCT	1.557	1.84	3.37	.18	.970	2.144	40
TOTAL POROSITY, PCT	3.143	2.09	4.36	.66	2.476	3.813	40
WEIGHT LOSS INITIAL, G/KG	9.473	3.06	9.38	.32	8.494	10.451	40
WEIGHT LOSS FINAL, G/KG	-.881	1.15	1.32	-1.31	0.000	-.513	40
TOTAL WEIGHT LOSS, G/KG	8.592	2.64	6.98	.31	7.747	9.436	40

Table 2.8 POROSITY DATA FOR SAMPLE C338-4872.

SEQUENCE NUMBER
PORE VOLUME .012 CC/G

PRESSURE ATMS	PRESSURE PSI	PORE DIAMETER MICRON	PORE VOLUME CC/G	CHANGE IN PORE VOLUME CC/G	PCT. PORES GREATER THAN DIA INDICATED
1	14.696	15.000	.0000	.0115	.0
2	29.392	7.500	.0011	.0104	9.8
3	44.088	5.000	.0020	.0095	17.6
4	58.784	3.700	.0020	.0095	17.6
5	73.480	3.000	.0020	.0095	17.6
6	88.176	2.500	.0020	.0095	17.6
7	102.872	2.00	.0032	.0084	27.5
8	117.568	1.800	.0032	.0084	27.5
9	132.264	.600	.0032	.0084	27.5
10	146.960	1.500	.0032	.0084	27.5
	161.656	.400	.0032	.0084	27.5
	176.35	1.300	.0043	.0072	37.3
3	191.048	1.200	.0043	.0072	37.3
4	205.744	1.100	.0043	.0072	37.3
5	220.440	1.000	.0043	.0072	37.3
6	235.136	.930	.0043	.0072	37.3
	249.832	.880	.0054	.0061	47.1
8	264.528	.830	.0054	.0061	47.1
9	279.224	.790	.0054	.0061	47.1
20	293.920	.750	.0054	.0061	47.1
25	367.400	.600	.0055	.0060	48.0
30	440.880	.500	.0057	.0059	49.0
35	514.360	.430	.0058	.0058	50.0
40	587.84	.70	.0059	.0057	51.0
45	661.320	.330	.0065	.0051	55.9
50	734.800	.300	.0070	.0045	60.8
55	808.280	.270	.0070	.0045	60.8
60	881.760	.250	.0070	.0045	60.8
65	955.240	.230	.0070	.0045	60.8
	1028.720	.210	.0070	.0045	60.8
5	1102.200	.190	.0076	.0040	65.7
80	1175.680	.180	.0081	.0034	70.6
85	1249.160	.170	.0083	.0033	71.6

Table 2.8 POROSITY DATA FOR SAMPLE C3B8-4872. (Continued)

PRESSURE ArMS			PORE VOLUME CC/G	CHANGE IN PORE VOLUME CC/G	PCT. PORES GREATER THAN DIA INDICATED,
90.	1322.640	.160	.0083	.0033	71.6
100.	1469.600	.150	.0083	.0033	71.6
UO.	1616.560	.140	.0000	.0115	.0
120.	1763.520	.130	.0000	.0115	.0
130.	1910.480	.120	.0000	.0115	.Q
140.	2057.440	.110	.0000	.0115	.0
150.	2204.400	.100	.0000	.0115	.0
170.	2498.320	.088	.0000	.0115	.0
180.	2645.280	.083	.0000	.0115	.0
190.	2792.240	.079	.0000	.0115	.0
200.	2939.200	.075	.0000	.0115	.0
22a.	3233.120	.068	.0000	.0115	.0
240.	3527.040	.062	.0093	.0023	80.4
260.	3820.960	.057	.0093	.0023	80.4
28O.	4114.880	.053	.0093	.0023	80.4
300.	4408.800	.050	.0093	.0023	80.4
330.	4849.680	.045	.0093	.0023	80.4
36Q.	5290.56a	.041	.0094	.0022	81.4
390.	5731.440	.038	.0094	.0022	81.4
420.	6172.320	.035	.0102	.0014	88.2
450.	6613.200	.033	.0103	.001Z	89.2
490	1.201,.0;D	.030	.0103	.0012	89.2
510.	7494.960	.029	.0103	.0012	89.2
540.	7935.840	.027	.0103	.0012	89.2
590.	8670.640	.025	.0103	.0OIZ	89.2
610.	8964.560	.024	.0104	.0011	90.2
640.	9405.440	.023	.0104	.0011	9a.2
700	10287.200	.021	.P115	.0000	10a.0
740.	10875.040	.020	.0115	.onoo	100.0
7.1D	11315.920	.019	.0115	.0000	100.0
800.	11756.800	.019	.0115	.0000	100.0
830.	12197.680	.018	.0115	.0000	100.0
860.	12638.560	.017	.0115	.0000	100.0
9na.	13226.40D	.017	.0115	.OD00	100.0
930.	13667.280	.016	.0115	.OOOO.	100.0
960	13961.200	.016	.0115	.0000	100.0
1000.	14696.000	.014	.0115	.0000	100.0

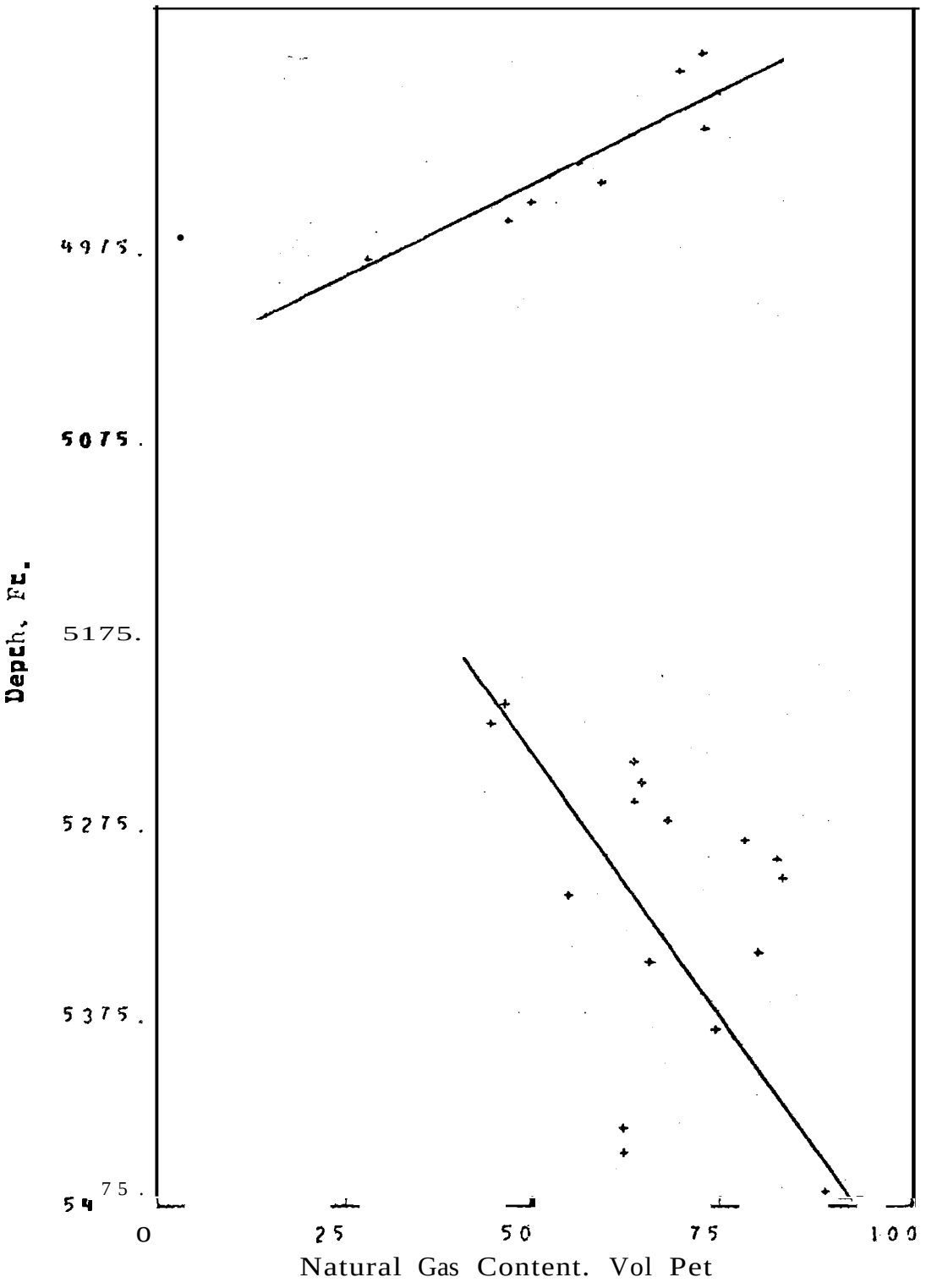


FIGURE 2'.1 GAS CONTENT AS A FUNCTION OF SAMPLE DEPTH FOR WELL C-338

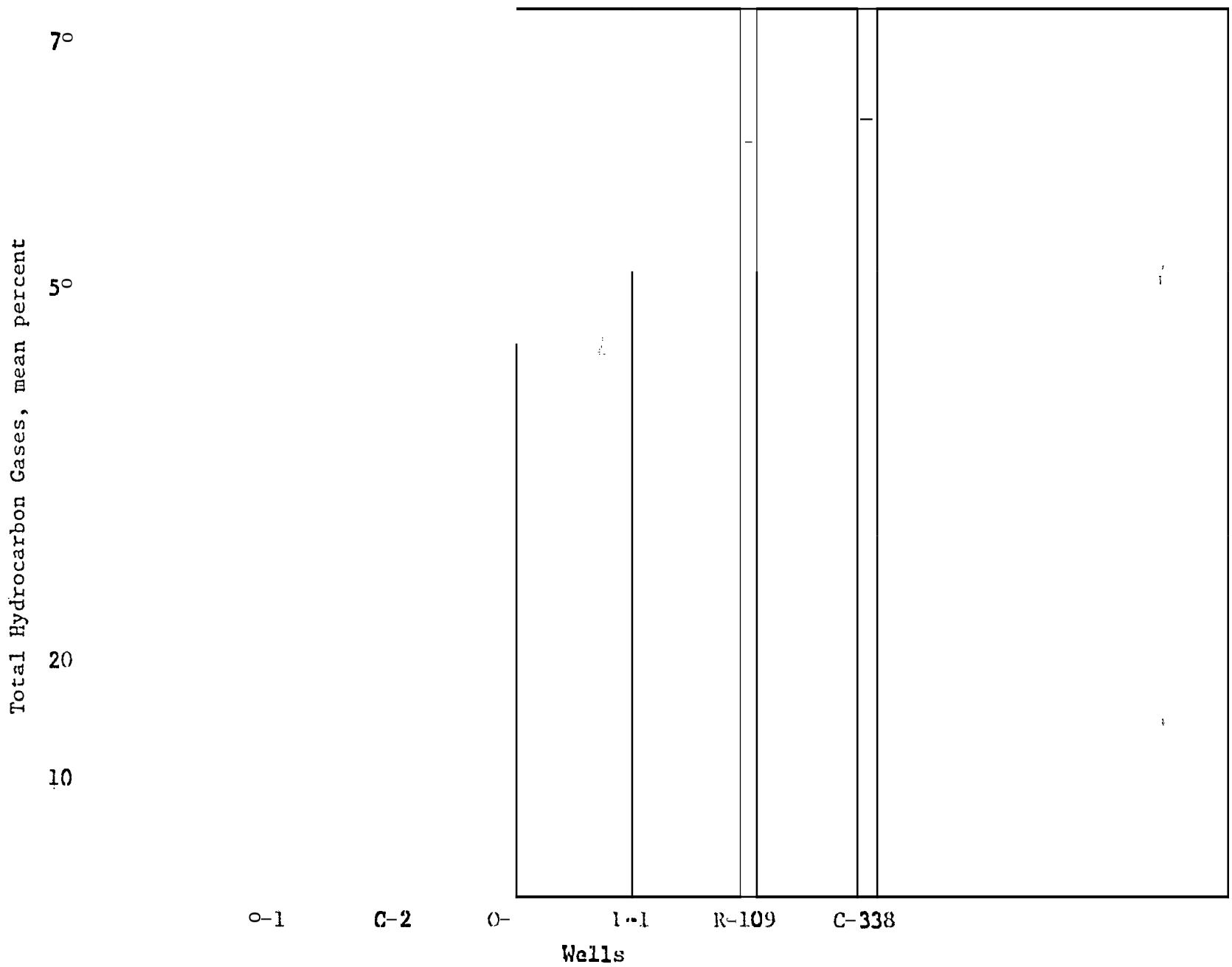


FIGURE 2.2 RANKING OF WELLS ACCORDING TO GAS CONTENTS

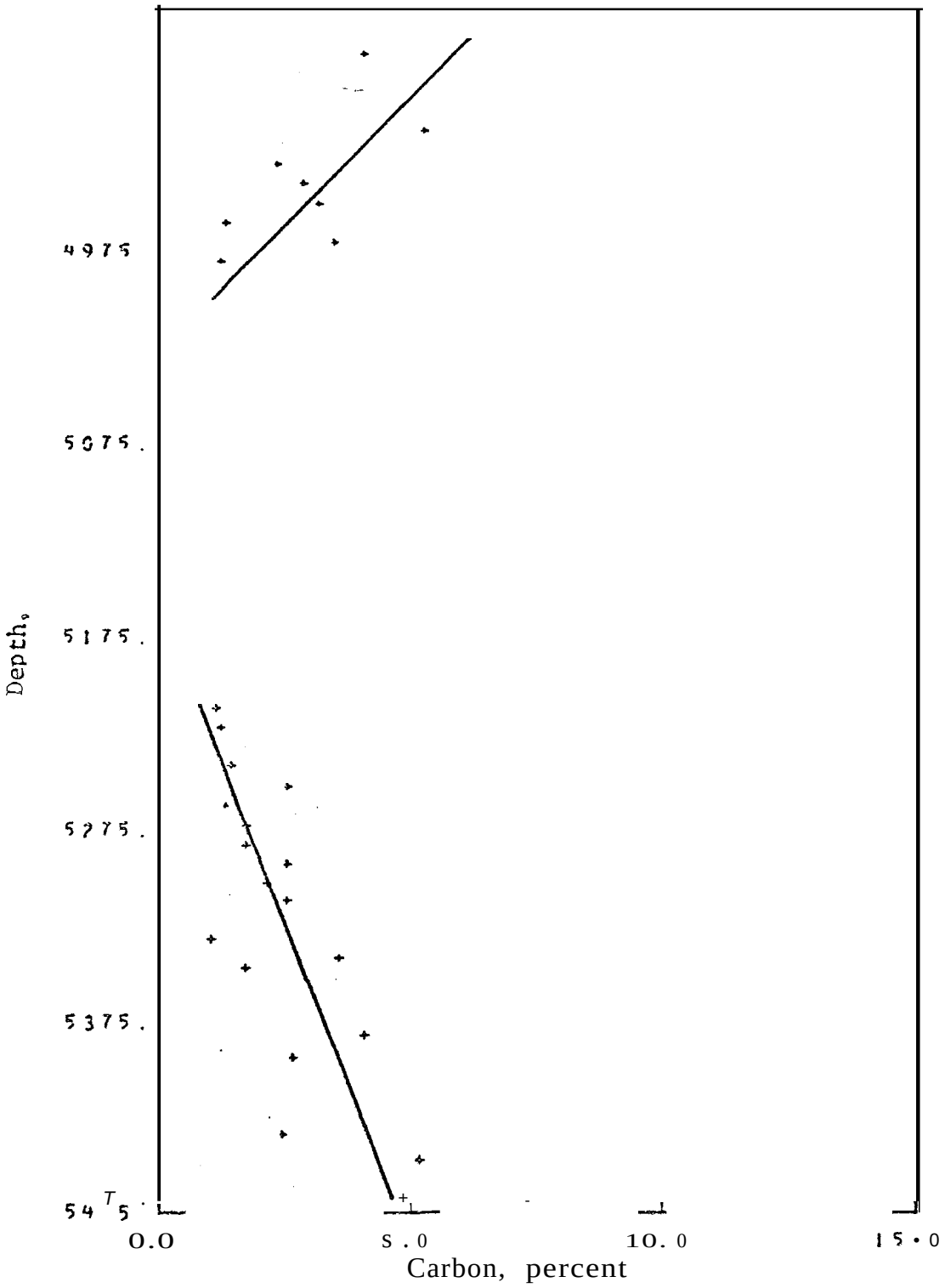


FIGURE 2.3 CARBON CONTENT AS A FUNCTION OF SAMPLE DEPTH FOR WELL C-J38

FIGURE 2.4 HYDROGEN CONTENT AS A FUNCTION OF SAMPLE DEPTH FOR WELL C-338

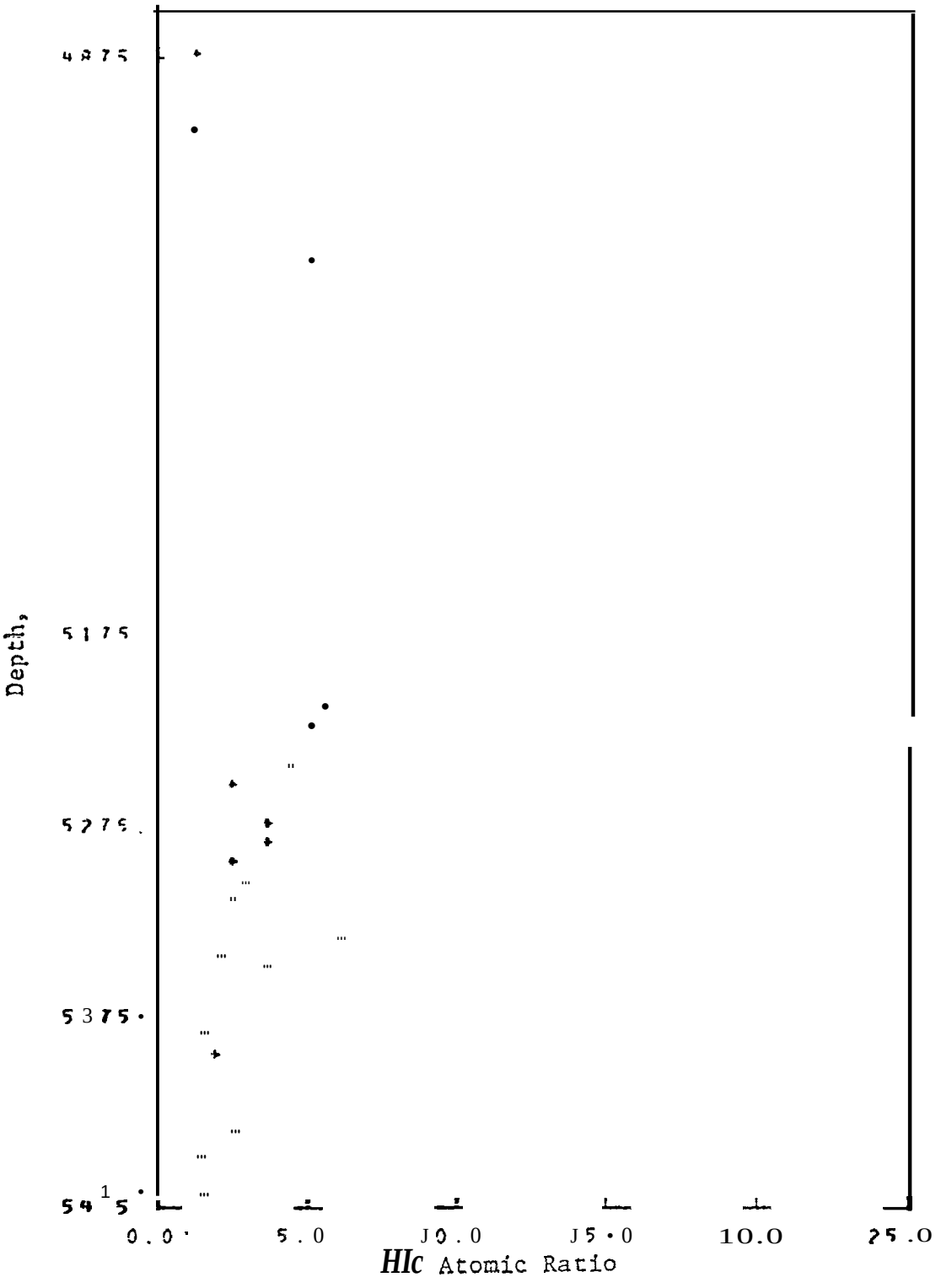


FIGURE 2.5 *HIe* ATOMIC RATIO AS A FUNCTION OF SAMPLE DEPTH FOR WELL C-338

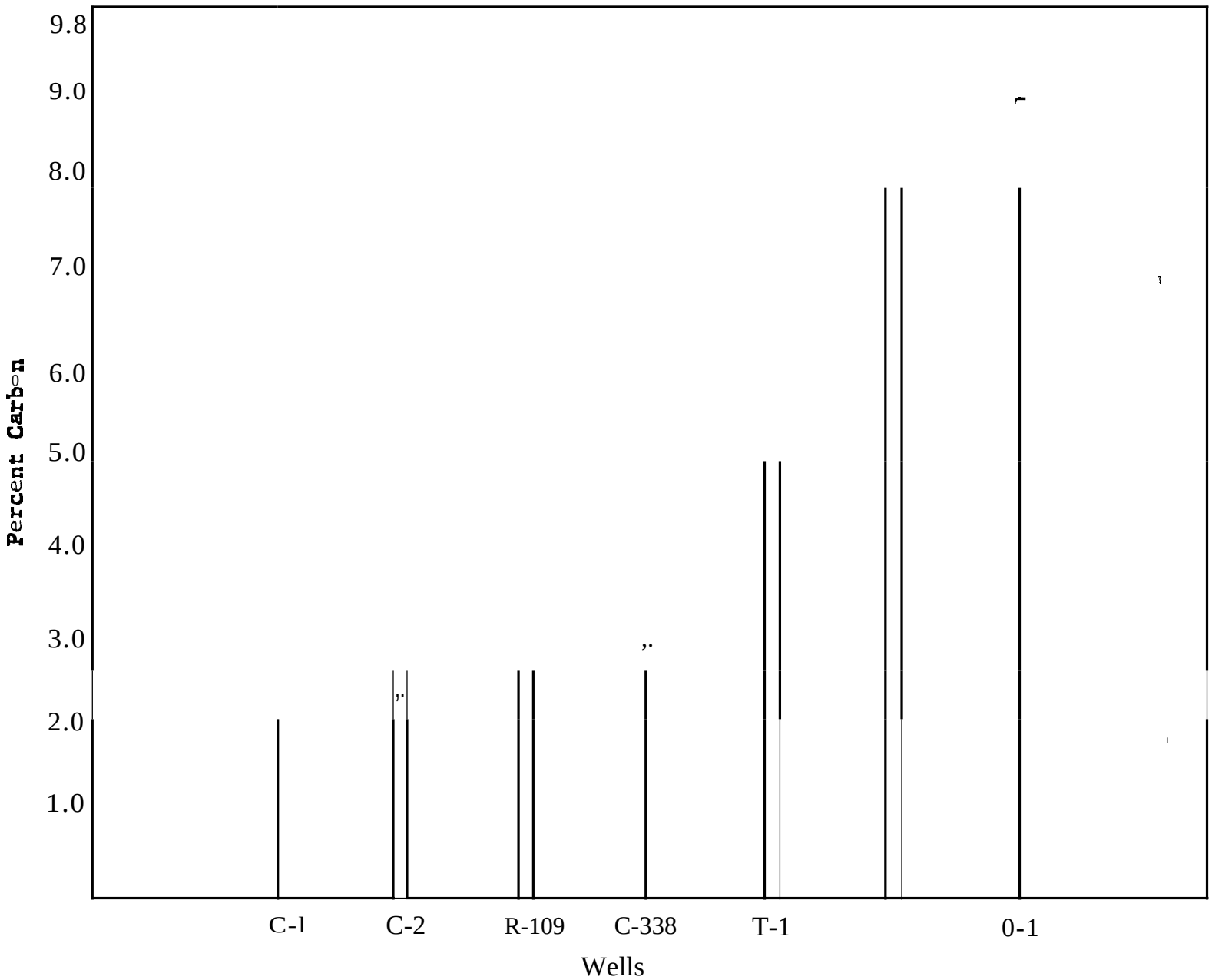


FIGURE 2.6 RANKING OF WELLS ACCORDING '1'0 CARBON CONTENTS

Percent Hydrogen
0.0
0.0
0
0.0
0.0
0.0
0.0
0.0
0.0

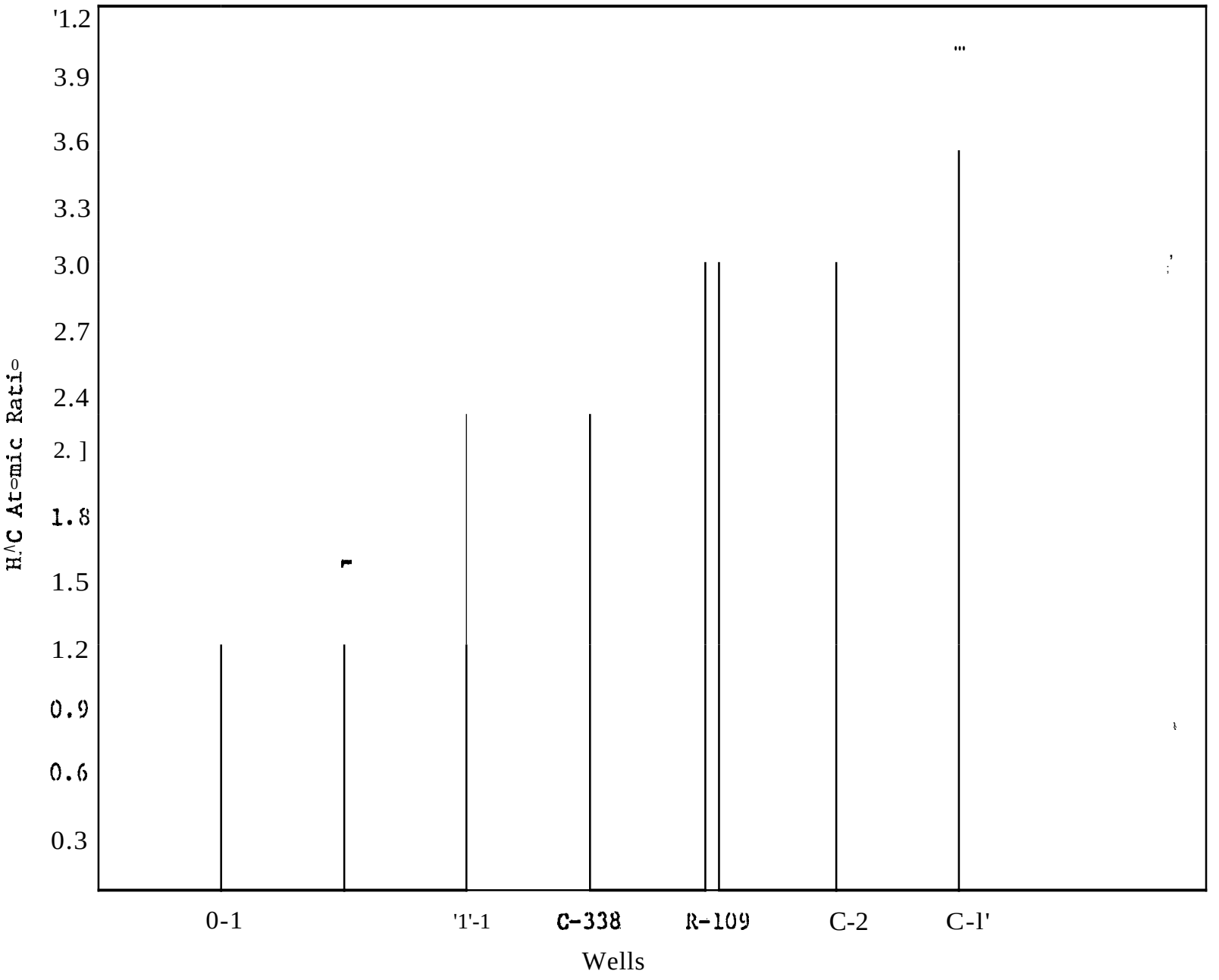


FIGURE 2·8 RANKING OF WELLS ACCORDING '10 n/c ATOMIC RATIOS

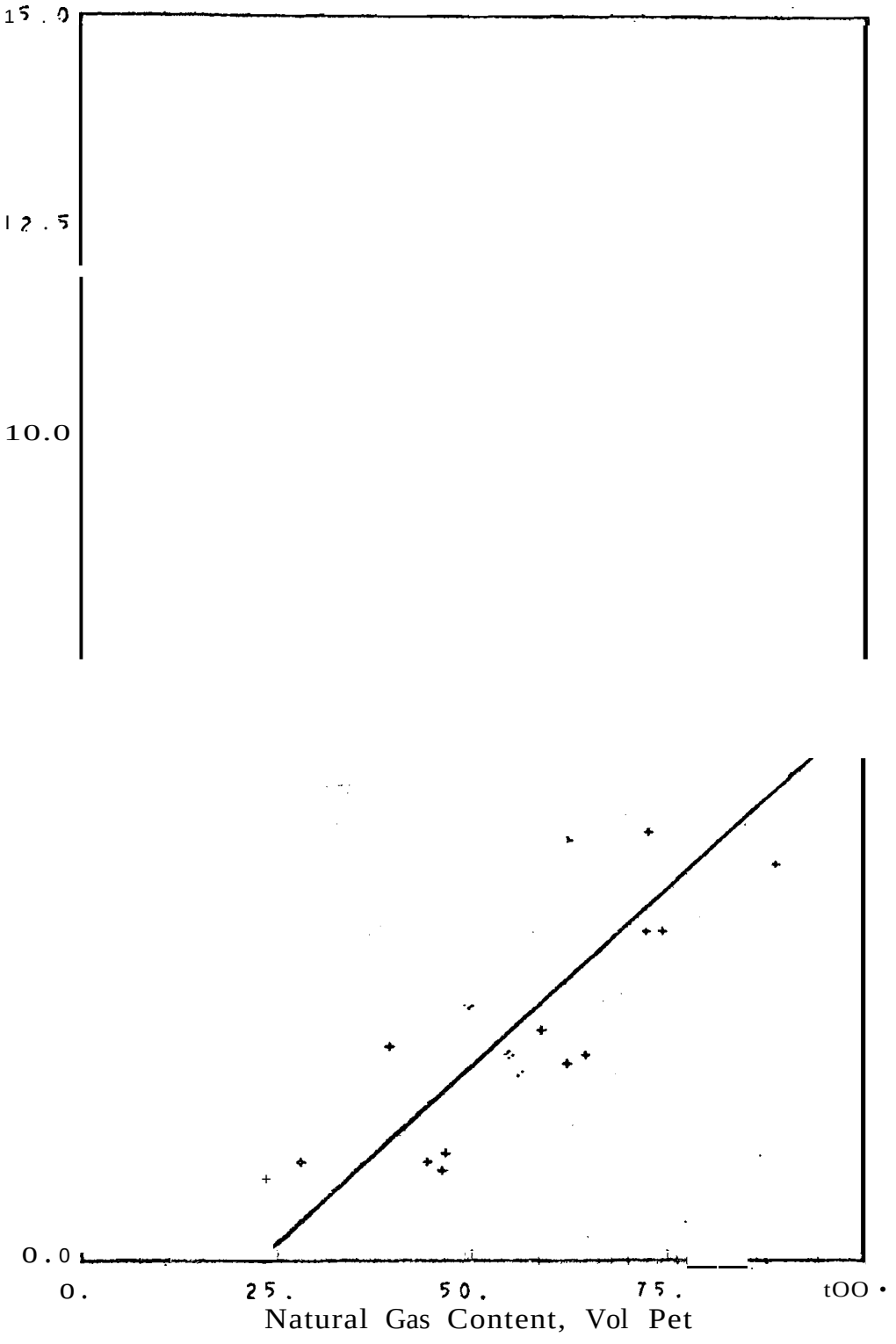


FIGURE 2.9 GAS CONTENT AS A FUNCTION OF CARBON CONTENT FOR WELL C-338

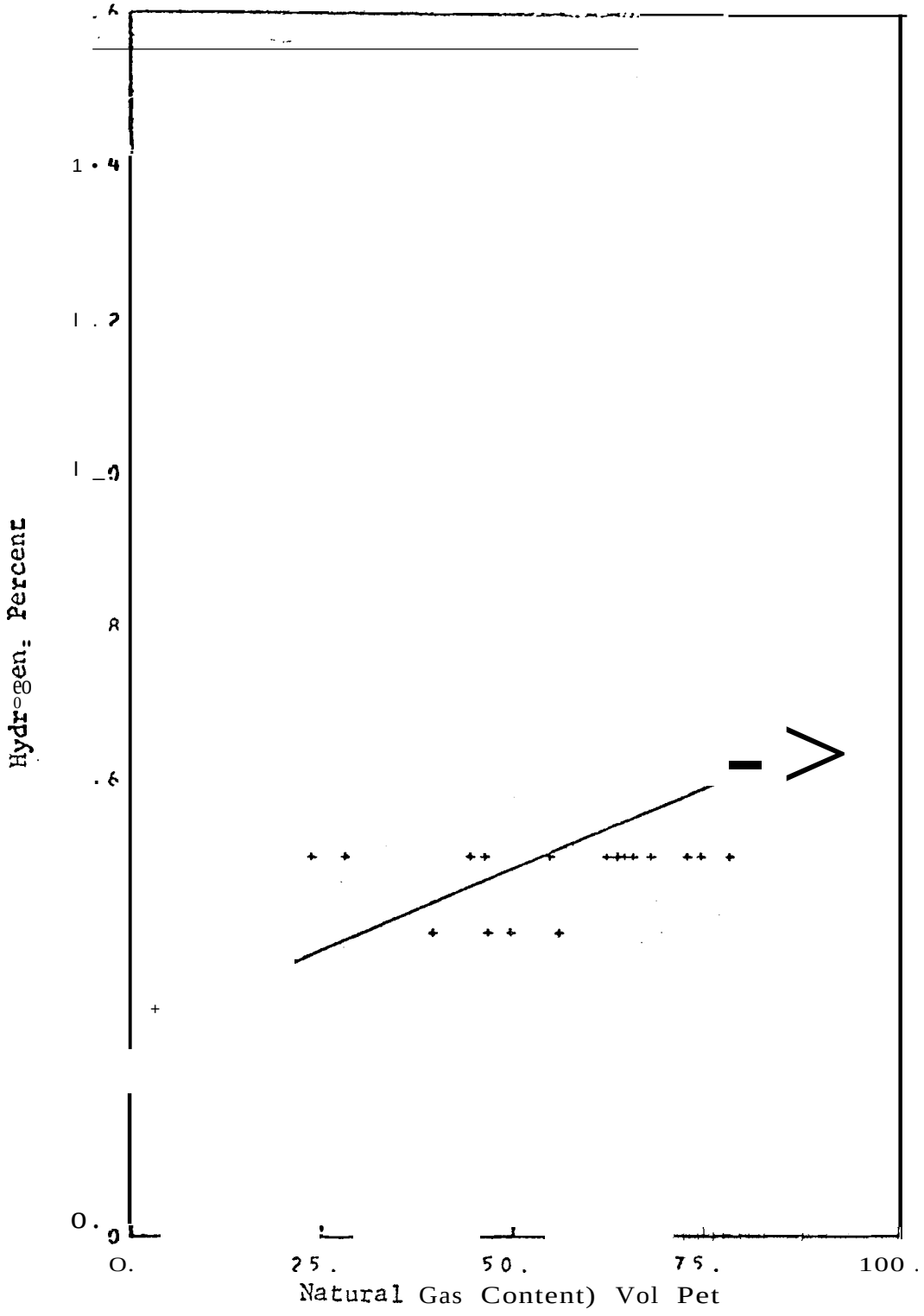


FIGURE 2.10 GAS CONTENT AS A FUNCTION OF HYDROGEN CONTENT FOR WELL C-388

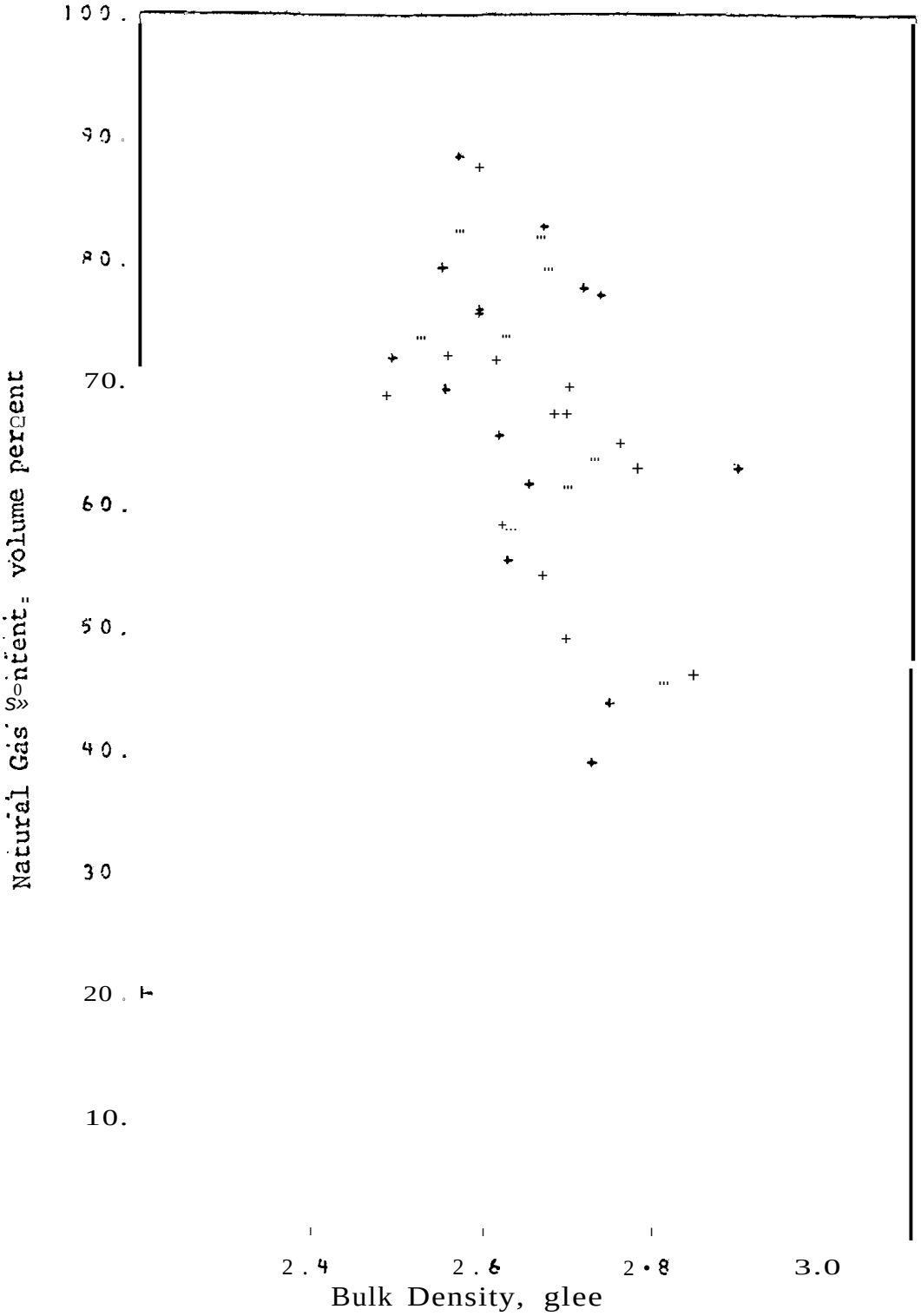


FIGURE 2.11 GAS CONTENT AS A FUNCTION OF BULK DENSITY FOR WELL C-338

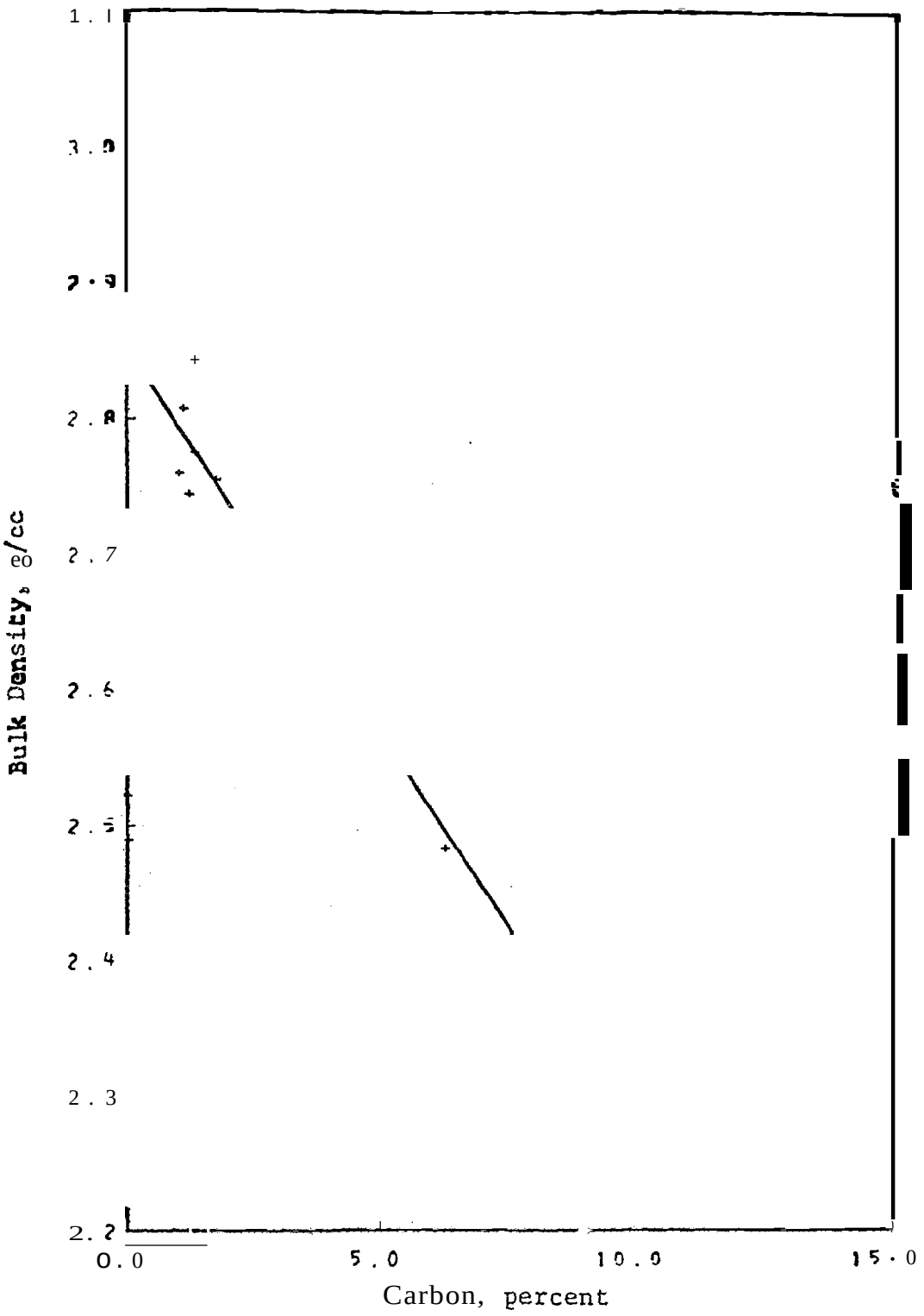


FIGURE 2.12 CARBON CONTENT AS A FUNCTION OF BULK DENSITY FOR WELL C-338

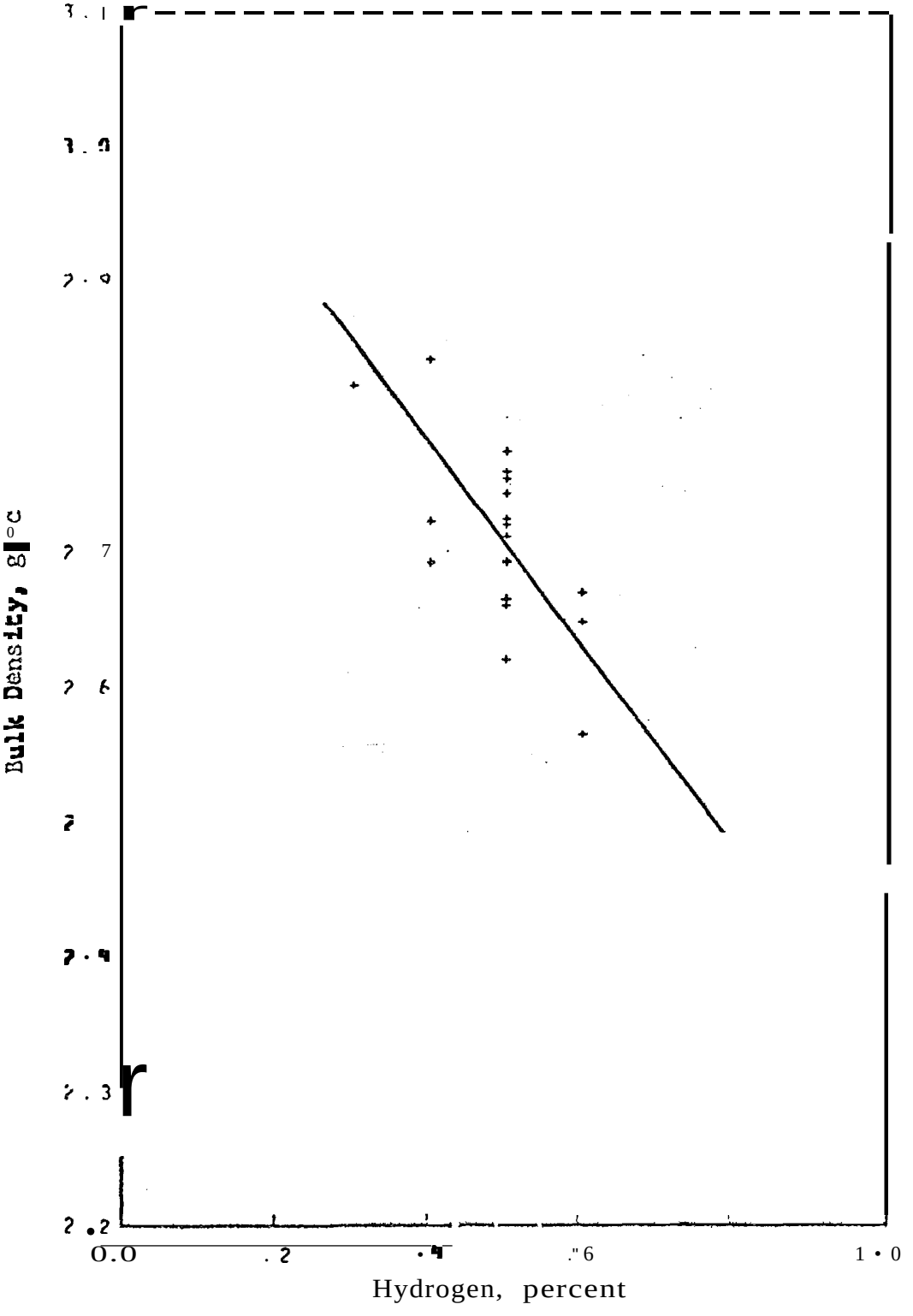


FIGURE 2.13 HYDROGEN CONTENT AS A FUNCTION OF BULK DENSITY FOR WELL C-338

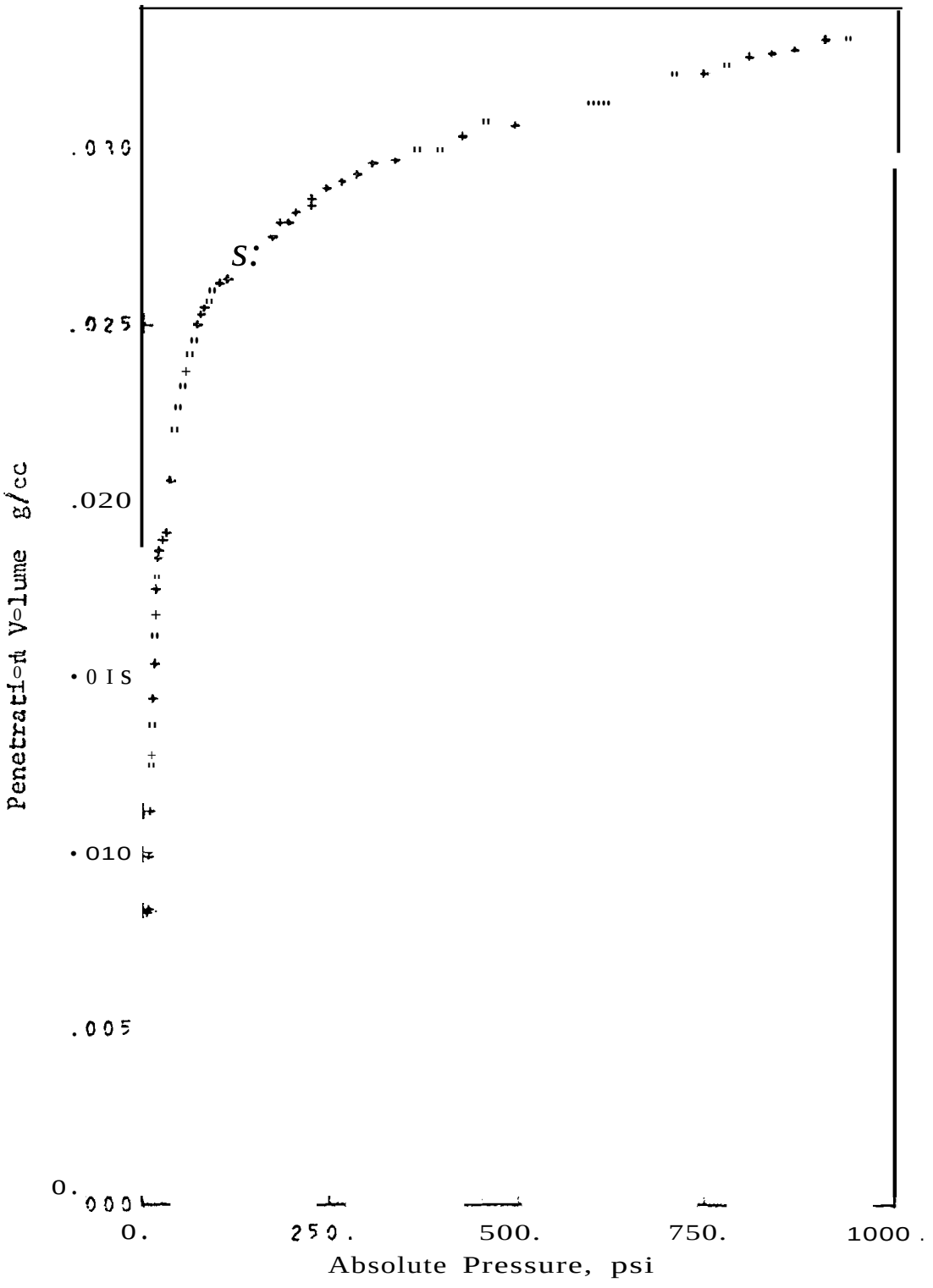


FIGURE 2.14 PORE VOLUME AS A FUNCTION OF PRESSURE
FOR WELL SAMPLE C-388-4872

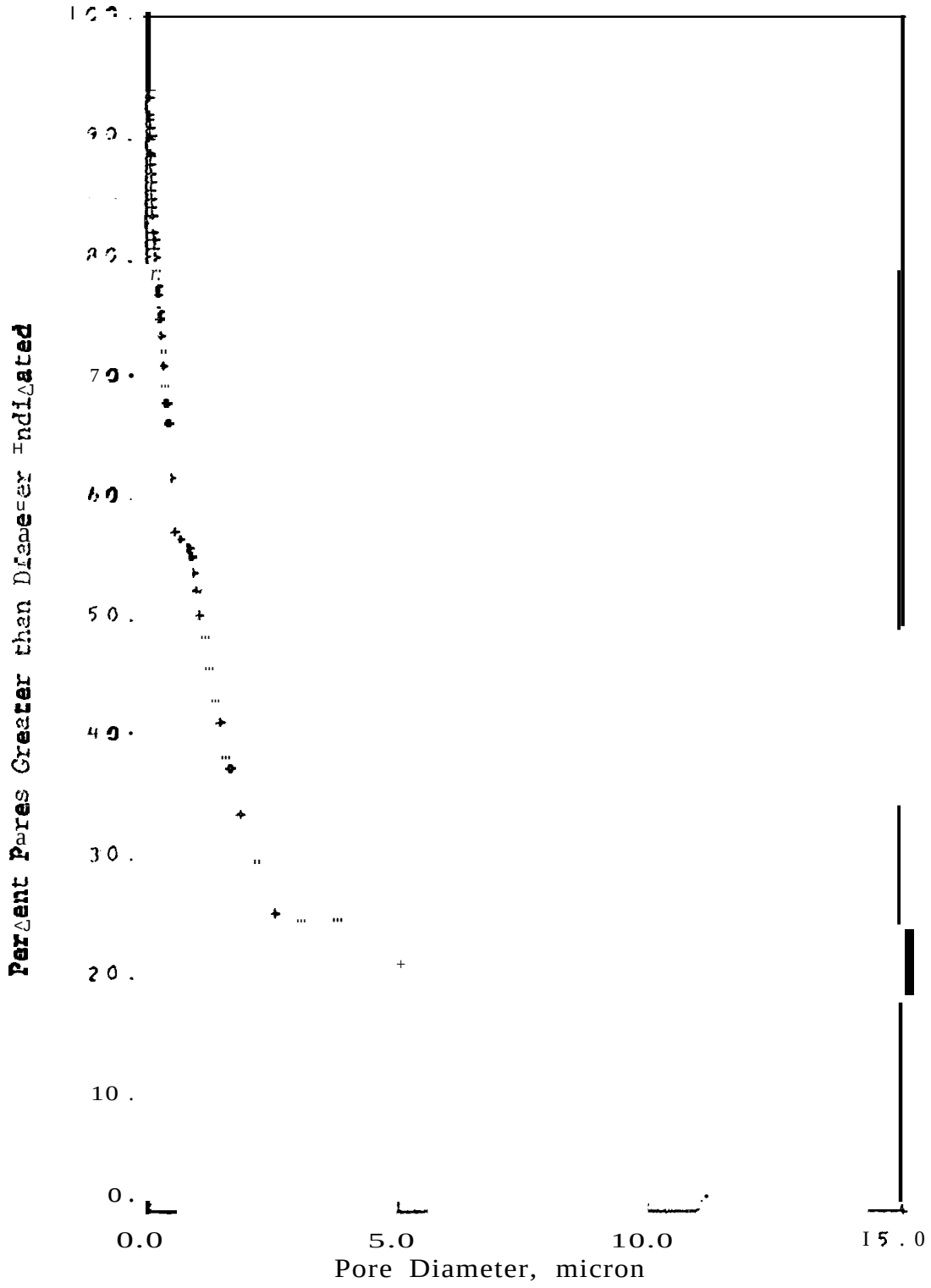


FIGURE 2.15 PORE SIZE DISTRIBUTION FOR SHALE SAMPLE C-388-4872·

APPENDIX C

CHEMICAL AND PHYSICAL ANALYSIS

BY

JUNIATA COLLEGE

This appendix includes the measurement of diffusion constants, isotherms, and specific degasibilities as determined by Juniata College. The depth of samples analyzed by Juniata College for the determination of these parameters, is shown in Table 3.1.

Helium and methane isotherms at 00C, nitrogen MET's at nOK, methane diffusion constants at 00C and N_2 diffusion constatns at 77^{0K} have been determined for samples from well #20338. These parameters were used to calculate specific degasibilities, helium densities, and amounts of non-gaseous methane residing in the samples. Data obtained are presented in Table 3.2-3.5.

The labelling system adopted for the extracted cores from well #20338 is given below:

COlGAS:	WV12	20338:5221
COlGAS:	WV9	20338:5421
COlGAS:	WV10	20338:4921
COlGAS:	WVll	20338:4971

List of Tables

Table		Page
3.1	Depth of the Core Sample From Wise County, VA	86
3.2	Diffusion and Isotherm Parameters	87-88
3.3	Composition of Gas in the Canister	89
3.4	Correction Factor Values for Various Diffusions	90
3.5	Minimum and Maximum Amount of Methane.	91
3.6	Isotherm	92-106

TABLE 3.1

Depth of the Core Samples from Wise County, VA
Well #20338

1. 4871.4' - 4871.52'
2. 4921.4' - 4921.70'
3. 4971.4' - 4971.68'
4. 5210.5' - 5210.65'
5. 5261.4' - 5261.57'
6. 5311.46' - 5311.62'
7. 5361.4' - 5361.8'
8. 5411.57' - 5411.8'
9. 5461.4' - 5461.7'

TABLE 3.2 DIFFUSION AND ISOTHERM PARAMETERS, Well #20338, Weis County, Virginia

Sample I.D.	PB	S_{He}	S_{CH_4}	BET	D_{N_2}	D_{CH_4}	G_{CH_4}	ρ_{He}	SCH4 (s)	Description
4871	2.57	0.621	12.7	1.13	6.41	5.25	5.19	2.70	12.0	
4921	2.57.	1.24	6.52	6.93	16.2	61.4	9.11	2.84	5.28	
4971	2.70	0.741	4.01	6.46	20.2	16.6	2.91	2.86	3.26	
5211	2.80	0.506	4.16	5.25	16.4	16.7	3.03	2.91	3.65	
5261	2.77	0.533	3.69	6.07	15.8	49.7	4.64	2.89	3.15	
5311	2.63	0.90	9.86	10.3	11.2	74.8	15.17	2.82	8.96	
5361	2.58	0.647	16.9	13.2	2.83	22.5	15.2	2.71	16.2	
5461	2.57	1.85	18.1	13.9	16.2	20.9	14.7	2.99	16.25	

Note: Definition scale factors for the column headings are included in Explanation of Column Headings, Table XIX, p. 88.

TABLE XIX. EXPLANATION OF COLUNN HEADINGS USED IN TABLE 3.2

Column 1	Sample"# -- Sample I.D.	
Column 2	PB -- Density of shale as measured by immersion in toluene *(g/cm^3)*	
Column 3,4	S	Initial Isotherm slope (vol$_{gas}$ sTP/volrockltorr x 10^{-7})
		STP -- 760 torr, 0^0 C. Measurements made at 0° C
		Column 3 -- Helium; Column 4 -- Methane
Column 5	BET	BET surface area expressed in units of vOl$_{gas}$ STP necessary t cover pore area with a monolayer of gas molecules.
Column 6,7	D -- diffusion constant (cm^2/sec x 10^{-7})	6 N_2 measured @ 77^0 K
		7 CH_4 measured @ 0° C
Column 8	Specific degassibility (cm$^3_{gas}$(STP)/cm^2/torr/sec$^{\frac{1}{2}}$ x 10^{-7})	
Column 9	density (g/cm^3). as obtained from He isotherm	
Column 10	$S_{CH_4(s)}$	that part of the isotherm slope for CH_4 that must be due to sorption (Volgas(STP)/Volrock/torr x 10^{-4})

Table 3.3 COMPOSITION OF GAS IN THE CANISTER

Sample #	Sample Wt. (g)	Can Pressure psi	% O_2	% N_2	% CH_4	% C_2H_6	% CO_2	V_{a_2}	V_{N_2}	V_{CH_4}	$V_{C_2H_6}$	V_{ca_2}	V_T
4921	1671,5	6,73	5,7	49,7	41,05	3.5	0	- .14	-.07	,677	.05	0	.519
4971	1270,1	.07	18.8	76.7	4.4	0	0	-.04	- .04	.08	0	0	0
5211	881.9	1.12	15.9	74.9	6.2	2.9	0	... 13	.05	,22	.10	0	.25
5261	878.6	.833	14,1	77.2	7.1	1.6	0	-.20	+,08	.Z4	.05	0	.19
5311.4	728.4	2.76	0.0	61.27	27.8	5.9	4.9	-.82	-.24	1.Z8	.27	.22	.73
,5411	1256.9	1. 78	13.83	70.9	13.7	1.6	0	-,108	,01	.302	.03	0	,24

Table 3.4 CORRECTION FACTOR VALUES FOR VARiOUS DIFFUSiONS

(Core diameter=lO em)

t (hrs)	D ee 10^{-5} em^2/see	2 x 10^{-6} em^2/see	5 x 10^{-7} em^2 {see
.1	1.03	1.01	1.01
.S	1.06	1.03	1.01
1.0	1.09	1.04	1.02
2.0	1.13	1.06	1.03
3.0	1.17	1.07	1.04
5.0	1.23	1.09	
12.0		1.15	1.07

Table 3.5 MINIMUM AND MAXIMUM AMOUNTS OF METHANE

Sample #	VCR_4	$V^M_{CH_4}$	$V^M_{CH_4}$ (t; = 0)
4921	.677	.737	1.11
4971	.08	.08	.10
5211	.22	.22	.27
5261	.24	.24	.29
5311	1.28	1.39	1.70
5411	.30	.30	.37

Date 10/31/19

Sample ID COLGAS:WV9

Gas Methane

Initials : PDS

Book 3

Page : 19

SAMPLE DATA

Weight : 4.8775 (grams)

Density : 2.5415 (gm/cc)

Sample Temp : 0 (cent)

Particle Size .085 Ccm)

DATA COLLECTED

SLOPE OF ISOTHERN

1.86339E-03 Vol Gas/Vol Rock/Torr
9.63651E-02 Vol Gas/Vol rock/PSI
1.41618 Vol Gas/Vol Rock/ATM
3.27105E-08 Moles Gas/Gram Rock/Torr

UNCERTAINTY .112933 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS COS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
217.977	8.88933E-06	.314963	1	0
501.362	1.75839E-05	.225758	1	0
800.199	2.51346E-05	.19394	1	0
879.083	2.68915E-05	.209621	1	0

Date 10/31/197

Sample 10 COLGAS:WV9

Gas : Helium

Tn//iels PDS

Book

Page 19

SAMPLE DATA

Weight 4.8775 Cgrams)

Density : 2.5415 (gm/cc)

Sample Temp : 0 (cent)

Porticle Size .085 Ccm)

DATA COLLECTED

SLOPE OF ISOTHERM

5.62616£-05 Vol Gas/Vol Rock/Torr
2.90956E-03 Vol Gas/Vol rock/PSI
4:27588£-02 Vol Gas/Vol Rock/ATM
9.87631E-10 Moles Gas/Gram RockrTorr

UNCERTAINTY : 3.56746 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Mo1es/Cret«	UNCERTAINTY %	FLAG	FLAG Persteeler
0	0	e	O	0
245.462	2.2/541£-01	12.6208	1	e
536.248	4.63656E-07	8.54292	1	0
824.677	8.68836E-07	5.59295	1	0
«e«.731	9.25021E-07	6.07184	1	0

FILE# 23 - 2 : 26

DIFFUSION

Date 10/31/1978

Sample ID COLGAS:WV9

Gas Nitrogen

Initials PDS

Book : 3

Page 19

SAMPLE DATA

Weight : 4.8775 Cerems)

Density : 2.5415 (gm/cc)

Sample Temp : -196 (cent)

Particle Size : .085 (cm)

DATA COLLECTED

P initial : 155.989

P equilibrium : 44.7548

PO: 22.5111

SPECIFIC DEGASIBILTV 6.20013E-06

UNCERTAINTY 2.55091E-02 %

System d Moles/ dP 8.26387E-06

Date 10/31/19

Sample 10 COLGAS:WV9

Gas Methane

Initials PDS

Book :

Page : 19

SAMPLE DATA

Weight 4.8775 (grams)

Density : 2.5415 (gm/cc)

Sample Temp; 0 (cent.)

Particle Size .085 (cm)

DATA COLLECTED

P inilia1 : 878.689

P equilibrium 230.626

P o 196.855

SPECIFIC DEGASIBILtv 8.89194E-07

UNCERTAINTY 4.73307E-02 %

System d Moles/ dP 2.00903E-06

FILE# 23 - 2 26

BET

Date 10/31/1978

Sample 10 COLGAS:WV9

Gas: Nitrogen

Lniliels PDS

Book 3

Page 19

SAMPLE DATA

Weight 4.8775 (grams)

Density : 2,5415 (gm/cc)

Sample Temp : 0 (cent)

Particle Size .085 Ccm)

.: DATA COLLECTED

INTERNRL AREA

2.5645E-04	Moles/Gram
1.00905E-04	Moles/ml.
14.5996	ml. gas/ml. rock
24.4013	Specific Area (sq.meters/gram)

UNCERTAINTY .043377

288.63

UNCERTAINTY IN C: 4.34048E-02

BAROMETRIC PRESSURE 747 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTHINTY %	FLAG	FLAG Parameter
0	0	0	0	0
.761906	6.31319E-05	.204857	1	0
14.2349	1.95634£-04	9.34972E-02	1	0
85.3896	2.91497E-04	7.68584£-02	1	0
168.916	3.37017E-04	7.67694E-02	1	0
230.72	3.65584E-04	7.91318E-02	1	0

ISOTHERN

Date 11/ 3/1978

t

Sample ID COLGAS:WV10

Gas Methane

Initials POS

Book : 3

Page 20

SAMPLE DATA

Weight 5.44299 (grams)

Density : 2.5658 (gm/cc)

Sample Temp : 0 Ccont)

Perticle Size .085 Ccm)

oot» COLLECTED

SLOPE OF ISOTHERH

6.33353E-04 (.101 Gas/Vol Rock/Torr
3.27538E-02 Vol Gas/Vol rock/PSI
.481348 Vol Gas/Vol Rock/ATM
1.10128E-08 Moles Gas/Gram Rock/Torr

UNCERTAINTY : .293758 %

DETAILED DATA 4 POINTS TAKEN

PRES8URE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	e
232.569	3.00867E-06	.833357	1	e
521.764	5.95945E-06	.596552	1	e
814.256	8.70219E-06	.501645	1	0
883.258	9.32205E-06	.541517	1	e

ISOTHERI1

Date 11/ 3/19

Sample ID COLGAS:WV1e

Gas Helium

Initials PDS

Book

Page 20

SAMPLE DATA

Weight 5.44299 (grams)

Density : 2.5658 (gm/cc)

Sample Temp: 0 (cent)

Particle Size .085 Ccte)

DATA COLLECTED

SLOPE OF ISOTHERM

5.13677E-05 Vol Gas/Vol Rock/Torr
2.65648E-03 Vol Gas/Vol rock/PSI
3.90394E-02 Vol Gas·,'·Vol Rock/ATM .
8.93182E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 3.53464 %

DETAILED DATA 4 POINTS TAKEN

PPESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
	0	0	0	0
243.775	2.31206E-07	10.828	1	0
532.574	4.27762E-07	8.29092	1	0
826.852	7.67705E-07	5.66759	1	0
902.219	8.1232E-07	6.19103	2	.167743

Date 11/ 3/197

Sample ID COLGAS:WV10

Gas Nitrogen

Lniliels PUS

Book 3

Page 20

SAMPLE DATA

Weight 5.44299 Ceretas)

Density : 2.5658 (gm/cc)

Sample Temp : -196 (cent)

Particle Size .085 (cm)

DATA COLLECTED

P initial : 235.668

P equilibrium 49.2476

P_0 30.6183

SPECIFIC DEGASIBILTY 4.48219£-86

UNCERTAINTY 3.14028E-02 %

System d Moles/ dP 8.26891£-06

DIFFUSION

Date 11/ 3/1978

Sample 10 : COLGAS:WV10

Gas : Methane

Initials PDS

Book

Page 20

SAMPLE DATA

Weight 5.44299 (grams)

Density : 2.5658 (gm/cc)

Sample Temp : 0 (cent)

Particle Size .085 Ccm)

DATA COLLECTED

P initial : 883.174

P equilibrium 204.705

P_0 190.948

SPECIFIC DEGASIBILTY 4.23889E-07

UNCERTAINTY .144476

System d Moles/ dP 2.00156E-06

BET

Date 11/ 3/1978

Sample 10 COLGAS:WV10

Gas Nitrogen

Initials PDS

Book 3

Page : 20

SAMPLE DATA

Weight 5.44299 (grams)

Density : 2.5658 (gm/cc)

Sample Temp: 0 Ccenl)

Particle Size .085 (cm)

DATA COLLECTED

INTERNAL AREA

9.93724E-05	Moles/Gram
3.87296E-05	Moles/ml.
5.71132	ml. gas/ml. rock
9.45529	Specific Area (sq.meters/gram)

UNCERTAINTY 9.72568E-02 %

C 120.588

UNCERTAINTY IN C : .103064 %

BAROMETRIC PRESSURE 746.897 mm Hg

DETAILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	e	e	0	0
5.70791	4.87863E-05	.237505	1	0
65.5483	9.43883E-05	.173625	1	0
132.548	1.16795E-04	.171868	1	0
187.489	1.32434E-04	.175037	1	0
239.9:39	1.47084E-04	.176222	1	0

ISOTHERN

Date 11/ 4/1

Sample ID COLGAS:WV11

Gas Methane

Initials PDS

Book : 3

Page : 21

SAMPLE DATA

Weight 6.63531 (grams)

Density : 2.69472 (gm/cc)

Sample Temp: 0 (cent)

Particle Size .085 Cctn)

DATA COLLECTED

SLOPE OF ISOTHERM

3.48611£-04 Vol Gas/Vol Rock/Torr
1.80284E-02 Vol Gas/Vol rock/PSI
.264945 Vol Gas/Vol Rock/ATM
5.77166E-09 Moles Gas/Gram Rock/Torr

UNCERTAINTY .473005 %

DETIHLED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UHCERTAINtv %	FLAG	FLAG Parameter
	0	0	e	e
224.753	1.40376E-06	1.4804	1	0
508.914	'2.97286£-06	.991117	1	0
799.399	4.56141E-06	.793143		.117144
875.753	4.96606E-06	.842428	1	e

Date 11/4/197

Sample ID COLGAS:WU11

Gas Helium

Initials PDS

Book 3

Page 21

SAMPLE DATA

Weight 6.63531 Cereos)

Density : 2.69472 (gm/cc)

Sample Temp : 0 (cent)

Particle Size .085 (cm)

oet» COLLECTED

SLOPE OF ISOTHERN

4.53138E-05 Vol Gas/IJol RockrTorr
2.3434E-03 Vol Gas/Vol rock/PSI
3.44385E-02 Vo1 Gas/Vol Rock/ATM
7.50222E-10 Moles Gas/Gram Rock/Torr

UNCERTAINTY : 3.58122 %

DETAILED DATA 4 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY	FLAG	rt.ac Peremeter
0	e	e	0	e
230 508	1.53096E-07	13.5531	1	0
51.64	3.3286E-07	8.83036	1	0
806 074	6.37508E-07	5.65615	1	0
889.613	7 1039E-07	5.86676	1	0

DIFFUSION

Date 11/ 4/15

Sample 10 COLGAS:WV11

Gas : Nitrogen

Initials PDS

Book 3

Page : 21

SAMPLE DATA

Weight : 6.63531 (grams)

Density : 2.69472 (gm/cc)

Sample Temp: -196 (cent)

Particle Size .085 Cctn)

DATA COLLECTED

P initial : -1.44402

P esuilibriuo -811.03

P_0 -902.145

SPECIFIC D£GASIBILTY 8.67988E-06

UNCERTAINTY 9.28677E-02

System d Moles/ dP 8.53016E-06

DIFFUSION

Date 11/ 4/15

Sample ID COLGAS:WV11

Gas Methane

Initials PDS

Book

Page 21

SAMPLE DATA

Weight 6.63531 (grams)

Density : 2.69472 (gm/cc)

Sample Temp: 0 Ccent)

Particle Size .085 (em.>

DATA COLLECTED

P initial : 874.91

P equilibrium 23:.482

P_0 226.146

SPECIFIC DEGRSISILTY 3.29341E-07

UNCERTAINTY .770817

System d Moles/ dP 2.11011E-06

BET

Date 11/ 4/197

Sample ID COLGAS:WV11

Gas Nitrogen

Initials PDS

Book

Page 21

SAMPLE DATA

Weight 6.63531 (grams)

Density : 2.69472 (gm/cc)

Sample Temp : 0 (cent)

Particle Size .085 (cm.>

DATA COLLECTED

INTERNRL AREA

1.01209E-04	Moles/Gram
3.75584E-05	Moles/ml.
6.10917	ml. gas/ml. rock
9.63007	Specific Area (sq.meters/gram)

UNCERTRINTY 6.99016E-02 %

C 767.257

UNCERTAINTY IN C : .069959 %

BAROMETRIC PRESSURE 744.71 mm Hg

DETHILED DATA 5 POINTS TAKEN

PRESSURE Torr	ADS GAS Moles/Gram	UNCERTAINTY %	FLAG	FLAG Parameter
0	0	0	0	0
.789832	4.56838E-05	.208277	1	0
51.9437	9.7889E-05	.137476	1	0
125.625	1.21212E-04	.135989	1	e
183.15	1.37993E-04	.137944	1	0
235.767	1.53521E-04	.13864	1	0

APPENDIX D

CHEMICAL, PHYSICAL AND MECHANICAL TESTS AND ANALYSIS

BY

MOUND FACILITY

This appendix gives the analysis of cores from a series of wells including #20338 labeled as VA-l. A total of thirty-two samples were analyzed and the results obtained are presented in tabular or graphical form. The section includs the measurement of kerogen, clay, and gases as determined by Mound Facility from the samples. In addition to the chemical, physical and mechanical properties of Devonian Shale, Mound Facility also described the utility of organic, geochemical data in relation to the basin geology, environments of deposition and source provinces. Details of their work have been reported elsewhere.* The list of figures and tables describes the various analysis performed on the core samples.

*Mounds Laboratory Interpretation: Organic Chemical Data Eastern Gas Shales Project, MLM-MERC-EGSP (78).

List of Tables

Tables		Page
4.1	Shale Samples from the VA-l, Wise County, VA	.111
4.2	Mass Spectrometric Results for the Wise County, VA Well.	.112-113
4.3	Clay Content - Well VA-1 (20338)	.114-115
4.4	Delta C or Organic Carbon in Whole Rock	.118
4.5	C_{1}-C_{7} Hydrocarbon Analyses of Head Space.	.119
4.6	Cl-C7 Hydrocarbon Analyses of Shale Core.	.120
4.7	C_{1}-C_{7} Hydrocarbon Analysis of Air Space and Shale Core	.121
4.8	Detailed C4-C7 Hydrocarbon Analysis.	.122-123
4.9	Gross Lithological Description and Organic Carbon Analysis	.125-126
4.10	Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography (A).	.129
4.11	Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography (B)	.130
4.12	Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography (C)	.131
4.13	Saturate Hydrocarbon Analyses, Paraffin-Naphthene Distribution	.132
4.14	Saturate Hydrocarbon Analyses, Normalized Paraffin Distribution	.133
4.15	Vitrinite Reflectance Summary for VA-l Well (20338).	.134
4.16	Kerogen Composition Sample From VA-l (20338)	.135
4.17	Material Balance Assay, Product Assay	.136
4.18	Material Balance Assay Carbon and Ash Data	.137
4.19	Material Balance Assay Gaseous Yield for VA-l (20338).	.138
4.20	Mechanical Test Data for the VA-l, Well	.144

List of Figures

Figures		Page
4.1.	A plot of 10Å peak height *vs*, percent organic carbon	116
4.2.	Clay mineralogy results in percent..	117
4.3.	Organic carbon data for care samples..	124
4.4.	C_{1-C_7} hydrocarbon data for core samples..	127
4.5.	C_{15}+ extract data for core samples	128
4.6	Material balance assay oil yield, gal/ton.	139
4.7.	Present organic carbon	140
4.8.	Material balance assay hydrocarbon gas yield, cm^3/g.	141-142
4.9.	Expansion as a function of fluid exposure.	143
4.10.	Gas spectrum for sample VA-l-1A.	145
4.11.	Gas spectrum for sample VA-1-5	146
4.12.	Gas spectrum for sample VA-1-9	147
4.13.	Gas spectrum for sample VA-1-14.	148
4.14.	Gas spectrum for sample VA-1-16A	149
4.15.	Gas spectrum for sample VA-1-28B	150
4.16.	Gas spectrum for sample VA-1-31A	151

TABLE 4. 1

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

Mound Sample No.	MERC Sample No.	Depth, Ft.
VA-I-I	C-33J-4885-A	-4885.13/.40
VA-1-2	C-338-4885-B	4885.40/.75
VA-I-3	C-338-491S-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-l.945-B*	4945.43/.77
VA-I-7	C-338-4969-A	4969.20/,35
VA-I-8	C-338-1.969-B	4969.35/.50
VA-1-9	C-338-4969-C	4969.50/.70
VA-I-IO	C-338-4975-A	4975.10/.32
VA-I-II	C-338-4975-B	4975.32/.54
VA-I-12	C-338-5229-A	5229.20/.35
VA-1-13	C-338-5229-B	5229.35/.65
VA-I-14	C-338-5259-A	5259.10/.25
VA-1-15	C-338-5259-B	5259.25/.65
VA-1-16	C-3J8-5289-A	5289.10/.46
VA-l-17	C-338-5289-B	5289.46/.60
VA-l-18	C-338-5319-A	5319.37/.56-
VA-l-I9	C-338-5319-B	5319.56/.70
VA-1-20	C-338-5348-A	5348.30/.62
VA-I-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-I-26	C-338-5393-C	5393.65/.90
VA-I-27	C-338-5409-A	5409.07/.37
VA-1-28	C-338-5409-B	5409.37/.55
VA-I-29	C-338-5439-A	5439.15/.40
VA-I-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 4.2(Cont'a.:

Mass Spectrometric Results for the
Wise County, Virginia, Samples

Components (Mole %)	VA-1-14	VA-1-16	VA-1-19	VA-1-23	VA-1-24*	VA-1-28	VA-1-30	VA-1-31
Methane	32.63	56.70	15.15	63.33	5.40	12.57	42.35	74.68
2-H_2	0.17	0.10	0.00	0.16	75.99	0.00	0.07	0.28
4-He	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18-H_2O	0.08	0.13	0.19	0.41	0.81	0.46	0.20	0.08
26-C_2H_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29-CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
28-N_2	58.85	37.33	64.83	29.45	17.03	70.72	48.91	20.10
28-C_2H_4	1.17	1.14	0.23	1.76	n.21	0.21	1.00	1.59
30-C_2H_6	1.07	loll	0.26	1.73	0.21	0.22	0.97	1.54
32-O_2	2.41	1.35	17.70	1.25	0.07	13.26	3.53	0.98
40-Ar	0.65	0.38	0.89	0.27	0.21	0.84	0.54	0.16
44-CO_2	2.73	1.58	0.69	1.42	0.04	1.60	2.25	0.46
45-CO:	0.04	0.03	0.02	0.02	0.00	0.03	0.03	0.00
46-CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
47-$C0_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
44-C_3H_8	0.21	0.14	0.01+	0.19	0.03	'0.07	0.12	0.14
Gas Pressure (atm)	2.738	4.420	2.218	1.943	1.281	2.018	2.780	2.092
O_2/N_2 Ratio	0.041	0.036	0.273	0.042	0.004	0.188	0.072	0.0/.9
Ar/N_2 Ratio	c.on	0.010	0.014	0.009	0.012	0.012	c.on	0.008
Time in Can (Days)	114	113	113	132	40	131	III	132

*Stored in Water.

TABLE 4.3

Clay Content .. Well VA-1

Mound Sample No.	VA-1-2	VA-1-4	VA-1-6	VA-1-l1	VA-l..13	VA-1-15	VA-l-li
Depth	4885'	4915'	4945'	4975'	5229'	5259'	5289'
Crystallinity	2.2	1.7	2.3	1.8	2.0	2.3·	2.0
Sharpness Ratio	3.2	3.7	2.9	3.6	3.1	2.6	. 3.3
lOÅ Peak Height	.38	60	109	112	108	85	112

TABLE 4.3 (Cont'd.)

Clay Content - Well VA-1

Mound Sample No.	VA-1-18	VA-1-21	VA-1-22	VA-1-25	VA-1-26	VA-1-27	VA-1-29	VA-1-32
Depth	5319'	5348'	5379'	5393'	5393'	5408'	5439'	5469'
Percent Distribution								
Montmorillonite								
Illite	76	73	75	79	83	79	76	85
Mixed-Layer	14	19	18	13	10	11	16	7
Kaolinite	0	a	0	0	0	0	0	0
Chlorite	10	8	7	8	7	10	8	8
Crystallinity	1.9	1.5	1.7	1.7	1.7	1.3	1.3	1.9
Sharpness Ratio	4.3	4.0	4.1	4.0	4.6	5.2	5.3	6.3
10Å Peak Height	104	86	54	98	55	119	55	88

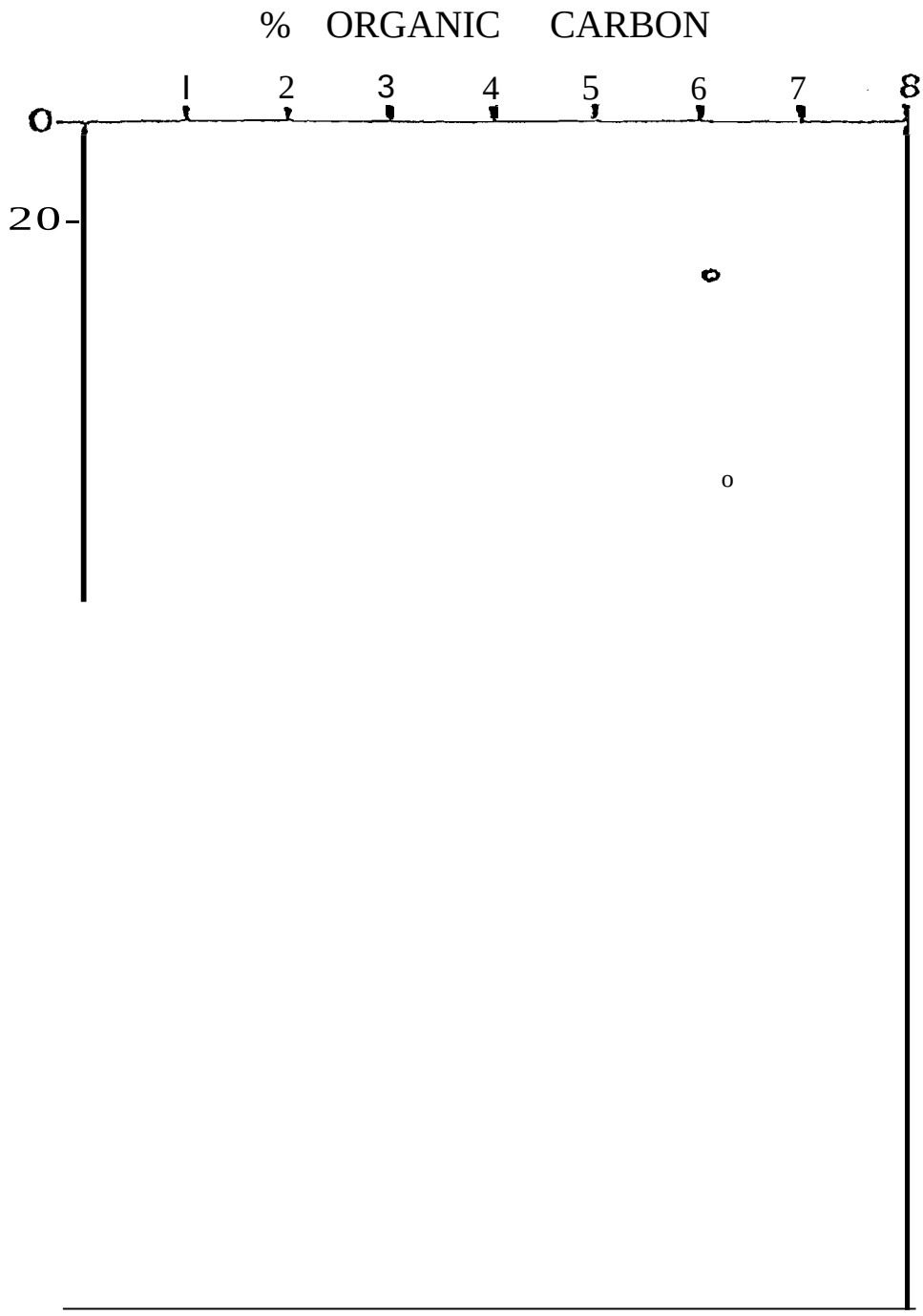
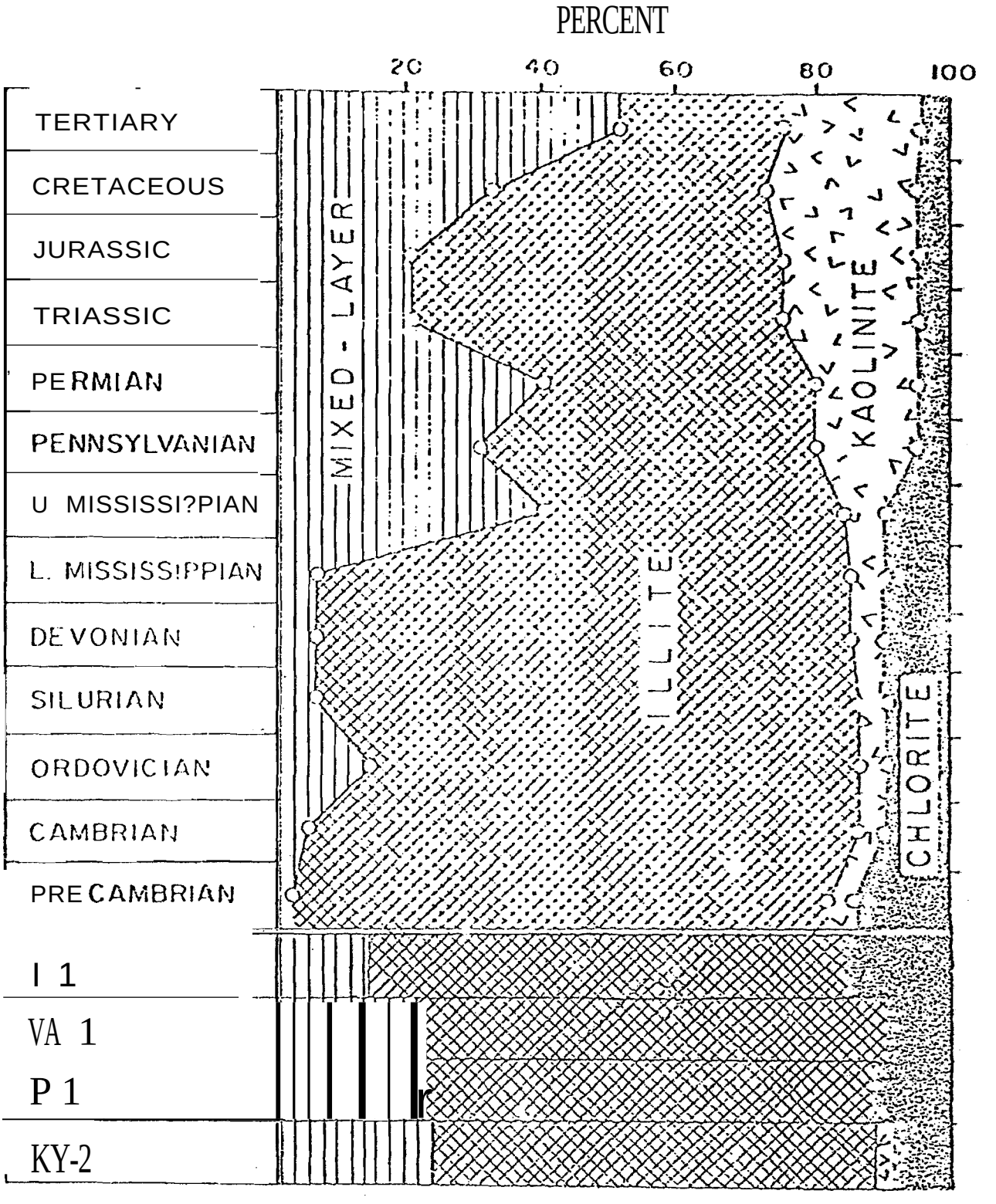


FIGURE 4.1

Figure 4..1is 'a plot of 10Å peak height vs. percent organic carbon for all samples. As expected. there is a good inverse linear relation for most samples. At this time. there is no apparent reason why five samples falloff the trend.



CLAY MINERALOGY RESULTS

FIGURE 4.2

* Organic Matter Type

Marine	Al = Algal
Marine	Am = Amorphous
Restricted Marine	H = Herbaceous
Nonmarine	W = Woody
Nonmarine	C = Coaly (Inertinite)

TABLE 4.5

C_1-C_7 Hydrocarbon Analyses of Head Space

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_1-C_4 PPM	Gas Wetness %	iC_4/nC_4
VA-1-2	4885.4-4885.75	1510422	232494	22275	1307	1659	38	1768157	257735	14.6	0.8
VA-1-4	4915.37-4915.68	1300687	158568	15943	967	1457	230	1477622	176935	12.0	0.7
VA-1-6	4945.43-4945.77	173739	13202	1241	57	74	9	188313	14574	7.7	0.8
VA-1-11	4975.32-4975.54	89903	7379	764	0	46	2	93092	8189	8.3	
VA-1-13	5229.35-5229.65	461123	33630	3207	215	196	6	498371	37248	7.5	1.1
VA-1-15	5259.25-5259.65	1020409	118567	8733	536	567	45	1148812	128403	11.2	0.9
VA-1-17	5289.46-5289.60	1340801	144916	14078	931	1084	0	1501810	161009	11.7	0.9
VA-1-18	5319.37-5319.56	2071391	184858	14524	759	780	1	2272312	200921	8.8	1.0
VA-1-21	5348.62-5348.80	2975296	311270	23719	953	1579	0	3312817	337521	10.2	0.6
VA-1-22	5379.08-5379.33	2326394	385470	22917	849	938	0	2736568	410174	15.0	0.9
VA-1-25*	5393.50-5393.65	27667	5858	634	32	39	4	34230	6563	19.2	0.8
VA-1-26	5393.65-5393.90	2331226	285052	20182	1011	1105	139	2638576	307350	11.6	0.9
VA-1-27	5408.07-5408.37	270384	15364	1082	38	41	0	286909	16525	5.8	0.9
VA-1-29	5439.15-5439.40	3357290	429227	23903	825	728	0	3811973	454683	11.9	1.1
VA-1-32	5469.53-5469.80	1543196	132697	8036	283	253	0	1684465	141269	8.4	1.1

ppm values expressed as volumes of gas per million volumes of core material.

*Sample stored in water.

TABLE 4.6

Cl-C, Hydrocarbon Analyses of Shale Core

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_1-C_3 PPM	Total C_1-C_4 PPM	Total C_2-C_4 PPM	Wetness %	iC_4/nC_4
VA-1-2	4885.4-4885.75	24098	56992	16642	1395	1261	153	100541	76443	76.0	1.1
V/I-1-4	4915.37-4915.68	22432	53735	17496	1606	1510	309	97088	74656	76.9	1.1
VA-1-6	4945.43-4945.77	2236	2116	1215	145	222	50	6084	3748	61.6	0.7
VA-1-11	4975.32-4975.54	2512	2681	1429	188	244	147	7211	4689	65.1	0.8
VX-1-1	5229.35-5229.65	6078	2043	1236	205	221	99	9882	3804	38.5	0.9
VA-1-15	5259.25-5259.65	6837	19982	6524	682	501	110	34636	27799	80.3	1.4
V,\-1-17	5289.16-5289.60	9718	18006	6302	573	447	81	35127	25409	72.3	1.3
VA-1-18	5319.37-5319.56	25921	34495	6946	531	416	38	68347	42426	62.1	1.3
VA-1-21	5348.62-5348.80	21432	104047	12607	670	563	60	139379	117947	84.6	1.2
VA-1-22	5379.08-5379.33	21786	63268	10288	567	502	18	96429	74643	77.4	1.1
VA-1-25*	5393.50-5393.65	30444	39621	6627	375	330	15	77412	46968	60.7	1.1
VII-1-26	5393.65-5393.90	54265	72874	9561	512	438	100	137750	83485	60.6	1.2
VA-1-27	5408.07-5408.37	3276	2973	1700	164	179		8292	5016	60.5	0.9
VA-1-29	5419.15-5439.40	38925	72813	9017	461	405	44	121665	82740	63.0	1.1
VA-1-32	5469.53-5469.80	75349	62091	8712	487	432	49	147120	71771	48.8	1.1

ppm values expressed as volumes of gas per million volumes of core material.

*Sample stored in water.

TABLE 4.7

C1-C, Hydrocarbon Analyses of Air Space and Shale Core

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_2-C_4 PPM	Total C_1-C_4 PPM	Total C_2-C_4 PPM	Gas Wetness %	iC_4/nC_4
VA-1-2	4885,f1.118SS.7S	1534520	,2S91.86	38917	2702	2920	191	1868736	334216	17.9	0.9
VA-1-4	4915.37-4915.68	1323119	212303	33439	2573	2967	539	1574940	251821	16.0	0.9
VA-1-6	4945.43-4945.77	175975	15318	2456	202	296	59	194306	18431	9.5	0.7
VA-1-11	4975.32-4975.54	92415	10060	2193	tss	290	149	105295	12880	12.2	0.7
VA-1-13	5229.35-5229.65	467201	35673	4443	420	417	105	508259	41058	8.1	1.0
VA-1-15	5259.25-5259.65	1027246	138549	15257	1218	1068	155	1183493	156247	13.2	1.2
VA-l-17	5289.46-5289.60	1350519	162922	rmso	1504	1531	81	1536937	186418	12.1	1.0
VA-1-18	5319.37-5319.56	2097312	219353	21',70	1290	1196	39	2340660	243338	10.4	1.1
VA-1-21	5348.62-5348.80	2996728	415317	36326	1623	2142	60	3452196	455468	13.2	0.8
VA-1-22	5379.08-5379.33	2348180	448738	33205	1416	1440	18	2832997	484817	17.1	1.0
V,\-l- 25*	5393.50-5393.65	58111	45479	7261	407	369	19	111646	53535	48.0	1.1
VA-1-26	5393.65-5393.90	2385491	357926	29743	1523	1543	2J9	2776465	390974	14.1	1.0
VA-1-27	sl,08.07-sl.QS.37	273660	18337	2782	202	220	0	295201	21542	7.3	0.9
VA-1-29	5'"39.15-54)9.40	3396215	502040	32920	1286	1133	44	3933638	537423	'13.7	1.1
VA-l-32	5469.53-5469.80	1618545	194788	16748	770	685	49	1831585	213089	11.6	1.1

ppm values expressed as volumes of gas per million volumes of core material.

*Sample stored in water.

TABLE ."4.8

Detailed C_4-C_7 Hydrocarbon Analyses

Mound Sample No.:	VA..1-2	VA-1-4	VA-1-6	VA-1-11	y"A-1-13	VA-1-15	VA-1-17
Isobutanc	33.3	26.5	13,7	12.9	19.1	34.8	32.6
n-Butane	40.1	32.9	30.2	33.9	29.7	36.8	35.8
Isopentane	9.1	15.9	10.4	9.3	14.9	14.6	15.1
n-Pentane \	4.5	9.6	9.0	8.5	8.3	5.2	6.4
2. 2-Dimethylbutane	0.5	0.8	0.9	1.8	1.8	1.1	1.2
Cyclopentanc	0.6	0.4	0.9	0.8	0.7	0.3	0.2
2, 3-Dimethylbutane	0.3	0.6	1.1	1.2	1.2	0.5	0.6
2-Methylpcntane	0.9	2.1	2.9	2.8	3.6	1.3	1.7
3-Methylpentane	0.7	1.6	2.5	2.2	2.9	0.9	1.2
n-Hexane	0.7	1.8	3.3	2.6	2.7	0.6	1.0
Methylcyclopentane	1.5	1.1	1.5	1.6	1.5	0.4	0.4
2, 2-Dimethylpentane	0.2	0.1	0.9	0.9	0.6	0.1	0.2
Benzene	0.5	0.5	0.9	1.0	1.1	0.5	0.3
2, 4-Dimethylpentane	0.0	0.0	0.8	0.7	0.0	0.0	0.1
2, .2, 3-Trimethylbutane	0.2	0.1	0.2	0.5	0.7	0.1	0.1
Cyclohexane	1.2	1.4	2.4	2.0	1.9	0.5	0.7
J, 3-Dimethylpentane	0.2	0.1	lor)	1.2	0.3	0.1	0.1
1, 1-Dimethylcyclopentane	0.3	0.2	0.8	0.4	0.1	0.1	0.1
2-Methylhexane	0.2	0.3	1.3	1.2	1.0	0.2	0.2
2. 3-Dimethylpentane	.0.3	0.2	1.1	1.0	0.8	0.1	0.1
J.-cis-3-Dimethylcyclopentane	0.4	0.2	0.8	0.7	0.4	0.0	0.1
3-Methylhexane	0.2	0.4	1.6	1.2	1.2	0.2	0.2
1 trans-3-Dimethylcyclopentane	0.4	0.2	0.8	0.6	0.3	0.1	0.0
1 trans-2-Dimethylcyclopentane	0.7	0.3	1.0	0.7	0.3	0.1	0.1
3-Ethylpcntanc	0.2	0.1	1.1	1.1	0.4	0.1	0.1
n-Heptane	0.3	0.4	1.7	1.6	1.0	0.1	0.2
1, cis-2-Dimethylcyclopentane	0.4	0.1	0.6	0.5	0.3	0.0	0.0
Methylcyclohexane	1.4	1.4	3.6	2.9	2.0	0.4	0.5
Toluene	0.8	0.6	3.1	4.2	0.7	0.9	0.4
C_4-C_7 Hydrocarbon Content (ppm*)	69681.3	36475.4	3149.2	2621.8	2287.4	17176.8	15715.4
2-methylpentane/3-methylpentane	1.29	1.31	1.16	1.27	1.24	1.44	1.42
isopentane/n-pentane	2.02	1,66	1.16	1.08	1.80	2.81	2.36
cyclohexane/methylcyclopentane	0.80	1.27	1.60	1.25	1.27	1.25	1.75
methylcyclopentane/methylcyclohexane	1.07	0.79	0.42	0.55	0.75	1.00	0.80

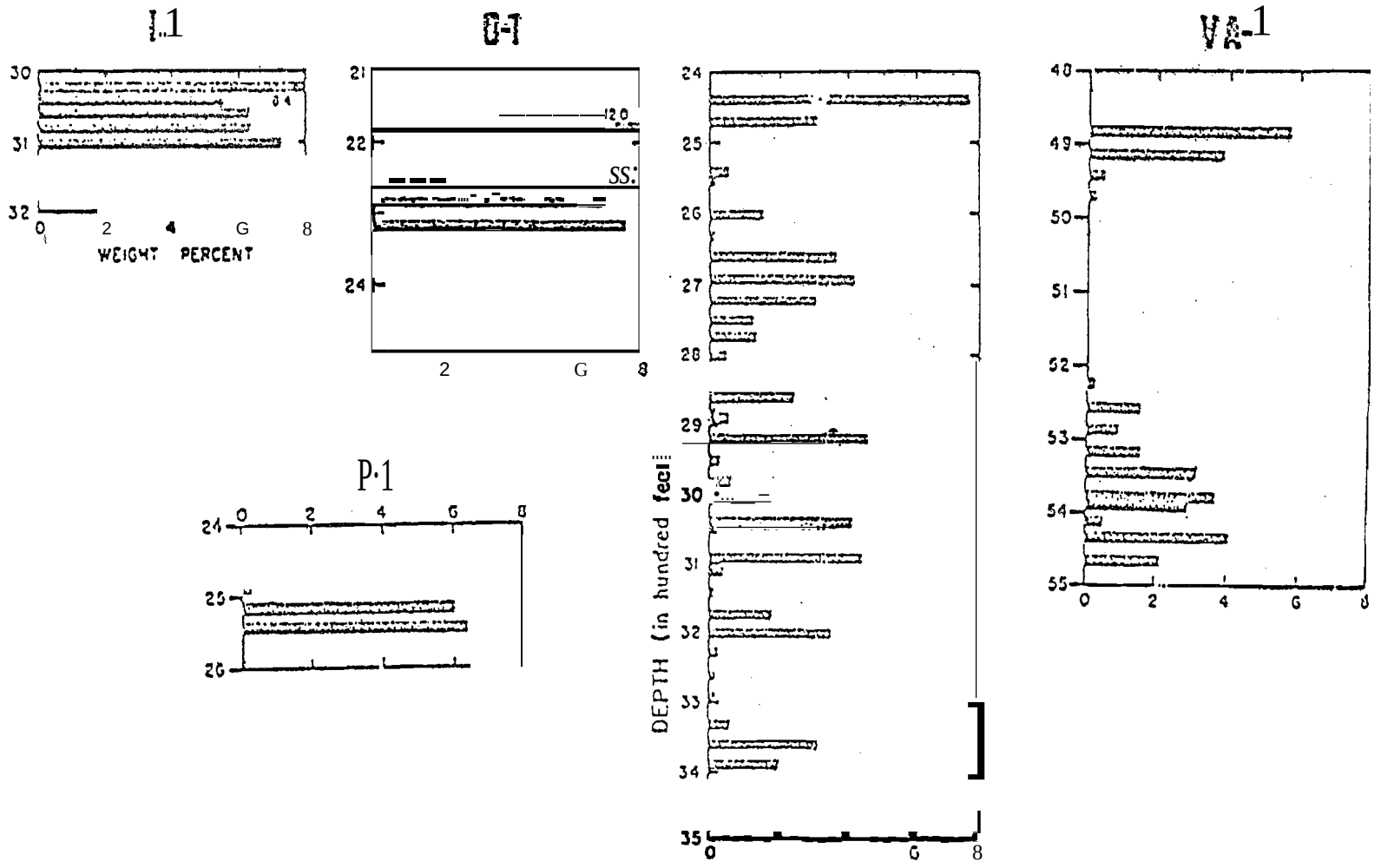
*ppm values are expressed as volumes of gas per million volumes of cuttings.

TABLE 4 • 8 (Cont'd.)

Detailed C₁-C₇ Hydrocnrbon Analyses

Mound Sample No.	VA-1-18	VA-1-21	VA-1-22	VA-1-25	VA-1-26	VA-1-27	VA-1-29	VA-1-32
Isobutane	31.4	35.7	33.6	24.9	40.3	17.5	33.0	37.2
n-Butane	35.7	39.7	40.4	37.9	42.3	29.1	39.1	41.4
Lsopcntnnc	12.5	10.5	11.8	13.4	6.7	12.0	12.1	8.8
n-Pentane	5.6	4.9	6.1	7.9	3.3	8.8	6.7	4.5
2, 2-Dimethylbutane	1.0	.0.6	0.5	0.8	0.5	1.1	0.5	0.5
Cyclopentane	0.3	0.3	0.3	0.4	0.3	0.6	0.3	0.3
2, 3-Dimethylbutane	0.5	0.3	0.3	0.6	0.2	1.1	0.4	0.3
2-Methylpentane	1.3	0.9	0.9	2.0	0.6	3.4	1.1	0.9
3-Methylpcntanc	1.1	0.8	0.7	1.5	0.5	2.6	0.8	0.6
n-Hexane	0.8	0.7	0.7	1.6	0.5	3.2	0.8	0.6
Methylcyclopentane	0.5	0.4	0.4	0.6	0.3	1.0	0.4	0.3
2, 2-Dimethylpentane	0.2	0.1	0.1	0.2	0.1	0.6	0.1	0.2
Benzene	0.5	0.6	0.6	1.3	0.6	0.6	0.6	0.6
2, 4-Dimethylpcnrane	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
2, 2, 3-Trimethylbutane	0.2	0.2	0.1	0.2	0.2	0,2	0.1	0.1
Cyclohexane	0.8	0.7	0.3	1.1	e.6	1.9	0.9	0.7
3, 3-Dimethylpentane	0.2	0.3	0.1	0.2	0.2	0.7	0.1	0.1
1, 1-Dimethylcyclopentane	0.2	0.1	0.1	0.2	0.1	0.4	0.1	0.1
2-Methylhexane	0.3	0.2	0.2	0,1	0.2	1.3	0.2	0.2
2, 3-Dimethylpentane	0.2	0.2	0.1	0.3	0.2	1.0	0.1	0.1
1-cis-3-Dimethylcyclopentane	0.1	0.1	0.1	0.1	0.1	0.6	0.1	0.1
3-Methylhexane	0.3	0.2	0.2	0.5	0.2	1.6	0.3	0.2
1 trans-3-Dimethylcyclopentane	0.1	0.2	0.0	O.1	0.1	0.6	0.1	0.1
1 trans-2-Dimethylcyclopentane	0.2	0.2	0.1	0.2	0.1	0.9	0.1	0.2
3-Ethylpentane	0.2	0.1	0.0	0.2	0.1	0.7	0.1	0.1
n-Heptane	0.4	0.3	n.2	0.5	0.2	1.7	0.2	0.2
1, cis-2-Dimethylcyclopentane	0.2	0,1	0.1	0.2	0.1	0.6	0.1	0.1
Methylcyclohexane	0.9	0.6	0.6	1.2	0.5	3.3	0.7	0.6
Toluene	1.2	0.9	0.8	1.6	0.9	2.4	0.a	0.8
C₁-C₇ Hydrocarbon Content (ppm*)	6763.6	14060.5	15517.1	11295.7	5769.3	1466.4	8169.4	6844.8
2-methylpentane/3-methylpentane	1.1S	1.13	1.29	1.33	1.20	1.31	1.38	1.50
isopentane/n-pentane	2.23	2.14	1.93	1.70	2.03	1.36	1.81	1.96
cyclohexane/methylcyclopentane	1.60	1.75	2.00	1.83	2.00	1.90	2.25	2.33
methylcyclopentane/methylcyclohexane	0.56	0.67	0.67	0.50	0.60	0.30	0.51	0.50

*ppm values are expressed as volumes of gas per million volumes or cuttings.



ORGANIC CARBON DATA
FOR CORE SAMPLES

FIGURE 4.3

TABLE 4.9

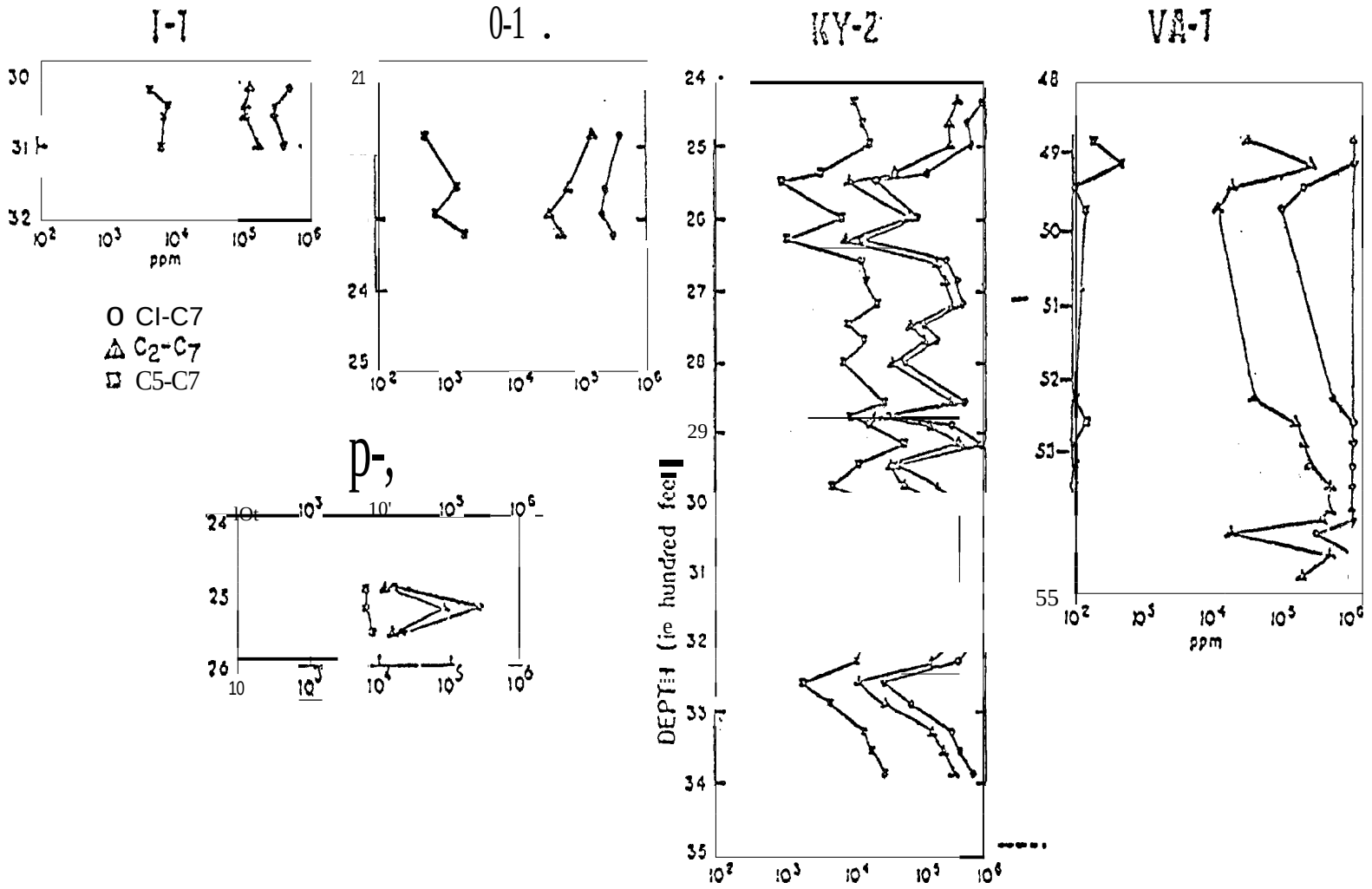
Gross Lithological Description and Organic Carbon Analyses

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
VA-1-2		100% Shale, carbonaceous, slightly silty, slightly micromicaceous, slightly pyritic, slaty clevage, indurated, hard, black.	Nl	5.66
VA-1-4		100% Shale, carbonaceous, slightly 'silty, micromicaceous, slaty clevage, indurated, hard, black.	Nl	3.85
VA-1-6		100% Shale, noncalcarcous, nonsilty, very slightly pyritic, fissile, indurated, hard, medium dark gray.	N4	0.47; O.44R
VA-I-ll		100% Shale, nonca1careous, nonsi1ty, fissile, indurated, hard, medium dark gray.	N4	0.18
VA-1-13		100% Shale, carbonaceous, slightly mottled, micromicaceous, fissile, indurated, hard, dark gray,	N3	0.18
VA-1-15		100% Argillite, carbonaceous, micromicaceous, very silty, fissile, highly indurated, hard, grayish black.	N2	1.51
VA-l-17		100% Argillite, carbonaceous, fissile, highly indurated. very hard, dark gray to grayish black.	N3 to N2	0.88

TABLE 4.9(Cont'd.)

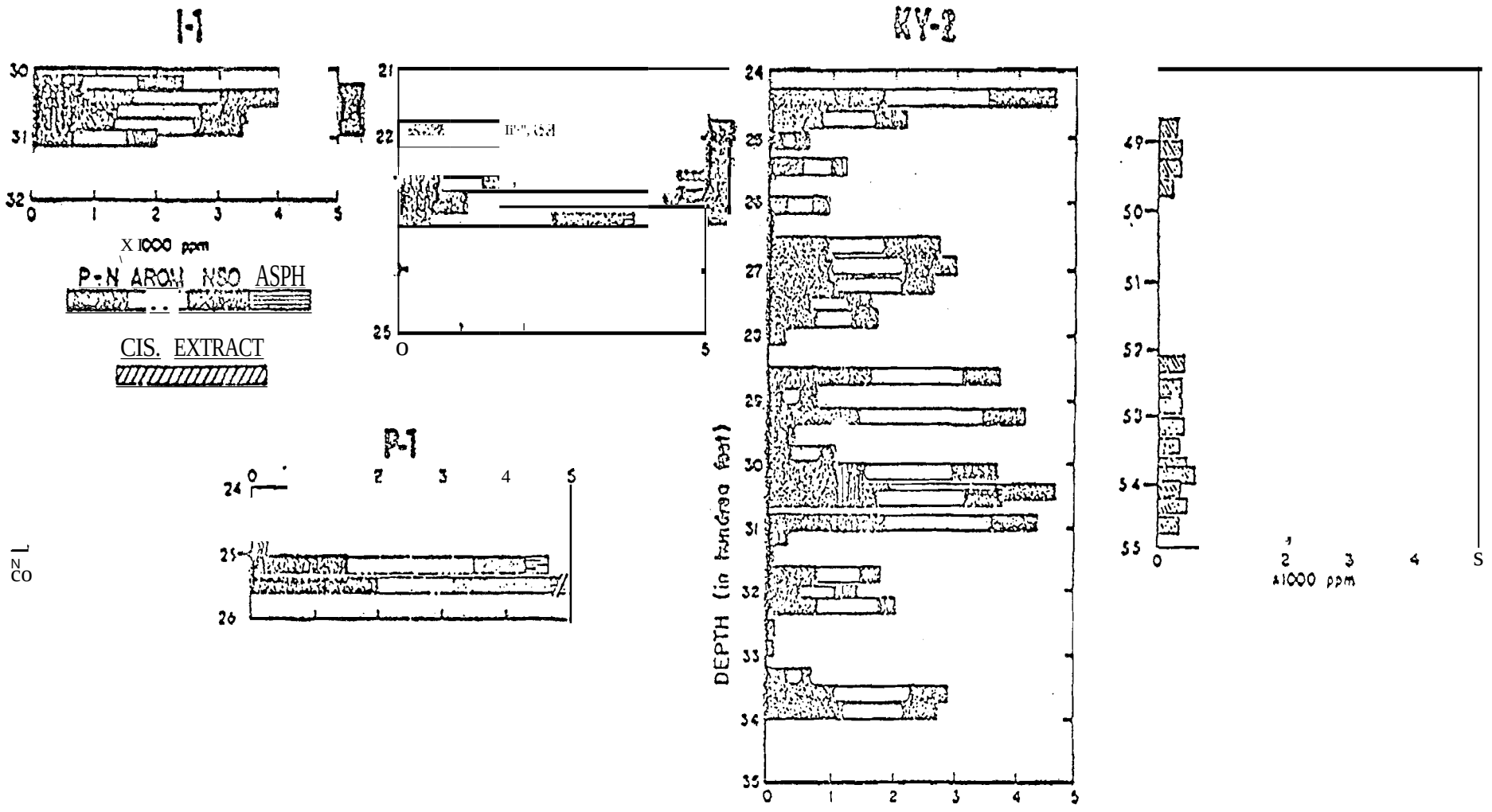
Gross Lithological Description and Organic Carbon Analyses

Mound Sample Number	Well Interval	Gross Lithological Description	GSA Color Code	Total Organic Carbon (% of Rock)
VA-1-18		100% Argillite, carbonaceous, fissile, highly indurated, very hard, grayish black.	N2	1.54; 1.54R.
VA-l-21		100% Shale, carbonaceous, moderately fissile, indurated, hard; grayish black.	N2	3.13
VA-1-22		100% Argillite, carbonaceous, fissile, highly indurated, very hard, grayish black.	N2	3.57
VA-1-25		100% Shale, carbonaceous, moderately fissile, indurated, hard, slicken-sides in part, grayish black.	N2	2.53
VA-1-26		100% Shale, carbonaceous, slicken-sides abundant, blocky, indurated, hard, grayish black.	N2	2.84
VA-1-27		100% Shale, noncalcareous, nonsilty, moderately fissile, very hard, medium dark gray.	N4	0.48; O.48R
VA-1-29		100% Argillite, carbonaceous, fissile, highly indurated, very hard, grayish black.	N2	3.97
VA-1-32		100% Argillite, carbonaceous, fissile, indurated, hard, grayish black.	N2	2.11



C_{1-C7} HYDROCARBON DATA
FOR CORE SAMPLES

FIGURE 4.4



C_{15}+ EXTRACT DATA
FOR CORE SAMPLES

FIGURE '4.5

TABLE 4.10

Summary of C15+ Soxhlet Extraction, Deasphaltening
and Liquid Chromatography

A. Weights of Extracts and Chromatographic Fractions

Mound Sample Number	Well Interval	Weight of Rock Extd. (Grams)	Total Extract (Grams)	Precipitated Asphaltenes (Grams)	N-C5 Soluble (Grams)	Sulfur (Grams)	Paraffins-Naphthenes (Grams)	Aromatics (Grams)	Eluted NSO'S (Grams)	Noneluted NSO's (Grams)
VA-1-2		100,0	0.0297	*0.0141*	0.0156	N.D.	0.0057	0.0045	0.0034	0.0020
VA-1-4		100.0	0.0357	0.0271	0.0086	N.D.	N.n.	N.D.	N.D.	N,D.
VA-1-6		100.0	0,0344	0.0304	O.0040	N.D.	N.D.	N.D,	N.D.	N.D.
VA-1-11		90,0	*0.0199*	0.0169	0.0030	N.D.	N.D.	N.D.	N.D.	N.D.
VA-1-13		100.0	0.0393	0.0366	0,0027	N.D.	N.D.	N.D.	N.D.	N.D.
VA-l-1S		100.0	0.0356	0.0314	0.0042	N.D.	N.D.	N.D.	N.D,	N.D.
VA-1-17		100,0	0.0347	0,0311	0.0036	N,D.	N.n,	N.D.	N.D,	N.D.
VA-l-18		*100.0*	0.0395	0.0350	0.,0045	N.D.	N.D,	N.D.	N.D.	N. D.
VA-1-21		*100.0*	0,0330	0.0271	0.0059	N.D.	N.D.	N.D.	N.D.	N.D.
VA-1-22		100.0	0.045.3	0.0379	0.0074	N.D.	N.D.	N.D.	N.D.	N.D.
VA-1-25		100.0	0,0256	0.0180	0.0076	N.D.	N.D.	N.D.	N.D.	N.n.
VA-1-26		100.0	0.0558	0.0459	0.0099	N.D.	N.D.	N.D.	N.D.	N.D.
VA-l-27		100.0	0.0336	0.0304	0.0032	N.P.	N.D.	N.D.	N.P.	N.D.
VA-l-29		*100.0*	0.0446	0.0352	0.0094	N.D.	N.D.	N.D.	N.D.	N.D.
VA-loon		100.0	0.0329	0.0282	0.0047	N.D.	N.P.	N.D.	N.D.	N.D.

TABLE 4.11

Summary of C15+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography

B. Concentration of Extracted Materials in Rock

Mound Sample Number	Well Interval	Total Extract (ppm)	Hydrocarbons: Paraffin-Naphthene (ppm)	Hydrocarbons: Aromatic (ppm)	Hydrocarbons: Total (ppm)	Sulfur (ppm)	Nonhydrocarbons: Precipitd. Asphaltene (oFm)	Nonhydrocarbons: Eluted NSO's (ppm)	Nonhydrocarbons: Noneluted NSO's (ppm)	Nonhydrocarbons: Total (ppm)
VA-1-2		297	57	45	102		141	34	20	195
VA-1-4		357					271			
VA-1-6		344					304			
vx-i-r;		221		--			188			
VA-1-13		393					366			
VA-1-15		356					314			
VA-1-17		347					311			
VA-1-18		395					350			
VA-l-21		330					271			
VA-1-22		453					379			
VA-1-25		256					180			
VA-1-26		558					459			
VA-1-27		336					304			
VA-1-29		446					352			
VA-1-32		329					282			

TABLE 4.12

Summary of C1S+ Soxhlet Extraction, Deasphaltening and Liquid Chromatography

C. Composition of Extracts

Mound Sample Number	Well Interval	Hydrocarbons: Paraffin-Naphthene %	Hydrocarbons: Aromatic %	Hydrocarbons: PNIArom	Sulfur %	Nonhydrocarbons: Eluted NS01S. %	Nonhydrocarbons: Noneluted NSO'S %	Nonhydrocarbons: Precipitd. Asphaltene %	Asph/NSO	He'S %	HC/Non HC
VA-1-2		19.2	15.2	1.27.		11.4	6.7	47.5	2.61	34.3	0.52
VA-1-4								75.9			
VA-1-6								88.4			
vx-r-n								84.9			
VA-1-13								93.1			
VA-l-1S								88.2			
VA-1-17								89.6			
VA-1-18								88.6			
VA-l-21								82.1			
VA-1-22								83.7			
VA-1-2St								70.3			
VA-1-26'								82.3			
VA-1-27								90.5			
VA-1-29								78.9			
VA-1-32								85.7			

TABLE 4•13

Saturate Hydrocarbon Analyses

Summary of Paraffin-Naphthene Distribution

Mound Sample Number	Well Interval	% Paraffin	% Isoprenoid	% Naphthene	C-P Index A	Coop Index B	ip19/ip20
VA-1-2		7.2	1.3	91.5-			0.64
VA-1-4		7.8	1.1	91.2			0.42
VA-1-6		3.8	0.0	96.2	1.03		0.00
VA-1-11		3.8	0.2	96.0	1.05		0.38
YA-l·13		6.9	0.0	93.1	1.20		0.00
VA-l-1S		3.1	0.4	96.5			0.24
VA-1-17		4.6	0.0	95.4	0.68		0.00
VA-1-18		2.1	0.4	97.5			0.52
VA-l-21		2.1	0.0	97.8			0.00
YA-1-22		1.5	0.1	98.4	1.05		0.00
VA-1-25		1.5	0.0	98.4			0.00
VA-1-26		1.4	0.1	98.5	1.02		0.00
VA-1-27		3.3	0.0	96.7	1.08		0.00
YA-1-29		1.5	0,1	98.4			0.00
VA-1-32.		2.7	0,0	97.3	1.02.		0.50

TABLE 4.14

Saturate Hydrocarbon Analyses

Normalized Paraffin Distribution

Hound 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
VA-1-2		0.0	3.2	10.5	5.9	17.9	9.2	17,9	12.8	9.2	6.5	3.8	2.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-4		0.0	0.0	6.0	3.6	16.0	8.6	20.4	17.2	11.5	8.1	4.9	2.6	1.3	0.0	0.0	0.0	0.0	0.0	0,0	0.0	0.0	0.0	0.0
VA-1-6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	13.9	19.8	17.0	11.7	10.5	7.1	4.6	2.8	2.5	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-rt		0.0	0.0	2.0	1.5	6.7	3.9	8.9	10.0	8.3	9.8	8.5	5.9	9.5	7.2	4.8	4.1	3.5	3.0	2.2	0.0	0.0	0.0	0.0
VA-1-13		0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	13.5	19.7	21.4	12.7	11.7	5.5	4.2	1.2	1.2	0.5	0.0	0.0	0.0	0.0	0.0
VA-1-15		0.0	0.0	2.7	2.0	12.9	S.2	16.1	16.5	11.8	u.e	8.2	5.1	3.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-17		0.0	0.0	0.0	0.0	0.0	0.0	7.2	16.2	12.0	14.9	12.0	21.5	6.4	4.5	2.7	1.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-18		0.0	0.0	5.1	5.6	15.7	10.6	16.2	15.7	10.6	9.1	6.1	2.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-21		0.0	0.0	0.0	0.0	6.8	2.1	11.9	21.7	11.5	15.3	10.6	9.8	6.t,	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-22		0.0	0.0	0.0	0.0	11.1	:l.S	14.6	15.8	10.5	11.7	S.S	4.1	7.6	7.0	4.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-25		0.0	0.0	0.0	0.0	11.4	3.0	17.4	23.5	13.2	0.0	13.6	5.3	5.3	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-26		0.0	0.0	0.0	0.0	8.6	3.4	13.2	20.1	13.8	16.1'	9.S	5.7	5.2	1.1	2.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	C.O
VA-1-27		0.0	0.0	0.0	0.0	0.0	0.0	4.7	u.s	15.8	20.5	16.2	9.8	9.0	5.6	3.8	1.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-29		0.0	0.0	0.0	0.0	9.2	3.4	14.3	20.2	16.0	16.8	10.1	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VA-1-32		0.0	0.0	0.4	0.0	4.6	0.8	7.5	10.0	10.4	14.6	14.6	12.1	10.8	7.5	4.6	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 4.15

Vitrinite Reflectance Summary
for VA-l Well

Mound Sample Number	Number of Readings	Minimum Reflectance (% R_o)	Maximum Reflectance (% R_o)	Average Reflectance (% R_o)
VA-1-2	50	0.47	1.39	0.96
VA-1-4	50	0.48	1.45	0.97
VA-1-6	6	0.67	1.41	1.19
VA-l-11	3	1.01	1.34	1.21
VA-1-13	1	1.28	1.28	1.28
VA-1-15	50	0.48	1.26	0.92
VA-l-:7	33	0.63	1.24	0.93
VA-1-18	50	0.66	1.28	0.92
VA-1-21	35	0.67	1.36	1.01
VA-l-22	46	0.46	1.39	0.96
VA-1-25	50	0.49	1.35	1.02
VA-1-26	50	0.68	1.44	1.02
VA-1-27	50	0.53	1.47	1.10
VA-1-29	50	0.69	1.15	0.94
VA-1-32	50	0.64	1.25	0.91

l'ABLE 4. 16

Kerogen Composition
Sample from VA-l Well Located in
Wise County, Virginia

Sample No.	Weight Percent (Ash Free) e	H	N	0	Weight Percent Ash	Atomic H/C'	Atomic O/C
VA-1-2	66.0	3.8	1.3	28.8	21.1	0.69	0.33
VA-1-4	78.9	4.1	1.6	15.3	15.4	0.62	0.15
VA-l-ll	85.5	4.0	2.4	8.1	9.3	0.56	0.07
VA-I-1S	85.9	4.0	1.2	8.9	9.1	0.56	0.08
VA-1-17	.77.8	3.8	1.9	16.5	6.7	0.59	0.16
VA-1-18	85.9	4.1	2.6	7.3	7.2	0.57	0.06
VA-1-21	84.4	4.2	1.7	9.6	25.0	0.60	0.09
VA-1-22	79.4	4.4	2.2	13.9	14.6	0.66	0.13
VA-1-25	77.6	4.8	6.4	11.2	12.8	0.74	0.11
VA..1-26	85.4	4.5	4.1	6.0	6.1	0.63	0.05
VA-1-29	82.0	4.3	5.0	8.7	10.2	0.63	0.08.
VA-1-32	80.6	4.6	8.7	6.1	6.4	0.63	0.06

TABLE 4.17

Material Balance Assay
Product Assay

Mound Sample No.	VA-l-2	VA-1-4	VA..1..6	VA-l-13	VA-1-15	VA-l-22	VA..1..27	VA-l..29	VA..1..32
Oil Yield (Gas/Ton)	<0.5	<0.5	<0.5	<0.5	<0.5	<0,5	<0.5	<0.5	<0.5
Specific Gravity (60°/60°)	.....	.....	.....	.....	.....	.....			
°API..Oil Gravity		.....		.....	.....		.....	.....	
Water Yield (Gal/Ton)	3.0	2.4	3.6	.3.5	3.2	1.8	1.6	1.7	2.0
pH	9.2	9.3	9.3	9,3	9.1	9.2	9.2	9.1	9.1
Hydrocarbon Gas Yield- (Ft^{3}/Ton)	49.2	29.5	1,9	1.7	4.2	17.0	<1.0	*32.0*	12.6

TABLE 4.18

Material Balance Assay Carbon and Ash Data
for Wise County, Virginia Samples

Mound Sample No.	VA-1..2	VA-1..4	VA-1··6	VA..1-13	VA..l-15	VA-1-22	VA-1..27	VA-1..29	VA..1-32
Pre-test:									
Total Carbon (%)	5.68	3.90	0.36	0.61	2.12	4.30	0.50	6.14	2.77
Organic Carbon (%)	5.60	3.69	0,38	0.63	2.27	4.39	0.24	5.65	2.81
Post-test:									
Tota.1 Carbon (%)	5.41	3.61	0.36	0.61	2.04	.4.10	0.35	5.45	2.56
Organic Carbon (%)	5.27	3.64	0.41	0.60	2.09	3.79	0.25	5.27	2.60
Carbon Transfer Ratio	5.89	1.36		4.76	7.93	13.67	·····	6.73	7.47
Retorting Weight Loss (%)	2.24	1.79	1.73	1.84	1.72	1.79	1.84	2.02	1.53.
Retorted Shale:									
Ash (%)	91.80	94.14	96.20	95.90	95.11	9-3.49	97.49	91.90	94.96
Ignition Loss (%)	8.20	5.86	3.80	4.10	4.89	6.51	2.51 .	8.10	5.04

TABLE 4.19

Material Balance Assay Gaseous Yield
for VA-l Well, Wise County, Virginia

Mound Sample No.	VA-1-2	VA-1-4	VA-1-6	VA-1-13	VA-1-15	VA-1-22
Hydrocarbons (cm^3/g)	1.536	0.920	0.060	0.052	0.134	0.529
Methane	1.127	0.670	0.037	0.030	0.100	0.448
Ethane	0.206	0.128	0.004	0.004	0.004	0.051
Ethylene	0.007	0.004	0.004	0.004	0.004	0.004
Propane	0.078	0.049	0.002	0.002	0.015	0.013
Propylene	0.021	0.016	0.002	0.002	0.002	0.004
i-Butane	0.019	0.012	0.001	0.001	0.001	0.001
n-Butane	0.038	0.017	0.001	0.001	0.001	0.001
Butene-l	0.005	0.005	0.001	0.001	0.001	0.001
t-Butene-2	0.002	0.001	0.001	0.001	0.001	0.001
c-Butene-2	0.002	0.001	0.001	0.001	0.001	0.001
i-Pentane	0.019	0.011	0.001	0.001	0.001	0.001
n-Pentane	0.008	0.005	0.001	0.001	0.001	0.001
Pentene-1	0.002	0.001	0.001	0.001	0.001	0.001
Non-Hydrocarbons (cm^3/g)						
Hydrogen	0.786	0.185	0.186	0.186	0.186	0.187
Hydrogen Sulfide	2.293	1.068	0.071	0.053	0.392	1.701
Carbon Monoxide	0.007	0.004	0.004	0.004	0.004	0.004
Carbon Dioxide	1.075	1.088	0.048	0.870	0.682	1.405

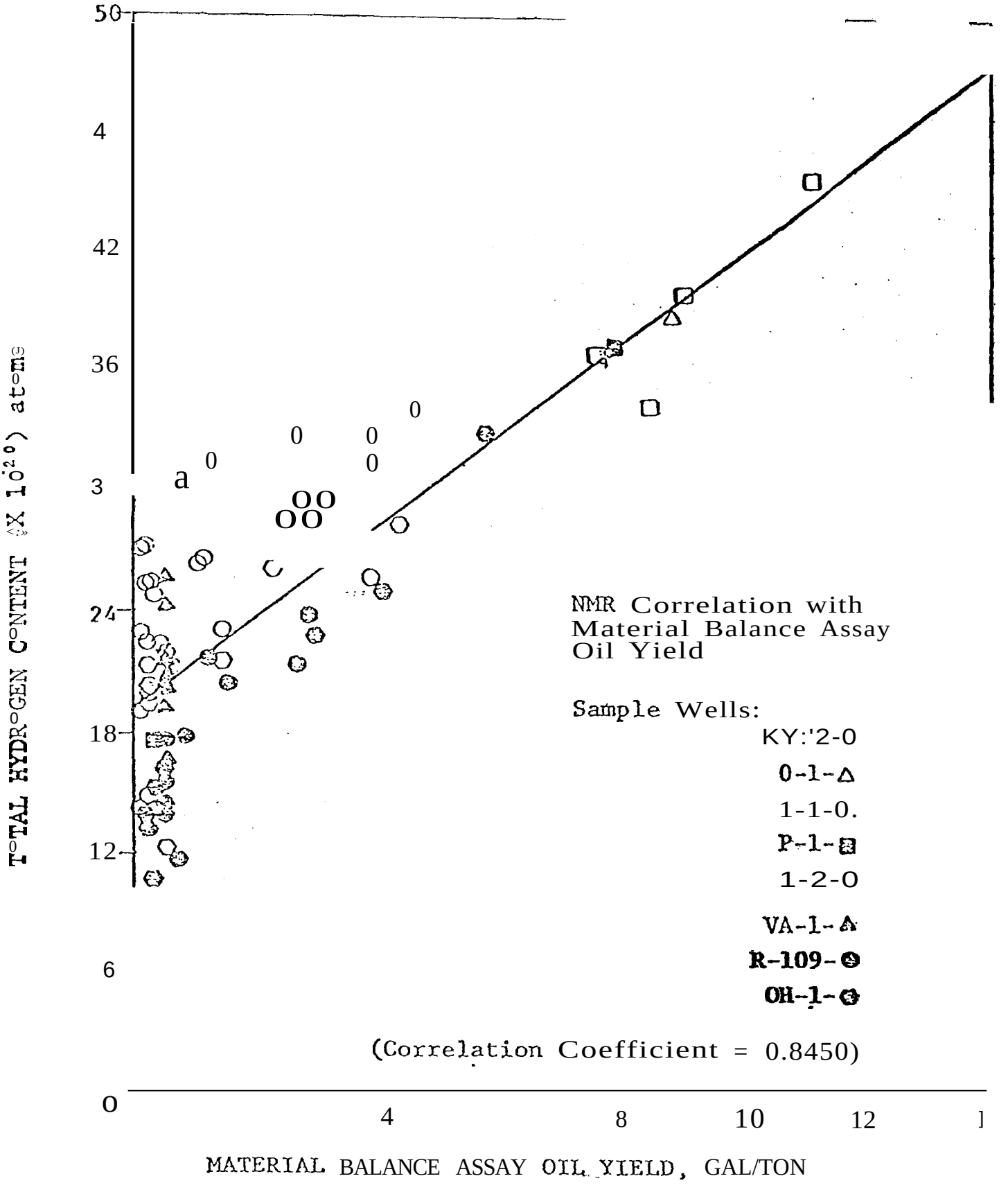

50
4
42
36
3
24
18
12
6
0
4
8
10
12
TOTAL HYDROGEN CONTENT (X 10^20) atoms
MATERIAL BALANCE ASSAY OIL YIELD, GAL/TON
NMR Correlation with
Material Balance Assay
Oil Yield
Sample Wells:
KY:'2-0
0-1-Δ
1-1-0.
P-1-
1-2-0
VA-1-
R-109-
OH-1-
(Correlation Coefficient = 0.8450)

FIGURE 4.6

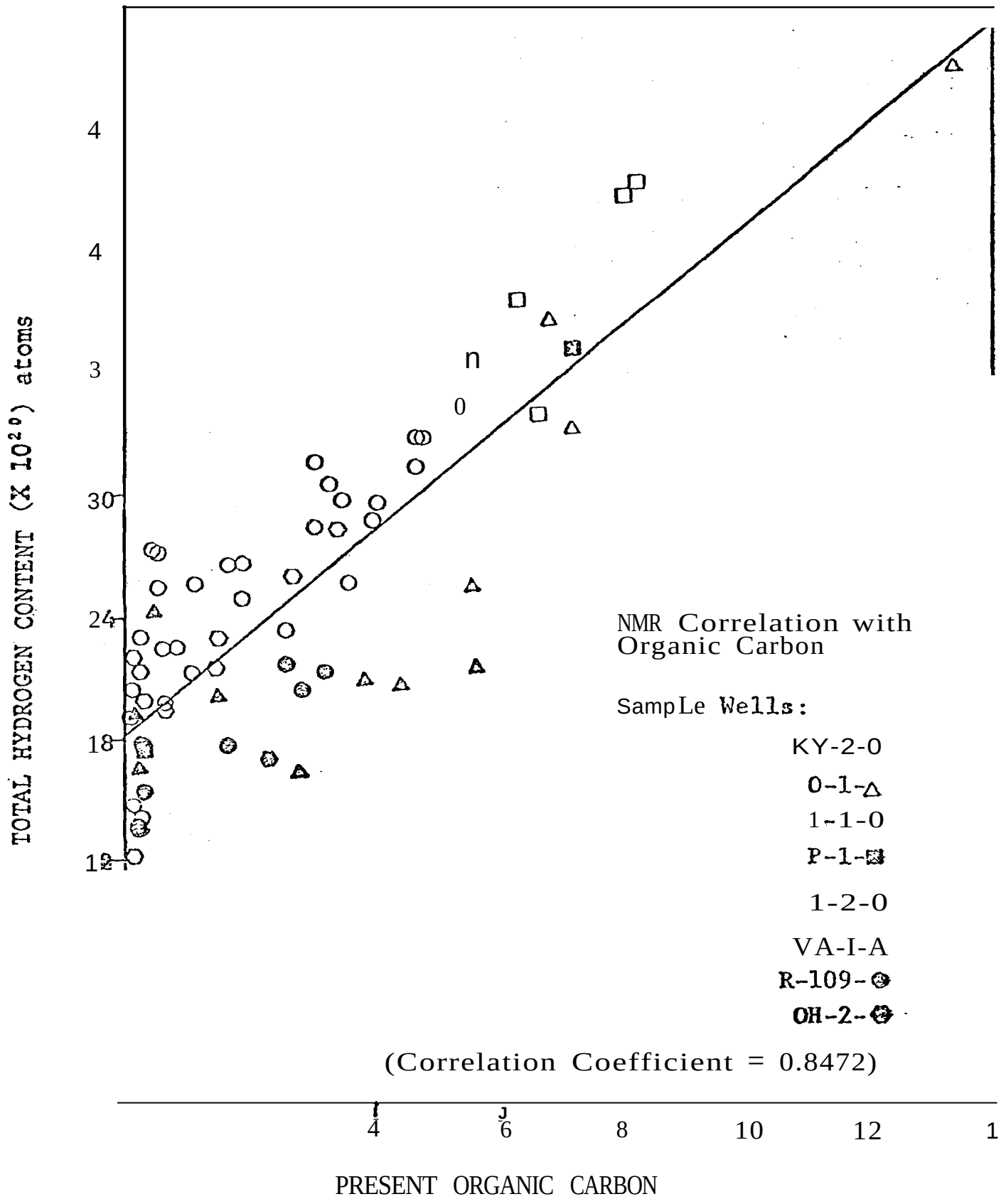

TOTAL HYDROGEN CONTENT (X 10²⁰) atoms
4
4
3
30
24
18
12
NMR Correlation with Organic Carbon
SampLe Wells:
KY-2-0
0-1-△
1-1-0
P-1-
1-2-0
VA-I-A
R-109-
OH-2-
(Correlation Coefficient = 0.8472)
4
6
8
10
12
PRESENT ORGANIC CARBON

FIGURE 4.7

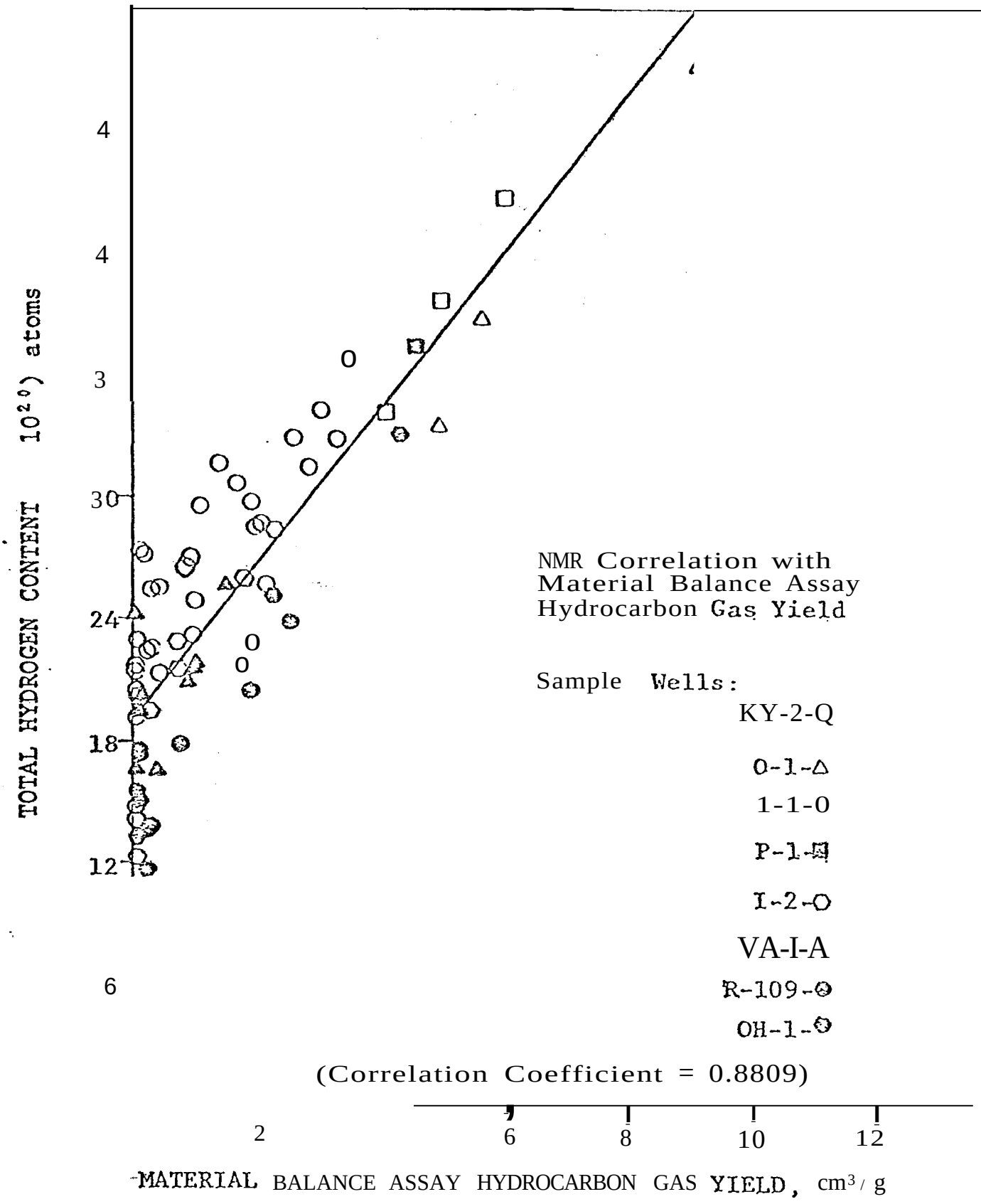

TOTAL HYDROGEN CONTENT 10²⁰) atoms
4
4
3
30
24
18
12
6
2
6
8
10
12
MATERIAL BALANCE ASSAY HYDROCARBON GAS YIELD, cm³/g
NMR Correlation with
Material Balance Assay
Hydrocarbon Gas Yield
Sample Wells:
KY-2-Q
O-1-△
1-1-O
P-1-□
I-2-O
VA-I-A
R-109-⊙
OH-1-⊙
(Correlation Coefficient = 0.8809)

FIGURE 4.8

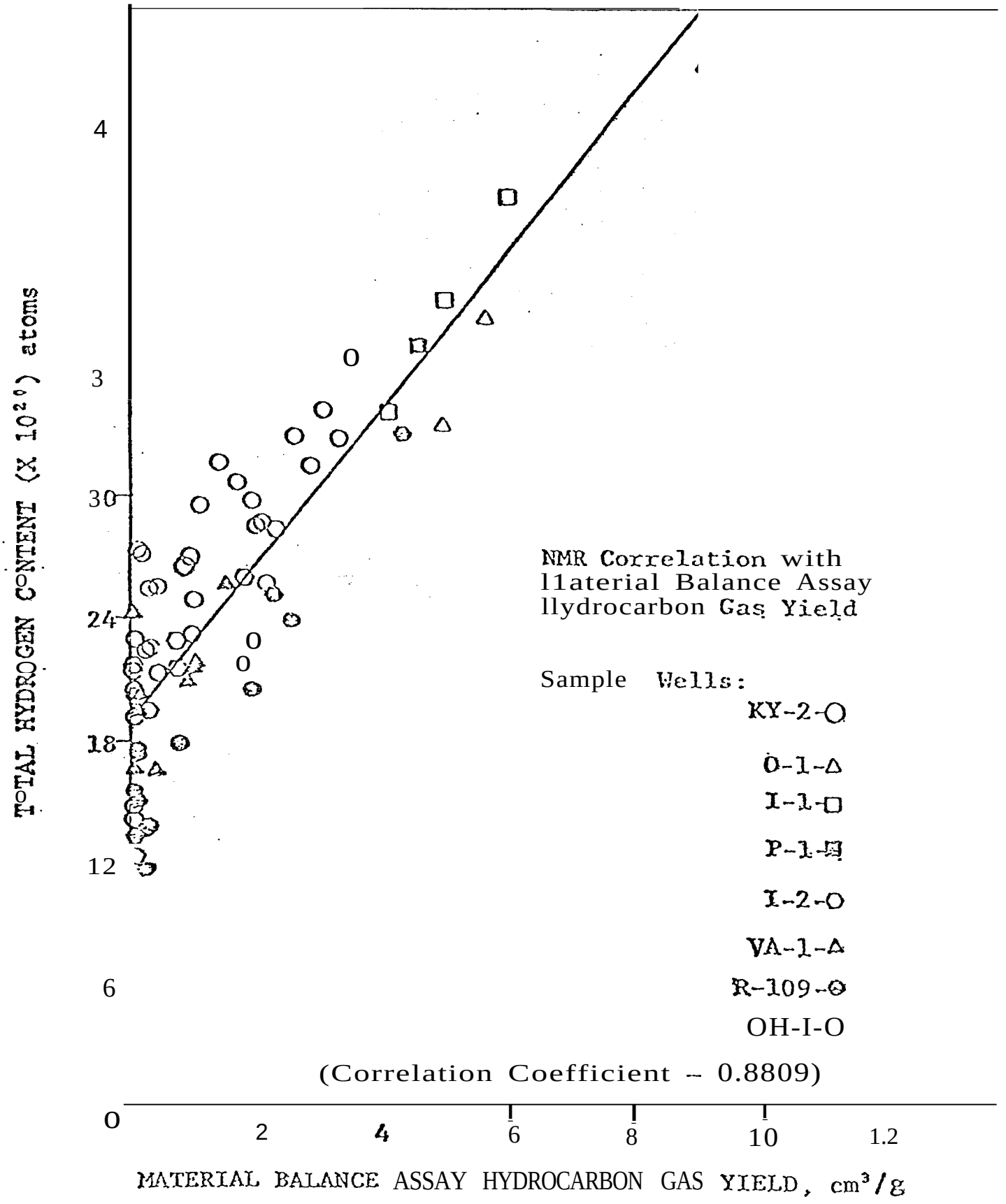

TOTAL HYDROGEN CONTENT (X 10²⁰) atoms
4
3
30
24
18
12
6
0
2
4
6
8
10
1.2
MATERIAL BALANCE ASSAY HYDROCARBON GAS YIELD, cm³/g
NMR Correlation with
Material Balance Assay
Hydrocarbon Gas Yield
Sample Wells:
KY-2-O
O-1-Δ
I-1-□
P-1-
I-2-O
VA-1-Δ
R-109-
OH-I-O
(Correlation Coefficient – 0.8809)

FIGURE 4.8

Sample VA-l-l

EXPANSION AS A FUNCTION OF FLUID EXPOSURE

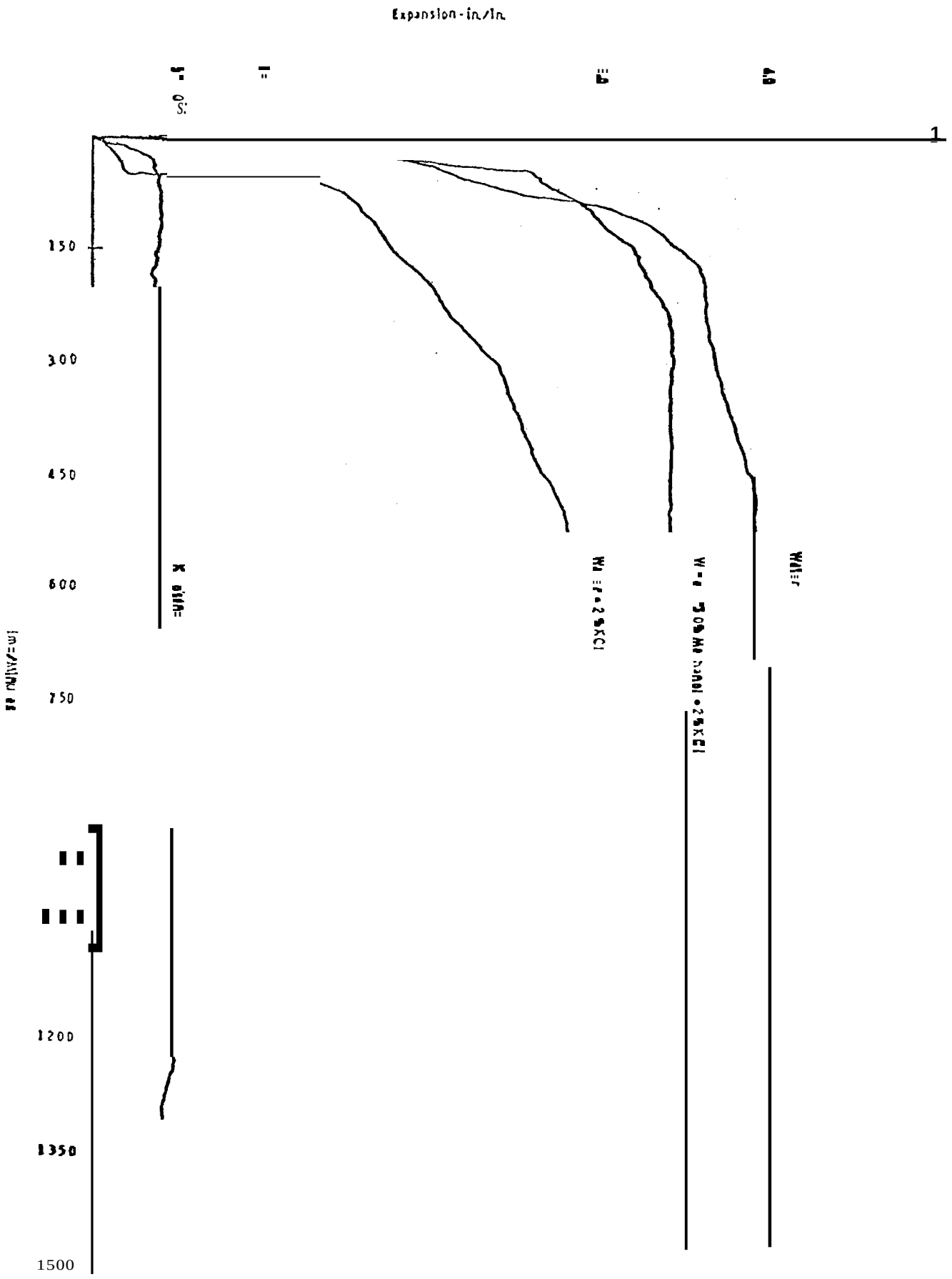


FIGURE 4.9 .

TABLE 4.20

Mechanical Test Data for the VA-I Well

Mound Sample No.	Shore Hardness ($\bar{S}_h$)	Splitting Tensile Strength (M Pa)
VA-l-IA*	9.80	1.518
VA-l-IB*	9.80	2.277
VA-I-3A	12.30	0.785
VA-I-3B	12.30	2.911
VA-1-5	8.35	2.847
VA-1-7	14.50	3.105
VA-1-9	11.60	1.214
VA-1-10	9.50	1.008
VA-1-14	Itr .00	2.613
VA-1-l6	15.70	1.937
VA-1-19	7.80	1.641
VA-1-19R**	7.80	1.681
VA-1-20	9.95	1.243
VA-1-28A	8.15-	0.548
VA-1-28B	8.15	0.722
VA-1-31A	19.85	1.631
VA-1-31B	19.85	3.035-

*A designates sample tested in maxLnum stress direction.
B designates sample tested in minimum stress direction.

** Duplicate sample tested in same direction.

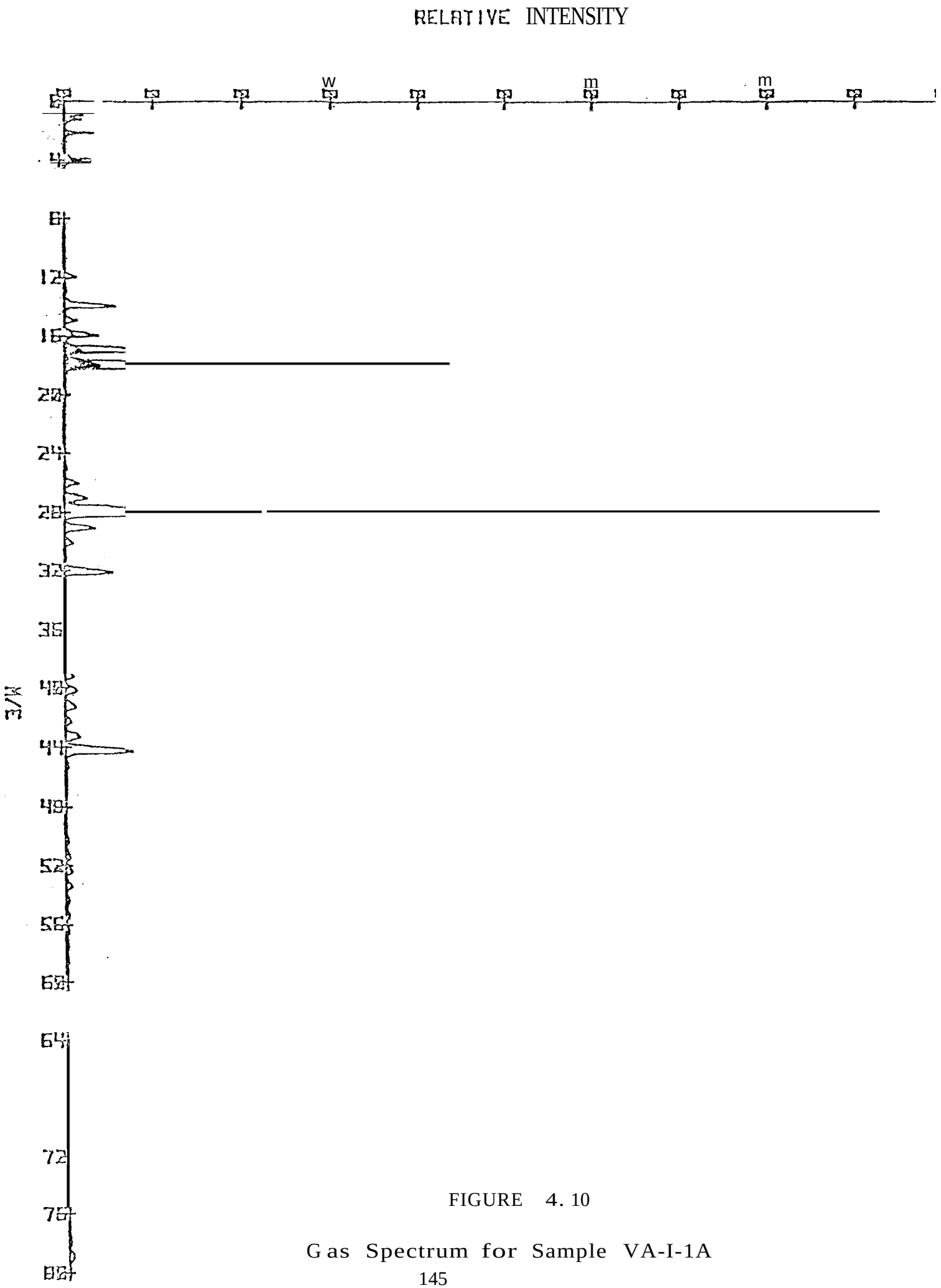


FIGURE 4. 10

Gas Spectrum for Sample VA-I-1A

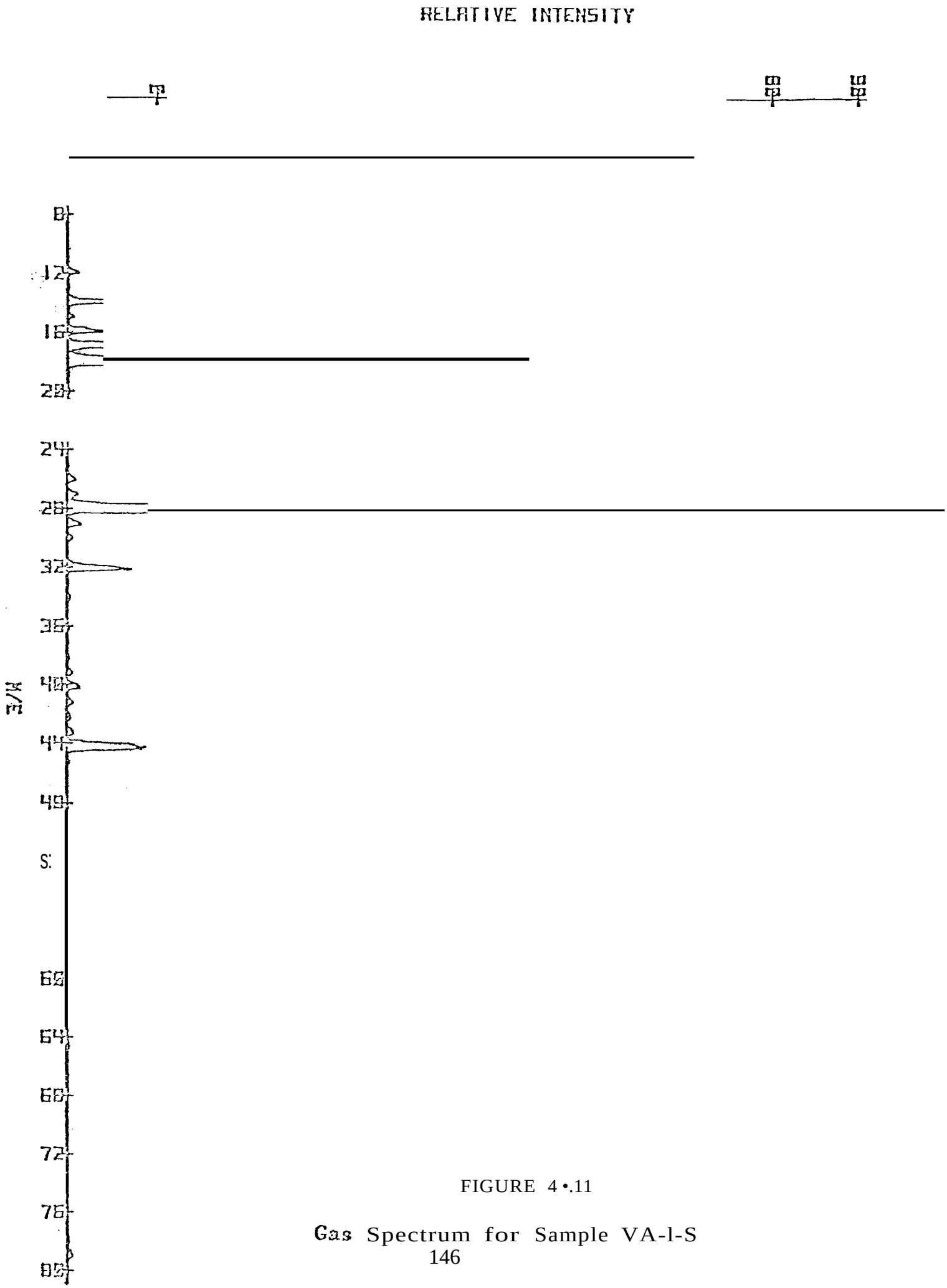


FIGURE 4•.11

Gas Spectrum for Sample VA-l-S

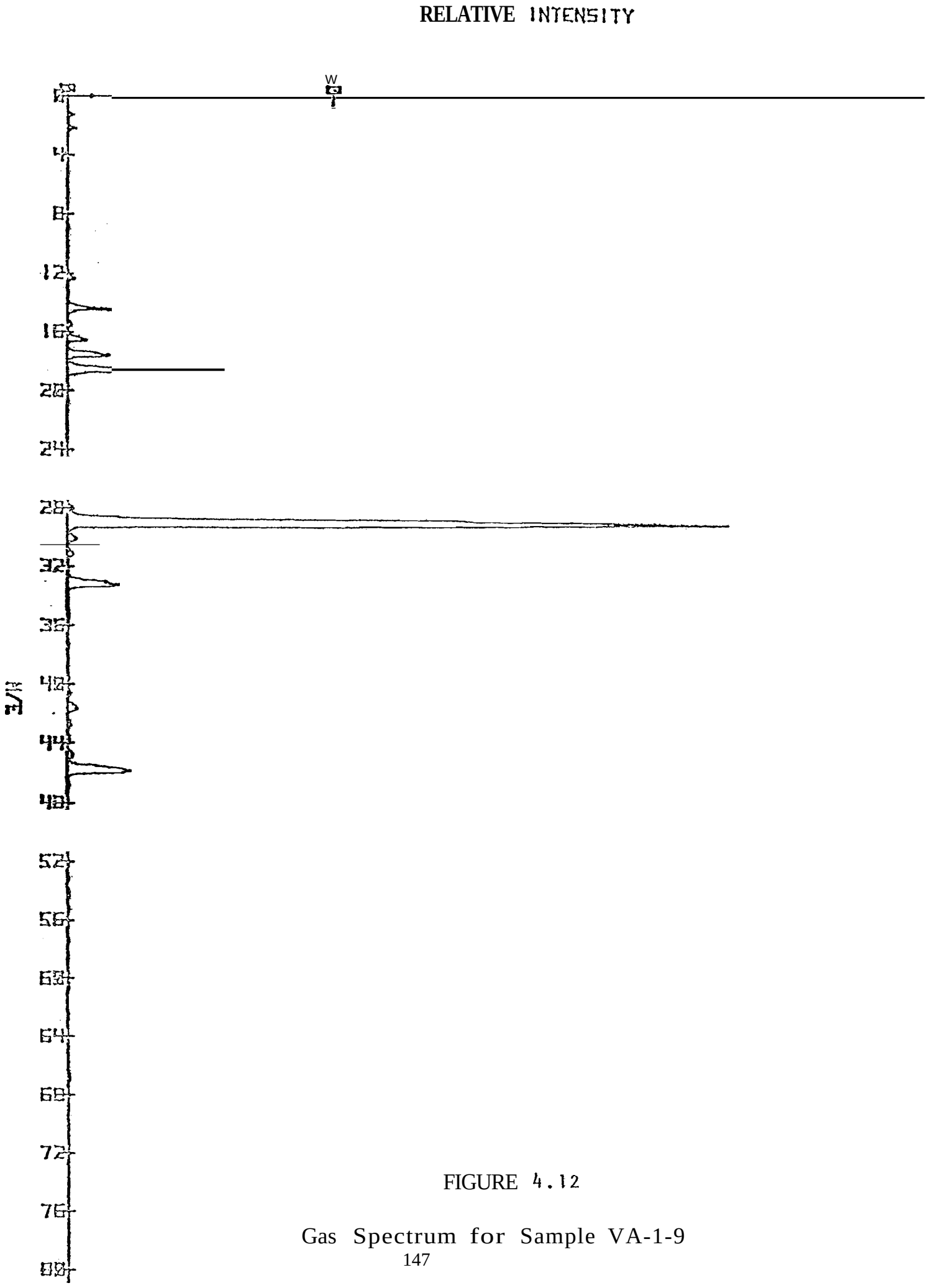


FIGURE 4.12

Gas Spectrum for Sample VA-1-9

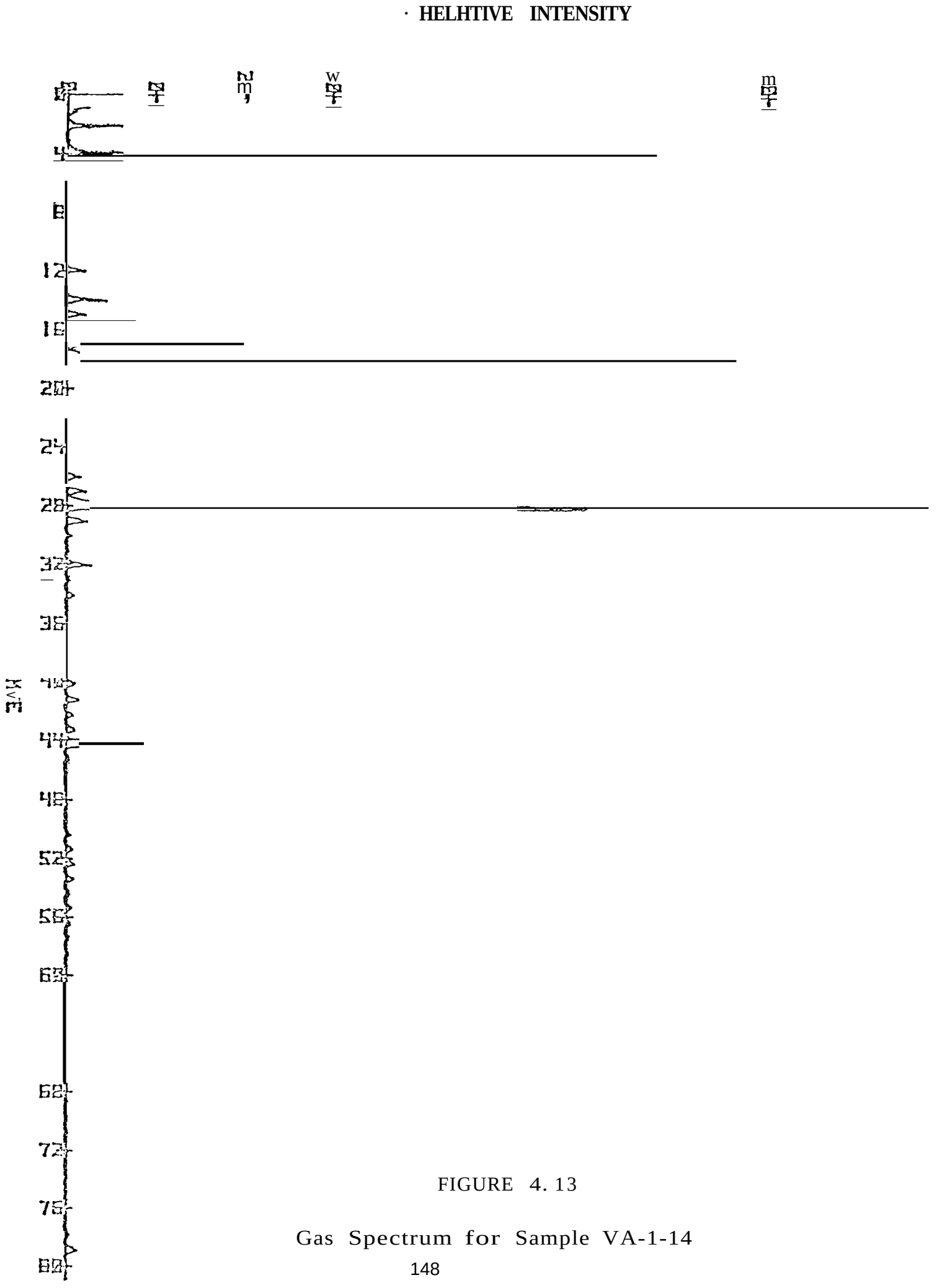


FIGURE 4. 13

Gas Spectrum for Sample VA-1-14

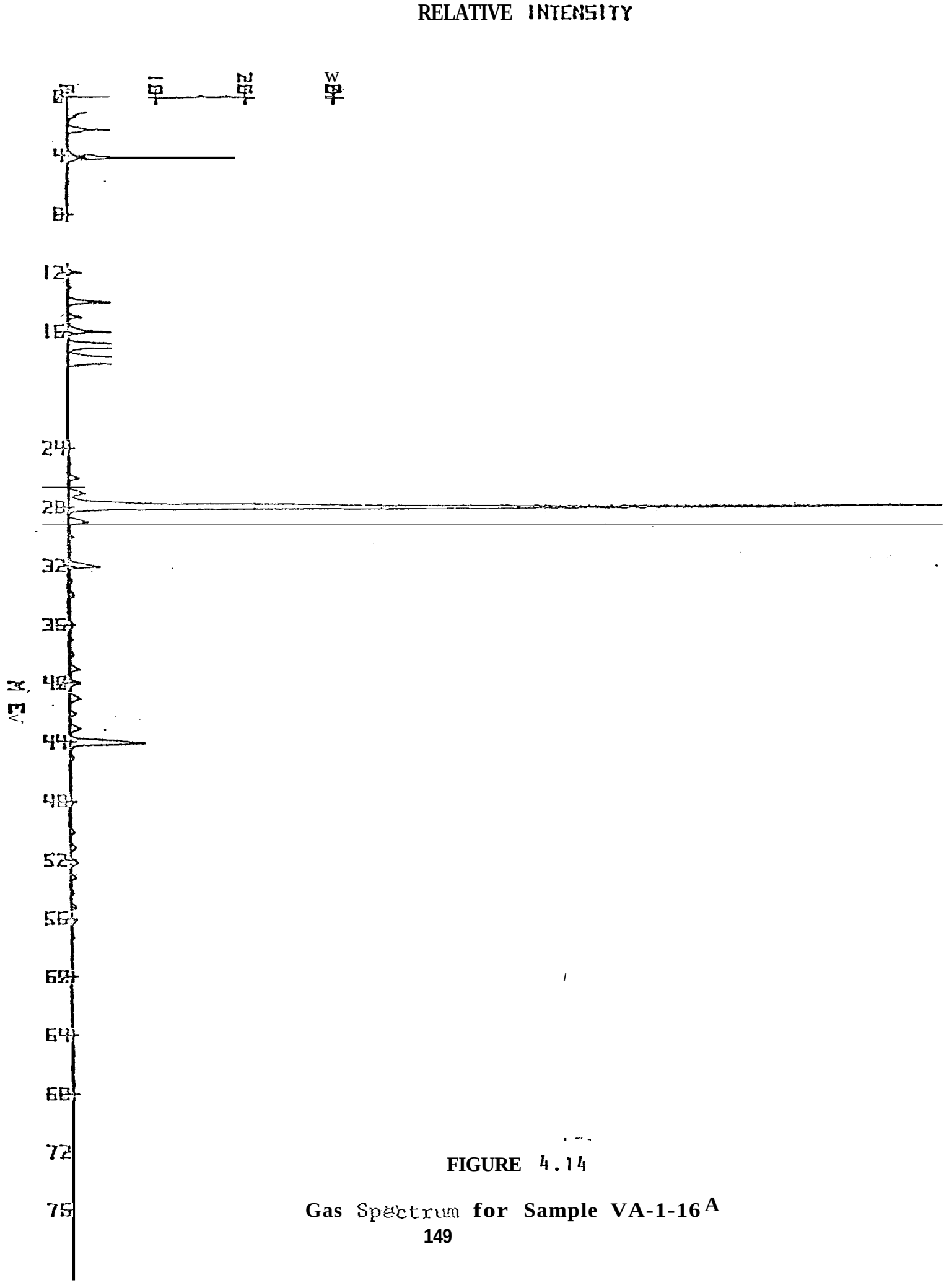


FIGURE 4.14

Gas Spectrum for Sample VA-1-16A

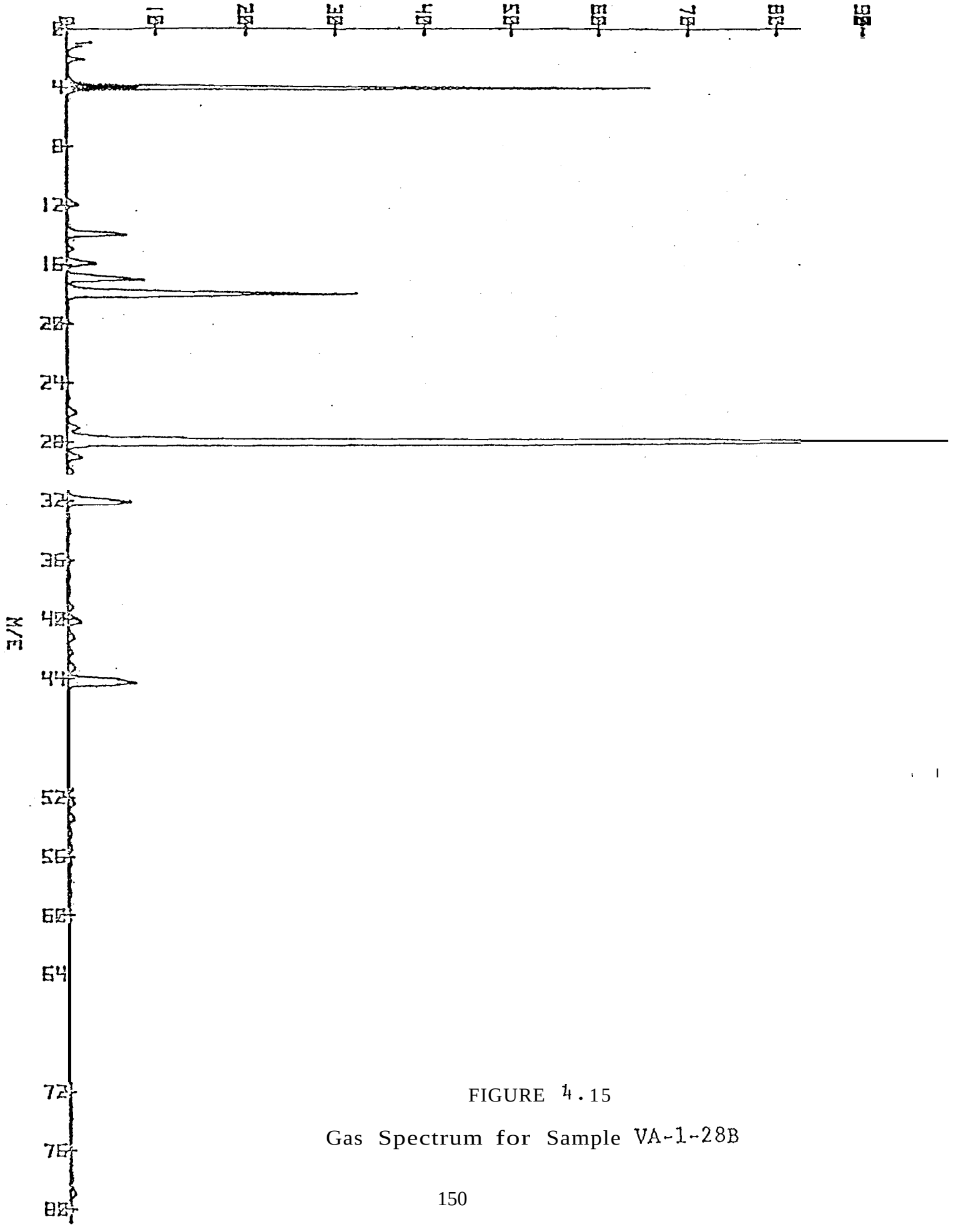


FIGURE 4.15

Gas Spectrum for Sample VA-1-28B

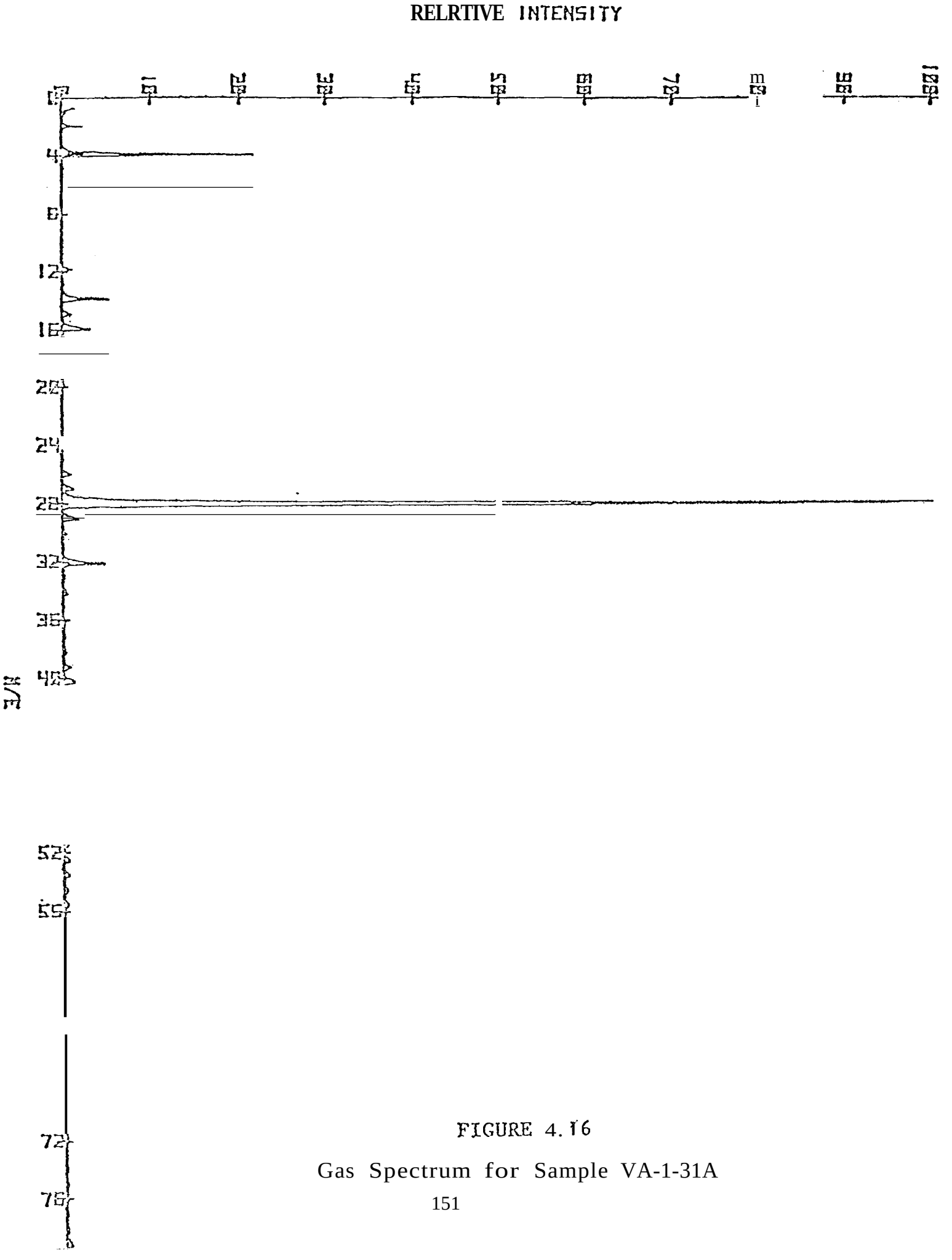


FIGURE 4.16

Gas Spectrum for Sample VA-1-31A