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ORO-5203-6

GEOLOGIC AND GEOCHEMICAL STUDIES OF THE NEW ALBANY GROUP (DEVONIAN BLACK SHALE) IN ILLINOIS TO EVALUATE ITS CHARACTERISTICS AS A SOURCE OF HYDROCARBONS

Quarterly Progress Report, January 1-March 31, 1978

By Robert E. Bergstrom Neil F. Shimp

Work Performed Under Contract No. EY-76-C-05-5203

Illinois State Geological Survey Urbana, Illinois

MASTER



U. S. DEPARTMENT OF ENERGY

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GEOLOGIC AND GEOCHEMICAL STUDIES OF THE NEW ALBANY GROUP (DEVONIAN BLACK SHALE) IN ILLINOIS TO EVALUATE ITS CHARACTERISTICS AS A SOURCE OF HYDROCARBONS

Quarterly Progress Report - January 1-March 31, 1978 Report ORO-EY-76-C-05-5203-6

> Robert E. Bergstrom and Neil F. Shimp Principal Investigators

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DOE Contract EY-76-C-05-5203

University of Illinois Code No. 1-46-26-80-360

Tilinois State Geological Survey

GEOLOGICAL EVALUATION

Introduction

This project is a detailed analysis of the lithology, stratigraphy, and structure of the New Albany Group in Illinois to determine those characteristics of lithology, thickness, regional distribution, vertical and lateral variability, and deformation that are most relevant to the occurrence of hydrocarbons.

This study will result in the preparation of cross sections, facies maps, and geologic structure maps based on subsurface data available in the Illinois Survey files. Previous work in Illinois is being re-evaluated and updated. New data on the physical, chemical, and mineralogic characteristics of the New Albany will be derived from the studies of new cores in Illinois and will be incorporated into the stratigraphic and structural investigations of existing data.

Advise DOE on Drill Sites and Coring

Progress

A few leads on drilling that might be possible to develop into cores through the New Albany have been received during the past quarter, but none has produced definite commitments. Discussion has continued on the feasibility of taking shallow cores in Illinois. Figure 1 shows the locations of presently available New Albany Group cores in Illinois and western Kentucky. Figure 2 shows the locations of four potential sites for shallow drilling to reach and core the New Albany. Below is an outline of the basic information on each of these potential drill sites.

Hardin County, Illinois

Possible sites:

On the flank of Hicks Dome, in any of Secs. 24, 25, 36, T. 11 S., R. 7 E., or Secs. 19, 20, 29, 30, 31, 32, 33, T. 11 S., R. 8 E. Drilling site should be located on the Fort Payne chert and as close to the center of the structure as possible. The Fort Payne is 280-640 feet thick in this area and will probably be very difficult to drill through, so the site should be selected to minimize the amount of drilling in chert. However, 60 to 70 feet of bedrock overburden will be necessary to accommodate the core barrel.

Thickness:

The New Albany is approximately 400 feet thick in this area and is dipping about 10-20 degrees in all directions away from the center of the structure. Total core thickness will be about 410-420 feet.

Stratigraphy:

We expect to encounter a very thin Hannibal-Saverton equivalent greenish-gray shale, very thick Grassy Creek Shales, and thick Sweetland Creek and Blocher Shales. The Grassy Creek, Sweetland Creek, Blocher, and total New Albany Group are all near their maximum thickness at this site.

Advantages to sites:

- -Near the Devonian depositional center of the Illinois Basin
- -Thick sequence of potentially gas-bearing black shales
- -Only shallow drilling site in entire Illinois Basin where deep basin facies is encountered

Disadvantages to sites:

- -- Any gas originally present in shale may have been lost due to proximity to outcrops and extensive fracturing.
- -Structural dip complicates interpretation of electric logs.
- -Extensive tracturing and mineralization may make data on physical properties and geochemical analyses difficult to relate to other areas.
- -- Most of the eastern and southern flanks of Hicks Dome are U.S. Forest Service land, and drilling on national forest land will probably require an environmental impact statement. This somewhat limits the choice of drilling sites.

References:

Baxter and Desborough, 1965, Illinois State Geological Survey Circular 385.

Baxter, Desborough, and Shaw, 1967, Illinois State Geological Circular 413.

Union County, Illinois

Possible sites:

Anywhere in eastern Union County, in any of townships T. 11 S., R. 1 W., T. 11 S., R. 1 E., T. 12 S., R. 1 E., or T. 13 S., R. 1 E.

Thickness:

The New Albany Shale is overlain by 200 to 700 feet of Mississippian limestones, cherty limestone, and shale in this area. The New Albany ranges from 30 feet thick near the outcrop in central Union County to approximately 100 feet at the east edge of the county. Both the thickness of shale and amount of overburden increase rapidly eastward.

Stratigraphy:

We expect to encounter a few feet of Chouteau Limestone, a thin Hannibal-Saverton interval, Grassy Creek Shale, Sweetland Creek Shale, doubtfully some Blocher Shale, and Alto and Lingle Formations below the New Albany.

Advantages to sites:

- -Proximity to previously studied outcrop localities
- —Will provide data on facies transitions associated with the Du Quoin Monocline
- -Most of shale is black to olive-black and potentially gas-bearing.
- -Area of sparse subsurface data

Disadvantages to sites:

- -New Albany Group is relatively thin.
- -- Most of area is surrounded by Shawnee National Forest and some land belongs to U.S. Forest Service. Drilling on national forest land will probably require an environmental impact statement.
- -Might be as much as 100 feet of Fort Payne chert to drill through

Jersey County, Illinois

Possible sites:

The stratigraphically most complete section is probably located in eastern Jersey County (T. 8 N., R. 10 W.). Alternative sites might be found in Greene County (thicker total section and thicker "black" shale interval, but stratigraphically less interesting), in western Pike County, or northwestern Jersey County (T. 8 N., R. 13 W., a thinner section but much shallower and probably posing fewer drilling problems).

Thickness:

The New Albany Shale is overlain by approximately 800 feet of Mississippian and Pennsylvanian rocks and surficial deposits in eastern Jersey County, and is shallower in eastern Greene County (250-500 feet) and northwestern Jersey County (0-200 feet). The total thickness of the New Albany Group ranges from about 100 to 200 feet.

Stratigraphy:

This is a stratigraphically complex area with very few subsurface records (no geophysical logs of the New Albany Group in Jersey County have been found in our files). Based on outcrop stratigraphy and sample studies, we expect to encounter a relatively thick Hannibal sequence that may include a dark gray to black member (the Nutwood) at near maximum thickness; both the "Glen Park" and Louisiana Formations; Grassy Crack and/or Sweetland Creek Shale; and possibly Sylamore Sandstone at the base of the New Albany.

Advantages to sites:

- -- Proximity to classical type sections of the New Albany Group in Illinois
- --Presence of Nutwood, "Glen Park," and Louisiana lithologies. The relationships of these three units are stratigraphically and environmentally very important in developing an overall model for New Albany deposition.
- -This is an area with virtually no reliable subsurface data.

Disadvantages to sites:

- —Section is predominantly greenish-gray shale, limestone, and siltstone, with little black shale.
 - —The Burlington Limestone, which lies a few feet above the New Albany in this area, is approximately 120 feet thick and contains several cherty intervals that will be significant drilling problems.
 - The presence of coal seams in eastern Jersey County might require casing of the hole.

References:

Baxter, 1970, Illinois State Geological Survey Circular 448. Workman and Gillette, 1956, Illinois State Geological Survey Report of Investigations 189.

Champaign-Douglas Counties, Illinois

Possible sites:

The most promising site is probably along the east flank of the Tuscola Anticline somewhere between the villages of Tolono and Camargo. An alternative site might be in eastern Douglas County in the general vicinity of the town of Newman.

Thickness:

The New Albany Group is generally 80-100 feet thick along the flanks of the Tuscola Anticline and is overlain by generally 200-500 feet of overburden consisting of glacial drift, possibly some Pennsylvanian strata, and Borden Siltstone. In northeastern Douglas County, the New Albany is generally 50-80 feet thick and is overlain by 600-900 feet of overburden, consisting of glacial drift, Pennsylvanian strata, and Borden Siltstone.

Stratigraphy:

In this general area the Chouteau Limestone is thin, and it appears to pinch out in eastern Douglas County. The Hannibal-Saverton Shales are very thin. The Grassy Creek and Sweetland Creek Shales appear to be of about equal thickness, but poorly differentiated, with no deep basin-type dark black shale facies present.

Advantages to sites:

- -Very shallow depth, should be easy drilling, especially of flanks of Tuscola Anticline
- -- May shed light on relationships between depositional facies and early development of La Salle Anticlinal Belt
- -May yield interesting data regarding effects of structure on strength of shale

Disadvantages to sites:

- -Total New Albany Shale section is relatively thin.
- -- Little or no "good" black shales, probably little gas potential
- -Probably will be lithologically similar to Tazewell County core

Problems

The lack of good core material from the central part of the basin, where the New Albany is 3000 feet or more below the surface, continues to pose a problem for our work. A partial solution would be to take the core in Hardin County where the New Albany is at shallow depth. Direct contract with a driller to take one or more of these shallow cores is possible, if suitable financial arrangements can be made. This may form the best alternative to getting a deep basin core.

It may prove to be difficult or impossible to process new core received later than the fall of 1978 in the time frame specified by the original proposal and contract.

New Albany Well Map and Tabulation

Progress

The listing of holes in the northeastern quadrant of the Illinois Basin is completed. Maps to a scale of 1:1,000,000 have been produced with locations plotted. Figure 3 shows the counties involved in the northeastern quadrant and indicates the total area completed to date.

The tabulation of drill holes through the Devonian black shale in the northwestern quadrant of Illinois is under way.

Stratigraphic Cross Sections

Progress

Stratigraphic cross sections have been essentially completed for several months, except for revising and refining of correlations as more data become available regionally. Supplementary cross sections are produced or extended as needed to help solve stratigraphic problems in certain areas. During the past quarter, supplementary north-south sections have been extended in central Illinois and along the eastern boundary of the state.

Isopach Maps

Progress

Tabulation of data on total thickness for the New Albany Group in Illinois is virtually complete (milestone 6). However, in many parts of the state, formational subdivisions of the New Albany are still only tentative and will require further detailed correlation work. Also, further work is needed in correlating some key geophysical horizons. A preliminary hand-contoured map of the New Albany Group thickness has been done for most of the state. Thickness contours have been drawn for formational units in some portions of the state, but these may be subject to revision as the greater regional picture is developed.

Discussion and Problems

Several stratigraphic problems have been encountered in recognition of mappable subunits on a regional basis. As a result of facies changes, contacts between formal stratigraphic units may need to be shifted vertically from one place to another. In some cases there is a transition zone through which the dominant lithology of one formation grades vertically to that of another, and there is no distinct contact between the two formations.

One stratigraphic nomenclatural problem arises from the lateral changes in the interval encompassing the Sweetland Creek and Grassy Creek Shales. In many areas distant from the center of the Illinois Basin, the distinction between these two shale formations becomes subtle to practically non-existent, being recognizable in neither geophysical logs nor sample lithologies. In these areas the entire interval is being left undifferentiated and tentatively referred to the Grassy Creek-Sweetland Creek Shales.

In central Illinois the succession from the Grassy Creek Shale to the overlying Saverton Shale is transitional through an interval several feet thick. This transition zone generally exhibits a low electrical resistivity, often only slightly higher than the Saverton above. However, the natural radio-activity of the zone is generally high, very nearly as high as that of the underlying Grassy Creek. Sample lithology, although variable, consists generally of relatively dark shales more similar to the Grassy Creek than the Saverton. For these reasons, the transition zone has in most cases been included with the Grassy Creek.

Stratigraphic problems also pervade the Saverton-Louisiana-"Glen Park"-Hannibal sequence in west-central Illinois. Several inconsistencies are apparent in past recognition of contacts between these formations. The most practical solutions to some of these problems are to define contacts on the basis of key beds that are readily recognizable on geophysical logs. Some past workers have evidently used this approach, although contacts defined in this way are not necessarily correlative with those defined in the type areas and may require some redefining of the age limits of some formations.

Considerable attention has been given to delineating the erosional boundaries of the New Albany Group. In much of west-central Illinois, the New Albany has been thinned by erosion and is disconformably overlain by Valmeyeran (middle Mississippian) strata—the Fern Glen Formation, or the Burlington Limestone. Near the northern limit of the New Albany, the overlying Mississippian rocks, as well as the New Albany itself, have been truncated and are disconformably overlain by Pennsylvanian strata. In some areas the New Albany is overlain by Pleistocene glacial drift.

Facies changes and truncation present special problems in contouring the thickness of the New Albany. The best approach to mapping is to subdivide the map into areas showing these special situations. Where the New Albany is essentially complete (conformably overlain by the Chouteau Limestone), contouring is relatively straightforward. It is, however, slightly complicated by lateral gradation of the Blocher Shale into the upper Lingle Limestone. Here, contours must be offset along an arbitrary vertical cutoff between Blocher and Lingle.

The greatest difficulties in contouring arise where the upper part of the New Albany has been eroded. Erratic distribution of thickness values indicates that the erosion surface is generally far from smooth. Furthermore, in most of the eroded areas, data are rather sparsely distributed, and many are of questionable reliability. For these reasons, in the eroded areas, a larger contour interval, depicting more generalized thicknesses, is probably in order.

Sample Studies

Progress

Sample studies of the New Albany in 35 strategically located wells were completed during February and March. Lithologic information from these studies was correlated with geophysical logs. Chips of various nonshale lithologies were collected for thin-section petrographic studies. Shale samples were taken from approximately 100-foot vertical intervals for vitrinite reflectance, clay mineralogy, and chemical analyses. Sampling was performed with great care to insure noncontamination.

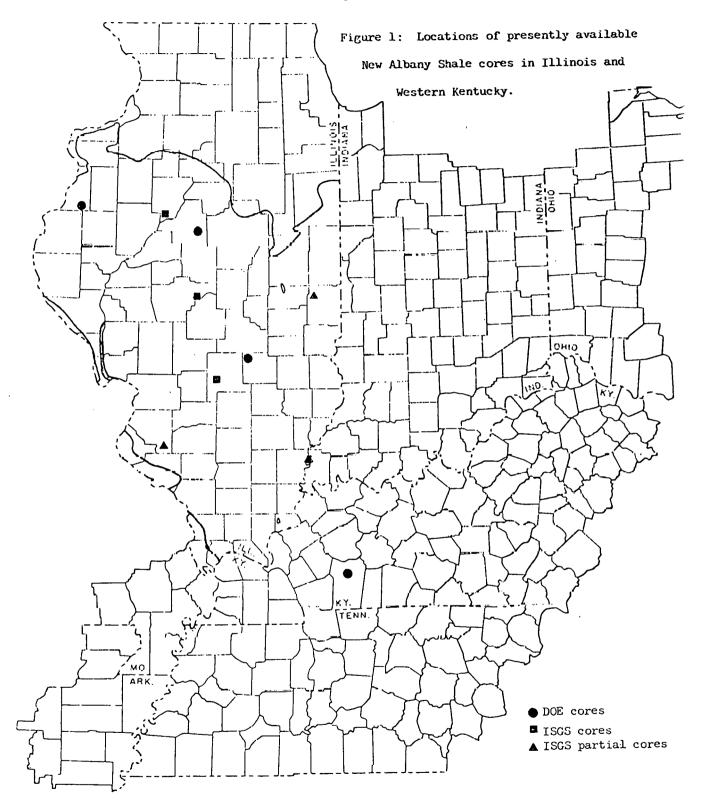
Problems

In a few wells, samples were unavailable for critical stratigraphic intervals. Contamination and mixing of the samples (during drilling) has made interpretation and sampling difficult or impossible in some cases.

Data Formats

Progress

With the recent finalization of data formats for stratigraphic data encoding, five counties in southwestern Illinois have been chosen for a test of the mapping function. The full data set for this area has been punched and will be used to test the data assembly capacity of the MINERS system. The first test maps will be produced during April.



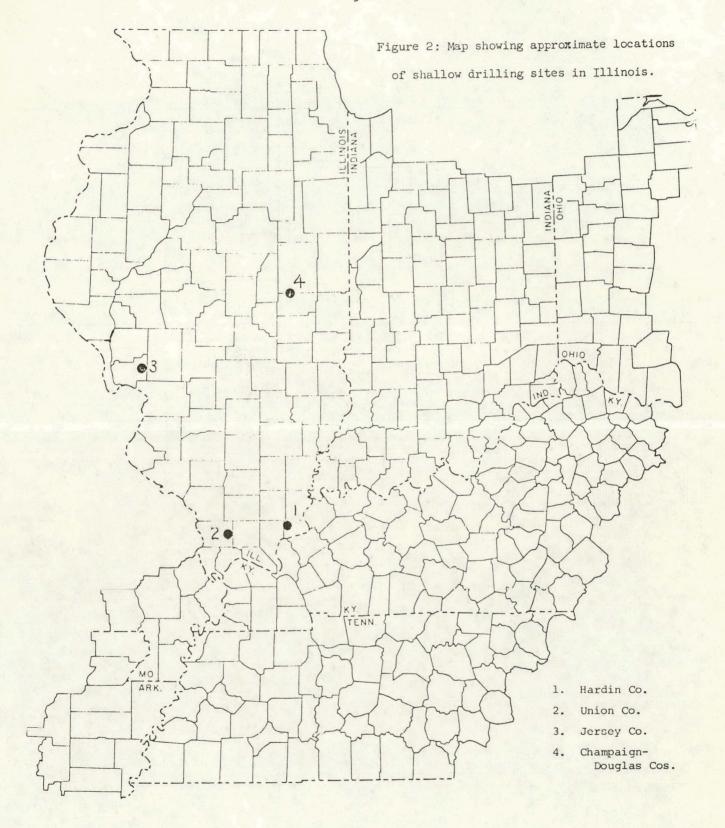




Fig. 3.

Index map showing portion of Illinois for which listing of holes penetrating upper Devonian shales has been completed. Maps showing location of these holes have also been plotted.

MINERALOGIC AND PETROGRAPHIC CHARACTERIZATION OF NEW ALBANY IN ILLINOIS

Introduction

This project is directed at characterizing in detail the mineralogic and petrographic properties of the New Albany Shale in Illinois. This includes the quantitative and qualitative characterization, by optical and X-ray techniques, of the inorganic mineral constitutents, the dispersed organic matter, and the fabric of the shale. The data generated will provide a fundamental basis for regional and local correlations of geologic data, for interpretation of the sedimentology, depositional environment, and diagenetic history, and for evaluation of hydrocarbon potentials based on the degree of thermal maturation of organic matter in the New Albany Shale.

Lithologic and Radiographic Characterization

Progress

Fifty-eight samples from the O4IL (Henderson Co., Illinois), O6IL (Tazewell Co., Illinois), and O7IL (Fayette Co., Illinois) cores were embedded in epoxy and slabbed during the last quarter. Radiography of these samples is still in progress.

Two cores from Survey files were described and sampled during February: one from Fayette County, Illinois (07IL), and one from St. Clair County, Illinois (09IL). Twelve samples were taken from these cores.

Approximately 189 samples of rotary drill cuttings from several wells in Illinois were picked during February and March. The distribution of samples was as follows:

Vitrinite reflectance: 51 samples Clay mineralogy: 53 samples Chemical analysis: 53 samples Thin-section petrography: 32 samples

Problems

Serious problems were encountered during the handling and initial water-sawing of the core samples. The low strength of the greenish-gray shales and their tendency to swell in water caused severe breakage and slaking. Many samples were reimbedded in epoxy between saw cuts, and this slowed our progress considerably. Radiographs of these samples are not expected to be of good quality. Severe difficulties in thin-section preparation are anticipated, and this may delay their preparation and/or reduce the number of thin sections made.

Microscopic Characterization

Progress

Thin-section analysis of the O2IL (Effingham Co., Illinois) core was completed in February. The data have been encoded for computer storage and handling, and a printout should be available soon. We will include a printout with our monthly report at that time.

Nine thin sections from the O3IL core (White Co., Illinois) were made during the quarter and are now being studied. Fifteen thin sections of well cutting samples were prepared, and a total of 33 thin sections of outcrop and well cutting samples were characterized during March. These samples are almost exclusively from sandstone and carbonate units below, within, and above the New Albany Group. Generally the thin sandstones within the New Albany Group are calcite cemented and do not appear to have significant porosity. The carbonate lithologies are quite variable and are principally of interest in deciphering the depositional environments of the shale and lateral facies transitions from shale to carbonate.

Fourteen samples from the OlKY (Christian Co., Kentucky) and the OlIL (Sangamon Co., Illinois) cores have been chosen for analysis with the Scanning Electron Microscope. Evaluation of various methods of sample preparation is in progress.

X-Ray Diffraction Mineralogy and Clay Orientation

Progress

Thirteen whole-rock samples from the O2IL core and 30 samples from the O4IL core were analyzed for silt mineralogy during February. The data are presented in tables 1 and 2.

Clay mineralogy has been determined for 30 samples from the 04TL core and for 22 samples from the 06IL core. The data are presented in tables 3 and 4. Clay orientation index slides are being prepared for all samples. The clay mineralogy of the two cores is very similar (fig. 1). Both are also similar to the 01IL and 02IL cores (fig. 2). At this time it appears that the New Albany contains more chlorite in the northern portion of the Illinois Basin than in the southern portion. Clay mineral analyses now in progress of well cuttings should allow us to map any regional variations more precisely.

Clay mineral analysis of a standard sample (SDO-1) provided by the U.S. Geological Survey was completed, and the data collected are presented in tables 5 and 6. The sample was divided into three splits, and four slides were made of each split: two by the smear technique (which we routinely use) and two by sedimentation. The results in table 5 are from the first slide from each group. Analyses of the duplicate slides are given in table 6.

As can be seen by comparing these two tables, the results within each group of samples are in good agreement, but there are significant diferences between the first set of slides and the duplicates that were run a few weeks later.

The following explanation accounts for the differences. To conserve energy, the heat is turned off in our X-ray laboratory overnight. The room temperature drops to about 24°C . This seems to be the temperature at which ethylene glycol can no longer enter between clay layers. Complete glycolation appears to occur at $26-27^{\circ}\text{C}$. The difference between the two sets of samples, therefore, is attributed to deglycolation during the night, which results in an apparent reduction of expandable clays when the slides are X-rayed early in the morning (before they re-equilibrate with the glycol atmosphere at higher, daytime room temperatures). This was a previously unsuspected source of error.

Vitrinite Reflectance

Progress

Reflectance analysis of the 02IL core was completed during January, and the results are summarized in table 7 and in figure 3. The reflectance values for this core are slightly higher than the 01KY and 01IL cores (fig. 4), which is consistent with its basinward position relative to those wells.

A single vitrain band was found within the 05IL partial core. Vitrains are generally a very reliable indicator of rank, and even this single sample is probably representative of the New Albany at that location. The measured reflectance of the sample (05IL01L4) was 0.47 ± 0.02 percent Ro.

A sample of New Albany Shale and associated vitrain from Marion County, Indiana, was provided by N. Shaffer of the Indiana Survey and measured during January. Both the macerated shale sample and the vitrain yielded identical results: 0.46 + 0.06 percent Ro.

Acid separation of dispersed coaly particles for vitrinite reflectance analysis was completed for a set of 8 samples from the 06IL (Tazewell Co., Illinois) core and 8 samples from the 04IL (Henderson Co., Illinois) core. Eight samples from the 07IL (Fayette Co., Illinois) and 21 samples from the supplementary drill cutting sets from various counties were acid digested during March. All samples are now being mounted and polished for reflectance analysis.

Problems

The greenish-gray shales in the O4IL and O6IL cores yielded very little organic matter. Additional samples will be processed if necessary.

Summary of Progress

Analysis of the 02IL and 03IL cores (milestone 16) is complete except for thin-section petrography of the 03IL core. Preparation of thin sections from the 03IL samples has been delayed because the initial sample preparation on the canned samples from the 04IL and 06IL core was deemed of higher priority.

Milestone 17 (acquisition of fluorescence equipment) has been deleted due to budget cuts directed by DOE.

Work towards milestone 18 (completion of 04IL and 05IL cores) is running slightly behind schedule, while work on milestone 19 (completion of 06IL core) is well ahead of schedule. All three cores will probably be completed more or less simultaneously.

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051F03C1	71.43	73,17	71.43	4.86	56,25	80 _ CE CE	≠4_ (P100)	47.62	45.05	46.67	
021L04C1	78.57	82.93	57.14	4,00	56,25	3.00	40 BASP	47.62	1000 499	1000.00	
021L04C2	85.71	68,29	45.71	80,00	62.58	6.20	39,46	71.43	72,73	89,70	
03110201	85,71	68,27	95,71	96,60	75,er	₹200	£6,21	95.24	72.73	66.67	
02118512	85.71	63,41	85.71	9,09	75.64	₩ _169.00	41.03	95,24	27.27	33,33	
051F09C1	85.71	65,85	85.71	6.86	87.58	3.00	12.62	71.43	54.55	44.67	
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021L07C1	188.88	63,41	71.43	80 ps	75.40	0,00	15.34	95_24	45.45	35.53	
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TABLE 2: SILT MINERALOGY; HENDERSON COUNTY, ILLINOIS, CORE SAMPLES (04IL).

DRSERVED PEAK HEIGHTS (COUNTS/SEC)

SAMPLE DEPTH	MCA	017	FLN	k g P	PLG	► 5P/PLG	CAL	סטר	CAL+DUL	SIU+APA	PYH	HAR	PYR+HAR	MINERAL
NUMBER	19,A	20.8	23,5	27.6	27,9		29.4	370.8		32,1	33.2	42.0		TWO THETA
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BAILPBC1	60	150	55	75	И	100/ 2	N	265	265	10	17	И	17	
04 I L Ø 7 C 1	7 y	100	65	75	a	100/ 3	И	252	225	24	26	Ø	56	
04IL08C1	64	90	55	45	ø	1007 8	Ø	2710	240	15	96	ย	6 L	
941L89C1	64	100	50	6.5	Ø	100/ 0	Ŷ,	160	169	17	15	14	15	
DAILIDGI	7.15	116	5 M	65	ř,	idus u	ν	135	135	15	18	14	10	
741L11C1	69	185	45	ħЙ	Ø	1707 0	a	169	165	15	8.0	ย	211	
BAILIZCI	68	115	45	70	9	1001 4	9	165	163	15	52	8	25	
04111301	60	110	50	7 (4	6	1887 6	n	150	150	10	а	Ø	Ø	
041L14C1	65	105	50	7 11	Ø	130/ 0	e	125	125	15	25	N;	25	
84 IL 15C1	85	165	56	45	45	50/ 50	×ν	45	65	25	17	i)	17	
341L16C1	75	175	3.5	56	а	100/ 0	5.9	70	918	25	15	0	15	
841L17C1	8.0	195	25	50	40	55/ 44	25	75	140	а	15	Ø	15	
741L18C1	80	190	25	50	45	52/ 47	2.5	49	65	50	15	а	15	
74 IL 19C 1	8.0	190	35	58	45	52/ 47	5 //	45	65	Ø.	Ø	9	Pt.	
841L2°C1	75	160	26	70	a	100/ 0	24	50	70	15	25	5	30	
84IL21C1	ጸብ	135	25	50	50	50/ 50	64	96	90	30	17	Ø	17	
112501	75	140	25	50	50	54/ 54	30	95	125	30	40	Ŋ	48	
041L23C1	75	125	30	54	50	50/ 50	Ø	90	90	30	30	5	35	
12451148	75	145	25	64	55	52/ 47	25	160	185	35	25	5	30	
04112501	75	120	30	5 N	50	50/ 50	61	200	280	0	15	Ü	15	
041L26C1	70	135	29	411	40	50/ 5H	54	65	85	25	35	19	45	
041L27C1	66	75	20	25	20	55/ 44	15	500	515	15	25	9	25	
13851149	70	95	20	25	15	62/ 37	60	500	569	ē	15	ű	15	
04IL29C1	20	175	- 5	25	P	100/ 0	590	500	1000	5	55	Ø	55	
041L30C1	50	40	ē	0	P	8/ N	a	500	500	.a	10	P	10	

RELATIVE PEAK HEIGHTS

SAMPLE	MCA	OTZ	FLO	KSP	Pl.G	C & L	nnı	diutant	o à o	μĀĢ	MINERAL
NUMBER	19,8	80.8	23,5	27.6	27.9	29.4	30,8	32.1	33,2	52.0	THO THETA

04110151	76.49	64.10	76,92	82.35	0.00	0,00	49.00	42.86	21.82	0.00	
04110201	70.59	74.36	55.85	76.47	0 00	0.00	56,00	57.14	45.45	6.60	
24110301	70.99	56.01	61.5 <i>0</i>	49,71	0.60	0.00	78.00	60.50	21.21	0,8 0	
041L04C1	76.47	53,85	69,23	A2.35	0.00	0.00	06.00	34.29	18,18	บ. ดด	
04110501	64.71	61.54	49.23	76.47	ผู้ผล	0.40	72.00	34.29	36.36	9.80	
04110601	70.59	61.54	84.62	88.24	8.89	0.00	53.00	28.57	30.91	0.00	
041L87C1	82.35	51.28	100.00	88.24	0.00	8.00	45.00	57,14	36,36	9.90	
09110861	76.31	46.15	64.62	146,64	0.00	8.00	48.80	42.86	36,36	0.00	
94118961	70,59	91,28	76,92	74.07	0.00	0.00	32,00	48.51	27,27	ம். ம்மி	
04111001	82.35	56.41	76,92	76,47	0.80	8.00	27.00	34.29	18,18	0.00	
041L11C1	70.59	53,85	69.23	70.59	8.88	0.00	33,00	42.86	36,36	v . na	
841L12C1	70.59	58,97	85,84	A2,35	0.00	0.40	33,00	34.29	45.45	6.88	
041L13C1	70.34	36.41	16.45	82,35	6.40	0.00	30.00	28.57	0.00	ଓ ୍ଟମ	
BAILIACI	76.47	53.85	76,92	82.35	0.00	0.00	25.00	42.86	45.45	อ.นด	
04IL15C1	188.00	84.62	40.00	52,94	A1.82	4.00	9.00	71.43	30.91	0.40	
841L16C1	88.24	89.74	53,85	58.82	0.00	4.00	14.00	71.43	27.27	0.00	
84111761	94.12	190.00	38.46	58.82	72.73	5.00	15.00	6.66	27.27	ଜ୍ଜର	
841L18C1	94.12	97.44	38.46	58.82	61.82	5.00	4,00	57.10	27.27	(g) is co	
04111901	94 12	97.44	53,85	58.62	81,82	4.00	9.20	0,66	0.00	ผ ู้ผล	
041L20C1	88,24	82.05	39.77	A2.35	0.00	4.00	10,00	34,29	45.45	50.00	
04IL21C1	94.12	69.23	38.46	58.82	90.91	0.00	18.00	A5.71	30,91	0.09	
04IL22C1	88.24	71.79	38.46	58.82	90.91	6.00	19.88	85.71	72.73	0.00	
041L23C1	88.24	64.19	46.15	58.82	90.91	0.00	18.00	85.71	54,55	54.04	
04IL24C1	88.24	74.36	38.46	70.59	100.00	5.00	32.00	100.00	45.49	50.00	
041L25C1	88,24	61.54	46.15	58.82	90.91	0.00	40.00	4.00	21.21	0.00	
041L26C1	82.35	69.23	30.77	47.06	72.73	4.00	13.00	71.43	63.64	100.00	
04112761	70.59	38,46	30.77	29.41	36,36	3,00	100.00	48.50	45.45	u.88	
04112801	82.35	48.72	30.77	29.41	21.27	12.00	100.00	0.00	27,27	9.00	
04IL29C1	23,53	89.74	7.59	29.41	0.00	100.00	100.00	14.29	100.00	0.00	
041L30C1	23.53	20.51	0.00	0.00	8.80	0.00	100.00	0.00	18,18	ท. ยต	•

TABLE 3. CLAY MINERALOGY, HENDERSON COUNTY, 'ILLINOIS CORE SAMPLES (041L)

Sample	Depth*	Clay	Minerals (pa	arts/10)+
Number	(ft)	Illite	Chlorite	Expandables
01C1	323.3	7.5	2.5	0.0
02C1	333.0	6.0	2.0	1.5
03C1	343.4	5.5	2.5	2.0
04C1	353.0	6.0	2.5	1.5
05C1	363.3	5.5	2.0	2.5
06C1	373.2	5.5	2.5	2.0
07C1	383.4	5.0	2.0	3.0
08C1	393.1	5.0	2.5	2.5
09C1	403.5	5.0	2.0	3.0
10C1	413.4	6.0	3.0	1.5
11C1	424.4	5.5	-3.0	1.5
1201	433.3	6.0	2.5	1.5
13C1	443.2	6.0	2.5	1.5
14C1	453.0	6.5	2.5	1.0
15C1	463.2	5.5	2.5	1.5
16C1	473.0	5.0	2.0	3.0
17C1	482.4	5.0	2.5	3.0
18C1	493.2	5.0	2.5	2.5
1901	503.2	6.5	2.0	1.0
20C1	513.4	6.5	2.0	1,5
21C1	523.2	6.5	2.0	2.0
22C1	533.0	5.5	2.5	1.5
23C1	542.2	5.0	2.5	2.5
24C1	553.4	6.5	2.5	1.5
25C1	563.2	6.5	2.5	1.5
26C1	573.0	6.0	2.5	1.5
27C1	583.4	6.0	2.5	1.5
28C1	493.2	5.5	2.5	2.0
29C1	604.5	6.5 [#]	1.5	2.0
30C1	613.3	6.0 [#]	2.0	2.0

^{*}Depth (to top of sample) below drilling reference at 772 ft. above mean sea level.
+Kaolinite was not detected in these samples.
#Illite is poorly crystalline.

TABLE 4. CLAY MINERALOGY, TAZEWELL COUNTY, ILLINOIS

CORE SAMPLES (04IL)

Sample Number	Depth* (ft)	Clar Illite		(parts/10)+ Mixed-Structure
			7 m : m em -	
04C1	933.4	4.5	2.0	3.5
. 05C1	943.5	7.5	2.0	0.5
06C1	954.0	5.5	2.0	2.5
07C1	962.2	5.0	2.0	2.5
0801	9/3.4	5.5	2.5	2.5
09C1	984.2	5.5	2.5	2.0
10C1	993.1	5.0	2.5	2.5
11C1	1003.2	6.0	3.0	1.0
12C1	1014.1	6.5	3.0	1.0
13C1	1024.1	6.0	2.5	1.0
14C1	1034.2	6.0	2.5	1.5 ·
15C1	1044.1	6.0	2.5	1.5
1601	1053.2	0.5	2.0	1.0
17C1	1063.2	6.5	2.0	1.5
18C1	1073.3	6.5	2.0	1.0
19C1	1083.2	7.0	2.5	0.5
20C1	1093.4	6.0	3.0	1.0
21C1	1103,1	6.5	2.5	1.0
22C1	1113.4	6.5	2.5	1.0
23C1	1123.5	6.5	2.5	1.0
24C1	1133.4	6.0	2.5	1.5
25C1	1143.5	6.0	1.5	2.5

^{*}Depth (to top of sample) below drilling reference at 641 feet above mean sea level.

⁺Kaolinite was not detected in these samples.

TABLE 6. CLAY MINERALOGY, USGS STANDARD SAMPLE SDO-1; DUPLICATE SLIDES

Slide Preparation		Clay Minerals (parts/10)							
Technique	Split	Illite		Mixed-Structure					
Smear			-						
	Α	5	2	2	0.5				
	В	5	2.5	2	0.5				
	С	5.5	1.5	2	0.5				
Sedimented				•					
	Α	6	1.5	2	0.5				
	В	5.5	2	2	0.5				
	С	5	1.5	3	0.5				

TABLE 5. CLAY MINERALOGY, USGS STANDARD SAMPLE SDO-1

Slide Preparation		Clay Minerals (parts/10)							
Technique	Split '	Illite		Mixed-Structure					
_									
Smear									
	Α	6.5	2.5	tr	0.5				
	В	7	2.5	0	1				
	С	6	2	1.5	0.5				
Sedimented									
	Α	7	2	0.5	0.5				
	В	6	2	1	0.5				
	С	7	1.5	1	0.5				
•									

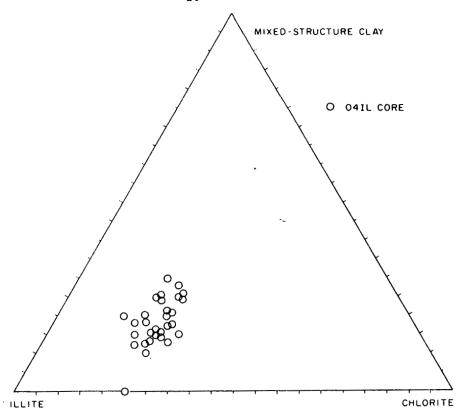
- 20 -

TABLE 7. VITRINITE REFLECTANCE EFFINGHAM COUNTY, ILLINOTS, CORE SAMPLES (021L)

Sample	Depth*	#	Ro(%)	Std.
Number	(ft)	Readings	Average	Deviation
01C1	3011.4	45	0.66	0.14
0201	3021.4	50	0.52	0.07
03C1	3043.3	50	0.44	0.07
03C1	3043.3	51 ⁺	0.49	0.03
04Cl	3053.0	26	0.49	0.06
04C2	3059.5	29	0.47	0.07
OPCI	3065.3	31	0.48	0.06
05L2	3071.5	. 26	0.47	0.08
06C1	3073.3	50	0.48	0.07
06L2	3081.1	27	0.52	0.09
07C1	3085.6	.36	0.51	0.10
08C1	3096.7	50 ⁺	0.56	0.03
·				

^{*} Depth below logging reference @ 612.1 ft. above mean sea level.

⁺ Handpicked sample from vitrain band lying on bedding plane (not macerated).



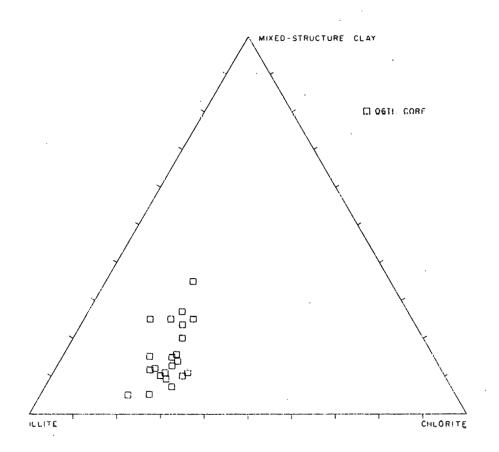
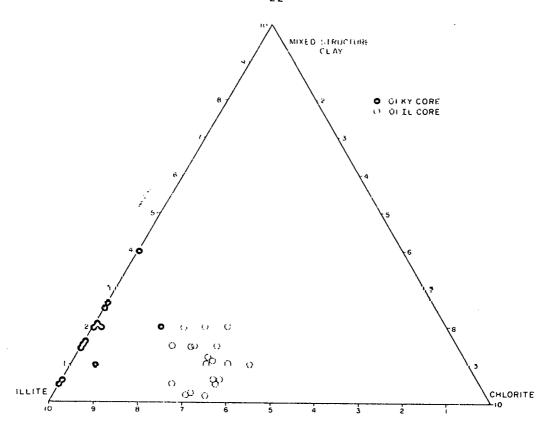


Fig. 1. Clay mineralogy: 04IL and 06IL cores.



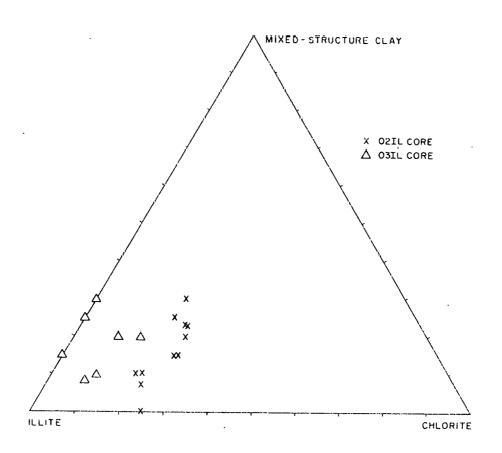


Fig. 2. Clay mineralogy: OlKY, OlIL, 02IL, and O3IL cores.

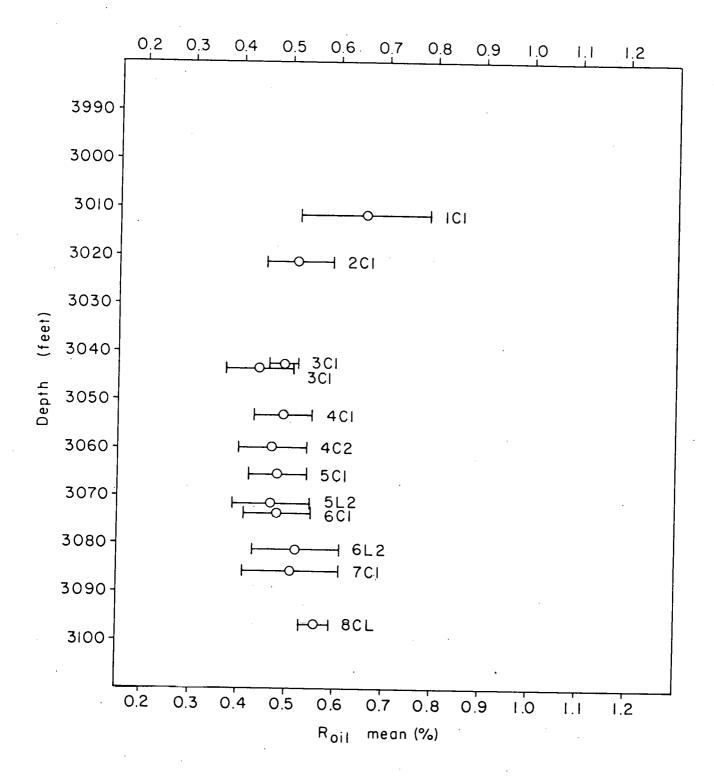


Fig. 3. Mean-random vitrinite reflectance, in oil, Effingham County, Illinois core samples (O2IL). Error bars correspond to + one standard deviation. Depths are below reference level of 612 feet above mean sea level.

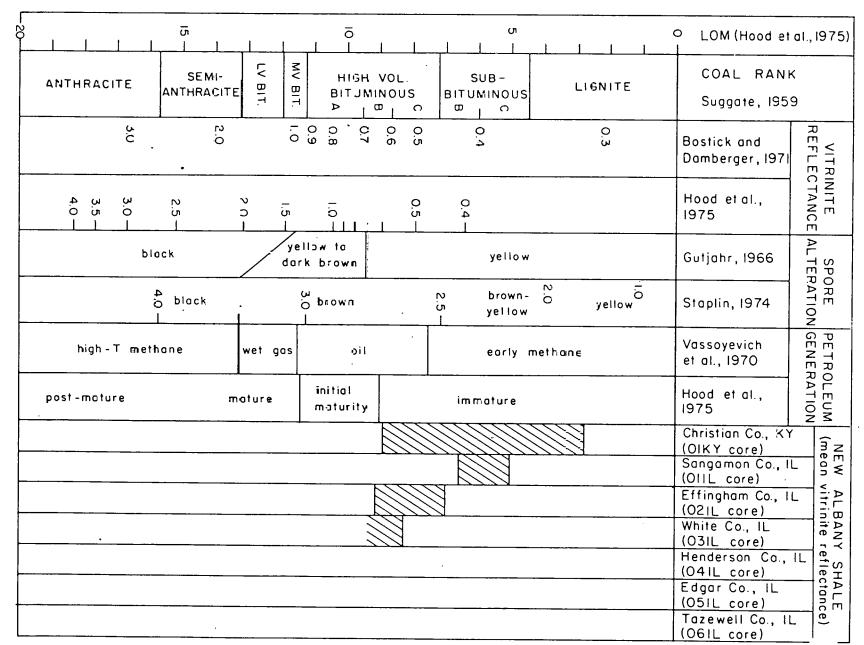


Fig. 4. Relation of of vitrinite Basin petroleum generation New Albany level of Shale organic spore samples. spore coloration, to reflectance, metamorphism (LOM), (LOM), coal rank, , and principal stages observed from Illinois

PHYSICAL CHARACTERIZATION

Introduction

This project is a study of the index properties, directional properties, and strength of oriented core of Devonian black shale from the Illinois Basin. Index properties include moisture content, specific gravity, bulk density, and Shore hardness. Directional seismic velocities will be determined with an acoustical bench. Strength tests include point-load fracture strength and indirect-tensile strength (Brazilian split). Fracture frequency, drilling rate, and core recovery are also compiled as an additional mechanical index.

Destructive Testing

Testing Procedure

All destructive testing for this study is being performed on a Tinius-Olsen Model 300CT-1 compression testing machine. The machine has electronic-load indicator and servo controls (fig.1). A specially designed subpress with interchangeable flat and point-load platens was used in the load frame for each of the two types of tests being run.

Figures 2 and 3 are typical examples of test results, showing the data-recording sheet and the load-deformation curve. The load curve has proven to be a good record of the test quality as well as a characterization of distinctive modes of failure for the various lithologies designated. While not specifically a part of this study, an analysis of the loading curves is in progress and will be presented at a later date.

The point-load tests are performed with quickly applied compression (approximately 8 cm/min), and the test value is recorded as the point-load index (load at failure divided by the sample thickness squared). The loading points of the compression machine are hardened 60-degree cones with a 5-mm radius point. Point-load samples are approximately half the core diameter in thickness with ends machined to within 0.05 cm parallelism. Sample preparation for the point-load test is not critical, as the credibility of the test is usually determined by splitting subparallel to the bedding. This splitting is caused by irregular bedding, fossils, mineralized nodules, or coring-induced fractures. The fast test rate (maximum machine rate) is the only control that has tended to minimize the effect of splitting.

The indirect-tensile tests are performed at a slow deformation rate (approximately .001 cm/min), and the test value is recorded as the tensile strength (2 x load divided by the sample diameter x sample thickness x π). The platens are flat with no cushion. Where the core has very irregular sides (core 02IL only), a thin fiber board cushion was used. As with the point-load test, splitting due to geologic flaws was a problem. There are too few comparable samples (lithology and orientation) to quantitatively assess the influence of this splitting on the test results.

Progress

Core 01KY

The destructive testing and initial analysis of core OlKY has been completed. In summary, there is a preferred orientation (northwest-southeast). The degree of expression and the orientation appear to be controlled by the lithology.

Near-vertical, natural fractures were noted in 22 of the 172 samples tested. The general direction of fracture orientation is northwest-southeast with 13 fractures oriented $135^{\circ}/315^{\circ}+20^{\circ}$, and 7 fractures oriented $90^{\circ}/270^{\circ}+10^{\circ}$. Figure 4a summarizes these data.

The point-load test was performed on 75 samples, most of which were lithologies III (poorly laminated brownish-black shales) or IV (finely laminated brownish-black shales). Figure 5 shows the position of the resulting fractures. The fractures resulting from the point-load tests show a preferred orientation of 130°/310° for lithologies III and IV (poorly laminated and finely laminated brownish-black shales). Lithology II (indistinctly bedded olive-gray shales) had only 10 samples and showed considerable scatter in orientation relative to lithologies III and IV (see figs. 4b,c,d).

The indirect tensile test was performed on 97 samples. Figure 6 summarizes the results. The preferred orientation shown by the indirect tensile strength (normal to axis of testing) is generally compatible with the point-load test data. However, the relative preference (fig. 6) is small (ratio of maximum value to minimum is 1.16) for all test values. Furthermore, subdivision by lithology is inconclusive at this point due to the small number of samples available for testing.

Core 02IL

As a result of poor core recovery and questionable orientation of available core, the results of the destructive testing are of questionable value. Figure 7 shows that one-third of the core was either broken or lost at the time of drilling. Another one-third of the core was either unoriented or unable to be oriented (had multiple orientation grooves or spiraling orientation grooves). Where questionable core was oriented, it was done by comparison with adjacent oriented core.

In summary, this core is of questionable value for orientation work and should probably be regarded as an unoriented core.

The distribution of destructive test samples by lithology is as follows:

	Lithology							
Test	$\frac{II}{a}$	$\frac{II_{b}}{}$	III _a	III _b	IV _a	IVb		
Point-Load	5	-	2		22	2		
Indirect- Tensile	2	2	1	3	29	-		

 $$\operatorname{As}$$ with core OlKY, most of the samples are the brownish-black shale (lithologies III and IV).

The results of the point-load tests (figs. 8 and 9) show a preferred orientation northeast/southwest. The core had nine data sets, two of which, 02IL06 and 02IL07, offered no destructive test samples. Furthermore, data sets 02IL01 and 02IL09 are largely the limestone from above and below the New Albany.

The indirect-tensile test was performed on 37 samples. Figure 10 summarizes the results. There is a preferred orientation indicated. This is compatible with the point-load test results; however, it is based on a small number of samples.

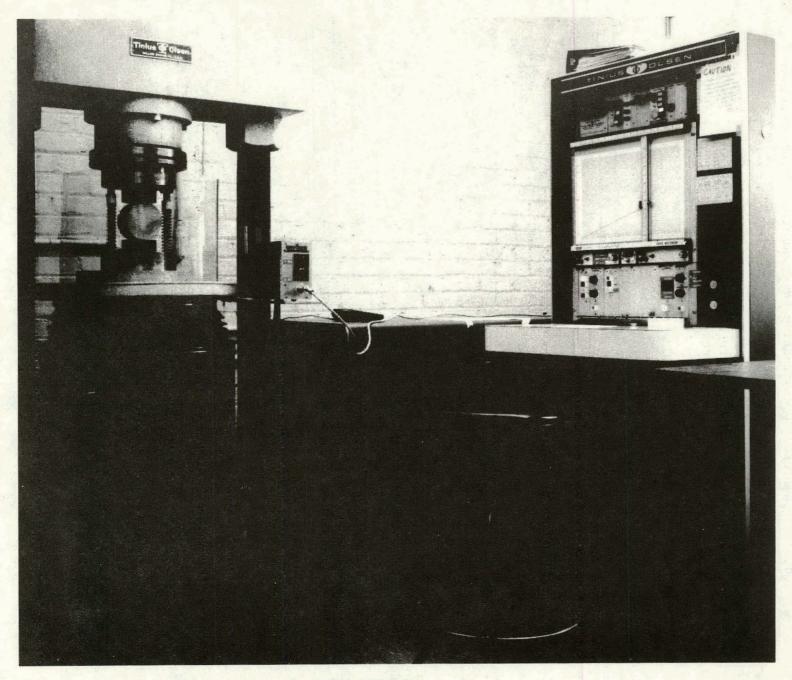


Fig. 1. Compressior Testing Machine, Model 300CT-1.

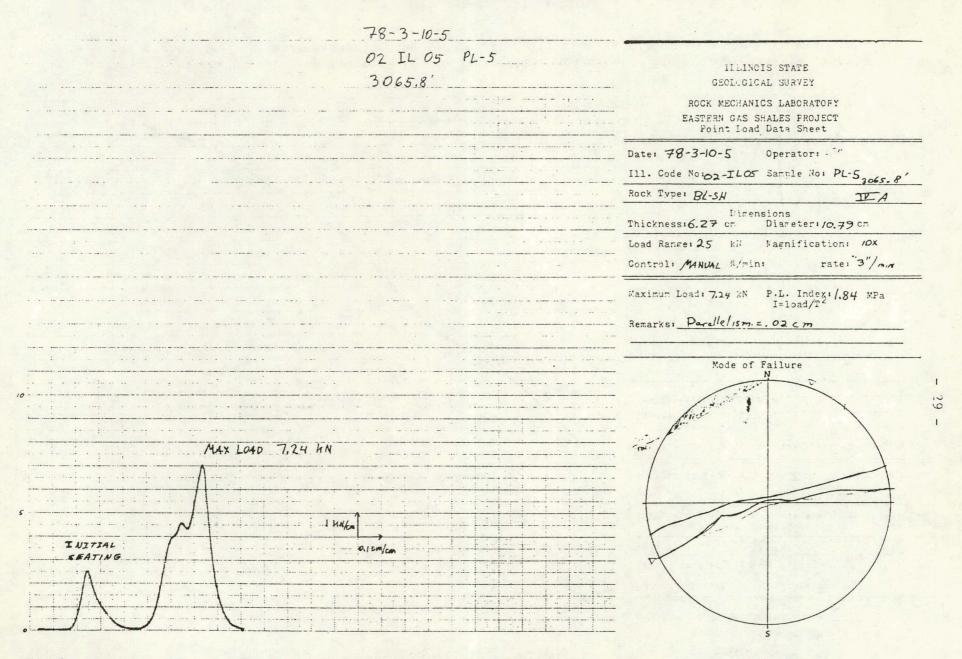


Fig.2. Example of a point-load test data sheet. A typical load deformation curve shows a peak for the initial seating of the point followed by loading to failure. The orientation of the resulting fracture(s) is shown at the right as "mode of failure."

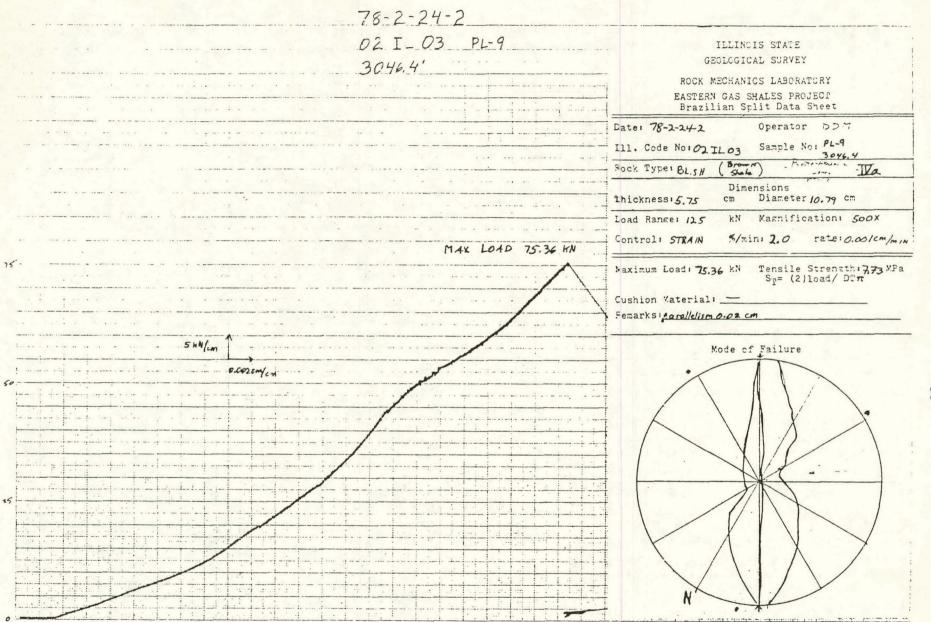


Fig. 3. Example of an indirect-tensile test (Brazilian split) data sheet. The mode of failure diagram at the right shows the test direction and the resulting fractures, relative to the core orientation.

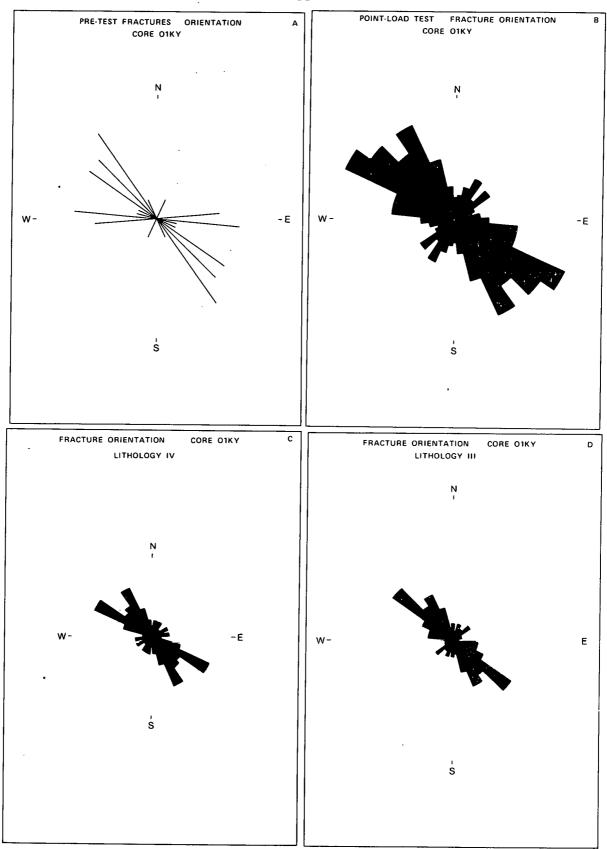


Fig. 4. Frequency plot of fracture orientations core OlKY.

- a) natural fractures
- b) point-load fractures, all tests
- c) point-load fractures, finely laminated brownish-black shales
- d) point-load fractures, poorly laminated brownish-black shales

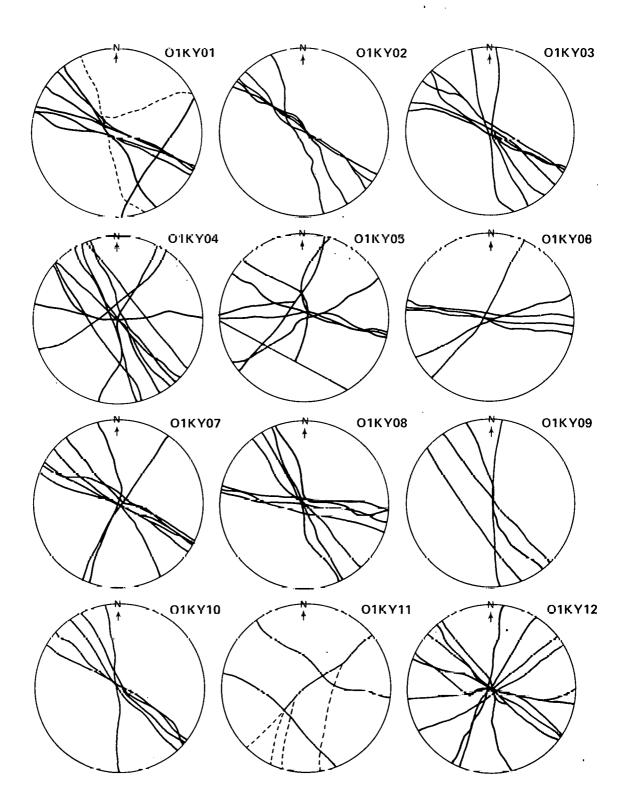
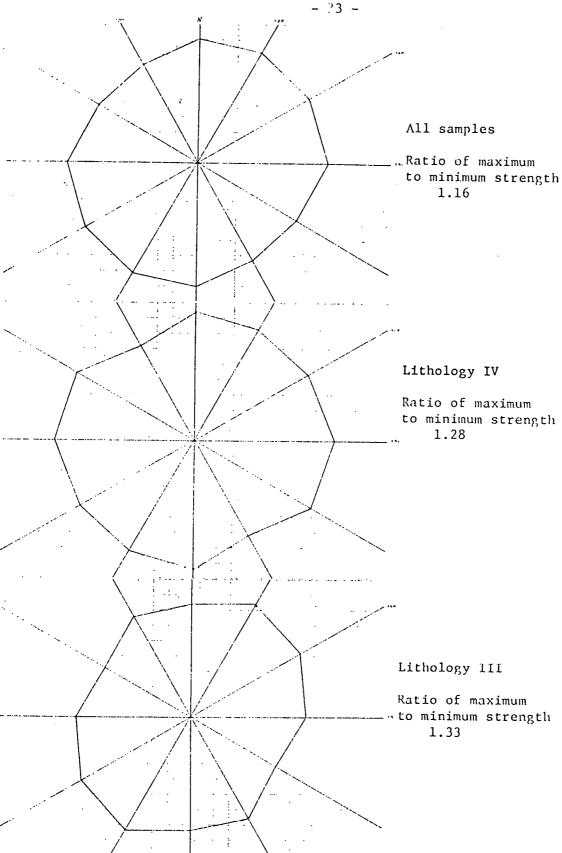


Fig. 5. Position of fractures resulting from point-load testing, lithologies II, III, IV, core OlKY. Fractures resulted from a point load applied at the center of the circle (core).



Relative preference of orientation of indirect-tensile strength. The average strength for each of the six test directions is proportional to the distance from the center of the diagram.

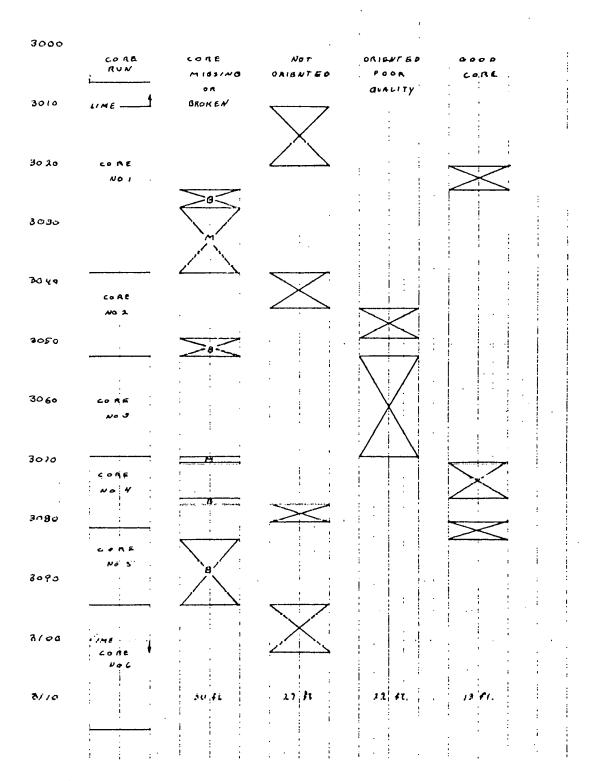


Fig. 7. Quality of oriented core, core 02IL.

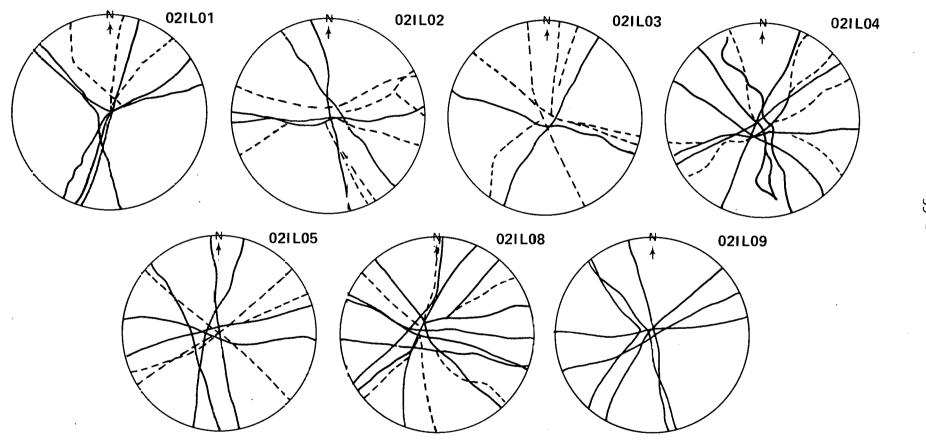


Fig. 8. Position of fractures resulting from point-load testing, lithologies II, III, IV and limestone, core O2IL.

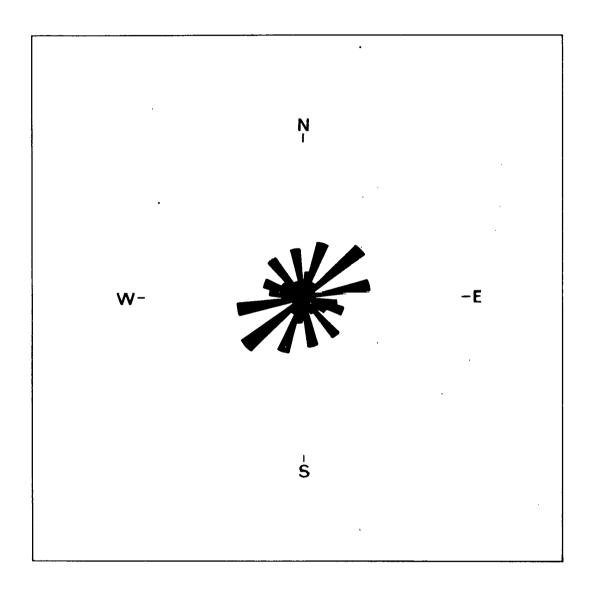


Fig. 9. Frequency plot of fracture orientations, core 0211.

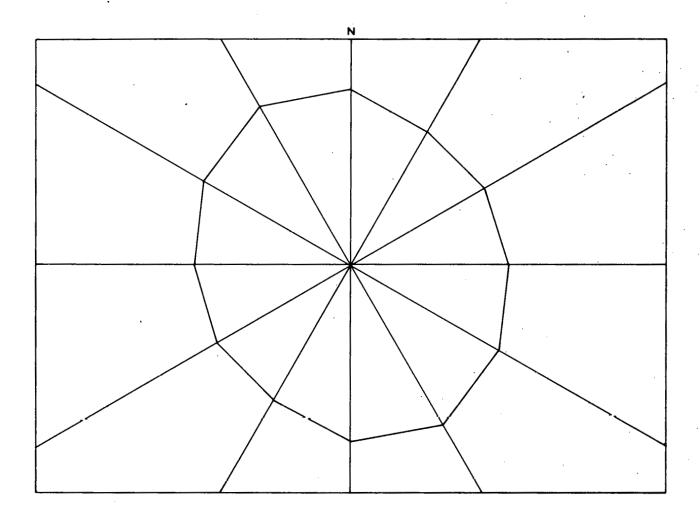


Fig. 10. Relative preference of orientation of indirect tensile strength, lithologies II, III, IV and limestone, core 02IL.

GEOCHEMICAL CHARACTERIZATION

QUANTITATIVE DETERMINATION OF MAJOR, MINOR, AND TRACE ELEMENTS IN SHALES

Introduction

Determine not less than 49 major, minor, and trace elements in 300-500 shale samples, which are representative cross sections of the cores taken. Include organic and mineral carbon; total hydrogen; pyritic*, sulfate*, and total sulfur; exchangeable cations (Ca, Na, K, Mg); and base exchange capacity. Also, report other elements observed during normal routine analysis. The data generated will be used to evaluate 1) the potential economic importance of trace element concentrations in organic-rich shales, 2) new geochemical exploration techniques for natural gas, 3) trace element enrichment in shale organic matter, 4) the occurrence of heavy metal sulfides in shale, 5) potential catalytic effects of trace elements on shale pyrolysis yields, and 6) potential disposal problems.

* Where total sulfur exceeds 0.5%

Elemental Analysis

Progress

Attached is the latest computer print-out of chemical analyses completed and entered as of March 1978. The print-out data are comprised of an updating of results previously reported for 37 core samples and results of analyses of 20 new shales. Statistical evaluations, interpretations etc. must await completion of additional analyses. In this regard, analytical progress is on schedule and no unsolvable problems are foreseen at this time.

TRACE ELEMENT DISTRIBUTION IN ORGANIC AND INORGANIC FRACTIONS OF SHALE

Introduction

Develop chemical and/or physical methods for the separation of the organic and inorganic phases of shales, and determine the trace elements that are associated with each phase. Methods tested include float-sink gravity separations, mechanical separations (Humphrey Spiral), acid extractions, and zonal centrifugation. Compare results of analyses for ten shales, their gravity fractions, and their separated organic phases to determine the elements closely associated with organic matter. Separation procedures that are most promising will be used to study further the organically combined trace elements in additional shale samples. This research is designed to yield new information concerning chemical variations in shale organic matter, which is the shale component about which little is known and which may be the most characteristic feature of gas-bearing shales.

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	\$102 (%)	ALPC3 (1)		FE AS % FE2D3 (NAA)	MGC (X)	CAO (%)	NA A5 % NA20 (NAA)	K20 (%) (XRF)	# AS % K20 (naa)	T102 (%)	P205 (%)	MN (PPM) (NAA)	
389881	81×Y81C1		53.2	10.1	6.85	7,46	.74	.14	.74	3.06	3.52	.56	.16	116	
6.5	8261	219:,1	59.3	9.65	5.40	6.88	1.21	1,63	.65	2.71	3.76	.52	. 66	310	
23	0301	2550.3	57,8	9.93	7,21	7.66	1.08	1.60	.68	2.76	3.24	.54	. 12	296	
94		5530.5	62,8	15,2	3,91	3,69	1.49	.56	.65	4.22	4.54	.71	4 .01	276	
P:5		2546.1	48,8	10.0	7.74	16.2	1.69	7.32	.74	2,61	2.75	. 45	4.25	410	
86		2250.0	20.14	16.9	4.47	5.30	1.95	1.25	,98	4,31	4.84	. 53	.07	366	
P. 7		5595.3	49.5	13.5	6.23	6.38	1.05	.26	.77	3.93	4.19	.74	.07	160	
8 9		2276.3	57,9	14.3	3,37	3,14	2.10	2.23	,92	4.23	a.a.	.73	.13	190	
6.9		2288.0	51.9	11,5	3.68	4.27	3,59	4.51	.63	3.49	3.46	.71	. 7 1	366	
18		2296.7	53.7	11.5	2,64	3,11	2.83	3,69	, 75	3.81	4.36	. 4.6	. 95	586	
11		2299.7	45.0	9.77	4.25	4.79	4.75	7.50	. 47	2,99	3,53	.52	.19	488	
12		2318.5	51.6	R.44	3.15	3,29	4.31	7.51	.56	2.87	3.34	, 43	. 15	322	
13	1301	2318.8	46.2	7.67	3.79	3,67	4.26	11,7	.45	5.61	3,05	.35	.19	360	
33	BBLI	2273.5	55.2	14.5	5.05	5.46	1.42	1,69	. 84	4.14	5.00	.71	.12	260	
34		8.7855	54,3	11.9	2.97	2.88	3,62	5.67	,75	3,62	4.35	.71	. 03	360	
35		5545.4	51.8	13.9	3.42	3,62	3.47	5,58	. 78	3.53	3.96	,63	.04	332	
36		2311.1	49.8	8,37	5.45	2,97	4.25	10.3	,53	2.64	3,03	.37	.19	378	
37	13L1	2312.6	49.8	7.59	3.05	3.33	4.19	9,32	.53	2,63	3.86	.36	.25	360	
			МŅ (РРМ)	V (PPH)	V (PP4)	S (X)	CL	TOTAL	ORGANIC	INORG.		TOTAL CEC	88 (PPM)	AS (PPM)	
			MN (PPM) (OE=P]	V (PPM) (OE-D)	V (PPM) (DE=P)	s (x)	CL (%)	TOTAL C (%)	ORGANIC C (%)	INORG. C (%)	(X)	TOTAL CEC MED/10PG	88 (PPM)	AS (PPM)	
566961			MN (PPH) (OE-P)	V (PPM) (OE-D)	V (PPM) (DE=P)	s (x)	CL (%)	TOTAL C (%)	ORGANIC C (%)	INORG. C (%)	(X)	TOTAL CEC	88 (PPM)	AS (PPM)	
65			MN (PPM) (OE-P) 12P 29A	V (PPM) (OE-D) 16P 14P	V (PPM) (OE-P) 202 167	s (x) 2,42 1,84	.02 .02	TCTAL C (%)	ORGANIC C (%) 14.03 10.29	: INORG. C (X) .10 .57	(X)	TOTAL CEC MED/12PG	88 (PPM) 4.9 3.3	A5 (PPM) 68 38	
Ø 2 Ø 3			MN (PPM) (OE-P: 12° 290 220	V (PPM) (OE-D) 16M 140 173	V (PP4) (OE-P) 202 162 163	S (X) 2,42 1,84 1,93	. 02 . 02 . 02 . 02	TCTAL C (X)	ORGANIC C (X)	INORG. C (X)	(X)	TOTAL CEC MED/12PG	88 (PPM) 4.9 3.3 5.6	A5 (PPM)	
© 2 Ø 3 Ø 4			MN (PPM) (OE-P: 12P 29A 22A 26A	V (PPM) (OE-0) 16P 14P 172 150	V (PPM) (OE-P) 200 167 163	8 (x) 2.42 1.84 1.93	. 02 . 02 . 02 . 01 . 02	TCTAL C (%) 14.13 10.86 7.78 2.24	ORGANIC C (%) 14.03 10.29 7.03 1.64	: INORG. C (X) .10 .57	1.93 1.43 1.27	TOTAL CEC MEQ/19PG 4.7 3.4	88 (PPM) 4.9 3.3	AS (PPM) 68 38 42 17	
02 03 04 P5			MN (PPM) (OE-P: 12P 29A 22A 26A 34A	V (PPM) (OE-O) 16P 14P 172 150 129	V (PPM) (OE-P) 200 160 160 150 120	S (X) 2.42 1.84 1.93 .35 2.27	. 02 . 02 . 02 . 02 . 01 . 02 . 02	TCTAL C (%) 14.13 10.86 7.76 2.24 7.01	ORGANIC C (%) 14.03 10.29 7.03 1.64 5.81	.10 (x) .10 .57 .75 .60	1.93 1.43 1.27 .74	TOTAL CEC MED/10PG 4.7 3.4 4.7 5.1 3.2	88 (PPM) 4.9 3.3 5.6 1.8 4.2	AS (PPM) 68 38 42 17	
02 03 04 P5 06			MN (PPM) (OE-P) 12P 29A 22A 26A 34A 310	V (PPM) (OE-D) 160 140 173 150 129 150	V (PPM) (OE-P) 200 160 160 150 123	S (X) 2.42 1.84 1.93 .35 2.27	. 02 . 02 . 02 . 02 . 01 . 02 . 02 . 02	TCTAL C (X) 14.13 10.86 7.78 2.24 7.01 1.69	ORGANIC C (%) 14.03 10.29 7.03 1.64 5.81	.10 (x) .10 .57 .75 .60 1.20	1.93 1.43 1.27 .74 .91	TOTAL CEC MEQ/10AG 4.7 3.4 4.7 5.1 3.2 7.3	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4	AS (PPM) 68 38 42 17 37 9.8	ا ع
02 03 04 P5 06 07			MN (PPM) (DE-P: 12P 29A 26A 26A 34A 31A 150	V (PPM) (OE-0) 160 140 173 150 129 150 >560	V (PPM) (OE-P) 200 167 150 150 150 450	S (X) 2.42 1.84 1.93 .35 2.27 .22 1.74	. 02 . 02 . 02 . 03 . 02 . 02 . 02 . 02 . 02	TCTAL C (%) 14.13 10.86 7.78 2.24 7.81 1.69 12.61	ORGANIC C (%) 14.03 10.29 7.03 1.64 5.81	. INORG. C (X) .10 .57 .75 .60 1.70 1.73	1.93 1.43 1.27 .74 .91 .59	TOTAL CEC MEQ/100G 4.7 3.4 4.7 5.1 3.2 7.3 5.0	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4	AS (PPM) 68 38 42 17 37 9.8	S
02 03 04 05 06 07 08			MN (PPM) (OE-P) 12P 29A 22A 26A 34A 31A 15B	V (PPM) (OE-D) 160 140 170 150 120 120 150	V (PPM) (OE-P)	S (X) 2.42 1.84 1.93 .35 2.27 .22 1.74 .53	. 02 . 02 . 02 . 02 . 02 . 02 . 02 . 02	14.13 10.86 7.78 2.24 7.01 1.69 12.61 6.00	ORGANIC C (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04	.1P .57 .75 .60 1.20 1.20 1.20 1.20 1.20 1.20 1.20 1.2	1.93 1.43 1.27 .74 .91 .59	TOTAL CEC MEQ/100G 4.7 3.4 4.7 5.1 3.2 7.3 64.9	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4	AS (PPM) 68 38 42 17 37 9.8 45	S
02 03 04 05 06 07 08			MN (PPM) (OE-P: 12P 290 220 340 310 150 17P 320	V (PPM) (OE-D) 16	V (PPM) (OE-P) 202 167 150 123 150 453 203 192	2.42 1.84 1.93 .35 2.27 .22 1.74 .53	CL (X) .02 .02 .02 .02 .02 .02 .02 .02 .02 .02	14,13 10.86 7.78 2.24 7,21 1.69 12.61 6.00	0RGANIC C (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.39	.10 (x) .10 .57 .75 .60 1.20 1.23 .31 .96 2.12	1.93 1.93 1.27 .74 .91 .59 1.72 1.29 1.10	TOTAL CEC MEQ/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3	89 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4 12.0	AS (PPM) 68 38 42 17 37 9.8 45	S
02 03 64 65 66 67 68 69			MN (PPM) (OE-P: 12P 29A 22A 34A 31A 150 17P 320 24A	V (PPM) (OE-D) 160 140 170 150 150 150 170 150 170 170 170 170	V (PPM) (OE-P) 200 160 150 150 450 200 190 200 200 200 200 200 200 200 200 200 2	2,42 1.84 1.93 .35 2.27 .22 1.74 .53	. 02 . 02 . 02 . 02 . 02 . 02 . 02 . 02	10.13 10.86 7.78 2.24 7.01 1.69 12.61 6.00 7.51 10.56	0RGANIC C (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04 9.23	.10 (x) .10 .57 .75 .60 1.73 .31 .96 2.12 1.33	1.93 1.43 1.27 .74 .91 .59 1.72 1.29	TOTAL CEC > E0/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4 11.2.0 2.8 1.8	AS (PPM) 68 38 42 17 37 9.8 45 15	S
02 03 64 85 86 87 88 89 10			MN (PPM) (OE-P: 12P 29A 22A 34A 31A 150 17P 32C 24A 36B	V (PPM) (OE-D) 160 140 170 150 120 150 170 170 170 170 170 170	V (PPM) (OE-P) 200 160 150 150 150 150 150 150 150 150 150 15	S (x) 2.42 1.84 1.93 .35 2.27 .22 1.74 .53 .64 1.38	. 02 . 02 . 02 . 02 . 02 . 02 . 02 . 02	14.13 10.86 7.21 1.69 7.21 1.69 7.51 10.56	0RGANIC (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04 5.30 9.23 7.43	. INORG. C (X)	1.93 1.43 1.27 .74 .91 .59 1.72 1.29 1.10 1.38	TOTAL CEC MEQ/19PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5	88 (PPM: 4.9 3.3 5.6 1.8 1.4 1.2.0 2.8 1.8 2.1	AS (PPM) 68 38 42 17 37 9.8 45 15 12	S
62 63 64 65 66 67 68 69 10 11			MN (PPM) (OE-P) 12P 290 220 267 340 310 150 17P 320 240 360 360 360	V (PPM) (OE-D) 16	V (PPM) (OE-P) 202 167 167 157 157 207 207 207 207 207	S (x) 2.42 1.84 1.93 .35 2.27 .22 1.74 .53 .62 .64 1.38 1.00	CL (X) .02 .02 .02 .02 .02 .02 .02 .02 .02 .02	14,13 10.86 7.76 2.24 7.01 1.69 12.61 6.00 7.51 10.56 10.16	0RGANIC C (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04 5.39 9.23 7.43 5.67	. INORG. C (X) .10 .57 .50 1.20 1.20 1.31 .96 2.12 1.33 2.65	1.93 1.43 1.27 .74 .91 .59 1.72 1.29 1.10 1.38	TOTAL CEC #EQ/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5 1.7	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4 1.2 2.8 2.8	AS (PPM) 68 38 42 17 37 9.8 45 15 12 18 16	S
02 03 64 85 86 87 88 89 10			MN (PPM) (OE-P: 12P 29A 22A 34A 31A 150 17P 32C 24A 36B	V (PPM) (OE-D) 160 140 170 150 120 150 170 170 170 170 170 170	V (PPM) (OE-P) 200 160 150 150 150 150 150 150 150 150 150 15	S (x) 2.42 1.84 1.93 .35 2.27 .22 1.74 .53 .64 1.38	. 02 . 02 . 02 . 02 . 02 . 02 . 02 . 02	14.13 10.86 7.21 1.69 7.21 1.69 7.51 10.56	0RGANIC (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04 5.30 9.23 7.43	. INORG. C (X)	1.93 1.43 1.27 .74 .91 .59 1.72 1.29 1.10 1.38	TOTAL CEC MEQ/19PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5	88 (PPM: 4.9 3.3 5.6 1.8 1.4 1.2.0 2.8 1.8 2.1	AS (PPM) 68 38 42 17 37 9.8 45 15 12	S
03 64 65 667 68 69 11 11 12 13			MN (PPM) (OE-P: 12P 29A 22A 24A 34A 31C 150 17P 32C 24A 34C 332	V (PPM) (OE-D) 16	V (PPM) (OE-P) 200 160 150 150 150 150 150 150 150 150 150 15	S (x) 2.42 1.84 1.93 .35 2.27 .22 1.74 .53 .62 .64 1.38 1.00	CL (X) .02 .02 .02 .02 .02 .02 .02 .01 .02 .01 .02 .01	14,13 10.86 7.76 2.24 7.01 1.69 12.61 6.00 7.51 10.56 10.16	0RGANIC C (%) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04 5.39 9.23 7.43 5.67	. INORG. C (x) . 10 12 15 15 15 12 12 12 . 12	1.93 1.43 1.27 .74 .91 .59 1.72 1.29 1.10 1.38	TOTAL CEC #EQ/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5 1.7	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4 1.2 2.8 2.8	AS (PPM) 68 38 42 17 37 9.8 45 15 12 18 16	S
03 03 05 05 07 08 09 11 12 13 33			MN (PPM) (OE-P: 12P 290 220 267 340 310 17P 320 240 360 350 337 170 310	V (PPM) (OE-D) 160 140 170 150 120 150 170 170 170 170 170 170 170 170 170 17	V (PPM) (OE-P) 200 167 150 150 150 200 190 200 150 200 150 200 320 200 320	S (x) 2.42 1.84 1.93 .35 2.27 .74 .53 .62 1.38 1.00	. 02 . 02 . 02 . 02 . 02 . 02 . 02 . 01 . 02 . 01	14.13 10.86 7.78 2.24 7.01 1.69 12.61 6.00 7.51 10.56 10.16 6.32 10.38	ORGANIC C (%) 14.03 10.29 7.03 1.64 5.81 5.84 5.30 9.23 7.43 5.67 7.30	. INORG. C (x) .19 .57 .60 1.73 .31 .96 2.12 1.33 2.65	1.93 1.43 1.43 1.43 1.74 .74 .91 1.72 1.72 1.29 1.10 1.38 .98 1.00	TOTAL CEC #EQ/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5 1.7 1.2	88 (PPM: 4.9 3.3 5.6 1.8 2.6 1.8 2.1 2.8 5.7	AS (PPM) 68 38 42 17 37 9.8 45 15 12 18 16 17	S
02 03 64 65 66 67 68 69 12 13 13			MN (PPM) (OE-P) 12P 29P 22P 26P 34P 31D 15P 32P 24P 36D	V (PPM) (OE-D) 16	V (PPM) (OE-P) 200 160 150 150 150 150 200 150	S (x) 2.42 1.84 1.93 2.27 2.21 7.4 53 62 64 1.38 1.00 1.18	CL (X) .02 .02 .02 .02 .02 .02 .02 .01 .02 .01 .02 .01	14.13 10.86 7.76 2.24 7.21 1.69 12.61 10.56 10.56 10.16 5.32 10.38	0RGANIC C (X) 14.03 10.29 7.03 1.64 5.81 66 12.30 9.23 7.43 5.57 7.39	. INORG. C (x) . 10 12 15 15 15 12 12 12 . 12	1.93 1.43 1.43 1.27 .74 .91 .59 1.72 1.29 1.10 1.38 .98 1.06	TOTAL CEC #EQ/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5 1.7 1.2	88 (PPM: 4.9 3.3 5.5 1.8 4.2 1.4 2.6 2.8 2.1 2.8 5.7	AS (PPM) 68 38 42 17 37 9.8 45 15 12 18 16 17	S
03 03 05 05 07 08 09 11 12 13			MN (PPM) (OE-P: 12P 290 220 267 340 310 17P 320 240 360 350 337 170 310	V (PPM) (OE-D) 16	V (PPM) (OE-P) 202 167 150 123 150 203 192 203 150 240 322 233 130	S (x) 2.42 1.84 1.93 .35 2.27 .22 1.74 .53 .62 .64 1.38 1.00 1.18	CL (X) .02 .02 .02 .02 .02 .02 .01 .01 .01	14,13 10.86 7.76 2.24 7.01 1.69 10.56 10.56 10.16 8.32 10.38	0RGANIC C (X) 14.03 10.29 7.03 1.64 5.81 .66 12.30 5.04 5.39 9.23 7.43 7.43 7.43	1 NORG. C (x) 19 .57 .59 1.20 1.20 1.33 .31 2.65 3.08	1.93 1.43 1.27 .74 .91 .59 1.72 1.29 1.10 1.38 .98 1.06	TOTAL CEC #E9/10PG 4.7 3.4 4.7 5.1 3.2 7.3 5.0 4.9 3.3 2.6 2.5 1.7 1.2 4.6 4.0	88 (PPM: 4.9 3.3 5.6 1.8 4.2 1.4 12.0 2.8 5.7	AS (PPM) 68 38 42 17 37 9.8 45 15 12 18 16 17 19	

SAMPLE NO.	GEOL.	DEPTH (FT)	8# (PPH)	8E (PPM1 (OE=0)	BE (PP4) (OE-P)	8 (PPM)	8 <i>P</i> (PPM)	CE (PP4)	C5 (PP ^M)	CR ('PPM') (MAA')	CR (PP*) (OE-D)	•	CO (PPH) (NAA)	CU (PPM) (OE-C)
500001	12104419 1250	1822.2	980 1129	3.6 4.3	3.6 5.9	129 140	5 4,5	82 65	5.4 4.5	65 56	7 a 6 2	84 65	39 29	44 32
03		2556.3	888	4,2	4.4	\$82	4	67	5.1	2 9	65	73	53	96
P4		5536.5	570	3.2	5,2	248	3	60	6,5	69	9.8	116	11	12
95		2246.1	7860	3.0	3,4	188	3	170	4.5	6.4	68	79	32	34
86 97		225g,8 226g,3	798 820	5,6	4,4 5.2	292 218	< 4 5	91 81	9.1 7.4	9 9:	165	112 128	12 23	11 29
88		2270.3	968	2.9 2.3	5,2	246	2	77	7.8	165	126	150	14	14
89		2286.6	352	2.5	5.1	225	3.6	70	6.9	85	99	110	11	13
18		2292.7	412	5.6	5.8	192	5.0	75	7.7	97	88	110	15	iź
11		2299.7	390	2.4	3.8	165	3	63	5.3	65	68	66	13	1 4
12	1201	2318:.5	278	2.0	3,3	150	3	48	4.2	55	56	75	11	1 4
13	1301	8.8165	518	5.2	3,6	132	4	58 1	4.9	87	6 R	9.6	13	3 4
33		2273.5	488	4.5	4.9	198	3	71	е,3	1150	110	142	13	14
34		2287.8	237	2,9	3,6	238	3,4	56	6,3	71	75	81	6.5	9,1
35		5545.4	288	4,4	4,2	315	<5	51	5.8	79	7 1	8.8	. 8.4	7.3
36		2311.1	298	5.8	4.4	150	< 4	52	4.0	61	5.5	75	1.1	14
37	1361	2312.6	460	5.6	4 , 1	120	5	47	4.8	67	61	83	11	12
			CO (PPM) (DE=P)		CU (FP4) (CE-P)		EU (PPM)	F (PPH)	GD (PPH)	GA (PPM)	GE (PP*) (DE-D)	нF (РРМ)	P8 (PPM) (OE=P)	LA (PPM)
500001	******		56	89	99	5,6	1,6	649	1,4	3.7	1.4	3.8	30	35
02			38	68	8 2	4 4	1.3	632	1.3	15	2.0	3.0	14	28
03			24	8 5	9.8	4.6	1,3	507	1.8	13	1.7	3.1	36	29
84			12	61	78	4.7	1.3	900	1,6	55	1.5	3,0	19	37
05			53	7 B	72	17	5,2	2925	6.5	11	< .4	4.5	56	43
26 87			9.5	36	35	5,4	1,4	895	1.9	23	٠,۵	5,2	11	42
68			16 26	168 147	178 242	6.4 5.6	1,9	745 885	1,3	22 19	1.6	3.5 4.6	23 23	38 44
89	-		11	132	186	6.8	1.5	770	1.4	16	< .4	5.1	14	36
10			ii	192	340	6.4	1,6	888	1.7	16	1.1	4.6	30	37
11			11	132	198	6.8	1,6	865	1.8	14	< .4	3.3	33	33
12			12	125	250	6.1	1.5	928	1,3	13	< ,4	2.3	24	30
13			1 6	213	272	7, e	1,9	920	2.3	15	. 6	2.6	14	31
33			12	150	210	6,5	1.7	956	2.6	55	.7	4.2	56	39
34			8.8	64	1.00	6,2	1.1	875	1.4	16	< .4	3,9	7.2	35
35			12	155	1.88	6.€	1.4	772	2.0	36	2.4	3,6	11	32
36			17	120	1.80	6,5	1,4	970	9	7 5	< ,4	5,2	7,0	5 9
37			16	110	1.60	7.8	1.5	868	2.3	8.7	< ,4	2,5	7,5	31

CHÉMICAL DATA ON CHRISTIAN COUNTY, RENTUCKY CORE

SAMPLE NO.	NO.	DEPTH (FT)	[U (PPM)	H∏ (P₽™) (OE=D)	NI (FP4) (CE-0)	VI (PPM) (DE-P)	N] (PPM) (NAA)	RP (PPH)	54 (PPH)	SC (PP")	AG (PP4) (PE-P)	59 (PPM) (GE=0)	TA (PPM)	TR (PP#)
199568	61KA01C1	1822.2	.5	180	102	182	13#	110	9.1	13	< ,7	110	.9	1.1
8.5		2191.1	. 3	56.0	76	100	9.3	95	8.2	15	< ,7	142	, A	, 8
6.3		2220.3	. 4	160	85	110	92	100	7.7	13	< ,7	190	. • ^	. •9
94 95		2.88.2	. 4	4 160	33	42	30	158	9,2	17	< .8	195	1.0	. 8
86		2298.1 2250.8	,5	41	84 23	87 38	15P 49	25	25	14	۰,7	>602 213	. 7	3.6
67		2556'3	.6	227	258	302	300	192	7.6 12	16 53	< ,8 < ,7	252	1.4 .A	, 8 1 . 8
r B		2278.3	1	1.5	80	180	157	132 162	11	98	87	197	1.7	,8
P 9		3.3852	٠	8.5	82	120	152	132	6.6	17	۸. >	210	1 . a	1.0
10		229:: 7	. 6	ž.	127	288	167	148	7.5	15	4 7	157	1.0	1.3
11		2299.7	.5	23	90	127	142	163	7.9	15	4 .7	170	,	1.1
12		2316.5	ā	10	120	192	138	77	6.8	10	< .8	137	. 6	, i
13		8.8185	. 5	110	287	252	286	93	9.5	13	< .6	160	. 6	1.3
33		2273.5	. 4	1.7	130	150	12"	170	7,9	5.0	۲, >	160	1.4	1.2
34		8.7855	. 4	4	59	76	6.R	110	5.6	15	< .8	172	1.0	7
35		5565.0	. 4	11	1 26	122	96	150	6,3	16	< .8	122	1.7	. 8
36		5311.1	,5	36	107	595	128	87	8.6	12	< ,8	160	, 7	, 8
37	1 3 L 1	5315.6	.5	3.9	15%	550	163	84	7.5	15	8. >	145	.7	1.0
			(PPH)	(PP=) (CE=0)	(PPH)	(PPm)	(PPM) (OE-P)	(PPM) (NAA)	(PPM) (DE-D)	(PPH) (RE-D)	(PPM) (OE-P)	45H (%)	(PPM)	
1 0099			7.1	2,4	61	2.3	72	128	8.8	71	516	79.64	32	
65			6.9	. 8	43	1.9	51	56	6 P	156	216	86.17	24	
03			7.3	. 9	22	2.0	170	535	568	149	550	57.62	31	
64			8.5	4.7	14	5.5	48	128	89	128	559	95,46	21	
05			12	1.4	37	5.3	110	239	160	279	272	92.12	8?	
86 87			14	4.4	5	5,9	43	152	66	180	518	95.88	54	
88			9.1 11	3.8 5.6	4 Ø 5	2.8	412	472	237 168	132 178	530	82.49	85	
89			15	2.6	6	2,9 3,3	200 83	288 158	61	596	282 278	91,23	16 45	
10			11	3 . 8	6	3,3	129	140	98	130	189	87.43	21	
ii			7.6	3.6	8	3.1	160	218	80	198	508	98.05	5.0	
12			6.4	3,6	10	2.6	100	66	48	132	132	92.64	ŽĀ	
13			6.5	3.7	5.5	3.1	532	368	182	172	188	98.43	35	
33			16	5.6	14	2.8	142	269	187	198	189	89,13	30	
34			9,2	4 9	6.8	1.9	51	72	29	168	182	95.51	24	
35			8.2	5.8	6	2.4	278	556	955	190	510	91.72	30	
36			5.8	4 , 2	11	2.4	230	190	89	170	553	93,13	8.5	
37			5.5	4.4	13	2.4	250	176	72	150	55 <i>ĕ</i>	92.56	26	

NO - NOT DETECTED

(%) % FE203

(XRIF) (NAA)

4.56

3.07

2.51

3.55

3.00

4.88

5.72

7.83

6.52

MGO

(x)

2.25

1.84

1.13

1.48

2.70

1.62

1.64

1.90

2.59 15.5

CAO

(1)

1.84

2.03

35

1.35

39

.30

.06

. 61

NA AS KZO

(%)

3,91

2.96

3.81

3.47

2.35

4.08

98.8

3.A5

5.40

(XRFY (NAA)

DSAN Z

1.00

1,25

1,37

1,22

1,02

1.11

.98

.71

,88

(NAA)

\$102 AL203 FE203 FE AS

2.61

2,20

2.88

4 . 81

4.72

5.84

5.22

2.07

18,5 4,31

.(2)

8,54

9.19

9.77

6,81

12,7

12.1

11.7

14,9

SAMPLE GEOL. DEPTH

(FT)

800014 0:IL01L2 1570.0 64.5

83L1 1589.4

84L1 1582.8

05L1 1015,1

07L1 1631.6

89L1 1647.4

89L2 1656.2

1811 1657,6

11L1 1667,5

(x)

71.8

74.2

70.0

51.7

58.8

65.4

65,3

57.9

NO.

NO.

15

16

17

18

19

20

51

55

66	1161 100/.5	21.4	14,4	5.76	6.52	1,90	. 61	.71	5.00	6,13	. 4 4	. 0.6	56%
53	1261 1678.6	62.2	15.2	5.01	5.86	2,63	. 4.3	.79	5.32	6.35	AG	< . 23	595
24	1311 1688.0	56.8	16.1	5.09	6.29	2.74	36	.75	5.63	6.41	.81	0.2	287
25	1411 1698.2	56.5	14.1	5.22	6.29	5.52	52	.75	4.69	5.31	.77	< . 01	230
56	1511 1710.0	51.5	13.2	5,19	6.88	2.17	.18	59	4.96	5,98	.66	.05	248
27	1661 1723.4	53.8	11.7	5.35	8.54	2.04	71	.73	3.78	4.22	.68	.03	266
28	1711 1730.6	57.1	12.2	4.62	5.92	1,54	61	. 8 2	3.74	4,02	.66	0.4	230
29	1811 1:40.2	62.5	11.7	4.15	4.46	1.27	.47	.84	3.44	4.16	.64	0.6	198
30	1961 1153.5	55.0	15.5	5.62	5.91	1.67	.56	.75	3.86	4.64	.62	10	278
31	2861 1163.3	58.0	12.3	4.37	4,41	2.22	5.56	92	3.87	4.72	.69	. 78	340
35	2161 1776.2	56.4	14.8	4.83	4,16	2.15	.77	.71	4.88	5.52	,67	. 63	340
	***********	MN	<u>-</u>			: CL	FOTAL	DRGANIC	THEFT		TOTAL	58	
		(PPM)	(PPH)	(PPH)	(%)	(%)	C (X)	C (X)	[(1)	(X)	CEC	30 (PPH)	(PPH)
		(OE-P)	(DE-D)	(0E-3)	(2)			U (4)			MED/1826		(,,,,,,
70014		845	556	278	.02	.13	,88	,43	.45	.75	7.3	.6	2,6
									4 4				2 2
15		296	78	142	.05	.08	.96		.67	. 44	2,9	• >	2,9
16		298 150	78 70	120	.07			.29 .80				,5 ,6	4.3
16 17						. 14	.97	.86	.17	.48	3,1	. 6	4,3
16 17 18		150	70	120	.07	.14	.97 .44	98. 85.	.17	.48	3,1	.6	
16 17 18 19		150 178	7 A 120	120	.07 .96 .87	.14	.97 .44 3,88	.82 .28 .15	.17 .16 3.73	.48 .44 .36	3,1 4,3 2.2	.6.7.3	4,3 3,9 2.3
16 17 18 19 20		150 178 822	70 120 83	120 178 98	.07 .96 .87 .69	.14 .11 .04 .12	.97 .44 3.88 .75	.82 .28 .15 .32	.17 .16 3,73 .43	.48 .44 .36	3,1 4,3 2,2 6,4	.6 .7 .3	4,3 3,9
16 17 18 19 20 21		150 170 822 340	70 120 83 110	120 178 98 168	.07 .96 .87	.14 .11 .04 .12	.97 .44 3.88 .75	.80 .28 .15 .32	.17 .16 3.73	.48 .44 .36 .66	3,1 4,3 2,2 6,4 5,8	.6 .7 .3 .5	4,3 3,9 2,3 5,9
16 17 18 19 20 21		150 170 822 340 230	70 120 83 110 86	120 178 90 160 120	.07 .86 .87 .P9	.14 .11 .24 .12 .12	.97 .44 3.88 .75 .66	.82 .28 .15 .32	.17 .16 3.73 .43 .09	.48 .44 .35 .65 .65	3,1 4,3 2,2 6,4 5,6 6,7	.6 .7 .3 .5	4.3 3.9 2.3 5,9 6.8
16 17 18 19 20 21 22		150 170 822 340 230 180	70 120 83 110 86 76	120 179 90 160 120	.07 ,86 .87 .99 .25 .89	.14 .11 .24 .12 .12	.97 .44 3.88 .75 .66 1.30 2.93	.80 .28 .15 .32 .57 1.28 2.98	.17 .16 3.73 .43 .e9 .02	.48 .4a .3b .6b .66 .78	3.1 4.3 2.2 6.4 5.6 6.7 9.4	.6 .7 .3 .5 .6	4,3 3,9 2,3 5,9 6,0 9,8 7,7
16 17 18 19 20 21 22 23		150 170 822 340 230 180 270	70 120 83 110 86 76 170	120 170 90 160 120 110	.07 .96 .97 .25 .89 .27	.14 .12 .12 .12 .19 .10	.97 .44 3.88 .75 .66 1.30 2.93	.82 .28 .15 .32 .57 1.28 2.90 1,72	.17 .16 3,73 .43 .e9 .02 .03	.48 .4a .3b .6b .6b .76 .91	3,1 4,3 2,2 6,4 5,6 6,7 9,4 7,7	.6 .7 .3 .5 .6	4,3 3,9 2,3 5,9 6.8 9,8 7,7
16 17 18 19 20 21 22 23 24		150 170 822 340 230 180 270 310	70 120 63 110 66 76 170 140	120 178 98 160 120 110 180	.07 .96 .97 .25 .89 .27 .18	.14 .12 .12 .12 .10 .10	.97 .44 3.88 .75 .66 1.30 2.93 1.88 2.96	.80 .28 .15 .32 .57 1.28 2.98	.17 .16 3.73 .43 .09 .02 .03 .16	.48 .44 .36 .66 .76 .91 .66	3.1 4.3 2.2 6.4 5.6 6.7 9.4 7.7 8.2	.6 .7 .3 .5 .6 .9 .9	4,3 3,9 2,3 5,9 6,0 9,8 7,7 8,2
16 17 18 19 21 22 23 25 25		150 170 822 340 230 180 270 310 270	70 120 63 110 66 76 170 140 160	120 178 98 160 120 110 180 180	.07 .96 .97 .25 .89 .27	.14	.97 .44 3.88 .75 .66 1.39 1.98 2.93 1.98	.82 .28 .15 .32 .57 1.28 2.90 1,72	.17 .16 3.73 .43 .09 .02 .03 .16	.48 .44 .36 .66 .76 .91 .66 1.07	3,1 4,3 2,2 6,4 6,7 9,4 7,7 8,2	.67 .35 .66 .99 1,22 1,7	4,3 3,9 2,3 5,9 6,0 9,8 7,7 8,2 10
16 17 18 19 21 22 23 23 25 27		150 178 820 340 230 180 270 310 270 220	70 120 83 110 86 76 170 140 160	120 178 98 160 120 110 180 198 200	.07 .96 .87 .25 .89 .27 .18	.14 .11 .04 .12 .10 .10 .12 .12	.97 .44 3,88 .75 .66 1.30 2.93 1.88 2.93 4.34 7.61	.82 .25 .152 .57 1.28 2.72 2.92 2.92 2.92	.17 .16 3.73 .43 .69 .02 .03 .16	.48 .44 .36 .66 .76 .91 .66 1.27 1.29	3,1 4,3 2.2 6,4 5.8 6.7 9.4 7.7 8.2 9.3 11,4	.6 .7 .3 .5 .6 .9 1,2 1.2	4,3 3,9 2,3 5,9 6.0 9,8 7,7 8,2 18 19
16 17 18 19 21 22 23 22 26 27 28		150 178 828 348 238 278 318 278 278 228	70 120 83 11P 86 76 17P 14P 16P 200	120 179 160 120 110 180 180 180 200	07 .07 .07 .07 .07 .07 .07 .07 .07 .07	.14 .11 .04 .12 .12 .10 .12 .12 .12	.97 .44 3.88 .75 1.30 2.93 1.88 2.96 4.34 7.61	.80 .28 .152 .377 1.28 2.98 1.72 2.96 4.254 9.59	.17 .16 3.73 .43 .02 .03 .16 .06 .07	.48 .44 .56 .66 .76 .91 .66 1.07 1.09 1.34	3,1 4,3 2,2 5,6 6,7 9,4 7,7 8,2 9,3 11,4	.6 .7 .3 .5 .6 .9 .9 1,2 1,2	4,3 3,9 2,3 5,9 6,8 9,8 7,7 8,2 18 19 25
167 1189 2123 223 223 223 223 223 223		150 170 822 340 230 270 270 270 220 240	70 120 83 110 86 70 140 160 160 240	120 170 90 160 110 180 190 200 240	07 .967 .97 .95 .27 .18 .31 .92 .92 1,10	.14	.97 .44 3.88 .75 1.30 2.98 2.98 2.98 4.34 7.61 9.55	.82 .28 .152 .57 1.92 1.92 4.55 9.52	.17 .173 .499 .003 .004 .005 .006 .006 .007	. 48 . 48 . 50 . 60 . 60 . 91 . 66 1 . 87 1 . 89 1 . 54	3,1 4.3 2.2 6.4 5.6 6.7 9.4 7.7 8.2 9.3 11,4 6.6	.6 .7 .3 .5 .9 .9 1,2 1.7 4.6 6.6	4,3 3,9 2,3 5,9 6,0 9,8 7,7 8,2 18 19 25 22
16 17 19 21 22 23 22 26 27 28		150 170 820 340 230 180 270 310 270 220 200 240 240	70 120 63 110 66 76 140 160 200 240 120	120 170 90 160 120 110 180 190 200 200 240	07 .09 .09 .09 .09 .09 .09 .09 .09 .09 .09	14 114 114 114 117 117 117 117 117 117 1	97 .44 3.85 .75 1.33 1.86 2.98 4.34 7.61 9.79 6.55	.82 .235 .378 .297 12.7964 12.7965 .57	.163 .749 .003 .003 .004 .005 .005 .005 .005 .005	. 48 . 48 . 56 . 66 . 76 . 91 . 67 1 . 67 1 . 69 1 . 51 1 . 15	3,1 4,3 2,2 6,4 6,7 9,4 7,7 8,2 9,3 11,4 6,6 6,2	.67 .35 .69 .92 1.77 4.66 32.0	4,3 3,9 2,3 5,9 6,0 9,8 7,7 8,2 1,9 25 22
167 1189 2123 223 223 223 223 223 223		150 170 824 230 230 270 270 200 240 240 240	70 120 83 110 86 70 140 140 160 240 140	120 170 160 120 110 180 180 200 200 240 170	07 .967 .97 .95 .27 .18 .31 .92 .92 1,10	.14	.97 .44 3.88 .75 1.30 2.98 2.98 2.98 4.34 7.61 9.55	.82 .28 .152 .57 1.92 1.92 4.55 9.52	.17 .173 .499 .003 .004 .005 .006 .006 .007	. 48 . 48 . 50 . 60 . 60 . 91 . 66 1 . 87 1 . 89 1 . 54	3,1 4.3 2.2 6.4 5.6 6.7 9.4 7.7 8.2 9.3 11,4 6.6	.6 .7 .3 .5 .9 .9 1,2 1.7 4.6 6.6	4,3 3,9 2,3 5,9 6,0 9,8 7,7 8,2 18 19 25 22

K 4S TIO2

(X)

. 87

93

. 95

9 9 56

. 93

1.25

, A 7

. P.4

×50

4.32

3.43

3.55

4.11

2.86

4.86

4.95

4.35

6,13

P205

(1)

.08

. 33

. 93

.31

.72

.05

.01 . 9.6

<.P1

(PPH)

(NAA)

228

292

150

150

960

349

242

210

262

SAMPLE NO.	GEOL. NO.	OEPTH (FT)	BA (PP4)	BE (RPH) (DE=D).		H (PPM)	8R (PPP)	CE (PPM)	C\$ (PPM)	CR (PPH) (NAA)	CR (PPH) (OE-D)	C4 (PPM) (OE=P)	CO (PPM) (NAA)	CU (PF4) (OE+D)
	91110112		289	2,8	4.4	168	8.1	7.5	8.1	117	102	152	10	9,6
15 16		1589.4	360	5,2	2.5	189	8,1	117	4,9	95	89	84	6,6	5,5
17		1602.0	420 410	2.1	2.6	188 118	11 8.5	8 8 9 9	5,2	94 110	78 84	96 122	6.2	4,4 6,4
18		1631.6	430	2,,7	3.2 3.2	72	€ 4	62	8.5 5.0	63	44	66	8,9 7,1	7,1
19		1647.4	466	5.² ę . •	4.4	130	6.4	91	16	120	80	117	13	11
56		1656.2	580	5.8	3.5	122	7	99	10	118	79	95	16	13
51		1657.6	530	3.0	3.4	160	5.8	8.4	11	117	7.8	97	15	14
55		1667,5	576	3.7	5.6	176	6.0	89	13	148	92	130	18	15
23		1678.5	550	3.6	5,1	148	8.5	86	14	118	93	132	14	12
24		1688.7	666	3.4	5.5	142	9.4	86	13	152	100	143	16	14
25		1698.2	582	2.9	4.6	150	6.7	79	12	120	95	110	16	15
56		1712.2	810	2,9	5.4	140	7	86	11	110	98	110	25	26
27		1723.4	1233	3,2	5.1	128	<8	120	9.5	94	73	96	44	47
28	17L1	1730.6	728	3.9	4.4	138	9	В3	6.4	94	74	84	26	21
29	18L1	1740.2	650	3.5	3,7	137	<7	5 R	6.5	69	67	70	52	2 R
30		1753.5	659	3.7	4.6	125	9,3	71	6.4	71	67	83	28	9.6
31		1763.3	468	3.2	3.7	149	9,4	54	6.1	8 🕫	66	9 0	18	56
35	2111	1776.2	418	4.8	4.5	586	6.7	55	8.4	85	100	126	- 12	16
			EO (PPM)	CU (PPR)	CU (PPM)	DY (PPM)	Ευ (PPH)	F	GD (PPM)	GA (PP4)	GE	HF	 РВ	. LA
			(DE-P)	(OE-D)	(OE-P)	•	•		(884)	(PP3)	(PPM) (DE-D)	(PPM)	(PPH) (DE-P)	(PPH)
502014					(OE-P)	•	•		2.7	16		(PP#)		(PPH)
502014 15				(OE-D)	(OE-P)						(DE-D)		(DE-P)	
15 16		• • • • • • •	9,1	(OE=0)	(0E-P)	5,6	1,1	920	2,7	16	(0E-0) 2.5 4.6 4.6	6,7	(DE-P) 5,8	36
15 16 17			9,1 5,8 5,4 6,7	(OE-0) 5.1 16 6.6 6.9	(OE-P) 13 32 14 13	5,6 9,8 6,1 6,9	1.1 3,0 1.1 1.5	920	2.7 2.7 2.8 3.0	16 12 14	(OE-D) 2.5 4.6 4.2 4.3	6.7 11 11	(DE-P) 5,8 8,1	36 45 37 4P
15 16 17 18		••••	9,1 5,6 5,4 6,7 5,1	(OE-D) 5.1 16 6.6 6.9 6.8	(OE-P) 13 32 14 13	5,6 9,8 6,1 6,9 6,5	1.1 3.0 1.1 1.5	920 810 375 505 570	2.7 2.7 2.0 3.0 2.2	16 12 14 16 8.2	(OE-D) 2.5 4.6 4.8 4.3	6.7 11 11 11 5.0	(DE-P) 5,8 8,1 <2.3 <2.4 <2.4	36 45 37 4P 34
15 16 17 18 19		•••••	9,1 5,6 5,4 6,7 5,1	5.1 16.6 6.9 6.8	13 32 14 13 11 20	5,6 9,8 6,1 6,9 6,5 4,5	1.1 3.0 1.1 1.5 1.8	920 810 375 505 570 560	2.7 2.7 2.0 3.0 2.2 2.8	16 12 14 16 8.2 2?	(DE-D) 2,5 4,6 4,2 4,3 <,4 1,8	6.7 11 11 11 6.6 7.6	(DE-P) 5,8 8,1 <2,3 <2,4 <2,4 <2,3	36 45 37 4P 34
15 16 17 18 19 20		•••••	9,1 5,6 5,4 6,7 5,1 13	5.1 16.6 6.9 6.8 8.4	13 32 14 13 11 29 24	5,6 9,8 6,1 6,9 6,5 4,5 6,3	1.1 3.0 1.1 1.5 1.6 1.2	920 810 375 505 570 560 685	2.7 2.7 2.0 3.0 2.2 2.0 2.2	16 12 14 16 8.2 22	(OE-D) 2.5 4.6 4.2 4.3 <.4 1.8 2.7	6.7 11 11 11 6.6 7.6 8.6	(DE-P) 5,8 8,1 <2,3 <2,4 <2,4 <2,4 <2,4	36 45 37 4P 34 39
15 16 17 18 19 20 21			9,1 5,6 5,4 6,7 5,1 13	(OE-D) 5.1 16. 6.6 6.9 6.8 8.4 13	(OE-P) 13 32 14 13 11 29 24 32	5,6 9,8 6,1 6,9 6,5 4,5 6,3	1.1 3.0 1.1 1.5 1.8 1.2 1.3	920 8:0 375 505 570 560 600	2.7 2.7 2.0 3.0 2.2 2.0 2.2	16 12 14 16 8.2 27 25	(DE-D) 2.5 4.6 4.2 4.3 <.4 1.8 2.7 2,4	6.7 11 11 11 6.0 7.6 8.6 7.1	(DE-P) 5,8 8.1 <2.3 <2.4 <2.4 <2.4 <2.4 <2.3	36 45 37 4P 34 39 43
15 16 17 18 19 20 21			9.1 5.8 5.4 6.7 5.1 13 135 12	(OE+D) 5.1 16. 6.6 6.9 6.8 13.	(OE-P) 13 32 14 13 11 20 24 32 63	5,6 9,8 6,1 6,9 6,5 4,5 6,3 4,1	1.1 3.0 1.1 1.5 1.8 1.2 1.3 1,3	920 8:0 375 505 570 560 685 680 910	2.7 2.7 2.9 3.9 2.2 2.0 2.2 2.3 2.2	16 12 14 16 8.2 2? 25 18 24	(OE-D) 2.5 4.6 4.9 4.3 < ,4 1.8 2.7 2.4 2.8	6,7 11 11 11 6,6 7,1 5,1	5,8 8,1 <2,3 <2,4 <2,4 <2,3 35	36 45 37 4P 34 39 43 34
15 16 17 18 19 20 21 22			9.1 5.6 5.4 6.7 5.1 13 35 22	(OE-D) 11. 6.6 6.9 6.8 8.4 13.	(OE-P) 13 32 14 13 11 20 24 32 63	5.6 9.8 6.1 6.9 6.5 4.5 6.3	1.1 3,0 1.1 1.5 1.8 1.2 1.3 1,3	920 8:0 375 505 570 605 600 910 825	2.7 2.7 2.0 3.0 2.2 2.0 2.3 2.3 2.6	16 12 14 16 8.2 27 25 18 24	(OE-D) 2.5 4.6 4.2 4.3 4.4 1.8 2.7 2.4 2.8 2.3	6.7 11 11 11 6.0 7.6 8.6 7.1 5.1	(DE-P) 5.8 8.1 <2.3 <2.4 <2.3 <2.4 <2.3 <3.5 3.5 3.0	36 45 37 4P 34 39 43 34 35
15 16 17 18 19 20 21 22 23			9.1 5.8 5.4 6.7 5.1 13 35 12 20 28	(OE-D) 5.1 16. 6.6 6.9 6.8 13 15	(OE-P) 13 32 14 13 11 20 24 32 63 45	5,6 9,8 6,1 6,9 6,5 4,5 6,3 4,1 3,9 5,5	1.1 3,0 1.1 1.5 1.8 1.2 1.3 1,3	920 8:00 375 525 570 685 686 910 825	2.7 2.7 2.0 3.0 2.2 2.0 2.2 2.3 2.2 2.2	16 12 14 16 8.2 27 25 18 24 26	(OE-D) 2.5 4.6 4.2 4.3 4,4 1.8 2.7 2.4 2.8 2.3	6.7 11 11 11 8.0 7.6 8.6 7.1 5.1	(DE-P) 5.8 8.1 <2.3 <2.4 <2.3 <2.4 <2.3 <2.5 2.4 <2.3 35 32	36 45 37 4P 39 43 39 43 34 35 39
15 16 17 18 19 20 21 22 23 24			9.1 5.8 6.7 5.1 13 35 12 20 28 28	(OE-D) 5.1 6.6 6.9 6.8 7.4 19 34 28 32	(OE-P) 13 32 14 13 11 20 24 32 63 45 39 54	5.6 9.8 6.1 6.9 6.5 6.3 4.1 3.9 5.5	1.1 3,0 1.1 1.5 1.8 1.2 1.3 1,3 1.2	920 8:0 375 505 570 685 680 910 825 940 815	2.7 2.7 2.0 3.0 2.2 2.2 2.3 2.2 2.3	16 12 14 16 8.2 23 25 18 24 26 25	(OE-D) 2.5 4.6 4.2 4.3 4.4 1.8 2.7 2.4 2.8 2.8	6.7 11 11 11 6.6 7.6 8.6 7.1 5.1 5.1	(DE-P) 5.8 6.1 42.3 42.4 42.4 42.3 35 36 24	36 45 37 4P 34 39 43 34 35 37
15 16 17 18 19 20 21 22 23 24 25			9.1 5.8 6.7 5.1 13 35 12 20 20 28 23 17	(OE-D) 5.1 16.6 6.6 6.8 8.4 13 14 29 28 34 29	(OE-P) 13 32 14 13 11 20 24 32 63 45 39	5,6 9,8 6,1 6,5 4,5 6,3 4,1 3,9 5,5 4,5	1.1 3.0 1.1 1.5 1.8 1.2 1.3 1.2 1.4 1.1	920 810 375 505 500 605 600 600 910 825 940 815 945	2.7 2.7 2.0 3.0 2.2 2.3 2.3 2.3 2.3 2.3	16 12 14 16 8.2 27 25 18 24 26 25 22	(OE-D) 2.5 4.6 4.2 4.3 4.4 1.8 2.7 2.8 2.8 2.3 6.5 1.5	6.7 11 11 11 15 6.6 7.6 8.6 7.1 5.1 5.4 4.8 4.8	(DE-P) 5.8 8.1 <2.3 <2.4 <2.3 <2.4 <2.3 <2.4 <2.3 35 30 24 17	36 45 37 4P 34 39 43 35 39 37 37
15 16 17 18 19 20 21 22 23 25 26 27			9,1 5,8 5,4 6,7 5,1 13 35 12 20 23 17 32 45	(OE-D) 5.1 6.6 6.9 6.8 15 15 20 20 28 32 59	(OE-P) 13 32 14 13 11 20 24 32 63 45 39 54 74 262	5,6 9,8 6,1 6,9 6,5 4,5 6,3 4,1 3,9 5,5 4,5 5,1 6,7	1.1 3.0 1.1 1.5 1.8 1.2 1.3 1,2 1,4	920 810 375 507 508 608 607 825 940 815 947 675	2.7 2.7 2.0 3.0 2.2 2.0 2.2 2.3 2.2 2.3 2.2 2.3	16 12 14 16 8.2 27 25 18 24 26 25 22	(OE-D) 2.5 4.6 4.9 4.3 < ,4 1.8 2.7 2.4 2.8 2.3 6.1.5 1.2	6.7 11 11 11 11 6.6 7.6 8.6 7.1 5.1 5.4 4.8 4.8 6.1	(DE-P) 5,8 8.1 <2.3 <2.4 <2.3 <2.4 <2.3 <2.4 <2.3 35 30 24 17 37 54	36 45 37 4P 34 39 43 34 35 39 37 30 33
15 16 17 18 19 20 21 23 24 25 27 28			9.1 5.8 5.7 5.1 13 15 12 20 23 17 32 45	(OE-D) 5-1 16-6 6-9 6-8 17 17 32 28 32 59 158 55	(OE-P) 13 32 14 13 11 20 24 32 63 45 39 54 74 262 78	5.6 9.8 6.1 6.9 6.5 6.3 4,1 3.9 5.5 4,5 5.1 5.7	1.1 3.0 1.1 1.5 1.8 1.2 1.3 1.3 1.2 1.1	928 818 375 525 570 685 685 686 918 825 948 815 9475 1088	2.7 2.7 2.0 3.0 2.2 2.2 2.3 2.2 2.3 2.2 2.3	16 12 14 16 8.2 25 18 24 26 25 22 21	(OE-D) 2.5 4.6 4.2 4.3 4,4 1.8 2.7 2.4 2.8 2.3 6 1.5 1.2	6.7 11 11 11 6.0 7.6 8.6 7.1 5.1 4.8 4.8 4.8	(DE-P) 5.8 8.1 2.3 42.4 42.3 42.3 42.3 52.4 17 54 18	36 45 37 4P 34 39 43 34 35 39 37 30 33 33 33
15 16 17 18 20 21 22 23 25 26 27 28			9.1 5.8 6.7 5.1 13 15 12 20 20 23 17 32 45 23 29	(OE-D) 1.1 1.6 6.6 6.9 8.4 1.7 1.9 2.6 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7	(OE-P) 13 32 14 13 11 20 24 32 63 45 39 54 74 260 78	5.6 9.8 6.1 6.9 6.5 6.3 4.1 3.9 5.5 5.1 5.1 6.7	1.1 3.0 1.1 1.5 1.8 1.2 1.3 1.2 1.4 1.1 1.2	920 8:0 375 525 570 685 680 910 825 940 815 945 1000 643	2.7 2.7 2.0 3.0 2.2 2.3 2.2 2.3 2.2 2.3 2.2 2.3	16 12 14 16 8.2 23 25 18 24 26 25 22 21 14	(OE-D) 2.5 4.6 4.2 4.3 4.8 2.7 2.4 2.8 2.5 1.5 1.2 1.5	6.7 11 11 6.6 7.6 8.6 7.1 5.1 5.1 4.8 4.8 6.1	(DE-P) 5.8 6.1 42.3 42.4 42.4 42.3 35 36 24 17 37 54 18 19	36 45 37 4P 34 39 43 34 35 37 37 34 33 33 31
15 16 17 18 19 20 21 23 24 25 27 28			9.1 5.8 5.7 5.1 13 15 12 20 23 17 32 45	(OE-D) 5-1 16-6 6-9 6-8 17 17 32 28 32 59 158 55	(OE-P) 13 32 14 13 11 20 24 32 63 45 39 54 74 262 78	5.6 9.8 6.1 6.9 6.5 6.3 4,1 3.9 5.5 4,5 5.1 5.7	1.1 3.0 1.1 1.5 1.8 1.2 1.3 1.3 1.2 1.1	928 818 375 525 570 685 685 686 918 825 948 815 9475 1088	2.7 2.7 2.0 3.0 2.2 2.2 2.3 2.2 2.3 2.2 2.3	16 12 14 16 8.2 25 18 24 26 25 22 21	(OE-D) 2.5 4.6 4.2 4.3 4,4 1.8 2.7 2.4 2.8 2.3 6 1.5 1.2	6.7 11 11 11 6.0 7.6 8.6 7.1 5.1 4.8 4.8 4.8	(DE-P) 5.8 8.1 2.3 42.4 42.3 42.3 42.3 52.4 17 54 18	36 45 37 4P 34 39 43 34 35 39 37 30 33 33 33

CHEMICAL DATA ON SANGAMON COUNTY, ILLINOIS CORE

BAMF_E ND,	GEDL, NO.	DEPTH (FT)	LU (PPM)	MO (PPM) (GE=D)	NI (PPH) (GE+O)	NI (PPM) (OE=P)	NI (PPM) (NAA)	RB (PP4)	3 н (РРН)	5C (PPM)	AG (PPM) (GE-P)	5P (PP*) (OE-D)	T# (PPM)	T8 (PPM)
	01 ILE : L2	1576,8	.4	< <u> </u>	38	55	49	169	5,3	15	< .8	73	1,3	, 8
15		1589.4	.7	<1	23	25	5 4	119	1 4	10	∢ ,8	91	1.0	1.8
16		1665.8	.6	<1	24	35	40	110	6.1	11	< ,8	91	1.5	1.0
17		1615.1	. 6	< 1	25	31	33	176	6,5	15	۵, ه	62	5.8	1,1
18		1631.6	. 5	4,1	23	51	1.8	166	7.8	1 2	₹ .8	190	1.2	1,3
19		1647,4	. 4	<1 _	39	49	46	269	6.1	19	٠, ٥	94	1.6	1,0
51 56		1656.2	. 5	7	42	66	64	206	6.7	19	< .8	89	1.5	, 9
55		1657.6	• 4	16	3 A	5?	43	190	5.9	16	< ,8	6.0	1.7	1,1
5.2		1667.5	• 4	0.7	68	104	83 78	272	6.6	20	٠.8	72 75	1.7	• 9
24		1678.6	• 5	1.5	55 63	9.5	7 B	530	5.7	23	< .6	87	1.6	.8
25			, 4	4.6	_	102	7 K	272	6.0	25	< .B	-	1.5	• 9
36		1698.2 1710.0	. 3	21	61	9.6		356	6.3	21	4 . 6	72	1.4	• 9
27		1723.4	. 4	82	78	94	91	535	6.0	55	4 .7	63	1.2	. 9
28		1732.6	• •	96 39	79 62	132	120	515	13	51	< ,7	64	1.6	1,2
50			. 3	-		-	50	172	18	16	< .7	64	1.2	1.0
50		1740.2		47	63	. 76	45	148	4.2	15	4 .7	69	1.0	• 7
51		1753.5	• 4	67	77	96	58	130	8.2	16	4 ,7	63	1.0	. 8
52		1763.3 1776.2	. 3	29 22	61 : 25	68 152	69 118	130 160	5.4 5.8	15 18	8. >	80 69	1.2	, 7 , 6
			TH	SN	U	Y5	ZN	ZN	ZN	ZR		'500 DEG.	ND ND	
			(PPH)	(PPM) (OE→D)	(PP4)	(PPM)	(PPM) (OE=P)	· (PPH) (NAA)	(PPH) (DE-D)	(PPM) (OE-D)	(PPH) (DE=P)	43H (%)	(PPH)	
36614				(0E=D)				(NAA)		(0E-0)		(X)		
30214 15	i.	·	(PPM) .2 .1	(0E-D)	• •	2,4	(0E-P)	(NAA)	(DE-D)	(OE-D)	(DE-P)		(PPH) 	,,
15 16	:	i	.2 .1 .2	3,9 1,7	4 5		(OE-P)	(AAN) 59	(DE-D)	(OE-D)	(DE-P)	(¥) 96,58	18	
15 16 17	<u>:</u> .	·	.2 .1 .2	3,9 1,7 2,6 2,3	<5 <6	2,4 3,8	(0E-P) 48 57	92 51	(OE-D) 59 3e 13e 49	(0E-D) 240 325	(DE-P) 478 718	(%) 96,58 97.89	18 54	,,,,
15 16 17 18	<u>:</u> .	.	.2 .1 .2	3,9 1,7 2,6 2,3	<5 <6 <5	2,4 3,8 3,1	(0E-P) 48 57 189	92 51 118	(OE-D) 59 30 130	(0E-0) 240 325 425	(DE-P) 478 718 578	(%) 96,50 97,09 97,35	18 54 25	
15 16 17 18 19	<u>.</u>	·	.2 .1 .2 .6 9.8	(OE-D) 3,9 1,7 2,6 2,3 ,7 5,2	<5 <6 <5 <5	2,4 3,8 3,1 3,3	(OE-P) 48 57 189 49	92 51 116 71	(OE-D) 59 3e 13e 49	(OE-O) 240 325 425 400	(DE-P) 478 719 578 489	(%) 96,50 97,09 97,35 98,50	18 54 25 44	
15 16 17 18 19	-		.2 .1 .2 .6 9.8 .4	3,9 1,7 2,6 2,3	<5 <6 <5 <5 <4	2,4 3,8 3,1 3,3 3,0	(OE-P) 48 57 18P 40 59	92 51 118 71 35	(OE-D) 59 30 130 49 5.5	(0E-0) 240 325 425 400 610	0E-P) 478 718 578 488 468 468 338	96,50 97,09 97,35 98,50 98,85 96,44 97,40	18 54 25 44 32 16	•••••
15 16 17 18 19 20	<u>-</u>		.2 .1 .2 .6 .9 .8 .4	3,9 1,7 2.6 2,3 .7 5,2 4.7 3,8	<5 <6 <5 <5 <4	2.4 3.8 3.1 3.3 3.0 2.6 2.8	(OE-P) 48 57 189 49 59	92 51 118 71 35	59 38 138 49 5,5	(OE-D) 240 325 425 400 610 280	(DE-P) 478 718 578 488 468	96,50 97,09 97,35 98,50 98,85 96,44 97,40 95,30	18 54 25 44 32 16 42 52	
15 16 17 18 19 20 21		·	.2 .1 .2 .6 .9,8 .4	3.9 1,7 2.6 2,3 -7 5.2 4.7 3,8 9,1	<5 <6 <5 <5 <4 <6 <4	2,4 3,8 3,1 3,3 3,0 2,6 2,8	(OE-P) 48 57 189 49 59 32 110	92 51 118 71 35 180	59 30 130 49 5,5 29	(OE-D) 240 325 425 400 610 280 310	0E-P) 478 718 578 488 468 468 338	96,50 97,09 97,35 98,50 98,85 96,44 97,40	18 54 25 44 32 16 42 52 35	
15 16 17 18 19 22 23		i	.2 .1 .2 .6 .9,8 .4 .5 .4	(OE-D) 3.9 1.7 2.6 2.3 .7 5.2 4.7 3.8 9.1 7.2	<5 <6 <5 <5 <4 <4 <4	2.4 3.8 3.1 3.3 3.0 2.6 2.8	(OE-P) 	(NAA) 92 51 118 71 35 180 150	(OE-D) 59 30 130 49 5.5 29 83	(0E-0) 240 325 425 425 426 610 286 310 250	(DE-P) 478 718 578 488 468 468 338 298	96,50 97,09 97,35 98,50 98,85 96,44 97,40 95,30	18 54 25 44 32 16 42 52	
15 17 16 19 21 21 23 24		:	.2 .1 .2 .6 .9 .8 .4 .5 .4 .5 .4 .5	[OE-D) 3.9 1,7 2.6 2,3 .7 5.2 4.7 3,6 9.1 7.2 8.5	<5 <6 <5 <4 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <	2,4 3,8 3,1 3,3 3,0 2,6 2,6 2,4 2,4 2,3	(OE-P) 48 57 189 49 59 32 110 848 188 188 188	(NAA) 92 51 11P 71 35 180 150 1290 120 128	(OE-D) 59 58 138 49 5.5 29 63 928 75 97	(OE - O) 240 325 425 400 610 280 310 250 210 220	(DE-P) 478 718 570 488 466 466 338 296 380 280	96,50 97,09 97,35 98,50 98,65 96,44 97,40 95,30 95,30 95,30	18 54 25 44 32 16 42 52 35 ND(<10) 21	
15 17 18 19 22 23 25 25			.2 .1 .2 .6 .9 .8 .5 .4 .5 .5 .15	(OE-D) 3.9 1.7 2.6 2.3 .7 5.2 4.7 3.6 9.1 7.2 8.5	<5 <5 <5 <4 <4 <6 <4 <6 <4	2.4 3.8 3.1 3.3 3.6 2.6 2.4 2.3 2.4 2.3	(OE-P) 48 57 187 48 59 32 118 842 128 128	(NAA) 72 51 116 71 35 180 150 1290 1290 120 120 170	(OE-D) 59 38 138 49 5.5 29 75 97 58	(OE - O) 240 325 425 400 610 286 310 250 210 250 210 200 150	(DE-P) ATB 718 578 488 468 468 338 298 388 288 288 288	(%) 97.89 97.35 98.50 98.85 96.44 95.30 95.30 95.30 95.30	18 54 25 44 32 16 42 52 35 ND (<18) 21 ND (<28)	
167 178 199 223 245 26		. <u></u> :	.2 .1 .2 .6 .9,8 .4 .5 .4 .5 .5 .5 .5 .5 .5 .5	(OE-D) 3,7 2,6 2,3 5,2 4,7 3,6 7,2 6,5 4,1 3,6	<5 <6 <5 <4 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <46 <	2,4 3,8 3,1 3,3 3,0 2,6 2,6 2,4 2,4 2,3	(OE-P) 48 57 189 49 59 32 110 848 188 188 188	(NAA) 92 51 11P 71 35 180 150 1290 120 128	(OE-D) 59 58 138 49 5.5 29 63 928 75 97	(OE - O) 240 325 425 400 610 280 310 250 210 220	(DE-P) 478 718 570 488 466 466 338 296 380 280	96,50 97,09 97,35 98,50 98,65 96,44 97,40 95,30 95,30 95,30	18 54 25 44 32 16 42 52 35 ND(<10) 21	
15 16 17 18 19 20 21 22 23 24 25 26		. <u></u> :	.2 .1 .2 .6 .9 .8 .4 .5 .4 .5 .5 .5 .5 .5 .5	(OE-D) 3,9 1,7 2,6 2,3 7 5,2 4,7 3,6 9,1 7,2 8,5 4,1 3,6 3,7	<5 <5 <5 <4 <4 <6 <4 <6 <4	2.4 3.8 3.1 3.3 3.6 2.6 2.4 2.3 2.4 2.3	(OE-P) 48 57 187 48 59 32 118 842 128 128	(NAA) 72 51 116 71 35 180 150 1290 1290 120 120 170	(OE-D) 59 38 138 49 5.5 29 75 97 58	(OE - O) 240 325 425 400 610 286 310 250 210 250 210 200 150	(DE-P) ATB 718 578 488 468 468 338 298 388 288 288 288	(%) 97.89 97.35 98.50 98.85 96.44 95.30 95.30 95.30 95.30	18 54 25 44 32 16 42 52 35 ND (<18) 21 ND (<28)	
15 16 17 18 19 22 23 25 27 28 27 28			.2 .1 .2 .6 .9 .8 .4 .5 .4 .5 .5 .5 .5 .5 .5 .5 .5 .5	[OE-D) 3.9 1.7 2.6 2.3 7.7 5.2 4.7 3.8 9.1 7.2 8.5 4.1 3.8 3.7 4.9	<5 <5 <5 <4 <4 <4 <6 <4 <4 <6 <4	2.4 3.8 3.1 3.3 3.6 2.6 2.4 2.3 2.2 2.3	(OE-P) 48 57 187 48 59 32 110 842 120 120 130 130 130 270	(NAA) 92 51 110 71 35 180 150 120 120 120 120 120 170 280	(OE-D) 59 30 130 49 5.5 29 83 920 75 97 58 99	(OE-O) 240 325 425 400 610 280 250 250 250 260 260 150 150 150	(DE-P) 478 718 578 488 468 338 298 388 288 288 288	95,30 95,50 97,29 97,35 98,50 98,44 97,40 95,30 95,30 95,30 93,60 93,60	18 54 25 44 32 16 42 35 ND(<10) 21 ND(<20) 35	
15 16 17 18 19 22 23 45 54 27 89		·i	.2 .1 .2 .6 .9 .8 .4 .5 .4 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5	(OE-D) 3,9 1,7 2,6 2,3 7 5,2 4,7 3,6 9,1 7,2 8,5 4,1 3,6 3,7	<5 <5 <5 <4 <6 <4 <6 <4 <1 11	2.4 3.8 3.1 3.3 3.0 2.6 2.6 2.3 2.4 2.2 2.2 2.3	(OE-P) 48 57 189 40 32 110 840 120 120 130 160 170 100	(NAA) 92 51 11.6 71 35 180 150 1290 120 120 110 170 280 140	(OE-D) 59 50 130 49 5.5 29 63 920 75 97 56 99 170 66	(OE-O) 240 325 425 400 610 280 250 210 250 210 200 150 130 170	(DE-P) 478 718 578 488 468 338 298 388 288 288 288 288 28	(%) 96.50 97.29 97.35 98.50 98.64 97.40 95.30 93.50 93.60 93.10 87.10 87.60	18 54 25 44 32 16 42 35 ND (<18) 21 ND (<28) 35	
15 16 17 18 19 22 23 25 26 27 29 29 29 29 29 29 29 29 29 29 29 29 29		:_	.2 .1 .2 .6 .9 .8 .4 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5	(OE-D) 3,7 2,6 2,3 5,2 4,7 3,6 7,2 8,5 4,1 3,6 3,7 4,9 5,2	<5 <5 <5 <4 <6 <4 <6 <4 <6 <4 5 31	2.4 3.8 3.1 3.3 3.6 2.6 2.4 2.3 2.2 2.3	(OE-P) 48 57 189 48 59 32 110 848 120 120 130 166 270 100 55	(NAA) 92 51 11P 71 35 180 150 1290 128 110 170 280 140 95	(OE-D) 59 30 130 49 5.5 29 83 920 75 97 58 99 170 86 53 92 35	(OE - O) 240 325 425 426 426 426 426 250 250 210 250 210 250 150 150 130 150 130	(DE-P) 478 718 578 488 468 338 298 388 288 288 288 288 288 288	90,50 97,29 97,35 98,50 98,44 97,40 95,30 95,30 93,60 93,10 93,10 85,80 88,90 98,40	18 54 25 44 32 16 42 35 ND (<10) 21 ND (<20) 35 55 43 27	
15 16 17 18 19 21 22 23 45 27 28 29 28			.2 .1 .2 .6 .9 .8 .4 .5 .4 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5 .5	[OE-D) 3.9 1.7 2.6 2.3 .7 5.2 4.7 3.8 9.1 7.2 8.5 4.1 3.8 3.7 4.9 4.9	<5 <5 <5 <4 <4 <4 <6 <4 <6 <4 <11 22 31 18	2.4 3.8 3.1 3.3 3.6 2.6 2.4 2.3 2.2 2.3 3.3	(OE-P) 48 57 189 48 59 32 110 848 188 189 169 278 109 278	(NAA) 92 51 11.7 71 35 180 150 120 120 120 110 128 110 140 140 150	(OE-D) 59 30 130 49 5.5 29 63 920 75 97 56 99 170 66 53 92	(OE-O) 240 325 400 610 280 250 210 250 210 250 150 170 170	(DE-P) ATE 718 578 488 468 338 298 388 288 288 288 288 28	(%) 97.09 97.09 98.50 98.85 96.40 95.30 95.30 95.30 95.30 95.30 95.30 95.30	18 54 25 44 32 16 42 52 35 ND (<18) 21 ND (<28) 35 55	

NO - NOT DETECTED

SAMPLE														
		DEPIH	2105	*F503		FE AS		CAC	NA 45	K 5 O	K AS	TICS	P2C5	PN:
٠,	NO.	(FT)	(x)	" አገ	(%)	1 FE203	(X)	(x)	# 4450	(x1	X K50	(1)	(x)	(PPH)
					(XPF)	(AAN)			(NAA) .		((NAA)
	65116115		13,31	2.47	1.36	1.17	2,07	47.90	1,52	.7b	.83	.89	.861	824
	02116512		67,95	16.95	5.13	4.87	2.45	1.70	. 80	4.45	5.10	. 89	.03	368
68848	651F66F5	3061.1	69.77	17.39	5.24	4,31	2.07	1.24	. 81	4.37	4.89	.89	30	410
00001	65116311	3105.8	55.41	.71	,76	. 49	2.29	27.94	943	. 89	. PI 9 7	< .21	.67	2436
20051	021L01C1	3211.4	77.71	15,59	4.63	3.79	1.29	.17	. 95	4.28	4.31	. 93	.03	230
2252	NSILRECT	3821:4	78.38	15.58	4.23	3.87	1.53	.27	. 98	4.23	4.54	95	P 4	246
e e u 5 3	WSILW3C1	3241,3	61,63	21.49	6.2%	4,94	1.27	1.38	.63	3.66	3.54	.69	. 71	376
	USILEACT		61,24	17.64	7.58	7.42	.79	,73	.56	3.39	3.55		<.01	286
48455	251F84C5	3:59.5	56.48	1.1,38	6.27	5.67	1.94	2.44	.59	3.73	3.74	.74	.04	520
	02IL05C1		56,69	1.3,79	6.52	5.04	. 90	.86	. 46	4.19	4.16	.74	. 06	346
	851F36C1		57,79	1.4.62	5.52	5,56	1.19	. 4 4	.72	4.51	4.57	.85	.08	210
	051F61C1		56,67	14.94	6.55	5.74	1.24	. 97	.76	4.45	4.48	. 42	. P 6	342
20059	021L#8C1	3096.5	55,51	17,57	6.24	5.00	1,69	,77	.73	4.94	4.88	.88	13.	337
60045	031L01L1	4444	42,19	11.10	4.46	2,56	1,65	23,58	. 47	2.98	3.17	. 47	. 1 1	1600
	03IL07L1		68,75	11,47	7.42	5.44	1.77	1.84	.75	2.98	3,35	.62	. 66	439
	031L12L1		66,73	14.27	6.13	4.73	1.52	1.07	.74	3.77	4.32	,67	. 86	348
	63175671		66.28	17.60	4.16	2,92	2.24	2.74	91	4.76	5,31	.82	. 8.8	266
	63115673		59,86	14.96	4.47	3,39	3.76	5.86	. 63	3.88	4.35	.68	. 0.7	616
	631F53F1		62,39	15.95	5.23	3,54	2.86	3.93	.74	3.65	3.98	.60	.10	593
16.66.08	83115611	4735	64,76	15,27	2.46	2.33	3.32	4,59	.58	3.89	4.21	•55	. 14	598
			MN;			5	:	TOTAL	DRGANIC	INORG	i	TOTAL	38	
			(PP4) (OE=P)	(PPM) (Di+D)	(PPM) (OE=P)	(x)	(1)		C (X)	C (x)	(1)	CEC MED/1296	(PPM)	(PPM)
P6538			780	3.5	8.2	.08	.08	12.68	.67	10.01	.55	1.2	.5	,5
			780 350	32 1 o e	82		. P.B . A 7	12.68	.67 3,43	10.01		1.2 5.6	.5 1.8	,5 21
26639	ı				_	.97	.07		3.43	.53	1.81		1.8	
20039 20040	ı L		350	1 > 12	197			3.96				5.6		21
20039 20040 20041	ı		350 380	1 30	192	.97 .83	.01 .96	3.96	3.43	.53 .34	1.81	5.6 4.8	1.8	21 17
20039 20041 20041 20051			350 380 1000 197 200	150 130 24 250 150	197 198 12	.97 .83 .30	.07 .96 .08	3.96 2.94 6.49 1.62 2.41	3.43 2.60 .35 1.61 2.37	.53 .34 6.14	1.01 .79 .31	5.6 4.8 .2 4.7 4.6	1.8	21 17 2.6 21 9.7
20039 20041 20041 20051 20053			350 380 1007 197 207 312	1 3 P 1 3 P 2 P	192	.97 .83 .30 .67 .42	.06 .08	3.96 2.94 6.49 1.62 2.41 7.95	3.43 2.60 .35 1.61 2.37 7.54	.53 .34 6.14	1.01 .79 .31	5.6 4.8 .2 4.7 4.6 4.7	1.8	21 17 2.6 27 9.7
20039 20041 20051 20053 20053			350 320 1002 192 202 312 232	150 130 24 200 150 155 165	197 198 12 227 209 193 183	.97 .83 .30 .67 .42 1.19 1.69	.07 .06 .08	3.96 2.94 6.49 1.62 2.41 7.95 8.77	3.43 2.69 .35 1.61 2.37 7.54 8.51	.53 .34 6.14 .91 .94 .41	1.01 .79 .31 .81 .58 .88	5.6 4.8 .2 4.7 4.6 4.7 4.7	1.8	21 17 2.6 27 9.7 41
20039 20041 20041 20051 20053 20053 20053			350 320 1002 192 202 312 232 359	100 140 24 200 150 155 165 140	197 198 12 227 208 198 188 188	.97 .83 .30 .67 .42 1.19 1.69 1.23	.07 .96 .08 .12 .08	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28	3.43 2.69 .35 1.61 2.37 7.54 8.51 8.45	.53 .34 6.14 .91 .94 .41 .26	1.01 .79 .31 .81 .58 .88 1.51	5.6 4.8 .2 4.7 4.6 4.7 4.7 5.1	1.8	21 17 2.6 27 9.7 41 64 40
20039 20041 20051 20051 20053 20053 20055			350 320 1000 197 207 317 237 350 257	100 140 24 200 150 155 140 240	197 198 12 227 208 198 188 168 220	.97 .83 .30 .67 .42 1.19 1.69 1.23	.07 .06 .08 .12 .08 .05 .05	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 9.45	3,43 2,60 .35 1,61 2,37 7,54 6,51 6,45 9,21	.53 .34 6.14 .01 .04 .41 .26 .83	1.81 .79 .31 .81 .58 .88 1.51 1.19	5.6 4.8 .2 4.7 4.6 4.7 4.7	1.8 .9 .2 1,3 .9 3.9 5.5 4.2 3,7	21 17 2.6 27 9.7 41 64 40 37
20039 20041 20041 20051 20052 20053 20054 20056 2056			350 380 1000 190 200 310 230 350 250 240	150 140 24 250 150 155 140 240 220	197 197 12 227 207 197 187 187 220 220	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24	.07 .06 .08 .12 .08 .05 .05 .05	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 7.25	3.43 2.60 .35 1.61 2.37 7.54 8.51 8.45 9.21 7.12	.53 .34 6.14 .01 .04 .04 .04 .04 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05	1.01 .79 .31 .81 .58 .68 1.51 1.19 1.42	5.6 4.8 4.7 4.6 4.7 4.7 5.1	1,8 ,9 1,3 3,9 5,5 4,2 3,7	21 17 2.6 27 9.7 41 64 40 37 37
20039 20041 20051 20053 20053 20053 20055 20055			350 340 1002 197 202 312 237 350 257 240 327	150 130 24 250 150 155 140 240 240	197 198 12 227 208 193 187 168 228 228	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24 .87	.07 .06 .08 .12 .05 .05 .05 .04	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 9.45 7.25 4.47	3,43 2,60 .35 1.61 2.37 7.54 8.51 8.45 9.21 7.12 4.27	.53 .34 6.14 .01 .04 .41 .26 .83 .24	1.01 .79 .31 .81 .58 .68 1.51 1.19 1.42 1.18	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1.8 .9 .2 1,3 3.9 5.5 4.2 3,7 3.2	21 17 2.6 27 9.7 41 64 40 37 32 21.
22039 22039 22039 22031 20031			350 380 1000 190 200 310 230 350 250 240	150 140 24 250 150 155 140 240 220	197 197 12 227 207 197 187 187 220 220	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24	.07 .06 .08 .12 .08 .05 .05 .05	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 7.25	3.43 2.60 .35 1.61 2.37 7.54 8.51 8.45 9.21 7.12	.53 .34 6.14 .01 .04 .04 .04 .04 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05	1.01 .79 .31 .81 .58 .68 1.51 1.19 1.42	5.6 4.8 4.7 4.6 4.7 4.7 5.1	1,8 ,9 1,3 3,9 5,5 4,2 3,7	21 17 2.6 27 9.7 41 64 40 37 37
20039 20041 20041 20051 20053 20055 20055 20055 20055 20055 20055 20055			350 370 1002 197 202 312 237 350 250 250 270 860	2.4 2.4 2.5 1.5 1.4 2.4 2.4 2.4 2.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1	197 198 12 227 209 193 189 189 220 220 170 190	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24 .72 .80	.07 .08 .12 .08 .05 .05 .04 .04 .05	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 9.45 7.25 4.47 6.36	3,43 2,60 .35 1,61 2,37 7,54 8,51 8,45 9,21 4,27 6,17	.53 .34 6.14 .01 .04 .04 .26 .83 .25 .13	1.01 .79 .31 .81 .58 .88 1.51 1.19 1.42 1.18 1.12 1.72	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1.8 .9 1,3 3.9 5.5 4.7 3.7 3.7 3.7	21 17 2.6 27 9.7 41 64 40 37 32 21,
20039 20039 20041 20051 20053 20053 20055 20055 20055 20055 20055 20055 20055 20055 20055 20055 20055 20055 20055 20055 20055			350 370 1002 197 207 312 237 350 257 240 327 270 867 318	2.50 1.50 2.50 1.55 1.40 2.40 2.50 1.55	197 198 12 227 200 198 169 220 220 170 190	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24 .87 .72 .80	.07 .068 .12 .085 .055 .044 .075 .076	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 9.45 7.25 7.25 4.47 6.36	3,43 2.60 .35 1.61 2.37 7.54 8.51 8.45 9.21 7.12 4.22 6.17	.53 .34 6.14 .91 .04 .26 .83 .24 .13 .25 .19	1.01 .79 .31 .81 .58 1.51 1.19 1.42 1.18 1.12 1.72	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1.8 .92 1,39 5.5 4.2 3,72 1.7 3.0 3.0	21 17 2.6 27 9.7 41 64 40 37 32 21. 21.
20039 20041 20051 20053 20053 20053 20055 20			350 370 1002 197 203 317 233 357 253 240 303 270 867 310 257	2 PP 150 155 140 220 155 140 155 155 155 155 155 155 155 155 155 15	197 197 197 227 200 197 187 180 220 170 190	.97 .83 .30 .67 .42 1.19 1.49 1.23 1.24 .87 .72 .80	.07 .08 .1855 .085 .085 .085 .085 .085 .085	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 9.45 7.25 4.36 5.93 6.36	3,43 2,60 .35 1,61 2,37 7,54 8,51 8,45 9,21 7,122 4,17	.53 .34 6.14 .91 .94 .41 .83 .24 .13 .19	1.01 .79 .31 .81 .58 .68 1.51 1.19 1.42 1.18 1.12 1.72	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1,8 ,9 2 1,3 ,9 3,9 5,5 4,2 3,7 3,2 1,7 3,8	21 17 2.6 27 9.7 41 64 40 37 32 21. 21.
22039 20041 20051 20053 20			350 370 1002 197 202 312 237 257 240 327 270 867 318 258 210	2 P P 1555 140 C 2 2 5 5 1 6 5 5 1 6 5 5 1 6 5 5 1 6 5 5 1 6 5 5 1 6 5 5 5 5	197 198 12 227 200 198 180 220 170 190 150 150 150 200 200	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24 .62	.07 .068 .1885 .085 .085 .085 .085 .085 .085 .085	3.96 2.94 6.49 1.62 2.41 7.25 8.77 9.45 7.25 4.47 6.36 5.93 9.94 8.61	3,43 2,60 .35 1,61 2,37 7,54 8,51 8,45 9,21 7,12 4,27 6,17 ,86 9,43 8,53	.53 .34 .01 .01 .04 .04 .04 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05	1.01 .79 .31 .51 .58 1.51 1.19 1.18 1.12 1.72	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1,8 ,9 2 1,3 ,9 3,9 5,5 4,2 3,7 3,2 1,7 3,8	21 17 2.6 27 9.7 41 64 40 37 32 21. 21.
22239 22239 22239 22239 22239 22239 22239 22239 22339 22339 22339 22339 22339 22339 22339 22339 23			350 370 1002 197 202 312 232 350 250 250 250 270 860 310 250 250 250 250 250 250 250 250 250 25	250 250 250 155 140 240 250 155 140 250 155 160 165 260 165 260	197 198 12 227 208 198 188 228 228 179 190 158 190 200 200 200 200 200 200 200 200 200 2	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24 .72 .80 .80	.07 .08 .18 .08 .08 .08 .08 .08 .08 .08 .08 .08 .0	3.96 2.94 6.49 1.62 2.41 7.95 8.77 9.28 9.45 7.25 4.47 6.36 5.93 9.94 6.98 5.93	3,43 2,60 .35 1,61 2,37 7,54 8,51 8,45 9,21 4,27 6,17 .86 9,40 8,52 1,93 3,51	.53 .53 .53 .6.14 .01 .041 .041 .041 .026 .033 .034 .035 .035 .035 .035 .035 .035 .035 .035	1.01 .79 .31 .81 .58 .59 1.19 1.19 1.12 1.12 1.12 1.12	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1.8 .9 2 1,3 .9 5.5 4.2 3.7 1.7 3.8	21 17 2.6 27 9.7 41 64 40 37 32 21. 21.
500238 500239 500041 500051 500053			350 370 1002 197 202 312 237 257 240 327 270 867 318 258 210	2 P P 1555 140 C 2 2 5 5 1 6 5 5 1 6 5 5 1 6 5 5 1 6 5 5 1 6 5 5 1 6 5 5 5 5	197 198 12 227 200 198 180 220 170 190 150 150 150 200 200	.97 .83 .30 .67 .42 1.19 1.69 1.23 1.24 .62	.07 .068 .1885 .085 .085 .085 .085 .085 .085 .085	3.96 2.94 6.49 1.62 2.41 7.25 8.77 9.45 7.25 4.47 6.36 5.93 9.94 8.61	3,43 2,60 .35 1,61 2,37 7,54 8,51 8,45 9,21 7,12 4,27 6,17 ,86 9,43 8,53	.53 .34 .01 .01 .04 .04 .04 .05 .05 .05 .05 .05 .05 .05 .05 .05 .05	1.01 .79 .31 .51 .58 1.51 1.19 1.18 1.12 1.72	5.6 4.8 2 4.7 4.6 7 4.7 5.1 4.7 5.1	1,8 ,9 2 1,3 ,9 3,9 5,5 4,2 3,7 3,2 1,7 3,8	21 17 2.6 27 9.7 41 64 40 37 32 21. 21.

SAMPLE	GEOL.	DEPTH	64	BE	BE	+	A.P.	C E	C 5	CH	CR	CR	c _o	CO	
NO.	NO.	(FT)	(PPH)	(PPM)	(PPH)	(PPH)	(PPH)	[PP#)	(PP*)	(PPM)	(PPH)	(PPH)	(PPM)	(PPH)	
	•			(CE=0)	(OE-P)		•			(NAA)	(OE-D)	(OE-P)	(NAA)	(0E-0)	
0P038	ESILBILS	3209.5	<6?	<1	< .87	24		25	1.6	3.5	26	22	4.3	12	
	ESILOSLE		632	2.6	5.4	162	< 7	71	7.2	5.5	9.5	110	17	Ş	
88999	ESILAPES	3281,1	532	5.2	د . 5	154	< 4	74	6.8	98	91	110	14	17	
00.041	65110911	3105,8	<60	<1	< .87	6.6	<4	7 1	. 5	5.7	8,5	<9.5	1 1	15	
89851	85116101	3011.4	470	2,5	4.9	160	∢ 6	71	6.2	77	92	129	19	23	
00052	ESIF65CI	3721.4	340	2.4	4.5	162	۵	87	7.9	P. 4	95	122	12	1.2	
0P353	ESIF63C1	3,43,3	452	3.0	4.7	129	4	63	6.5	6.7	67	80	25	3 5	
P0054	PRILEACT	3253,2	524	3.5	4.6	122	4	75	6.2	64	6.4	R 5	31	31	
Ø2255	ESIL@4CS	3059.5	518	3,1	4.9	120	4	75	6.4	7 ?	15	69	27	3.5	
66836	E2ILP5C1	3:65,3	572	2.9	5.2	15%	3	79	6.9	65	79	99	24	28	
88857	13447IS4	3273,4	65W	3.4	5.2	160	< 4	95	8,2	8.14	79	100	25	56	
PPHSA	ESILP7C1	.3885,5	432	2.7	4.5	150	5	7 1	7.2	8 2	97	112	55	21	
655259	ESIFCSCI	3096.5	588	3.4	5.6	258	<5	74	8.4	7 9	92	116	51	53	
86695	ESILAILI	4482	268	.84	2.9	192	<4	41	a# I	58	62	8.8	13	22	
800003	@31La7L1	4542	666	3.1	4.8	142	< 5	76	5.2	63	55	53	27	56	
	E31F15F1		663	3.4	5.2	152	< 4	72	6.5	92	77	8 1	25	56	
22045	E3IL20L1	4673	487	2.6	5.2	286	2	112	9.7	118	112	136	15	16	
	63115613		450	2.3	4,4	250	4	77	7.9	137	168	110	13	15	
	631L23L1		388	2.4	4.3	152	3	51	6.6	77	67	75	5.0	21	
	23IL26L1		426	2.7	4.6	223	<7	73	8.1	93	8.5	91	19	19	
			CC (PPM)	CU (PPH)	CU (PP≅)	DY (PPM)	EU (PPM)	F (PPM)	G.A (₽₽Ч)	GF (PPM)	GE (PPP)	HF (PPM)	PB (PPH)	LA (PPM)	
			(OE=P)	(DE=0)-	(OE-P)	•				(0£=0)	(DE=P)		(DE-P)		
00238			(OE-P)		(OE-P)			536	4		(∩E-P) ≪7.5			17	
				15		4.8	.9 1.2	968 53 <i>b</i>	4 24	•			(0E-P)	17 38	
C0239			<3.4		(OE-P)	4.¢ 5.2	1.2			<1, 6,4	<7.5	. 8	(OE-P) <2,4		
68639 66646			<3.4 23	12 53	(OE-P) 6.1 68	4.8		968	24	<1,	<7.5 <7,3	. 8 5. 6	(0E-P) <2,4 9,0	3.8	
60239 00242 00241	•••••		43.4 23 26	12 53 47 3.7	(QE-P) 6,1 68 55 <1,4	4.8 5.2 7.6 3.2	1.2	968 1835	24 24	<1, 6.4 6.7 5.6	<7.5 <7,3 <7,3	.8 5.6 4,8	(DE-P) <2,4 9.0 8,2	38 39	
60239 60242 60241			<3.4 23 26 7.6	12 53 47 3.7	(OE-P) 6,1 68 55	4.8 5.2 7.6 3.2 5.3	1.2	968 1935 1968	24 24 .5	<1, 6,4 6,7 5,0	<7.5 <7,3 <7,3 <7,5	.8 5.8 4,8	(OE-P) <2,4 9.0 8,2 <2,4	38 39 6	
00039 00040 100041 100051			<3.4 23 26 7.6	12 53 47 3.7	(QE-P) 6,1 67 55 <1,4 45,	4.8 5.2 7.6 3.2 5.3 6.5	1.2	968 1835 1868 825	24 24 .5	<1, 6.4 6.7 5.6	<7.5 <7,3 <7,3 <7,5 <7.5	.8 5.8 4,8 .6	<2.4 9.0 8.2 <2.4	38 39 6	
00039 00040 00041 00041 00051 00053			<3.4 23 26 7,6 37 15	12 53 47 3.7 38 32	(QE-P) 6,1 67 55 <1,4	4.8 5.2 7.6 3.2 5.3 6.5 5.7	1.2	968 1835 1868 825 738	24 24 .5 22 27	<1, 6.4 6.7 5.0 2.3 2.4 2.5	<7.5 <7,3 <7,3 <7,5 <7.5	.8 5.6 4,8 .6 5.5 6.8	<2.4 9.0 8.2 <2.4 6.3	38 39 6	
C0239 00242 00241 CP251 90252 90253 90254		••••	<3.4 23 26 7.6 37 15 46	12 53 47 3.7 38 32 74	(OE-P) 6.1 67 55 <1.4 45 40 62	4.8 5.2 7.6 3.2 5.3 6.5 5.7	1.2	968 1835 1868 825 738 858	24 24 .5 22 22	<1, 6.4 6.7 5.0 2.3 2.4	<7.5 <7,3 <7,3 <7,5 <7.5 <7.3 <7.2 <6.8	.8 5.6 4,8 .6 5.5 6.8 3.7	<2.4 9.0 8.2 <2.4 8.3 11	38 39 6 41 41 34	
00239 00242 00241 00241 00251 00252 00253 00254			33.4 23 26 7.6 37 15 46 41	12 53 47 3.7 38 32 74 82	(OE-P) 6,1 67 55 <1.4 45 40 82 8A	4.0 5.2 7.6 3.2 5.3 6.5 5.7 5.6 5.8	1.2 1.4 .3 1.0 1.2 1.1 1.1	950 1935 1960 825 732 859 895	24 24 .5 22 28 17	<1, 6.4 6.7 5.0 2.3 2.4 2.5 2.3 1.6	<7.5 <7.3 <7.3 <7.5 <7.5 <7.2 <6.8 <6.7	.8 5.6 4,8 .6 5.5 6.8 3.7	(OE-P) <2.4 9.0 8.2 <2.4 6.3 11 12	38 39 6 41 41 34 32	
C0239 00242 00241 CP251 00252 00253 00253 00255 00255			<3.4 23 26 7.6 37 15 46 41 33	12 53 47 3.7 38 32 74 82 76	(OE-P) 6,1 67 55 <1.4 45 40 88 78	4.0 5.2 7.6 3.2 5.3 6.5 5.7 5.6 7.1	1.2 1.4 .3 1.0 1.2 1.1 1.1 1.3	950 1935 1963 825 732 859 895	24 24 .5 22 28 17 17	<1, 6,4 6,7 5,6 2,3 2,4 2,5 1,8	<7.5 <7,3 <7,3 <7.5 <7.3 <7.5 <6.8 <6.7 <6.7	5.5 5.8 5.5 6.8 3.7 4.0 3.8	(OE-P) <2,4 9,0 8,2 <2,4 8,3 11 12 19 12	38 39 6 41 41 34 32 37	
C0239 00242 00241 CP251 60252 60253 60253 60255 60255 60257			33, 4 23 26 7, 6 37 15 46 41 33 36	12 53 47 3.7 38 32 74 82 76	(OE-P) 6.1 67 55 <1.4 45 40 82 87 78	4.0 5.2 7.6 3.2 5.3 6.5 5.7 5.6 5.8	1.2 1.4 .3 1.0 1.2 1.1 1.1	962 1235 1863 825 732 858 895 982	24 24 .5 22 27 17 17 19 24	<1, 6.4 6.7 5.0 2.3 2.4 2.5 2.3 1.6	<7.5 <7,3 <7,3 <7.5 <7.6 <7.2 <6.8 <6.7 <6.7	5.6 4,8 .6 5.5 6.8 3.7 4.0 3.8	(OE-P) <2,4 9,0 8,2 <2,4 6,3 11 12 19 12 12	38 39 6 41 41 34 32 37 38	
E0239 00242 00241 CP251 00252 00253 00253 00255 00255			33.4 23 24 7,6 37 15 46 41 33 36 39	12 53 47 3.7 38 32 74 82 76 100 87	(OE-P) 6.1 6.7 55 <1.4 45 40 82 8A 78 99	5.2 7.6 3.2 5.3 6.5 5.7 5.6 5.6	1.2 1.4 .3 1.0 1.2 1.1 1.1 1.3 1.5	968 1735 1868 825 738 859 859 895 982 982 982	24 24 .5 22 27 17 17 19 24 23	<1, 6.4 6.7 5.0 2.3 2.4 2.5 2.3 1.8	<7.5 <7,3 <7,3 <7.5 <7.3 <7.2 <6.8 <6.7 <6.7 <6.6	5.6 5.5 6.8 3.7 4.8 3.4 4.5	(OE-P) <2.4 9.0 8.2 <2.4 6.3 11 12 19 12 16	38 39 6 41 34 32 37 38 63	
COC39 00044 00041 CPC51 00053 00055 00055 00055 00055 00055			33.4 23.4 24.7.6 37.5 46.41 33.3 36.39 34.36	12 53 47 3.7 38 32 74 82 76 100 87 68 97	(OE-P) 6.1 67 55 <1.4 45 40 82 8A 78 99 74 97	5.2 7.6 3.2 5.3 6.5 5.7 5.8 7.1 6.4 5.9	1.2 1.4 .3 1.0 1.2 1.1 1.3 1.5 1.6	962 1735 1862 825 732 858 895 982 982 883 883 883 883 883	24 24 .5 22 27 17 17 19 24 23 18	2.3 2.4 2.5 2.3 1.6 1.7 2.2	<7.5 <7,3 <7,5 <7.5 <7.2 <6.8 <6.7 <6.6 <6.8 <7.2	.8 5.6 4,8 .6 5.5 6.8 3.7 4.8 3.8 3.4 4.5 3.5	(OE-P) <2,4 9,0 8,2 <2,4 6,3 11 12 12 18 16	38 39 6 41 34 32 37 38 63 38	
00039 00044 00041 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00025 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00024 00025			33.4 23.2 24.7,6 37.15 42.41 33.3 36.39 34.32	12 53 47 3.7 38 32 74 87 160 87 60 97	(OE-P) 6.1 6.1 55 <1.4 45 40 82 8A 78 99 74 97	5.2 7.6 3.2 5.3 6.5 5.7 5.6 5.8 7.1 6.4 5.5 7.1	1.2 1.4 .3 1.6 1.2 1.1 1.3 1.5 1.6 1.2	968 1935 1968 825 732 859 895 982 982 986 868 875 1965 1965	24 24 .5 22 27 17 17 19 24 23 18 26	<1, 6.4 6.7 5.0 2.3 2.4 2.5 2.3 1.6 1.7 2.0 2.2	<7.5 <7,3 <7,3 <7,5 <7.3 <7.2 <6.8 <6.7 <6.6 <6.8 <7.2 <6.8 <7.3 <7.3	3.4 4.5 5.5 6.8 3.7 4.0 3.4 4.5 4.5 3.5	(OE-P) <2.4 9.0 8.2 <2.4 6.3 11 12 19 12 16 16 22 3.6	38 39 6 61 41 34 32 37 38 63 38 61	
C0239 00244 00241 C0255 00255 00255 00255 00256 00256 00242			33, 4 23 26 7, 6 37 15 46 41 33 36 39 34 36	12 53 47 3.7 38 32 74 82 76 100 87 69 97	(GE-P) 6,1 67 55 41.4 45 48 88 78 99 74 97	5.2 7.6 3.2 5.3 6.5 5.6 5.6 7.1 6.5 5.9	1.2 1.4 .3 1.0 1.2 1.1 1.3 1.5 1.6 1.2 1.3	962 1735 1862 825 732 859 982 982 982 983 850 1851	24 24 .5 22 27 17 17 19 24 23 18 26	<1, 6.4 6.7 5.2 2.3 2.4 2.5 2.3 1.6 1.7 2.2 2.2	<7.5 <7,3 <7,3 <7.5 <7.3 <7.2 <6.8 <6.7 <6.6 <7.3 <6.6 <7.3 <6.6	3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8	(OE-P) <2,4 9,0 8,2 <2,4 6,3 11 12 13 14 15 16 22 3,8	38 39 6 41 34 32 37 38 63 38 61	
CRC39 00044 00041 CRC55 000554 000555 000655 000655 000656 000656 000656 000656			<33,4 23 26 7,6 37 15 46 41 33 36 39 34 36 39 34 36 39 34 38	12 53 47 3.7 38 32 74 87 68 67 69 75	(OE-P) 6.1 6.1 55 <1.4 45 40 82 8A 78 99 74 97	5.2 7.6 3.2 5.3 6.5 5.6 5.6 7.1 6.4 5.9 4.9	1.2 1.4 .3 1.0 1.2 1.1 1.3 1.5 1.6 1.3	968 1935 1968 825 732 859 895 982 982 986 868 875 1965 1965	24 24 .5 22 27 17 17 19 24 23 18 26	21, 6.4 6.7 5.0 2.3 2.9 2.5 2.3 1.6 1.7 2.0 2.2	<7.5 <7,3 <7,3 <7,5 <7.2 <6.8 <6.7 <6.6 <7.3 <7.2 <6.6 <7.3 <6.6 <7.3 <6.6	5.6 5.5 6.8 3.6 3.6 3.6 3.6 3.5 3.5	(OE-P) <2.4 9.0 8.2 <2.4 6.3 11 12 19 12 16 16 22 3.6	38 39 6 61 41 34 32 37 38 63 38 61	
000440 000440 000440 00055 00055 00055 00055 00055 00055 000445 000445			33.4 23.4 24.7.6 37.5 46.41 33.3 36.39 34.36 39.34 36.39	12 53 47 3.7 38 32 74 82 76 100 87 69 97	(GE-P) 6.1 67 55 <1.4 45 40 82 8A 78 99 96 74 97	5.2 7.62 7.62 5.7 5.8 7.1 6.45 5.9 4.9 4.9 4.9	1.2 1.4 2 1.2 1.1 1.3 1.5 1.6 1.2 1.3	968 1935 1962 825 732 859 895 982 982 988 858 31851 578 828	24 24 .5 22 22 17 17 19 24 23 16 26	2.3 2.4 2.5 2.3 1.6 1.7 2.2 3.7 7.8 8.0 8.9	<7.5 <7,3 <7,5 <7.2 <6.8 <6.7 <6.6 <6.8 <7.2 <6.6 <7.3 <6.6 <7.3 <6.6	3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8	(OE-P) <2.4 9.0 8.2 <2.4 6.3 11 12 13 16 22 3.6 14 10	38 39 6 41 34 32 37 38 63 38 63 38 61	
00238 500239 600249 600241 60025 60025 60025 60025 60025 60025 60024 600			<33,4 23 26 7,6 37 15 46 41 33 36 39 34 36 39 34 36 39 34 38	12 53 47 3.7 38 32 74 82 76 100 87 68 97 34 75 100	(OE-P) 6.1 6.1 55 <1.4 45 40 82 8A 78 99 74 97 35 86 102	5.2 7.6 3.2 5.3 6.5 5.6 5.6 7.1 6.4 5.9 4.9	1.2 1.4 .3 1.0 1.2 1.1 1.3 1.5 1.6 1.3	968 1935 1968 825 732 859 982 982 982 982 982 1951 579 502 1990	24 24 .5 22 27 17 17 19 24 23 16 26 15 17 21	21, 6.4 6.7 5.0 2.3 2.9 2.5 2.3 1.6 1.7 2.0 2.2	<7.5 <7,3 <7,3 <7,5 <7.2 <6.8 <6.7 <6.6 <7.3 <7.2 <6.6 <7.3 <6.6 <7.3 <6.6	3.4 4.5 3.4 3.4 4.5 4.5 4.5 4.5 4.5 4.5 4.5	(OE-P) < 9.0 8.2 < 8.3 11 12 13 14 15 16 22 3.8 14 17 13	38 39 61 31 32 37 38 63 38 61 31 31 32	

NO.	GEDL. NO,	CEPTH (FT)	LU (PPH)	MC (PPM) (OE=D)	PPM) (NAA)	NI (PPH) (OE=D)	NI (PPM) (QE=P)	%] (PPM) (MAA)	R3 (PP™)	SM (PPH)	SC (PP")	AG (PPM) (OE-P)	SR (PP#) (NAA)	5R (PPH) (OE=U)
	SSIFBIFS		, 2	9,5	ND	19	13	10	31	3.6	4.1	< .8	94	236
	85168265	- • -	, 4	18,	5.0	6.4	9.5	76	177	6.4	19	< .8		100
	651F69F5		.5	3.7	NO	ع ه	71	54	152	9.6	26	< .8	30	130
06601	85116911	3185.4	. 67	5,5	ND	15	15	9	< 3%	1.4	.6	< .8	140	130
	651F61C1		.3	3.1	ND	83	148	67	140	6.4	15	< .8	135	100
	851F85C1		. 4	. 9	ND	4 &	63	34	150	h . 8	16	< .8	129	90
	051F63C1		, 3	·52	81	73	123	64	110	6.2	13	< .7		65
	021L04C1		. 3	74	77	74	100	85	150	7.3	14	< .7		52
10855	02112402	3259.5	. 4	55	88	AP	100	69	137	B.7	15	< .7	100	6.6
12656	P21LP5C1	3045,3	. 4	89	112	168	136	84	130	16	16	< .7	97	72
10057	65116901	3073,6	. 4	6 A	112	100	160	99	162	12	19	< .8	149	95
2258	PRILETCE	3285.5	۰	1 9	24	63	110	36	170	7.8	19	< .A	•	95
	021L28Ci		. 4	35	77	69	110	73	164	18	50	< ,6	196	100
6005	e31Le1L1	3824	. 3	5.6	ND	62	7.8		110	5.6	. 12	< .6	92	250
2203	231L27L1	454C	. 4	133	142	8.2	130	95	130	9.7	13	< .7	172	99
2204	D31L12L1	4592	٠	89	83	95	130	150	160	و ع	18	< ,7	200	98
	031L27L1		. 4	5.7	37	68	94	99	500	5.6	5.5	< A	50	112
	831L27L3	-	. 4	13	20	72	95	180	168	7.9	έè	< .8	200	140
	031L23L1		. 3	29	52	68	100	95	130	6.0	15	< .8		98
	831r59F1		. 5	56	56	180	210	190	178	7.9	18	4 .7	189	98
·:														
			. ТА (РРМ)	TB (PPM)	ŢΗ (₽₽™)	SN (PPM) (OE=D)	3N (PPM) (DE=P)	(PP")	YB (PPM)	ZN (PPM) (OE+P)	7N (PPM) (NAA)	(PPH) (OE-D)		ZR (PPM) (OE-P)
2038			(PP#)	(PPH)	(PP")	(PPH)	(PPM) (OE-P)		(PPM)	(PPM) (OE+P)	(PPM)	(PPH)	(PPH) (OE=D)	(PPM)
			(PPM) .3	((PPM) ,6	(PPM)	(PPM) (OE-D) 4.4	(PPM) (OE=P)	(PP4) 	(PPM)	(PPM) (OE+P) <2.1	(PPM) (NAA) 42	(PPH) (OE-D)	(PPH) (OE-D)	(PPM) (OE-P)
8839			(PPM) .3 1.6	(PPH) ,6 ,7	1.9	(PPM) (OE-D) 4.4 10,	(PPM) (OE-P) 41.8 5.2	(PP4)	(PPM) 1.0 2.4	(PPM) (OE+P) <2.1 26P	(PPM) (NAA) 42 290	(PPH) (OE-D) 4.7 332	(PPH) (OE-D) 81 140	(PPM) (OE-P) 87 348
0039 0040			(PPM) .3	((PPM) ,6	(PPM)	(PPM) (OE-D) 4.4	(PPM) (OE=P)	(PP4) <3 11	(PPM)	(PPM) (OE+P) <2.1	(PPM) (NAA) 42	(PPM) (OE-D)	(PPH) (CE-D)	(PPM) (OE-P)
0039 0040 0041		_:	(PPM) .3 1.6 1.2	,6 ,7 ,8	(PP") 1.9 12 11	(PPM) (OE=D) 4.4 10. 12.	(PPM) (OE-P) <1.8 5.2 5.7	(PP") <3 11 8	(PPM) 1.0 2.4 2.0	(PPM) (OE-P) <2.1 26P 61	(PPM) (NAA) 42 290 13P	(PPH) (OE-D) 4.7 332 43	(PPH) (OE-D) 81 140 155	(PPM) (OE-P) 87 348 349
0039 0040 0041			(PPM) .3 1.6 1.2 < .1 1.3	,6 ,7 ,8 ,3	1.9 12 11	(PPM) (OE-D) 4.4 10. 12. < ,7	(PPM) (OE=P) <1.8 5.2 5.7 <1.8	(PP")	(PPM) 1.0 2.4 2.0 .3	(PPM) (OE-P) <2.1 26P 61 <2.1	(PPM) (NAA) 42 290 130 34	(PPH) (OE-D) 	(PPH) (OE=0) 81 140 155 37	(PPM) (OE-P) 87 348 349 27
0041 0041 0051 0052		<u></u>	(PPM) .3 1.6 1.2 < .1 1.3 1.2	.6 .7 .8 .3	1.9 12 11 .4	(PPM) (OE-D) 4.4 10. 12. < .7 7.5 7.4	(PPM) (OE-P) <1.8 5.2 5.7 <1.8 6.1 5.8	(PPM)	1.0 2.4 2.0 .3 2.1 2.5	(PPM) (OE-P) <2.1 26P 61 <2.1 48P 41P	(PP*) (NAA) 	(PPH) (OE-D) 	(PPH) (DE-D) 81 140 155 37 190 200	(PPM) (OE-P) 87 340 340 27 370 400
0039 2042 2041 2051 2052			,3 1,6 1,2 < ,1 1,3 1,2	,6 ,7 ,8 ,3	1.9 12 11 .4 12 12	(PPM) (OE-D) 4.4 10. 12. < .7 7.5 7.4 5.8	(PPM) (OE-P) 	<pre></pre>	(PPM) 1.0 2.4 2.0 3 2.1 2.5	(PPM) (OE-P) <2.1 26P 61 <2.1 48P 41P 150	(PPM) (NAA) 42 290 130 34 260 220 91	(PPH) (OE-D) 4.7 332 43 3.5 470 430 180	(PPH) (OE+D) 81 140 155 37 190 200 120	(PPM) (OE-P) 87 340 340 27 370 480 270
0041 0041 0051 0052 0053		<u></u>	(PPH) .3 1.6 1.2 <.1 1.3 1.2 .8 1.6	(PPH) ,6 ,7 ,8 ,3	1.9 12 11 12 12 12 10	(PPH) (OE-D) 4.4 10. 12. <,7 7,5 7,4 5.8 3,9	(PPM) (OE-P) 	(PP*)	(PPM) 1.0 2.4 2.6 .3 2.1 2.5 1.9 2.0	(PPM) (OE-P) <2.1 26P 61 <2.1 48P 41P 150 16P	(PPM) (NAA) 42 290 130 34 260 220 91	(PPM) (OE-D) 4.7 332 43 3.5 47P 43P 18P 175	(PPH) (OE-D) 81 140 155 37 190 200 120 115	(PPM) (OE-P) 87 340 340 27 376 400 270 250
0041 0041 0041 0051 0052 0054		<u></u>	(PPM) , 3 1,6 1,2 < ,1 1,3 1,2 ,8 1,0	((PPH)) .6 .7 .8 .36 .8 .7 .8 .8 .7 .8 .8 .7 .8 .8	1.9 12 11 .4 12 12 12 10 11	(PPM) (OE-D) 4.4 10. 12. <,7 7.5 7.8 5.8 3.9 6.7	(PPM) (OE-P) 	(PP")	(PPM) 1.0 2.4 2.0 .3 2.1 2.5 1.9 2.0 2.4	(PPH) (OE-P) (Z-1 26P 61 (Z-1 48P 41P 15P 16P 31	(PPM) (NAA) 42 290 130 34 260 220 91 86	(PPM) (OE-D) 4.7 332 43 3.5 478 438 189 175 38	(PPH) (OE-D) 81 140 155 37 19P 20R 12P 115 13R	(PPM) (OE-P) 87 340 340 27 370 400 270 250 270
0041 0041 0041 0051 0053 0054 0055		<u></u>	(PPM) .3 1.6 1.2 4.1 1.3 1.2 .8 1.6 1.0 1.0	((PPH)) ,6 ,7 ,8 ,3 .6 ,8 ,7 ,6	(PP*) 1.9 12 11 12 12 12 10 11 11 11	(PPM) (OE-D) 10. 12. <.7 7.5 7.4 5.8 3.9 6.7	(PPM) (OE-P) 	(PP") 43 11 8 45 7 23 25 27 29	(PPM) 1.0 2.4 2.0 .3 2.1 2.5 1.9 2.0 2.4 2.3	(PPM) (OE-P)	(PPM) (NAA) 42 290 13P 34 260 220 91 66 29 150	(PPM) (OE-D) 	(PPH) (OE-D) 81 140 155 37 190 200 120 115 130 110	(PPM) (OE-P) 67 340 340 27 370 480 270 250 270 300
2039 2042 2041 2051 2053 2054 2055 2056 2056			(PPM) .3 1.6 1.2 <.1 1.3 1.2 .8 1.0 1.0 1.0 1.2	((PPH)) ,6 ,7 ,8 ,3 ,6 ,8 ,7 ,6 ,8	(PP") 1.9 12 11 12 12 10 11 11 11	(PPH) (OE-D) 4.4 10. 12. <.7 7.5 7.4 5.8 3.9 6.7 10	(PPM) (OE-P) 41.8 5.2 5.7 <1.8 6.1 5.8 3.0 2.2 3.6	(PP") 43 11 8 45 7 23 25 27 29 26	(PPM) 1.0 2.4 2.e .3 2.1 2.5 1.9 2.0 2.4 2.2	(PPM) (OE-P) 42.1 26P 61 42.1 48P 41P 150 16P 31 220	(PPM) (NAA) 42 290 130 34 260 220 91 86 29 110	(PPM) (OE-D) 	(PPH) (OE-D) 81 140 155 37 190 200 115 130 115 130	(PPM) (OE-P) 87 340 34P 27 370 400 270 250 270 250 270 300 300
2039 2041 2041 2051 2053 2054 2055 2055 2055 2055 2055 2055 2055		<u></u>	(PPM) .3 1.6 1.2 4.1 1.3 1.2 .8 1.6 1.0 1.0	((PPH)) ,6 ,7 ,8 ,3 .6 ,8 ,7 ,6	(PP*) 1.9 12 11 12 12 12 10 11 11 11	(PPM) (OE-D) 10. 12. <.7 7.5 7.4 5.8 3.9 6.7	(PPM) (OE-P) 	(PP") 43 11 8 45 7 23 25 27 29	(PPM) 1.0 2.4 2.0 .3 2.1 2.5 1.9 2.0 2.4 2.3	(PPM) (OE-P)	(PPM) (NAA) 42 290 13P 34 260 220 91 66 29 150	(PPM) (OE-D) 	(PPH) (OE-D) 81 140 155 37 190 200 120 115 130 110	(PPM) (OE-P) 67 340 340 27 370 480 270 250 270 300
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CHEMICAL DATA ON EFFINGHAM COUNTY (SSIL) AND MPITE COUNTY (SSIL), ILLINOIS CORES

BAMPLE	GEOL.	DEPTH	Ser DEG.	ND	
NO.	NO.	(FT)	ASH:	(PPH)	
	NO.	(1)	(3)	(FFE)	
			(4)		
Sugala	NSILEILE	3349 5	99,56		
	SSIFN2F5		96.73	4.9	
	BSIF89F5		97.43	• •	
				39	
ורמטטכ	851LB9L1	2162.0	99,65	37	
30005t	BSILEICI	3011.4	96.58	1.9	
	BSILASCI		96.83	19	
	021L03C1		92.22	23	
	E51C04C1		89,50	26	
	MZILG4C2		89.48	35.	
	M21L05C1		88.39	ā5.	
	25114961		96.45	25.	
	621L6761			28	
			93.50		
YC3386	651F08C1	3446.5	91.24	1:5:	
500042	PBILAILI	4480	96.86	9 0.	
	031L27L1		88.27	<u> </u>	
	03111211		88.65	21	
	831L28L1		95.18	71.	
	031L28L3		91.33	31	
	e31L23L1		92.52	18	
	03IL26L1		88.09	45	

ND . NIT DETECTED

Development of Separation Methods

Progress

Investigations have continued on the development of methods which can be utilized to demineralize shales. Standard float-sink procedures, the Humphrey Spiral, and froth flotation procedures did not produce an organic fraction deemed satisfactory for this study. Funds have just become available for the purchase of zonal centrifugation equipment, considered necessary for such separations.

However, results of the investigation have led to development of the following scheme which should yield valuable information:

- 1. Pulverize shale to less than 325 mesh
- React sample with 1N $\mathrm{NH_4AC}$ for exchangeable cations React sample with 1N HCI to remove chelated elements
- 4. Reflux sample with benzene and methyl alcohol to extract bitumens
- 5. Reflux sample with HNO, to remove pyrite etc.
- 6. React sample with HF to remove silicates
- 7. Reflux sample with HCl to remove fluorides
- 8. Float residue at 1.40 specific gravity to remove insoluble titanium minerals

This procedure will yield significant information about the associations of various elements. Optimization of the scheme is still necessary, but until zonal centrifugation equipment is received, it seems to be a reasonable approach. Data, however, will need careful and, perhaps, qualified interpretation.

Characterization of Elemental Concentrations in Separated Shale Fractions

Progress

Data collected thus far indicate that very few elements show a significant concentration in the shale organic-rich fraction. Most elements are depleted to about 5-10% of concentration found in the whole shale material.

Most of the data acquired so far have been from developmental procedure. and from fractions of different samples. During the next quarter, the procedure outlined above will be applied to fractions of the same shale samples and should allow a much improved characterization of elemental associations.

MODE OF OCCURRENCE AND RELATIVE DISTRIBUTION OF HYDROCARBON PHASES IN SHALE

Introduction

Determine the character of off-gases from approximately 10-foot intervals in cores collected in the Illinois Basin. In addition, determine the relative distribution of hydrocarbons in ten specially prepared core samples, which are the same as those in previous unit. Preserve the samples in airtight containers and subsequently analyze them for evolved gases; highly volatile, low-molecular weight liquids; medium-volatile hydrocarbons; and solvent-extracted, low volatile hydrocarbons using GC-MS methods. Determine non-volatile, high-molecular weight hydrocarbons by GC analysis of shale pyrolytic products.

Determine the carbon isotopic composition of methane in off-gases from core samples whenever sufficient methane can be collected. Compare this data to other pertinent data such as gas composition and vitrinite reflectance for the purpose of making interpretations as to the origin and maturity of the gas. Perform laboratory experiments to study the relative effects and significance of chemical and isotopic fractionation that occur as gas is released from core samples.

Data accumulated can be evaluated to gain a better understanding of the origin, migration, and location of natural gas associated with the shales.

Released Gas Analysis

Progress

Studies of released gases from all cores collected in the Illinois Basin have been completed, and no new core samples have become available.

Medium Volatile Hydrocarbon Analyses

Progress

Progress on this project has been minimal due to the delay in purchase of necessary gas chromatographic equipment. Word has been received indicating that funds are being made available. In the interim the bidding process for the equipment has been completed and the final orders have been prepared.

The project is 7 to 8 months behind schedule. However, with limited equipment already available, the preliminary analysis of two standard black shale samples has been started. Other samples (2) are being prepared for analysis.

Low-Volatile Hydrocarbon Analysis

(See Medium Volatile above.)

Isotopic Analysis of Off-Gases

No additional cores have been made available containing sufficient methane for an isotopic analysis.

Laboratory Study of Chemical and Isotopic Fractionation

(Titled "Carbon-13/Carbon-12 Studies" in January 1978 Report)

Progress

The core sample that was pressurized with natural gas at 1000 psi continued to outgas for more than 6 months after the pressure was released. Because the oth samples from this core stopped outgassing a few weeks after they were initially collected, it is apparent that the initial pressure within this core was much lower than that used in this experiment. Future experiments will be carried out at much lower pressures.

The results of the analyses of the gas released from the pressurized shale samples are summarized in figure 1 as a function of the time (in days) after the initial pressure release (a detailed description of the procedure was given in the last annual report). Outgassing had essentially stopped when the last gas sample shown on figure 1 was collected. After this gas sample was collected, the core sample was partially evacuated (to 20" of mercury). Although the pressure is building, it is very slow implying that there is very little gas left in the shale.

The data show that the first gas released (after the initial pressure bleed down) was depleted in methane relative to the gas that was injected. This is not entirely what would be expected. As discussed in the annual report, it is believed that the gas had not equilibrated with the shale before degassing was initiated. Also, all of the gas samples are depleted in ${\rm CH}_4$ relative to the initial gas indicating that there must have been a significant loss of ${\rm CH}_4$ -rich gas sometime during the experiment. Therefore there must have been a leak in the system, possibly of molecular size such that ${\rm CH}_4$ was lost preferentially.

The isotopic data are also not entirely understood. Figure 1 shows that all of the offgas is isotopically lighter than the initial gas. During the period from 10 to 25 days after the initial pressure leak, there was an increase in the δC^{13} value for methane. This may have been the period during which the leakage occurred. Although there was a small leak detected later in the experiment, this leak does not appear to explain the changes observed.

In an attempt to eliminate some of the problems encountered, future experiments will be carried out using 3/4-inch diameter cores instead of the 4-inch core used in this experiment. Several cores will be pressurized simultaneously and the pressure vessels will be kept submerged in water so that leaks can be detected. These samples will then be degassed after having been pressurized for different lengths of time.

Problems

Continuation of the degasification experiments awaits release of funds for the purchase of some necessary equipment.

ADSORPTION/DESORPTION STUDIES OF GASES THROUGH SHALES

Introduction

With nitrogen and carbon dioxide, determine internal surface area on shale core samples; on selected samples, use methane as the adsorbate (sorbate) at pressures within the range of 1 to 80 atmospheres. Comparison of these properties in gas-producing and non-gas-producing shales will be mdade to determine the relationship of shale physical properties to gas recovery.

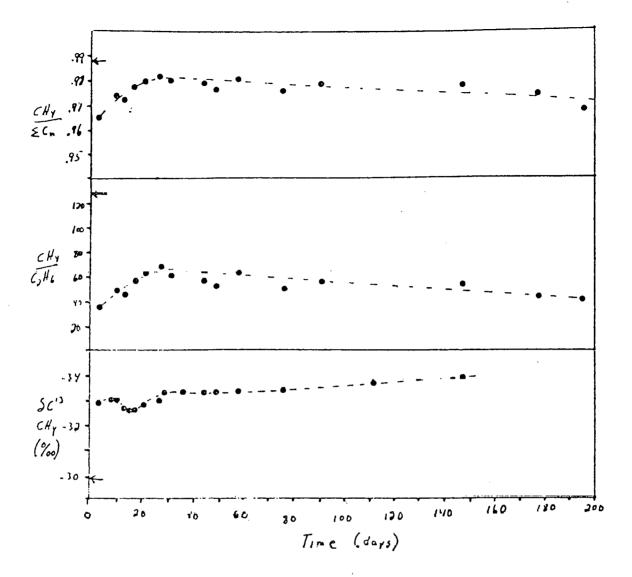


Fig. 1. Composition of off-gas during degasification experiments. Arrows indicate the composition of the gas originally injected.

Internal Surface Area Measurement

Progress

Internal surface area measurements with carbon dioxide and nitrogen as adsorbates were completed on twenty-two samples from a Tazewell County, Illinois core. Values were reported in our February, 1978 monthly report. The organic carbon content of samples from this core was relatively low. As a consequence, there was little plugging of pores by organic matter. Internal surface area values using nitrogen as the adsorbate were similar to those obtained with carbon dioxide as the adsorbate.

Samples from the Illinois Basin follow the same pattern. With increasing organic carbon content there is increased pore-plugging in the shales, leading to low internal surface area values (less than $5 \text{ m}^2/\text{g}$) from nitrogen adsorption, whereas the internal surface area values from carbon dioxide remain large (up to $39 \text{ m}^2/\text{g}$).

We recently studied some samples with high organic matter content from the Appalachian Basin that did not behave similarly. They were supplied by Dr. J. Barry Maynard (University of Cincinnati). Values are shown in the accompanying table 1.

The first eight samples in the table do not exhibit the afore-mentioned anomalous characteristic. Although fluctuations in both CO₂ and N₂ values occur, N₂ generally has more difficulty in permeating the shales than does CO₂ due to the partial clogging of pores with organic matter. In contrast, the Wise Co., VA shale samples are just as permeable to N₂ as they are to CO₂. (Note the low CO₂/N₂ ratios of about 1.0.) The Wise Co. samples are dark, and very likely contain relatively high carbon percentages. This kind of behavior has not been observed in Illinois Basin samples which contain high organic carbon contents, although it is typical behavior for northern Illinois Basin samples which are gray and contain little organic matter.

As we reported at the First Eastern Gas Shales Symposium (Morgantown - October 17, 18, 19, 1977), N_2 internal surface area values can be markedly increased for dark samples from the Illinois Basin without significantly changing the CO_2 ISA values. This was accomplished by outgassing the samples at 300° C, while losing approximately 6% of the volatile matter.

Deeper burial depth, with the consequent higher temperatures for the Wise Co. samples, may have induced a greater loss of low molecular weight volatile matter resulting in a more mature shale than those from the Illinois Basin and the first eight samples shown in the table. However, we have examined one sample from a deep core near the center of the Illinois Basin (White Co., Ill.) - the sample coming from 4673 feet, which is a comparable depth as present to those from Wise Co., Va - and found that the N2 ISA was 2.55 m 2 /g, the CO2 ISA was 12.9 m 2 /g, and the CO2/N2 ISA ratio was about 5.0. Thus, it is likely that this burial depth is still insufficient to open the pores in the White Co. sample to the same extent as in the Wise Co. samples. Perhaps the Wise Co. samples were at one time more deeply buried than at present, or perhaps there have been forces at work which have generated still greater temperatures in the shale than mere depth of burial would indicate.

Table 1. Internal Surface Area Values for Selected Samples from the Appalachian Basin

	Appalachian Basin		<u> </u>	
	Sample	CO ₂ ISA	N ₂ ISA	CO ₂ /N ₂
Ку.	PM 214	21.3 m ² /g	1.64 m ² /g	13.0
Ку.	PM 234	13.0	1.3	10.0
Ку.	Perry Co., 2375	26.2	2.62	10.0
Ку.	Perry Co., 2399	8.63	2.32	3.7
Ку.	Perry Co., 2410	16.0	2.43	6.6
Ку.	Martin Co., 2432.8	11.6	4.88	2.4
Ку.	Martin Co., 2488.4	16.2	3.28	4.9
ку.	Martin Co., 2504.8	12.95	2.47	5.2
Va.	Wise Co., 4870.0	22.4	18.3	1.2
Va.	Wise Co., 4878.3	28.4	22.2	1.3
٧a.	Wise Co., 4887.8	27.7	22.7	1.2
Va.	Wise Co., 4896.1	28.4	24.6	1.15
Va.	Wise Co., 4907.5	23.4	19.5	1.2
Va.	Wise Co., 4916.5	24.4	20.4	1.2
Va.	Wise Co., 4925.4	14.8	11.1	1.3
۷a.	Wise Co., 4935.2	14.5	11.9	1.2

Studies at present are being made on thirty samples from Henderson County, Illinois. Data for these samples will appear in the April monthly report.

SDO-1 standard shale sample gave the following values:

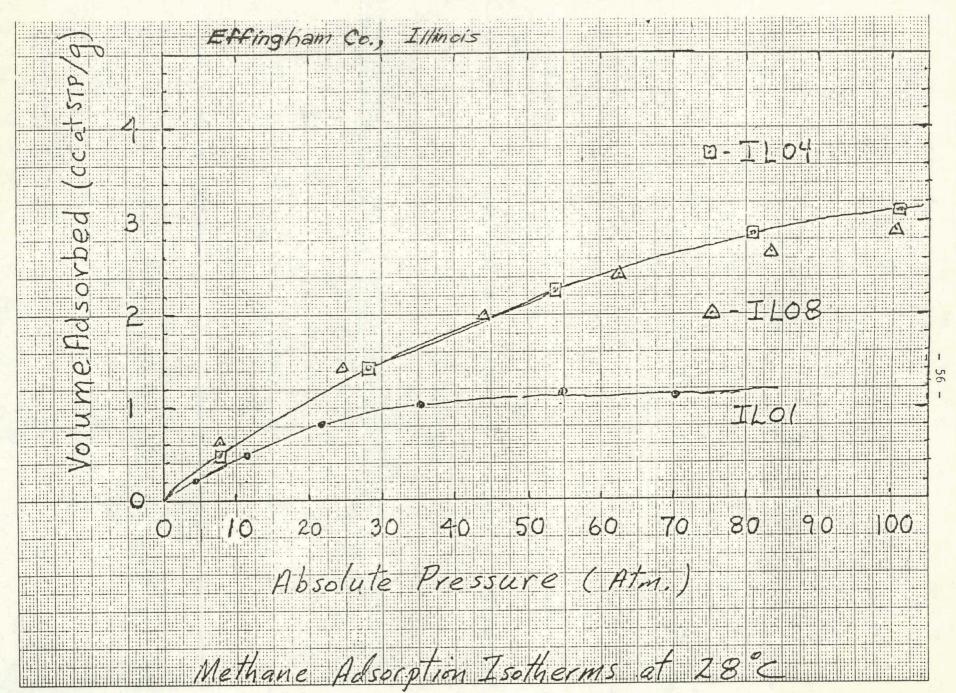
CO₂ ISA = 36.4 m²/g N₂ ISA = 4.57 m²/g CO₂/N₂ ISA = \sim 8

Methane Adsorption Isotherms

Progress

Methane adsorption isotherms at high pressures (1 to 80 atmospheres and, in some cases, up to 100 atmospheres) are being obtained on selected shale samples from different cores. Selections are based on variations in the internal surface area measurements made with nitrogen and carbon dioxide. These measurements are non-routine because the diffusion rate of methane into the fine pore structures of samples containing relatively high organic matter contents is low, and several hours are needed for equilibrium to be reached at each experimental pressure. Thus far, nine samples have been evaluated - three from the Christian Co., Ky core, three from the Sangamon Co., Ill core, and three from Effingham Co., Ill core (shown on fig. 2). Greater adsorption of methane at increased pressures is shown by samples containing the higher organic carbon contents. We do not know at this time how much of this increased adsorption is associated with ultramicroporosity (greater surface area) and how much may be associated with increased solubility of methane in the organic matter phases that are present.

To help in this regard, we are obtaining for comparative purposes the methane adsorption isotherms for molecular sieves having different pore sizes. We are also studying the diffusion kinetics of methane from the shales by reducing the pressure (from an initial 80 atmospheres) to 1 atmosphere rather suddenly, and then measuring the release rate while maintaining atmospheric pressure. Sufficient data have not yet been generated for formal presentation.



INFORMATION

DATA COMPILATION

Data Encoding

Progress

The Illinois Survey has been designated to receive all data on the DOE Eastern Gas Shales Project that pertain to the Illinois Basin. Some of the data may be sent on to Petroleum Information. A total of six contractors, including the Illinois Survey, plus the U.S. Geological Survey, are generating or gathering data pertaining to the Illinois Basin. Encoding forms in use at the Illinois Survey are being sent to the contractors for their use, if they so desire. MINERS can accept any file format, however.

Mound Laboratory is the only contractor to have sent any data so far. Some determinations on a Kentucky core were sent to the Illinois Survey on a floppy disk.

MINERAL RESOURCES EVALUATION SYSTEM (MINERS)

Introduction

This project involves the development of a Mineral Resources Evaluation System that will store all the data related to Illinois State Geological Survey ctudies of the Nevonian black shale of the Illinois Basin, and retrieve, process in many ways, and display in various ways these data.

File Generation and Maintenance

Progress

The end of the time period covered in this quarterly report is also a milestone. Completion of this portion of MINERS was scheduled for the end of March 1978. Most of the programming required for file generation and maintenance has been completed, and most of it tested. However, we are about 10 percent behind and are still coding some routines.

We have not encountered any problems that present hurdles and are not concerned with the slippage in schedule.

Design of the data base, the record management routines, and file management routines are completed and in most cases tested. Only the operating system interface, and the routines which communicate with the IBM-360 system tables and are written in ASSEMBLER LANGUAGE, are incomplete.

Retrieval

Progress

Many of the routines used in file generation are also used in retrieval. Hence, about one-half the expected programming has already been completed.

		HEPOR	T FOR MONTH END	DING		
CONTRACTOR FINANCIAL MANAGEMENT F	REPORT	Fel	bruary 28, 19	78		
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6 REPORTING CATEGORY	DUPING MONTH M	TO DATE b.	SVUSEQUENT MONTH	BALANCE OF FISCAL YEAR b.	BALANCE OF CONTRACT C.	9. ESTIMATED
Salaries, wages	\$ 16,362.22	\$ 83,471.38	\$ 16,500.00	\$-14,602.05		
Indirect cost	10,635.44	54,256.39	10,700.00	9,008.89	!	
Fringe benefits	844.24	5,929.71	1,100.00	17,509.81	<u> </u>	
Commodities, materials, supplies	592.80	4,244.55	700.00	1,233.27		
Travel		2,229.74	300.00	-1,681.82	: :	
Equipment	-	3,576.77	4,000.00	27,183,73		
Laboratory preparation	ļ	1,011.30	500.00	1,988.60		
Computer	1,415.29	5,296.23	1,000.00	3,968.99		-
Contractual	ļ		· · · · · · · · · · · · · · · · · · ·			
Nuclear reactor		<u> </u>	_	665.00		
Mass spectrograph				4,800.00		
Telecommunications	63.13	189.70	40.00	60.30	<u> </u>	
Totals	\$29,912.12	\$160,205.77	\$ 34,840.00	\$29,650.40		