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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

By
Robert E. Bergstrom
Neil F. Shimp

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

Illinois State Geological Survey
Urbana, Illinois

MASTER

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Robert E. Bergstrom and Neil F. Shimp
Principal Investigators

DOE Contract EY-76-C-05-5203

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

Illinois 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 fracturing 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 Creek 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 radioactivity 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

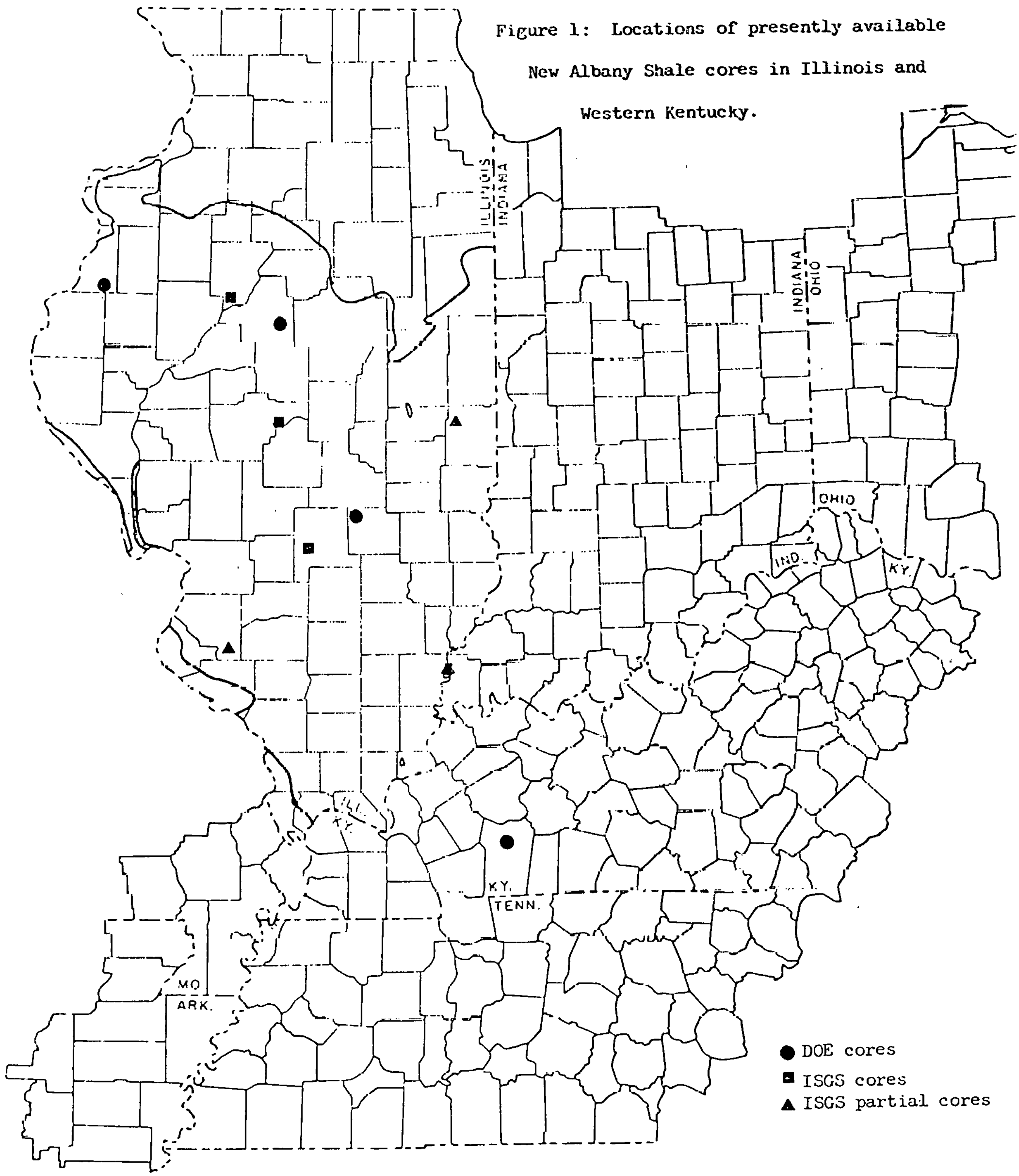
In a few wells, samples were unavailable for critical stratigraphic intervals. Contamination and mixing of the samples (during drilling) has made interpretation and sampling difficult or impossible in some cases.

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.

Figure 1: Locations of presently available New Albany Shale cores in Illinois and Western Kentucky.



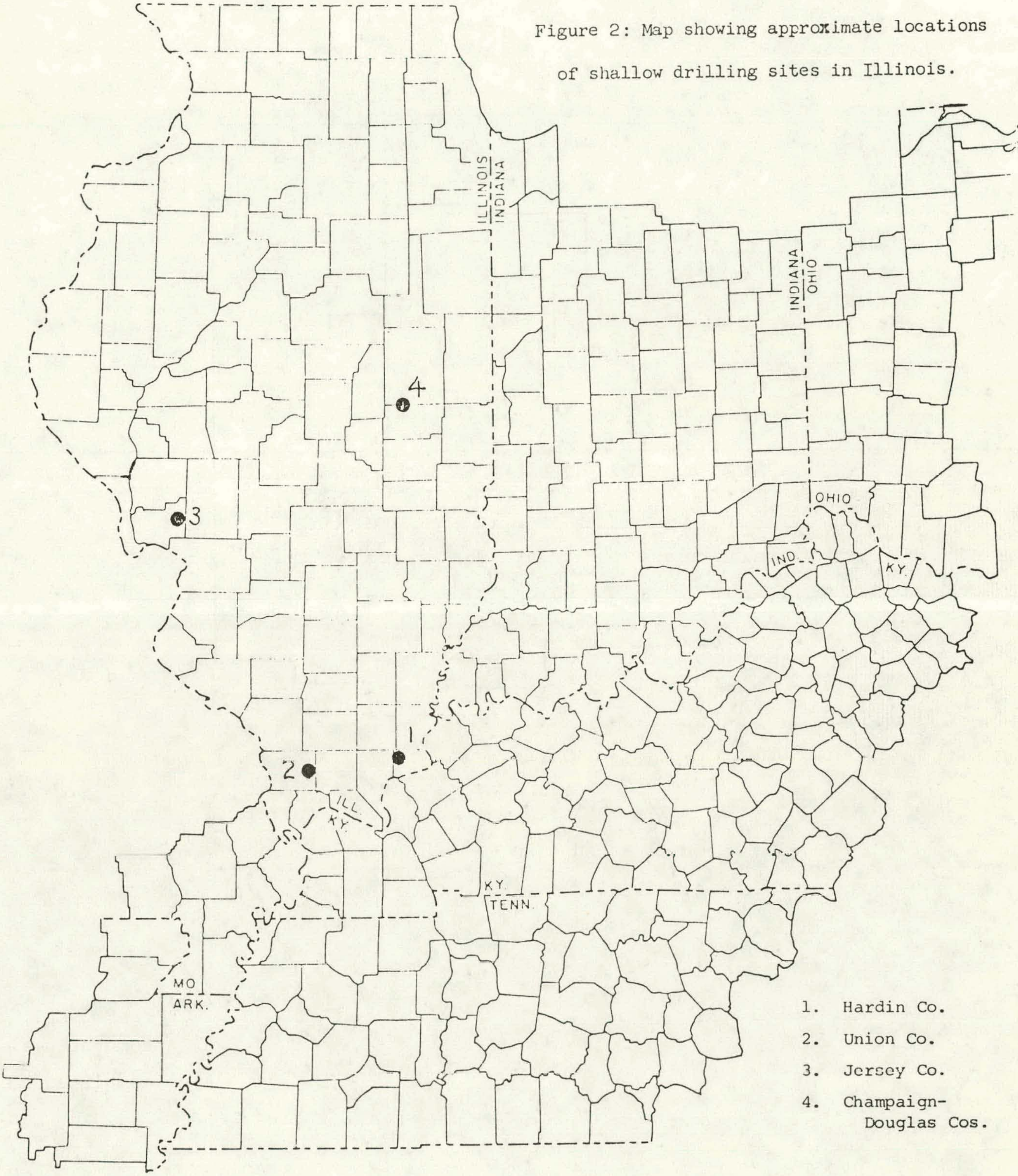


Figure 2: Map showing approximate locations of shallow drilling sites in Illinois.

1. Hardin Co.
2. Union Co.
3. Jersey Co.
4. Champaign-Douglas Cos.

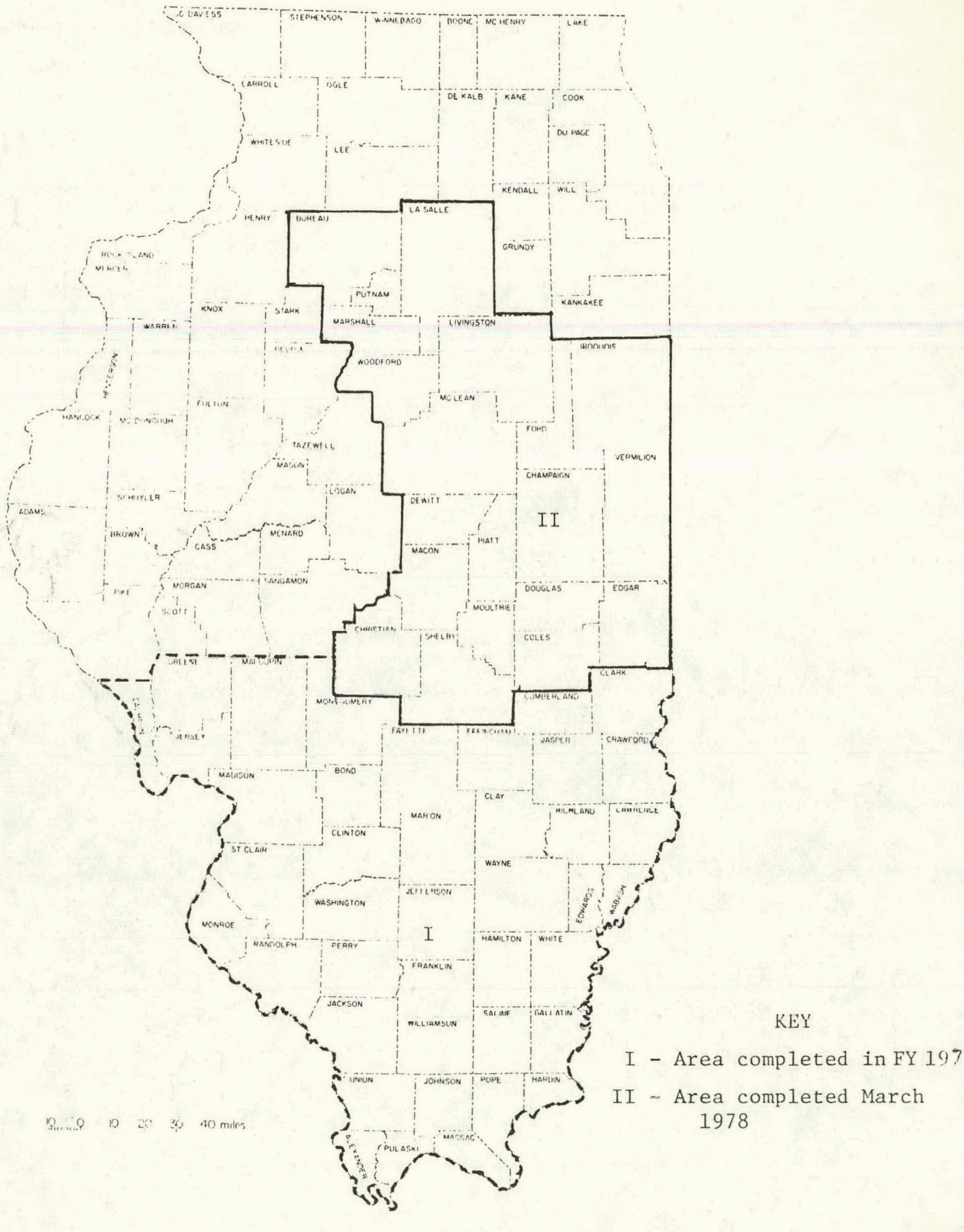


Fig. 3.
Index map showing portion of Illinois for which listing of holes penetrating upper Devonian shales has been completed. Maps showing location of these holes have also been plotted.

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 04IL (Henderson Co., Illinois), 06IL (Tazewell Co., Illinois), and 07IL (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 02IL (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 03IL 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 01KY (Christian Co., Kentucky) and the 01IL (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 02IL core and 30 samples from the 04IL 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 04IL 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°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 $\pm$ 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 $\pm$ 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 04IL and 06IL 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.

TABLE 1: SILT MINERALOGY; EFFINGHAM COUNTY, ILLINOIS, CORE SAMPLES (02IL).

OBSERVED PEAK HEIGHTS (COUNTS/SEC)

SAMPLE NUMBER	DEPTH	MCA 19.8	QTZ 20.8	FLD 23.5	KSP 27.6	PLG 27.9	KSP/PLG	CAL 29.4	DOL 30.8	CAL+DOL	SIO+APA 32.1	PYR 33.2	MAR 52.0	PYR+MAR	MINERAL TWO THETA
02IL01C1		55	175	30	0	80	0/100	0	0	0	10	0	0	0	
02IL01L2		15	30	0	0	10	0/100	500	50	550	0	0	0	0	
02IL02C1		60	185	35	5	70	7/ 93	0	0	0	10	5	5	10	
02IL03C1		50	150	25	0	35	0/100	0	0	0	10	25	10	35	
02IL04C1		55	170	20	0	45	0/100	15	0	15	10	55	15	70	
02IL04C2		60	140	30	40	50	44/ 55	0	75	75	15	40	12	52	
02IL05C1		60	140	30	45	50	47/ 53	10	55	65	20	40	10	50	
02IL05L2		60	130	30	0	60	0/100	0	40	40	20	15	5	20	
02IL06C1		60	135	30	0	70	0/100	15	25	40	15	30	10	40	
02IL06L2		70	140	30	5	55	8/ 91	55	35	90	21	18	5	23	
02IL07C1		70	130	25	40	60	39/ 59	0	30	30	20	25	5	30	
02IL08C1		70	105	25	50	60	45/ 54	15	45	60	20	32	7	39	
02IL09L1		0	205	0	0	0	0/ 0	500	195	695	10	10	0	10	

RELATIVE PEAK HEIGHTS

SAMPLE NUMBER	MCA 19.8	QTZ 20.8	FLD 23.5	KSP 27.6	PLG 27.9	CAL 29.4	DOL 30.8	SIO+APA 32.1	PYR 33.2	MAR 52.0	MINERAL TWO THETA
02IL01C1	78.57	85.37	85.71	0.00	100.00	0.00	0.00	47.62	0.00	0.00	
02IL01L2	21.43	14.63	0.00	0.00	12.50	100.00	25.64	0.00	0.00	0.00	
02IL02C1	85.71	90.24	100.00	10.00	87.50	0.00	0.00	47.62	9.09	33.33	
02IL03C1	71.43	73.17	71.43	0.00	56.25	0.00	0.00	47.62	45.45	66.67	
02IL04C1	78.57	82.93	57.14	0.00	56.25	3.00	0.00	47.62	100.00	100.00	
02IL04C2	85.71	68.29	85.71	80.00	62.50	0.00	38.46	71.43	72.73	80.00	
02IL05C1	85.71	68.29	85.71	90.00	75.00	2.00	28.21	95.24	72.73	66.67	
02IL05L2	85.71	63.41	85.71	0.00	75.00	0.00	41.03	95.24	27.27	33.33	
02IL06C1	85.71	65.85	85.71	0.00	87.50	3.00	12.82	71.43	54.55	66.67	
02IL06L2	100.00	68.29	85.71	10.00	68.75	11.00	17.95	100.00	32.73	33.33	
02IL07C1	100.00	63.41	71.43	80.00	75.00	0.00	15.38	95.24	45.45	33.33	
02IL08C1	100.00	51.22	71.43	100.00	75.00	3.00	23.08	95.24	58.18	46.67	
02IL09L1	0.00	100.00	0.00	0.00	0.00	100.00	100.00	47.62	18.18	0.00	

TABLE 2: SILT MINERALOGY; HENDERSON COUNTY, ILLINOIS, CORE SAMPLES (04IL).

OBSERVED PEAK HEIGHTS (COUNTS/SEC)

SAMPLE	DEPTH	MCA	QTZ	FLD	KSP	PLG	KSP/PLG	CAL	DOL	CAL+DOL	SIO+APA	PYR	HAR	PYR+HAR	MINERAL
NUMBER		19,8	20,8	23,5	27,6	27,9		29,4	30,8		32,1	33,2	52,0		TWO THETA
04IL01C1		65	125	50	70	0	100/ 0	0	245	245	15	12	0	12	
04IL02C1		60	145	35	65	0	100/ 0	0	280	280	20	25	0	25	
04IL03C1		60	110	40	55	0	100/ 0	0	360	360	15	15	0	15	
04IL04C1		65	105	45	70	0	100/ 0	0	230	230	12	10	0	10	
04IL05C1		55	120	45	65	0	100/ 0	0	360	360	12	20	0	20	
04IL06C1		60	120	55	75	0	100/ 0	0	265	265	10	17	0	17	
04IL07C1		70	100	65	75	0	100/ 0	0	225	225	20	20	0	20	
04IL08C1		60	90	55	85	0	100/ 0	0	200	200	15	20	0	20	
04IL09C1		60	100	50	65	0	100/ 0	0	160	160	17	15	0	15	
04IL10C1		70	110	50	65	0	100/ 0	0	135	135	12	10	0	10	
04IL11C1		60	105	45	60	0	100/ 0	0	165	165	15	20	0	20	
04IL12C1		60	115	45	70	0	100/ 0	0	165	165	12	25	0	25	
04IL13C1		60	110	50	70	0	100/ 0	0	150	150	10	0	0	0	
04IL14C1		65	105	50	70	0	100/ 0	0	125	125	15	25	0	25	
04IL15C1		85	165	26	45	45	50/ 50	20	45	65	25	17	0	17	
04IL16C1		75	175	35	50	0	100/ 0	20	70	90	25	15	0	15	
04IL17C1		80	195	25	50	40	55/ 44	25	75	100	0	15	0	15	
04IL18C1		80	190	25	50	45	52/ 47	25	40	65	20	15	0	15	
04IL19C1		80	190	35	50	45	52/ 47	20	45	65	0	0	0	0	
04IL20C1		75	160	20	70	0	100/ 0	20	50	70	12	25	5	30	
04IL21C1		80	135	25	50	50	50/ 50	0	90	90	30	17	0	17	
04IL22C1		75	140	25	50	50	50/ 50	30	95	125	30	40	0	40	
04IL23C1		75	125	30	50	50	50/ 50	0	90	90	30	30	5	35	
04IL24C1		75	145	25	60	55	52/ 47	25	160	185	35	25	5	30	
04IL25C1		75	120	30	50	50	50/ 50	0	200	200	0	15	0	15	
04IL26C1		70	135	20	40	40	50/ 50	20	65	85	25	35	10	45	
04IL27C1		60	75	20	25	20	55/ 44	15	500	515	15	25	0	25	
04IL28C1		70	95	20	25	15	62/ 37	60	500	560	0	15	0	15	
04IL29C1		20	175	5	25	0	100/ 0	500	500	1000	5	55	0	55	
04IL30C1		20	40	0	0	0	0/ 0	0	500	500	0	10	0	10	

RELATIVE PEAK HEIGHTS

SAMPLE	MCA	QTZ	FLD	KSP	PLG	CAL	DOL	SIO+APA	PYR	HAR	MINERAL
NUMBER	19,8	20,8	23,5	27,6	27,9	29,4	30,8	32,1	33,2	52,0	TWO THETA
04IL01C1	76,47	64,10	76,92	82,35	0,00	0,00	49,00	42,86	21,82	0,00	
04IL02C1	70,59	74,36	53,85	76,47	0,00	0,00	56,00	57,14	45,45	0,00	
04IL03C1	70,59	56,41	61,54	64,71	0,00	0,00	72,00	42,86	27,27	0,00	
04IL04C1	76,47	53,85	69,23	82,35	0,00	0,00	46,00	34,29	18,18	0,00	
04IL05C1	64,71	61,54	69,23	76,47	0,00	0,00	72,00	34,29	36,36	0,00	
04IL06C1	70,59	61,54	84,62	88,24	0,00	0,00	53,00	28,57	30,91	0,00	
04IL07C1	82,35	51,28	100,00	88,24	0,00	0,00	45,00	57,14	36,36	0,00	
04IL08C1	70,59	46,15	84,62	100,00	0,00	0,00	40,00	42,86	36,36	0,00	
04IL09C1	70,59	51,28	76,92	76,47	0,00	0,00	32,00	48,57	27,27	0,00	
04IL10C1	82,35	56,41	76,92	76,47	0,00	0,00	27,00	34,29	18,18	0,00	
04IL11C1	70,59	53,85	69,23	70,59	0,00	0,00	33,00	42,86	36,36	0,00	
04IL12C1	70,59	58,97	69,23	82,35	0,00	0,00	33,00	34,29	45.45	0.00	
04IL13C1	70,59	56,41	76,92	82,35	0,00	0,00	30,00	28,57	0,00	0,00	
04IL14C1	76,47	53,85	76,92	82,35	0,00	0,00	25,00	42,86	45,45	0,00	
04IL15C1	100,00	84,62	40,00	52,94	81,82	4,00	9,00	71,43	30,91	0,00	
04IL16C1	88,24	89,74	53,85	58,82	0,00	4,00	14,00	71,43	27,27	0,00	
04IL17C1	94,12	100,00	38,46	58,82	72,73	5,00	15,00	0,00	27,27	0,00	
04IL18C1	94,12	97,44	38,46	58,82	81.82	5.00	8,00	57,14	27,27	0,00	
04IL19C1	94,12	97,44	53,85	58,82	81,82	4,00	9,00	0,00	0,00	0,00	
04IL20C1	88,24	82,05	30,77	82,35	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	85,71	30,91	0,00	
04IL22C1	88,24	71,79	38,46	58,82	90,91	6,00	19,00	85,71	72,73	0,00	
04IL23C1	88,24	64,10	46,15	58,82	90,91	0,00	18,00	85,71	54,55	50,00	
04IL24C1	88,24	74,36	38,46	70,59	100,00	5,00	32,00	100,00	45.45	50,00	
04IL25C1	88,24	61,54	46,15	58,82	90,91	0,00	40,00	0,00	27,27	0,00	
04IL26C1	82,35	69,23	30,77	47,06	72,73	4,00	13,00	71,43	63,64	100,00	
04IL27C1	70,59	38,46	30,77	29,41	36,36	3,00	100,00	42,86	45.45	0.00	
04IL28C1	82,35	48,72	30,77	29,41	27,27	12,00	100,00	0,00	27,27	0,00	
04IL29C1	23,53	89,74	7,69	29,41	0,00	100,00	100,00	14,29	100,00	0,00	
04IL30C1	23,53	20,51	0,00	0,00	0,00	0,00	100,00	0,00	18,18	0,00	

TABLE 3. CLAY MINERALOGY, HENDERSON COUNTY, ILLINOIS
CORE SAMPLES (04IL)

Sample Number	Depth* (ft)	Clay Minerals (parts/10)+		
		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
12C1	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
19C1	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)	Clay Minerals (parts/10)+		
		Illite	Chlorite	Mixed-Structure
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
08C1	973.4	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
16C1	1053.2	6.5	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 Technique	Split	Clay Minerals (parts/10)			
		Illite	Chlorite	Mixed-Structure	Kaolinite
Smear					
	A	5	2	2	0.5
	B	5	2.5	2	0.5
	C	5.5	1.5	2	0.5
Sedimented					
	A	6	1.5	2	0.5
	B	5.5	2	2	0.5
	C	5	1.5	3	0.5

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

Slide Preparation Technique	Split	Clay Minerals (parts/10)			
		Illite	Chlorite	Mixed-Structure	Kaolinite
Smear					
	A	6.5	2.5	tr	0.5
	B	7	2.5	0	1
	C	6	2	1.5	0.5
Sedimented					
	A	7	2	0.5	0.5
	B	6	2	1	0.5
	C	7	1.5	1	0.5

TABLE 7. VITRINITE REFLECTANCE
EFFINGHAM COUNTY, ILLINOIS, CORE SAMPLES (02IL)

Sample Number	Depth* (ft)	# Readings	Ro(%) Average	Std. Deviation
01C1	3011.4	45	0.66	0.14
02C1	3021.4	50	0.52	0.07
03C1	3043.3	50	0.44	0.07
03C1	3043.3	51+	0.49	0.03
04C1	3053.0	26	0.49	0.06
04C2	3059.5	29	0.47	0.07
05C1	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).

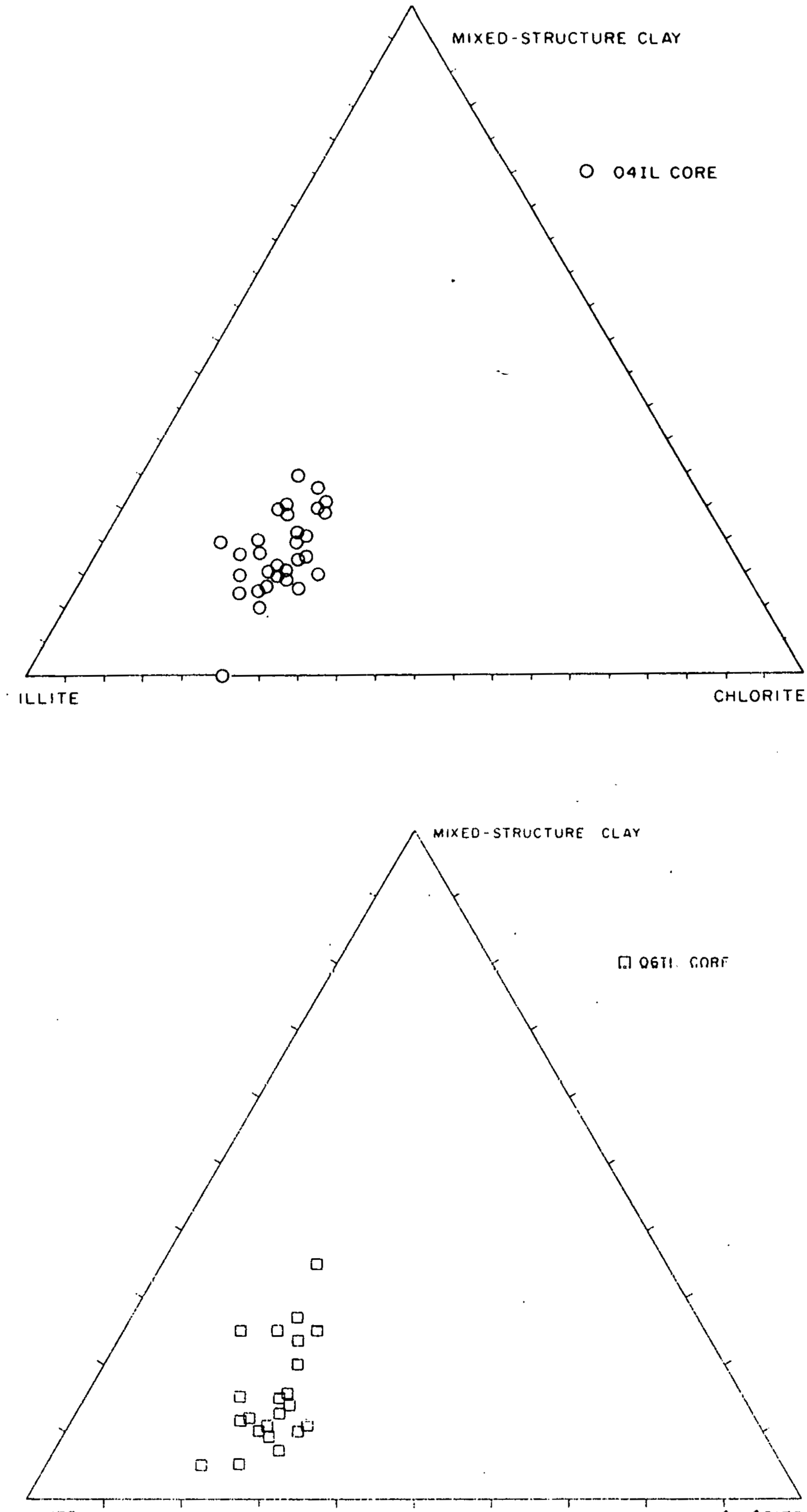


Fig. 1. Clay mineralogy: 04IL and 06IL cores.

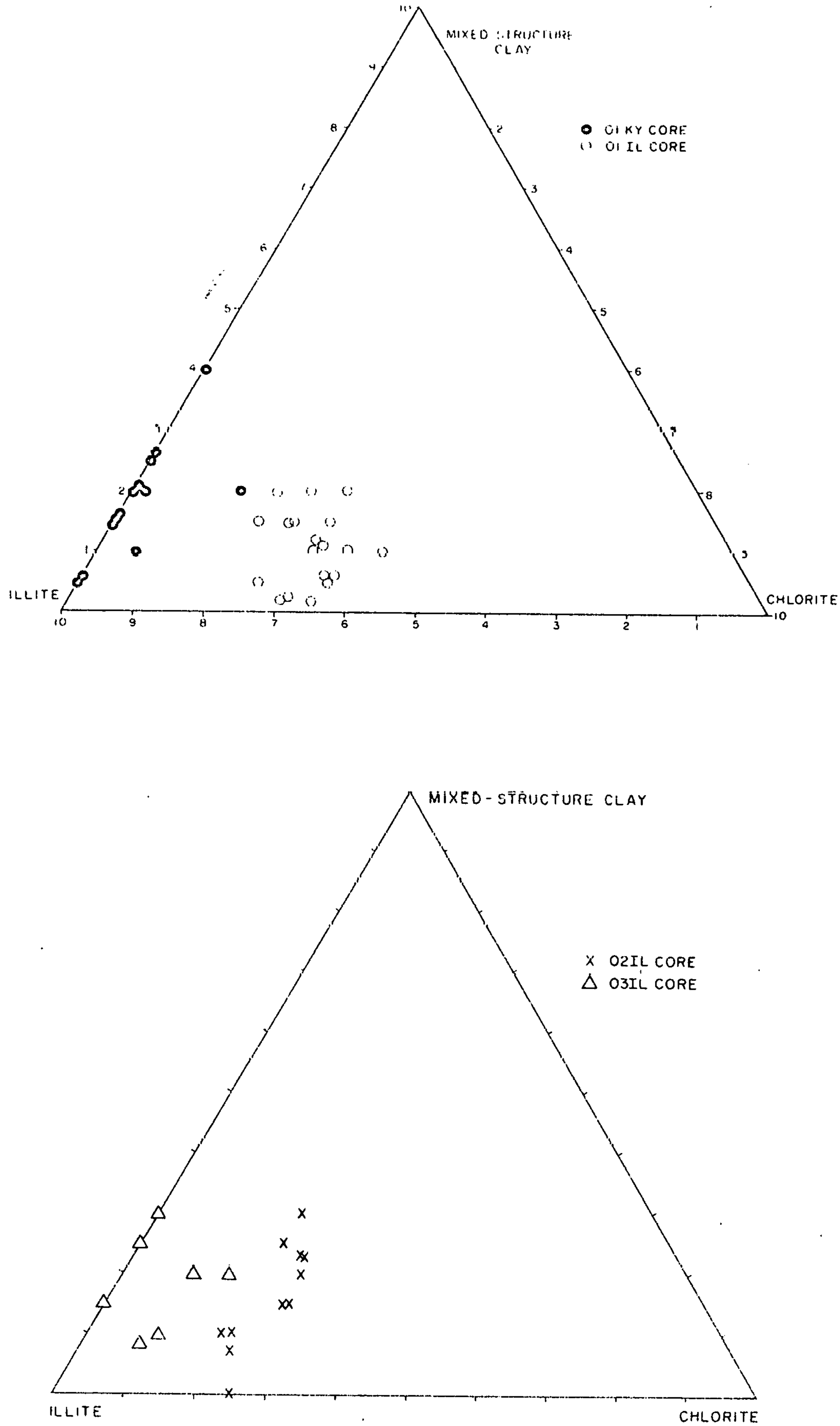


Fig. 2. Clay mineralogy: 01KY, 01IL, 02IL, and 03IL cores.

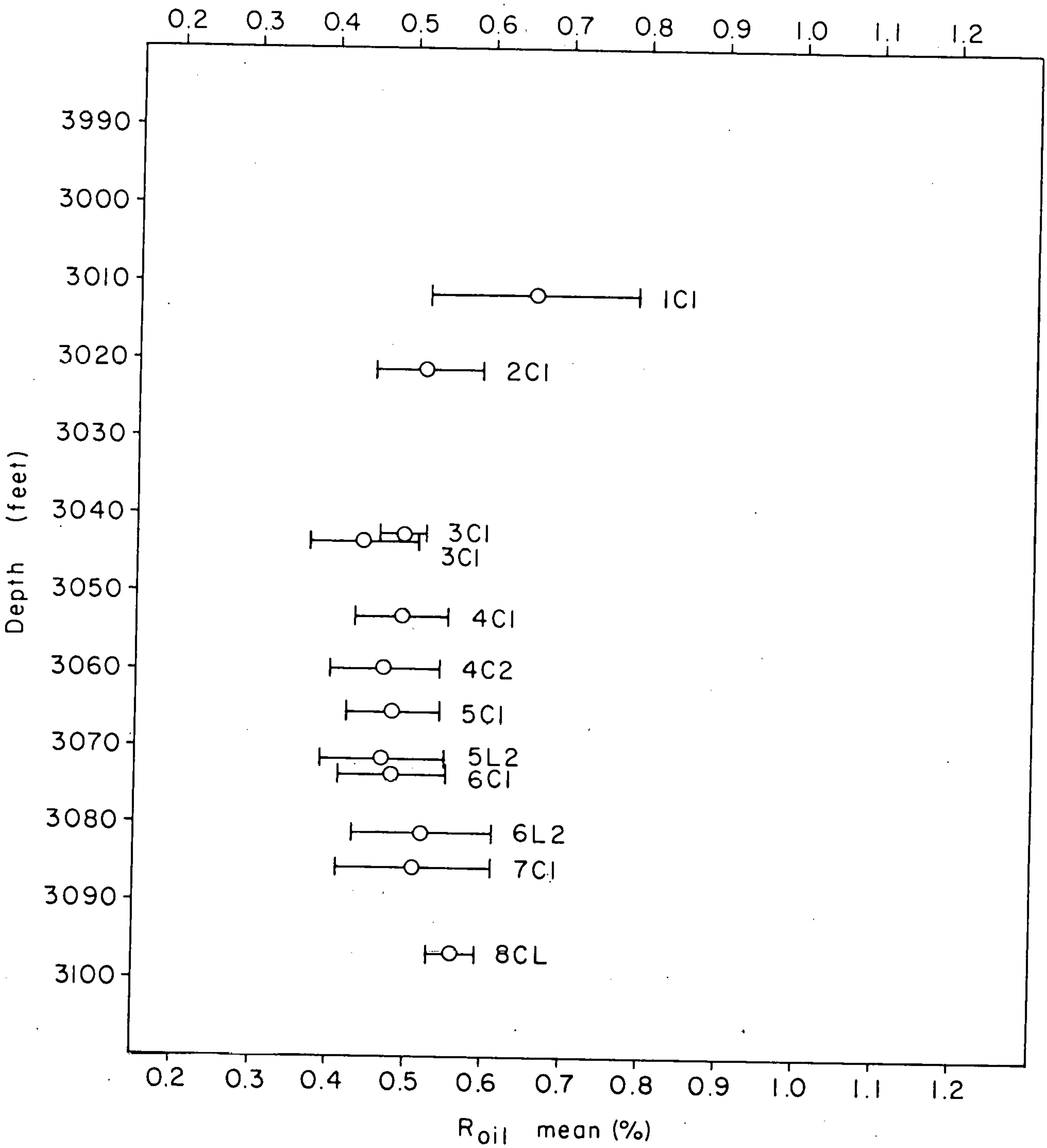


Fig. 3. Mean-random vitrinite reflectance, in oil, Effingham County, Illinois core samples (02IL). Error bars correspond to ± one standard deviation. Depths are below reference level of 612 feet above mean sea level.

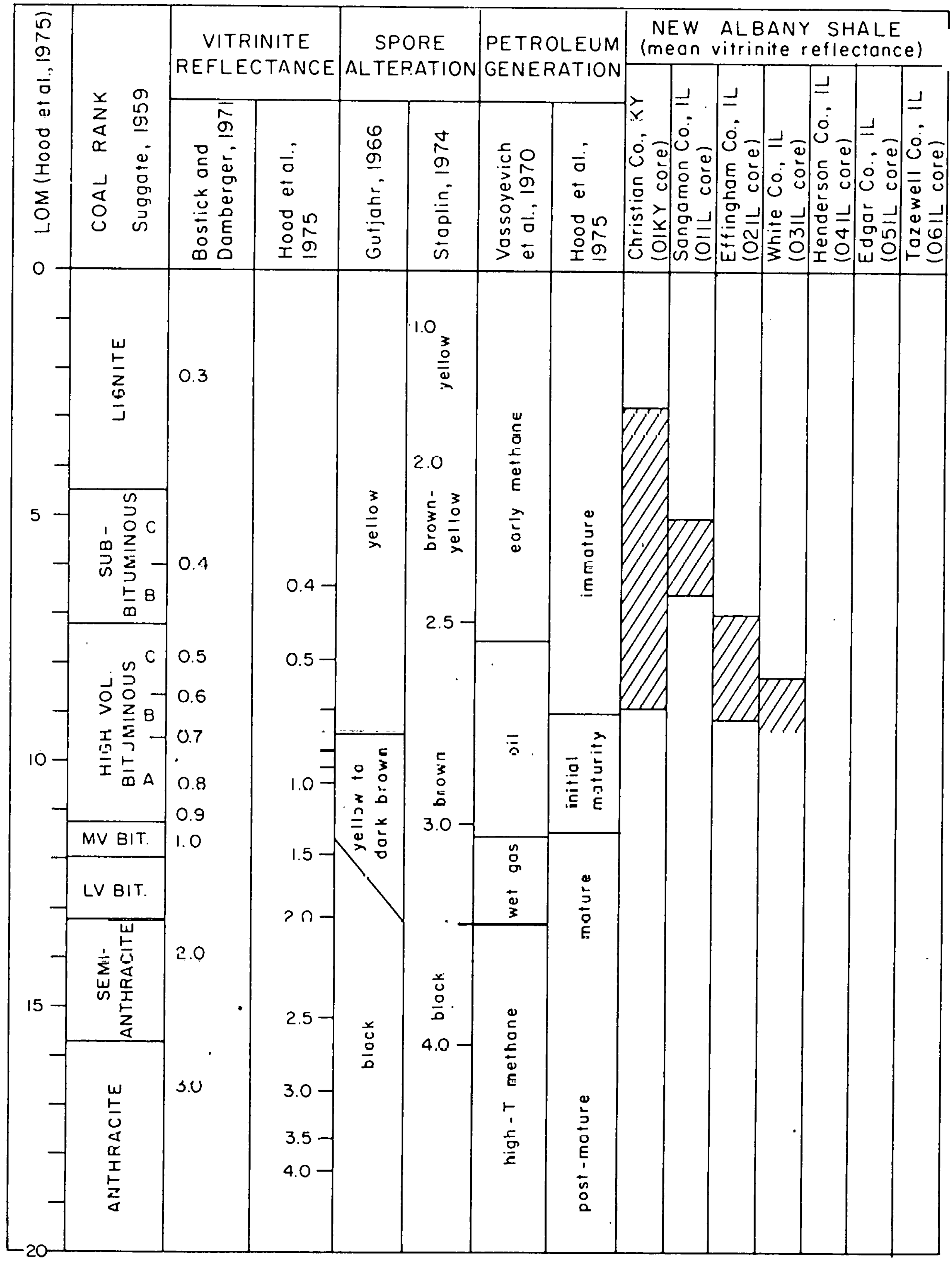


Fig. 4. Relation of level of organic metamorphism (LOM), coal rank, vitrinite reflectance, spore coloration, and principal stages of petroleum generation to reflectance, observed from Illinois Basin New Albany Shale samples.

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 01KY 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 $135^{o}/315^{o}\pm20^{o}$, and 7 fractures oriented $90^{o}/270^{o}\pm10^{o}$. 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 $130^{o}/310^{o}$ 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	II_a	II_b	III_a	III_b	IV_a	IV_b
Point-Load	5	-	2	-	22	2
Indirect-Tensile	2	2	1	3	29	-

As with core 01KY, 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.

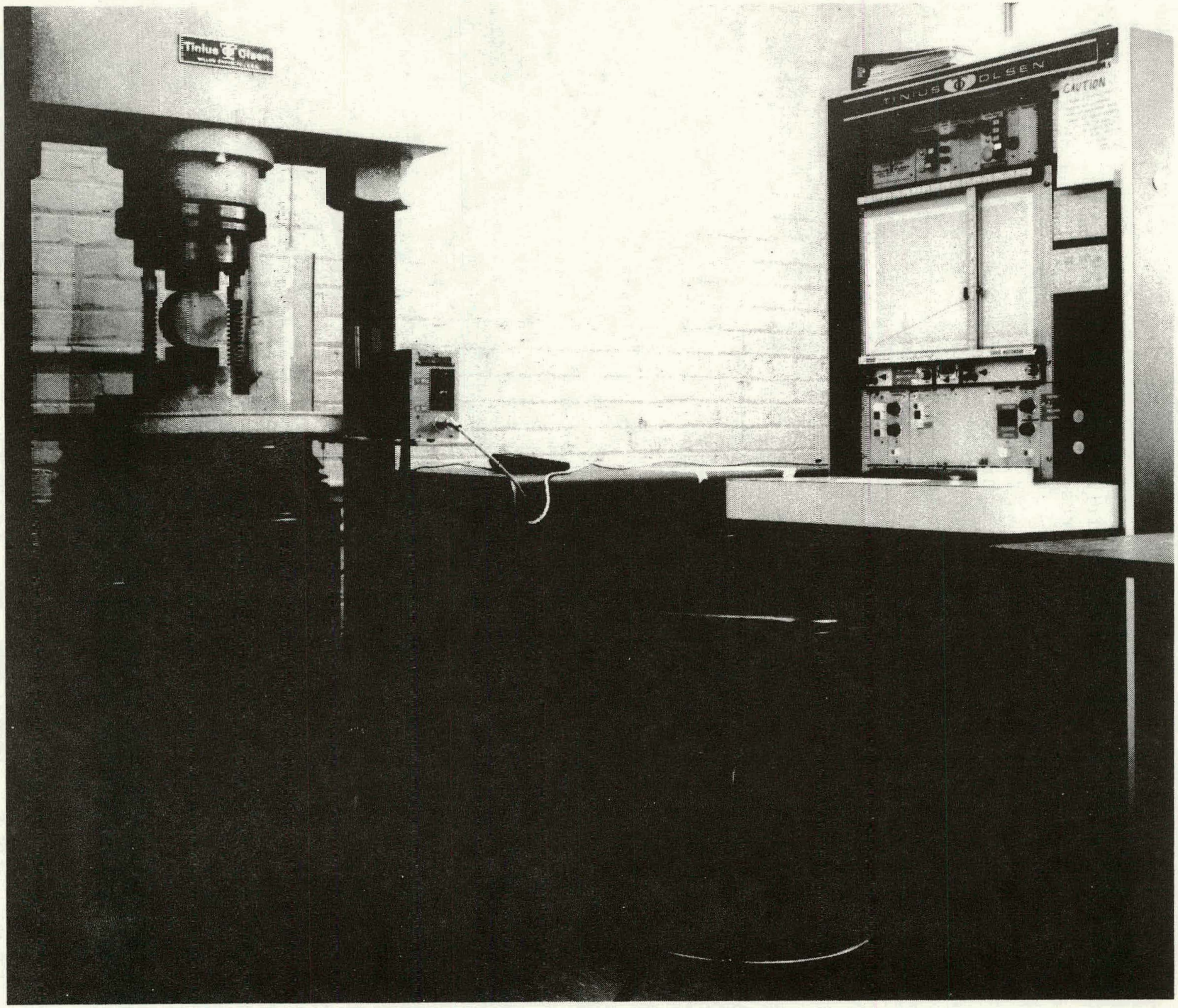
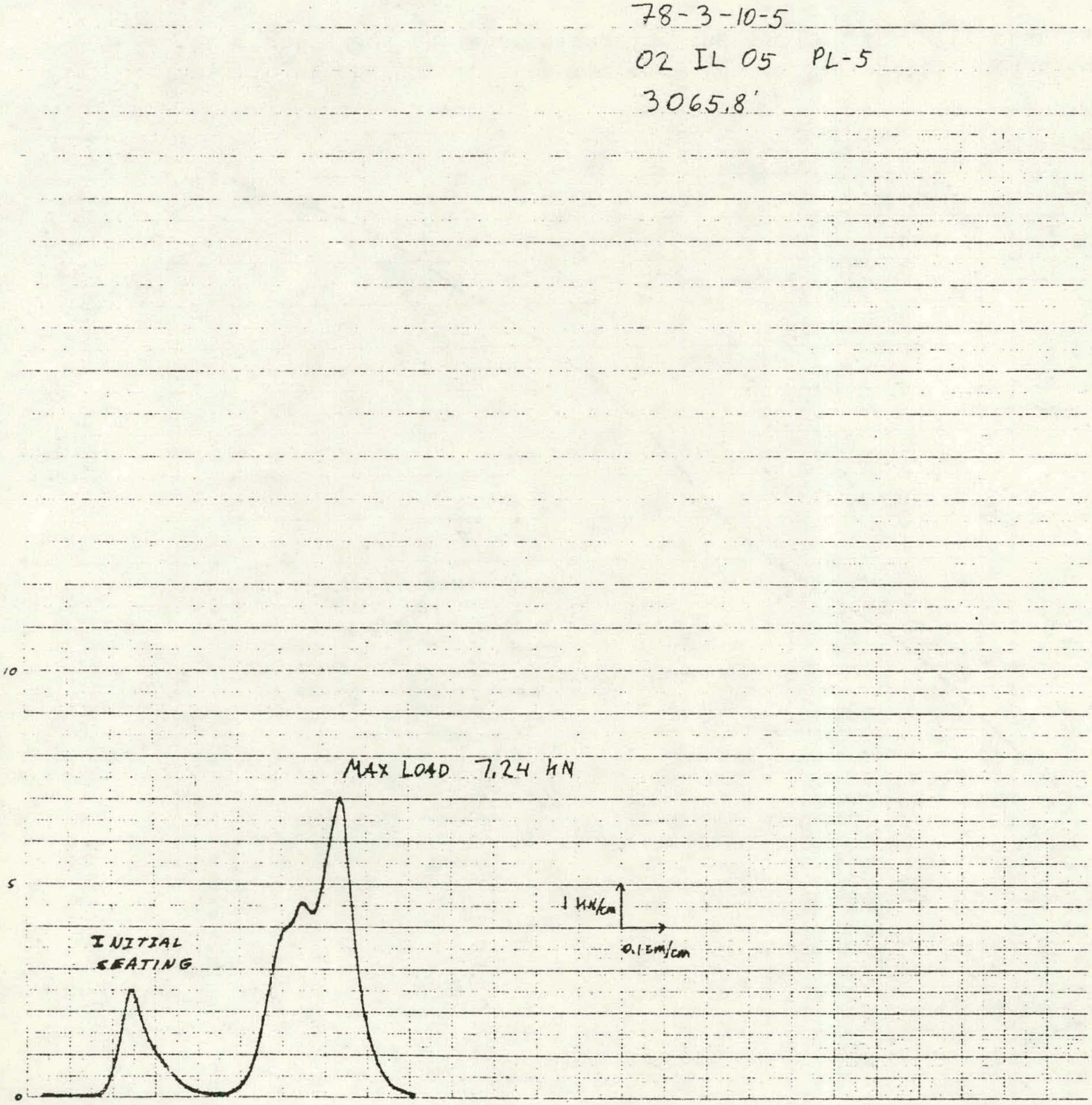


Fig. 1. Compression Testing Machine, Model 300CT-1.



ILLINOIS STATE
GEOLOGICAL SURVEY

ROCK MECHANICS LABORATORY
EASTERN GAS SHALES PROJECT
Point Load Data Sheet

Date: 78-3-10-5 Operator: [illegible]

Ill. Code No: 02-IL05 Sample No: PL-5 3065.8'

Rock Type: BL-SH IV A

Dimensions

Thickness: 6.27 cm Diameter: 10.79 cm

Load Range: 25 kN Magnification: 10X

Control: MANUAL %/min: rate: "3"/min

Maximum Load: 7.24 kN P.L. Index: 1.84 MPa
I=load/T^2

Remarks: Parallelism = .02 cm

Mode of Failure

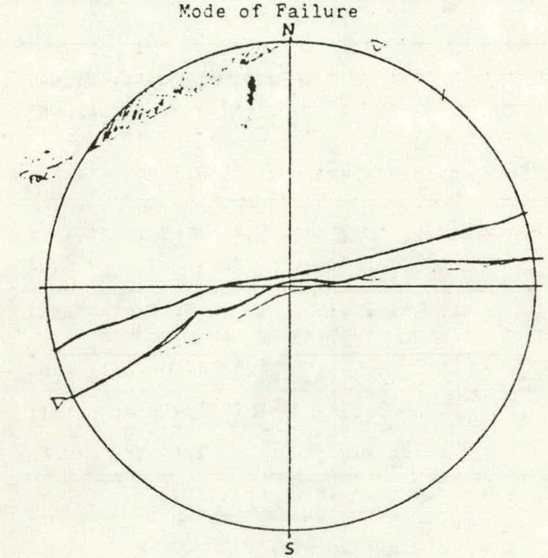


Fig.2. Example of a point-load test data sheet. A typical load deformation curve shows a peak for the initial seating of the point followed by loading to failure. The orientation of the resulting fracture(s) is shown at the right as "mode of failure."

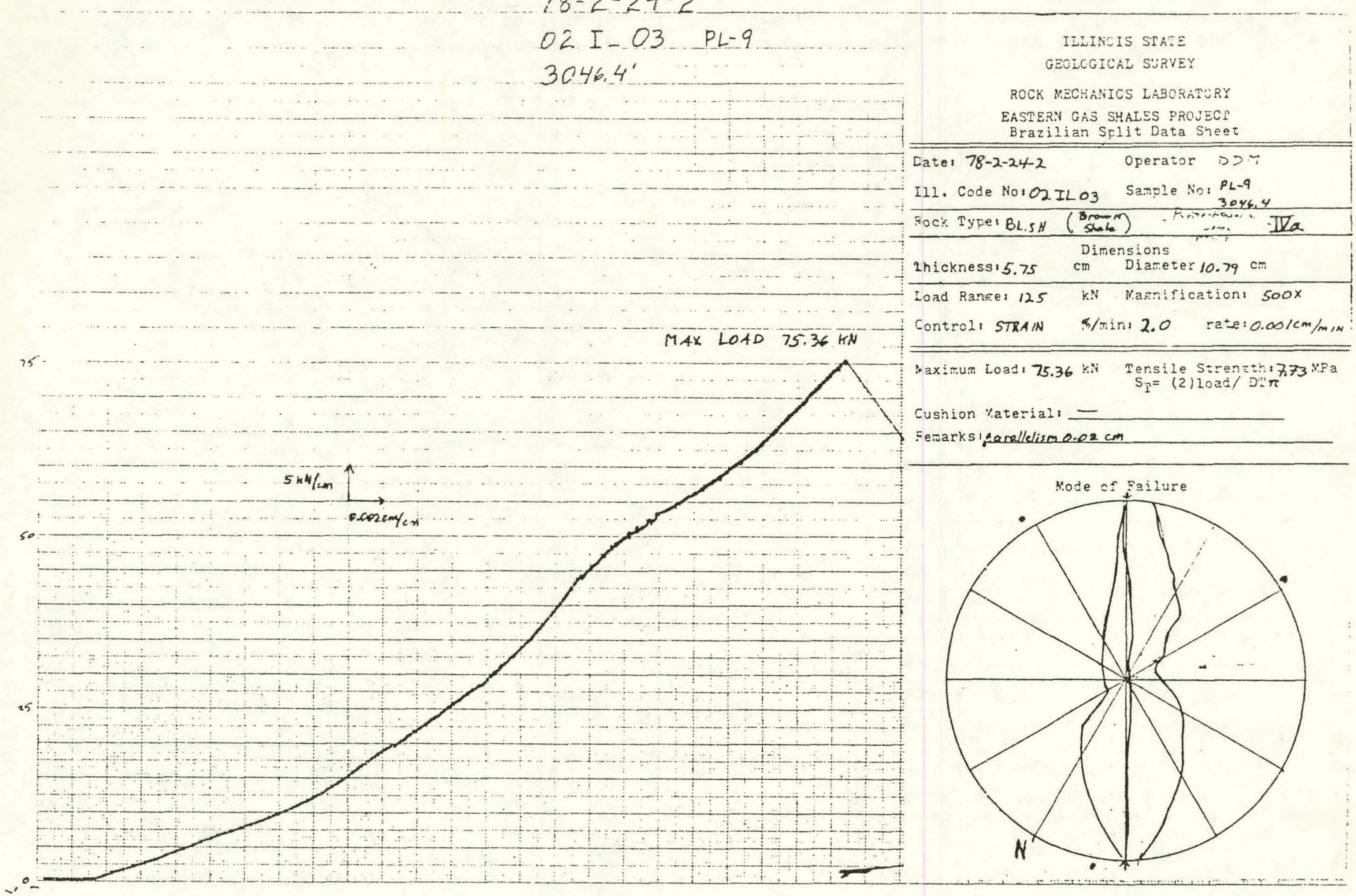


Fig. 3. Example of an indirect-tensile test (Brazilian split) data sheet. The mode of failure diagram at the right shows the test direction and the resulting fractures, relative to the core orientation.

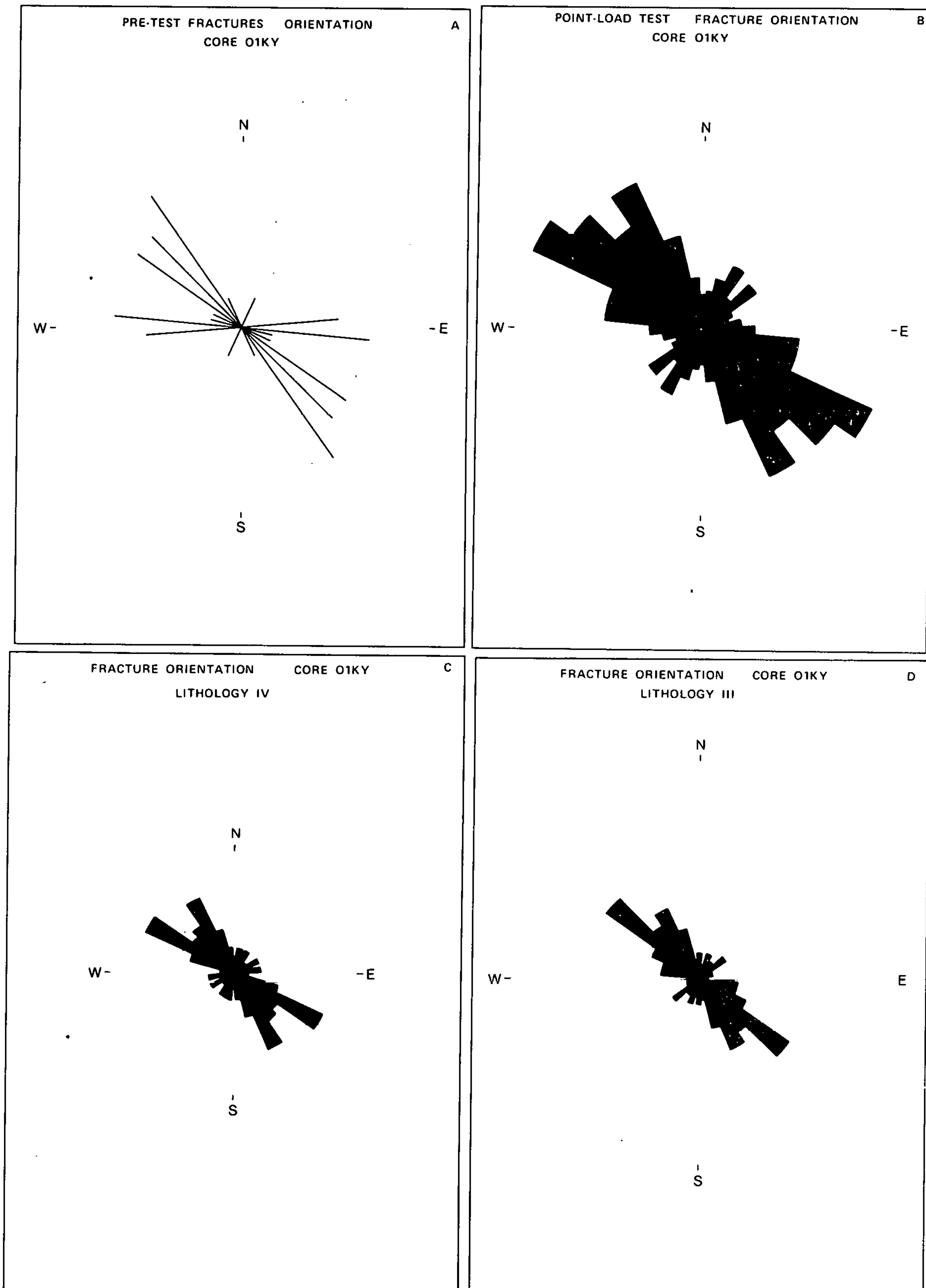


Fig. 4. Frequency plot of fracture orientations core O1KY.
a) natural fractures
b) point-load fractures, all tests
c) point-load fractures, finely laminated brownish-black shales
d) point-load fractures, poorly laminated brownish-black shales

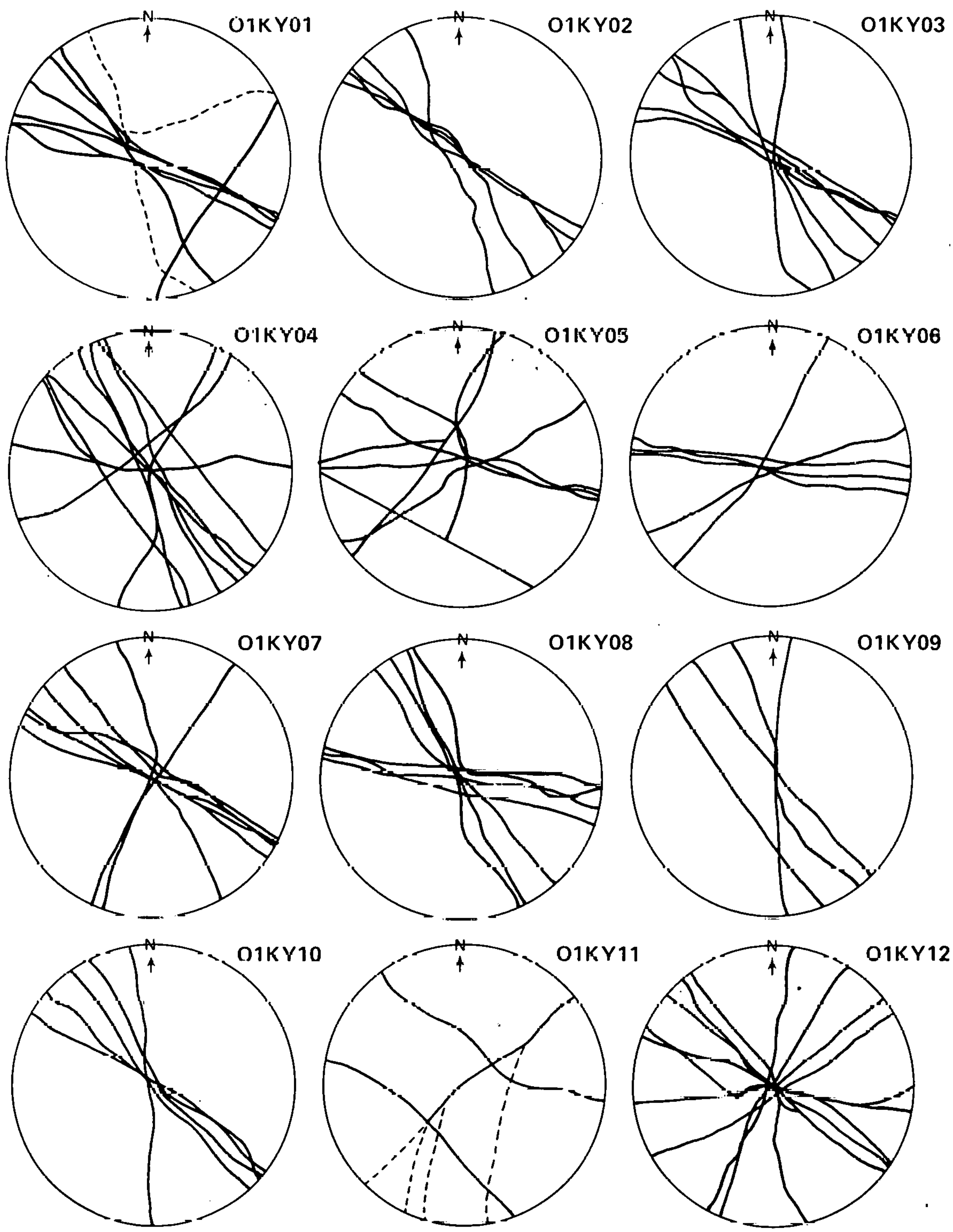


Fig. 5. Position of fractures resulting from point-load testing, lithologies II, III, IV, core 01KY. Fractures resulted from a point load applied at the center of the circle (core).

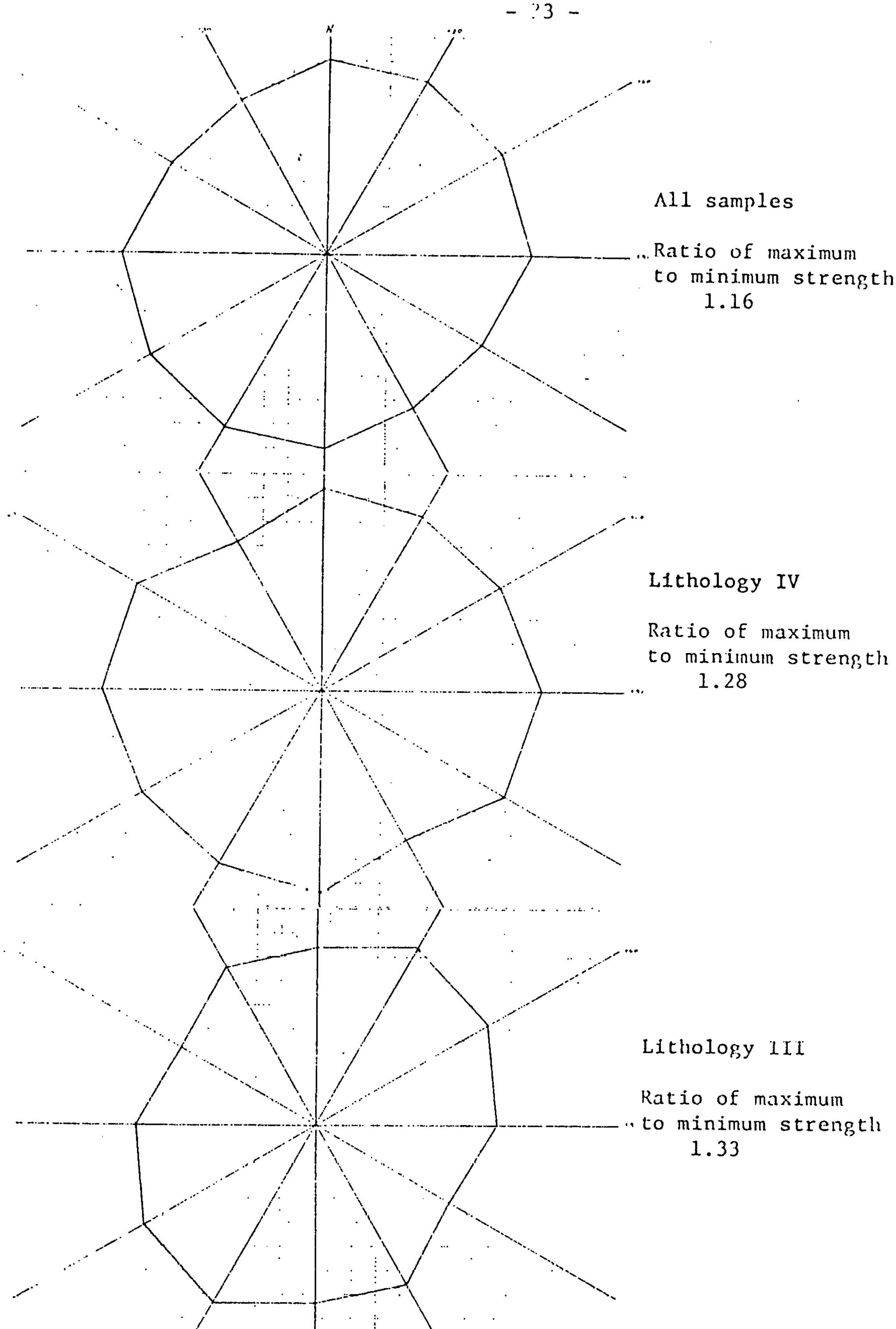


Fig. 6. Relative preference of orientation of indirect-tensile strength. The average strength for each of the six test directions is proportional to the distance from the center of the diagram.

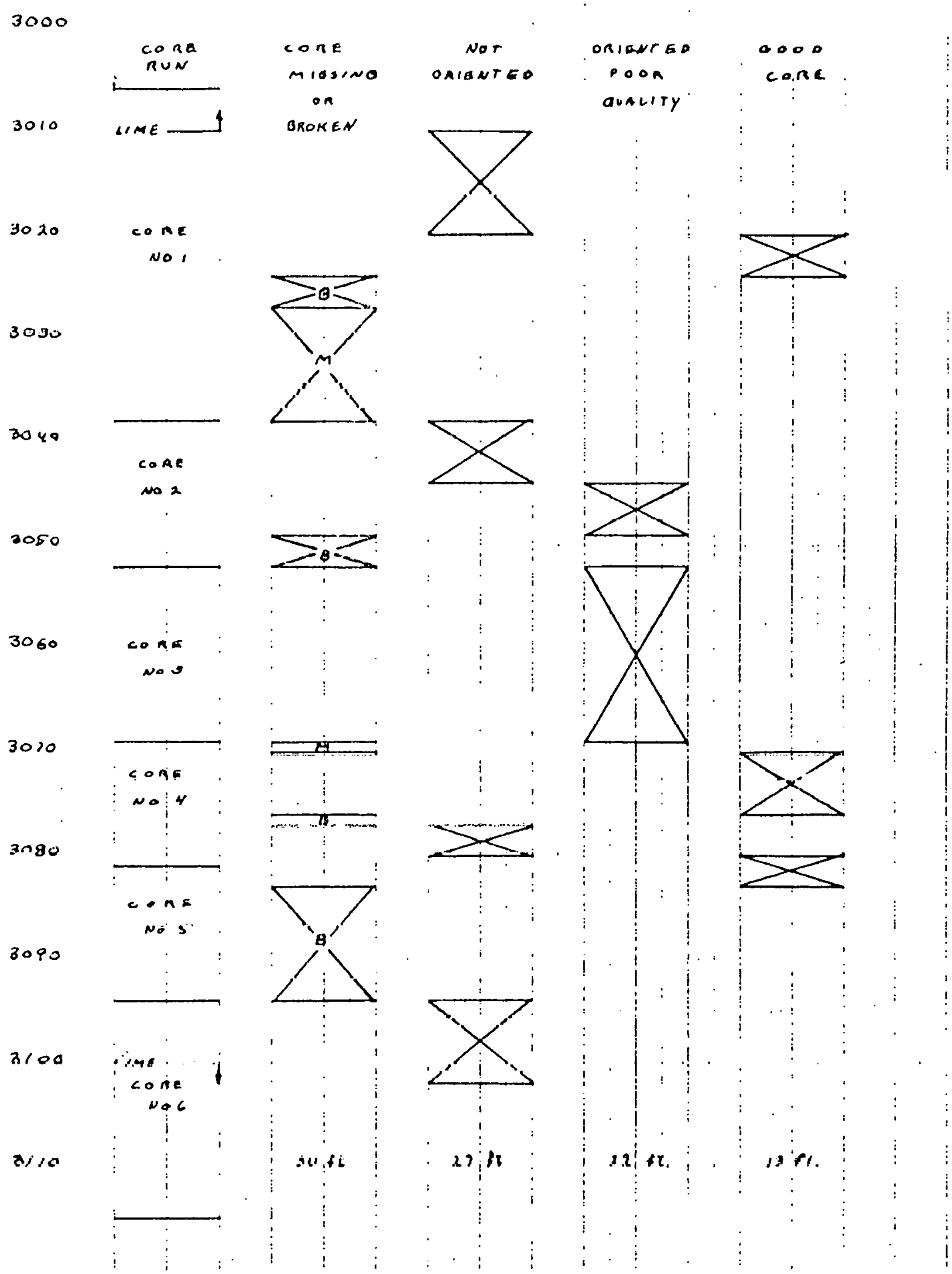


Fig. 7. Quality of oriented core, core 02IL.

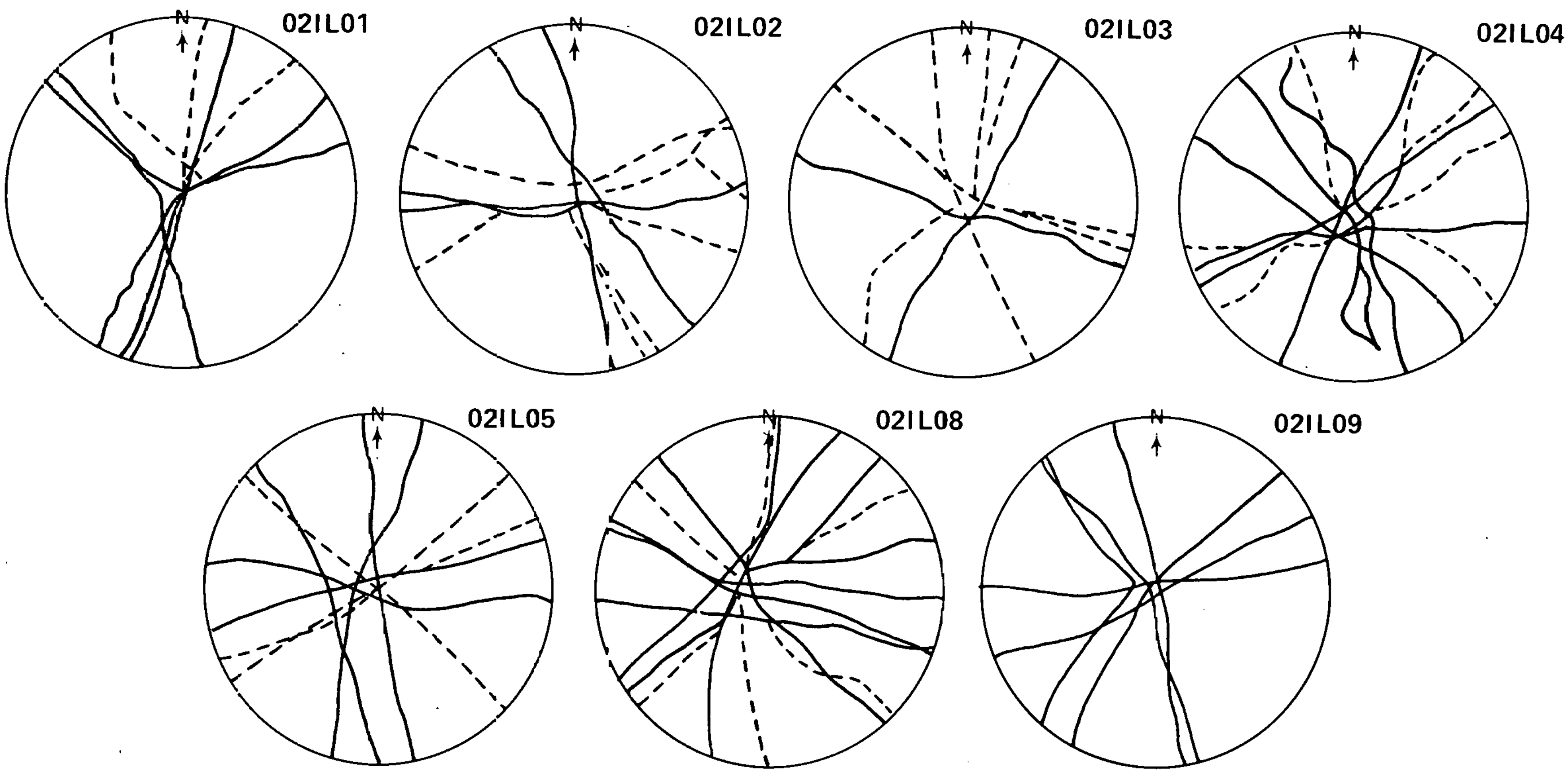


Fig. 8. Position of fractures resulting from point-load testing, lithologies II, III, IV and limestone, core 02IL.

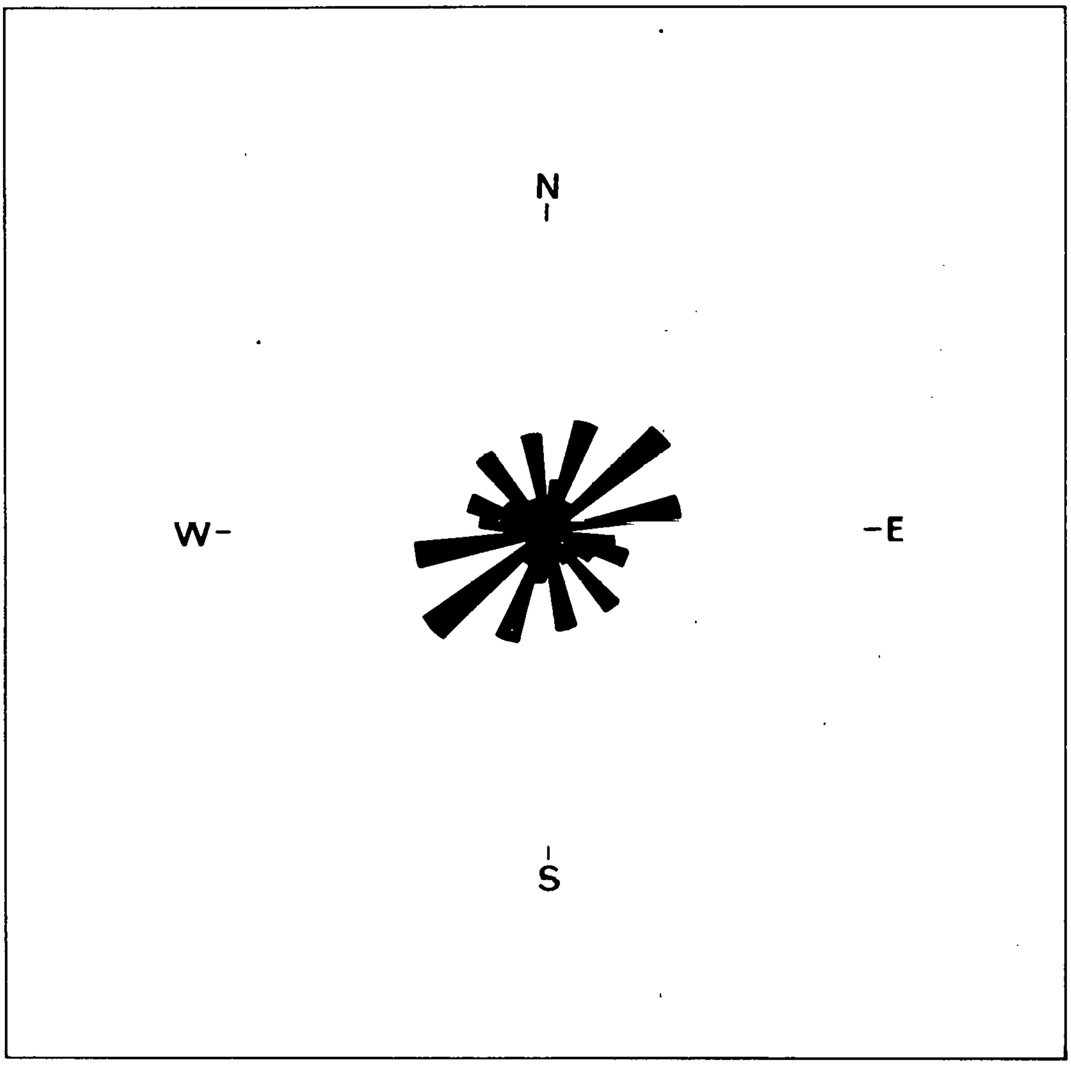


Fig. 9. Frequency plot of fracture orientations, core 02TL.

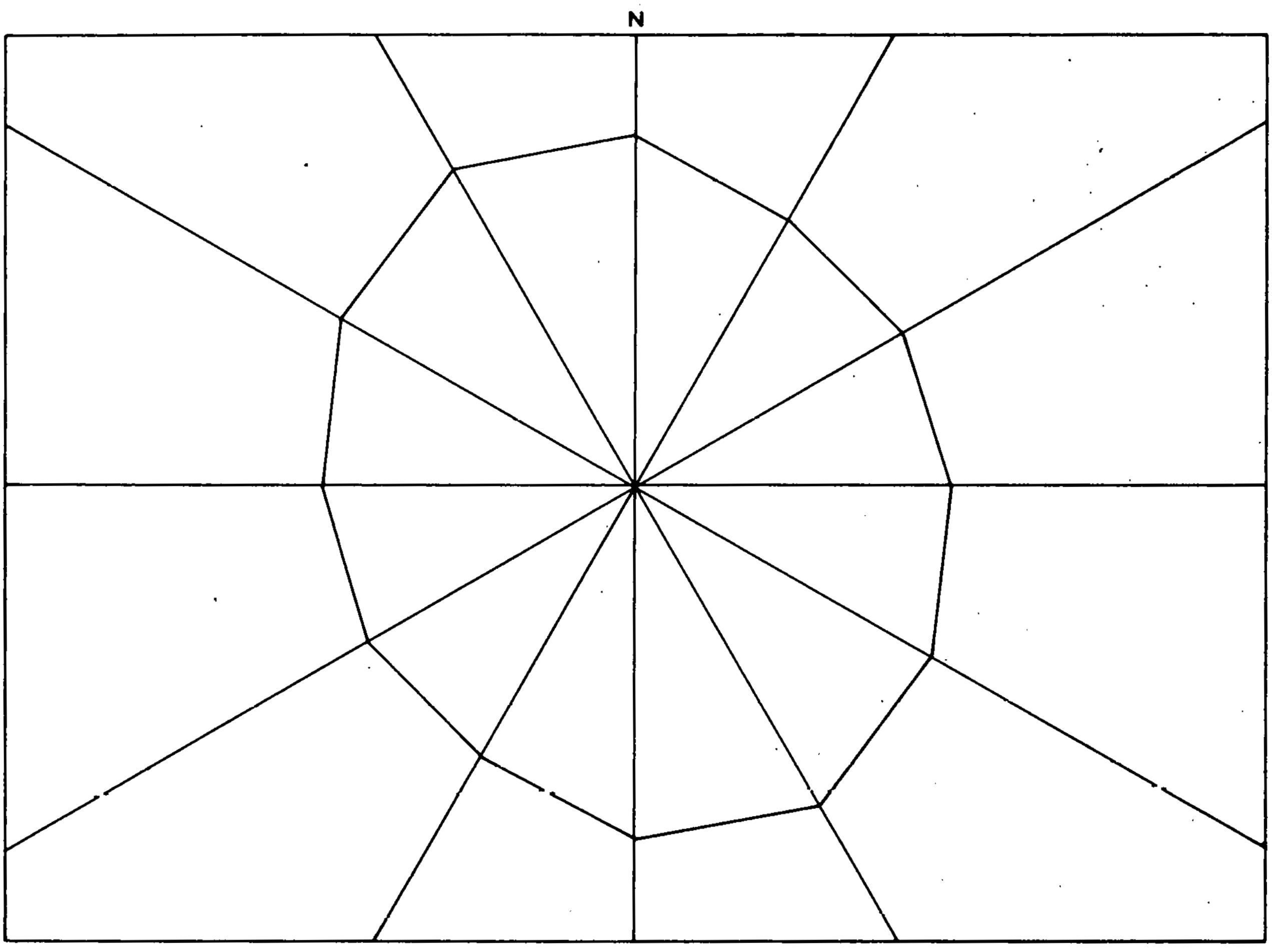


Fig. 10. Relative preference of orientation of indirect tensile strength, lithologies II, III, IV and limestone, core 02IL.

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.

CHEMICAL DATA ON CHRISTIAN COUNTY, KENTUCKY CORE

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	SIO2 (%)	AL2O3 (%)	FE2O3 (%) (XRF)	FE AS % FE2O3 (NAA)	MGO (%)	CAO (%)	NA AS % NA2O (NAA)	K2O (%) (XRF)	K AS % K2O (NAA)	TIO2 (%)	P2O5 (%)	MN (PPM) (NAA)
SR00P1	01KY01C1	1822.2	53.2	10.1	6.85	7.46	.74	.14	.74	3.06	3.52	.56	.10	110
02	02C1	2190.1	59.3	9.65	5.40	6.08	1.21	1.63	.65	2.71	3.06	.52	.06	310
03	03C1	2220.3	57.0	9.93	7.21	7.66	1.08	1.60	.68	2.76	3.24	.54	.10	260
04	04C1	2230.2	62.8	15.2	3.91	3.69	1.49	.56	.86	4.22	4.54	.71	< .01	270
05	05C1	2240.1	48.0	10.0	7.74	10.2	1.69	7.32	.74	2.61	2.75	.45	4.25	410
06	06C1	2250.0	59.0	16.4	4.40	5.30	1.98	1.25	.98	4.31	4.84	.83	.07	360
07	07C1	2262.3	49.9	13.5	6.22	6.38	1.05	.26	.77	3.93	4.19	.72	.07	160
08	08C1	2272.3	57.9	14.4	3.37	3.19	2.10	2.23	.92	4.23	4.86	.73	.13	190
09	09C1	2282.0	51.9	11.5	3.62	4.27	3.59	4.81	.82	3.49	3.66	.71	.01	360
10	10C1	2290.7	53.2	11.5	2.64	3.11	2.83	3.69	.75	3.81	4.36	.66	.05	200
11	11C1	2295.7	45.0	9.77	4.28	4.79	4.75	7.50	.87	2.99	3.53	.52	.19	400
12	12C1	2310.5	51.6	8.40	3.16	3.29	4.31	7.51	.56	2.87	3.34	.43	.15	320
13	13C1	2318.8	46.2	7.07	3.09	3.67	4.06	11.7	.45	2.61	3.02	.35	.19	360
33	08L1	2273.5	55.2	14.5	5.05	5.46	1.82	1.69	.84	4.14	5.00	.71	.12	200
34	10L1	2287.8	54.3	11.9	2.97	2.88	3.62	5.67	.75	3.62	4.05	.71	.03	360
35	11L1	2292.9	51.8	10.9	3.02	3.62	3.47	5.58	.78	3.53	3.96	.63	.04	330
36	12L1	2311.1	49.8	8.37	2.62	2.97	4.25	10.3	.53	2.64	3.03	.37	.19	370
37	13L1	2312.6	49.8	7.59	3.05	3.33	4.19	9.32	.53	2.63	3.06	.36	.25	360

SAMPLE NO.	MN (PPM) (OE-P)	V (PPM) (OE-D)	V (PPM) (OE-P)	S (%)	CL (%)	TOTAL C (%)	ORGANIC C (%)	INORG. C (%)	H (%)	TOTAL CEC MEQ/100G	BR (PPM)	AS (PPM)
SE0001	120	160	200	2.42	.02	14.13	14.03	.10	1.93	4.7	4.9	68
02	290	140	160	1.84	.02	10.86	10.29	.57	1.43	3.4	3.3	38
03	220	170	160	1.93	.01	7.78	7.03	.75	1.27	4.7	5.6	42
04	260	150	150	.35	.02	2.24	1.64	.60	.74	5.1	1.8	17
05	340	120	120	2.27	.02	7.01	5.81	1.20	.91	3.2	4.2	37
06	310	150	150	.22	.02	1.69	.66	1.03	.59	7.3	1.4	9.8
07	150	>560	450	1.74	.01	12.61	12.30	.31	1.72	5.0	11	45
08	170	190	200	.53	.02	6.00	5.04	.96	1.29	4.9	2.0	15
09	320	170	190	.62	.01	7.51	5.39	2.12	1.10	3.3	2.8	12
10	240	190	200	.64	.01	10.56	9.23	1.33	1.38	2.6	1.8	10
11	360	150	150	1.38	.02	10.16	7.43	2.73	.98	2.5	2.1	16
12	360	230	240	1.00	.01	8.32	5.67	2.65	1.06	1.7	2.8	17
13	330	490	320	1.18	.01	10.38	7.30	3.08	.89	1.2	5.7	19
33	170	260	230	.89	.01	8.84	8.02	.82	1.27	4.6	3.2	23
34	310	120	130	.42	.01	5.65	3.40	2.25	.75	4.0	.8	5.7
35	300	120	130	.78	.02	8.64	6.74	1.90	1.23	3.2	1.0	11
36	400	220	250	.90	.01	8.90	5.79	3.11	.86	1.6	2.2	11
37	360	245	330	1.02	.01	8.93	5.93	3.00	.85	1.2	4.1	17

CHEMICAL DATA ON CHRISTIAN COUNTY, KENTUCKY CORE

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	BA (PPM)	BE (PPM) (OE-D)	BE (PPM) (OE-P)	B (PPM)	BR (PPM)	CE (PPM)	CS (PPM)	CR (PPM) (NAA)	CR (PPM) (OE-D)	CR (PPM) (OE-P)	CO (PPM) (NAA)	CO (PPM) (OE-C)
S00001	01PY01C1	1822.2	900	3.6	3.6	120	5	82	5.4	65	74	84	39	44
02	02C1	2191.1	1100	4.3	5.0	140	4.5	65	4.5	56	62	65	29	32
03	03C1	2220.3	880	4.2	4.4	180	4	67	5.1	59	65	73	23	26
04	04C1	2230.2	570	3.2	5.2	240	3	60	6.5	69	98	110	11	12
05	05C1	2240.1	7800	3.0	3.4	180	3	170	4.5	64	60	70	32	34
06	06C1	2250.0	790	2.6	4.4	290	<4	91	9.1	99	102	112	12	11
07	07C1	2260.3	820	2.9	5.0	210	5	81	7.4	89	100	120	23	29
08	08C1	2270.3	460	2.3	5.2	240	4	77	7.8	100	120	150	14	14
09	09C1	2280.0	350	2.5	5.1	225	3.6	70	6.9	85	99	110	11	13
10	10C1	2290.7	410	2.6	5.0	190	5.0	75	7.7	97	88	110	12	12
11	11C1	2299.7	390	2.4	3.8	165	3	63	5.3	65	60	66	13	14
12	12C1	2310.5	270	2.0	3.3	150	3	48	4.2	55	56	75	11	14
13	13C1	2318.8	510	2.2	3.6	130	4	58	4.0	87	68	90	13	14
33	08L1	2273.5	480	4.5	4.9	190	3	71	8.3	120	110	142	13	14
34	10L1	2287.8	230	2.9	3.6	230	3.4	56	6.3	71	75	81	6.5	9.1
35	11L1	2292.9	280	4.4	4.0	315	<5	51	5.8	79	71	88	8.4	7.3
36	12L1	2311.1	290	2.8	4.4	150	<4	50	4.0	61	58	75	11	14
37	13L1	2312.6	400	2.6	4.1	120	2	47	4.0	67	61	83	11	12

SAMPLE NO.	CO (PPM) (OE-P)	CU (PPM) (OE-D)	CU (PPM) (CE-P)	DY (PPM)	EU (PPM)	F (PPM)	GD (PPM)	GA (PPM)	GE (PPM) (OE-D)	HF (PPM)	PB (PPM) (OE-P)	LA (PPM)
S00001	56	89	99	5.6	1.6	640	1.4	17	1.4	3.0	30	35
02	38	60	82	4.6	1.3	630	1.3	15	2.0	3.0	14	28
03	24	82	90	4.6	1.3	500	1.0	13	1.7	3.1	36	29
04	12	61	78	4.7	1.3	900	1.6	22	1.5	3.0	19	37
05	23	78	72	17	5.0	2925	6.2	11	< .4	4.5	26	43
06	9.6	36	35	5.4	1.4	895	1.9	23	< .4	5.2	11	42
07	26	160	170	6.4	1.9	745	1.3	22	1.0	3.5	23	38
08	16	140	240	5.6	1.8	885	1.4	19	< .4	4.6	29	44
09	11	130	180	6.8	1.4	770	1.7	16	< .4	5.1	14	36
10	11	190	340	6.4	1.6	800	1.7	16	1.1	4.6	30	37
11	11	130	190	6.0	1.6	865	1.8	14	< .4	3.3	33	33
12	12	125	250	6.1	1.5	920	1.3	13	< .4	2.3	24	30
13	10	210	270	7.0	1.9	920	2.3	12	.6	2.6	14	31
33	12	150	210	6.5	1.7	950	2.6	22	.7	4.2	26	39
34	8.0	64	100	6.0	1.1	875	1.4	18	< .4	3.9	7.2	35
35	12	155	180	6.8	1.4	770	2.0	16	2.4	3.6	11	32
36	17	120	180	6.5	1.4	970	.9	12	< .4	2.2	7.0	29
37	16	110	160	7.8	1.5	860	2.3	8.7	< .4	2.5	7.5	31

CHEMICAL DATA ON CHRISTIAN COUNTY, KENTUCKY CORE

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	LU (PPM)	MO (PPM) (OE-D)	NI (PPM) (OE-D)	NI (PPM) (OE-P)	NI (PPM) (NAA)	RB (PPM)	SM (PPM)	SC (PPM)	AG (PPM) (OE-P)	SR (PPM) (OE-D)	TA (PPM)	TB (PPM)
800001	01KY01C1	1822.2	.5	180	102	180	130	110	9.1	13	< .7	110	.9	1.1
02	02C1	2191.1	.3	200	76	100	93	95	8.2	12	< .7	140	.8	.8
03	03C1	2220.3	.4	160	85	110	92	100	7.7	13	< .7	190	.8	.9
04	04C1	2230.2	.4	4	33	42	30	150	9.2	17	< .8	190	1.0	.8
05	05C1	2240.1	.9	160	84	87	150	25	25	14	< .7	>600	.7	3.6
06	06C1	2250.0	.5	41	23	30	49	190	7.6	23	< .8	210	1.4	.8
07	07C1	2260.3	.6	220	280	300	300	132	12	16	< .7	250	.8	1.0
08	08C1	2270.3	.3	1.5	60	180	150	160	11	20	.87	190	1.0	.8
09	09C1	2280.2	.5	8.5	82	120	152	132	6.6	17	< .8	210	1.0	1.0
10	10C1	2290.7	.6	28	122	200	160	140	7.5	16	< .7	150	1.0	1.2
11	11C1	2299.7	.5	23	90	120	140	160	7.9	15	< .7	170	.7	1.1
12	12C1	2310.5	.4	39	120	192	130	77	6.8	10	< .8	130	.6	.7
13	13C1	2318.8	.5	110	202	250	260	93	9.5	13	< .6	160	.6	1.3
33	08L1	2273.5	.4	17	130	150	120	170	7.9	20	< .7	160	1.4	1.2
34	10L1	2287.8	.4	4	69	76	68	110	5.6	15	< .8	170	1.0	.7
35	11L1	2292.9	.4	11	100	120	96	120	6.3	16	< .8	120	1.0	.8
36	12L1	2311.1	.5	36	140	200	120	87	8.6	12	< .8	160	.7	.8
37	13L1	2312.6	.5	39	150	220	160	84	7.5	12	< .8	145	.7	1.0

SAMPLE NO.	TH (PPM)	SN (PPM) (OE-D)	U (PPM)	YB (PPM)	ZN (PPM) (OE-P)	ZN (PPM) (NAA)	ZN (PPM) (OE-D)	ZR (PPM) (OE-D)	ZR (PPM) (OE-P)	500 DEG. ASH (%)	ND (PPM)
800001	7.1	2.4	61	2.3	72	120	80	71	210	79.68	32
02	6.9	.8	43	1.9	51	56	60	120	210	86.17	24
03	7.3	.9	22	2.0	170	232	260	140	220	87.62	31
04	8.5	4.7	14	2.2	48	120	89	120	223	95.46	21
05	12	1.4	37	5.3	110	230	160	270	272	92.12	82
06	14	4.4	5	2.9	43	150	66	180	210	95.88	26
07	9.1	3.8	40	2.8	410	470	230	130	230	82.49	28
08	11	5.6	5	2.9	200	200	160	170	280	91.23	16
09	12	2.6	6	3.3	83	150	61	200	270	90.82	46
10	11	3.8	6	3.3	120	140	98	130	180	87.83	21
11	7.6	3.6	8	3.1	160	210	80	190	200	90.09	29
12	6.0	3.6	10	2.6	100	66	48	130	130	92.04	28
13	6.2	3.7	22	3.1	532	360	180	170	180	90.43	32
33	10	5.6	14	2.8	140	260	180	190	180	89.13	34
34	9.0	4.9	6.8	1.9	51	72	29	160	180	95.51	28
35	8.2	5.0	6	2.4	270	220	220	190	210	91.72	30
36	5.8	4.2	11	2.4	230	190	89	170	220	93.13	28
37	5.5	4.4	13	2.4	250	170	72	150	220	92.56	26

ND = NOT DETECTED

CHEMICAL DATA ON SANGAMON COUNTY, ILLINOIS CORE

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	SIO2 (%)	AL2O3 (%)	FE2O3 (%) (XRF)	FE AS % FE2O3 (NAA)	MGO (%)	CAO (%)	NA AS % NA2O (NAA)	K2O (%) (XRF)	K AS % K2O (NAA)	TIO2 (%)	P2O5 (%)	MN (PPM) (NAA)
S00014	01IL01L2	1576.0	64.5	10.5	4.31	4.56	2.25	1.04	1.00	3.91	4.32	.87	.08	220
15	03L1	1589.4	71.8	8.54	2.61	3.07	1.84	2.03	1.25	2.96	3.43	.93	.33	290
16	04L1	1602.0	74.0	9.19	2.20	2.51	1.13	.32	1.37	3.81	3.55	.95	.03	120
17	05L1	1615.1	70.4	9.77	2.88	3.55	1.48	.39	1.22	3.47	4.11	.99	<.01	150
18	07L1	1631.6	51.7	6.81	2.07	3.00	2.59	15.5	.88	2.35	2.80	.56	.31	960
19	09L1	1647.4	58.8	12.7	4.01	4.88	2.70	1.35	1.02	4.08	4.86	.93	.02	340
20	09L2	1656.2	65.4	12.1	4.72	5.72	1.62	.30	1.11	4.26	4.95	1.00	.05	240
21	10L1	1657.6	65.3	11.7	5.84	7.83	1.60	.06	.96	3.85	4.38	.87	.01	210
22	11L1	1667.5	57.9	14.9	5.02	6.52	1.90	.01	.71	5.40	6.12	.84	.06	260
23	12L1	1678.6	62.2	15.2	5.01	5.86	2.63	.03	.79	5.32	6.35	.89	<.01	280
24	13L1	1688.0	56.8	16.1	5.09	6.29	2.74	.36	.75	5.63	6.41	.81	.02	280
25	14L1	1698.2	56.5	14.1	5.20	6.29	2.22	.52	.75	4.69	5.31	.77	<.01	230
26	15L1	1710.0	51.5	13.2	5.19	6.88	2.17	.18	.59	4.96	5.90	.66	.05	240
27	16L1	1723.4	53.8	11.7	5.35	8.54	2.04	.71	.73	3.78	4.22	.68	.03	260
28	17L1	1730.6	57.1	12.2	4.62	5.92	1.54	.61	.82	3.74	4.02	.66	.04	230
29	18L1	1740.2	62.5	11.7	4.15	4.46	1.27	.47	.84	3.48	4.16	.64	.08	190
30	19L1	1753.5	55.0	12.2	5.62	5.91	1.67	.56	.75	3.86	4.64	.62	.10	270
31	20L1	1763.3	58.0	12.3	4.37	4.41	2.22	2.26	.92	3.87	4.72	.69	.08	340
32	21L1	1776.2	56.4	14.8	4.83	4.16	2.15	.77	.71	4.88	5.52	.67	.03	340

SAMPLE NO.	MN (PPM) (OE-P)	V (PPM) (OE-D)	V (PPM) (OE-P)	S (%)	CL (%)	TOTAL C (%)	ORGANIC C (%)	INORG. C (%)	H (%)	TOTAL CEC MEQ/100G	SB (PPM)	AS (PPM)
S00014	240	220	270	.02	.13	.88	.43	.45	.75	7.3	.6	2.6
15	290	78	140	.05	.08	.96	.29	.67	.44	2.9	.5	2.9
16	150	70	120	.07	.14	.97	.80	.17	.48	3.1	.6	4.3
17	170	120	170	.06	.11	.44	.28	.16	.40	4.3	.7	3.9
18	820	83	90	.07	.04	3.88	.15	3.73	.36	2.2	.3	2.3
19	340	110	160	.09	.12	.75	.32	.43	.66	6.4	.5	5.9
20	230	86	120	.25	.12	.66	.57	.09	.66	5.8	.6	6.8
21	180	76	110	.09	.09	1.30	1.28	.02	.70	6.7	.9	9.8
22	270	170	180	.27	.10	2.93	2.90	.03	.91	9.4	.9	7.7
23	310	140	180	.18	.12	1.88	1.72	.16	.66	7.7	1.2	8.2
24	270	160	190	.31	.14	2.96	2.90	.06	1.07	8.2	1.2	10
25	220	160	200	.54	.12	4.34	4.26	.08	1.09	9.3	1.7	19
26	200	200	200	.92	.09	7.61	7.54	.07	1.49	11.4	4.6	25
27	240	240	240	1.28	.09	9.74	9.59	.15	1.54	8.0	6.6	22
28	200	120	160	1.10	.09	6.55	6.50	.05	1.01	8.6	3.1	14
29	200	140	170	.92	.09	5.63	5.57	.06	1.15	8.2	2.0	11
30	240	140	170	1.36	.10	6.41	6.28	.13	1.32	7.7	4.5	36
31	340	120	130	.84	.09	3.86	3.09	.77	.94	5.7	1.9	16
32	280	290	290	.71	.11	4.06	3.79	.27	1.14	7.9	2.7	17

CHEMICAL DATA ON SANGAMON COUNTY, ILLINOIS CORE

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	BA (PPM)	BE (PPM) (OE-D)	BE (PPM) (OE-P)	B (PPM)	BR (PPM)	CE (PPM)	CS (PPM)	CR (PPM) (NAA)	CR (PPM) (OE-D)	CR (PPM) (OE-P)	CO (PPM) (NAA)	CU (PPM) (OE-D)
302014	011L01L2	1576.0	280	2.8	4.4	160	8.1	78	8.1	110	100	150	10	9.6
15	03L1	1589.4	360	2.2	2.5	100	8.1	110	4.9	95	80	84	6.6	5.5
16	04L1	1602.0	420	2.1	2.6	100	11	88	5.2	94	78	96	6.2	4.4
17	05L1	1615.1	410	2.7	3.2	110	8.5	99	8.5	110	84	100	8.9	6.4
18	07L1	1631.6	430	.6	2.3	72	<4	62	5.0	63	44	66	7.1	7.1
19	09L1	1647.4	460	2.6	4.4	130	6.4	91	10	120	80	110	13	11
20	09L2	1656.2	580	2.8	3.5	122	7	99	10	110	79	95	16	13
21	10L1	1657.6	530	3.0	3.4	160	5.8	88	11	110	78	97	15	14
22	11L1	1667.5	570	3.7	5.6	170	6.4	89	13	140	92	130	18	15
23	12L1	1678.5	550	3.6	5.1	140	8.5	86	14	110	93	130	14	12
24	13L1	1688.0	600	3.4	5.5	140	9.4	86	13	150	100	140	16	14
25	14L1	1698.2	580	2.9	4.6	150	6.7	79	12	120	95	110	16	15
26	15L1	1712.0	810	2.9	5.4	140	7	86	11	110	90	110	25	26
27	16L1	1723.4	1230	3.2	5.1	120	<8	120	9.5	96	73	96	44	47
28	17L1	1730.6	720	3.9	4.4	130	9	83	6.4	94	74	84	26	21
29	18L1	1740.2	650	3.5	3.7	130	<7	58	6.5	60	67	70	20	20
30	19L1	1753.5	620	3.7	4.6	125	9.3	71	6.4	71	67	83	28	26
31	20L1	1763.3	400	3.2	3.7	140	9.4	50	6.1	80	66	90	18	20
32	21L1	1776.2	410	4.0	4.5	200	6.7	55	8.4	85	100	120	12	16

SAMPLE NO.	CO (PPM) (OE-P)	CU (PPM) (OE-D)	CU (PPM) (OE-P)	DY (PPM)	EU (PPM)	F (PPM)	GD (PPM)	GA (PPM)	GE (PPM) (OE-D)	HF (PPM)	PB (PPM) (OE-P)	LA (PPM)
302014	9.1	5.1	13	5.6	1.1	920	2.7	16	2.5	6.7	5.8	36
15	5.8	16	32	9.8	3.0	810	2.7	12	4.6	11	8.1	45
16	5.4	8.6	14	6.1	1.1	375	2.0	14	4.0	11	<2.3	37
17	6.7	8.9	13	6.9	1.5	505	3.0	16	4.3	11	<2.4	40
18	5.1	8.8	11	6.5	1.8	570	2.2	8.2	< .4	8.0	<2.4	34
19	13	8.4	20	4.5	1.2	560	2.0	23	1.8	7.6	<2.3	39
20	15	13	24	6.3	1.3	685	2.2	25	2.7	8.6	<2.4	43
21	12	19	32	4.1	1.3	600	2.3	18	2.4	7.1	<2.3	34
22	20	34	63	3.9	1.2	910	2.0	24	2.8	5.1	35	35
23	20	20	45	5.5	1.4	825	2.2	26	2.3	5.4	30	39
24	23	28	39	4.5	1.1	940	2.0	25	.6	4.8	24	37
25	17	32	54	5.1	1.2	815	1.9	22	1.5	4.8	17	34
26	32	59	74	5.1	1.3	945	2.2	21	1.2	4.0	37	33
27	45	150	260	6.7	1.4	675	3.3	14	1.2	6.1	54	33
28	23	55	70	5.4	1.3	1000	1.9	16	1.2	5.5	18	31
29	29	48	70	4.7	1.2	600	1.7	11	1.5	4.4	19	32
30	38	56	85	6.0	1.3	865	1.5	19	.8	3.7	18	34
31	29	39	65	5.3	1.1	810	2.2	23	.9	5.6	16	34
32	15	64	79	4.3	1.0	1075	1.7	23	1.0	3.2	31	36

CHEMICAL DATA ON SANGAMON COUNTY, ILLINOIS CORE

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	LU (PPM)	MO (PPM) (OE-D)	NI (PPM) (OE-D)	NI (PPM) (OE-P)	NI (PPM) (NAA)	RB (PPM)	SM (PPM)	SC (PPM)	AG (PPM) (OE-P)	SR (PPM) (OE-D)	TA (PPM)	TB (PPM)
S00014	01IL01L2	1576.0	.4	<1	38	55	49	160	5.3	15	< .8	73	1.3	.8
15	03L1	1589.4	.7	<1	23	25	29	110	14	10	< .8	91	1.4	1.8
16	04L1	1602.0	.6	<1	24	32	40	110	6.1	11	< .8	91	1.5	1.0
17	05L1	1615.1	.6	<1	25	31	33	170	6.5	15	< .8	82	2.0	1.1
18	07L1	1631.6	.5	4.1	23	21	18	100	7.8	10	< .8	190	1.2	1.3
19	09L1	1647.4	.4	<1	39	49	46	200	6.1	19	< .8	94	1.6	1.0
20	09L2	1656.2	.6	.7	42	46	64	200	6.7	19	< .8	89	1.5	.9
21	10L1	1657.6	.4	16	38	52	43	190	5.9	18	< .8	60	1.7	1.1
22	11L1	1667.5	.4	4.7	68	104	83	270	6.6	20	< .8	72	1.7	.9
23	12L1	1678.6	.4	1.5	55	92	78	230	5.7	23	< .8	75	1.6	.8
24	13L1	1688.0	.4	4.6	63	100	70	270	6.0	25	< .8	87	1.5	.9
25	14L1	1698.2	.3	21	61	98	70	220	6.3	21	< .8	72	1.4	.9
26	15L1	1710.0	.4	82	78	99	91	230	6.0	22	< .7	63	1.2	.9
27	16L1	1723.4	.4	96	79	132	100	210	13	21	< .7	60	1.6	1.2
28	17L1	1730.6	.4	39	62	46	50	170	10	18	< .7	64	1.2	1.0
29	18L1	1740.2	.3	47	63	76	42	140	9.2	15	< .7	60	1.0	.7
30	19L1	1753.5	.4	67	77	96	58	130	8.2	16	< .7	63	1.0	.8
31	20L1	1763.3	.4	22	61	68	69	130	5.4	15	< .8	80	1.2	.7
32	21L1	1776.2	.3	29	125	150	110	160	5.8	18	< .8	69	1.0	.6

SAMPLE NO.	TH (PPM)	SN (PPM) (OE-D)	U (PPM)	YB (PPM)	ZN (PPM) (OE-P)	ZN (PPM) (NAA)	ZN (PPM) (OE-D)	ZR (PPM) (OE-D)	ZR (PPM) (OE-P)	500 DEG. ASH (%)	ND (PPM)
S00014	.2	3.9	<5	2.4	48	92	59	240	470	96.50	18
15	.1	1.7	<6	3.8	57	51	30	325	710	97.09	54
16	.2	2.6	<5	3.1	180	110	130	425	570	97.35	25
17	.6	2.3	<5	3.3	40	71	49	400	480	98.50	44
18	9.8	.7	<4	3.0	59	35	5.5	610	460	98.85	32
19	.4	5.2	<6	2.6	32	180	29	280	460	96.44	16
20	.5	4.7	<4	2.8	110	150	83	310	330	97.40	42
21	.4	3.8	<6	2.4	840	1290	920	250	290	95.30	52
22	.5	9.1	<6	2.3	100	100	75	210	300	93.30	35
23	.5	7.2	<4	2.4	100	120	97	220	320	95.30	ND(<10)
24	.5	8.5	6	2.2	130	110	58	200	280	93.60	21
25	.3	4.1	11	2.2	160	170	99	150	280	93.10	ND(<20)
26	.3	3.8	22	2.3	270	280	170	130	200	87.00	35
27	.4	3.7	31	3.0	100	140	86	170	300	85.80	55
28	.1	4.9	18	2.3	55	95	53	180	240	88.90	43
29	8.8	4.9	14	1.9	93	80	92	170	210	90.10	27
30	8.8	5.0	32	1.9	33	76	35	130	210	88.40	31
31	.0	5.0	6	2.3	20	44	34	300	290	93.40	27
32	9.1	6.2	10	1.5	100	120	85	160	200	94.54	28

ND = NOT DETECTED

CHEMICAL DATA ON EFFINGHAM COUNTY (02IL) AND WHITE COUNTY (03IL), ILLINOIS CORES

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	SIO2 (%)	AL2O3 (%)	FE2O3 (%) (XRF)	FE AS % FE2O3 (NAA)	MGO (%)	CAO (%)	NA AS % NA2O (NAA)	K2O (%) (XRF)	K AS % K2O (NAA)	TIO2 (%)	P2O5 (%)	MN (PPM) (NAA)
S00038	02IL01L2	3009.5	13.31	2.47	1.36	1.17	2.07	47.90	1.52	.76	.83	.09	.001	820
S00039	02IL05L2	3071.5	67.95	16.95	5.13	4.87	2.45	1.70	.80	4.45	5.10	.89	.03	360
S00040	02IL06L2	3081.1	69.77	17.39	5.04	4.31	2.07	1.24	.81	4.37	4.89	.89	.30	410
S00041	02IL09L1	3105.8	55.41	.71	.76	.49	2.29	27.94	.043	.09	.097	<.01	.67	2400
S00051	02IL01C1	3211.4	77.71	15.59	4.63	3.79	1.29	.17	.95	4.28	4.31	.93	.03	230
S00252	02IL02C1	3221.4	78.38	15.58	4.23	3.87	1.53	.27	.98	4.24	4.54	.95	.04	240
S00053	02IL03C1	3243.3	61.60	21.49	6.20	4.94	1.27	1.38	.63	3.66	3.84	.69	.01	370
S00054	02IL04C1	3253.0	61.24	12.64	7.66	7.00	.70	.73	.56	3.39	3.55	.69	<.01	280
S00055	02IL04C2	3259.5	56.48	11.38	6.27	5.67	1.94	2.44	.59	3.73	3.74	.74	.04	520
S00056	02IL05C1	3265.3	56.69	13.79	6.52	5.04	.90	.86	.66	4.19	4.18	.79	.06	340
S00057	02IL06C1	3273.4	57.70	14.62	5.82	5.56	1.19	.44	.72	4.51	4.57	.85	.08	270
S00058	02IL07C1	3285.5	58.67	14.96	6.22	5.70	1.20	.90	.76	4.45	4.48	.82	.06	342
S00059	02IL08C1	3296.5	55.51	17.57	6.24	5.06	1.69	.77	.70	4.94	4.88	.88	<.01	337
S00042	03IL01L1	4480	42.10	11.10	4.46	2.56	1.65	23.58	.47	2.98	3.17	.47	.11	1600
S00043	03IL07L1	4540	68.75	11.47	7.42	5.44	1.77	1.84	.75	2.98	3.35	.62	.06	430
S00044	03IL12L1	4590	66.73	14.27	6.13	4.03	1.52	1.07	.74	3.77	4.32	.67	.06	340
S00045	03IL20L1	4673	68.28	17.60	4.16	2.92	2.24	2.74	.91	4.76	5.31	.82	.08	280
S00046	03IL20L3	4676	59.06	14.96	4.47	3.39	3.76	5.86	.80	3.88	4.35	.68	.07	610
S00047	03IL23L1	4705	62.39	12.62	5.23	3.54	2.86	3.93	.74	3.65	3.98	.60	.10	262
S00048	03IL26L1	4735	64.76	13.27	2.96	2.33	3.32	4.59	.58	3.89	4.21	.55	.14	290

SAMPLE NO.	MN (PPM) (OE-P)	W (PPM) (OE-D)	V (PPM) (OE-P)	S (%)	CL (%)	TOTAL C (%)	ORGANIC C (%)	INORG. C (%)	H (%)	TOTAL CEC MEQ/100G	SB (PPM)	AS (PPM)
S00238	700	32	82	.08	.08	10.68	.67	10.01	.55	1.2	.5	.5
S00039	350	150	190	.97	.07	3.96	3.43	.53	1.01	5.6	1.8	21
S00040	320	130	190	.83	.06	2.94	2.60	.34	.79	4.8	.9	17
S00041	1000	24	12	.30	.08	6.49	.35	6.14	.31	.2	.2	2.6
S00051	190	290	220	.67	.12	1.62	1.61	.01	.81	4.7	1.3	27
S00052	200	150	200	.42	.08	2.41	2.37	.04	.58	4.6	.9	9.7
S00053	310	155	190	1.19	.05	7.95	7.54	.41	.88	4.7	3.9	41
S00054	230	165	180	1.69	.05	8.77	8.51	.26	1.51	4.7	5.5	64
S00055	350	140	160	1.23	.05	9.28	8.45	.83	1.19	5.1	4.2	40
S00056	250	240	220	1.24	.04	9.45	9.21	.24	1.42	4.7	3.7	37
S00057	240	220	220	.87	.04	7.25	7.12	.13	1.18	4.9	3.2	32
S00056	320	150	170	.72	.05	4.47	4.22	.25	1.12	5.0	1.7	21.
S00059	270	155	190	.80	.06	6.36	6.17	.19	1.02	5.1	3.0	21.
S00042	860	160	150	.30	.01	5.93	.86	5.07	.82		.6	12
S00043	310	180	190	2.90	.02	9.94	9.40	.54	1.18		3.8	46
S00044	250	195	200	1.90	.02	6.98	8.52	.46	1.18		3.7	28
S00045	210	230	200	.62	.05	3.01	1.93	1.08	.78		2.1	11
S00046	320	220	200	.60	.05	5.71	3.51	2.20	.76		1.9	9.6
S00047	200	160	150	2.48	.05	8.30	7.11	1.19	.99		2.3	22
S00048	240	450	320	1.26	.03	9.95	8.85	1.11	.99		5.4	21

CHEMICAL DATA ON EFFINGHAM COUNTY (02IL) AND WHITE COUNTY (03IL), ILLINOIS CORES

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	BA (PPM)	BE (PPM) (OE-D)	BE (PPM) (OE-P)	B (PPM)	BR (PPM)	CE (PPM)	CS (PPM)	CR (PPM) (NAA)	CR (PPM) (OE-D)	CR (PPM) (OE-P)	CO (PPM) (NAA)	CO (PPM) (OE-D)
S00038	02IL01L2	3009.5	<60	<1	< .87	24	4	25	1.6	30	26	20	4.3	12
S00039	02IL05L2	3071.5	630	2.6	5.4	160	<7	71	7.2	92	92	110	17	20
S00040	02IL06L2	3081.1	530	2.2	5.0	150	<4	74	6.8	90	91	110	14	17
S00041	02IL09L1	3105.8	<60	<1	< .87	6.6	<4	71	.2	5.7	8.5	<9.5	11	12
S00251	02IL01C1	3011.4	470	2.5	4.9	160	<6	71	6.2	77	92	120	19	23
S00252	02IL02C1	3021.4	340	2.4	4.6	160	4	87	7.9	80	95	120	12	10
S00253	02IL03C1	3043.3	450	3.0	4.7	120	4	63	6.5	60	67	80	25	28
S00254	02IL04C1	3053.0	520	3.5	4.6	120	4	75	6.2	64	64	85	31	31
S00255	02IL04C2	3059.5	510	3.1	4.9	120	4	75	6.4	70	75	89	27	26
S00256	02IL05C1	3065.3	570	2.9	5.2	150	3	79	6.9	66	79	99	24	28
S00257	02IL06C1	3073.4	620	3.4	5.2	160	<4	95	8.2	80	79	100	25	26
S00258	02IL07C1	3085.5	430	2.7	4.6	180	2	71	7.2	80	97	110	22	21
S00259	02IL08C1	3096.5	580	3.4	5.6	250	<5	74	8.4	79	92	110	21	23
S00042	03IL01L1	4480	260	.84	2.9	190	<4	41	4.1	58	60	88	13	20
S00043	03IL07L1	4540	660	3.1	4.8	140	<5	76	5.2	63	55	53	27	26
S00044	03IL12L1	4590	660	3.4	5.0	150	<4	72	6.5	92	77	81	25	26
S00045	03IL20L1	4673	480	2.6	5.2	260	2	110	9.7	110	110	130	15	16
S00046	03IL20L3	4676	450	2.3	4.4	250	4	77	7.9	130	100	110	13	15
S00047	03IL23L1	4705	300	2.4	4.3	160	3	51	6.6	77	67	75	20	21
S00048	03IL26L1	4735	420	2.7	4.6	220	<7	73	8.1	93	86	91	19	19

	CO (PPM) (OE-P)	CU (PPM) (OE-D)	CU (PPM) (OE-P)	DY (PPM)	EU (PPM)	F (PPM)	GA (PPM)	GE (PPM) (OE-D)	GE (PPM) (OE-P)	HF (PPM)	PB (PPM) (OE-P)	LA (PPM)
S00038	<3.4	12	6.1	4.0	.9	230	4	<1.	<7.5	.8	<2.4	17
S00039	23	53	60	5.2	1.2	960	24	6.4	<7.3	5.0	9.0	38
S00040	20	47	55	7.6	1.4	1035	24	6.7	<7.3	4.8	8.2	39
S00041	7.6	3.7	<1.4	3.2	.3	1060	.5	5.0	<7.5	.6	<2.4	6
S00251	37	38	45	5.3	1.0	825	22	2.3	<7.3	5.5	8.3	41
S00252	15	32	40	6.5	1.2	730	20	2.4	<7.2	6.8	11	41
S00253	40	74	82	5.7	1.1	850	17	2.5	<6.8	3.7	12	34
S00254	41	80	88	5.6	1.1	895	17	2.3	<6.7	4.0	19	32
S00255	33	76	78	5.8	1.3	900	19	1.8	<6.7	3.0	12	37
S00256	36	100	99	7.1	1.5	900	24	1.0	<6.6	3.4	12	38
S00257	39	87	96	6.4	1.6	880	23	1.7	<6.8	4.5	18	43
S00258	34	60	74	5.5	1.2	850	18	2.0	<7.0	4.0	16	38
S00259	30	97	97	5.9	1.3	1051	26	2.2	<6.9	3.5	22	41
S00042	15	34	35	4.9	1.1	570	15	3.7	<7.3	3.6	3.8	31
S00043	30	75	66	6.4	1.3	500	17	7.8	<6.6	6.2	14	34
S00044	33	100	100	7.4	1.4	820	21	8.0	<6.7	5.3	10	35
S00045	16	93	110	6.8	1.5	1090	23	8.0	<7.2	7.2	13	43
S00046	13	87	88	6.8	1.5	870	22	6.5	<6.9	6.2	13	39
S00047	24	98	120	4.2	1.0	1230	15	6.7	<6.8	4.9	23	31
S00048	19	190	170	6.4	1.6	1875	17	1.8	<6.6	4.8	11	33

CHEMICAL DATA ON EFFINGHAM COUNTY (02IL) AND WHITE COUNTY (03IL), ILLINOIS CORES

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	LU (PPM)	MO (PPM) (OE-D)	MO (PPM) (NAA)	NI (PPM) (OE-D)	NI (PPM) (OE-P)	NI (PPM) (NAA)	RB (PPM)	SM (PPM)	SC (PPM)	AG (PPM) (OE-P)	SR (PPM) (NAA)	SR (PPM) (OE-D)
S00038	02IL01L2	3029.5	.2	9.5	ND	19	13	10	31	3.6	4.1	< .8	94	230
S00039	02IL05L2	3071.5	.4	18.	50	64	92	76	170	6.4	19	< .8		100
S00040	02IL06L2	3081.1	.5	3.7	ND	48	71	54	150	9.6	20	< .8	30	130
S00041	02IL09L1	3105.8	.07	5.5	ND	15	12	9	<30	1.4	.6	< .8	140	130
S00051	02IL01C1	3011.4	.3	3.1	ND	83	140	67	140	6.4	15	< .8	132	100
S00052	02IL02C1	3021.4	.4	.9	ND	48	83	34	150	6.8	16	< .8	120	90
S00053	02IL03C1	3043.3	.3	52	81	73	120	64	110	6.2	13	< .7		65
S00054	02IL04C1	3053.0	.3	74	77	74	100	85	120	7.3	14	< .7		52
S00055	02IL24C2	3259.5	.4	55	88	80	100	69	130	8.7	15	< .7	100	66
S00056	02IL05C1	3065.3	.4	89	112	102	130	84	130	12	16	< .7	97	72
S00057	02IL06C1	3073.0	.4	68	112	100	160	99	162	12	19	< .8	140	95
S00058	02IL07C1	3285.5	.4	19	28	63	110	36	170	7.8	19	< .8		95
S00059	02IL28C1	3296.5	.4	35	77	69	110	73	160	10	20	< .6	100	100
S00042	03IL01L1	4480	.3	5.6	ND	62	78		110	5.6	12	< .6	92	220
S00043	03IL07L1	4540	.4	133	140	82	130	95	130	9.7	13	< .7	170	99
S00044	03IL12L1	4590	.4	89	83	95	100	100	160	8.9	18	< .7	200	98
S00045	03IL22L1	4573	.4	5.7	37	60	94	99	200	8.2	22	< .8	50	110
S00046	03IL23L3	4576	.4	13	20	72	95	100	160	7.9	20	< .8	200	140
S00047	03IL23L1	4725	.3	29	52	68	100	62	130	6.0	15	< .8		90
S00048	03IL26L1	4735	.5	56	56	180	210	190	170	7.9	18	< .7	180	90

SAMPLE NO.	TA (PPM)	TB (PPM)	TH (PPM)	SN (PPM) (OE-D)	SN (PPM) (OE-P)	U (PPM)	YB (PPM)	ZN (PPM) (OE-P)	ZN (PPM) (NAA)	ZN (PPM) (OE-D)	ZR (PPM) (OE-D)	ZR (PPM) (OE-P)
S00038	.3	.6	1.9	4.4	<1.8	<3	1.0	<2.1	40	4.7	81	87
S00039	1.6	.7	12	10.	5.2	11	2.4	260	290	330	140	340
S00040	1.2	.8	11	12.	5.7	8	2.0	61	130	43	155	340
S00041	< .1	.3	.4	< .7	<1.8	<5	.3	<2.1	34	3.5	37	27
S00051	1.3	.6	12	7.5	6.1	3	2.1	480	260	470	190	370
S00052	1.2	.8	12	7.4	5.8	7	2.5	410	220	430	200	400
S00053	.8	.7	10	5.8	3.0	23	1.9	150	91	180	120	270
S00054	1.0	.6	11	3.9	2.2	25	2.0	160	86	175	115	250
S00055	1.0	.8	11	6.7	3.6	27	2.4	31	29	30	130	270
S00056	1.0	.9	11	10	3.3	29	2.3	220	150	200	110	300
S00057	1.2	.9	14	10	6.2	26	2.4	160	110	220	130	320
S00058	1.2	.8	12	11	6.3	<9	2.2	150	92	140	120	340
S00059	1.2	.9	13	13	5.8	18	2.3	120	91	150	110	300
S00042	.5	.7	6.8	6.9	2.8	3	1.6	25	120	22	185	230
S00043	1.1	.8	9.6	3.8	3.1	40	2.3	140	89	72	120	270
S00044	1.0	.9	11	22.	12	29	2.3	410	130	81	110	260
S00045	1.3	1.0	15	14.	9.1	11	2.9	91	100	73	122	320
S00046	1.1	.9	12	11.	5.6	11	2.5	77	200	52	150	280
S00047	.7	.6	8.9	6.4	3.4	11	1.5	62	130	63	130	220
S00048	1.0	1.0	11	10	5.8	16	2.7	240	290	340	100	210

CHEMICAL DATA ON EFFINGHAM COUNTY (02IL) AND WHITE COUNTY (03IL), ILLINOIS CORES

SAMPLE NO.	GEOL. NO.	DEPTH (FT)	500 DEG. ASH (%)	ND (PPM)
S00038	02IL01L2	3009.5	99.56	
S00039	02IL05L2	3071.5	96.73	49
S00040	02IL06L2	3081.1	97.43	
S00041	02IL09L1	3105.8	99.65	39
S00051	02IL01C1	3011.4	96.58	19
S00052	02IL02C1	3021.4	96.03	19
S00053	02IL03C1	3043.3	92.20	23
S00054	02IL04C1	3053.0	89.50	26
S00055	02IL04C2	3059.5	89.48	32
S00056	02IL05C1	3065.3	88.39	25
S00057	02IL06C1	3073.4	90.45	35
S00058	02IL07C1	3085.5	93.50	28
S00059	02IL08C1	3096.5	91.20	15
S00042	03IL01L1	4480	96.86	10
S00043	03IL07L1	4540	88.27	59
S00044	03IL12L1	4590	88.65	31
S00045	03IL20L1	4673	95.18	11
S00046	03IL20L3	4676	91.33	31
S00047	03IL23L1	4705	90.52	18
S00048	03IL26L1	4735	88.09	45

ND = NOT 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
2. React sample with 1N NH_4AC for exchangeable cations
3. React sample with 1N HCl to remove chelated elements
4. Reflux sample with benzene and methyl alcohol to extract bitumens
5. Reflux sample with HNO_3 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 other 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 CH_4 relative to the initial gas indicating that there must have been a significant loss of CH_4-rich gas sometime during the experiment. Therefore there must have been a leak in the system, possibly of molecular size such that 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.

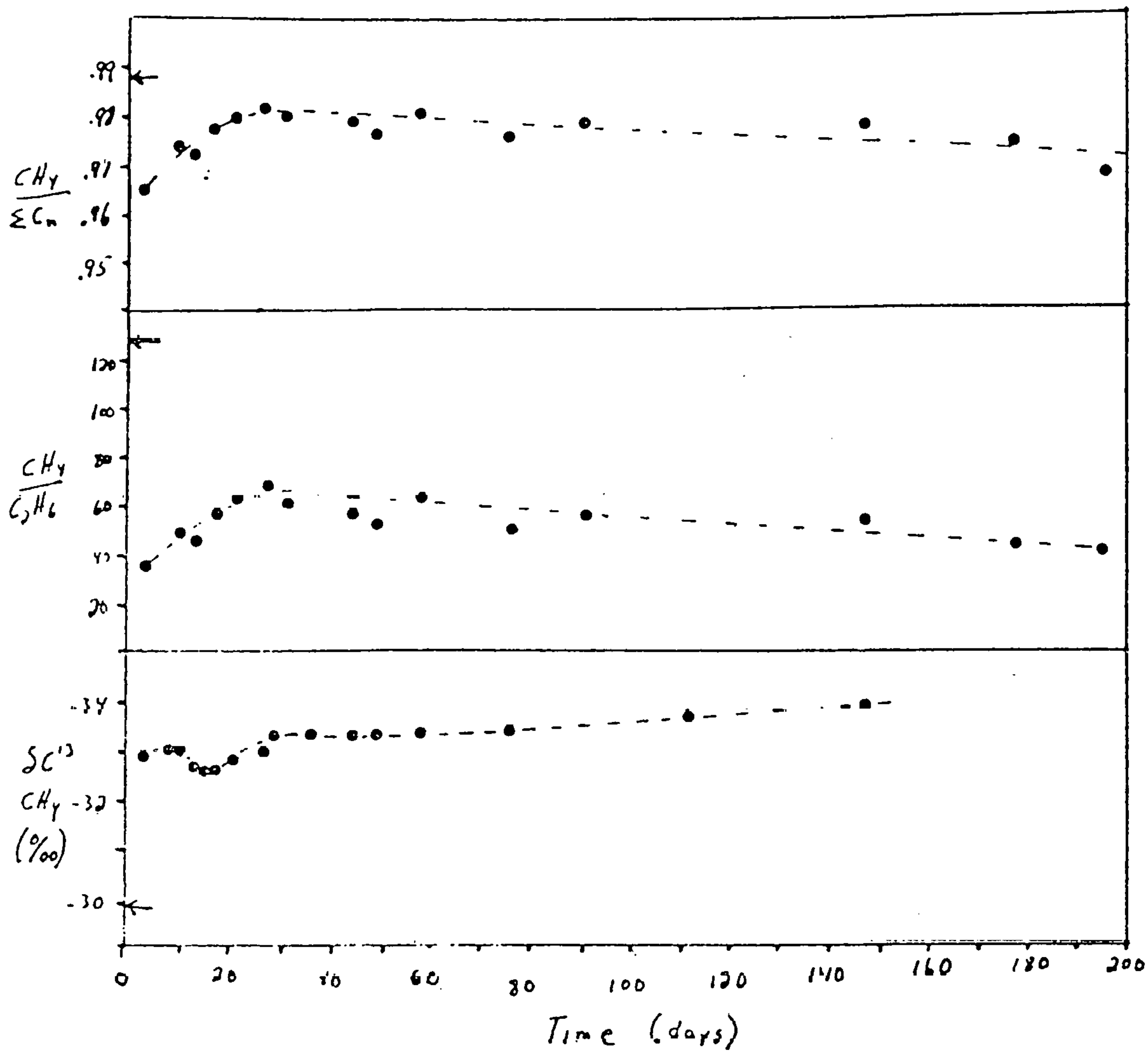


Fig. 1. Composition of off-gas during degasification experiments. Arrows indicate the composition of the gas originally injected.

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 m^2/g) from nitrogen adsorption, whereas the internal surface area values from carbon dioxide remain large (up to 39 m^2/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 CO_2 and N_2 values occur, N_2 generally has more difficulty in permeating the shales than does CO_2 due to the partial clogging of pores with organic matter. In contrast, the Wise Co., VA shale samples are just as permeable to N_2 as they are to CO_2. (Note the low CO_2/N_2 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 N_2 ISA was 2.55 m^2/g, the CO_2 ISA was 12.9 m^2/g, and the CO_2/N_2 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

Sample		CO_2 ISA	N_2 ISA	CO_2/N_2
Ky.	PM 214	21.3 m^2/g	1.64 m^2/g	13.0
Ky.	PM 234	13.0	1.3	10.0
Ky.	Perry Co., 2375	26.2	2.62	10.0
Ky.	Perry Co., 2399	8.63	2.32	3.7
Ky.	Perry Co., 2410	16.0	2.43	6.6
Ky.	Martin Co., 2432.8	11.6	4.88	2.4
Ky.	Martin Co., 2488.4	16.2	3.28	4.9
Ky.	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
Va.	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
Va.	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:

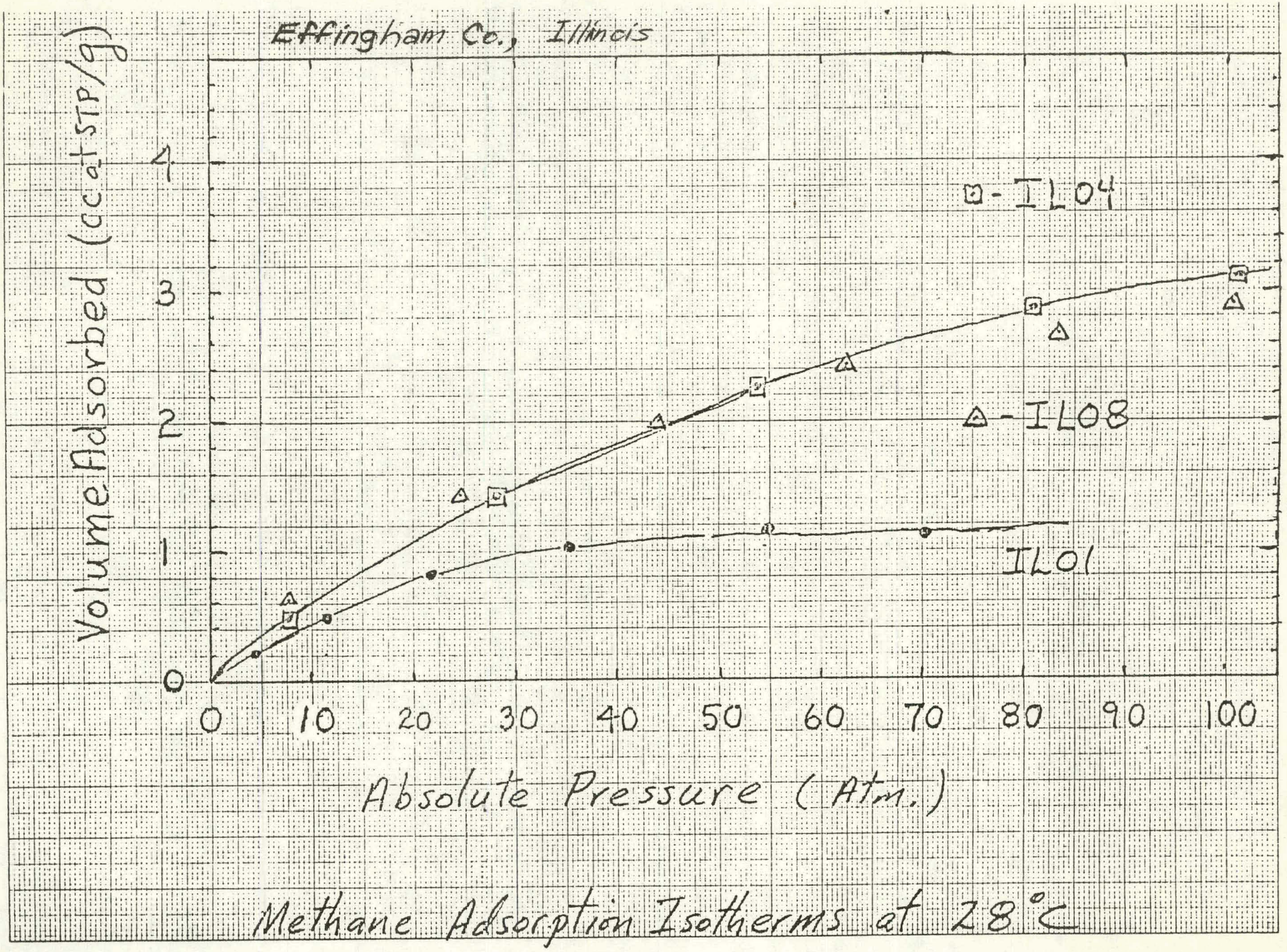
CO_2 ISA = 36.4 m^2/g
N_2 ISA = 4.57 m^2/g
CO_2/N_2 ISA = $\sim$8

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.



Effingham Co., Illinois
Volume Adsorbed (cc at STP/g)
0
1
2
3
4
IL04
IL08
IL01
0
10
20
30
40
50
60
70
80
90
100
Absolute Pressure (Atm.)
Methane Adsorption Isotherms at 28°C

Fig. 2.

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 studies of the Devonian 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.

☆U.S. GOVERNMENT PRINTING OFFICE: 1978-740-206/49

CONTRACTOR FINANCIAL MANAGEMENT REPORT

REPORT FOR MONTH ENDING: February 28, 1978

TO: U.S. Department of Energy
Contract Division
Research Contracts, Procedures and Reports Branch
P.O. Box E, Oak Ridge, Tennessee 37830

FROM: Robert E. Bergstrom
Neil F. Shimp
Illinois State Geological Survey
Urbana, Illinois 61801

2. CONTRACT VALUE $

3. FUND LIMITATION $

4. INVOICE AMOUNTS BILLED $

5. TOTAL PAYMENTS RECEIVED $

1. DESCRIPTION OF CONTRACT
a. TYPE: Contract
b. NO: EY-76-C-05-5203
c. SCOPE OF WORK: Geology, Geochemistry
Devonian Black Shale

d. AUTH. CONTRACT REPRESENTATIVE (Signature): Robert E. Bergstrom
Neil F. Shimp

PREPARATION DATE: 4/6/78

6. REPORTING CATEGORY	7. COSTS INCURRED: DURING MONTH a.	7. COSTS INCURRED: CUMULATIVE TO DATE b.	8. ESTIMATED COSTS/$ TO COMPLETE: SUBSEQUENT MONTH a.	8. ESTIMATED COSTS/$ TO COMPLETE: BALANCE OF FISCAL YEAR b.	8. ESTIMATED COSTS/$ TO COMPLETE: BALANCE OF CONTRACT c.	9. ESTIMATED FINAL COSTS
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		
Commodities, materials, supplies	591.80	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	-	1,011.30	500.00	1,988.60		
Computer	1,415.29	5,296.23	1,000.00	3,968.99		
Contractual						
Nuclear reactor	-	-	-	665.00		
Mass spectrograph	-	-	-	4,800.00		
Telecommunications	63.13	189.70	40.00	60.30		
Totals	$29,912.12	$160,205.77	$ 34,840.00	$29,650.40		