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DOE Contract EY-76-C-05-5204

INDIANA GEOLOGICAL SURVEY

Carbonaceous Shales of Indiana as Sources of Energy,
Petrochemicals, and Ceramic Materials

Quarterly Technical Progress Report
April, May, June, 1978
Report ORO-EY-76-C-05-5204-27

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QUARTERLY TECHNICAL PROGRESS REPORT

April, May, June, 1978

INDIANA GEOLOGICAL SURVEY

DOE Eastern Gas Shales Project

Contract No. EY-76-C-05-5204

Personnel

The following persons participated in work related to the New Albany Shale Project in Indiana during the quarter.

Geological Survey Staff:

Dr. John B. Patton, Principal Investigator
Dr. Donald D. Carr, Co-Principal Investigator
Mr. Richard K. Leininger, Co-Principal Investigator
Mr. Gerald Carpenter, Investigator
Dr. Pei-Yuan Chen, Geologist
Mr. Nelson Shaffer, Geologist
Dr. Robert F. Blakely, Geophysicist
Mrs. Margaret Golde, Geochemist
Mr. Paul Irwin, Preparator
Ms. Licia Weber, Geologic Assistant
Dr. Maurice E. Biggs, Responsible Person

Staff employed under DOE contract:

Mr. John Bassett, Geologist
Mrs. Nancy Hasenmueller, Geologist
Dr. Wen-Yen Huang, Organic Geochemist
Mr. Paul Lechler, Analytical Chemist
Mrs. Marilyn Ryerson, Draftsman
Mr. Robert D. Gunther, Draftsman
Mr. Mike Bonadio, Preparator
Mr. Joseph L. Reed, Preparator
Mr. Roger McCay, Electronics Technician

Organic Geochemistry Group, Indiana University:

Dr. Warren Meinschein, Professor of Organic Geochemistry
Mr. William Wimberg, Research Assistant

Meetings, Reports, and Travel

Three abstracts for papers to be presented at the Second Eastern Gas Shales Symposium were submitted on April 28.

Paul Lechler attended and satisfactorily completed the course on operation of the ICP spectrometer at Waltham, Mass.

On April 20 Paul Lechler and Dick Leininger attended the seminar in Morgantown that dealt with the analysis of the U.S. Geological Survey reference sample.

Representatives of the Illinois, Kentucky, and Indiana Geological Surveys met in Bloomington on May 9 to coordinate efforts on the shale project. Special attention was given data handling, correlation of members of the New Albany Shale in the Illinois Basin, and preparation of plans to analyze samples jointly with the Illinois Survey.

On May 23 Nancy Hasenmueller, John Bassett, and Dick Leininger attended a meeting in Indianapolis with the State Planning Services Director and representatives of the Mitre Corporation. Mitre representatives were given ideas on how to prepare an environmental impact statement for a proposed shale gas demonstration project in southwestern Indiana.

On June 9 Bob Blakely, Barbara Lewis, and Jim Dillard visited the Illinois Geological Survey to coordinate efforts to digitize map data for preparation of an INDYMAP. The Illinois Survey has a DOE contract to digitize southwestern Indiana; the Indiana Survey is working on the rest of the State in order to handle data for the shales of the Michigan Basin portion of Indiana.

Status of Tasks

3.2.1.1 Task (1) Selecting the location of drill sites.

A site for taking a core of New Albany Shale has been selected in Clark County. A contract for the Indiana Geological Survey rig to cut the core was received, reviewed and returned through channels. Coring is expected to begin about the middle of July.

Task (5) Interlocking stratigraphic cross sections.

Work continued on drafting final copies of the interlocking stratigraphic cross sections in the Illinois and Michigan Basins. Minor corrections and additions are being made as drafting continues.

Task (6) Isopach maps of lithologic units within the New Albany Shale interval.

Illinois Basin: Work continues on preparation of the preliminary isopach map of the Sweetland Creek Member in the Illinois Basin. Samples from key wells were examined to establish the relationship of the Sweetland Creek Member with the overlying Grassy Creek Member and underlying Blocher Member as accurately as possible.

Preparation of an isopach map of the Blocher also continued during the quarter. Correlations have been established for the unit from its type section in Scott County to sections in the Illinois Basin and along the outcrop. Sample studies are being made at intervals along each of the stratigraphic cross section lines.

Task (13) Analysis of geological and reservoir engineering data on Devonian shale gas fields in Indiana.

Detailed maps at a scale of 1:24,000 were compiled for the Corydon, New Middleton, and Laconia gas fields in Harrison County to show relationships between locations of wells and structure on top of the New Albany Shale. Maps showing structure and gas wells are being compared with other maps of the region on which lineaments are plotted. A summary of the study of these relationships will be included in the preprints of the Second Eastern Gas Shales symposium.

3.2.2.1 Task: Mineralogic and Petrographic Characterization of the New Albany in Indiana.

Preliminary results of x-ray and petrographic studies of New Albany Shale from the Phegley well, from Survey Drill Hole No. 275, and from core C-2, which was drilled near Indianapolis by the American Aggregates Company are shown in the tables which accompany this report. These tables indicate a preliminary but rather complete, summary of the minerals comprising the New Albany Shale.

3.2.2.3 Task: Organic and Inorganic Chemical Analysis.

The data for these tests will be sent to the Illinois Geological Survey on July 31:

Completed tests for the Phegley Core

1. Scleroscope (Shore) hardness - 139 samples tested.
2. Point load fracture - 130 samples tested.
3. Directional tensile strength (Brazilian split) 58 samples tested.
4. Directional sonic velocity - 18 samples tested.
5. Young's modulus - 18 samples tested.
6. Average shear modulus - 18 samples tested.
7. Average Poisson's ratio - 18 samples tested.
8. Average true density - 42 samples tested.
9. Average apparent density - 63 samples tested.
10. 42 Samples tested for 17 major chemicals - 714 entries of data.
11. 42 Samples tested for 6 trace elements - 102 entries of data.

Survey Drill Hole 273

1. 31 Samples tested for 15 major elements - 465 entries of data.
2. 31 Samples tested for 6 trace elements - 186 entries of data.
3. Scleroscope (Shore) hardness - wet - 20 samples.
4. Scleroscope (Shore) hardness - dry - 29 samples.
5. Bulk density and moisture loss - 42 samples and 8 repeats.
6. True density - 31 samples.

Survey Drill Hole 241

1. 26 Samples tested for 5 major elements - 130 entries of data.

Survey Drill Hole 275

1. Bulk density - 32 samples.
2. Percent moisture - 58 samples.
3. Scleroscope (Shore) hardness - 31 samples.

Thin sections also were prepared from samples of the New Albany Shale: 11 from the Phegley well; 18 from SDH 273; 13 from SDH 275; 7 from samples from the Harding Street Quarry of American Aggregates Company; and 9 NS-78 samples were prepared.

PETROGRAPHIC CHARACTERISTICS AND COMPOSITION OF THE NEW ALBANY SHALE AND ASSOCIATED FORMATIONS BASED ON THIN SECTION STUDY

Page 1

Stratigraphic position	Phegley Core No. Depth (feet)	Color	Rock Type	Texture & Structure			Clay Type	Carbonaceous Content	Spores 2	Carbonates 3	Pyrite 4	Fossils & other special features
				Silt content & mode 1	Burrows	Orientation						
New Providence	2499.8	olive-gy	claystone	v. low (~30μ)			Illitic	Low		Mod	Rare	Too thick
Grassy Creek Number	2505.4	blk	sh	mod-high ~15μ		mod-good	Illitic & sericitic	Mod	Abdt, v. thin to med skin	v. low, dol	Mod. spotty	Drusy-chert-pyrite bearing
	2516.3	blk	sh	mod-high 20-10μ		mod	Illitic & sericitic	Mod (nearly cont.)	Mod, thin to v. thin	v. low, dol	Mod-high in drusy layer, low in shale	Drusy-chert-pyrite bearing
	2524.0	blk	sh	mod 25-5μ		mod	Illitic & sericitic	Mod	Rare, thin to v. thin	Mod-low	Mod, dusty	
	2542.0	blk	sh	mod-high 30-15μ		mod	Sericitic > illitic	Mod, nearly cont.	Rare-mod, med to thin	v. low	Mod, dusty to spotty, most assoc w/carbonaceous mat.	With quartzose-sericitic seams rare cherty lenses
	2553.7	blk	sh	mod <25μ		mod	Illitic > sericitic	Mod to high (nearly cont.)	Mod-Abdt, many thick also thin	Mod to low, dol	Mod, dusty	+ quartzose-carbonate seams
	2573.5	blk	sh	low-mod <15μ		good	Illitic	High to mod. nearly cont.	Rare, thin to v. thin	Low, dol & minor Fe-dol	Mod, dusty	+ carbonate-pyrite seams
Sweetland Creek Number	2590.5	blk	sh w/ intercalated microparite bands	mod <20μ		mod	Mainly illite	Heavy, brownish red, cont.	Mod, thin & short (0.2 mm); some med	Low (in sh); Dol & Fe-dol dominant in microparite	Mod-rare in sh, (High in a clastic layer)	A thin lamina + pebbly pyrite & conodont & round quartz sd
	2605.0	blk	sh (or mudst)	v. low	Rather massive	Lightly burrowed	poor-mod Illitic	Mod-diffused, cont.	Tr.	Mod-high dol and Fe-dol (3:2)	Mod dusty w/ a large nodule	Some microfossils
Blanchet	2619.9	blk	sh	low <20μ		mod	Illitic	Mod-high, nearly cont., brownish red with v. fine opaque stringers		Mod-high, dol	Mod, dusty	W/ a rounded quartz ss laminae ~6 mm thick
	2627.4	blk	sh	low <20μ		mod	Mainly illitic	Heavy, brownish, red, cont.	-?	Mod, dol, in sh; high in carbonate seams (cal & dol)	Mod to rare in sh; high to mod in carbonate layers	+ carbonate seams w/ Styliolina

Stratigraphic position	C-2* Core Depth (feet)	Color	Rock Type	Texture & Structure			Clay Type	Carbonaceous Content	Spores	Carbonates	Pyrite	Fossils & other special features
				Silt content & mode	Burrows	Orientation						
Crazy Creek Member	91.4	blk	sh	Mod-high <0.02 _u 35%		Mod	Illitic>> sericitic	Mod (long discont.) nearly cont.	mod to Med, thick (0.3 mm long)	Mod-low, dol & subordinate Fe-dol & cal	Mod (spotty & dusty)	+ quartzose-carbonate seams (c)
Crazy Creek Member	91.5		1) conodont ss 2) sh	Randomly oriented conodont fragments with accessory round quartz Mod-high <0.02 _u			Sericitic & illitic	Mod (discont.) Sparse (dol)	Common mod thick (one 0.3 mm long)	High, mainly calcite cement.	Mod, spotty Mod, dusty	1) Conodont sand (re-worked); qtz, py, carbonate cement 2) Clay 30%, carbon 20-30, qtz 25-30, carbonate 5, py-3-5, glauconite tr
Sweetland Creek Member	103.4	dark gy	carbonaceous micrite		columnar calcite in layers	-	Illitic?	Low, in interlayer shale	V.R.	High, layers of short columnar calcite	Mod-rare spotty (single large cubes)	
	103.7	light gy	quartz ss	Well rounded, fine-grained qtz grains		-				High, euhedral dol and accessory calcite	Mod-high, large spotty	Conodont common
	108.2	Gy	sh	Mod-low (<0.015 _u dom)	Greenish burrows	Mod	Illitic>> sericitic	Mod (opaque stringers common)	V.R. thin	High-mod in sh (dol) colorless V.H. in lenses (blue minor)	Mod, spotty	Some chert in pores interfingering with carbonate-round quartz layers (+ glauconite & conodont)
Blocher	130.5	gy	cal mudst (micrite, carbonaceous)	V. slightly (<10%) <0.02	Burrowed	-	Illitic?	V. low	V.R.	High, skeletal cal. and colorless dol	Rare spotty (replace fossils) & some dusty	Fossilif. rare <u>Styliolina</u>
	131.4	blk	sh	v. slightly <0.015 _u		Mod	Illitic	High-mod, v.f. particle, nearly cont.		High, skeletal cal & subhedral f. crystall. dol	Rare, dusty	<u>Styliolina</u> -bearing (rare Tentaculite)

*Core drilled by American Aggregates Corp., Indianapolis, Indiana

Stratigraphic position	SDH 275 Core Depth (feet)	Color	Rock Type	Texture and Structure			Clay Type	Carbonaceous Content	Spores	Carbonates	Pyrite	Fossils & other special features
				Silt content & mode	Burrows	Orienta- tion						
New Providence	141	grn-gy	calc mudst w/ layers of bio- micrite	no qtz	Burrowed	Poor?	Illitic	-	-	Abdt, skeletal cal. domt	V.R., dusty	Microfossils
	149	blk	sh	High-mod <20 μ	-	Mod	Sericitic & minor illitic	Mod. dark to opaque stringers common	V.R., thin and short	-	Mod-rare, dusty assoc w/ carbona- ceous material	Chert-filled elongate pores in some layers
Grassy Creek Number	151	blk	sh	Mod-low 30-15 μ	-	Mod	Sericitic & illitic	Mod (discont.) (alternating of more carbonaceous & less carbonaceous bands)	R., thin, some w/hollow	V.R.	Mod, spotty	+ bands, drusy chert- pyrite spots
	153	Gy	sh	Mod <30 μ (a few c. silt)	Interfingering of more quartzose and more clayey layers	-	Illitic	R.	R., med to thin, short	Mod, Fe-dol dom. dol & cal, subordinate	Mod-rare, dusty & spotty	+ quartzose-carbonate lenses
	154.5	grn-gy	claystone	Mod-low <20 μ	Rare	Poor?	Illitic	V. low or none	-	Mod, Fe-dol. domt, some cal	Mod, dusty, some assembled into bands	Scattered spots of conodonts
	192	blk	sh	Mod-low <15 μ	-	Mod	Sericitic > illitic	Mod-rare, opaque; or dark stringers common	R.	Low	Rare	+ quartzose-carbonate seams
	208.5	blk	sh	Mod 15 μ	Planar lamination	Mod-good	Sericitic > illitic	Mod, uniformly distributed	R., thin & short	Low	Rare	Thin, quartzose and some cherty lenses
	215.5	blk	sh	Mod <20 μ	Planar lamination	Mod	Sericitic & illitic	Mod, discont.	Mod, thick to med (some 0.05-0.3 mm)	Mod, dol & minor cal	Mod, dusty to spotty	+ quartzose-carbonate seams
Sweetland Creek Number	217	gy	sh or mudst	Mod <20 μ	Burrowed	Poor	Illitic & sericitic	V.R. (isolate stringers)	R., thick to med (some have pyritic core)	Mod, Fe-dol domt, dol and cal minor	Mod. spotty	-
	229	blk	sh	Mod <20 μ	-	Mod-good	Sericitic & illitic	Mod	Abdt. thin, and some thick; long coalesce thin spores common	Low-mod, Fe-dol	Mod-rare	+ quartzose-carbonate seams frequent
	231	gy	Mudst	Mod <20 μ	Burrowed	Poor to mod	Illitic > sericitic	Mod-rare	R., thin to med long	Mod-low, dol rhombs	Mod-rare, dusty	Interfingering of more carbonaceous and non-carbonaceous layers
Blackfoot	256	blk	sh	Low <20 μ	-	Mod-good	Illitic	High-mod (dark brownish common)	-	Abdt, cal and less dol	Rare, spotty	Styliolina-bearing

Strati-
graphic
position

SDH 275

Core Depth
(feet)

Color

Rock
Type

Texture & Structure

Silt
content
& mode

Burrows

Orienta-
tion

Clay Type

Carbonaceous
Content

Spores

Carbonates

Pyrite

Fossils &
other special
features

Strati- graphic position	SDH 275 Core Depth (feet)	Color	Rock Type	Silt content & mode	Burrows	Orienta- tion	Clay Type	Carbonaceous Content	Spores	Carbonates	Pyrite	Fossils & other special features
261	brn-gy	carbona- ceous micrite	V.R.	V. finely crystal (fine silt to clay size)			Illitic?	R., isolate stringers	Rare, thin & short, a few thick and short	V. abdt, cal: dol ~3:2	Mod-low, dusty some aggregate into band	

Stratigraphic position	SDH 273 Core Depth (feet)	Color	Rock Type	Texture and Structure			Clay Type	Carbonaceous Content	Spores	Carbonates	Pyrite	Fossils & other special features
				Silt content & mode	Burrows	Orientation						
New Providence Shale	197.4	olive gray	claystone (marl)	Low (fine)	?	Poor	Illitic & minor sericitic	None		Mod (dol)?	Mod-rare, spotty	Fossilif. (some pyrite replaced)
	212.6	brn	sh	Mod (c to fine)		Mod	Sericitic and illitic			Rare	- (some hematite)	
	219.0	grn-gy	calc claystone (marl)	v. low	burrowed	Poor	Illitic	V. low or none		Abdt, skeletal cal. and patches of tiny dol and Fe-dol	Rare	Fossilif., ostracods? common
	221.6	olive gray	ls. (micro-sparite)		micro-vuggy		Glauconitic	None		V. abdt. dol.	V. R. (dusty)	
Grassy Creek Member	225.4	blk	sh	Mod (<35μ)	Laminar	Well-mod	Illitic	Heavy, dark material common, some vitrain	R, thin skin dom.	None or v. low	Mod-rare, dusty (mostly in carbonaceous material)	
	245	blk	sh	Low <15μ dom.		Mod	Sericitic & illitic	Mod	Rare, med to thin	Mod, tiny dol	Mod, spotty	+ quartzose-carbonate seams
	258.3	blk	sh	Mod-low <20μ		Mod	Illitic > sericitic	Mod (nearly cont.)	Mod-rare, thin skin	Mod-abdt, cal & dol	Mod-rare, dusty	+ quartzose-carbonate seams
	271.5	blk-gy	sh	Mod <15μ		Mod	Sericitic > Illitic	Mod (nearly cont.)	Med skin abdt. (some 0.5 mm long)	Low	Mod-rare, spotty	+ thin quartzose-carbonate seams
Sweetland Creek Member	291.9	Grn-gy	mudst	Mod-low	burrowed	Poor-mod	Illitic > sericitic	V. low	V.R.	Mod-abdt, cal dol & Fe-dol	Mod-rare, dusty	
	297.8	grn-gy	mudst	Mod	Highly burrowed	Poor	Illitic	V. low		Mod-abdt, dol & Fe dol, with minor cal as cement	Mod, spotty	
	299.8	blk	sh	Mod <20μ		Good	Illitic & some sericitic	Heavy-mod	Mod-abdt, thin some thick	Low	Mod-rare, mod in carbonaceous matter	Chert in lenticular pores
	303.7	blk	sh	Mod <20μ		Mod	Sericitic & illitic	Mod-high	Abdt thin corrugated spores (coal-esce spores)	Mod-low (dol)	Some nodules	+ calcite-dol seams
	308.0	blk	sh	Mod <20μ		Mod-poor	Illitic > sericitic	Mod-nearly cont.	R-M, thin to v. thin	Low-mod	Rare-mod, dusty	Round pores with pyrite & carbonate
	309.2	blk-gy	micrite	-			Illitic?	Mod-low Scattered carbonaceous & argill. laminae		V. abdt, columnar calcite	Mod-abdt, spotty most assoc. carbonaceous layers	

PRELIMINARY X-RAY DATA OF NEW ALBANY SHALE AND ASSOCIATED ROCKS
of Survey Drill Hole 275 and Core C-2 drilled by American Aggregate Corporation

Page 1

Stratigraphic position	X-ray file no.	Core SDH 275 depth (ft)	Rock Type	Composition							
				Illt Mix.	Ch+K	Qtz	Cal	Dol	Py	Others	
New Providence Shale	71	140.8	Limy intraclasts in greenish sh.*	-	-	M	VS	W (ankerite)	-	Siderite (VW)	
	115a	141.8	Limy intraclasts in greenish sh.*	W-M		S	VS	M	-	Siderite Rhodocrosite	
	115b	141.8	Clay matrix of #115 (slide)	S	M-W	W	VS			Rhodocrosite (VW)	
	124	141.8	Clay (insoluble residual in HCl) (powder)	VS	S					+ Kaolinite	
Rockford Limestone	70	147.2	Insoluble residual of Rockford Ls. (glauconitic clay) (powder)	S(2M)	W	-	-	VW	W		
Grassy Creek Number	121	149.5	Black sh.*	M	W	S	-	-	W-M		
	69	149.8	Whitish pyrite nodules in blk sh. (powder)	-	-	-	-	-	S		
	85	149.8	Blk sh.*	S	W (+Kao)	S	-	-	VW	Plag.	
	125	151	Blk sh.*	45	15	75	-	-	24	Plag. (?)	
	136	151	Blk sh. with chert-filled pores	10	2?	75	-	-	11	+13.5°	
	116	153	Greenish sh.*	M	M-W	VS	VW	M (Fe)	VW		
	86	159.5	Blk sh.*	M	M-W	S	M-W	-	WM	Plag. (VW)	
	119a	175	Blk sh. (coarse clay) (powder)	2	1	3	-	-	W (-Mar)		
	119b	175	Blk sh. (fine clay) slide	8	1	-	-	-	-		
	127	194	Blk (clay fraction) slide	3.1	1	1	-	-	0.8		
	129	205.5	Blk sh.*	35	18	75	tr	tr	10		
	137	208.0	Blk sh. (sericitic)*24		12	40	-	3	12		

X-ray Data Cont'd.

Page 2

Page 2

Strati- graphic position	X-ray series no.	Core SDH 275 depth (ft)	Rock Type	Ilt Mix.	Composition										Others
					Ch+K	Qtz	Cal	Dol	Py						
Grassy Creek Member	117	208.5	Blk sh*	M		MW		VS		?		W		M-W (+Mar)	
	87	208.5	Blk sh	M		MW		VS		-		-		WM (+Mar)	
	84	211.9	Blk sh* with abundant spores	M		MW		VS		S		W		MS (+Mar)	+13.5°, Plag(?)
	138	211.9		20		8		45		26		4		16	Plag. 8
Sweetland Creek Member	109	217	Burrowed gray sh.*	S		M		VS		M		M		W	+13.5° peak
	118	229	Blk sh.*	M		WM		VS		W		M (Fe)		W	
	74	232.9	Thin granular ls interbed in blk sh.	W		?		WM		S					
	110	237	Greenish mudstone*	S		M		VS		M		W		W	
	75	243.7	Greenish mudstone* (broad)	MW		W		S		VW		W		VW	
Blocher	128a	253.5	Greenish sh.*	2.5		1		5.5		8		4.2		0.7	
	128b	253.5	Greenish (clay slide)	5.0		1		0.4		-		-		-	
North Vernon Limestone?	72a	258.5	Carbonaceous, micrite*	VW				MS		S		M			
	72b	258.5	Carbonaceous insoluble residue (powder)	WM		?		VS		-		-		W	
	73	267.2	Fossiliferous ls.* (N. Vernon Ls)					S-M		VS		S-M (Fe)		VW	

Strati-
graphic
position

SDH 273

Core Depth
(feet)

Color

Rock
TypeSilt
content
& mode

Burrows

Orienta-
tion

Clay Type

Carbonaceous
Content

Spores

Carbonates

Pyrite

Fossils &
other special
features

Texture & Structure

Strati- graphic position	SDH 273 Core Depth (feet)	Color	Rock Type	Silt content & mode	Burrows	Orienta- tion	Clay Type	Carbonaceous Content	Spores	Carbonates	Pyrite	Fossils & other special features
315	grn-gy	mudst	Mod-low	Burrowed	Poor	Illitic	sericitic	V. low	-	Mod-abdt, dol	Mod-rare, spotty	Too thick
323	blk-gy	sh	Low <25 μ		Mod	Illitic		Low	R-v.r. thin	Abdt, dol rhombs	R, spotty to dusty	
328	blk	st.	Mod-low <20 μ		Mod	Illitic		Mod	R-v.r. thin, some brownish	Abdt, cal>dol 40% in total	Mod, spotty	Styliolina-bearing
332.8	olive gray	sh	Low		Mod-poor	Illitic		Mod-low	Tr.	Abdt-mod dol 65%, cal 35% & dusty	Mod-rare, spotty	Carbonate seams
336	brn-gy	micrite	-	Carbonaceous, v. fine crystalline	-	Illitic?		V.R-R (some stringers)	V.R	~75% in total dol and cal	Mod-low, dusty > spotty	

REMARKS:

1. Silt fraction is composed substantially of quartz and accessory mica; mode indicates the most dominant range of grain-size.
2. The thickness of the skin (wall) of spore was divided into very thin
thin
medium
thick
very thick

<5 micron.
5-10 micron
10-15 micron
15-20 micron
>20 micron
3. Carbonates were distinguished by staining method (Alizarine) colorless-dolomite,
blue-Fe-dolomite;
pink-calcite.
4. Spotty - particles can be seen clearly under a 25x magnification.
Dusty - particles can not be observed clearly under a 25x magnification.

Abbreviation:

Color: Blk-black, Brn-brown, Grn-green, Gy-gray

Amount or degree: V-very, Mod-moderate, Med-medium, R-rare, Abdt-abundant

Lithologic:

Argil.-argillaceous, C-coarse, Cal-calcite, Calc-calcareous, Carbon-carbonaceous, Dol-dolomite, Fe-dol-Fe-dolomite, Ls-limestone, Mudst-mudstone, Sh-shale,
Sd-sand, Ss-sandstone.

Strati- graphic position	X-ray series no.	Core C-2 (depth)	Rock Type	Composition							
				Illt Mix.	Ch+K	Qtz	Cal	Dol	Py	Others	
Sweetland Creek Number	135	91.55	Conodont s.s.*	VW	tr	M	VS	MS (Fe)	M	Fluorapatite MS	
	130	95	Greenish sh.*	40	18	80	4	25	8		
	111	103-104	Greenish sh.*	MS	MW	VS	VW	MS	W		
	112	106	Greenish sh.*	MS	MW	VS	W	W	W		
	120a	110	Greenish sh. (rock fragments)	2.7	1	5	3.2	2.5	0.8		
	120b	110	Greenish sh. (clay slide)	4	1	0.1	-	-	-		
	113	115	Blk sh.*	MS	MW	VS	-	S	W		
Blucher	131	124	Blk sh. styliolina- bearing*	18	8	50	>100	28	19		
North Vernon Limestone ?	107	134	Limy mudstone*	VW	?	MW	VS	S	-		
	108	143.2	Light color ls.* (North Vernon Ls)	-	-	W	VS	W	-		
	109	143.3	Dark color argil. ls.*	-	-	W	VS	W	-		

REMARKS:

Explanation

* whole rock powder.

Ill+Mix illite with minor mixed layer clay (peak at $8.8^{\circ}2\theta$).Ch+K chlorite, possibly with trace kaolinite (peak at 12.4°).Qtz quartz (peak at 20.8°).Cal calcite (peak at 29.4°).Dol dolomite, if Fe-dolomite or ankerite is present, a (Fe) is marked,
(peak at $30.8^{\circ}-31^{\circ}$).Py pyrite, if associated with marcasite is indicated by +Mar (peak at 33.1°).Plag plagioclase (peak at 28°).

The quantitative expression of the component minerals in the table is not unified yet. They are shown either by a notation from very strong (VS) to very weak (VW) with S, MS, M, MW, WM, W between them, or they are indicated by peak height ratio.