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# BUFF-BURNING CLAY RESOURCES OF SOUTHWESTERN AND SOUTHERN ILLINOIS

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# BUFF-BURNING CLAY RESOURCES OF SOUTHWESTERN AND SOUTHERN ILLINOIS

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## ABSTRACT

Some 66 samples of Pennsylvanian clays that occur in the Spoon and Abbot Formations in Calhoun, Cass, Gallatin, Greene, Jackson, Jersey, Johnson, Madison, Monroe, Pike, St. Clair, Saline, Scott, and Williamson Counties, Illinois, were tested to determine their potential uses. Their bonding and ceramic properties were determined.

## INTRODUCTION

This report is another in a series of guides to locate new clay deposits (fig. 1) which may be used in the manufacture of china, drain tile, flower pots, flue liners, lightweight aggregate, paper, refractories, refractory cements, sewer pipe, stoneware, structural clay products (brick, hollow block, and tile), terra cotta and terra sigillata (a mixture of clay and pigments dispersed in water to be sprayed or dipped on ceramic ware), and which may be used as fillers and bonding clays. Tabulated data on the individual samples of clays tested are given in Appendix A; thickness of beds and stratigraphic sequence of clays are shown by the measured sections in Appendix B; and some supplemental references are given in Appendix C. The three previous reports on clays of this nature have been published for LaSalle (Parham, 1959), Knox (Parham, 1960), and Rock Island, Mercer, and Henry Counties (Parham, 1961).



Fig. 1 - Locations from which samples of clay were taken for ceramic tests.

## GEOLOGY

## Stratigraphy

Because most of the counties included in this report are covered by glacial deposits, exposures of the Pennsylvanian rocks are limited mainly to stream cuts, road cuts, and mines. Many of the samples reported here were taken from beds of clay that normally occur directly beneath layers of coal. Such beds of gray, fine-grained, nonbedded clay, called underclay, range in thickness from a few inches to about 20 feet. The remaining samples were from shales.

Classification of the Pennsylvanian strata of the area of this report is indicated in figure 2 (Kosanke et al., 1960). Only members that will aid in locating the samples stratigraphically are listed.

Throughout most of the area concerned in this report the Pennsylvanian rocks have a gentle regional dip. In western Illinois the rocks dip gently toward the east, but in the southern counties they have a slightly greater dip toward the north. In Saline and Gallatin Counties, however, where there has been a great deal of faulting, the direction and degree of dip of the rocks can vary greatly within short distances; nevertheless the regional dip is generally northward.

Many of the Pennsylvanian rocks, originally deposited in the Illinois Basin, now crop out near the eastern, southern, and western borders of Illinois and along a belt across the north-central portion of the state. Some of these rocks form continuous beds that extend from outcrops on one side of the Illinois Basin to the other, but in the deeper portions of the basin in south-central Illinois the same beds may be buried under several hundred feet of younger rocks.

Most of the samples of clay tested were taken from various beds of the Spoon Formation; some samples were taken from beds of uncertain stratigraphic position.

The detailed geology at each of the outcrops sampled is given in the measured geologic sections (appendix B), listed by counties arranged alphabetically. The sample numbers, location, stratigraphy, lithology, and thickness of each lithologic unit are given. The clay or shale sampled is indicated by the sample number, which is also the cross reference to the chemical data (table 1) and the tabulated ceramic tests and suggested uses (table 2).

For detailed geology of the area, see the references listed in the bibliography at the end of this report (appendix C).

## Mineralogy

The mineralogy of the clay samples was determined by x-ray, differential thermal analyses, microscopic techniques, and by visual observation. The clay minerals common to many of the samples are illite, kaolinite, mixed-layer clay minerals, and chlorite. The nonclay minerals are chiefly quartz with minor amounts of pyrite, siderite, calcite, and gypsum.

The clays and shales vary in clay mineral composition from almost pure kaolinite to almost pure mixed-layer clay material. Most of the clays, however, are mixtures of two or more clay minerals.

System	Group	Formation	Members				
			Monroe County and north	south of Monroe County			
Pleistocene Series							
Pennsylvanian	McLeansboro	Mattoon	Pleasantview Ss Purinton Sh Francis Creek Sh Colchester (No. 2) Coal	Colchester (No. 2) Coal			
		Bond					
		Modesto					
	Kewanee	Carbondale					
					Spoon	DeKoven Coal Davis Coal Seahorne Ls Vergennes Ss Mt. Rorah Coal Creal Springs Ls	
					Brush Coal	Granger Ss	
					Hermon Coal Selville Ls Rock Island (No. 1) Coal	Murphysboro Coal Bidwell Coal	
		McCormick			Abbott	Bernadotte Ss Pope Creek Coal Tarter Coal Manley Coal	Murray Bluff Ss Delwood Coal Willis Coal
						Babylon Ss	Grindstaff Ss
					Caseyville		Reynoldsburg Coal
Mississippian							

Fig. 2 - Modified stratigraphic section.

Quartz and pyrite occur in various concentrations in all the clays, whereas siderite, calcite, and gypsum are less common. Gypsum usually occurs only on or near the surface of the weathered clay outcrops.

During weathering of pyrite in the clays, iron sulfate and sulfuric acid are formed. The sulfuric acid reacts with any calcite present and/or the calcium on the exchange positions of the clay minerals to form gypsum. Pyrite-bearing calcareous clays are apt to have their weathered outcrops covered with this form of gypsum. In addition, products leached from overlying coal or other lithologic units may finally form gypsum in joints in an underlying clay bed.

### REPORT OF TESTS

Information about the geology of the clay samples, their location, thickness, overburden, and type of underlying and overlying sediments, is given in Appendix B. Chemical data are given in table 1, and the results of tests for the physical and ceramic properties and the suggested uses for each sample are given in table 2. The ceramic test results include the drying and firing shrinkage, water of plasticity, fired color, and, where applicable, the bonding properties of the clay.

#### Formation and Firing of Test Bars

Samples collected in Madison County and to the north were formed into test bars by hand, but those collected in St. Clair County and to the south were made with a laboratory-size extrusion machine. The extruded samples are marked with an asterisk in table 2. The clay used for the hand-molded samples was ground to a powder in a disc grinder. Clays ground to  $\frac{1}{4}$ -inch in diameter and less were used for extruded test bars. The percentage of water necessary to hand form or extrude a satisfactory test bar is listed as water of plasticity. More water is needed in hand forming test bars and, as a result, water of plasticity and drying and total shrinkage values for any given clay are higher for hand-molded than for extruded test bars. Both methods were used for the preparation of test bars from a selected clay and a selected shale for comparison of results. Table 3 illustrates the variations in values obtained with the two techniques.

Three individual test bars were made from each sample of clay. The bars were measured after drying to determine the percentage of drying shrinkage. The first bar was fired to 1832°F. (1000 °C.), the second 2012° F.(1100° C.), and the third to 2200° F. (1205°C.). The test bars were measured after each firing to determine the percentage of firing shrinkage. The method of preparing the test bar, hand molding vs. extrusion, has little effect on the fired properties of a clay.

Those clays listed as having "good" extrusion properties are those that give sharp, even edges on the test bar during extrusion. Clays that show some tearing of the edges of the test bar during extrusion are considered as having "fair" extrusion properties, and those that show considerable tearing are listed as having "poor" extrusion properties.

Pyrite, which is normally disseminated throughout the clay, will oxidize during weathering to form ferrous sulfate. The latter will, in turn, alter to limonite and sulfuric acid as weathering continues. The formation of iron sulfate and iron oxide tend to give the fired clay a dark color. For a better indication of the true ceramic properties and burning color, it would be necessary to obtain unweathered samples of the clay from drill holes in the area under consideration but at some distance from the outcrops.

If soluble salts are present in a clay, they will migrate outward to the surface of an unfired brick during the drying period. If ferrous sulfate is the soluble salt, the fired color is generally dark brick red, but if calcium sulfate is the soluble salt, a white scum forms on the surface during firing.

#### High-Temperature Properties

On the basis of mineralogical data, samples with the largest amounts of kaolinite were selected for tests to determine their fusion temperature P.C.E. (pyrometric cone equivalent).

Refractories are classified in the following manner (American Society of Testing Materials, 1958):

	Minimum P.C.E.
Super duty	33
High heat duty	31
Medium heat duty	29
Low heat duty	15

One Clay (996N) from Pike County can be assigned to the super duty heat class. Clays sampled in Madison, Jersey, Greene, Scott, and Calhoun Counties could be used for medium heat duty refractories; samples 1719 in St. Clair, 1806 in Jackson, 1809 in Gallatin, and 1813, 1814, and 1818 in Saline Counties would be most suitable for low heat duty refractories.

#### Bonding Tests

Some underclays have been found to be satisfactory for use as bonding clays for foundry sands. The clay mineralogy of an underclay may be used to predict its bonding properties. Clays that have poorly crystalline kaolinite and those that have large amounts of mixed-layer clay minerals are better bonding clays than the more crystalline clay mineral varieties.

Mixtures of 92 percent foundry sand and 8 percent clay were made and mixed with varying amounts of water. Bonding tests were then run in a manner described in the "Foundry Sand Handbook" (American Foundrymen's Society, 1952). The green compression strength of each sample tested, in pounds per square inch (GCS psi), is listed in table 1 under bonding properties. The maximum green strength is that strength developed by the clay at its optimum water content. Samples 958H and 958Z from Greene County, 393, 960C, and 960F from Madison County, and 1803 from Williamson County gave favorable green strengths in the bonding tests.

#### SUMMARY AND CONCLUSIONS

The clays and shales tested in this report may serve as raw materials for a wide variety of uses. Clays or shales can be mixed to enhance or develop certain desired properties or to minimize undesirable characteristics. For instance, a wide variation in fired color can be obtained in a product by the mixing of light and dark firing clays in varying proportions. Plasticity, drying shrinkage, firing shrinkage, and refractoriness also can be varied by the mixing process.



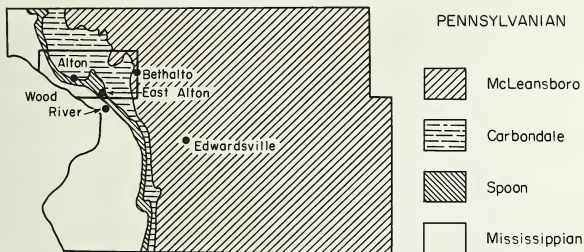


Fig. 3 - Generalized bedrock geology of Madison County and location of fig. 4.

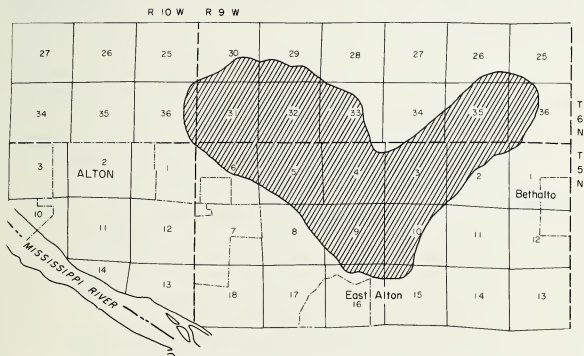


Fig. 4 - Location of samples studied and suggested area for prospecting for strippable clay resources.

The tables of this report may serve as a general guide to predict the properties, uses, and values of combined samples. However, the actual commercial value of a sample or combination of samples is dependent not only upon the qualities listed in the table but also upon a complex of factors involving local geologic, geographic, and economic conditions at the site of the deposit.

In Madison County, because outcrops below the Colchester No. 2 Coal are rare, sampling was limited to two locations. However, the outcrop areas of sediments above the coal and below the clay suggest an area (figs. 3 and 4) in which the overburden may be thin enough to permit mining the clay by stripping operations. Core drilling will be necessary to reveal the thickness of the overburden, thickness of the clay, and quality of the clay.

Sample 996N from Pike County, compared with other samples, is unusual in its measured physical properties. It is composed primarily of the clay mineral kaolinite, which gives the fired clay a white color. Because of its high kaolinite content it is the only sample with a P.C.E. high enough (P.C.E. 33) to be assigned to the super heat duty refractory class and may have some potential for use in the china or paper industries.

Samples taken from Scott County south to Madison County could be used for medium heat duty refractories. A few samples in the counties studied to the south and east can be classed in the low heat duty class.

Samples 958H and 958Z in Greene County and all of the samples of Madison County produced satisfactory green strength in the bonding tests. This group of samples is of the poorly crystalline kaolinite variety and, therefore, would be more refractory. Samples 954D of Cass County and 1803 of Williamson County have good bonding strength but are rich in the mixed-layer clay mineral component and, therefore, are less refractory.

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#### REFERENCES

- American Foundrymen's Society, 1952, Foundry sand handbook: 6th ed., p. 17-28, 85-89, 93-95.
- American Society of Testing Materials, 1958, Standard classification of fireclay refractory bricks: Am. Soc. Testing Materials, sec. C, p. 27-58, pt. 5, p. 277-279.
- Kosanke, R. M., Simon, J. A., Wanless, H. R., and Willman, H. B., 1960, Classification of the Pennsylvanian strata of Illinois: Illinois Geol. Survey Rept. Inv. 214, 84 p.
- Parham, W. E., 1959, Light-burning clay resources in LaSalle County, Illinois: Illinois Geol. Survey Circ. 277, 27 p.
- Parham, W. E., 1960, Lower Pennsylvanian clay resources of Knox County, Illinois: Illinois Geol. Survey Circ. 302, 19 p.
- Parham, W. E., 1961, Lower Pennsylvanian clay resources of Rock Island, Mercer, and Henry Counties, Illinois: Illinois Geol. Survey Circ. 322, 40 p.

TABLE 1 - CHEMICAL ANALYSES AND DATA

Sample 393		Sample 996N	
Oxide	Percent	Oxide	Percent
SiO <sub>2</sub>	56.92	SiO <sub>2</sub>	53.11
TiO <sub>2</sub>	1.40	TiO <sub>2</sub>	1.98
Al <sub>2</sub> O <sub>3</sub>	26.80	Al <sub>2</sub> O <sub>3</sub>	32.39
Fe <sub>2</sub> O <sub>3</sub>	2.51	Fe <sub>2</sub> O <sub>3</sub>	0.36
FeO	0.35	FeO	0.09
MgO	0.51	MgO	0.30
CaO	0.17	CaO	0.13
Na <sub>2</sub> O	0.50	Na <sub>2</sub> O	0.28
K <sub>2</sub> O	0.48	K <sub>2</sub> O	0.29
Ign.	10.41	Ign.	11.49
Total	100.05	Total	100.42
H <sub>2</sub> O-	2.06	H <sub>2</sub> O-	0.84
P <sub>2</sub> O <sub>5</sub>	trace	P <sub>2</sub> O <sub>5</sub>	trace
SO <sub>2</sub>	0.00	SO <sub>2</sub>	0.00

Exchangeable cations (Sample 393):

Al <sup>+3</sup>	0.00 me/100 gm.	Na <sup>+</sup>	9.07 me/100 gm.
Fe <sup>+3</sup>	0.00	K <sup>+</sup>	0.75
Mg <sup>++</sup>	3.85	SO <sub>4</sub> <sup>=</sup>	1.25
Ca <sup>++</sup>	5.35		

Cation exchange capacity 17.5 me/100 gm.; pH 8.1

TABLE 3 - COMPARISON OF DATA FOR HAND-MOLDED AND EXTRUDED SAMPLES

	Clay		Shale	
	Molded	Extruded	Molded	Extruded
Water of plasticity	24.5	18.0	21.5	19.0
Linear drying shrinkage	6.25	4.68	4.17	2.34
Linear firing shrinkage				
1832°	1.04	1.05	2.08	4.95
1922°		2.09	6.25	6.51
2012°	4.17	3.13	8.33	8.64
Total firing shrinkage				
1832°	7.29	5.73	6.25	7.29
1922°		6.77	10.42	8.85
2012°	10.42	7.81	12.50	10.98

TABLE 2 - CERAMIC AND OTHER DATA

Sample no.	Thickness	Extrusion properties and workability	Water of plasticity (%)	Linear drying shrinkage (%)	Firing temperatures in degrees Fahrenheit									Bonding properties	
					Linear firing shrinkage (%)			Total linear shrinkage (%)			Fired color			GCS	Opt.**
					1832°	2012°	2200°	1832°	2012°	2200°	1832°	2012°	2200°	(psi)	H <sub>2</sub> O(%)
Calhoun County															
1067B	3' 6"	sticky	36.6	10.4	2.1	3.1	5.2	12.5	13.5	15.6	Buff	Buff	Buff		
1067D	2'	good	21.4	5.2	1.0	8.3	5.2	6.2	13.5	10.4	Buff	Buff	Gray		
Cass County															
994D	2' 1"	good	54.3	16.7	8.3	-	-	25.0	-	-	Salmon				
994C	5' 3"	good	36.8	10.4	2.1	6.3	8.3	12.5	16.7	18.7	Buff	Buff	Brown		
994B	2' 9"	good	26.6	6.3	1.0	7.3	5.2	7.3	13.6	11.5	Salmon	Salmon	Salmon		
Gallatin County															
1809	5'	fair*	22.0	4.5	1.1	2.7	3.8	5.6	7.2	8.3	Pink	Salmon	Tan		
1810	2'	fair*	23.0	3.5	4.3	6.7	6.3	7.8	10.2	9.8	Salmon	Tan	Tan		
Greene County															
958F	1'	good	33.8	9.4	2.3	2.3	6.2	11.7	11.7	15.6	Pink	Buff	Buff	6.2	1.5
958H	4'	good	36.4	10.9	+3.9	4.7	5.8	7.0	15.6	16.7	Pink	Buff	Buff	8.0	1.9
958K	1'	good	23.8	8.6	0.7	1.8	2.9	9.3	10.4	11.5	Pink	Buff	Buff	6.5	1.3
958U	6'	good	20.8	5.5	0.0	0.0	2.3	5.5	5.5	7.8	Buff	Buff	Buff		
958W	3½'	good	23.4	7.8	2.3	4.7	7.8	10.1	12.5	15.6	Pink	Buff	Buff		
958X	5'	good	24.6	6.3	3.1	5.2	7.3	9.4	11.5	13.6	Pink	Buff	Buff		
958Y	5'	good	22.0	4.7	1.6	2.6	3.6	6.3	7.3	8.3	Pink	Buff	Buff		
958Z	6'	good	26.6	7.8	3.1	4.2	6.8	10.9	12.0	14.6	Pink	Buff	Buff	9.2	1.4
958V	5'	good	21.5	3.9	2.4	8.3	9.6	6.3	12.2	13.5	Pink	Buff	Buff		
958BB	2'	good	34.7	10.9	2.4	4.7	5.9	13.3	15.6	16.8	Pink	Buff	Buff	6.4	1.3
958VV	2'	good	22.2	5.5	+0.8	2.8	4.9	4.7	8.3	10.4	Pink	Buff	Buff		
958FFF	5'	good	31.3	9.4	3.1	5.2	6.2	12.5	14.6	15.6	Pink	Buff	Buff		
955	6'	good	-	5.5	0.8	3.9	7.0	6.3	9.4	12.5	Pink	Buff	Buff		
956	5'	good	24.0	6.3	1.5	2.7	5.4	7.8	9.0	11.7	Pink	Buff	Buff		
957	5'	good	26.0	7.0	0.8	1.6	4.7	7.8	8.6	11.7	Pink	Buff	Buff	5.7	1.3
Jackson County															
1800	3'	good*	18.1	4.7	1.5	3.6	5.0	6.2	8.3	9.7	Buff	Salmon	Tan		
1801	1'-3'	fair*	22.3	5.0	2.7	6.0	6.7	7.7	11.0	11.7	Buff	Salmon	Tan		
1806	3'	good*	14.0	2.5	0.8	3.3	5.0	3.3	5.8	7.5	Buff	Buff	Buff		
Jersey County															
959E	7'	good	26.9	7.0	1.6	3.4	-	8.6	10.4	-	Buff	Buff		3.8	1.3
959F	5½'	good	26.5	7.8	2.4	4.7	4.7	10.2	12.5	12.5	Buff	Buff	Buff	6.8	2.4
959G	2½'	good	23.5	4.0	0.7	8.0	8.5	4.7	12.0	12.5	Buff	Buff	Buff	7.8	1.4
Johnson County															
1807	2½'	poor*	22.8	3.8	1.4	6.4	6.9	5.2	10.2	10.7	Buff	Salmon	Tan		
Madison County															
393	6'	good good but stiff	31.6	8.9	0.5	3.6	4.6	9.4	12.5	13.5	Cream	Cream	Gray	11.5	1.8
960C	1' 3"	stiff	35.0	9.4	1.0	6.2	6.2	10.4	15.6	15.6	Buff	Buff	Buff	10.0	1.4
960D	1' 3"	good	31.6	9.4	1.0	5.2	6.2	10.4	14.6	15.6	Gray	Buff	Buff	9.2	1.7
960E	3'	good	30.8	8.3	1.6	6.3	7.3	9.9	14.6	15.6	Buff	Buff	Buff	10.4	1.7
960F	3'	good but stiff	27.8	7.8	0.5	6.8	7.8	8.3	14.6	15.6	Buff	Buff	Buff	9.5	1.4

## OF CLAY MATERIALS AND THEIR USES

Sample no.	Suggested Uses											Remarks ox = oxidation gd = good drcd = drying conduct diff = difficult				
	China	Drain tile	Fillers	Flower pots	Flue liners	Light weight aggregate	Paper	Pottery	Refractories & ref. cements	Sewer pipe	Stoneware		Structural clay products	Terra cotta	Terra sigillata	Bonding clay
1067B	X			X	X			X	X	X	X					ox, gd; too much water added to clay mix
1067D				X	X			X		X	X					ox, gd; overfired at 2200°F.
994D														X		ox, gd; drcd, warped and cracked.
994C				X				X		X						ox, gd; drcd, fair.
994B	X			X				X			X					ox, gd; drcd, gd; overfired at 2200°F.
1809	X			X				X	X		X					Surface scum at 1832 and 2012°F.
1810	X			X				X			X					Surface scum at 1832 and 2012°F; slightly rough edges during extrusion; overfired at 2200°F.
958F	X			X	X			X	X	X	X	X				ox, gd; drcd gd; weathered clay shows ferrous sulfate scumming.
958H	X			X	X			X	X	X	X	X		X		ox, gd; drcd, gd.
958K	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
958U	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
958W	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
958X	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
958Y	X			X	X			X	X	X	X	X	X			ox, gd; drcd, gd.
958Z	X			X	X			X	X	X	X	X		X		ox, gd; drcd, gd.
958V	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
958BB	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
958VV	X			X	X			X	X	X	X	X	X			ox, gd; drcd, gd.
958FFF	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
955	X			X	X			X	X	X	X	X	X			ox, gd; drcd, gd.
956	X			X	X			X	X	X	X	X	X			ox, gd; drcd, gd.
957	X			X	X			X	X	X	X	X	X			ox, gd; drcd, gd.
1800	X			X	X			X	X	X	X	X	X			Normal
1801	X			X	X			X	X	X	X	X	X			Surface scum at 1832° and 2012; some tearing during extrusion
1806	X			X	X			X	X	X	X	X	X			Some tearing during extrusion
959E	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
959F	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
959G	X			X	X			X	X	X	X	X				ox, gd; drcd, gd.
1807	X			X								X				Surface scum at 2012°; tends to tear during extrusion.
960C	X	X	X	X				X	X	X	X		X	X		ox, gd; drcd, gd. Chemical data in table 4.
960D		X		X				X	X	X	X		X	X		ox, diff; drcd, gd.
960E		X	X	X				X	X	X	X		X	X		ox, diff; drcd, gd.
960F		X		X				X	X	X	X		X	X		ox might be diff; drcd, gd.

Sample no.	Thickness	Extrusion properties and workability	Moisture of plasticity (%)	Linear drying shrinkage (%)	Firing temperatures in degrees Fahrenheit									Bonding properties	
					Linear firing shrinkage (%)			Total linear shrinkage (%)			Fired color			GCS	Opt.**
					1832°	2012°	2200°	1832°	2012°	2200°	1832°	2012°	2200°	(psi)	H <sub>2</sub> O(%)
Monroe County															
1797	5'	good*	22.6	7.2	4.3	5.0	3.0	11.5	12.2	10.2	Red	Red	Brown	6.4	2.0
1798	3' 4"	fair*	17.6	4.5	2.3	6.0	4.1	6.8	10.5	8.6	Red	Red	Red	4.8	1.5
1799	3' 3"	good*	18.6	5.5	1.3	4.7	5.2	6.8	10.2	10.7	Red	Red	Red	4.3	1.7
Pike County															
G17	2'	good	26.7	5.9	1.4	0.9	1.4	7.3	6.8	7.3	Cream	Cream	Buff		
G18	1'	good	29.8	6.3	1.0	4.1	7.2	7.3	10.4	13.5	Cream	Cream	Cream		
G19	2' 6"	good	26.5	5.2	1.6	2.1	5.2	6.8	7.3	10.4	Pink	Pink	Tan		
G20	3' 2"	good	20.8	5.2	2.1	6.3	8.9	7.3	11.5	14.1	Pink	Buff	Tan		
996E	4' 6"	poor	23.0	5.2	0.0	2.1	3.1	5.2	7.3	8.3	Cream	Cream	Cream		
996D	5'	good	57.4	12.5	3.1	7.3	12.5	15.6	19.8	25.0	Cream	Cream	Tan		
996B-C		good	30.0	6.3	+1.1	4.1	7.2	5.2	10.4	13.5	Cream	Cream	Tan		
996N	8'	good	46.0	12.5	2.1	2.1	11.5	14.6	14.6	24.0	White	White	White		
996F	6'	good	29.5	7.3	2.1	5.2	8.3	9.4	12.5	15.6	Cream	Cream	Tan		
St. Clair County															
1719	3'	good*	23.9	8.5	0.1	0.9	1.5	8.6	9.4	10.0	Salmon	Salmon	Salmon	3.8	1.3
Saline County															
1804	5'	fair*	11.4	4.7	1.8	5.0	5.3	6.5	9.7	10.0	Salmon	Red	Tan		
1805	3'	good*	23.0	6.0	5.3	5.6	+12.2	11.3	11.6	+6.2	Salmon	Red	Tan		
1808	3'	good*	18.7	6.0	1.3	3.7	4.2	7.3	9.7	10.2	Buff	Buff	Buff	5.5	1.8
1811	2' 4"	poor*	18.9	3.0	0.6	4.4	6.0	3.6	7.4	9.0	Buff	Tan	Buff		
1812	3'	fair*	14.0	4.5	1.3	2.9	2.3	5.8	7.4	6.8	Cream	Buff	Buff		
1813	6'	good*	18.4	5.0	1.6	2.4	4.1	6.6	7.4	9.1	Cream	Buff	Buff		
1814	3'	good*	14.1	4.0	1.6	2.9	3.5	5.6	6.9	7.5	Pink	Buff	Cream	3.4	1.3
1815	3'	good*	22.0	6.0	3.8	5.7	+0.8	9.8	11.7	5.2	Salmon	Red	Red	6.6	1.3
1816	3' 6"	fair*	20.0	4.5	1.3	5.2	6.5	5.8	9.7	11.0	Salmon	Red	Brown		
1817	2' 8"	good*	20.0	4.0	1.0	5.7	5.1	5.0	9.7	9.1	Salmon	Salmon	Buff		
1821	8'	fair*	17.6	4.0	4.5	7.3	6.0	8.5	11.3	10.0	Red	Red	Brown		
Scott County															
995A	6'	good	35.3	8.3	3.2	6.3	11.5	11.5	14.6	19.8	Buff	Buff	Buff		
995B	8'	good	49.9	12.5	4.2	9.4	11.5	16.7	21.9	24.0	Buff	Buff	Tan		
995H	4' 8"	good	40.2	10.4	2.1	6.3	8.4	12.5	16.7	18.8	Buff	Buff	Buff		
Williamson County															
1802	5'	good*	19.3	4.5	1.9	5.0	5.7	6.4	9.5	10.2	Pink	Buff	Tan	5.1	2.0
1803	3'	fair*	25.0	5.3	4.7	8.3	3.2	10.0	13.6	8.5	Salmon	Red	Red	8.4	1.8
1818	3'	fair*	21.0	5.0	1.3	3.7	4.1	6.3	8.7	9.1	Cream	Buff	Buff		
1819	5' 6"	good*	21.5	5.5	4.3	6.7	5.2	9.8	12.2	10.7	Red	Red	Red	6.7	2.0
1820	4'	fair*	27.8	4.0	1.8	7.4	6.7	5.8	11.4	10.7	Red	Red	Red		

\* Extruded sample

\*\* Optimum water content for maximum strength



## DESCRIPTION OF DEPOSITS SAMPLED

	Thickness (Ft. In.)		Thickness (Ft. In.)
CALHOUN COUNTY			
Sample 1067B - SE $\frac{1}{2}$ SW $\frac{1}{2}$ NE $\frac{1}{2}$ sec. 26, T. 13 S., R. 2 W.		Shale, black, soft, micaceous, poorly bedded, fossiliferous	2 2
Pleistocene Series		Limestone, blue-gray weathering to grayish brown, hard, fine- grained, fossiliferous	3-4
Loess	50±	Shale, black, fissile, hard, with pyrite concretions	18-28
Pennsylvanian System		Shale (Francis Creek), gray, slightly sandy, conchoidal fracture, concretions, pyrite	11 8
Carbondale Formation		Colchester (No. 2) Coal	2 9
Limestone	?		
Shale (Purington) (?)		Spoon Formation	
gray, silty	30±	Clay, dark gray, shaly	5
Shale, black, clayey	1	Clay, blue-gray, hard, shaly	1 2
Colchester (No. 2) Coal	3 6	Clay, gray, very rusty with reddish weathered calcareous concretions near base, sandy	2 3
Spoon Formation		Clay, gray, hard, calcareous concretions, sandy	1 9
Underclay, gray, yellow- stained (sample 1067B)	3	Clay, purplish gray, blocky Wiley (?) Coal	3-4 1½-3
Clay, gray (sample 1067B)	6	Clay, dark purplish gray, soft, blocky	3
Clay, gray, calcareous (Seahorne Limestone zone)	2	Clay, gray, rust brown in fractures, blocky, hard	8-18
Clay, green	2	Limestone (Seahorne), blue- gray, weathering gray, nodu- lar, bedded in clay, pyrite, fossiliferous	2-3
Clay, gray, yellow-stained (exposed)	1	Clay, gray, hard, blocky (sample 994D)	2 1 ½
Sample 1067D - Old clay pit along Mississippi River, center of sec. 1, T. 14 S., R. 2 W.		Coal	
Pleistocene Series		Clay, gray to purplish gray, blocky (sample 994C)	3
Loess	10-15	Clay, gray, hard, blocky (sample 994C)	2
Pennsylvanian System		Covered interval	3-4
Carbondale Formation		Clay, gray, blocky (sample 994C)	1 2
Limestone, gray and tan	5	Clay, dark gray, shaly (coal zone) (sample 994C)	3-6
Covered interval	11	Clay, gray, shaly (sample 994C)	1 1
Clay, mottled red, yellow, and gray	4	Clay, dark gray to black, shaly (coal zone) (sample 994C)	1-2
Shale, mottled, red and green near top and gray below	50	Clay, gray, sandy, blocky	16-34
Coal	4	Sandstone, blue-gray, fine- grained, hard, bedded to massive	14-24
Clay, dark gray, almost sandstone in places	1	Clay, gray, iron-stained on fracture surfaces shaly, sandy	2 6
Shale, black, soft	6	Hermon (?) Coal	3-4
Colchester (No. 2) Coal	2 1	Clay, purplish gray, sandy, blocky (sample 994B)	4
Spoon Formation		Clay, gray rusty on fracture surfaces, sandy, blocky becoming shaly near base (sample 994B)	2 2
Clay, gray with iron stains, noncalcareous, massive (sample 1067D) (exposed)	2		
CASS COUNTY			
Samples 994B, C, and D - Tributary along east bluff to Illinois River NE $\frac{1}{2}$ sec. 15, T. 18 N., R. 11 W.			
Pleistocene Series			
Glacial till and loess	80-100		
Pennsylvanian System			
Carbondale Formation			
Sandstone (Pleasantview), gray, iron-stained on sur- face, shaly at top 15-20 feet, remainder massive, carbonaceous, and coaly at bottom	35		



(CASS COUNTY Cont.)	Thickness (Ft. In.)		Thickness (Ft. In.)
Shale, gray, thinly bedded	1	Pennsylvanian System	
Limestone (Seville), dark blue-gray, pyritic	1-2	Carbondale Formation	
Shale, dark blue-gray, well bedded, sandy, contains concretions	1 6	Shale, gray	10±
		Shale, black, fissile	1 6
		Colchester (No. 2) Coal	2
GALLATIN COUNTY			
Sample 1809 - Outcrop south side of road in NE¼ NW¼ NE¼ sec. 19, T. 10 S., R. 8 E.		Spoon Formation	
Pleistocene Series		Covered interval	2
Soil	10±	Clay, gray (sample 958H)	4
Pennsylvanian System		Limestone, blue-gray (in creek bed)	
Carbondale Formation		Sample 958K - N line of NE¼ SW¼ NW¼ sec. 28, T. 12 N., R. 11 W.	
Rocks undifferentiated	10-30	Pleistocene Series	
Colchester (No. 2) Coal	4	Alluvium	2-3
Spoon Formation		Pennsylvanian System	
Underclay, gray, (sample 1809)	5	Spoon Formation	
Shale		Limestone (Seahorne), blue-gray	1 6
		Clay, gray (sample 958K) (exposed)	1
Sample 1810 - SE¼ NE¼ NE¼ sec. 19, T. 10 S., R. 8 E.		Sample 958U - Abandoned underground mine south of road in center NE¼ NW¼ NW¼ sec. 31, T. 12 N., R. 11 W.	
Pleistocene Series		Pleistocene Series	
Soil	10±	Till reported by owner	45
Pennsylvanian System		Pennsylvanian System	
Carbondale and Spoon Formations		Spoon Formation	
Rocks undifferentiated	50-70	Clay, gray (sample 958U)	6
Dekoven Coal	2 6	Samples 958W, X, Y - South cutbank of creek, NW¼ NW¼ NW¼ sec. 12, T. 10 N., R. 12 W.	
Underclay, gray	2	Pleistocene Series	
Shale, dark gray, micaceous	2	Drift	15
GREENE COUNTY			
Sample 958 F - South cutbank of Birch Creek, NE¼ NW¼ NW¼ sec. 25, T. 12 N., R. 11 W.		Pennsylvanian System	
Pennsylvanian System		Carbondale Formation	
Carbondale Formation		Shale, blue-gray	5 2
Sandstone (Pleasantview), upper part shaly, lower part massive and cross bedded	16-18	Colchester (No. 2) Coal	1
Pyrite zone	0-½	Spoon Formation	
Shale, blue-gray, thin-bedded, noncalcareous	6-30	Clay, gray, sample 958W top 3½ feet; 958X middle 5 feet; 958Y bottom 5 feet)	13 6
Shale, black, soft, noncalcareous	3	Mississippian System	
Shale, black, hard, fissile	1 5	Shale, red	6
Colchester (No. 2) Coal	2 8	Shale, blue	9
Spoon Formation		Sandstone	4
Clay, dark gray, noncalcareous	½-1	Shale, gray (exposed)	5½
Clay, gray, noncalcareous (Sample 958F) (exposed)	1	Sample 958Z - South of center NW¼ sec. 12, T. 10 N., R. 12 W.	
Sample 958H - NW cor. SW¼ SW¼ sec. 28, T. 12 N., R. 11 W.		Pleistocene Series	
Pleistocene Series		Drift	10±
Drift	5±	Pennsylvanian System	
		Carbondale Formation	
		Shale, gray	11
		Colchester (No. 2) Coal	1 9
		Spoon Formation	
		Clay, gray (sample 958Z) (exposed)	6



(JERSEY COUNTY Cont.)	Thickness (Ft. In.)		Thickness (Ft. In.)
Pennsylvanian System			
Spoon Formation		Limestone (Seahorne), blue-gray	1½-5
Clay, yellowish gray (sample 959E) (exposed)	7	Clay, gray, iron-stained (sample 960E)	2 6
Sample 959F - Exposed in road and west side of ditch, NE¼ NE¼ NW¼ sec. 20, T. 7 N., R. 10 W.		Clay, dark gray, equivalent to coal member (sample 960E)	6
Pleistocene Series	30-40	Clay, gray, iron-stained, (sample 960F) (exposed)	3
Pennsylvanian System			
MONROE COUNTY			
Spoon Formation		Sample 1797 - 200 yards from road up Andys Run at waterfall near junction of tributaries, SW¼ NE¼ NW¼ sec. 15, T. 2 S., R. 10 W.	
Clay, gray, iron-stained (sample 959F) (exposed)	5 6	Mississippian (?) System	
Sample 959G - In west ravine south of house, SE¼ NE¼ NW¼ sec. 20, T. 7 N., R. 10 W.		Sandstone, forms waterfall	5±
Pleistocene Series	30±	Clay, gray, green, maroon (sample 1797)	5±
Pennsylvanian System			
Spoon Formation		Sandstone (covered)	
Clay, light gray, red and yellow stained, sandy (sample 959G) (exposed)	2 6	Samples 1798 and 1799 - South side of road, NW¼ NE¼ SW¼ sec. 26, T. 2 S., R. 10 W.	
JOHNSON COUNTY			
Sample 1807 - Stream in NW¼ SE¼ NE¼ sec. 8, T. 11 S., R. 4 E.		Pleistocene Series	
Pleistocene Series		Loess	6
Alluvium	10	Mississippian (?) System	
Pennsylvanian System			
Spoon Formation		Sandstone	8
Sandstone	2	Clay, purple and tan, shaly toward top (sample 1798)	3 4
Bidwell Coal	0-½	Sandstone	6
Clay, shaly (sample 1807)	2 6	Clay, purple and tan (sample 1799)	3 3
MADISON COUNTY			
Sample 393 - Underground mine, SE¼ SE¼ sec. 35, T. 6 N., R. 10 W.		PIKE COUNTY	
Pennsylvanian System			
Spoon Formation		Samples G17, G18, G19, and G20 - Outbank south of tributary to branch of Kiser Creek, SE¼ SE¼ SW¼ sec. 25, T. 4 S., R. 5 W.	
Seahorne Limestone	3±	Pleistocene Series	
Clay, gray, silty (sample 393)	4	Soil	2
Clay (floor of mine)		Pennsylvanian System	
Samples 960C, D, E, and F - South cutbank of East Wood River, NE¼ NW¼ NW¼, sec. 15, T. 5 N., R. 9 W.		Spoon Formation	
Pleistocene Series		Clay, gray (sample G20)	3 2
Drift	20±	Clay, dark gray, with 2-inch shaly zone near top	1
Pennsylvanian System			
Carbondale Formation		Clay, gray, iron-stained, hard and gritty (sample G19)	2½
Shale (Purington), gray, well bedded	20	Clay, purplish gray, hard, gritty (sample G18)	1
Shale, black, fissile	1	Clay, light gray with yellow sandy masses throughout (sample G17)	2
Colchester (No. 2) Coal	2 6	Covered interval	1 3
Pleistocene Series			
Spoon Formation		Sandstone, yellowish gray, clayey	8
Clay, gray, iron-stained, (sample 960C)	1 3	Shale, sandy (exposed)	5
Clay, gray, (sample 960D)	1 3	Samples 996B-C, D, and E - Outcrop in east bank of creek south of road, NW¼ NW¼ sec. 26, T. 4 S., R. 5 W.	
Clay, gray, iron-stained	6	Pleistocene Series	
		Loess	6-12

(PIKE COUNTY Cont.)	Thickness (Ft. In.)	Thickness (Ft. In.)	
Pennsylvanian System		Sample 1805 - Old coal strip pit on north side of road, SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 23, T. 9 S., R. 7 E.	
Spoon or Abbott Formation		Pennsylvanian System	
Sandstone, gray	1	Spoon Formation	
Clay, gray, very sandy (sample 996E)	4 6	Sandstone and shale	50±
Clay, dark gray (sample 996D)	5	Shale, black, ironstone concretions	2
Sandstone layer	9	DeKoven Coal	4
Shale, gray, hard, flinty (samples 996B-C)	4	Clay, gray, shaly (sample 1805)	3
Sample 996N - Outcrop in ditch along north-south road, NW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 10, T. 4 S., R. 5W.		Shale	10
Pleistocene Series		Sandstone	3
Soil	2	Sample 1808 - Outcrop along north side of east-west road, NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 25, T. 10 S., R. 7 E.	
Pennsylvanian System		Pleistocene Series	
Spoon or Abbott Formation		Loess and till	15
Clay, gray, sandy near base (sample 996N)	8	Pennsylvanian System	
Mississippian System		Spoon Formation	
Limestone	20	Sandstone, thinly bedded	2
Sample 996F - Outcrop west side of roadcut, NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 4, T. 4 S., R. 5 W.		Shale, sandy	5
Pleistocene Series		Sandstone	2
Loess	20±	Shale, sandy	1
Pennsylvanian System		Coal	4
Spoon or Abbott Formation		Clay, gray, greenish toward base, shaly (sample 1808) (exposed)	3 6
Clay, gray (sample 996F) (exposed)	6	Samples 1811 and 1812 - High wall of coal strip pit, center of sec. 4, T. 10 S., R. 7 E.	
Sample 1719 - Outcrop in east bank of Prairie du Pont Creek 150 yards southwest of bridge, SW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 34, T. 1 N., R. 9 W.		Pennsylvanian System	
Pennsylvanian System		Spoon Formation	
Carbondale Formation		Palzo Sandstone	15
Shale, red to purple	5-10	Shale	30
Sandstone, gray, thinly bedded, micaceous with thin silty layers	15	DeKoven Coal	3
Shale, black	1 5	Clay, gray, micaceous (sample 1811)	2 4
Colchester (No. 2) Coal	2	Siltstone, sandy	12
Spoon Formation		Shale, black	3
Clay, gray (sample 1719)	3	Davis Coal	4 5
Siltstone, light gray	2-3	Clay, gray (sample 1812) (exposed)	6
Sandstone at creek level		Sample 1813 - High wall of coal strip pit, SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 5, T. 10 S., R. 7 E.	
SALINE COUNTY		Pennsylvanian System	
Sample 1804 - High wall of coal strip pit, NW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 26, T. 10 S., R. 7 E.		Carbondale Formation	
Pennsylvanian System		Sandstone and shale	15
Carbondale Formation		Shale, coaly	6
Sandstone	20±	Shale, dark gray	5
Shale, gray	20±	Colchester (No. 2) Coal	4
Shale, black	1 6	Spoon Formation	
Colchester (No. 2) Coal	7	Clay, gray, root traces (sample 1813)	6
Spoon Formation		Palzo Sandstone	15
Clay, gray (sample 1804)	5	Sample 1814 - Outcrop east of Battle Ford Creek, NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 21, T. 10 S., R. 6 E.	
Shale, gray	20-30	Pennsylvanian System	
DeKoven Coal	2½-3	Spoon Formation	
Clay, gray, micaceous (exposed)	1		

(SALINE COUNTY Cont.)		Thickness (Ft. In.)		Thickness (Ft. In.)
Sandstone and shale		15	Spoon Formation	
Mt. Rorah Coal		1 5	Clay	2-3
Clay, gray, slightly shaly (sample 1814)		3	Seahorne Limestone	1-3
Sandstone			Covered interval	2
Sample 1815 - Outcrop west of Battle Ford Creek, NW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20, T. 10 S., R. 6 E.			Clay (sample 995A) (exposed)	6
Pennsylvanian System			Sample 995B - Along stream east of road in NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 14, T. 13 N., R. 12 W.	
Spoon Formation			Pleistocene Series	
Sandstone, shaly at base		20	Drift	not measured
Shale, black, highly organic		2	Pennsylvanian System	
Shale, brown		1	Carbondale Formation	
Clay, shaly (sample 1815) (exposed)		3	Pleasantview Sandstone	50
Sample 1816 - Abandoned coal strip pit, SW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 21, T. 10 S., R. 5 E.			Shale, dark gray to black, soft	1
Pleistocene Series			Shale, black, fissile	2 6
Loess		10	Covered interval	5
Pennsylvanian System			Spoon Formation	
Carbondale Formation			Limestone (Seahorne), blue- gray, knobby	4
Shale, black		5	Clay, gray, red-stained (sample 995B)	6
Colchester (No. 2) Coal		9	Clay, gray (sample 995B) (exposed)	2
Spoon Formation			Sample 995H - High cutbank east side of ravine in SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 23, T. 15 N., R. 13 W.	
Shale, dark gray to black		1 6	Pleistocene Series	
Clay, gray, greenish toward base (sample 1816)		3 6	Loess and till	10-15
Shale			Pennsylvanian System	
Sample 1817 - Old coal strip pit SW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 21, T. 10 S., R. 5 E.			Spoon Formation	
Pennsylvanian System			Limestone (Seahorne), gray, knobby	4
Spoon Formation			Clay, gray, rusty (sample 995H)	5
Rocks, undifferentiated		25	Clay, dark gray, coal horizon, gypsum	1
Shale, black		3	Clay, gray, purplish at top	6 6
DeKoven Coal		3	Shale, dark gray, sandy, poorly bedded, iron sulphate	2 3
Clay, gray (sample 1817)		2 8	Abbott Formation	
Sandstone (exposed)		4	Sandstone, bluish gray, fairly coarse-grained, shaly, plant impressions	0-10
Sample 1821 - Along roadcut on section line in NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 23, T. 10 S., R. 5 E.			WILLIAMSON COUNTY	
Pennsylvanian System			Sample 1802 - Near top of east end of old quarry east of Creal Springs, SW $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 25, T. 10 S., R. 3 E.	
Spoon Formation			Pennsylvanian System	
Sandstone		15	Spoon Formation	
Shale, black		2	Sandstone	3
Clay (sample 1821)		8	Shale, gray	10
Coal		2	Mt. Rorah Coal	
Clay (covered)			Coal	1 4
SCOTT COUNTY			Clay, shaly	9
Sample 995A - Along ravine in E $\frac{1}{2}$ NE $\frac{1}{4}$ sec. 14, T. 13 N., R. 12 W.			Coal	5
Pennsylvanian System				
Carbondale Formation				
Pleasantview Sandstone		5		
Shale, black, soft, ferrous sulphate stained		1 2		
Shale, black, fissile		2 9		
Colchester (No. 2) Coal		2 7		

(WILLIAMSON COUNTY Cont.) Thickness  
(Ft. In.)

Clay (sample 1802)	5
Siltstone	1
Shale, gray	5
Creal Springs Limestone	1 6
Shale, gray	5
Granger Sandstone	40

Sample 1803 - East side of road south of Palzo,  
NW $\frac{1}{4}$  SW $\frac{1}{4}$  NW $\frac{1}{2}$  sec. 22, T. 10 S., R. 4 E.

Pennsylvanian System

Spoon Formation	
Palzo Sandstone	6
Shale, black	2
Clay, shaly	6
Clay, gray, pale green toward base (sample 1803)	3
Clay, limonite	4
Shale	5

Samples 1818, 1819, and 1820 - West side of road  
at the NW edge of Stonefort, SW $\frac{1}{4}$  NE $\frac{1}{4}$  SE $\frac{1}{4}$   
sec. 25, T. 10 S., R. 4 E.

Pennsylvanian System

Spoon Formation	
Sandstone and covered intervals	40
Shale, black	4-5
Clay (sample 1820)	4
Coal	2
Clay, gray to pale green at base (sample 1819)	5 6
Shale, black	1-1 $\frac{1}{2}$
Shale, sandy	7 6
Shale	3
Clay, greenish gray (sample 1818)	3
Shale	

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