STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

SULFUR REDUCTION OF ILLINOIS COALS– WASHABILITY STUDIES. PART 2.

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ILLINOIS STATE GEOLOGICAL SURVEY
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CIRCULAR 484
1974

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ABSTRACT

Washability (float-sink) tests, which are part of a continuing study of the physical and chemical properties of Illinois coals, were run on 28 coal samples from 22 Illinois coal mines. Primary attention was given to potential reduction of sulfur in the coals. In only a few of the coals tested was the sulfur content reduced to less than 1.5 percent, and in a few of the coals the lowest percentage of sulfur obtained with a reasonable recovery was greater than 3.5 percent. The maximum and average reductions in sulfur were 65 percent and 38 percent, respectively, with 80 percent recovery.

Washability tests were made on both 10-pound and 100-pound representative splits from 23 samples. The results from these tests with the two quantities exhibited a close correlation. A fairly good correlation is shown between data from cores 2 inches in diameter and data from column samples obtained from nearby locations in the mines.

INTRODUCTION

Ever since it was organized, more than 65 years ago, the Illinois State Geological Survey has been making investigations concerning sulfur in coal. The investigation described in this report is the second in a recent series on the washability (float-sink) characteristics of Illinois coals. The first report, published in 1971 as Illinois State Geological Survey Circular 462 (Helfinstine et al., 1971), gives the results of tests and analyses made on 37 samples from 32 mines. The present report provides the results of tests and analyses of 28 additional samples from 22 mines.

Acknowledgments

The U.S. Public Health Service, Department of Health, Education and Welfare, through Contract No. PH 86-67-206, provided substantial support for this study.

We wish to thank the coal companies for their assistance to Survey personnel when samples were obtained and for their permission to identify the sources of the samples.

OBJECTIVES OF INVESTIGATION

The basic objective of this series of investigations was to determine the washability (float-sink) characteristics of Illinois coals, with particular emphasis on the quantity, distribution, and varieties (forms) of sulfur in the coals. An additional objective of Part 2 was to evaluate the suitability of 2-inch diameter diamond-drill cores of coal as sources of samples for determining washability characteristics of coals obtained during exploratory drilling in areas where mines are not operating.

PROCEDURE AND EQUIPMENT

Part 1 of this study indicated that the washability characteristics of Illinois coals crushed to a maximum size of 1 1/2 inches usually did not vary significantly from the washability characteristics of the same coals when crushed to a maximum size of 3/8 inch. Because the results with the two size ranges were similar and since the 3/8-inch maximum size would allow the use of a smaller quantity of coal for the washability tests, a 3/8-inch maximum size was used for all tests described in this report. The minimum size of 28 mesh (Tyler screen series) was selected because (1) it was considered the finest size of Illinois coal that could be readily separated by gravity methods, and (2) only a small proportion of the coal would be finer than 28 mesh after crushing and screening in stages to the maximum size of 3/8 inch.

During Part 1 of the investigation, a 1-ton sample of raw coal, which generally was sampled in 20 to 30 increments through most of one shift of operation, was obtained from the tipple; a few samples were obtained from the pit. None of the samples was considered representative of a mine's output. A different method of sampling was used for the study described in this report. Instead of obtaining a 1-ton sample, an approximately 80-pound sample, which will be referred to subsequently as a column sample, was cut from each of three freshly exposed coal faces at separate working areas of a mine. This procedure provided a total sample of about 240 pounds per mine. Although these samples may not be representative of the output of the mine either, they are considered to be superior to those obtained by the tipple- or pit-sampling procedure used in Part 1 of this study. Face-channel samples, from which mineral bands of more than 3/8 inch in thickness were excluded in accordance with U.S. Bureau of Mines procedures (Holmes, 1911), also were cut from the same general locations.

The column samples were stage-crushed to a maximum size of 3/8 inch with a roll crusher and screened at 28 mesh to give 3/8-inch by 28-mesh and 28-mesh by 0 fractions. Chemical analyses, including total sulfur and varieties of sulfur, proximate analysis, free-swelling index, Gieseler plasticity, and heating value, were made on representative samples of these two size fractions.

Gravity separations were made with approximately 100 pounds of 3/8-inch by 28-mesh coal. These separations were made in vessels containing mixtures of perchloroethylene and naphtha in the ratios appropriate to give the desired specific gravities. The separations were made progressively, i.e., the sink fraction of coal from a bath with a lower specific gravity was placed progressively in baths of higher specific gravity until the desired maximum specific gravity of 1.60 was reached. Five different gravity solutions were used for most coal samples. Chemical analyses, which included total sulfur, sulfate sulfur, pyritic sulfur, organic sulfur, and ash, were made on all float-coal fractions and on the material that sank at a specific gravity of 1.60. For most samples, the free-swelling index, Gieseler plasticity, and heating value were determined on the float coal of the lightest gravity. The Hardgrove grindabilities and ash fusion temperatures were determined for the 1.60 sink material by a commercial laboratory.

The procedure for determining the suitability of coal cores as samples for washability studies is to make comparable tests on a core sample and on a column sample obtained from a location adjacent to the core sample. However, only three sets of core and column samples were obtained as desired for this comparative study. In these three sets, the coal core sample was obtained from a location that was less than 100 feet from the corresponding column sample.

To gain additional information about the suitability of small samples, such as coal cores, washability tests were made on 10-pound samples that had been riffled from the large samples of coal used for basic washability tests. A 10-pound sample is about the quantity of coal obtained from a 2-inch diameter core of a 6-foot coal seam. Only four different gravity solutions were used for the float-sink tests of the core samples and 10-pound samples because of the small quantity utilized.

The tests and chemical analyses made on the face-channel samples of coal included proximate analysis, ultimate analysis, free-swelling index, Gieseler plasticity, heating value, varieties of sulfur, chlorine, Hardgrove grindability, and ash fusion temperatures. All but two of these tests and analyses were made by the Analytical Chemistry Section of the Illinois State Geological Survey; the grindability and ash fusion tests were made by a commercial laboratory.

Sources of Samples

Twenty-eight samples from 22 mines were obtained for the part of the investigation described in this report (fig. 1). Table 1 identifies the sources of samples by county, company, mine, and seam.

Sample 23 was cut from a coal face that had been exposed for an appreciable period and might have been oxidized; hence, sample 24 was cut at a later date from a freshly exposed coal face in the same mine. Column samples 1, 14, and 15 were obtained for comparisons with coal core samples that had been

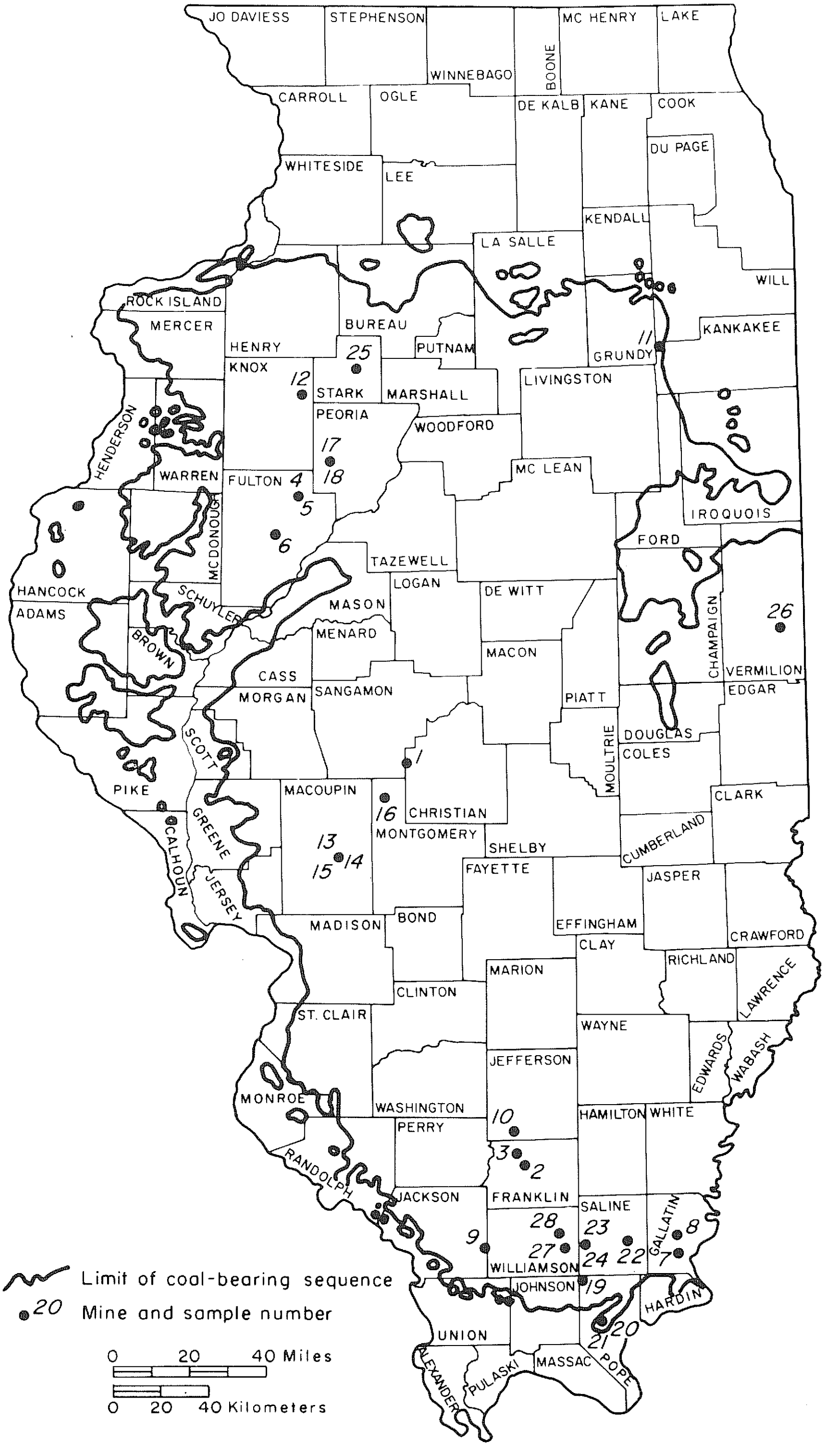

Fig. 1 - Locations of coal samples. See table 1 for mine name and coal sampled.

TABLE 1 - SOURCES OF SAMPLES

Sample no.	County	Company	Mine	Seam
1	Christian	Peabody Coal Co.	No. 10	6
2	Franklin	Old Ben Coal Co.	No. 24	6
3	Franklin	Old Ben Coal Co.	No. 26	6
4	Fulton	Consolidation Coal Co.	Norris[a]	6
5	Fulton	Consolidation Coal Co.	Norris[a]	5
6	Fulton	United Electric Coal Cos.	No. 9[a]	5
7	Gallatin	Peabody Coal Co.	Eagle Strip[a]	6
8	Gallatin	Peabody Coal Co.	Eagle No. 2	5
9	Jackson	Tab Mining Co.	No. 2[a]	Murphysboro
10	Jefferson	Inland Steel Co.	Inland	6
11	Kankakee[b]	Peabody Coal Co.	Northern[a]	4
12	Knox	Midland Coal Co.	Mecco[a]	6
13	Macoupin	Monterey Coal Co.	No. 1	6
14	Macoupin	Monterey Coal Co.	No. 1	6
15	Macoupin	Monterey Coal Co.	No. 1	6
16	Montgomery	Freeman Coal Mining Co.	Crown	6
17	Peoria[c]	Midland Coal Co.	Elm[a]	5
18	Peoria	Midland Coal Co.	Elm[a]	6
19	Pope	E and L Coal Co.	[a]	1
20	Pope	Mt. Zion Coal Co.	Mt. Zion[a]	[d]
21	Pope	Mt. Zion Coal Co.	Mt. Zion[a]	[d]
22	Saline	Big Ridge Coal Co.	No. 1[a]	6
23	Saline	Sahara Coal Co., Inc.	No. 6[a]	6
24	Saline	Sahara Coal Co., Inc.	No. 6[a]	6
25	Stark	Midland Coal Co.	Allendale[a]	6
26	Vermilion	Deep Valley Coal Co.		7
27	Williamson	Amax Coal Co.	Delta[a]	6
28	Williamson	Barbara Kay Coal Co., Inc.	Barbara Kay	5

[a] Strip mine.
[b] Coal mined in Grundy County.
[c] Coal mined in Fulton County.
[d] Coal in lower part of Abbott Formation.

drilled nearby, but no comparative channel samples were obtained for these three samples. Although column samples were obtained from the Mt. Zion mine at two different times (samples 20 and 21), a comparative channel sample was obtained only for sample 20.

Use of Computer

Most of the data obtained from this study were punched on cards, and an IBM 360/75 computer was used for the compilation of most of the tables and the appendix. In addition, a computer program was developed to provide a second-degree equation that would "fit" the datum points obtained in the float-sink tests.

The computer then used this equation to determine the percentages of total sulfur, pyritic sulfur, and ash for any desired percentage of coal recovery.

RESULTS

Size Analyses

All of the float-sink tests were made on 3/8-inch by 28-mesh coal. The amount of minus-28-mesh coal that was screened from the 3/8-inch by 0 coal for the preparation of this 3/8-inch by 28-mesh fraction varied from 6 percent from sample 17 to 13 percent from sample 19, with an average of 8 percent.

Channel-Sample Analyses

The chemical analyses for the channel samples are given in table 2. As previously stated, mineral bands that were more than 3/8 inch in thickness were excluded from the channel samples. The channel samples are considered to be similar to coals from the same mine that have received a minimal amount of preparation. At a few mines there were no mineral bands greater than 3/8 inch in thickness; hence the column and channel samples were taken in the same manner.

Washability Data

The complete data from the float-sink tests on the samples are given in the appendix. The data labeled "calc. (calculated) raw coal" are the data from the washability tests as calculated by proportionally combining the individual float-sink fractions to give values that should be equivalent to the values given in the original raw coal analysis. The analyses of representative fractions of the raw coal sample are labeled "anal. (analyzed) raw coal" and appear directly below the calculated raw coal figures for convenient comparison. In most cases the agreement is excellent.

The letter S after a sample number refers to a 10-pound sample that was split from the crushed column samples. The letter C indicates a 2-inch diameter diamond-drill core sample. All analyses given in the appendix are reported on a dry basis.

Sulfur Removal Potential

A major objective of this investigation was to determine the sulfur content to which Illinois coals can be reduced by gravity separations. Table 3 was prepared to provide this information for the 28 samples included in this report. Listed are the percentages of total sulfur, pyritic sulfur, and ash, at 80, 60, and 40 percent recoveries, as calculated by the IBM 360/75 computer, with the samples arranged in ascending order of total sulfur percentage. There are four samples (10, 19, 20, and 21) that had less than 1 percent total sulfur at all recovery levels shown. Of these four, only sample 10 was obtained from a mine

TABLE 2 — CHEMICAL ANALYSES OF CHANNEL SAMPLES*

Sample no.	Moist.† (%)	V.M.† (%)	F.C.† (%)	Ash (%)	H† (%)	C† (%)	N† (%)	O† (%)	Sulfur Sl.† (%)	Sulfur Pyr.† (%)	Sulfur Org.† (%)	Sulfur Total (%)	Chlorine Total (%)	Chlorine W.S.† (%)	Heating value (Btu/lb.)	Gieseler plasticity†	Free-swelling index
1	14.4	43.3	44.6	12.1	4.98	69.49	1.27	7.91	0.03	1.66	2.56	4.25	0.13	0.09	12465	27	4.0
2	8.3	38.3	51.4	10.3	5.08	72.06	1.56	8.61	0.01	1.21	1.15	2.37	0.40	0.10	12980	34	5.5
3	9.0	39.0	50.2	10.9	4.77	72.25	1.38	8.43	0.01	1.28	1.01	2.30	0.41	0.14	12889	10	5.5
4	18.2	41.4	49.1	9.5	4.97	71.79	1.11	9.43	0.04	1.22	1.94	3.20	0.01	0.01	12810	3	3.0
5	15.8	43.3	44.3	12.4	4.88	68.99	1.14	7.94	0.05	2.33	2.14	4.52	0.01	0.01	12480	25	
6	16.0	43.3	43.8	12.9	4.91	69.53	1.10	8.02	0.05	1.54	1.96	3.55	0.02	0.02	12455	150	4.5
7	3.2	37.7	50.3	12.0	4.83	71.96	1.35	6.44	0.04	1.87	1.60	3.51	0.18	0.0	13140	28500	8.0
8	5.9	39.5	48.7	11.8	5.03	71.57	1.48	6.00	0.02	2.62	1.51	4.14	0.26	0.04	12947	1100	6.5
9	5.3	37.0	51.8	11.2	4.91	71.21	1.35	6.43	0.05	3.78	1.07	4.90	0.09	0.0	12990	220	6.0
10	10.2	36.8	54.3	8.9	4.90	75.13	1.52	8.77	0.0	0.29	0.56	0.85	0.34	0.23	13290	6	
11	12.5	45.8	44.2	10.0	5.22	70.61	1.18	9.18	0.03	1.67	2.10	3.80	0.04	0.01	12920	300	4.0
12	17.0	43.0	45.1	11.9	5.07	68.71	1.11	10.02	0.04	1.20	1.91	3.15	0.04	0.02	12380	2	4.0
13	13.3	43.6	44.4	11.9	4.90	68.04	1.36	8.52	0.18	1.95	3.09	5.22	0.10	0.09	12254	14	4.5
16	13.7	41.2	44.7	14.1	4.59	66.25	1.23	9.01	0.10	2.27	2.46	4.84	0.17	0.08	12050	4	4.5
17	13.9	42.8	42.6	14.7	5.04	68.33	1.20	8.02	0.02	0.92	1.81	2.75	0.02	0.0	12301	8	5.0
18	13.0	39.4	48.6	12.0	4.58	69.97	1.25	8.95	0.33	0.97	1.95	3.25	0.02	0.0	12400	2	2.5
19	9.1	35.0	56.7	8.2	4.93	75.43	1.50	8.67	0.10	0.76	0.37	1.23	0.11	0.01	13280	3	1.0
20	6.7	32.0	61.0	7.1	4.81	77.72	1.43	7.32	0.03	1.10	0.54	1.66	0.12	0.02	13794	120	7.0
22	7.3	39.2	47.7	13.2	4.89	69.47	1.29	6.77	0.02	2.81	1.57	4.40	0.13	0.01	12627	2000	7.5
23	7.3	38.0	49.6	12.4	4.54	69.49	1.27	8.96	0.08	1.79	1.44	3.31	0.10	0.01	12470	317	6.0
24	6.8	38.3	50.3	11.4	4.88	70.95	1.27	8.14	0.02	2.07	1.26	3.35	0.05	0.02	12869	290	6.5
25	15.8	42.0	43.5	14.5	4.63	67.70	1.04	8.51	0.05	1.81	1.82	3.68	0.0	0.0	12109	21	2.5
26	12.8	46.4	42.5	11.1	5.06	71.06	1.33	7.70	0.02	1.97	1.78	3.77	0.19	0.08	12850	1950	5.5
27	6.4	39.3	47.4	13.3	4.79	69.59	1.36	7.46	0.02	2.11	1.38	3.50	0.14	0.02	12562	240	6.5
28	7.6	37.0	50.8	12.2	4.66	71.23	1.42	7.36	0.04	2.30	0.83	3.17	0.32	0.01	12728	31	6.5

* Values (except moisture) are given on a dry basis.

† Moist. - moisture; V.M. - volatile matter; F.C. - fixed carbon; H - hydrogen; C - carbon; N - nitrogen; O - oxygen; Sl. - sulfate; Pyr. - pyritic; Org. - organic; W.S. - water soluble; Gieseler plasticity - maximum fluidity, dial divisions per minute.

TABLE 3 — PERCENTAGES OF TOTAL SULFUR, PYRITIC SULFUR, AND ASH WITH 40, 60, AND 80 PERCENT RECOVERIES*

40 percent recovery				60 percent recovery				80 percent recovery			
Sample no.	Sulfur (%) Total	Sulfur (%) Pyritic	Ash (%)	Sample no.	Sulfur (%) Total	Sulfur (%) Pyritic	Ash (%)	Sample no.	Sulfur (%) Total	Sulfur (%) Pyritic	Ash (%)
19	0.53	0.02	3.0	19	0.53	0.02	3.6	19	0.57	0.07	4.6
21	0.71	0.15	3.5	21	0.71	0.17	4.1	21	0.72	0.19	4.7
20	0.81	0.17	3.4	10	0.80	0.23	3.7	10	0.79	0.22	5.1
10	0.84	0.26	3.2	20	0.85	0.22	4.3	20	0.93	0.31	5.5
3	1.37	0.41	3.1	3	1.41	0.43	3.9	3	1.48	0.50	5.5
2	1.62	0.36	2.9	2	1.74	0.48	4.1	2	1.91	0.65	6.0
28	1.76	0.72	4.5	28	1.86	0.84	5.5	28	2.07	1.08	6.9
9	1.85	0.75	3.6	27	2.04	0.63	3.8	24	2.21	0.73	6.0
27	1.92	0.45	2.1	24	2.06	0.55	4.1	17	2.26	0.42	8.6
24	1.99	0.44	3.0	23	2.16	0.51	4.2	23	2.32	0.72	6.6
23	2.06	0.39	2.9	17	2.23	0.36	7.0	27	2.35	0.95	6.6
8	2.07	0.45	4.5	8	2.24	0.67	5.9	8	2.59	1.04	7.6
7	2.15	0.44	3.5	9	2.24	1.10	5.0	7	2.66	1.06	7.2
17	2.21	0.32	6.0	7	2.32	0.65	4.9	12	2.67	0.71	4.9
4	2.39	0.49	2.8	12	2.49	0.52	3.2	18	2.80	0.87	5.5
12	2.40	0.43	2.3	4	2.55	0.66	3.8	9	2.84	1.67	6.9
25	2.46	0.48	2.2	18	2.57	0.58	3.4	25	2.84	0.88	4.8
18	2.46	0.42	2.4	25	2.58	0.60	3.1	4	2.90	1.01	6.1
26	2.49	0.71	3.0	26	2.68	0.87	4.3	26	2.93	1.13	6.6
22	2.56	0.51	3.1	22	2.71	0.69	4.5	6	2.93	0.66	6.8
6	2.59	0.33	2.9	6	2.75	0.48	4.4	22	2.95	1.02	6.8
11	2.77	0.56	3.5	11	2.88	0.67	4.3	11	3.08	0.85	5.7
5	2.81	0.55	6.1	5	2.91	0.65	6.5	5	3.22	0.96	7.5
1	3.18	0.49	4.1	1	3.16	0.53	4.7	1	3.36	0.79	6.3
16	3.21	0.44	4.2	16	3.32	0.56	5.4	16	3.51	0.81	7.3
14	3.58	0.37	3.3	14	3.58	0.50	4.4	14	3.80	0.82	6.3
15	3.79	0.28	3.0	15	3.80	0.38	4.2	15	3.88	0.58	6.0
13	3.83	0.38	3.7	13	3.85	0.54	4.9	13	4.07	0.90	6.8

* Chemical analyses are given on a dry basis.

in current production and with appreciable unmined reserves. Samples 20 and 21 were obtained from one small strip mine (currently abandoned) at different times and locations within the mine. Sample 19 was from a small strip mine which also has been abandoned.

One measure of the efficiency of coal cleaning is the amount of combustible material discarded in the reject. Table 4 lists the percentages of combustible losses for the 28 coals included in this report for 40, 60, and 80 percent recoveries (60, 40, and 20 percent rejects). The losses shown range

TABLE 4 — PERCENTAGES OF ASH, SULFUR, AND COMBUSTIBLE MATERIAL IN SINK*

Sample no.	40 percent recovery				60 percent recovery				80 percent recovery			
	Ash (%)	Comb. loss (%)	Sulfur (%)	Mod.-comb. loss† (%)	Ash (%)	Comb. loss (%)	Sulfur (%)	Mod.-comb. loss† (%)	Ash (%)	Comb. loss (%)	Sulfur (%)	Mod.-comb. loss† (%)
1	18.1	49.1	7.1	44.9	24.1	30.4	9.1	26.7	37.0	12.6	14.1	9.8
2	16.9	49.9	4.0	47.5	22.1	31.2	5.0	29.2	32.4	13.5	7.7	12.0
3	15.1	50.9	2.4	49.5	20.0	32.0	2.8	30.9	29.5	14.1	4.0	13.3
4	31.9	40.9	5.8	37.4	44.9	22.0	7.2	19.1	76.9	4.6	10.6	2.5
5	14.9	51.1	5.5	47.8	18.6	32.5	6.6	29.9	26.7	14.7	9.2	12.8
6	31.0	41.4	4.6	38.6	42.8	22.9	5.4	20.7	71.7	5.7	7.4	4.2
7	31.8	40.9	8.1	36.1	43.8	22.5	10.8	18.2	73.5	5.3	17.8	1.7
8	15.5	50.7	4.9	47.7	18.8	32.5	6.1	30.0	24.9	15.0	8.6	13.3
9	16.9	49.9	7.4	45.5	21.5	31.4	9.6	27.6	30.2	14.0	14.5	11.1
10	14.2	51.5	0.9	50.9	19.0	32.4	1.0	32.0	28.6	14.3	1.3	14.0
11	14.0	51.6	5.1	48.6	17.9	32.8	6.1	30.4	25.9	14.8	8.5	13.1
12	26.0	44.4	4.5	41.8	36.5	25.4	5.3	23.3	62.8	7.4	7.5	5.9
13	18.9	48.6	7.4	44.2	24.8	30.1	9.1	26.4	36.9	12.6	13.5	9.9
14	18.2	49.1	6.9	44.9	23.9	30.4	8.6	27.0	36.1	12.8	12.8	10.2
15	16.6	50.0	7.0	45.8	21.6	31.4	8.7	27.9	31.6	13.7	13.2	11.0
16	19.3	48.4	6.5	44.5	25.1	30.0	8.0	26.7	37.0	12.6	12.0	10.2
17	19.4	48.3	3.6	46.2	24.6	30.2	4.3	28.5	35.9	12.8	6.2	11.6
18	26.2	44.3	5.1	41.2	36.6	25.4	6.3	22.9	61.5	7.7	9.0	5.9
19	11.0	53.4	1.8	52.3	14.0	34.4	2.4	33.4	20.3	15.9	4.1	15.1
20	12.5	52.5	3.9	50.1	15.8	33.7	5.4	31.5	22.4	15.5	9.6	13.6
21	9.6	54.2	2.1	53.0	11.8	35.3	2.8	34.2	17.2	16.6	4.9	15.6
22	24.6	45.3	6.3	41.5	33.3	26.7	7.9	23.5	52.5	9.5	12.2	7.1
23	21.9	46.9	4.8	44.0	29.4	28.3	5.9	25.9	44.9	11.0	9.1	9.2
24	22.0	46.8	4.8	43.9	29.9	28.0	6.1	25.6	48.1	10.4	9.6	8.4
25	20.3	47.8	5.7	44.4	28.0	28.8	7.2	25.9	46.1	10.8	10.8	8.6
26	20.0	48.0	6.2	44.3	26.5	29.4	7.7	26.3	39.6	12.1	11.8	9.7
27	23.6	45.8	4.7	43.0	31.9	27.2	5.9	24.9	48.9	10.2	8.5	8.5
28	15.3	50.8	4.2	48.3	19.2	32.3	5.2	30.2	27.1	14.6	7.7	13.0

* Chemical analyses are given on a dry basis.

† Modified-combustible loss $= [100 - (\%\ \text{ash} + \%\ \text{sulfur})]\ [\frac{\%\ \text{sink}}{100}]$.

from a low of 4.6 percent with sample 4 (80 percent recovery) to a maximum of 54.2 percent with sample 21 (40 percent recovery).

Sulfur, because it is a combustible material, is included in the values given in table 4 and is thereby classified as a "loss." However, the removal of pyritic sulfur is one of the aims of coal cleaning; hence, a measure of coal-cleaning efficiency should include allowance (credit) for sulfur removal. One method is to subtract the sum of the percentages of ash and sulfur from 100 to give the percentage of modified-combustible loss. These computations were made and the values are given in table 4. As a measure of cleaning efficiency, this modified-combustible loss has several faults, including the error due to retention of some sulfur in the ash as determined by analytical laboratory ashing procedures. A negative modified-combustible loss is thus possible by these calculations.

A computer program was developed that estimated the percentage of recovery that would result in 10, 20, and 30 percent combustible loss in the reject and 10, 20, and 30 percent modified-combustible loss ([100 - (% ash + % sulfur)] [% sink/100]) in the reject. These values are given in table 5. The amount of combustible loss that is acceptable to the mine operator will depend upon many conditions, but it may be appreciable if a saleable product can be produced.

A computer program was also developed that gave an estimated percentage of sulfur with any selected percentage of recovery if channel samples had been used instead of column samples for the washability tests. These calculated data are referred to as "channel-sample basis" data. Table 6 lists these estimated sulfur contents for the 28 coals described in this report with 50, 70, and 90 percent recoveries on channel-sample bases. The sulfur values given in this table are comparable with those given in table 12 of Circular 462 because the same procedure was used for obtaining channel samples for both Part 1 and Part 2 of this investigation.

Table 7 summarizes some of the data given in tables 3 and 6. It is shown that 14 percent of the samples prepared were in the 0 to 1.0 percent sulfur range, irrespective of the recovery percentage. The reduction of recovery from 80 to 40 percent did not increase the percentage of samples in the 0 to 1.5 percent sulfur range. In the higher sulfur ranges, the percentage of samples at each sulfur level does increase at the 40 percent recovery level from the percentage at the 80 percent level. The combustible loss (table 4) was increased significantly.

The annual production of coal from the mines sampled ranged from a few thousand tons to a few million tons. Therefore, the percentage of samples that were prepared within certain sulfur limits, as shown in table 7, is not the same as the percentage of coal production within the same sulfur limit. Table 8 shows the percentage of Illinois coal production within various sulfur ranges.

The production figures used for the compilation of table 8 were obtained from the 1972 Annual Coal, Oil and Gas Report, Illinois Department of Mines and Minerals. Most of the sulfur values used were based upon the chemical analyses of the channel samples obtained during the two parts of this study. The sulfur values for those mines not sampled were assumed to be the same as those from nearby mines that were sampled. As previously stated, the percentage of sulfur in a channel sample is considered to be about the same as that in a prepared sample of coal from the same mine after a minimal amount of preparation.

Percentage of Sulfur Reduction

Only a very small proportion of Illinois coals can be prepared to be within the sulfur limits proposed by many regulations. However, a substantial reduction in the sulfur content of a large proportion of Illinois coals can be achieved. Table 9 was prepared to show the total and pyritic sulfur reductions

TABLE 5 — PERCENTAGE OF RECOVERIES THAT GIVE 10, 20, AND 30 PERCENT COMBUSTIBLE LOSS

Sample no.	Percentage of coal recovery					
	With combustible loss of:			With modified-comb. loss* of:		
	10%	20%	30%	10%	20%	30%
1	83	72	60	80	68	56
2	84	73	61	83	71	59
3	85	73	62	84	72	61
4	74	62	51	71	59	48
5	85	74	63	84	72	60
6	75	63	52	73	61	50
7	74	63	52	70	58	47
8	86	74	63	84	72	60
9	85	73	62	82	69	57
10	85	74	63	85	73	62
11	86	74	63	84	72	61
12	77	66	55	75	64	53
13	83	71	60	80	68	56
14	83	72	61	80	68	57
15	84	73	62	81	69	58
16	83	71	60	80	68	56
17	83	72	60	82	70	58
18	77	66	55	75	63	52
19	87	76	65	86	75	64
20	86	75	64	84	73	62
21	87	76	66	86	75	64
22	80	68	56	76	64	53
23	81	69	58	79	67	55
24	81	69	58	78	66	55
25	81	70	59	78	67	56
26	83	71	59	80	67	56
27	80	68	57	78	66	54
28	85	74	63	84	72	60

* Modified-combustible loss = $[100 - (\%\ \text{ash} + \%\ \text{sulfur})]\ [\frac{\%\ \text{sink}}{100}]$.

TABLE 6 — ESTIMATED TOTAL SULFUR CONTENTS AT 50, 70, AND 90 PERCENT RECOVERIES ON CHANNEL-SAMPLE BASES

	Column sample	Channel sample			Total sulfur					
					50% recovery		70% recovery		90% recovery	
Sample no.	Ash, dry basis (%)	Ash, dry basis (%)	Moisture (%)	Estimated recovery*	Dry basis (%)	Moist basis (%)	Dry basis (%)	Moist basis (%)	Dry basis (%)	Moist basis (%)
1	11.8	12.1	14.4	100.0	3.14	2.69	3.23	2.77	3.55	3.04
2	11.8	10.3	8.3	97.2	1.67	1.53	1.80	1.65	1.99	1.82
3	11.4	10.9	9.0	99.3	1.39	1.26	1.44	1.31	1.52	1.38
4	22.0	9.5	18.2	83.3	2.40	1.96	2.53	2.07	2.79	2.28
5	10.8	12.4	15.8	100.0	2.84	2.39	3.04	2.56	3.45	2.90
6	21.3	12.9	16.0	88.2	2.62	2.20	2.76	2.32	2.93	2.46
7	20.3	12.0	3.2	86.5	2.17	2.10	2.32	2.25	2.61	2.53
8	11.8	11.8	5.9	100.0	2.14	2.01	2.39	2.25	2.82	2.66
9	12.2	11.2	5.3	96.9	1.99	1.89	2.45	2.32	3.11	2.94
10	10.0	8.9	10.2	97.8	0.79	0.71	0.79	0.71	0.80	0.72
11	10.5	10.0	12.5	99.3	2.82	2.46	2.97	2.60	3.20	2.80
12	19.2	11.9	17.0	91.4	2.42	2.01	2.52	2.09	2.69	2.23
13	13.4	11.9	13.3	97.3	3.81	3.31	3.91	3.39	4.21	3.65
14	13.0	11.9	13.3	98.3	3.55	3.08	3.65	3.16	3.96	3.44
15	15.2	11.9	13.3	96.7	3.79	3.28	3.82	3.31	3.92	3.40
16	13.0	14.1	13.7	100.0	3.25	2.81	3.41	2.94	3.65	3.15
17	15.3	14.7	13.9	99.0	2.22	1.91	2.24	1.93	2.27	1.95
18	18.3	12.0	13.0	91.5	2.48	2.16	2.61	2.27	2.83	2.46
19	7.8	8.2	9.1	100.0	0.53	0.48	0.55	0.50	0.61	0.55
20	8.9	7.1	6.7	95.8	0.83	0.77	0.88	0.82	0.96	0.90
21	6.8	7.1	6.7	100.0	0.71	0.66	0.71	0.67	0.72	0.67
22	15.2	13.2	7.3	95.3	2.60	2.41	2.78	2.58	3.05	2.82
23	16.5	12.4	7.3	93.8	2.09	1.93	2.20	2.04	2.36	2.19
24	14.4	11.4	6.8	94.4	2.01	1.87	2.10	1.95	2.25	2.10
25	12.0	14.5	15.8	100.0	2.50	2.11	2.70	2.27	3.02	2.55
26	13.3	11.1	12.8	95.6	2.56	2.23	2.76	2.41	3.01	2.62
27	16.5	13.3	6.4	94.8	1.94	1.82	2.12	1.98	2.47	2.31
28	11.5	12.2	7.6	100.0	1.79	1.66	1.95	1.80	2.22	2.05

*Percent recovery of the column sample that would provide a coal with the same percentage of ash as that found in the channel sample.

that were obtained with the 28 samples described in this report. The greatest percentage of total sulfur reduction with 80 percent recovery was 65.3 with sample 20. The greatest numerical reduction in total sulfur at the same recovery rate was from 7.70 to 3.88 percent with sample 15. The reduction in total sulfur was also large with sample 7—from 5.64 percent to 2.66 percent.

The percentage reduction of pyritic sulfur, as given in table 9, is a good index of the effectiveness of a gravity separation process with a coal. Although the average reduction of pyritic sulfur, with 80 percent recovery, for the 28 coals listed was 65.9 percent, the reductions ranged from a low of 19.7 percent to a high of 91.2 percent. The reduction was greater than 50 percent for 27 of the 28 coals listed.

TABLE 7 - PERCENTAGES OF SAMPLES WITHIN VARIOUS SULFUR RANGES WITH SELECTED PREPARATION CONDITIONS

Sulfur range, dry basis (%)	Percentage of samples				
	Channel sample*	90% recovery, channel-sample basis†	80% recovery	60% recovery	40% recovery
0 - 1.0	4	14	14	14	14
0 - 1.5	7	14	18	18	18
0 - 2.0	14	21	21	25	36
0 - 2.5	21	39	39	54	68
0 - 3.0	25	61	75	82	82
0 - 3.5	50	82	86	89	89
0 - 4.0	68	96	96	100	100
0 - 4.5	79	100	100		
0 - 5.0	89				
0 - 5.5	100				

* Mineral bands thicker than 3/8 inch were removed during sampling procedure.
† 10 percent of "sink" material has been removed from channel samples.

TABLE 8 - ESTIMATED PERCENTAGES OF 1972 ILLINOIS COAL PRODUCTION, WITH TWO DEGREES OF PREPARATION, BY SULFUR RANGES

Sulfur range (%)	Channel sample*		90% recovery, channel-sample basis†	
	Moist basis	Dry basis	Moist basis	Dry basis
0 - 1.0	3	3	10	6
0 - 1.5	11	10	17	14
0 - 2.0	17	14	26	25
0 - 2.5	26	25	43	31
0 - 3.0	33	28	73	59
0 - 3.5	67	36	93	83
0 - 4.0	81	65	100	96
0 - 4.5	95	85		100
0 - 5.0	100	97		
0 - 5.5		100		

* Mineral bands thicker than 3/8 inch are excluded from channel samples.
† 10 percent of "sink" material has been removed from channel samples.

TABLE 9 — SULFUR REDUCTIONS WITH 80 AND 40 PERCENT RECOVERIES

Sample no.	Raw coal		80 percent recovery				40 percent recovery			
	Total sulfur (%)	Pyritic sulfur (%)	Total sulfur (%)	Reduction* (%)	Pyritic sulfur (%)	Reduction† (%)	Total sulfur (%)	Reduction* (%)	Pyritic sulfur (%)	Reduction† (%)
1	5.48	2.54	3.36	38.7	0.79	69.0	3.18	41.9	0.49	80.9
2	3.46	2.07	1.91	44.8	0.65	68.5	1.62	53.1	0.36	82.4
3	1.95	1.06	1.48	24.3	0.50	53.2	1.37	29.7	0.41	61.4
4	4.67	2.90	2.90	38.0	1.01	65.3	2.39	48.8	0.49	83.2
5	4.61	2.23	3.22	30.2	0.96	57.1	2.81	39.0	0.55	75.3
6	3.96	2.08	2.93	25.9	0.66	68.2	2.59	34.5	0.33	84.2
7	5.64	4.15	2.66	52.8	1.06	74.4	2.15	61.9	0.44	89.4
8	4.00	2.46	2.59	35.3	1.04	57.9	2.07	48.2	0.45	81.7
9	5.41	4.17	2.84	47.5	1.67	60.1	1.85	65.7	0.75	81.9
10	0.84	0.28	0.79	5.4	0.22	19.7	0.84	0.1	0.26	6.9
11	4.58	2.33	3.08	32.7	0.85	63.4	2.77	39.5	0.56	75.8
12	3.72	1.89	2.67	28.3	0.71	62.6	2.40	35.5	0.43	77.4
13	6.03	2.72	4.07	32.5	0.90	67.1	3.83	36.5	0.38	85.9
14	5.83	2.52	3.80	34.8	0.82	67.4	3.58	38.7	0.37	85.2
15	7.70	4.24	3.88	49.6	0.58	86.3	3.79	50.8	0.28	93.4
16	5.10	2.24	3.51	31.1	0.81	64.0	3.21	37.1	0.44	80.2
17	3.08	1.21	2.26	26.7	0.42	64.9	2.21	28.3	0.32	73.4
18	4.46	2.51	2.80	37.3	0.87	65.3	2.46	44.8	0.42	83.1
19	1.36	0.76	0.57	58.0	0.07	91.2	0.53	60.9	0.02	97.7
20	2.68	2.00	0.93	65.3	0.31	84.4	0.81	69.7	0.17	91.4
21	1.49	0.93	0.72	52.0	0.19	79.4	0.71	52.4	0.15	83.4
22	4.60	2.80	2.95	35.8	1.02	63.5	2.56	44.3	0.51	81.9
23	3.90	2.61	2.32	40.5	0.72	72.6	2.06	47.2	0.39	85.2
24	4.00	2.63	2.21	44.9	0.73	72.2	1.99	50.3	0.44	83.4
25	4.33	2.34	2.84	34.3	0.88	62.6	2.46	43.3	0.48	79.6
26	4.73	2.98	2.93	38.2	1.13	62.2	2.49	47.3	0.71	76.3
27	4.15	2.81	2.35	43.3	0.95	66.1	1.92	53.7	0.45	84.1
28	3.42	2.45	2.07	39.4	1.08	55.9	1.76	48.5	0.72	70.5
AVE	4.11	2.35	2.52	38.1	0.77	65.9	2.23	44.7	0.42	79.1

* Percentage of reduction from total sulfur in raw coal.

† Percentage of reduction from pyritic sulfur in raw coal.

(Chemical analyses are given on a dry basis.)

Although a high percentage of pyritic sulfur can be readily removed from many Illinois coals by gravity processes, the percentage of organic sulfur remains essentially the same for all the gravity fractions.

Washability Tests on Core Samples of Coal

Three sets of core and column coal samples were obtained as desired for the investigation of the suitability of the cores as samples for float-sink tests. For all three sets, the coal core samples were obtained at a location that was less than 100 feet from the corresponding column samples.

Figures 2, 3, and 4 show the relations between the total sulfur, pyritic

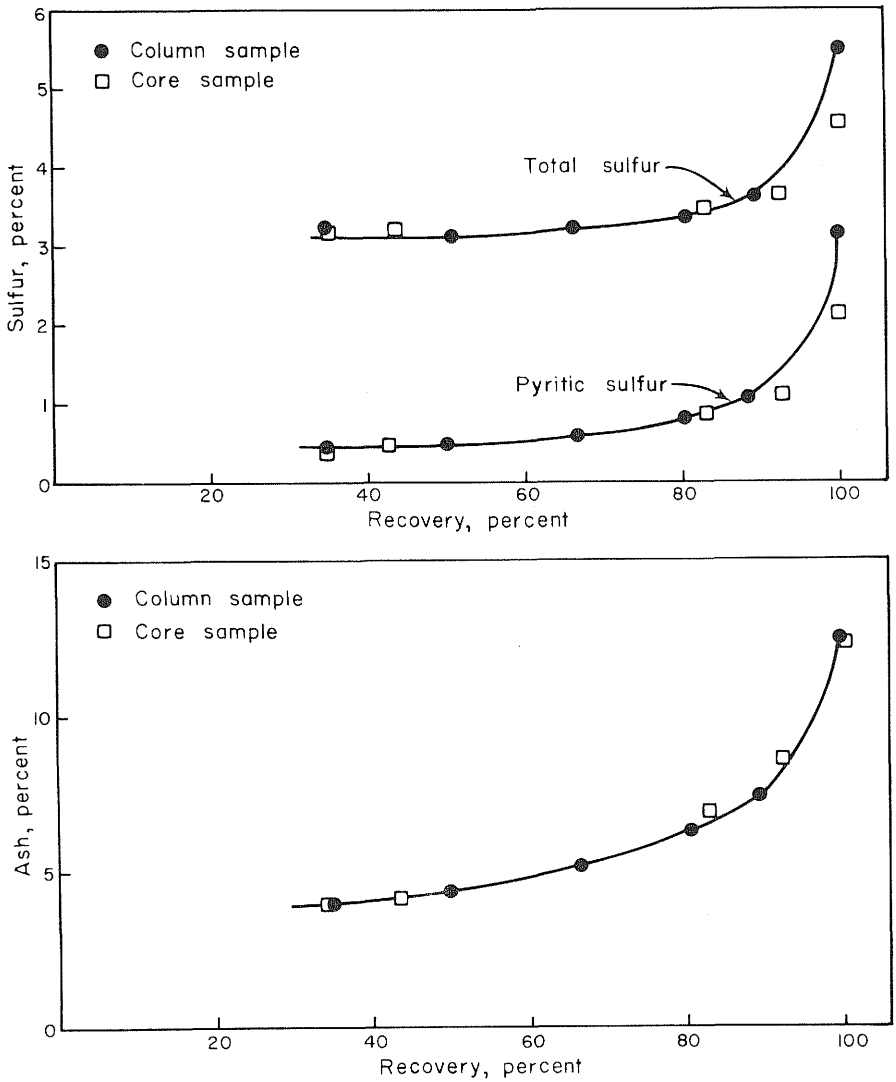

Fig. 2 - Comparison of washabilities of column sample 1 and core sample 1C.

sulfur, ash, and recovery percentages for the three core samples and the corresponding column samples. The curves shown on the figures are considered to be the "best fit" for the data from the tests on the column samples.

The results of the washability tests of samples 1 and 1C (fig. 2) are nearly identical except for the raw coal values (100 percent recovery). Although some differences in the results of the washability tests are shown in figure 3 for samples 14 and 14C, the differences are not considered significant. However, significant differences between the washability test results for the column sample 15 and the core sample 15C are shown in figure 4. When assessing the significance of the differences shown, it should be remembered that the maximum

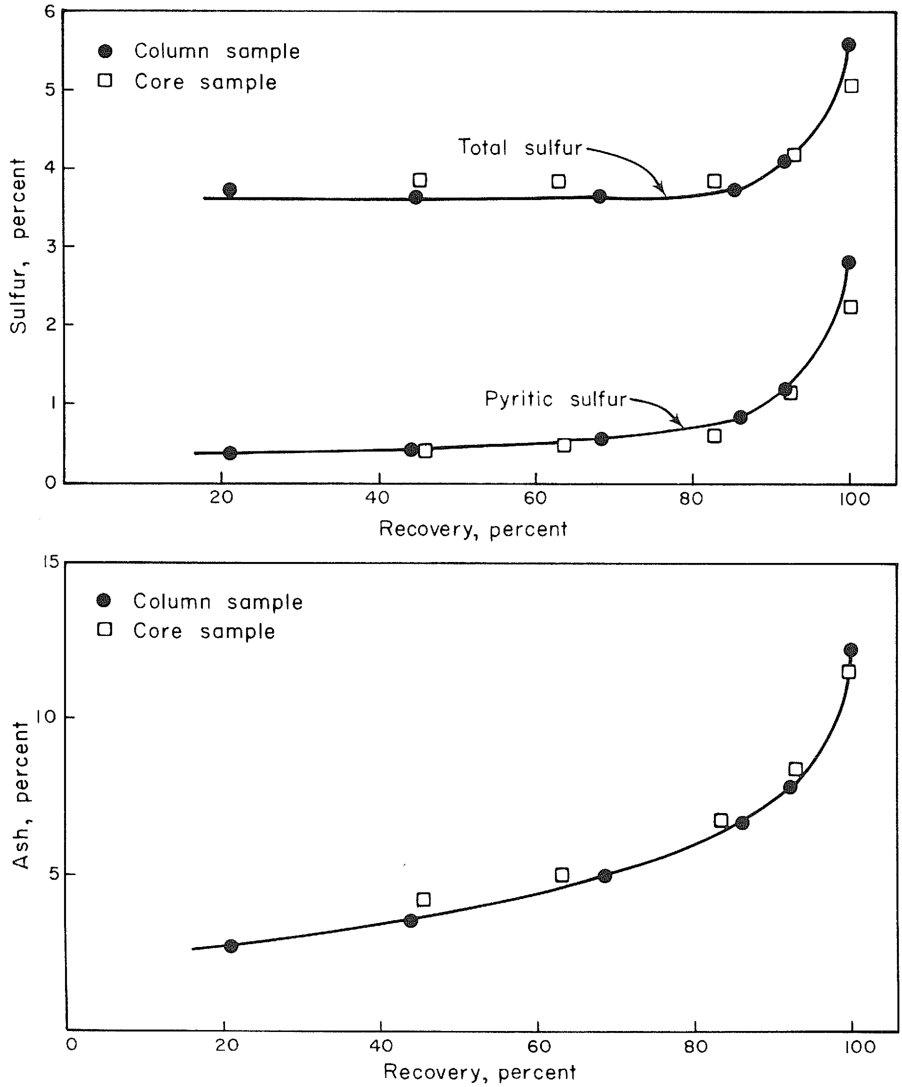

Fig. 3 - Comparison of washabilities of column sample 14 and core sample 14C.

analytical variation in total sulfur determinations allowed by ASTM is 0.2 percentage figure with 60-mesh samples. The maximum permissible difference for ash is 1.0 percentage figure. (See ASTM Standards, Part 19, pages 46 and 439, 1968.) It is therefore possible that analytical variations may account for an appreciable part of the differences displayed in figure 4.

Small Samples for Washability Tests

The number of comparative coal core samples available was not considered sufficient to judge the adequacy of the cores as samples for float-sink

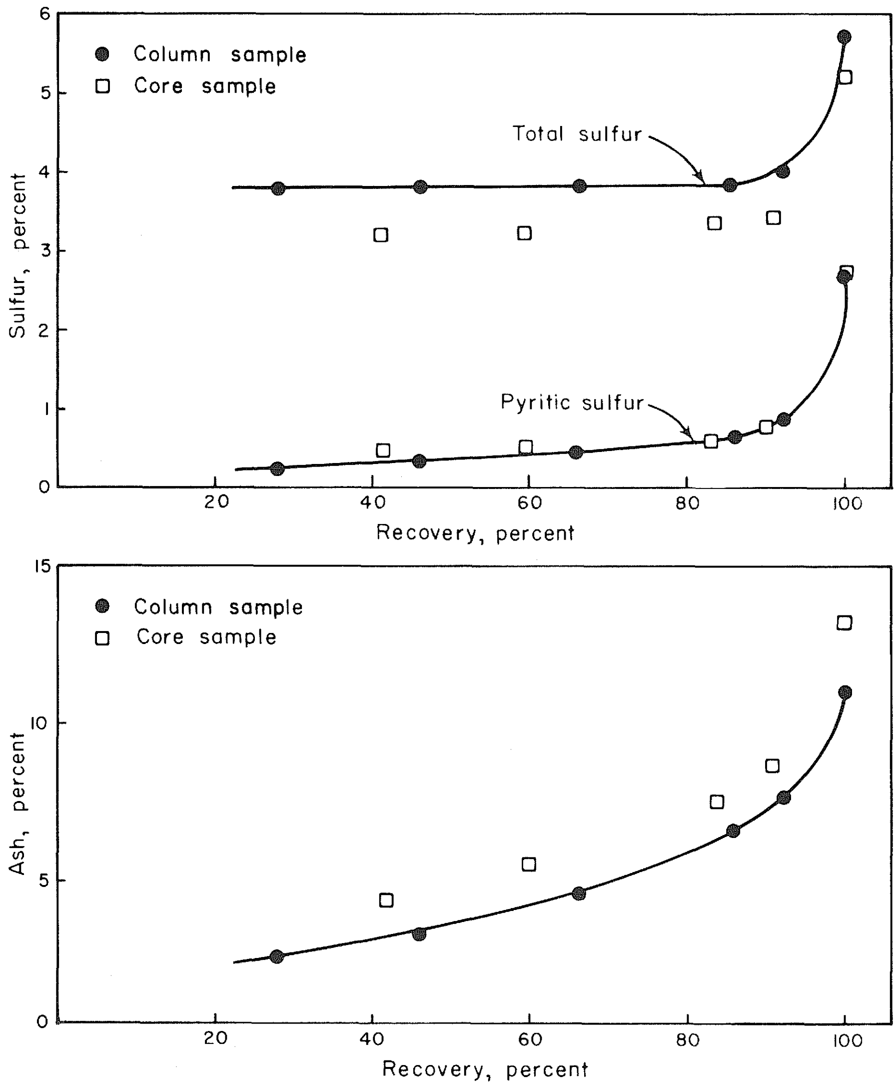

Fig. 4 - Comparison of washabilities of column sample 15 and core sample 15C.

tests. However, the effect of reducing the size of the sample was investigated by making float-sink tests on 10-pound samples of coal that were riffled from 23 of the 28 original samples.

The results from the float-sink tests of the small samples are remarkably close to those obtained from the tests of large samples. Table 10 shows that the greatest numerical variation in computed total sulfur at 80 percent recovery with the 23 pairs of samples was only 0.33, with samples 9 and 9S. This difference is only slightly greater than analytical tolerances allowable between different laboratories with the same sample. The greatest numerical differences in pyritic sulfur and ash between the two sample sizes were 0.26 (samples 6 and 6S) and 0.7 (samples 4 and 4S), respectively, with 80 percent recoveries. The average arithmetic differences for the 23 pairs of samples with 80 percent recoveries were 0.08, 0.04, and 0.2 for total sulfur, pyritic sulfur, and ash, respectively.

Although the data obtained from the washability tests on 10-pound samples of 3/8-inch by 28-mesh coal were generally satisfactory, the use of more than 10 pounds, if available, is recommended.

Ash Fusion and Hardgrove Grindability

The refuse from a coal-cleaning plant, which may contain an appreciable percentage of combustible material, might be used as a source of sulfur and heat. To properly design equipment to burn this refuse, information about the ash fusion and the grindability of the fuel may be required. To gain some of the information desired, the ASTM ash fusion temperatures and Hardgrove grindabilities were obtained for the 1.60 specific gravity sink material; they are shown in table 11. Similar data for the channel samples, which are considered similar to coals with minimal preparation, also are included in table 11 for comparison. These data indicate no consistent differences between the Hardgrove grindabilities or ash fusion temperatures of the refuse material (material that sank at a specific gravity of 1.60) and those of the channel samples of coal. The average ash fusion temperatures were slightly higher with the refuse material than with the channel samples. The average Hardgrove grindability was 81.6 with the refuse material and 72.5 with the channel samples. The Hardgrove grindability of some refuse samples, such as that of sample 4, was considerably higher than the grindability of the corresponding channel coal samples.

CONCLUSIONS

1. In only a small proportion of Illinois coals can sulfur be reduced by gravity separation methods to 1.5 percent or less. These coals are all relatively low in sulfur as mined.

2. The percentage of reduction of the sulfur with many Illinois coals is high, even with only a moderate quantity of reject. The maximum reduction of total sulfur in cleaned coal reported in this study with 80 percent recovery was 65 percent, and the average reduction was 38 percent. Expressed in percentage figures, the maximum reduction in sulfur was nearly 4 (from 7.70% to 3.88%) and the average reduction in sulfur was slightly more than 1.5 (from 4.11% to 2.52%).

TABLE 10 — COMPARISON OF WASHABILITIES OF LARGE AND SMALL SAMPLES*

Sample no.	40 percent recovery			60 percent recovery			80 percent recovery		
	Sulfur (%)		Ash	Sulfur (%)		Ash	Sulfur (%)		Ash
	Total	Pyritic	(%)	Total	Pyritic	(%)	Total	Pyritic	(%)
1	3.14	0.48	4.1	3.16	0.53	4.7	3.36	0.79	6.3
1S	3.38	0.46	4.0	3.43	0.52	4.7	3.62	0.76	6.2
2	1.62	0.36	2.9	1.74	0.48	4.1	1.91	0.65	6.0
2S	1.64	0.40	2.8	1.78	0.50	4.0	1.95	0.67	5.9
3	1.37	0.41	3.1	1.41	0.43	3.9	1.48	0.50	5.5
3S	1.25	0.33	2.4	1.32	0.38	3.3	1.39	0.47	5.3
4	2.39	0.49	2.8	2.55	0.66	3.8	2.90	1.01	6.1
4S	2.40	0.49	2.5	2.55	0.64	3.4	2.85	0.94	5.4
5	2.81	0.55	6.1	2.91	0.65	6.5	3.22	0.96	7.5
5S	2.96	0.65	5.6	3.03	0.73	6.1	3.30	1.00	7.0
6	2.59	0.33	2.9	2.75	0.48	4.4	2.93	0.66	6.8
6S	2.75	0.60	3.9	2.80	0.66	4.6	3.01	0.92	7.4
8	2.07	0.45	4.5	2.24	0.67	5.9	2.59	1.04	7.6
8S	2.20	0.54	4.6	2.34	0.67	6.0	2.63	1.02	7.7
9	1.85	0.75	3.6	2.24	1.10	5.0	2.84	1.67	6.9
9S	1.88	0.89	4.2	2.02	1.09	5.1	2.51	1.64	6.9
11	2.77	0.56	3.5	2.88	0.67	4.3	3.08	0.85	5.7
11S	2.66	0.56	3.3	2.75	0.65	4.1	2.94	0.86	5.5
12	2.40	0.43	2.3	2.49	0.52	3.2	2.67	0.71	4.9
12S	2.42	0.42	2.4	2.51	0.53	3.3	2.66	0.70	5.0
13	3.81	0.38	3.7	3.85	0.54	4.9	4.07	0.90	6.8
13S	3.82	0.43	4.1	3.82	0.52	5.1	4.02	0.86	7.0
14	3.55	0.37	3.3	3.58	0.50	4.4	3.80	0.82	6.3
14S	3.62	0.41	3.8	3.62	0.49	4.9	3.78	0.76	6.7
16	3.21	0.44	4.2	3.32	0.56	5.4	3.51	0.81	7.3
16S	3.29	0.53	4.2	3.30	0.57	5.2	3.45	0.79	7.0
17	2.21	0.32	6.0	2.23	0.36	7.0	2.26	0.42	8.6
17S	2.26	0.34	7.0	2.26	0.34	7.2	2.29	0.41	8.6
18	2.46	0.42	2.4	2.57	0.58	3.4	2.80	0.87	5.5
18S	2.50	0.51	2.9	2.56	0.58	3.4	2.77	0.84	5.5
19	0.53	0.02	3.0	0.53	0.02	3.6	0.57	0.07	4.6
19S	0.57	0.08	3.2	0.57	0.08	3.8	0.58	0.08	4.7
20	0.81	0.17	3.4	0.85	0.22	4.3	0.93	0.31	5.5
20S	0.84	0.20	3.4	0.87	0.23	4.1	0.94	0.32	5.4
21	0.71	0.15	3.5	0.71	0.17	4.1	0.72	0.19	4.7
21S	0.70	0.12	3.5	0.70	0.12	4.0	0.70	0.15	4.6
22	2.56	0.51	3.1	2.71	0.69	4.5	2.95	1.02	6.8
22S	2.66	0.63	4.2	2.71	0.70	4.8	2.91	0.97	6.9
24	1.99	0.44	3.0	2.06	0.55	4.1	2.21	0.73	6.0
24S	1.93	0.44	3.2	1.99	0.52	3.9	2.15	0.71	6.0
26	2.49	0.71	3.0	2.68	0.87	4.3	2.93	1.13	6.6
26S	2.77	0.89	4.1	2.91	1.02	5.1	3.08	1.22	7.0
27	1.92	0.45	2.1	2.04	0.63	3.8	2.35	0.95	6.6
27S	2.08	0.47	3.3	2.13	0.56	4.5	2.39	0.87	6.8
28	1.76	0.72	4.5	1.86	0.84	5.5	2.07	1.08	6.9
28S	1.78	0.76	4.8	1.82	0.83	5.6	1.97	1.04	6.9

* Chemical analyses are given on a dry basis.

TABLE 11 - ASH FUSION AND HARDGROVE GRINDABILITY

Sample no.	Ash fusion temperatures, °F								Hardgrove grindability	
	Init. def. temp.*		Softening temp.		Hemispherical temp.		Fluid temp.			
	1.60 s.g. sink†	Channel sample	1.60 s.g. sink†	Channel sample	1.60 s.g. sink†	Channel sample	1.60 s.g. sink†	Channel sample	1.60 s.g. sink†	Channel sample
1	1960	----	2060	----	2100	----	2200	----	75.3	----
2	1900	1960	2000	2090	2020	2110	2120	2200	81.3	77.7
3	2010	2020	2110	2150	2140	2180	2250	2260	92.5	70.1
4	2190	2110	2290	2210	2320	2230	2460	2340	105.2	77.3
5	1890	1940	2050	2030	2070	2050	2170	2150	91.1	79.9
6	2040	2040	2150	2140	2170	2160	2280	2250	94.7	72.0
7	2000	1900	2100	2140	2135	2160	2290	2320	74.3	77.7
8	2180	1950	2310	2050	2340	2080	2470	2230	75.3	73.6
9	2000	1870	2100	2030	2120	2050	2220	2150	78.0	69.4
10	2220	----	2310	----	2330	----	2400	----	89.1	----
11	1930	1870	2020	2050	2040	2080	2130	2180	76.3	79.2
12	2130	2110	2230	2200	2250	2230	2340	2320	84.2	81.9
13	1920	1940	2020	2080	2050	2110	2150	2280	73.6	73.6
16	1920	----	2020	----	2050	----	2150	----	77.9	----
17	2280	1970	2490	2080	2530	2110	2650	2220	78.3	73.0
18	1960	2120	2170	2220	2190	2240	2280	2330	92.4	73.3
19	1970	2070	2080	2400	2110	2450	2210	2600	78.6	60.2
20	2080	----	2320	----	2340	----	2430	----	102.6	----
21	1980	1950	2100	2220	2130	2260	2250	2460	82.0	71.4
22	1960	1980	2100	2100	2130	2130	2250	2260	78.3	73.7
23	1920	1970	2100	2160	2120	2180	2280	2280	68.6	70.7
24	1900	1950	2000	2040	2020	2060	2120	2150	74.0	58.6
25	2030	----	2120	----	2150	----	2250	----	89.0	----
27	1920	2030	2030	2120	2050	2140	2160	2240	65.1	68.7
28	2140	1960	2350	2060	2370	2080	2470	2170	88.9	68.7
Average‡	2011	1985	2140	2128	2165	2155	2278	2270	81.6	72.5

* Init. def. temp. - abbreviation for initial deformation temperature.

† 1.60 s.g. sink - abbreviation for 1.60 specific gravity sink fraction.

‡ Averages given for the 20 samples with complete data.

3. Three comparisons were made of washability tests of diamond-drill cores from exploratory drilling with those of large column samples obtained in a mine from a face near the drill-hole site. These tests, which were made with 3/8-inch by 28-mesh coal, gave similar washability data on the two types of samples.

4. The data obtained from washability tests made with 10-pound samples riffled from larger samples of 3/8-inch by 28-mesh coal were quite similar to the data obtained with 100-pound samples.

5. The 1.60 specific gravity sink material did not exhibit consistent differences in grindabilities or in ash fusion temperatures from the face-channel samples.

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APPENDIX: WASHABILITY (FLOAT-SINK) DATA

All of the data from the washability (float-sink) tests on the samples are presented in the tables below. The data labeled "calc. [calculated] raw coal" are the data from the washability tests as calculated by proportionally combining the individual float-sink fractions to give values that should be equivalent to the values given in the original raw coal analysis. The analyses of representative fractions of the raw coal sample are labeled "anal. [analyzed] raw coal"; they appear directly below the calculated raw coal figures for convenient comparison.

The letter S after a sample number indicates a 10-pound sample that was split from the crushed column sample. The letter C indicates a 2-inch diameter diamond-drill core sample.

These abbreviations are also used: SP. GRAV. - specific gravity; CUM. WT. - cumulative weight; TOT. S - total sulfur; PYR. S - pyritic sulfur; and ORG. S - organic sulfur.

All values (except specific gravity) are reported as percentages, dry basis.

SAMPLE 1

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,280	35,1	4,0	3,21	0,49	2,71	64,9	17,1	6,76	4,60	2,14
1,300	50,5	4,4	3,16	0,52	2,64	49,5	20,7	7,91	5,85	2,04
1,325	66,7	5,2	3,21	0,59	2,61	33,3	27,1	10,14	8,30	1,81
1,400	80,7	6,3	3,32	0,75	2,57	19,3	38,4	14,67	13,25	1,38
1,600	89,6	7,5	3,57	1,02	2,54	10,4	55,1	22,24	21,55	0,63
CALC, RAW CØAL	100,0	12,5	5,51	3,16	2,34					
ANAL, RAW CØAL	100,0	11,8	5,48	2,54	2,92					

SAMPLE 1S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,275	27,9	3,8	3,41	0,48	2,93	72,1	14,5	5,89	3,37	2,51
1,300	45,5	4,2	3,42	0,50	2,91	54,5	17,6	6,69	4,28	2,38
1,400	83,3	6,3	3,60	0,74	2,85	16,7	37,2	13,20	11,65	1,48
1,600	91,4	7,5	3,85	1,04	2,80	8,6	53,6	19,57	18,69	0,78
CALC, RAW CØAL	100,0	11,5	5,20	2,56	2,62					
ANAL, RAW CØAL	100,0	11,8	5,48	2,54	2,92					

SAMPLE 1C

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,280	34,5	3,8	3,19	0,38	2,80	65,5	16,8	5,20	3,02	2,13
1,300	43,4	4,2	3,20	0,43	2,76	56,6	18,6	5,51	3,40	2,06
1,400	83,0	7,0	3,45	0,82	2,61	17,0	38,3	9,67	8,37	1,17
1,600	92,4	8,6	3,59	1,02	2,54	7,6	57,7	15,72	15,32	0,19
CALC, RAW CØAL	100,0	12,3	4,51	2,11	2,36					

SAMPLE 2

SP.GRAV.	FLOAT FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S	SINK FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S
1,290	17,7	2,3	1,53	0,30	1,23	82,3	13,2	3,39	2,19	1,18
1,310	37,5	3,0	1,64	0,38	1,26	62,5	16,3	3,91	2,73	1,15
1,330	56,8	3,8	1,73	0,46	1,26	43,2	21,1	4,81	3,69	1,09
1,400	79,0	5,7	1,85	0,60	1,25	21,0	32,5	7,60	6,57	0,97
1,600	92,4	7,7	2,07	0,82	1,24	7,6	54,6	15,07	14,39	0,55
CALC. RAW COAL	100,0	11,3	3,06	1,85	1,19					
ANAL. RAW COAL	100,0	11,8	3,46	2,07	1,37					

SAMPLE 2S

SP.GRAV.	FLOAT FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S	SINK FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S
1,295	26,7	2,4	1,56	0,35	1,20	73,3	14,3	3,59	2,36	1,19
1,320	46,3	3,3	1,71	0,44	1,26	53,7	17,9	4,20	3,02	1,14
1,400	81,9	5,8	1,93	0,65	1,27	18,1	35,1	8,10	7,14	0,85
1,600	92,5	7,5	2,10	0,82	1,26	7,5	55,2	14,67	14,19	0,29
CALC. RAW COAL	100,0	11,1	3,05	1,82	1,19					
ANAL. RAW COAL	100,0	11,8	3,46	2,07	1,37					

SAMPLE 3

SP.GRAV.	FLOAT FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S	SINK FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S
1,285	17,9	3,2	1,36	0,44	0,92	82,1	11,9	2,12	1,15	0,96
1,300	32,3	3,1	1,36	0,41	0,95	67,7	13,8	2,28	1,32	0,96
1,315	50,2	3,5	1,39	0,42	0,97	49,8	17,2	2,58	1,63	0,94
1,400	84,0	5,7	1,49	0,50	0,98	16,0	34,5	4,59	3,76	0,82
1,600	94,0	7,3	1,54	0,58	0,96	6,0	56,7	8,89	8,01	0,86
CALC. RAW COAL	100,0	10,3	1,98	1,02	0,95					
ANAL. RAW COAL	100,0	11,4	1,95	1,06	0,89					

SAMPLE 3S

SP.GRAV.	FLOAT FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S	SINK FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S
1,290	29,4	2,3	1,21	0,31	0,89	70,6	14,7	2,36	1,54	0,82
1,300	44,0	2,7	1,27	0,34	0,92	56,0	17,6	2,61	1,83	0,78
1,400	81,8	5,3	1,39	0,47	0,91	18,2	36,7	4,87	4,34	0,52
1,600	92,0	7,1	1,44	0,54	0,89	8,0	56,8	8,78	8,49	0,26
CALC. RAW COAL	100,0	11,0	2,02	1,18	0,84					
ANAL. RAW COAL	100,0	11,4	1,95	1,06	0,89					

SAMPLE 4

SP.GRAV.	FLOAT FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S	SINK FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S
1,250	21,2	2,8	2,41	0,48	1,91	78,8	24,9	4,97	3,49	1,39
1,285	43,3	3,1	2,43	0,53	1,88	56,7	33,4	5,95	4,63	1,21
1,335	65,9	4,2	2,61	0,72	1,86	34,1	51,2	7,94	6,99	0,80
1,400	72,5	4,8	2,72	0,83	1,86	27,5	60,9	8,92	8,19	0,56
1,600	78,9	6,2	2,90	1,01	1,84	21,1	72,9	10,14	9,74	0,22
CALC. RAW COAL	100,0	20,2	4,43	2,85	1,50					
ANAL. RAW COAL	100,0	22,0	4,67	2,90	1,71					

SAMPLE 4S

SP.GRAV.	FLOAT FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S	SINK FRACTION CUM.WT.	ASH	TOT.S	PYR.S	ORG.S
1,260	30,3	2,3	2,37	0,46	1,90	69,7	24,1	4,97	3,45	1,41
1,285	50,7	3,0	2,47	0,56	1,88	49,3	32,5	5,94	4,58	1,22
1,400	77,6	4,8	2,78	0,86	1,87	22,4	61,6	9,04	8,37	0,48
1,600	82,6	5,9	2,93	1,02	1,85	17,4	72,7	10,13	9,78	0,15
CALC. RAW COAL	100,0	17,5	4,18	2,55	1,56					
ANAL. RAW COAL	100,0	22,0	4,67	2,90	1,71					

SAMPLE 5

SP,GRAV,	FLØAT FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	SINK FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,260	25,3	6,1	2,85	0,59	2,22	74,7	13,1	4,93	2,78	2,03
1,295	45,6	6,2	2,87	0,61	2,22	54,4	15,7	5,69	3,58	1,96
1,320	62,2	6,6	2,94	0,68	2,22	37,8	19,1	6,81	4,77	1,86
1,400	84,0	7,6	3,19	0,94	2,19	16,0	31,0	10,75	8,96	1,51
1,600	94,4	8,7	3,64	1,38	2,17	5,6	55,2	17,35	16,50	0,52
CALC, RAW CØAL	100,0	11,3	4,40	2,23	2,08					
ANAL, RAW CØAL	100,0	10,8	4,61	2,23	2,26					

SAMPLE 5S

SP,GRAV,	FLØAT FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	SINK FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,265	24,2	5,6	3,03	0,72	2,27	75,8	12,3	4,94	2,72	2,11
1,305	46,8	5,8	3,00	0,69	2,27	53,2	15,0	5,78	3,59	2,05
1,400	87,5	7,3	3,35	1,06	2,23	12,5	34,3	12,40	10,46	1,62
1,600	94,2	8,1	3,68	1,37	2,23	5,8	52,4	17,49	16,17	0,94
CALC, RAW CØAL	100,0	10,7	4,48	2,23	2,15					
ANAL, RAW CØAL	100,0	10,8	4,61	2,23	2,26					

SAMPLE 6

SP,GRAV,	FLØAT FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	SINK FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,225	24,2	2,3	2,49	0,23	2,20	75,8	25,4	4,25	2,25	1,67
1,270	39,4	3,2	2,62	0,35	2,17	60,6	30,5	4,61	2,68	1,55
1,300	58,6	4,1	2,71	0,45	2,13	41,4	41,9	5,39	3,62	1,33
1,400	72,4	5,5	2,85	0,57	2,10	27,6	57,1	6,37	4,89	0,99
1,600	80,0	7,0	2,94	0,68	2,07	20,0	70,8	7,35	6,11	0,69
CALC, RAW CØAL	100,0	19,8	3,82	1,76	1,80					
ANAL, RAW CØAL	100,0	21,3	3,96	2,08	1,78					

SAMPLE 6S

SP,GRAV,	FLØAT FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	SINK FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,270	39,7	3,9	2,76	0,60	2,12	60,3	32,6	4,81	3,41	1,26
1,305	56,6	4,4	2,77	0,64	2,08	43,4	43,0	5,60	4,45	0,97
1,400	72,6	5,9	2,92	0,80	2,07	27,4	61,8	6,85	6,25	0,37
1,600	78,8	7,3	2,98	0,90	2,03	21,2	73,0	7,77	7,49	0,02
CALC, RAW CØAL	100,0	21,2	4,00	2,29	1,60					
ANAL, RAW CØAL	100,0	21,3	3,96	2,08	1,78					

SAMPLE 7

SP,GRAV,	FLØAT FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	SINK FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,285	25,8	2,9	2,13	0,41	1,71	74,2	26,6	6,93	5,64	1,26
1,305	46,4	4,0	2,22	0,52	1,68	53,6	34,7	8,70	7,55	1,11
1,335	59,4	4,8	2,29	0,62	1,65	40,6	43,3	10,66	9,65	0,97
1,400	71,5	5,9	2,45	0,82	1,61	28,5	56,9	13,81	12,99	0,77
1,600	78,6	7,2	2,66	1,06	1,58	21,4	69,3	16,82	16,15	0,61
CALC, RAW CØAL	100,0	20,5	5,69	4,29	1,37					
ANAL, RAW CØAL	100,0	20,3	5,64	4,15	1,45					

SAMPLE 8

SP,GRAV,	FLØAT FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	SINK FRACTIØN CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,275	18,2	3,2	2,04	0,35	1,69	81,8	12,8	4,18	2,69	1,4[illegible]
1,295	30,9	4,0	2,10	0,44	1,66	69,1	14,2	4,55	3,08	1,4[illegible]
1,315	49,4	5,2	2,17	0,58	1,59	50,6	16,9	5,38	3,91	1,4[illegible]
1,400	83,4	7,8	2,54	0,98	1,56	16,6	27,6	10,10	8,73	1,3[illegible]
1,600	95,2	9,3	3,05	1,51	1,53	4,8	47,4	18,62	17,26	1,3[illegible]
CALC, RAW CØAL	100,0	11,1	3,79	2,27	1,52					
ANAL, RAW CØAL	100,0	11,8	4,00	2,46	1,53					

SAMPLE 8S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,300	31,4	4,1	2,17	0,52	1,65	68,6	14,3	4,56	3,24	1,29
1,315	49,3	5,3	2,30	0,63	1,66	50,7	16,8	5,29	4,08	1,15
1,400	85,5	8,1	2,67	1,06	1,59	14,5	28,7	10,57	10,19	0,28
1,600	95,1	9,3	3,01	1,51	1,47	4,9	46,8	19,46	19,31	0,03
CALC. RAW CØAL	100,0	11,1	3,81	2,38	1,40					
ANAL. RAW CØAL	100,0	11,8	4,00	2,46	1,53					

SAMPLE 9

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,285	14,5	2,7	1,63	0,59	1,03	85,5	13,1	5,77	4,67	1,07
1,310	33,7	3,4	1,82	0,73	1,08	66,3	15,7	6,88	5,78	1,05
1,335	52,0	4,4	2,07	0,95	1,11	48,0	19,3	8,54	7,48	1,02
1,400	74,2	6,1	2,58	1,40	1,15	25,8	27,3	12,64	11,79	0,80
1,600	86,4	7,8	3,12	1,94	1,16	13,6	35,6	18,22	17,70	0,48
CALC. RAW CØAL	100,0	11,6	5,17	4,08	1,06					
ANAL. RAW CØAL	100,0	12,2	5,41	4,17	1,19					

SAMPLE 9S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,310	38,0	4,1	1,86	0,88	0,97	62,0	16,2	6,69	5,96	0,97
1,335	57,4	5,0	2,08	1,06	1,00	42,6	20,5	8,59	8,03	0,93
1,400	76,7	6,4	2,30	1,50	1,03	23,3	28,6	13,26	12,35	0,77
1,600	90,7	8,3	2,95	2,09	1,05	9,3	44,1	23,38	22,97	0,16
CALC. RAW CØAL	100,0	11,6	4,85	4,03	0,97					
ANAL. RAW CØAL	100,0	12,2	5,41	4,17	1,19					

SAMPLE 10

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,275	22,0	3,5	0,90	0,32	0,57	78,0	11,6	0,89	0,34	0,54
1,300	50,7	3,5	0,81	0,24	0,57	49,3	16,3	0,97	0,44	0,53
1,320	68,2	4,1	0,80	0,23	0,57	31,8	22,1	1,08	0,58	0,50
1,400	87,0	5,7	0,80	0,23	0,57	13,0	37,5	1,50	1,06	0,44
1,600	93,7	6,8	0,81	0,24	0,56	6,3	54,8	2,11	1,73	0,37
CALC. RAW CØAL	100,0	9,8	0,89	0,34	0,55					
ANAL. RAW CØAL	100,0	10,0	0,84	0,28	0,56					

SAMPLE 11

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,260	25,4	3,0	2,73	0,52	2,19	74,6	12,1	4,67	2,50	2,09
1,280	46,3	4,0	2,84	0,63	2,19	53,7	14,7	5,32	3,18	2,06
1,305	63,6	4,3	2,88	0,67	2,18	36,4	19,2	6,44	4,32	2,01
1,400	89,3	6,3	3,19	0,94	2,19	10,7	38,4	12,40	10,81	1,49
1,600	95,2	7,3	3,31	1,07	2,18	4,8	59,0	21,32	20,44	0,83
CALC. RAW CØAL	100,0	9,8	4,17	2,00	2,12					
ANAL. RAW CØAL	100,0	10,5	4,58	2,33	2,21					

SAMPLE 11S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,270	33,6	3,2	2,64	0,55	2,06	66,4	12,6	4,72	2,80	1,83
1,300	60,6	4,2	2,77	0,67	2,06	39,4	17,5	5,95	4,17	1,68
1,400	90,1	6,3	3,04	0,97	1,99	9,9	38,2	12,96	11,80	1,14
1,600	95,5	7,1	3,18	1,14	1,98	4,5	58,3	21,98	21,35	0,34
CALC. RAW CØAL	100,0	9,4	4,02	2,05	1,91					
ANAL. RAW CØAL	100,0	10,5	4,58	2,33	2,21					

SAMPLE 12

SP.GRAV.	FLØAT FRACTIØN					SINK FRACTIØN				
	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.250	22.8	2.3	2.38	0.42	1.93	77.2	20.7	4.00	2.42	1.47
1.270	42.2	2.5	2.40	0.43	1.93	57.8	26.7	4.53	3.07	1.31
1.285	56.3	3.0	2.47	0.50	1.93	43.7	34.0	5.13	3.84	1.12
1.400	79.0	4.5	2.66	0.69	1.90	21.0	61.6	7.29	6.75	0.34
1.600	84.0	5.6	2.71	0.76	1.87	16.0	73.7	8.48	8.26	0.01
CALC. RAW CØAL	100.0	16.5	3.63	1.96	1.58					
ANAL. RAW CØAL	100.0	19.2	3.72	1.89	1.79					

SAMPLE 12S

SP.GRAV.	FLØAT FRACTIØN					SINK FRACTIØN				
	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.260	31.1	2.3	2.40	0.39	1.99	68.9	22.7	3.79	2.17	1.50
1.290	54.8	3.1	2.48	0.50	1.95	45.2	32.4	4.43	2.97	1.29
1.400	79.3	4.7	2.66	0.68	1.91	20.7	60.9	6.04	5.18	0.65
1.600	84.5	5.8	2.70	0.75	1.88	15.5	73.9	6.95	6.33	0.41
CALC. RAW CØAL	100.0	16.3	3.36	1.61	1.65					
ANAL. RAW CØAL	100.0	19.2	3.72	1.89	1.79					

SAMPLE 13

SP.GRAV.	FLØAT FRACTIØN					SINK FRACTIØN				
	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.276	26.4	3.2	3.92	0.38	3.37	73.6	16.3	6.68	4.03	2.48
1.310	49.6	4.5	3.87	0.49	3.22	50.4	21.1	8.00	5.61	2.22
1.348	69.0	5.5	3.90	0.65	3.09	31.0	29.2	10.52	8.45	1.88
1.400	80.9	6.8	4.01	0.84	3.01	19.1	38.6	14.18	12.51	1.48
1.600	90.8	8.4	4.33	1.23	2.93	9.2	57.1	21.94	21.21	0.59
CALC. RAW CØAL	100.0	12.8	5.95	3.07	2.72					
ANAL. RAW CØAL	100.0	13.4	6.03	2.72	3.09					

SAMPLE 13S

SP.GRAV.	FLØAT FRACTIØN					SINK FRACTIØN				
	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.280	34.5	4.0	3.93	0.44	3.35	65.5	16.8	6.37	3.86	2.44
1.315	56.0	4.9	3.85	0.53	3.23	44.0	21.9	7.66	5.42	2.15
1.400	82.0	7.1	3.99	0.83	3.08	18.0	36.4	12.53	11.10	1.26
1.600	92.0	8.7	4.31	1.23	2.99	8.0	55.5	19.58	19.35	0.03
CALC. RAW CØAL	100.0	12.4	5.53	2.68	2.75					
ANAL. RAW CØAL	100.0	13.4	6.03	2.72	3.09					

SAMPLE 14

SP.GRAV.	FLØAT FRACTIØN					SINK FRACTIØN				
	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.274	21.0	2.8	3.76	0.39	3.35	79.0	14.7	6.09	3.45	2.58
1.292	44.4	3.6	3.61	0.46	3.13	55.6	19.1	7.18	4.68	2.44
1.328	68.3	5.1	3.63	0.58	3.03	31.7	27.7	9.83	7.62	2.13
1.400	86.1	6.7	3.79	0.83	2.93	13.9	46.4	16.82	15.05	1.62
1.600	92.2	8.0	4.15	1.21	2.91	7.8	62.7	22.66	21.65	0.84
CALC. RAW CØAL	100.0	12.2	5.60	2.81	2.75					
ANAL. RAW CØAL	100.0	13.0	5.83	2.52	3.25					

SAMPLE 14S

SP.GRAV.	FLØAT FRACTIØN					SINK FRACTIØN				
	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.280	34.1	3.6	3.75	0.43	3.30	65.9	17.4	6.41	3.96	2.39
1.341	70.6	5.8	3.70	0.63	3.04	29.4	29.3	9.84	7.86	1.87
1.400	84.3	7.1	3.80	0.80	2.97	15.7	42.7	14.64	13.27	1.22
1.600	91.6	8.3	4.01	1.05	2.93	8.4	61.3	21.79	21.38	0.19
CALC. RAW CØAL	100.0	12.7	5.50	2.76	2.70					
ANAL. RAW CØAL	100.0	13.0	5.83	2.52	3.25					

SAMPLE 14C

	FLØAT FRACTIØN					SINK FRACTIØN				
SP,GRAV,	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,275	45,5	4,4	3,83	0,43	3,39	54,5	17,7	6,18	3,73	2,43
1,315	63,4	5,2	3,84	0,48	3,34	36,6	22,9	7,32	5,25	2,03
1,400	82,9	6,9	3,87	0,65	3,21	17,1	34,7	11,15	9,87	1,21
1,600	92,7	8,4	4,19	1,12	3,07	7,3	52,8	16,80	16,37	0,29
CALC, RAW CØAL	100,0	11,7	5,11	2,23	2,87					
ANAL, RAW CØAL	100,0	11,2	4,14	1,73	2,41					

SAMPLE 15

	FLØAT FRACTIØN					SINK FRACTIØN				
SP,GRAV,	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,276	28,0	2,5	3,80	0,26	3,55	72,0	14,5	6,50	3,63	2,86
1,290	45,9	3,3	3,83	0,34	3,49	54,1	17,8	7,37	4,68	2,68
1,320	66,3	4,7	3,80	0,42	3,38	33,7	23,8	9,57	7,15	2,40
1,400	86,2	6,6	3,85	0,60	3,25	13,8	39,7	17,56	15,74	1,81
1,600	92,4	7,6	4,01	0,82	3,19	7,6	53,9	26,79	25,36	1,41
CALC, RAW CØAL	100,0	11,1	5,75	2,69	3,05					
ANAL, RAW CØAL	100,0	15,2	7,70	4,24	3,44					

SAMPLE 15C

	FLØAT FRACTIØN					SINK FRACTIØN				
SP,GRAV,	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,280	41,6	4,5	3,22	0,47	2,75	58,4	19,6	6,68	4,32	2,36
1,315	59,7	5,5	3,24	0,50	2,74	40,3	25,0	8,21	6,00	2,21
1,400	83,4	7,5	3,32	0,63	2,69	16,6	42,6	14,89	13,21	1,69
1,600	90,7	8,7	3,45	0,80	2,65	9,3	58,7	22,69	21,40	1,29
CALC, RAW CØAL	100,0	13,3	5,24	2,72	2,52					
ANAL, RAW CØAL	100,0	13,7	5,69	2,72	2,97					

SAMPLE 16

	FLØAT FRACTIØN					SINK FRACTIØN				
SP,GRAV,	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,270	17,6	3,6	3,18	0,43	2,68	82,4	15,3	5,64	3,16	2,35
1,305	38,1	4,1	3,22	0,47	2,67	61,9	18,9	6,42	4,04	2,25
1,330	52,4	4,9	3,28	0,52	2,68	47,6	22,5	7,32	5,06	2,11
1,400	76,3	6,7	3,42	0,69	2,65	23,7	34,3	10,94	9,07	1,62
1,600	90,0	8,7	3,67	1,01	2,58	10,0	54,8	18,99	17,71	0,86
CALC, RAW CØAL	100,0	13,3	5,20	2,68	2,41					
ANAL, RAW CØAL	100,0	13,0	5,10	2,24	2,82					

SAMPLE 16S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP,GRAV,	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,290	35,5	4,0	3,35	0,54	2,78	64,5	17,0	5,69	3,32	2,31
1,325	53,6	4,9	3,32	0,57	2,71	46,4	21,0	6,64	4,37	2,21
1,400	79,5	6,8	3,41	0,75	2,63	20,5	34,0	10,47	8,50	1,87
1,600	91,9	8,6	3,64	1,03	2,58	8,1	55,5	18,61	17,16	1,29
CALC, RAW CØAL	100,0	12,4	4,86	2,33	2,48					
ANAL, RAW CØAL	100,0	13,0	5,10	2,24	2,82					

SAMPLE 17

	FLØAT FRACTIØN					SINK FRACTIØN				
SP,GRAV,	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S	CUM,WT,	ASH	TØT,S	PYR,S	ØRG,S
1,275	29,5	5,6	2,19	0,31	1,87	70,5	17,6	3,39	1,71	1,67
1,310	48,3	6,4	2,23	0,35	1,88	51,7	21,2	3,79	2,18	1,60
1,325	62,7	7,2	2,23	0,36	1,85	37,3	25,5	4,40	2,86	1,53
1,400	85,8	9,0	2,24	0,42	1,81	14,2	44,9	7,87	6,58	1,27
1,600	91,3	9,8	2,30	0,50	1,78	8,7	58,3	10,84	9,62	1,19
CALC, RAW CØAL	100,0	14,1	3,04	1,29	1,73					
ANAL, RAW CØAL	100,0	15,3	3,08	1,21	1,86					

SAMPLE 17S

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.275	46.7	7.0	2.27	0.35	1.92	53.3	20.2	3.85	2.17	1.67
1.310	55.0	7.2	2.28	0.36	1.92	45.0	22.5	4.13	2.49	1.63
1.400	86.6	9.2	2.29	0.43	1.85	13.4	45.5	8.46	7.06	1.38
1.600	91.4	10.0	2.36	0.53	1.83	8.6	56.9	11.15	9.78	1.35
CALC. RAW CØAL	100.0	14.0	3.11	1.32	1.79					
ANAL. RAW CØAL	100.0	15.3	3.08	1.21	1.86					

SAMPLE 18

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.250	22.5	2.4	2.45	0.39	2.03	77.5	20.9	4.51	2.89	1.54
1.290	49.0	3.0	2.51	0.50	1.98	51.0	29.8	5.51	4.08	1.34
1.330	66.5	3.8	2.62	0.64	1.94	33.5	42.3	6.87	5.67	1.08
1.400	75.6	4.7	2.73	0.78	1.91	24.4	54.0	8.13	7.12	0.86
1.600	83.9	6.3	2.86	0.96	1.85	16.1	70.9	10.20	9.43	0.60
CALC. RAW CØAL	100.0	16.7	4.04	2.33	1.65					
ANAL. RAW CØAL	100.0	18.3	4.46	2.51	1.89					

SAMPLE 18S

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.255	27.0	3.4	2.55	0.58	1.93	73.0	21.0	4.77	3.15	1.52
1.300	47.2	3.0	2.51	0.52	1.96	52.8	28.1	5.65	4.19	1.34
1.400	76.9	4.7	2.72	0.77	1.90	23.1	54.7	8.97	8.06	0.76
1.600	84.6	6.4	2.85	0.94	1.85	15.4	70.8	11.41	10.80	0.43
CALC. RAW CØAL	100.0	16.3	4.17	2.46	1.63					
ANAL. RAW CØAL	100.0	18.3	4.46	2.51	1.89					

SAMPLE 19

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.290	20.4	2.6	0.57	0.04	0.51	79.6	9.1	1.46	0.93	0.45
1.310	44.0	3.3	0.54	0.03	0.49	56.0	11.3	1.86	1.31	0.45
1.330	65.4	3.8	0.54	0.03	0.48	34.6	15.3	2.68	2.09	0.43
1.400	88.0	4.8	0.57	0.06	0.47	12.0	29.5	6.52	5.76	0.42
1.600	96.0	6.0	0.66	0.15	0.47	4.0	50.2	16.19	15.07	0.43
CALC. RAW CØAL	100.0	7.8	1.28	0.75	0.47					
ANAL. RAW CØAL	100.0	7.8	1.36	0.76	0.52					

SAMPLE 19S

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.290	24.2	3.0	0.64	0.14	0.47	75.8	9.2	1.52	1.01	0.43
1.310	50.3	3.6	0.59	0.09	0.46	49.7	11.9	2.04	1.52	0.41
1.400	90.4	5.0	0.58	0.08	0.46	9.6	33.2	8.17	7.57	0.27
1.600	95.6	5.8	0.61	0.11	0.46	4.4	49.7	16.40	15.78	0.06
CALC. RAW CØAL	100.0	7.7	1.31	0.80	0.44					
ANAL. RAW CØAL	100.0	7.8	1.36	0.76	0.52					

SAMPLE 20

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.290	18.7	2.8	0.80	0.15	0.64	81.3	10.3	3.10	2.51	0.55
1.310	41.6	3.6	0.83	0.19	0.62	58.4	12.7	3.99	3.41	0.53
1.330	65.1	4.6	0.87	0.24	0.62	34.9	17.0	6.04	5.50	0.48
1.400	87.0	5.9	0.94	0.33	0.59	13.0	29.3	14.27	13.76	0.41
1.600	95.0	6.8	1.03	0.42	0.58	5.0	49.4	33.97	33.43	0.37
CALC. RAW CØAL	100.0	8.9	2.67	2.07	0.57					
ANAL. RAW CØAL	100.0	8.9	2.68	2.00	0.66					

SAMPLE 20S

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,300	36,8	3,3	0,84	0,20	0,63	63,2	11,9	3,56	2,99	0,55
1,325	67,2	4,6	0,89	0,26	0,62	32,8	17,2	5,98	5,44	0,50
1,400	87,9	5,9	0,96	0,34	0,60	12,1	29,4	14,22	13,70	0,46
1,600	95,2	6,7	1,03	0,43	0,59	4,8	48,5	32,90	32,31	0,48
CALC. RAW CØAL	100,0	8,7	2,56	1,96	0,58					
ANAL. RAW CØAL	100,0	8,9	2,68	2,00	0,66					

SAMPLE 21

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,290	14,8	2,7	0,69	0,14	0,52	85,2	7,9	1,70	1,21	0,46
1,310	32,3	3,5	0,73	0,17	0,54	67,7	8,9	1,94	1,48	0,44
1,320	49,1	3,8	0,71	0,16	0,53	50,9	10,4	2,37	1,92	0,42
1,400	86,7	4,6	0,69	0,18	0,50	13,3	24,1	7,19	6,77	0,33
1,600	95,5	5,4	0,74	0,23	0,49	4,5	45,5	18,80	18,42	0,20
CALC. RAW CØAL	100,0	7,2	1,55	1,05	0,47					
ANAL. RAW CØAL	100,0	6,8	1,49	0,93	0,54					

SAMPLE 21S

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,300	27,8	3,2	0,71	0,12	0,58	72,2	8,5	1,69	1,21	0,45
1,315	42,9	3,6	0,71	0,12	0,58	57,1	9,6	1,95	1,49	0,41
1,400	89,6	4,8	0,68	0,15	0,52	10,4	26,7	7,73	7,39	0,21
1,600	95,8	5,3	0,71	0,18	0,50	4,2	47,4	17,61	17,37	0,02
CALC. RAW CØAL	100,0	7,0	1,42	0,91	0,48					
ANAL. RAW CØAL	100,0	6,8	1,49	0,93	0,54					

SAMPLE 22

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,285	16,5	2,6	2,51	0,46	2,05	83,5	18,6	5,26	3,73	1,50
1,300	33,9	3,1	2,56	0,51	2,05	66,1	22,6	5,96	4,56	1,35
1,325	54,9	4,0	2,66	0,63	2,03	45,1	30,6	7,42	6,30	1,06
1,400	71,7	5,5	2,81	0,84	1,97	28,3	42,6	9,85	9,14	0,63
1,600	81,5	7,2	2,99	1,08	1,91	18,5	54,4	12,77	12,49	0,18
CALC. RAW CØAL	100,0	16,0	4,80	3,19	1,59					
ANAL. RAW CØAL	100,0	15,2	4,60	2,80	1,78					

SAMPLE 22S

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,295	37,2	4,2	2,66	0,63	2,66	62,8	20,8	5,65	4,04	1,57
1,320	57,7	4,8	2,71	0,70	2,41	42,3	28,1	7,03	5,59	1,37
1,400	76,7	6,2	2,84	0,89	2,26	23,3	42,3	10,12	8,96	1,05
1,600	86,4	8,0	3,01	1,11	2,17	13,6	57,0	14,21	13,33	0,74
CALC. RAW CØAL	100,0	14,6	4,54	2,77	1,97					
ANAL. RAW CØAL	100,0	15,2	4,60	2,80	1,78					

SAMPLE 23

SP.GRAV.	FLØAT FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	SINK FRACTIØN CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1,285	25,4	2,4	2,01	0,35	1,65	74,6	18,3	4,24	2,87	1,33
1,300	43,4	3,3	2,08	0,41	1,66	56,6	22,7	4,90	3,63	1,21
1,330	61,0	4,3	2,17	0,52	1,64	39,0	29,9	6,03	4,92	1,04
1,400	76,3	5,8	2,27	0,65	1,60	23,7	41,7	8,21	7,32	0,80
1,600	87,1	7,9	2,40	0,82	1,56	12,9	57,3	12,29	11,76	0,40
CALC. RAW CØAL	100,0	14,3	3,68	2,23	1,41					
ANAL. RAW CØAL	100,0	16,5	3,90	2,61	1,26					

SAMPLE 24

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.290	18.6	2.6	1.99	0.38	1.61	81.4	17.1	4.08	2.87	1.18
1.310	42.3	3.3	2.00	0.46	1.54	57.7	22.6	4.93	3.83	1.06
1.340	61.4	4.1	2.06	0.56	1.51	38.6	30.8	6.28	5.34	0.88
1.400	74.9	5.2	2.15	0.66	1.49	25.1	42.0	8.28	7.59	0.60
1.600	85.9	6.9	2.27	0.81	1.46	14.1	60.3	12.36	12.13	0.09
CALC. RAW CØAL	100.0	14.4	3.69	2.40	1.26					
ANAL. RAW CØAL	100.0	14.4	4.00	2.63	1.36					

SAMPLE 24S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.300	35.4	3.2	1.93	0.43	1.50	64.6	20.3	4.61	3.37	1.18
1.330	63.8	4.3	2.02	0.56	1.46	36.2	31.8	6.55	5.46	1.01
1.400	78.2	5.5	2.12	0.68	1.44	21.8	45.6	9.17	8.27	0.78
1.600	87.0	7.1	2.24	0.81	1.41	13.0	62.0	13.19	12.50	0.51
CALC. RAW CØAL	100.0	14.2	3.66	2.33	1.29					
ANAL. RAW CØAL	100.0	14.4	4.00	2.63	1.36					

SAMPLE 25

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.260	30.4	2.1	2.44	0.46	1.95	69.6	17.8	5.30	3.56	1.62
1.280	44.0	2.3	2.48	0.50	1.94	56.0	21.4	5.97	4.27	1.55
1.300	57.4	2.9	2.56	0.57	1.94	42.6	26.7	6.95	5.36	1.42
1.400	80.9	4.7	2.85	0.88	1.91	19.1	48.3	11.14	9.98	0.91
1.600	86.3	5.6	2.96	1.00	1.90	13.7	59.7	13.68	12.76	0.62
CALC. RAW CØAL	100.0	13.0	4.43	2.61	1.72					
ANAL. RAW CØAL	100.0	12.0	4.33	2.34	1.90					

SAMPLE 26

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.240	6.9	2.9	2.30	0.67	1.63	93.1	14.0	4.88	3.27	1.58
1.270	16.2	2.7	2.33	0.65	1.68	83.8	15.2	5.16	3.57	1.56
1.285	27.8	2.8	2.40	0.65	1.74	72.2	17.2	5.58	4.03	1.52
1.400	76.6	6.0	2.89	1.09	1.79	23.4	36.7	10.62	9.65	0.90
1.600	89.5	8.1	3.05	1.28	1.76	10.5	56.7	18.74	18.59	0.04
CALC. RAW CØAL	100.0	13.2	4.70	3.09	1.58					
ANAL. RAW CØAL	100.0	13.3	4.73	2.98	1.72					

SAMPLE 26S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.250	29.2	3.9	2.70	0.84	1.86	70.8	17.3	5.62	4.03	1.56
1.275	48.0	4.4	2.83	0.94	1.88	52.0	21.7	6.56	5.09	1.43
1.400	85.2	7.6	3.11	1.26	1.84	14.8	46.9	14.32	13.71	0.54
1.600	90.5	8.5	3.20	1.37	1.82	9.5	59.9	19.69	19.57	0.02
CALC. RAW CØAL	100.0	13.4	4.77	3.10	1.65					
ANAL. RAW CØAL	100.0	13.3	4.73	2.98	1.72					

SAMPLE 27

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.300	22.6	1.5	1.96	0.38	1.59	77.4	19.0	4.06	2.89	1.12
1.320	40.3	2.3	1.96	0.48	1.48	59.7	23.6	4.68	3.57	1.05
1.340	53.7	3.2	1.97	0.57	1.40	46.3	28.8	5.45	4.36	1.02
1.400	69.5	4.7	2.14	0.73	1.40	30.5	38.5	6.89	5.96	0.83
1.600	85.8	7.7	2.50	1.09	1.40	14.2	59.4	10.16	9.79	0.19
CALC. RAW CØAL	100.0	15.0	3.59	2.32	1.22					
ANAL. RAW CØAL	100.0	16.5	4.15	2.81	1.32					

SAMPLE 27S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.320	42.9	3.4	2.06	0.46	1.59	57.1	23.6	4.99	3.83	1.09
1.340	58.6	4.4	2.15	0.57	1.57	41.4	29.8	5.97	4.95	0.93
1.400	75.8	6.1	2.28	0.75	1.52	24.2	42.4	8.29	7.51	0.63
1.600	86.1	7.8	2.53	1.03	1.49	13.9	58.7	11.16	10.80	0.16
CALC. RAW CØAL	100.0	14.9	3.73	2.39	1.30					
ANAL. RAW CØAL	100.0	16.5	4.15	2.81	1.32					

SAMPLE 28

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.310	24.2	3.9	1.75	0.70	1.05	75.8	13.2	3.66	2.76	0.89
1.335	49.8	5.1	1.86	0.82	1.03	50.2	16.8	4.53	3.68	0.83
1.365	73.2	6.3	1.96	0.96	1.00	26.8	23.6	6.59	5.79	0.75
1.400	83.1	7.0	2.04	1.06	0.98	16.9	30.2	8.89	8.14	0.70
1.600	94.6	8.4	2.36	1.39	0.96	5.4	56.1	17.97	17.47	0.40
CALC. RAW CØAL	100.0	11.0	3.20	2.26	0.93					
ANAL. RAW CØAL	100.0	11.5	3.42	2.45	0.94					

SAMPLE 28S

	FLØAT FRACTIØN					SINK FRACTIØN				
SP.GRAV.	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S	CUM.WT.	ASH	TØT.S	PYR.S	ØRG.S
1.320	33.4	4.6	1.78	0.75	1.02	66.6	14.0	3.63	2.86	0.73
1.340	51.9	5.2	1.82	0.82	0.99	48.1	17.0	4.30	3.59	0.65
1.400	85.1	7.3	1.97	1.06	0.89	14.9	31.5	8.98	8.39	0.46
1.600	94.2	8.2	2.19	1.30	0.87	5.8	54.0	16.39	16.06	0.11
CALC. RAW CØAL	100.0	10.9	3.01	2.15	0.83					
ANAL. RAW CØAL	100.0	11.5	3.42	2.45	0.94					

Illinois State Geological Survey Circular 484
32 p., 4 figs., 11 tables, 1 app., 3500 cop., 1974
Urbana, IL 61801

Printed by Authority of State of Illinois, Ch. 127, IRS, Par. 58.25.

CIRCULAR 484

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA, IL 61801