FE-2722-7
Distribution Category UC-90i

THE EFFECTS OF MINERALS ON COAL BENEFICIATION PROCESSES

QUARTERLY REPORT NO. 7

April 1 - June 30, 1979

Barry G. McMillan
Richard B. Muter
William H. Buttermore
William C. Grady
John K. Alderman
Thomas Simonyi
Diane Gierl

Approved for Submittal by:

Joseph W. Leonard

WEST VIRGINIA UNIVERSITY
COLLEGE OF MINERAL AND ENERGY RESOURCES
COAL RESEARCH BUREAU
MORGANTOWN, WEST VIRGINIA 26506

September 15, 1979

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Under Contract No. EF-77-S-01-2722

ACKNOWLEDGMENTS

The authors would like to acknowledge the services and skills of Bureau personnel whose efforts are not otherwise documented in this report: Charles R. McFadden for a number of the illustrations presented; Larry L. Nice and the analytical group at the Coal Research Bureau for extensive chemical testing; and Sally See and Martha Fekete who typed and proofed this report.

OBJECTIVE AND SCOPE

The purpose of this research program is to examine the effect of coal cleaning and preparation on the distribution of mineral materials in coal and the influence of the mineral materials on the coal cleaning operation. The research program will involve the examination of, for coal mineral materials: (1) the natural occurrence and distribution of mineral materials in run-of-mine coal, (2) the changes in these characteristics during cleaning and preparation, (3) the specific effects of coal mineral materials on individual cleaning and preparation processes, and (4) improved methods for controlling their distribution.

In order to accomplish these objectives samples will be obtained from three commercial coal preparation plants which are: (1) handling coal from major (by volume) coal seams, (2) handling coal most likely to be used in future large scale coal conversion processes (for example, the Bi-Gas process), and (3) using a range of different types of modern cleaning methods. At least one of these plants shall process a coal likely to be used as a feed to a D.O.E.-supported conversion process or similar to a type of coal likely to be used.

SUMMARY OF PROGRESS TO DATE

At this time, approximately half-way through the contract period, progress has been as scheduled in most areas although somewhat behind in a few. The net effect does not appear to preclude meeting schedule deadlines, although that assumes that no major problems occur with equipment or instrumentation necessary for the remainder of the contract.

This report continues the documentation of detailed characterization of both raw and prepared fractions of coal feeds, products, and refuse from preparation plants in northern West Virginia, southern West Virginia and central Illinois. It also documents the continuing modifications and additions to the pilot scale preparation plant and the installation and initial operation of two recently acquired instruments, i.e. a Scanning Electron Microscope and an X-Ray Powder Diffractomer. These units are both operable at this time, although quantitative/semi-quantitative capabilities are still being refined.

Other areas where significant work was achieved include froth flotation of Pittsburgh, Pocahontas No. 3, and Illinois No. 6 samples and the quantitative determination of kaolinite using IR. This work is documented herein. Additionally, major and minor elemental analysis of samples is on-going and should be reported in the next report.

DESCRIPTION OF TECHNICAL PROGRESS

Coal Preparation Plant Samples

As reported in Quarterly Report No. 5, all major bulk coal sampling has been completed. Testing and characterization of these samples has continued this quarter as reviewed in this report.

Coal Preparation Pilot Plant

Bids for the construction of the heavy media sump have been opened during the quarter. It is estimated that the sump will be completed by the end of October. This reservoir is designed to provide for the recirculation of media for both the Wemco drum heavy media separator and the 8" cyclone.

Operational tests were performed on the jig during the past quarter. Good separation was obtained; however, the refuse gate control device would not function properly. While not absolutely essential to the satisfactory operation of the jig, the control device allows the variation of effective gravities of separation without altering other operating parameters. Work is continuing to restore proper function to the gate control.

Also during the past quarter, floor drains were installed for the jig and the concentrating table. A slurry/distributor tank and platform were also constructed to feed the table. Water supply to the distributor and table are provided by a hose from the elevated head tank. The following photograph (Figure 1) shows the present condition of the pilot plant and sample storage area. In the near foreground crushing and sampling equipment can be seen and the coal cleaning equipment is shown in the background.

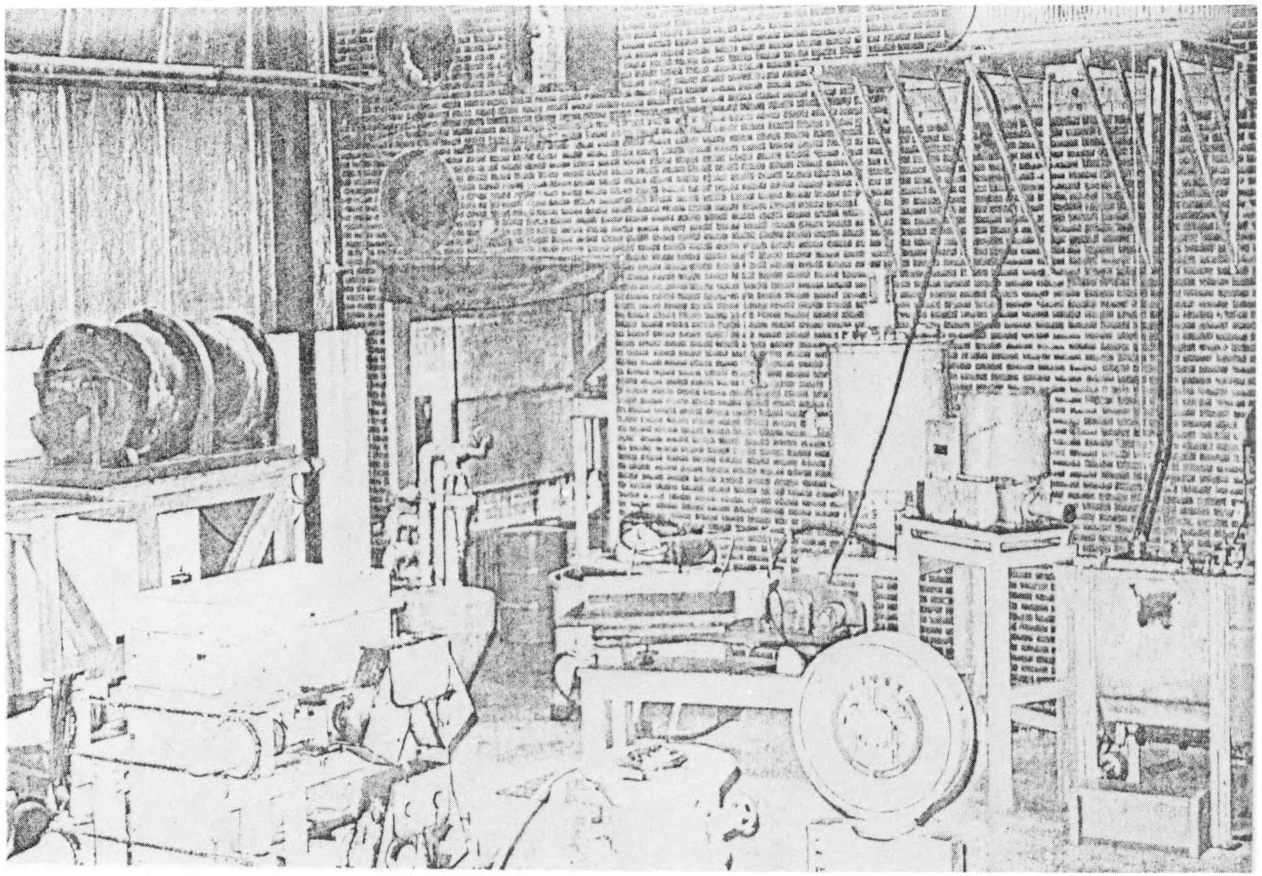


FIGURE 1. Coal Preparation Equipment - left to right: heavy media drum separator, 3" cyclone, concentrating table and distributor, elevated head tank and jig.

Froth Flotation Tests

Work on the froth flotation section of the contract continued with the bench-scale flotation testing of samples from the District 3 (Pittsburgh Seam), District 7 (Pocahontas #3 Seam), and District 10 (Illinois No. 6 Seam) preparation plants. The results of these tests are reported in Tables 1, 2, and 3. The flotation test parameters, proximate analysis, sulfur breakdown and BTU are presented in the tables. From this data, at least one sample will be chosen from each of the districts to be submitted for mineralogical analysis. The criteria used for sample selection will be based on the commercial value of each separation.

Representative 500 gram portions of coal were used in all flotation tests. These samples represented a screen fraction of the raw feed to the preparation plants. The percentage of solids in the flotation feed cell was held constant in the individual trials at 9.1%. The pH of the slurry ranged from 5.5 to 5.8 and the slurry temperature was 23°C $\pm$ 2°C. A 15 minute conditioning period was followed by air induction and a 1 minute collection of the froth overflow. Both the product and refuse were vacuum-filtered and oven-dried at 100°C for 24 hours. The weights of the product and refuse fractions were recorded and a fraction of each was submitted for proximate analysis, sulfur forms, and BTU.

In Table 1 the results of the froth flotation tests on the -50 mesh Pittsburgh seam samples are reported. The best overall product was obtained at an MIBC level of 0.23 pounds per ton. At a higher level of MIBC (0.53 pounds per ton) the product yield decreased but the ash and total sulfur increased relative to the product produced using 0.23 pounds per ton of MIBC. The use of either a pyrite depressant or a wetting agent appear to produce no beneficial effect in froth flotation of the Pittsburgh sample.

TABLE 1

FROTH FLOTATION RESULTS
-50 M Pittsburgh

Sample Description	Reagents[1]	Yield	Moisture	Ash[2]	Volatile[2] Matter	Fixed[2] Carbon
Head Sample	--------	---	0.7	19.6	34.1	46.3
Flotation Product	MIBC-0.53	72%	0.4	11.3	34.9	53.9
Flotation Refuse	MIBC-0.53	28%	0.3	40.1	28.3	31.6
Flotation Product	MIBC-0.23	75%	0.5	8.6	35.6	55.8
Flotation Refuse	MIBC-0.23	25%	0.2	50.9	25.1	24.0
Flotation Product	MIBC-0.23 Pyrite Depressant	70%	1.0	9.3	33.7	57.0
Flotation Refuse	MIBC-0.23 Pyrite Depressant	30%	1.0	37.2	28.3	34.5
Flotation Product	MIBC-0.23 Wetting Agent	76%	0.9	9.9	36.0	54.1
Flotation Refuse	MIBC-0.23 Wetting Agent	24%	1.0	35.6	28.4	36.8

1. lb./ton
2. percentage of whole coal, dry basis

TABLE 1 (Continued)

FROTH FLOTATION RESULTS
-50 M Pittsburgh

Sample Description	Total Sulfur[2]	Sulfate Sulfur[2]	Pyritic Sulfur[2]	Inorganic Sulfur[2]	Organic Sulfur[2]	BTU
Head Sample	3.26	----	----	----	----	------
Flotation Product	3.14	0.02	1.60	1.62	1.52	13,350
Flotation Refuse	3.65	0.03	2.63	2.66	0.99	------
Flotation Product	2.85	0.02	1.37	1.39	1.46	13,776
Flotation Refuse	4.45	0.05	3.78	3.83	0.62	------
Flotation Product	2.95	0.05	1.31	1.36	1.59	13,359
Flotation Refuse	3.95	0.08	2.83	2.91	1.04	------
Flotation Product	3.01	0.10	1.47	1.57	1.47	13,568
Flotation Refuse	3.78	0.11	2.67	2.78	1.00	8,845

2. percentage of whole coal, dry basis

TABLE 2

FROTH FLOTATION RESULTS
-50 M Pocahontas #3

Sample Description	Reagents[1]	Yield	Moisture	Ash[2]	Volatile Matter[2]	Fixed Carbon[2]
Head Sample	--------	---	0.8	14.9	17.3	67.8
Flotation Product	MIBC-0.05 Wetting Agent	69%	1.0	5.1	18.9	76.0
Flotation Refuse	MIBC-0.05 Wetting Agent	31%	0.9	34.9	15.6	49.5
Head Sample	--------	---	0.9	14.7	16.8	68.5
Flotation Product	MIBC-0.10 Wetting Agent	73%	0.7	5.4	17.4	77.2
Flotation Refuse	MIBC-0.10 Wetting Agent	27%	0.7	38.2	15.4	46.4
Flotation Product	MIBC-0.15 Wetting Agent	79%	0.5	6.1	18.0	75.9
Flotation Refuse	MIBC-0.15 Wetting Agent	21%	0.7	45.6	15.2	39.2
Flotation Product	MIBC-0.20 Wetting Agent	82%	0.5	6.5	18.0	75.5
Flotation Refuse	MIBC-0.20 Wetting Agent	18%	0.8	48.4	15.0	36.6
Head Sample	--------	---	1.0	14.8	17.2	68.0
Flotation Product	MIBC-0.25 Wetting Agent	79%	0.5	6.4	17.5	76.1
Flotation Refuse	MIBC-0.25 Wetting Agent	21%	0.8	43.4	15.3	41.3

---

1. lb./ton
2. percentage of whole coal, dry basis

TABLE 2 (Continued)

FROTH FLOTATION RESULTS
-50 M Pocahontas #3

Sample Description	Total[2] Sulfur	Sulfate[2] Sulfur	Pyritic[2] Sulfur	Inorganic[2] Sulfur	Organic[2] Sulfur	BTU
Head Sample	0.75	0.10	0.16	0.26	0.49	13,209
Flotation Product	0.70	0.01	0.06	0.07	0.62	15,027
Flotation Refuse	0.69	0.03	0.30	0.33	0.36	9,705
Head Sample	0.72	0.06	0.15	0.21	0.51	13,306
Flotation Product	0.68	0.02	0.11	0.13	0.55	14,956
Flotation Refuse	0.66	0.06	0.30	0.36	0.30	8,994
Flotation Product	0.67	0.01	0.01	0.12	0.56	14,826
Flotation Refuse	0.62	0.06	0.33	0.39	0.23	7,632
Flotation Product	0.67	0.01	0.12	0.13	0.54	14,765
Flotation Refuse	0.56	0.06	0.28	0.34	0.22	7,149
Head Sample	0.72	0.08	0.16	0.24	0.48	13,273
Flotation Product	0.66	0.01	0.11	0.12	0.54	14,709
Flotation Refuse	0.58	0.05	0.26	0.31	0.27	8.049

2. percentage of whole coal, dry basis

TABLE 3

FROTH FLOTATION RESULTS
-100 M Illinois #6

Sample Description	Reagents[1]	Yield	Moisture	Ash	Volatile Matter[2]	Fixed Carbon[2]
Head Sample	--------	---	3.3	34.2	26.4	39.4
Flotation Product	MIBC-0.38	6.8%	1.1	15.9	24.8	59.3
Flotation Refuse	MIBC-0.38	93.2%	1.4	34.4	26.7	39.8
Flotation Product	MIBC-1.53	41.0%	1.3	12.9	26.8	60.3
Flotation Refuse	MIBC-1.53	59.0%	1.4	45.7	26.0	27.5
Flotation Product	MIBC-1.15 Kerosene-0.23	57.0%	0.6	12.0	32.0	55.4
Flotation Refuse	MIBC-1.15 Kerosene-2.03	43.0%	2.0	59.4	19.2	21.4
Flotation Refuse	MIBC-0.38 Kerosene-0.81	18.0%	0.9	12.2	26.7	61.1
Flotation Refuse	MIBC-0.38 Kerosene-0.81	82.0%	0.9	35.9	25.7	38.4
Flotation Product	MIBC-0.76 Kerosene-1.62	62.0%	0.8	15.7	28.3	56.0
Flotation Refuse	MIBC-0.76 Kerosene-1.62	38.0%	0.5	59.2	19.4	21.4
Flotation Product	MIBC-0.38 Kerosene-1.62	60.6%	0.8	13.3	31.8	54.9
Flotation Refuse	MIBC-0.38 Kerosene-1.62	40.0%	2.5	62.5	18.1	19.4

1. lb./ton
2. percentage of whole coal, dry basis

TABLE 3 (Continued)

FROTH FLOTATION RESULTS
-100 M Illinois #6

Sample Description	Total[2] Sulfur	Sulfate[2] Sulfur	Pyritic[2] Sulfur	Inorganic[2] Sulfur	Organic[2] Sulfur	BTU
Head Sample	3.99	0.19	2.23	2.42	1.57	------
Flotation Product	2.16	0.02	0.60	0.62	1.54	11,940
Flotation Refuse	3.88	0.02	2.23	2.25	1.63	------
Flotation Product	2.62	0.04	0.76	0.80	1.82	12,002
Flotation Refuse	4.55	0.03	3.06	3.09	1.46	------
Flotation Product	3.51	0.02	1.34	1.36	2.15	12,407
Flotation Refuse	4.16	0.02	3.31	3.33	0.83	------
Flotation Refuse	2.61	0.04	0.78	0.82	1.79	12,284
Flotation Refuse	4.16	0.05	2.56	2.61	1.55	------
Flotation Product	3.48	0.06	1.35	1.41	2.07	11,573
Flotation Refuse	4.54	0.12	3.81	3.93	0.61	------
Flotation Product	3.49	0.02	1.33	1.35	2.14	12,239
Flotation Refuse	4.50	0.04	3.69	3.73	0.77	------

2. percentage of whole coal, dry basis

The results of the froth flotation tests using the Pocahontas #3 sample are reported in Table 2. A small quantity of wetting agent was used in each test to help thoroughly wet the coal in the flotation cell. In preliminary tests, the Pocahontas #3 sample proved difficult to thoroughly wet. As can be seen in the table, the initial trial with the Pocahontas #3 sample was run at an MIBC level of 0.05 pounds per ton. In each successive test the amount of MIBC was increased by 0.05 pounds per ton over the previous test. The yield increased as the amount of MIBC used increased until a yield of 82 percent was achieved. At this point the yield should remain at 82 percent with additional increases of MIBC even though the data indicate a decrease in yield at MIBC levels exceeding 0.20 pounds per ton. It should be noted that for the Pocahontas #3 sample, as the yield increased, total sulfur remains relatively constant. This indicates that the majority of the sulfur present in the coal sample is in the organic portion and is unaffected by common coal cleaning practice.

Effective flotation of the Illinois #6 sample proved to be difficult. It can be seen in Table 3 that the product yields for this sample were much lower than either the Pittsburgh or Pocahontas #3 samples. By the addition of kerosene to the flotation cell acceptable product yields were obtained. The sulfur and ash content of the products were comparable to those of the clean coal product at the original commercial preparation plant cleaning the coal.

During the next quarter, chemical analyses will be performed on a few remaining samples and mineralogical evaluation will begin on selected product and refuse fractions from the froth flotation tests.

Characterization of Coal Samples

The following section is a review of progress in the chemical, physical, and mineralogical characterization of samples from Facet I.

Chemical Characterization

Additional chemical characterization data have been determined for each group of twenty-five size and gravity fractions of the Illinois No. 6, Pittsburgh, and Pocahontas No. 3 coals (see Tables 4, 5, and 6). This data, which includes the proximate analyses and sulfur breakdown determinations for the Illinois coal (Table 4), and the recently completed ultimate analyses for the Pittsburgh Seam (Table 5) and the Pocahontas No. 3 Seam (Table 6), are being added to the computerized data file for subsequent data processing in combination with other sample parameters.

Sample fractions were prepared for analysis using the conventional procedure previously described (Quarterly Report No. 5), producing twenty-five individual components from the plus 100 mesh coal. The minus 100 mesh sample and the raw coal head sample were also analyzed and are reported in Table 4 to facilitate comparisons.

Table 4 data indicate the difficulty of producing a low sulfur, clean coal product from this seam using conventional cleaning techniques. The head sample is not only high in total S, ash, and moisture, but contains this sulfur in roughly equivalent amounts of organic and inorganic fractions. An examination of the components shows that not only does the total S remain high, but that even cleaning at a 1.40 gravity a high ash, high sulfur product is obtained. Normal variation within size fractions is apparent and additional trends may be determined using more sophisticated trend analysis techniques.

Tables 5 and 6 contain ultimate analyses for the Pittsburgh and Pocahontas No. 3 samples. For these data several trends are noticeable

TABLE 4

CHEMICAL CHARACTERIZATION DATA
(ILLINOIS NO. 6 COAL - SIZED, GRAVITY FRACTION)*

	Proximate Analysis				Sulfur Breakdown			
	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulfate S	Pyrite S	Organic S	Total S
+1" Coal								
Float 1.3	7.9	6.4	47.9	45.7	0.01	0.66	3.13	3.80
1.3 x 1.4	7.1	13.8	41.5	44.7	0.03	1.46	2.82	4.31
1.4 x 1.6	5.2	22.5	36.0	41.5	0.08	6.00	2.28	8.36
1.6 x 1.8	4.0	36.7	29.7	33.6	0.11	7.44	1.92	9.47
Sink 1.8	2.2	83.6	9.8	6.4	0.06	6.64	0.31	7.01
1" x 1/4" Coal								
Float 1.3	1.7	6.0	45.4	48.6	0.04	0.69	3.18	3.91
1.3 x 1.4	1.4	14.1	40.7	45.2	0.06	1.87	2.69	4.61
1.4 x 1.6	1.2	23.2	34.7	42.1	0.12	4.84	2.09	7.05
1.6 x 1.8	1.1	37.6	28.5	33.9	0.14	6.15	1.63	7.92
Sink 1.8	0.6	84.0	9.8	6.2	0.02	6.64	0.33	6.99
1/4" x 8 Mesh								
Float 1.3	4.4	6.0	47.8	46.2	0.04	0.70	3.16	3.90
1.3 x 1.4	3.0	16.8	38.9	44.3	0.03	2.01	2.66	4.70
1.4 x 1.6	2.2	23.2	33.9	42.9	0.03	3.96	2.31	6.30
1.6 x 1.8	2.4	27.6	31.8	40.6	0.10	4.77	2.21	7.08
Sink 1.8	1.0	78.2	11.8	10.0	0.03	6.66	0.43	7.10

*Data reported in percent, on a moisture free whole coal basis (for each fraction).

TABLE 4 (Continued)

CHEMICAL CHARACTERIZATION DATA
(ILLINOIS NO. 6 COAL - SIZED, GRAVITY FRACTION)*

	Proximate Analysis				Sulfur Breakdown			
	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulfate S	Pyrite S	Organic S	Total S
8 x 28 Mesh Coal								
Float 1.3	8.7	5.0	45.7	49.3	0.01	0.57	3.09	3.67
1.3 x 1.4	6.5	19.5	35.6	44.9	0.09	1.99	2.36	4.33
1.4 x 1.6	0.7	25.1	33.4	41.5	0.10	2.06	2.17	4.44
1.6 x 1.8	0.4	36.0	27.3	36.7	0.16	4.05	1.58	5.79
Sink 1.8	0.4	77.4	13.9	8.7	0.14	6.30	0.30	6.74
28 x 100 Mesh Coal								
Float 1.3	0.6	8.0	43.9	48.1	0.02	0.54	2.93	3.49
1.3 x 1.4	1.3	26.6	32.2	41.2	0.10	1.53	2.04	3.67
1.4 x 1.6	0.6	29.3	30.0	40.7	0.13	1.62	1.93	3.68
1.6 x 1.8	0.4	39.5	25.7	34.8	0.15	2.41	1.48	4.04
Sink 1.8	0.5	69.1	17.9	13.0	0.38	6.02	0.21	6.61
Minus 100 Mesh								
	3.3	34.2	26.4	39.4	0.19	2.23	1.57	3.99
Raw Coal Head								
	7.9	28.1	34.9	37.0	0.10	2.79	2.21	5.10

*Data reported in percent, on a moisture free whole coal basis (for each fraction).

TABLE 5

ULTIMATE ANALYSIS
(PITTSBURGH SEAM - SIZED, GRAVITY FRACTIONS)

Sample	C	H	O	N	S
+1 Coal					
Float 1.3	79.70	5.28	4.17	1.51	2.45
1.3 x 1.4	74.69	4.97	3.60	1.25	3.72
1.4 x 1.6	66.86	4.38	0.51	1.09	3.80
1.6 x 1.8	52.64	3.35	1.21	0.81	3.10
Sink 1.8	17.72	1.24	2.39	0.27	7.55
1" x 1/4" Coal					
Float 1.3	78.39	5.35	7.34	0.65	2.22
1.3 x 1.4	72.54	4.94	5.86	0.54	3.92
1.4 x 1.6	62.42	4.13	2.53	0.41	5.62
1.6 x 1.8	51.59	3.16	1.38	0.04	6.64
Sink 1.8	15.64	1.25	3.44	0.10	6.49
1/4" x 8 Mesh Coal					
Float 1.3	78.41	5.28	7.36	0.76	2.15
1.3 x 1.4	62.29	4.42	4.99	0.52	4.72
1.4 x 1.6	62.60	4.15	3.49	0.49	5.85
1.6 x 1.8	54.06	3.28	0.96	0.20	6.89
Sink 1.8	15.78	1.19	1.11	0.10	8.67
8 x 28 Mesh Coal					
Float 1.3	78.09	5.29	9.37	0.48	2.04
1.34 x 1.4	72.19	4.86	7.51	0.34	3.43
1.4 x 1.6	65.46	4.46	3.40	0.48	5.49
1.6 x 1.8	54.03	3.10	0.45	0.75	6.82
Sink 1.8	15.83	1.21	0.29	0.24	9.92
28 x 100 Mesh Coal					
Float 1.3	78.80	5.19	5.95	1.78	2.11
1.3 x 1.4	76.83	4.99	4.09	1.30	2.76
1.4 x 1.6	70.31	4.47	2.71	1.24	4.09
1.6 x 1.8	58.70	3.26	0.34	0.71	5.99
Sink 1.8	17.25	0.94	2.30	0.26	11.13
Minus 100 Mesh Coal					
	64.36	4.14	5.29	0.24	3.60
Raw Coal Head					
	72.38	4.68	3.38	1.25	3.01

*Percent element on a moisture free whole coal basis (for each fraction).

TABLE 6

ULTIMATE ANALYSIS
(POCAHONTAS NO. 3 SEAM - SIZED, GRAVITY FRACTIONS)

Sample	C	H	O	N	S
+1" Coal					
Float 1.3	89.20	4.41	0.97	1.27	0.74
1.3 x 1.4	86.96	4.03	0.39	1.34	0.62
1.4 x 1.6	74.33	3.35	1.28	0.97	0.56
1.6 x 1.8	58.43	2.80	0.84	0.74	0.42
Sink 1.8	16.76	1.20	1.63	0.32	0.36
1" x 1/4" Coal					
Float 1.3	89.62	4.37	9.88	1.29	0.61
1.3 x 1.4	84.54	3.96	1.56	0.97	0.59
1.4 x 1.6	72.51	3.37	0.63	0.77	0.51
1.6 x 1.8	57.80	2.88	1.83	0.56	0.43
Sink 1.8	10.05	1.02	2.01	0.11	0.34
1/4" x 8 Mesh Coal					
Float 1.3	87.73	4.30	3.28	1.04	0.64
1.3 x 1.4	84.87	4.11	1.07	0.88	0.62
1.4 x 1.6	75.11	3.42	2.42	0.58	0.58
1.6 x 1.8	60.32	2.74	2.38	0.50	0 54
Sink 1.8	10.72	0.93	3.15	0.10	0.37
8 x 28 Mesh Coal					
Float 1.3	88.64	4.49	2.35	1.25	0.65
1.3 x 1.4	81.36	3.97	0.74	1.03	0.62
1.4 x 1.6	75.70	3.41	1.98	0.72	0.57
1.6 x 1.8	60.34	2.68	4.55	0.50	0.64
Sink 1.8	16.50	1.11	2.62	0.14	0.59
28 x 100 Mesh Coal					
Float 1.3	88.40	4.50	2.27	1.33	0.66
1.3 x 1.4	83.72	4.24	2.46	1.13	0.67
1.4 x 1.6	77.89	3.75	2.64	0.89	0.63
1.6 x 1.8	67.80	3.15	3.36	0.72	0.74
Sink 1.8	21.21	1.27	3.27	0.26	1.73
Minus 100 Mesh Coal					
	77.94	3.77	2.40	0.90	0.71
Raw Coal Head					
	59.51	3.06	0.53	0.70	0.50

*Percent element on a moisture free whole coal basis (for each fraction).

within size fractions, i.e. C, H, and N decrease as gravity and sulfur increase. The O content does not show a consistent trend, with higher concentrations occurring somewhat at random. Further examinations of this data will be reported in the future.

Physical Characterization

Table 7 contains the data from the float and sink separations of the various size fractions of the Illinois No. 6 coal. The following gravities were employed: 1.3, 1.4, 1.6, and 1.8. An overview of the data indicates that cleaning at 1.4, the product will vary between 50 and 78 weight percent float with S ranging from about 1.8 to 3.5 for a given size fraction. Significant decreases in yield occur in the gravity fractions 1.4 x 1.6 and 1.6 x 1.8 with significant increases in both ash and total sulfur. These relationships will be related to mineral content when this data is quantified in more detail.

Figure 2 shows the cumulative logarithmic plot of the screen analysis of the Illinois No. 6 raw coal head sample (District 10 Preparation Plant). The following data was used to generate the curve:

Size Fraction	Weight %
+1"	8%
1" x 1/4"	24%
1/4" x 8 M	26%
8 M x 28 M	23%
28 M x 100 M	17%
-100 M	2%

TABLE 7

FLOAT AND SINK DATA (+1" Carlinville Head Sample)

Specific Gravity	Individual Fractions			Cumulative Float			Cumulative Sink			Cumulative Sulfur
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Wt. %	Ash %	Ash Prod.	Wt. %	Ash Prod.	Ash %	Wt. %	Ash Prod.	Ash %	
Float 1.3	29.1	6.4	186.24	29.10	186.24	6.40	100.00	4240.35	42.40	0.96
1.3 x 1.4	20.7	13.8	285.66	49.80	471.90	9.48	70.90	4054.11	57.18	1.85
1.4 x 1.6	4.0	22.5	90.00	53.80	561.90	10.44	50.20	3768.45	75.07	2.19
1.6 x 1.8	4.1	36.7	150.47	57.90	712.37	12.30	46.20	3678.45	79.62	2.58
Sink 1.8	42.1	83.8	3527.98	100.00	4240.35	42.40	42.10	3527.98	83.80	5.53

FLOAT AND SINK DATA (1" x 1/4" Carlinville Head Sample)

Specific Gravity	Individual Fractions			Cumulative Float			Cumulative Sink			Cumulative Sulfur
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Wt. %	Ash %	Ash Prod.	Wt. %	Ash Prod.	Ash %	Wt. %	Ash Prod.	Ash %	
Float 1.3	48.3	6.0	289.80	48.30	289.80	6.00	100.00	2901.18	29.01	1.89
1.3 x 1.4	19.4	14.1	273.54	67.70	563.34	8.32	51.70	2611.38	50.51	2.78
1.4 x 1.6	4.8	23.2	111.36	72.50	674.70	9.31	32.30	2337.84	72.38	3.12
1.6 x 1.8	1.8	37.6	67.68	74.30	742.38	9.99	27.50	2226.48	80.96	3.26
Sink 1.8	25.7	84.0	2158.80	100.00	2901.18	29.01	25.70	2158.80	84.00	5.06

TABLE 7 (Continued)

FLOAT AND SINK DATA (1/4" x 8 M Carlinville)

Specific Gravity	Individual Fractions			Cumulative Float			Cumulative Sink			Cumulative Sulfur
(1)	(2) Wt. %	(3) Ash %	(4) Ash Prod.	(5) Wt. %	(6) Ash Prod.	(7) Ash %	(8) Wt. %	(9) Ash Prod.	(10) Ash %	(11)
Float 1.3	60.8	6.00	364.80	60.80	364.80	6.00	100.20	2032.70	20.29	2.37
1.3 x 1.4	17.0	16.80	285.60	77.80	650.40	8.36	39.40	1667.90	42.33	3.55
1.4 x 1.6	4.6	23.20	106.72	82.40	757.12	9.19	22.40	1382.30	61.71	4.04
1.6 x 1.8	2.3	27.60	63.48	84.70	820.60	9.69	17.80	1275.58	71.66	4.21
Sink 1.8	15.5	78.20	1212.10	100.20	2032.70	20.29	15.50	1212.10	78.20	5.31

FLOAT AND SINK DATA (8 x 28 M Carlinville)

Specific Gravity	Individual Fractions			Cumulative Float			Cumulative Sink			Cumulative Sulfur
(1)	(2) Wt. %	(3) Ash %	(4) Ash Prod.	(5) Wt. %	(6) Ash Prod.	(7) Ash %	(8) Wt. %	(9) Ash Prod.	(10) Ash %	(11)
Float 1.3	50.1	5.00	250.50	50.10	250.50	5.00	100.00	2107.19	21.07	1.84
1.3 x 1.4	25.0	19.50	487.50	75.10	738.00	9.83	49.90	1856.69	37.21	2.92
1.4 x 1.6	7.9	25.10	198.29	83.00	936.29	11.28	24.90	1369.19	54.99	3.27
1.6 x 1.8	3.5	36.00	126.00	86.50	1062.29	12.28	17.00	1170.90	68.88	3.47
Sink 1.8	13.5	77.40	1044.90	100.00	2107.19	21.07	13.50	1044.90	77.40	4.38

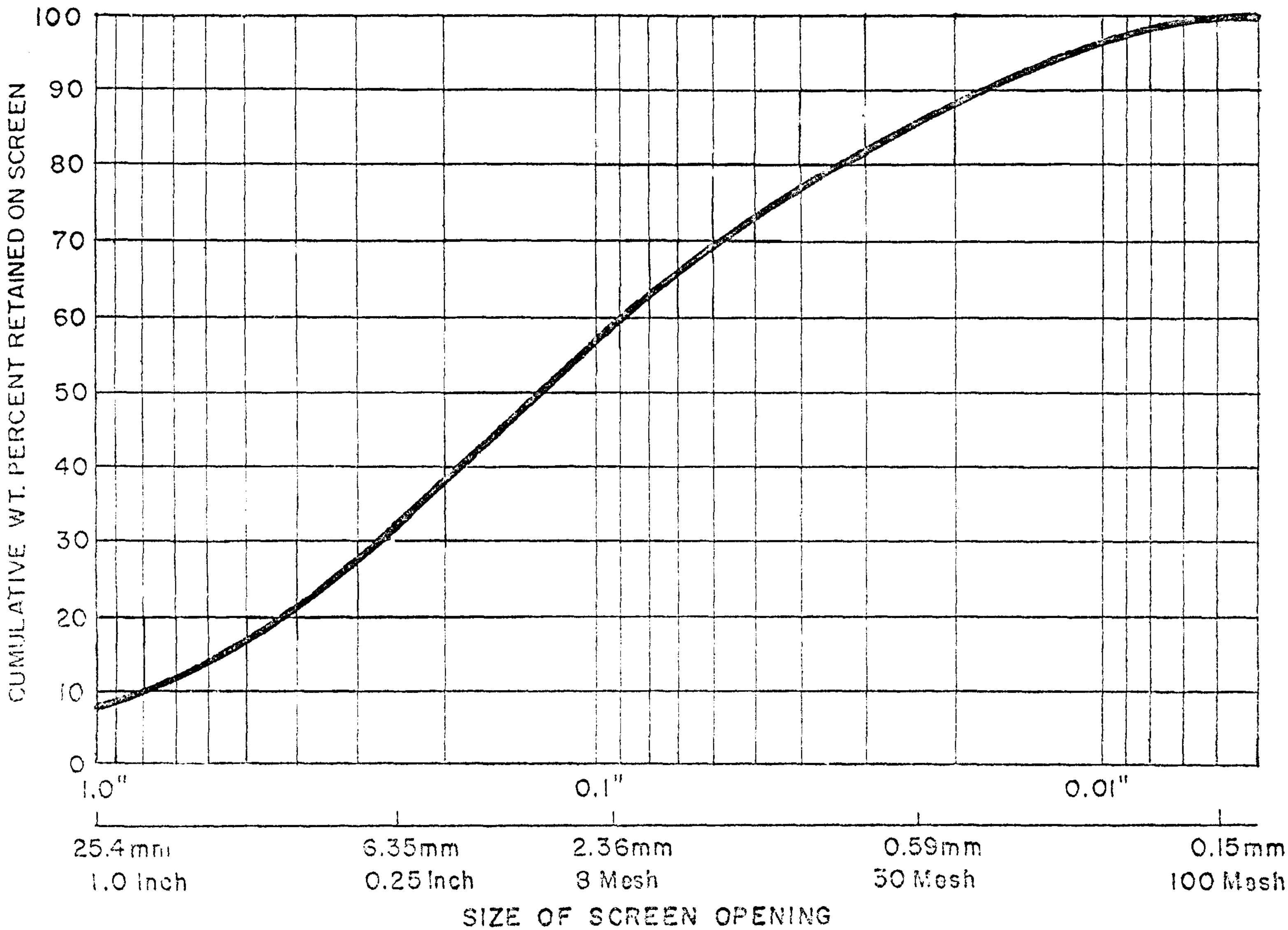
TABLE 7 (Continued)

FLOAT AND SINK DATA (28 x 100 M Carlinville)

Specific Gravity	Individual Fractions			Cumulative Float			Cumulative Sink			Cumulative Sulfur
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Wt. %	Ash %	Ash Prod.	Wt. %	Ash Prod.	Ash %	Wt. %	Ash Prod.	Ash %	
Float 1.3	14.0	8.00	112.00	14.00	112.00	8.00	100.10	2990.73	29.88	0.49
1.3 x 1.4	64.8	26.60	1723.68	78.80	1835.68	23.30	86.10	2878.73	33.43	2.87
1.4 x 1.6	6.1	29.30	178.73	84.90	2014.41	23.73	21.30	1155.05	54.23	3.09
1.6 x 1.8	2.5	39.50	98.75	87.40	2113.16	24.18	15.20	976.32	64.32	3.19
Sink 1.8	12.7	69.10	877.57	100.10	2990.73	29.83	12.70	877.57	69.10	4.03

FIG. 2

ILLINOIS NO. 6 RAW COAL (CUMULATIVE LOGARITHMIC PLOT OF SCREEN ANALYSIS)



Mineralogical Characterization

During this quarter a Cambridge Stereoscan 150 Scanning Electron Microscope was acquired by the Coal Research Bureau. This instrument, operated in conjunction with a Kevex X-Ray Dispersion Unit (acquired but not yet operational), will be utilized to study the nature and distribution of coal-associated minerals. The capability provided by the S.E.M. will enable the detailed study of the morphology (size, shape, etc.) of single particles (crystals) within the coal matrix, and together with the Kevex Unit, elemental ratio daya may be determined. The elemental concentrations obtained may then be utilized to formulate mineralogical composition on a semi-quantitative basis (eg. high concentrations of iron and sulfur indicative of pyrite occurrence).

The S.E.M. has been set up and is now functional. Personnel are in the process of becoming familiar with its routine operational parameters. The Kevex is expected to be installed and in operation in the next quarter.

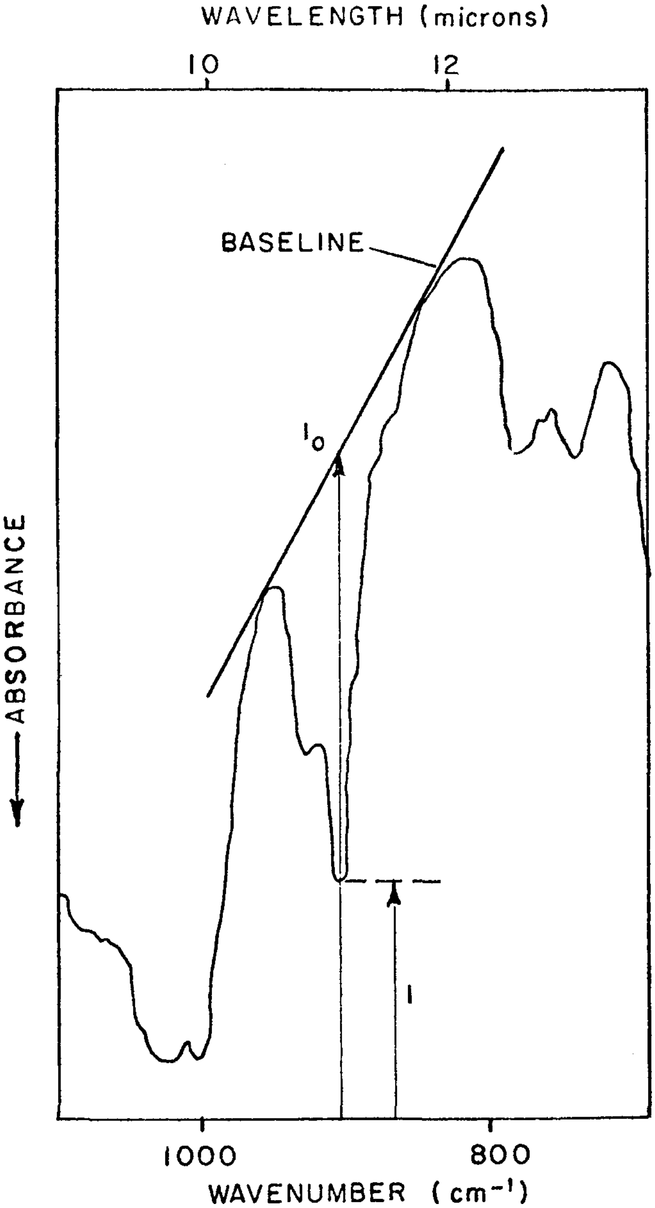
Other areas of this section report progress achieved in kaolinite determination using IR and continued progress in achieving X-ray Powder Diffraction capabilities.

Petrographic Analysis - Work showing the mass balance of both macerals and minerals through the three preparation plants studied is nearly complete and will be reported next quarter. The important contribution of this study will be to follow mineral occurrences such as microscopic pyrite types or carbonate types (fracture filling, cell filling, etc.) through the plants. This will provide valuable information to be coupled with the mineral species determination by X-ray powder diffraction and I. R. spectroscopy.

Infrared Analysis - This quarter the quantitative distribution of kaolinite was determined in the float-sink fractions of the Pittsburgh, Pocahontas No. 3, and Illinois No. 6 coals. Kaolinite concentration in the low-temperature ash (LTA) of the coals studied was determined from infrared spectra utilizing the baseline method.[1] The absorption band chosen for quantitative analysis occurred at 910 cm^{-1}. The incident radiation (I_o) was measured by drawing a straight line tangential to the shoulders of the band. The transmitted radiation (I) was measured at the point of greatest absorbance (Figure 3). The value of log I_o/I, or absorbance, was then plotted against kaolinite concentration. A kaolinite calibration curve was thus prepared utilizing five synthetic mixtures containing various concentrations of American Petroleum Institute kaolinite standard No. 5 (Bath, S.C.), (Figure 4). These standard curves do not take into account effects of other minerals in the LTA, and for this reason are being currently re-evaluated.

Using this technique for Pittsburgh coal, kaolinite seemed to be highest in the 1.30 floats as shown in Table 8. In the 1.30 float group, as well as in the other gravity fractions of the Pittsburgh coal, the percentage of kaolinite appeared to be a function of specific gravity and not particle size. Kaolinite concentration is shown to successively decrease with increasing specific gravity, with the lowest concentrations occurring in the 1.80 float and 1.80 sink fractions. This is contrasted with the Pocahontas coal, in which the percentage of kaolinite increases successively with increasing specific gravity up to sp. gr. 1.60. The average kaolinite concentration in the 1.60 float group was 31% (Table 9). As was determined in the Pittsburgh coals, the lowest percentage of the mineral was found in the 1.80 sink fractions, and further, the kaolinite concentration again appeared to be a function of specific gravity alone. The trend shown by the Illinois No. 6 coal with respect to kaolinite distribtuion was in contrast to both the Pittsburgh and Pocahontas coals, i.e., the mineral was evenly distributed in all of the float-sink fractions and did not appear to be concentrated in any one fraction (Table 10). Kaolinite values ranged from an average value of 15% in the 1.80 sink group to 18% in the 1.40 group.

FIGURE 3



METHOD OF DRAWING BASELINE
FOR PLOTTING COMPOSITION VERSUS LOG I_o/I

FIGURE 4

Kaolinite Calibration Curve Utilizing The 910 CM^{-1} Absorption Band

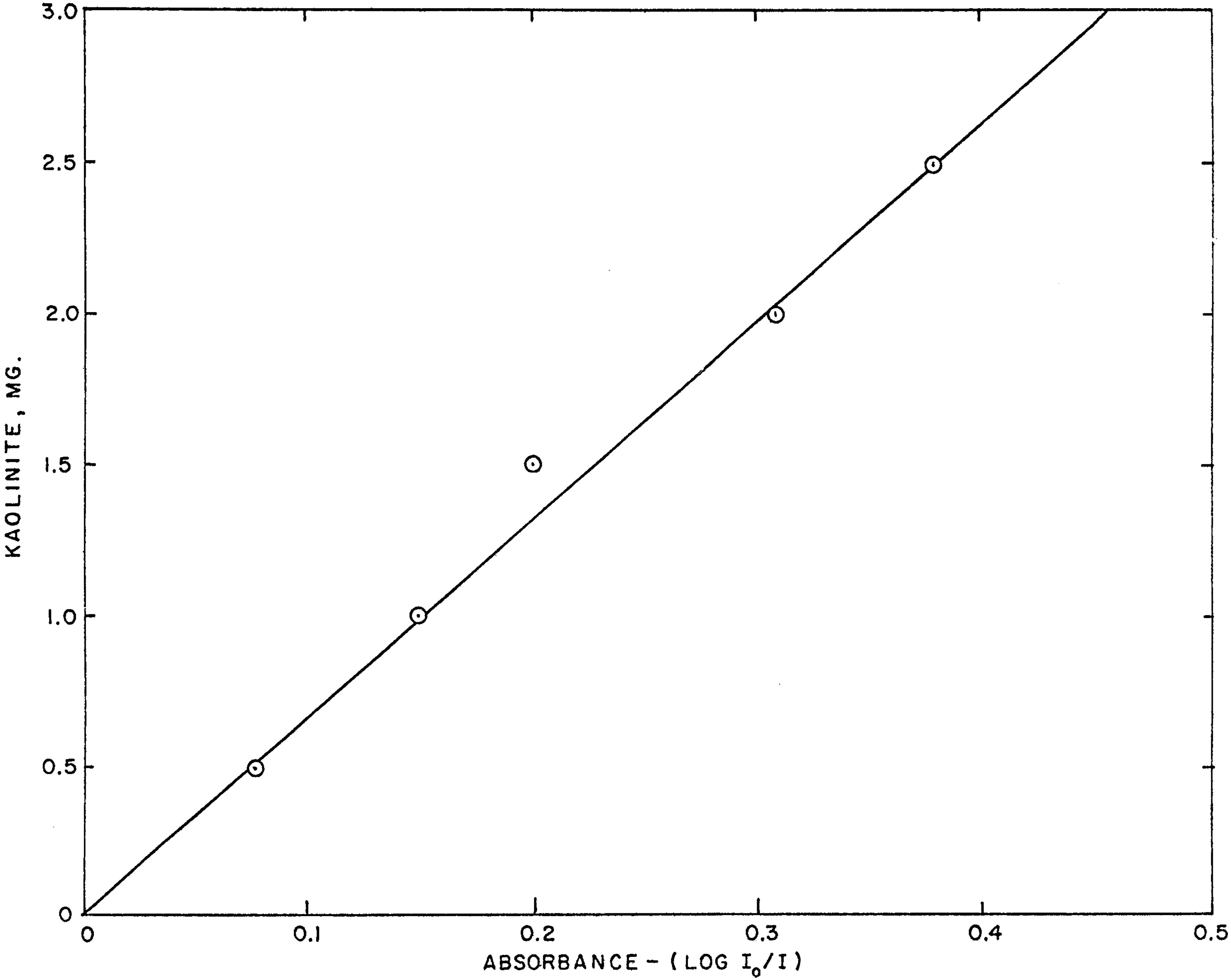


TABLE 8

PITTSBURGH COAL

Sample Description	Absorbance($\log I_o/I$)	Percent Kaolinite	
+1", 1.30 Float	.166	22	
1 x 1/4, 1.30 Float	.194	26	
1/4 x 8 Mesh, 1.30 Float	.168	22	
8 x 28 Mesh, 1.30 Float	.201	27	
28 x 100 Mesh, 1.30 Float	.219	29	AVE = 25%
+1", 1.40 Float	.107	14	
1 x 1/4, 1.40 Float	.161	21	
1/4 x 8 Mesh, 1.40 Float	.125	16	
8 x 28 Mesh, 1.40 Float	.185	24	
28 x 100 Mesh, 1.40 Float	.184	24	AVE = 20%
+1", 1.60 Float	.066	9	
1 x 1/4, 1.60 Float	.099	13	
1/4 x 8 Mesh, 1.60 Float	.097	13	
8 x 28 Mesh, 1.60 Float	.131	17	
28 x 100 Mesh, 1.60 Float	.170	22	AVE = 15%
+1", 1.80 Float	.085	11	
1 x 1/4, 1.80 Float	.083	11	
1/4 x 8 Mesh, 1.80 Float	.073	10	
8 x 28 Mesh, 1.80 Float	.078	10	
28 x 100 Mesh, 1.80 Float	.101	13	AVE = 11%
+1", 1.80 Sink	.114	15	
1 x 1/4, 1.80 Sink	.116	15	
1/4 x 8 Mesh, 1.80 Sink	.088	12	
8 x 28 Mesh, 1.80 Sink	.079	10	
28 x 100 Mesh, 1.80 Sink	.060	8	AVE = 12%

TABLE 9

POCAHONTAS COAL

Sample Description	Absorbance($\log I_o/I$)	Percent Kaolinite	
+1", 1.30 Float	.040	5	
1 x 1/4, 1.30 Float	.085	11	
1/4 x 8 Mesh, 1.30 Float	.204	27	
8 x 28 Mesh, 1.30 Float	.200	26	
28 x 100 Mesh, 1.30 Float	.176	23	AVE = 18%
+1", 1.40 Float	.190	25	
1 x 1/4, 1.40 Float	.206	27	
1/4 x 8 Mesh, 1.40 Float	.213	28	
8 x 28 Mesh, 1.40 Float	.199	26	
28 x 100 Mesh, 1.40 Float	.249	33	AVE = 28%
+1", 1.60 Float	.219	29	
1 x 1/4, 1.60 Float	.222	29	
1/4 x 8 Mesh, 1.60 Float	.219	29	
8 x 28 Mesh, 1.60 Float	.219	29	
28 x 100 Mesh, 1.60 Float	.287	38	AVE = 31%
+1", 1.80 Float	.174	23	
1 x 1/4, 1.80 Float	.183	24	
1/4 x 8 Mesh, 1.80 Float	.185	24	
8 x 28 Mesh, 1.80 Float	.204	27	
28 x 100 Mesh, 1.80 Float	.225	30	AVE = 26%
+1" x 1.80 Sink	.069	9	
1 x 1/4, 1.80 Sink	.106	14	
1/4 x 8 Mesh, 1.80 Sink	.101	13	
8 x 28 Mesh, 1.80 Sink	.122	16	
28 x 100 Mesh, 1.80 Sink	.085	11	AVE = 13%

TABLE 10

ILLINOIS NO. 6 COAL

Sample Description	Absorbance ($\log I_o/I$)	Percent Kaolinite	
+1", 1.30 Float	.128	17	
1 x 1/4, 1.30 Float	.125	16	
1/4 x 8 Mesh, 1.30 Float	.134	18	
8 x 28 Mesh, 1.30 Float	.116	15	
28 x 100 Mesh, 1.30 Float	.129	17	AVE = 17%
+1", 1.40 Float	.119	16	
1 x 1/4, 1.40 Float	.133	17	
1/4 x 8 Mesh, 1.40 Float	.139	18	
8 x 28 Mesh, 1.40 Float	.134	18	
28 x 100 Mesh, 1.40 Float	.143	19	AVE = 18%
+1", 1.60 Float	.106	14	
1 x 1/4, 1.60 Float	.110	14	
1/4 x 8 Mesh, 1.60 Float	.141	19	
8 x 28 Mesh, 1.60 Float	.154	20	
28 x 100 Mesh, 1.60 Float	.136	18	AVE = 17%
+1", 1.80 Float	.073	10	
1 x 1/4, 1.80 Float	.126	17	
1/4 x 8 Mesh, 1.80 Float	.136	18	
8 x 28 Mesh, 1.80 Float	.143	19	
28 x 100 Mesh, 1.80 Float	.137	18	AVE = 16%
+1", 1.80 Sink	.106	14	
1 x 1/4, 1.80 Sink	.109	14	
1/4 x 8 Mesh, 1.80 Sink	.119	16	
8 x 28 Mesh, 1.80 Sink	.109	14	
28 x 100 Mesh, 1.80 Sink	.116	15	AVE = 15%

A general trend for the qualitative distribution of quartz in the float-sink fractions of the three coals studied was also observed. Quartz was not detectable by IR spectroscopy in the 1.30 and 1.40 float fractions of both the Pittsburgh and Pocahontas coals, but was concentrated in the 1.80 float and 1.80 sink fractions of both coals. Infrared spectra of the specific gravity fractions of the Illinois No. 6 coal revealed an even distribution of quartz in all the fractions.

In summary, kaolinite was generally concentrated in the lighter gravity fractions (1.30 and 1.40 floats), with the lowest concentrations occurring in the sink fractions. Distribution did not appear to be a function of particle size. Quartz, as expected, was concentrated in the heavier gravity fractions (1.80 float and 1.80 sink), with minimal concentrations in the lighter fractions. The Illinois NO. 6 coal proved to be the exception to both these cases, with both minerals generally being evenly distributed with respect to specific gravity and size.

X-Ray Powder Diffraction (XRPD) - The installation of the Philips APD 3501 X-Ray unit was completed during quarter seven.

Calibration of the APD is currently in progress. Standard mineral samples (calcite, pyrite, quartz, gypsum, illite, montmorillite, rutile, hematite, and other coal associated minerals) are being analyzed on the APD and the results compared with mineralogical data available from the JCPDS Inorganic Powder Diffraction File.

Combined samples using various weight percentages of the standard minerals will also be analyzed to enable the preparation of standard mineral curves which will show the percent mineral occurring in the sample in accordance with the peak intensities produced. These curves will be utilized in determining the percent mineral present in the low temperature ashed coals, on a whole coal basis.

Analyses of low-temperature ashed coals using the standard mineral curves will be presented in future reports.

References

1. O'Gorman J. V., "Studies of Mineral Matter and Trace Elements in North American Coals," Ph.D. Dissertation, Pennsylvania State University, 1971, p. 122.

Blank Page

APPENDIX A

EFFECTS OF MINERALS ON COAL BENEFICIATION PROCESSES

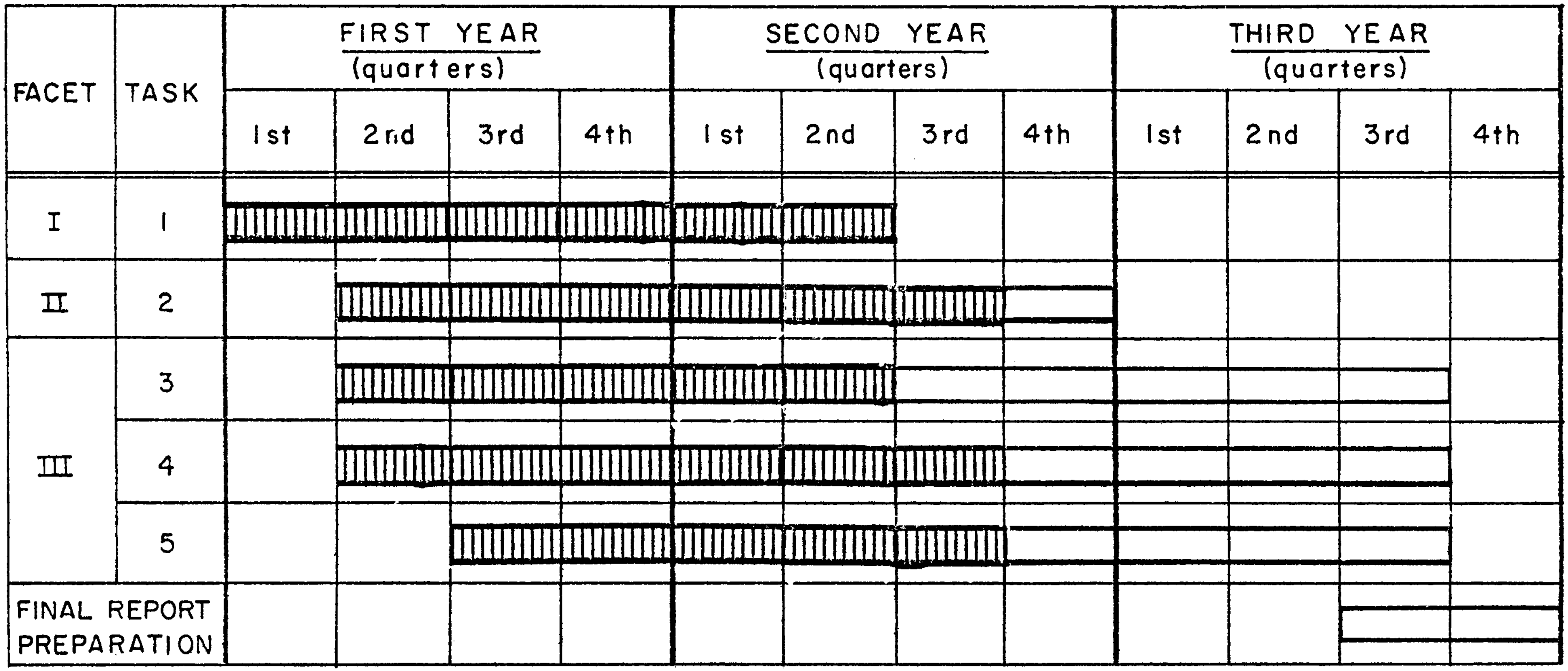
FINANCIAL REPORT

7TH QUARTER, APRIL, 1979 - JUNE 30, 1979

Expenditures This Quarter	
Personal Services	$12,833.50
Equipment, R & A	976.48
Current Expense	
Overhead	7,242.40
Supplies	7,010.60
Travel	55.05
Printing	-----
Benefits	1,954.60
TOTAL EXPENDITURES 6TH QUARTER	30,072.63
TOTAL EXPENDITURES TO DATE	208,101.14
TOAL CONTRACT AWARD TO 9/30/79	280.000.00
CONTRACT BALANCE	$71,898.96

THE EFFECTS OF MINERALS ON COAL BENEFICIATION PROCESSES

West Virginia University



Legend

Scheduled

Progress

Figure 1 - WORK SCHEDULE