NOTICE

**CERTAIN DATA
CONTAINED IN THIS
DOCUMENT MAY BE
DIFFICULT TO READ
IN MICROFICHE
PRODUCTS.**

DOE/PC/88856---T4

DE92 016137

Quarterly Technical Progress Report No. 4
For Period
November 1, 1988 thru January 31, 1989

SURFACE MAGNETIC ENHANCEMENT FOR COAL CLEANING

Submitted to:

U.S. Department of Energy
Pittsburgh Energy Technology Center
P.O. Box 10940
Pittsburgh, PA 15236

4

Contract Number: DE-AC22-88PC88856

Technical Program Officer: McMahan L. Gray

Prepared by:

Project Manager

Tom E. Scott
Director

Principal Investigator

J. Y. Hwang
Program Manager - Minerals

Institute of Materials Processing
Michigan Technological University
Houghton, Michigan 49931

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

SUMMARY AND FUTURE WORK

The progress achieved during this quarter includes the ten months shelf life study of magnetizing reagent, the effect of cation regulators on minerals and coals, the combination effect of depressant and activator on the adsorption of magnetizing reagent, optimum magnetite size for magnetizing reagent, and the magnetic field strength for separating magnetic enhanced minerals. The work is generally on schedule with the original plan.

The Phase I study (a fundamental study) is nearly completed. Selective conditions for adsorbing magnetizing reagent on minerals have been identified. The work for the next quarter will be mainly on the Phase II study. Coal will be selected, procured, characterized, and processed.

INTRODUCTION

Utilizing magnetizing reagents to enhance the magnetic properties of minerals in coal is the coal cleaning method studied in this research. The enhancement is achieved through the adsorption of magnetizing reagent on the surface of minerals. The objectives of the research include: (i) to define the conditions for optimal selectivity and magnetic property enhancement of minerals by magnetizing reagents; (ii) to determine the effect of such magnetic enhancement on the efficiency of coal cleaning by magnetic separations; and (iii) to evaluate where this method can be adapted to existing coal preparation process schemes to achieve maximum effectiveness.

Three phases of work are included in this research: a fundamental study, an application study, and an industrial laboratory study. The fundamental study investigates the basic chemistry involved in the interactions of magnetizing reagents and minerals. The work performed during this reporting period is part of the fundamental study, which includes the preparation of magnetizing reagents (Task 1), mineral-reagent interactions (Task 2), magnetite size effect (Task 3), Phase I data evaluation (Task 4) and report (Task 5). The progress in these tasks is documented in this report.

PROGRESS BY WORK BREAKDOWN STRUCTURE

Task 1. Magnetizing Reagent Preparation.

Reagent Preparation.

Thirty five magnetizing reagents with various surfactant functional groups have been prepared for this study. These reagents have been

described in the previous reports. This report will use the same MR-number assigned for these reagents.

Shelf Life of Reagents.

Five magnetizing reagents, selected from different cationic, anionic, and nonionic categories, were investigated for their activities of various shelf age. The activity was determined by the magnetic susceptibility enhancement of calcite after the interactions of magnetizing reagents and calcite at various pHs. The results for reagents at ten months shelf age are compared with that of previous tests, as shown in Table 1. For all of the five magnetizing reagents, there is no significant change of the activity in the ten month period of study. Therefore, it is concluded that the magnetizing reagents are stable for long term storage.

Task 2. Mineral/Reagent Interactions.

Mineral Preparation.

Research grade mineral samples of pyrite, kaolinite, calcite, and quartz were prepared by washing and grinding to -325 mesh. The procedures of preparation to avoid contamination and oxidation have been described in the previous reports.

Selection of Reagent Dosage.

The dosage of magnetizing reagent for standard mineral/reagent interaction tests was selected at 0.002 g magnetite per gram of mineral in the previous tests. There is no change of this dosage in this task unless otherwise stated.

Effect of pH on Mineral/Reagent Interactions.

The effect of pH on mineral/reagent interactions has been established and documented in the previous reports. Many reagents were found capable to increase the magnetic susceptibilities of minerals over a wide pH range. No

further tests on pH effects were carried out in this period except those involved in the activators and depressants.

Selection of Magnetizing Reagent.

Eight magnetizing reagents have been selected from the thirty five reagents for activator and depressant tests. The criteria of selection were described in the Quarterly Report No. 3. The selected reagents include four anionic (MR-30, MR-60, MR-33, and MR-58), three cationic (MR-1, MR-3, MR-89), and two nonionic (MR-45 and MR-73).

Activator Investigation.

Multivalent cations, such as calcium and iron, can activate the adsorption of anionic and nonionic magnetizing reagents on minerals and coals. Cationic magnetizing reagents are not affected by the cations, but these reagents are strongly adsorbed even without the presence of cations. Multivalent anions depress some minerals from adsorbing anionic magnetizing reagents. The extent of depression may relate to specific adsorption of anions on minerals. For example, sodium silicate shows a strong depressing effect on silicate minerals. Anions may have little activation effect for the adsorption of cationic magnetizing reagent, but the effect varies with minerals, anions, and magnetizing reagents. The results for each system, which include the variations of minerals, cations and anions, magnetizing reagents, and pHs, were documented in Table 3 of the last report.

Coal Depressant Investigation.

Five coal depressants were screened out from a large number of chemicals for this study. These depressants are: humic acid, lignin sulfonate, dextrin, Aero 633 (hydrophillic colloid) of American Cyanamid, and molasses. The experiments include the variations of depressant dosage, pH, and magnetizing reagent for coal and each mineral. The results, as

shown in the last report, were evaluated to select the conditions for the depressant-activator combination tests.

Regulator Investigation.

During the course of this study, a hypothesis for the adsorption of magnetizing reagent on coal was developed on the basis of the results of activator and depressant investigations. This hypothesis assumes that the hydrophillic anionic and nonionic magnetizing reagents are not adsorbed on coal through a direct mechanism, but through an indirect mechanism using multivalent cation as a bridge. A regulator study was added to the program under this background. In this study, chemicals which can complex or precipitate multivalent cations are investigated. The results show that coal is depressed from the adsorption of magnetizing reagents at the presence of these chemicals. Further tests to determine if these chemicals would depress minerals were performed. The results are shown in Table 2. Minerals are generally depressed at less extent than coal. This depressing effect is possibly due to the adsorption of complexing agents on the metal site of minerals. But the dosage of chemicals may not be high enough to cover all the metal sites of minerals to yield complete mineral depression. The pH also plays an important role. High pH causes unselective depression of coal and minerals, due to strong dissociation of hydrogen ion from the complexant and subsequently the strong metal reactivity. Selective depression of coal occurs usually at pH 7 or below.

Combination Effect of Coal Depressant and Mineral Activator.

Many conditions for selective adsorption of magnetizing reagent on minerals have been identified in the activator, depressant, and regulator investigations. These conditions are shown in Table 3.

To determine whether the presence of activator will be deleterious to the selectivity or will selectively activate minerals, a combination effect study of depressant and activator was carried out. Standard test procedures were utilized. The materials were mixed with depressant, activator, and magnetizing reagent sequentially. The dosage of depressant is the same as that determined in the depressant investigations. The dosage of activator is 60 ppm for calcium and 34 ppm for ferrous iron. The dosage of magnetizing reagent is fixed at 0.002 g magnetite per gram of minerals or coals. The pH is controlled at 7 except at 9 for the system of MR-45 and Na_2S . After the conditioning, the materials were filtered, dried, and measured for the magnetic susceptibility.

Coal and quartz were studied first. If coal is preferentially activated by the activator, the tests for the other minerals are suspended. The results for utilizing calcium and ferrous iron activators are shown in Table 4 and 5, respectively. In all cases, the cations are deleterious at various extent to the adsorption selectivity. This agrees well with the hypothesis described earlier that multivalent cations serve as a bridge for coal and magnetizing reagent. To control the activity of cations will be a major task in the Phase II separation studies.

Ten conditions which are less sensitive to the deleterious cations are selected from this investigation. They are:

- (i) MR60 - Na_2S - CaCl_2
- (ii) MR30 - Na_2S - CaCl_2
- (iii) MR30 - Humic Acid - CaCl_2
- (iv) MR01 - Molasses - CaCl_2
- (v) MR45 - Na_2S - CaCl_2
- (vi) MR58 - $\text{Na}_4\text{P}_2\text{O}_7$ - FeSO_4
- (vii) MR58 - Na_3PO_4 - FeSO_4
- (viii) MR30 - molasses - FeSO_4
- (ix) MR1 - Humic Acid - FeSO_4
- (x) MR3 - molasses - FeSO_4

Task 3. Magnetite Size Effect.

Four magnetizing reagents were selected to study the effect of magnetite size. The objective is to reduce the surfactant consumption by increasing the magnetite size (or reducing the surface area). However, this approach should not reduce the collection of magnetized particles at a magnetic field strength. Experiments were performed to determine the optimum magnetite size.

For each kind of magnetizing reagent, the test includes eight different magnetite sizes. A total of thirty two magnetizing reagents were prepared for the evaluation. The test was carried out using a magnetic separator with ball matrix. In each test, ten grams of calcite were conditioned with a magnetizing reagent for two minutes and fed through the separator. Speed valve control was fully open to allow the free fall velocity. The dosage of magnetizing reagent varies from 2 to 12 lb/ton of calcite. Two magnetic field strengths were investigated: 3.5 and 5 kilogauss. These strengths were selected on the basis of the previous tests as described in the last report.

The results are shown in Table 6 through 9 for each kind of magnetizing reagent. Surfactant reduction cannot be achieved for magnetite longer than 160 angstroms, except for MR-60 and MR-30. In the size range from 100 to 160 angstroms, surfactant consumption can be reduced significantly (in a factor from 1 to 0.5). However, the magnetite size increase shows a reduction effect on the recovery of magnetized calcite. Improvement on the recovery can be achieved by increasing the magnetizing reagent dosage or the magnetic field strength, but the associated costs may not compensate the surfactant savings. Since the cost of each variable is not clear at this point, we can only conclude that the optimum magnetite size lies between 100

and 160 angstroms. The other conclusion which can be drawn from this study is that high magnetic field strength, such as 20 kilogauss in many applications, is unnecessary for the magnetizing reagent approach. The magnetic separation of the magnetized particles apparently can be achieved in the most energy efficient range of magnetic field strengths.

Table 1
 SHELF LIFE OF MAGNETIZING REAGENTS -6
 MAGNETIC SUSCEPTIBILITY (X 10)
 AGE FRESH 7 MONTHS 10 MONTHS

MR-1	pH	5	61.3	73.9	64.2
	pH	7	50.9	57.9	54.4
	pH	9	55.6	57.6	54.7
	pH	11	51.2	52.9	53.2
MR-3	pH	5	49.9	73.6	61.8
	pH	7	47.4	54.0	54.6
	pH	9	49.6	52.2	54.7
	pH	11	49.0	53.3	55.8
MR-30	pH	5	38.0	59.3	43.6
	pH	7	35.4	44.4	38.8
	pH	9	36.7	41.7	41.5
	pH	11	35.3	42.4	43.8
MR-45	pH	5	56.4	63.5	65.6
	pH	7	47.4	49.4	55.3
	pH	9	45.9	51.4	57.9
	pH	11	46.0	50.8	56.8
MR-58	pH	5	65.5	59.2	53.6
	pH	7	60.6	45.1	50.5
	pH	9	66.1	45.8	57.8
	pH	11	59.8	42.0	47.9

Table 2. Magnetic susceptibility of minerals and coal in
the presence of regulator

MR-58

=====

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	65.5	46.8	40.9	57.0	62.9
	7.0	60.6	35.0	38.0	56.9	51.2
	9.0	66.1	17.0	18.4	48.8	49.2
	11.0	59.8	17.2	17.9	16.2	45.3
Quartz	3.0	60.2	7.2	10.9	21.3	43.4
	5.0	61.4	4.5	4.7	0.9	36.7
	7.0	62.6	2.6	0.7	0.5	33.0
	9.0	58.6	2.5	0.4	0.6	27.0
	11.0	59.3	2.4	1.0	0.6	34.5
Koalin	3.0	65.2	44.6	36.1	51.2	47.2
	5.0	56.0	23.6	22.3	56.2	47.1
	7.0	64.5	11.2	13.8	25.5	49.1
	9.0	66.6	11.1	11.3	13.8	45.7
	11.0	62.7	15.2	11.1	7.4	52.2
Pyrite	3.0	49.5	39.5	46.5	57.0	41.7
	5.0	69.8	42.7	45.6	57.1	44.9
	7.0	75.7	41.2	45.0	56.6	50.0
	9.0	69.0	6.3	12.3	35.4	55.5
	11.0	78.0	14.2	12.6	13.9	53.5
Coal	3.0	65.7	2.1	3.8	46.4	49.7
	5.0	65.1	3.2	3.7	31.9	49.3
	7.0	62.0	2.7	3.0	2.2	45.1
	9.0	61.0	3.6	2.8	1.6	50.8
	11.0	61.4	2.5	3.2	1.6	14.2

MR-30

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	38.0	59.2	18.6	44.9	46.8
	7.0	35.4	22.7	18.2	38.4	39.4
	9.0	36.7	6.7	1.3	36.4	42.6
	11.0	35.3	6.2	2.3	14.9	41.2
Quartz	3.0	26.6	18.8	18.4	22.6	26.7
	5.0	3.0	0.9	0.3	1.2	1.2
	7.0	1.2	0.4	0.3	0.7	0.5
	9.0	0.8	0.4	0.6	1.2	0.6
	11.0	17.5	0.6	0.8	1.0	26.0
Kaolin	3.0	35.8	46.5	28.2	40.0	39.5
	5.0	36.6	8.5	7.5	39.4	42.6
	7.0	39.5	5.7	2.7	18.4	42.1
	9.0	25.4	6.2	4.1	14.4	32.2
	11.0	34.7	6.4	2.9	13.0	38.3
Pyrite	3.0	34.7	49.2	17.8	35.1	40.3
	5.0	33.2	56.2	19.4	38.6	39.2
	7.0	36.4	48.9	22.2	42.3	40.5
	9.0	34.3	4.4	9.2	23.9	45.4
	11.0	37.9	3.9	3.5	9.3	44.3
Coal	3.0	18.4	33.2	8.9	42.6	43.3
	5.0	31.5	24.9	15.0	34.0	40.9
	7.0	40.5	3.2	2.0	1.9	43.5
	9.0	37.9	2.7	1.2	1.0	36.1
	11.0	22.3	1.3	1.8	2.2	6.7

MR-33

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	44.1	30.5	46.2	52.8	53.4
	7.0	40.2	8.5	35.1	44.8	45.7
	9.0	39.4	7.9	7.4	28.4	37.5
	11.0	38.1	8.1	6.4	10.2	32.3
Quartz	3.0	30.1	19.8	21.1	15.4	36.7
	5.0	49.6	6.7	7.5	6.2	1.1
	7.0	4.5	6.8	9.2	2.7	0.9
	9.0	3.5	1.0	4.7	1.8	0.4
	11.0	2.3	0.4	5.9	1.2	0.4
Kaolin	3.0	38.9	38.2	40.9	49.0	35.5
	5.0	35.2	8.8	17.4	39.8	45.2
	7.0	39.9	11.8	14.7	28.8	40.7
	9.0	29.1	11.8	14.3	16.2	23.2
	11.0	28.3	12.6	13.5	17.3	23.8
Pyrite	3.0	31.8	43.4	43.8	44.6	44.4
	5.0	34.9	21.6	46.2	45.4	44.4
	7.0	39.6	11.1	18.3	43.9	53.4
	9.0	39.7	2.3	1.7	13.3	47.7
	11.0	35.4	5.2	7.4	8.4	46.1
Coal	3.0	42.9	38.1	44.1	47.1	42.9
	5.0	37.3	14.5	19.6	43.3	54.2
	7.0	48.5	5.8	8.8	14.5	45.0
	9.0	14.6	3.1	9.7	10.8	10.4
	11.0	65.8	4.6	10.8	8.8	16.4

MR-60

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	59.4	74.1	71.6	41.7	60.8
	7.0	58.9	70.5	60.4	46.1	51.8
	9.0	61.7	9.1	9.3	39.9	47.5
	11.0	59.0	9.3	11.0	30.5	47.8
Quartz	3.0	56.0	64.4	58.0	31.2	41.0
	5.0	7.6	1.2	4.9	4.6	12.0
	7.0	4.9	0.4	0.7	1.2	6.1
	9.0	31.5	.0	0.6	1.4	14.3
	11.0	58.8	0.3	0.6	5.2	43.0
Kaolin	3.0	60.9	65.5	75.5	45.2	52.1
	5.0	60.2	8.6	17.8	40.5	62.6
	7.0	58.9	7.1	7.7	41.8	62.4
	9.0	46.3	8.8	8.7	23.8	57.3
	11.0	59.6	9.6	8.9	17.6	52.7
Pyrite	3.0	46.4	82.4	92.7	41.3	43.1
	5.0	56.2	73.7	94.0	46.7	51.4
	7.0	57.2	43.9	83.9	51.0	58.2
	9.0	60.0	5.4	7.4	28.2	55.4
	11.0	27.6	45.6	61.0	19.9	55.5
Coal	3.0	61.7	66.2	69.0	42.3	41.6
	5.0	63.2	8.3	61.9	38.5	45.8
	7.0	63.0	2.4	0.3	4.7	61.1
	9.0	65.6	2.2	0.3	4.5	32.2
	11.0	58.8	1.8	0.4	6.8	15.8

MR-01

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	61.3	56.7	48.9	55.8	62.9
	7.0	50.9	51.3	45.7	52.1	55.4
	9.0	55.6	56.5	36.9	52.3	64.6
	11.0	51.2	40.9	33.4	38.0	58.5
Quartz	3.0	56.2	44.8	38.2	45.6	56.5
	5.0	53.1	53.0	45.6	51.3	56.6
	7.0	50.4	47.1	49.4	50.9	60.8
	9.0	47.0	15.0	46.1	50.8	56.9
	11.0	30.3	20.4	22.2	28.2	29.3
Kaolin	3.0	50.0	38.6	43.5	50.8	50.7
	5.0	51.8	39.0	34.4	48.4	48.7
	7.0	54.9	25.9	46.7	49.3	51.3
	9.0	52.1	32.6	46.2	48.9	52.4
	11.0	48.2	24.5	49.9	39.0	53.6
Pyrite	3.0	41.8	36.7	49.6	47.8	43.5
	5.0	48.1	48.8	47.9	48.6	50.1
	7.0	48.5	41.4	54.2	55.6	57.1
	9.0	45.6	13.8	32.2	18.3	56.3
	11.0	24.6	16.6	24.7	22.2	56.6
Coal	3.0	55.9	54.2	42.9	51.6	60.1
	5.0	61.5	52.5	45.0	50.4	66.2
	7.0	53.8	35.7	29.7	39.7	61.5
	9.0	60.9	7.8	18.5	21.2	63.4
	11.0	60.5	9.3	23.2	12.9	71.0

MR-03

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	49.9	53.4	49.1	58.8	67.3
	7.0	47.4	56.3	44.8	49.0	53.8
	9.0	49.6	47.6	43.3	50.8	55.5
	11.0	49.0	44.4	46.4	49.8	55.4
Quartz	3.0	37.4	50.4	44.6	45.8	48.4
	5.0	45.1	50.6	43.5	52.4	52.5
	7.0	44.3	56.0	50.2	52.7	49.8
	9.0	41.3	42.7	44.6	51.6	58.9
	11.0	42.3	46.4	41.3	49.0	53.5
Kaolin	3.0	48.3	42.2	48.1	56.1	52.5
	5.0	48.1	36.5	31.9	54.4	57.0
	7.0	47.0	41.1	13.9	50.0	50.8
	9.0	48.7	34.1	37.1	50.3	60.4
	11.0	49.0	41.8	39.7	42.2	50.9
Pyrite	3.0	45.1	34.6	36.7	44.6	47.2
	5.0	44.9	51.6	45.6	54.0	52.4
	7.0	52.3	37.4	44.2	55.0	56.4
	9.0	59.7	30.4	30.2	39.9	54.9
	11.0	55.1	21.4	25.0	23.8	62.9
Coal	3.0	52.0	53.2	42.8	49.0	49.5
	5.0	47.2	46.5	44.0	46.9	53.5
	7.0	52.6	16.6	45.7	43.8	54.1
	9.0	60.0	7.7	12.6	15.3	49.8
	11.0	52.1	20.4	34.6	14.5	34.7

MR-89

=====

===

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	54.0	50.6	68.8	35.2	73.8
	7.0	47.4	37.3	47.8	37.8	55.9
	9.0	47.6	38.7	42.9	36.3	72.0
	11.0	47.9	17.8	25.6	29.5	48.3
Quartz	3.0	46.4	21.6	18.1	17.5	44.7
	5.0	41.8	10.6	14.9	19.4	45.3
	7.0	47.5	28.5	28.7	24.4	41.5
	9.0	43.5	32.9	32.3	28.9	45.5
	11.0	48.2	31.9	19.7	21.2	47.1
Kaolin	3.0	50.8	35.1	40.4	39.2	53.4
	5.0	50.6	30.9	32.9	38.6	51.8
	7.0	49.2	23.0	59.4	38.2	55.4
	9.0	58.3	31.4	31.1	39.8	55.3
	11.0	49.2	31.5	51.2	31.8	50.3
Pyrite	3.0	44.5	21.7	36.5	33.2	48.2
	5.0	53.6	39.0	95.8	33.0	50.9
	7.0	57.0	25.5	49.6	40.2	56.6
	9.0	50.6	28.8	72.9	24.2	55.8
	11.0	55.0	31.3	38.8	15.7	56.8
Coal	3.0	48.7	53.5	31.9	29.1	52.9
	5.0	54.3	60.7	59.7	35.3	50.2
	7.0	53.3	56.4	68.4	28.0	48.3
	9.0	57.4	42.8	33.8	42.0	54.4
	11.0	63.4	36.6	24.1	9.2	19.6

MR-45

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	56.4	54.9	58.8	40.0	74.9
	7.0	47.4	9.4	39.4	54.9	68.3
	9.0	45.9	3.6	3.9	19.7	65.4
	11.0	46.0	5.2	4.5	3.2	60.1
Quartz	3.0	45.0	54.2	44.3	42.9	67.2
	5.0	44.5	50.3	43.8	36.4	56.3
	7.0	27.6	5.2	1.4	4.3	17.5
	9.0	0.4	0.8	1.6	1.5	0.8
	11.0	0.1	0.7	0.4	1.1	0.5
Kaolin	3.0	46.9	46.6	50.0	56.9	47.6
	5.0	46.7	49.3	27.2	59.6	51.3
	7.0	49.5	10.4	9.4	31.2	51.6
	9.0	36.3	8.0	6.8	12.2	49.5
	11.0	39.7	11.7	6.7	9.8	52.2
Pyrite	3.0	46.2	55.9	53.2	54.3	48.3
	5.0	49.7	54.7	54.4	59.6	53.4
	7.0	49.1	55.4	57.7	62.4	63.5
	9.0	39.1	11.3	4.4	32.9	64.2
	11.0	20.3	6.1	5.7	8.9	69.8
Coal	3.0	52.3	54.2	48.2	52.5	51.1
	5.0	54.8	52.5	47.2	48.9	56.7
	7.0	60.2	35.7	6.3	20.8	56.5
	9.0	59.9	7.8	3.9	5.4	62.7
	11.0	56.8	6.3	3.0	2.8	57.8

MR-73

===

	pH	0.0	Na5P3O10	Na4P2O7	Na3PO4	Na2CO3
Calcite	3.0					
	5.0	33.5	55.8	56.9	55.8	54.6
	7.0	29.3	52.2	49.7	47.0	43.7
	9.0	34.2	52.7	46.4	45.1	45.0
	11.0	31.3	49.4	38.3	34.2	45.0
Quartz	3.0	27.6	42.5	48.6	40.7	43.4
	5.0	32.3	48.1	49.4	48.8	41.6
	7.0	31.9	47.4	48.6	43.8	43.6
	9.0	34.2	50.3	50.6	43.8	43.0
	11.0	37.7	44.2	38.3	26.9	25.9
Kaolin	3.0	36.8	37.6	34.4	48.0	44.1
	5.0	32.5	34.0	37.3	46.2	47.1
	7.0	37.6	36.4	38.3	45.9	45.9
	9.0	36.9	46.3	62.3	56.7	47.7
	11.0	38.4	63.8	84.9	56.9	47.8
Pyrite	3.0	29.0	45.3	35.8	47.4	40.5
	5.0	29.4	50.7	32.3	45.9	47.0
	7.0	38.9	32.9	55.0	50.4	48.9
	9.0	38.5	22.6	32.2	39.8	49.5
	11.0	39.2	38.7	47.4	22.6	80.2
Coal	3.0	27.6	45.4	45.7	43.5	39.3
	5.0	32.9	42.0	46.1	44.4	42.3
	7.0	33.1	13.3	35.8	38.6	43.5
	9.0	32.5	19.0	23.3	17.1	34.5
	11.0	38.6	30.9	20.7	5.8	18.4

Table 3. Promising conditions for selective adsorption.

<u>Magentizing Reagent</u>	<u>Chemicals</u>	<u>pH</u>
MR-30	Na ₂ S	7-9
MR-30	Na ₅ P ₃ O ₁₀	7
MR-30	Humic Acid	5-7
MR-30	Molasses	5-9
MR-30	Na ₃ PO ₄	7-9
MR-30	Na ₂ SiO ₃	7
MR-58	Na ₂ S	7-11
MR-58	lignosulfonate	5-9
MR-58	Aero-633	9
MR-58	Molasses	5-9
MR-58	Na ₄ P ₂ O ₇	3-7
MR-58	Na ₃ PO ₄	7
MR-60	Na ₂ S	7-9
MR-60	Na ₅ P ₃ O ₁₀	5-7
MR-60	lignosulfonate	5-9
MR-60	Aero-633	9
MR-60	Molasses	5-9
MR-60	Na ₄ P ₂ O ₇	7
MR-60	Humic Acid	7
MR-60	Na ₂ SiO ₃	7
MR-01	Humic Acid	7
MR-01	Molasses	7
MR-03	Humic Acid	7
MR-03	Molasses	7
MR-45	Na ₂ S	7-9
MR-45	Na ₄ P ₂ O ₇	7
MR-45	Humic Acid	5-7
MR-83	Na ₂ S	7
MR-33	Na ₂ S	7-9

Table 4. Effect of Depressant on the susceptibility of coal and quartz in the presence of depressant and CaCl_2 as activator

		Na ₂ S	Na ₂ SO ₃	Lignin	Aero-100	Molasses	Na ₄ PO ₃	H ₂ A	Na ₃ PO ₄	Na ₂ SiO ₃
MR-58	Coal	30.1		51.5	42.2	43.5	55.7		50.2	
	Quartz	5.1		4.3	17.7	18.6	52.2		42.7	
MR-60	Coal	8.9	21.2	47.5	53.8	73.7	30.8	55.5	58.8	67.9
	Quartz	40.1	3.1	1.8	16.1	4.8	3.6	4.2	6.5	5.7
	Kaolin	78.0								
	Calcite	51.7								
	Pyrite	52.4								
MR-80	Coal	12.2	20.7			48.8		7.9	42.8	53.0
	Quartz	6.4	2.3			5.6		2.4	4.6	4.9
	Kaolin	51.3						21.4		
	Calcite	45.2						33.3		
	Pyrite	41.2						41.0		
MR-01	Coal					18.8		35.7		
	Quartz					9.1		6.6		
	Kaolin					58.0				
	Calcite					55.6				
	Pyrite					55.7				
MR-03	Coal					19.5		24.7		
	Quartz					26.2		8.1		
	Kaolin					48.6				
	Calcite					54.5				
	Pyrite					55.0				
MR-45	Coal	12.4					50.7			
	Quartz	2.7					28.2			
	Kaolin	64.6								
	Calcite	53.3								
	Pyrite	59.2								
MR-83	Coal	12.3								
	Quartz	3.4								
MR-33	Coal	12.7								
	Quartz	5.4								

Table 5. Effect of Depressant on the susceptibility of coal and quartz in the presence of depressant and FeSO₄ as activator

		Na ₂ S	Na ₂ SP3010	Lignin Aero-633	Molasses	Na ₄ P ₂ O ₇	H.A.	Na ₂ PO ₄	Na ₂ SO ₄
MR-56	Coal	67.1		59.4	50.5	62.4	6.0		5.7
	Quartz	8.5		9.3	7.1	5.2	4.4		3.3
	Kaolin						15.7		25.2
	Calcite						18.5		57.9
	Pyrite						58.4		60.8
MR-60	Coal	38.5	13.1	37.4	20.4	49.5	13.0	67.6	55.3
	Quartz	2.3	1.2	1.7	1.4	5.6	2.1	4.5	33.9
	Kaolin		19.2				10.0		12.8
	Calcite		22.3				21.7		66.5
	Pyrite		57.9				60.5		58.9
MR-30	Coal	40.6	3.4			11.8		4.3	43.3
	Quartz	0.4	1.1			1.1		1.4	30.6
	Kaolin		10.9			51.4		9.4	
	Calcite		38.8			23.8		43.5	
	Pyrite		40.8			41.1		41.5	
MR-01	Coal					21.6		15.4	
	Quartz					7.7		17.1	
	Kaolin					55.1		40.2	
	Calcite					21.5		51.1	
	Pyrite					35.0		58.4	
MR-03	Coal					14.3		14.0	
	Quartz					4.8		7.8	
	Kaolin					52.0		35.3	
	Calcite					32.8		53.1	
	Pyrite					56.1		59.3	
MR-45	Coal	58.9				52.3		2.2	
	Quartz	0.7				3.8		0.7	
	Kaolin							26.7	
	Calcite							9.4	
	Pyrite							54.0	
MR-83	Coal	40.9							
	Quartz	0.1							

Table 6. Magnetite Size Effect of MR-30

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 5000 Gauss)

Dosage (lb/ton)	30-11	30-12	30-13	30-14
2.0	53.42	60.33	53.21	26.88
4.0	84.22	82.10	76.60	50.79
8.0	96.53	96.77	96.68	88.57
12.0	100.00	100.00	100.00	96.41

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 3500 Gauss)

Dosage (lb/ton)	30-11	30-12	30-13	30-14
2.0	34.18	40.21	44.91	23.45
4.0	66.73	76.34	67.34	46.99
8.0	92.57	95.62	95.61	57.33
12.0	97.74	97.17	98.04	88.39

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 5000 Gauss)

Dosage (lb/ton)	30-21	30-22	30-23	30-24
2.0	65.35	59.59	47.65	55.32
4.0	84.09	82.10	80.86	79.63
8.0	98.99	98.36	95.13	95.08
12.0	100.00	99.16	99.28	96.63

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 3500 Gauss)

Dosage (lb/ton)	30-21	30-22	30-23	30-24
2.0	45.62	48.53	44.80	44.67
4.0	61.63	61.31	74.90	74.75
8.0	96.71	95.31	95.27	96.12
12.0	98.41	98.40	97.58	96.55

	Surfactant (g/g Mt)	Calculated Magnetite Size Expect to Reach		Surfactant (g/g Mt)	Calculated Magnetite Size Expect to Reach
30-11	0.569	100(A) (reference)	30-21	0.379	144(A)
30-12	0.365	159(A)	30-22	0.292	171(A)
30-13	0.305	191(A)	30-23	0.262	191(A)
30-14	0.569	252(A)	30-24	0.262	208(A)

Table 7. Magnetite Size Effect of MR-58

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 5000 Gauss)

Dosage (lb/ton)	58-11	58-12	58-13	58-14
2.0	64.21	46.73	47.23	55.39
4.0	93.84	77.15	81.94	81.22
8.0	98.54	98.93	95.05	90.15
12.0	98.79	98.98	97.50	99.39

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 3500 Gauss)

Dosage (lb/ton)	58-11	58-12	58-13	58-14
2.0	57.44	52.40	39.77	53.78
4.0	83.02	66.30	76.82	69.32
8.0	95.05	88.77	84.93	83.84
12.0	99.14	97.31	97.57	98.97

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 5000 Gauss)

Dosage (lb/ton)	58-21	58-22	58-23	58-24
2.0	47.81	36.31	32.77	43.74
4.0	78.03	61.75	67.65	56.63
8.0	93.81	96.70	90.91	82.11
12.0	97.46	97.91	97.32	94.13

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 3500 Gauss)

Dosage (lb/ton)	58-21	58-22	58-23	58-24
2.0	40.51	26.57	30.00	18.64
4.0	63.98	36.49	55.52	49.49
8.0	95.65	85.03	85.01	76.43
12.0	98.01	94.94	89.48	83.50

	Surfactant (g/g Mt)	Calculated Magnetite Size Expect to Reach		Surfactant (g/g Mt)	Calculated Magnetite Size Expect to Reach
58-11	0.864	100(A) (reference)	58-21	0.720	144(A)
58-12	0.425	159(A)	58-22	0.432	171(A)
58-13	0.497	191(A)	58-23	0.432	191(A)
58-14	0.493	252(A)	58-24	0.432	208(A)

Table 9. Magnetite Size Effect of MR-60

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 5000 Gauss)

Dosage (lb/ton)	60-11	60-12	60-13	60-14
2.0	51.20	59.48	49.19	59.06
4.0	80.67	83.86	76.36	84.55
8.0	98.11	99.50	98.12	96.01
12.0	100.00	98.45	98.28	100.00

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 3500 Gauss)

Dosage (lb/ton)	60-11	60-12	60-13	60-14
2.0	46.49	54.25	52.26	52.95
4.0	70.56	73.48	72.59	68.42
8.0	93.27	97.18	91.53	91.50
12.0	97.04	97.51	96.16	97.39

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 5000 Gauss)

Dosage (lb/ton)	60-21	60-22	60-23	60-24
2.0	49.64	56.62	46.49	60.09
4.0	80.43	77.97	76.89	75.20
8.0	96.03	94.39	95.44	92.94
12.0	96.38	97.02	97.56	96.55

Magnetite Size Effect on Calcite Recovery
at Different Dosage (Field Strength 3500 Gauss)

Dosage (lb/ton)	60-21	60-22	60-23	60-24
2.0	51.21	50.73	55.00	52.09
4.0	69.43	73.09	74.17	73.81
8.0	92.13	86.55	92.37	91.06
12.0	95.99	95.45	94.39	95.53

	Surfactant (g/g Mt)	Calculated Magnetite Size Expect to Reach
60-11	0.864	100(A) (reference)
60-12	0.576	159(A)
60-13	0.403	191(A)
60-14	0.288	252(A)

	Surfactant (g/g Mt)	Calculated Magnetite Size Expect to Reach
60-21	0.531	144(A)
60-22	0.399	171(A)
60-23	0.399	191(A)
60-24	0.399	208(A)

Table 6. Magnetite Size Effect of MR-01

Magnetite Size Effect on Calcite Recovery at Different Dosage (Field Strength 500 Gauss)					Magnetite Size Effect on Calcite Recovery at Different Dosage (Field Strength 350 Gauss)				
Dosage (lb/ton)	01-11	01-12	01-13	01-14	Dosage (lb/ton)	01-11	01-12	01-13	01-14
2.0	44.01	30.37	18.39	5.46	2.0	33.19	22.51	16.46	9.91
4.0	75.93	55.93	38.84	13.55	4.0	45.07	31.75	27.93	18.75
8.0	95.51	80.59	62.26	41.33	8.0	62.05	54.41	43.54	31.23
12.0	99.24	95.31	83.79	57.53	12.0	67.67	62.63	76.99	50.10

Magnetite Size Effect on Calcite Recovery at Different Dosage (Field Strength 500 Gauss)					Magnetite Size Effect on Calcite Recovery at Different Dosage (Field Strength 350 Gauss)				
Dosage (lb/ton)	01-21	01-22	01-23	01-24	Dosage (lb/ton)	01-21	01-22	01-23	01-24
2.0	34.27	21.18	6.13	10.55	2.0	22.17	15.83	6.41	10.71
4.0	42.87	35.12	33.72	17.30	4.0	40.55	31.54	20.25	13.63
8.0	66.24	51.55	40.31	23.55	8.0	65.53	53.52	44.01	24.51
12.0	81.74	63.75	44.13	33.27	12.0	81.52	55.33	45.77	35.41

Surfactant (g/g Mt)	Calculated Magnetite Size Exempt to Resch	Surfactant (g/g Mt)	Calculated Magnetite Size Exempt to Resch
01-11	0.531	01-21	0.443
01-12	0.473	01-22	0.363
01-13	0.473	01-23	0.235
01-14	0.473	01-24	0.235

END

**DATE
FILMED**

8 / 24 / 92