1 of 6

**Geotechnical/Geochemical Characterization of
Advanced Coal Process Waste Streams - Task 2**

Topical Report

**C.J. Moretti
E.S. Olson**

September 1992

Work Performed Under Contract No.: DE-AC21-89MC26255

**For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia**

**By
Energy and Environmental Research Center, University of North Dakota
Universal Fuel Development Associates, Inc.
Grand Forks, North Dakota**

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GEOTECHNICAL/GEOCHEMICAL CHARACTERIZATION OF ADVANCED COAL PROCESS WASTE STREAMS: TASK 2 REPORT

1.0 INTRODUCTION

Successful disposal practices for solid wastes produced from advanced coal combustion and coal conversion processes must provide for efficient management of relatively large volumes of wastes in a cost-effective and environmentally safe manner. At present, most coal-utilization solid wastes are disposed of using various types of land-based systems, and it is probable that this disposal mode will continue to be widely used in the future for advanced process wastes.

Proper design and operation of land-based disposal systems for coal combustion wastes normally require appropriate waste transfer, storage, and conditioning subsystems at the plant to prepare the waste for transport to an ultimate disposal site. Further, the overall waste management plan should include a by-product marketing program to minimize the amount of waste that will require disposal. In order to properly design and operate waste management systems for advanced coal-utilization processes, a fundamental understanding of the physical properties, chemical and mineral compositions, and leaching behaviors of the wastes is required.

In order to gain information about the wastes produced by advanced coal-utilization processes, 55 waste samples from 16 different coal gasification, fluidized-bed coal combustion (FBC), and advanced flue gas scrubbing processes were collected by the U.S. Department of Energy (DOE) and sent to Universal Fuel Development Associates (UFDA), Inc. for characterization. Thirty-four of these wastes were analyzed for their bulk chemical and mineral compositions and tested for a detailed set of disposal-related physical properties. The results of these waste characterizations are presented in this report. The leaching characteristics of these wastes have been examined in a previous study.

In addition to the waste characterization data, this report contains a discussion of potentially useful waste management practices for advanced coal utilization processes. Since the properties of advanced process wastes are in some respects different from conventional coal combustion wastes, an analysis was performed to identify any potential problems that could occur when conventional, off-the-shelf waste management technologies are used for handling and disposal of advanced process wastes. When potential problems were identified, possible alternative technologies were evaluated.

2.0 ACCOMPLISHMENTS

The following tasks were accomplished in this research project:

- Task 1. Thirty-four solid waste samples collected from various facilities employing advanced coal combustion and coal conversion technologies were characterized. The characterization protocol used for each waste included an extensive set of waste management-related physical property tests, bulk chemical analyses, and mineral analyses.

- Task 2. Eight coal samples were analyzed. These coals were some of the fuels used to produce the advanced process wastes. The samples were analyzed for major and trace element contents, proximate and ultimate data, and higher heating value.
- Task 3. A report was prepared which summarized and evaluated the results of the waste characterizations. The report focused on 1) the suitability of current coal combustion waste management practices for advanced process wastes, 2) the possible use of alternative waste management practices for the advanced process wastes, and 3) evaluating any deficiencies in our understanding of how to safely and economically dispose of the advanced process wastes.

3.0 MATERIALS AND METHODS

3.1 Advanced Process Wastes

Fifty-five waste samples were sent to UFDA by the DOE for geochemical/geotechnical characterization. The wastes were produced from 21 different advanced coal-utilization facilities located in the United States. The various types of processes sampled included coal gasification, FBC, and advanced flue gas cleaning. The waste samples ranged from fairly coarse materials such as bottom ashes and spent bed materials to very fine materials such as fly ashes and economizer ashes. In addition to the advanced process wastes, eight coals which were used to produce the wastes were also characterized.

Upon receipt by UFDA, the advanced process waste samples were examined to make sure that they had been properly preserved while in storage. Next, 34 representative waste samples were selected for characterization. Of the 34 wastes studied, 9 were produced from coal gasification processes, 7 were produced from processes employing flue gas desulfurization systems, 17 were produced from fluidized-bed combustion processes, and 1 was obtained from an advanced slagging coal combustor.

Table 1 lists the specific processes from which each of the 34 wastes were generated, and Table 2 gives a brief description of each waste. The sample numbers listed in Table 1 identify the facility where the waste was produced and the specific waste streams from which the samples were collected. The first one or two digits are the site number and the last two digits refer to the waste stream. This numbering system applies to all but the EER sample. Additional information on each of the sites where the wastes were produced is given below.

3.1.1 Waste Production Site 1

Waste samples 102 and 104 were produced by a process development-scale, pulverized coal gasifier. The fuel was a low-sulfur subbituminous coal. Sample 102 consisted of fine particulates scrubbed from the gasifier product gas and separated from a wet slurry. Sample 104 is a slag, consisting of spent solids, which was removed from the gasifier by a slag lock-hopper system.

TABLE 1

Advanced Processes from which the Waste Samples Originated

Sample No.	Coal Utilization Process
102	Coal gasification
104	Coal gasification
202	Ash agglomerating fluidized-bed coal gasification
203	Ash agglomerating fluidized-bed coal gasification
302A	Fixed-bed coal gasification
403A	Coal combustion with flue gas cleaning
502A	Coal combustion with flue gas cleaning
503	Coal combustion with flue gas cleaning
602A	Coal combustion with flue gas cleaning
603A	Coal combustion with flue gas cleaning
702A	Coal combustion with flue gas cleaning
703A	Coal combustion with flue gas cleaning
1202	Fluidized-bed combustion with limestone injection
1203	Fluidized-bed combustion with limestone injection
1204	Fluidized-bed combustion with limestone injection
1204A	Fluidized-bed combustion with limestone injection
1205A	Fluidized-bed combustion with limestone injection
1302A	Fluidized-bed combustion with limestone injection
1304A	Fluidized-bed combustion with limestone injection
1305A	Fluidized-bed combustion with limestone injection
2002	Pressurized fixed-bed coal gasification
2102A	Fluidized-bed coal gasification
2201	Fluidized-bed coal gasification
2201A	Fluidized-bed coal gasification
2302A	Fluidized-bed combustion with limestone injection
2303A	Fluidized-bed combustion with limestone injection
2304A	Fluidized-bed combustion with limestone injection
2402A	Fluidized-bed combustion with limestone injection
2403A	Fluidized-bed combustion with limestone injection
2404	Fluidized-bed combustion with limestone injection
2404A	Fluidized-bed combustion with limestone injection
2503A	Fluidized-bed combustion with limestone injection
2504A	Fluidized-bed combustion with limestone injection
EER	Slagging coal combustion with limestone injection

TABLE 2

Descriptions of the Advanced Process Wastes

Sample No.	Waste Description
102	Grey-brown coal gasification ash
104	Glassy black coal gasification slag
202	Grey-white coal gasification ash
203	Grey-black coal gasification ash
302A	Tan coal gasification ash
403A	Grey fly ash
502A	Grey-black bottom ash
503	Spent scrubber sludge
602A	Black-brown bottom ash
603A	Tan-white fly ash and scrubber sludge
702A	Red-brown bottom ash
703A	Grey ESP* fly ash
1202	Red-brown spent bed material
1203	Grey-white cyclone ash
1204	Red-brown spent bed material
1204A	Grey-white baghouse fly ash
1205A	Black-grey superheater ash
1302A	Brown-white spent bed material
1304A	Grey-brown economizer ash
1305A	Grey baghouse fly ash
2002	Black-brown gasifier ash
2102A	Black-brown gasifier ash and spent limestone
2201	Grey-brown gasifier ash
2201A	Black gasifier ash
2302A	Tan spent bed material
2303A	Grey-brown economizer ash
2304A	Grey baghouse fly ash
2402A	Tan spent bed material
2403A	Grey economizer ash
2404	Grey baghouse fly ash
2404A	Grey baghouse fly ash
2503A	Grey-white economizer ash
2504A	Black-grey baghouse fly ash
EER	Glassy black slag

* Electrostatic precipitator.

3.1.2 Waste Production Site 2

Waste samples 202 and 203 were produced by an agglomerating ash, fluidized-bed coal gasification pilot plant. Both samples were obtained from a run during which dolomite was injected into the gasifier as a sorbent. Sample 202 was a fine ash produced by the gasifier, and sample 203 was an ash discharged from the bottom of the gasifier.

3.1.3 Waste Production Site 3

Waste sample 302A was produced by a commercial-scale, fixed-bed coal gasifier. The gasifier was operated at atmospheric pressure, and the fuel was an eastern Kentucky low-sulfur (<1%) bituminous coal. Sample 302A was a coarse ash removed from the bottom of the gasifier.

3.1.4 Waste Production Site 4

Waste sample 403A was produced from a 487-MW, pulverized coal-fired boiler equipped with a wet-limestone scrubber system. The fuel was a Pittsburgh #8 bituminous coal with a sulfur content between 1.6 and 1.9 percent. Sample 502A was a 4:1 mixture of fly ashes obtained from mechanical collectors and electrostatic precipitators, respectively.

3.1.5 Waste Production Site 5

Waste samples 502A and 503 were produced from a pulverized coal-fired boiler equipped with a wet-limestone scrubber system. The fuel was an Illinois #6 bituminous coal. Sample 502A was a bottom ash collected from the boiler, and sample 503 was a spent scrubber sludge collected from a vacuum filter.

3.1.6 Waste Production Site 6

Waste samples 602A and 603A were produced from a 450-MW, pulverized coal-fired boiler equipped with a wet-limestone scrubber system. The fuel was a North Dakota lignite. Sample 602A was a bottom ash which was discharged from the boiler into a quench tank and collected after it was dewatered. Sample 603A was a mixture of fly ash and spent scrubber material. The mixture was collected in a baghouse.

3.1.7 Waste Production Site 7

Waste samples 702A and 703A were produced from a 450-MW, pulverized coal-fired boiler equipped with a wet-limestone scrubber system. The fuel was a Utah subbituminous coal. Sample 702A was a bottom ash which was discharged from the boiler into a quench tank and collected after it was dewatered. Sample 703A was a fly ash that was collected in an electrostatic precipitator.

3.1.8 Waste Production Site 12

Waste samples 1202, 1203, 1204, 1204A, and 1205A were produced from an FBC boiler which used limestone addition to the bed for SO₂ capture. In this unit, the fine particles leaving the combustion zone first passed through a steam superheater where a portion of the particulates were collected and reinjected into the boiler. The particles that passed through the superheater

were collected first in an economizer, with final cleanup in a baghouse. The fuel was a mixture of Illinois #5 and Illinois #6 coals with a sulfur content between 3 and 3.5 percent. Samples 1202 and 1204 were spent bed materials, sample 1203 was an economizer ash collected in a cyclone, and sample 1205A was a fly ash collected in a baghouse. Sample 1205A was a superheater ash.

3.1.9 Waste Production Site 13

Waste samples 1302A, 1304A, and 1305A were produced from an FBC boiler which used limestone addition to the bed for SO₂ capture. In this unit, the fine particles leaving the combustion zone first passed through a cyclone where a portion of the particulates were collected and reinjected into the boiler. The particles that passed through the cyclone were deentrained in an economizer and collected in the economizer hopper, with final cleanup in a series of baghouses. The fuel was a Tennessee bituminous coal with a sulfur content of approximately 3 percent. Sample 1302A was a spent bed material, sample 1304A was an economizer ash, and sample 1305A was a baghouse fly ash.

3.1.10 Waste Production Site 20

Waste sample 2002 was produced by a fixed-bed coal gasifier firing Illinois #6 coal. Sample 2002 was an ash material that dropped from the bottom of the gasifier, passed through a grinder, and was cooled in a quench tank. The sample was collected as a slurry, the water was decanted, and the ash was air-dried prior to storage.

3.1.11 Waste Production Site 21

Waste sample 2102A was produced by a pilot-scale, agglomerating ash, fluidized-bed coal gasifier. In this process, limestone was injected coaxially into the gasifier with the coal, air, and steam. The fuel used was a Pittsburgh #8 bituminous coal. Sample 2102A was a mixture of gasifier ash and spent limestone which dropped out of the bottom of the gasifier into a lock hopper. The sample was collected below the lock hopper.

3.1.12 Waste Production Site 22

Waste samples 2201 and 2201A were produced by a process development-scale, fluidized-bed coal gasifier. The fuel used was a Pittsburgh #8 bituminous coal. Samples 2201 and 2201A were ashes that dropped out of the bottom of the gasifier into a lock hopper. The samples were collected below the lock hopper.

3.1.13 Waste Production Site 23

Waste samples 2302A, 2303A, and 2304A were produced from an FBC boiler which used limestone injection for SO₂ capture. After combustion, the flue gas passed through the convection and economizer units where some of the particulates were collected in a hopper. There was no particulate recycled back to the boiler. The particulates that were not removed from the flue gas in the economizer were collected in a baghouse. The fuel used was a Pittsburgh #8 bituminous coal. Sample 2302A was a spent bed material, sample 2303A was a fly ash collected from the economizer hopper, and sample 2304A was a baghouse fly ash.

3.1.14 Waste Production Site 24

Waste samples 2402A, 2403A, 2404, and 2404A were produced from an FBC boiler which used limestone injection for SO₂ capture. After combustion, the flue gas passed through a cyclone where some of the particulates were collected and recycled to the boiler. A portion of the particulates that were not recycled was deentrained in an economizer and collected in the economizer hopper. The particulates that passed through the economizer were collected in a baghouse. The fuel used was an Illinois bituminous coal with a sulfur content of approximately 2.5 percent. Waste sample 2402A was a spent bed material, sample 2403A was an economizer ash, and samples 2404 and 2404A were baghouse fly ashes.

3.1.15 Waste Production Site 25

Waste samples 2503A and 2504A were produced at a bubbling-bed, FBC boiler which used limestone injection for SO₂ capture. After combustion, the flue gas passed through a cyclone where some of the particulates were collected and recycled to the boiler. A portion of the particulates that were not recycled was deentrained in an economizer and collected in the economizer hopper. The particulates that passed through the economizer were collected in a baghouse. The fuel used was a Utah low-sulfur bituminous coal. Waste sample 2503A was an economizer ash, and sample 2504A was a baghouse fly ash.

3.1.16 Waste Production Site (EER Sample)

The EER sample was a glassy slag produced from a slagging coal combustor which used limestone injection for SO₂ control.

3.2 Test Methods

The various tests and analyses performed to characterize the advanced process wastes are listed in Table 3. Since some of these tests were not applicable to all of the wastes, a preliminary examination of the wastes followed by a review of selected preliminary test results was used to determine which tests would be required for a specific waste.

The amount of material supplied for each waste for this project ranged from a few pounds to a few hundred pounds. For all but one of the samples, there was enough material to perform all of the scheduled tests and analyses.

Most of the waste samples were received in a dry form, but a few had significant moisture contents. A high moisture content was not necessarily considered a problem as long it was determined that the waste had been originally collected wet.

3.2.1 Physical Tests

The physical tests included in the waste-characterization protocol are discussed in this section.

TABLE 3

Tests and Analyses Included in the Waste-Characterization Protocol

Poured Bulk Density	Pozzolanic Reactivity
Packed Bulk Density	Permeability
Particle Specific Gravity	Moisture-Density Relation
Moisture Content	Particle Analysis
Compressibility/Consolidation	Blaine Fineness
Heat of Hydration	Specific Surface Area
Angle of Internal Friction	Unconfined Compressive Strength
Particle Species Analysis:	X-Ray Diffraction
Scanning Electron Microscopy:	Thermogravimetric Analysis
Photographs	Sulfur Forms Analysis
Chemical Point Counts	Bulk Chemical Analysis
Angle of Repose	Chloride Analysis

3.2.1.1 Bulk Density

Bulk densities are used to estimate volume requirements for storage facilities and transportation equipment for coal-utilization wastes. Both poured and packed bulk densities were determined for each of the advanced process wastes. The poured bulk density estimates the volume occupied by the waste during temporary storage, before the material has time to compact under its own weight, and the packed bulk density estimates the volume occupied by the waste during long-term storage.

To perform the poured bulk-density test, the dry waste was poured into a tared 100-mL graduated cylinder and weighed. The density was calculated by dividing the weight of the dry solids by their volume. To perform the packed bulk-density test, the poured waste sample was compacted by dropping the graduated cylinder 100 times using a 1/2-inch drop. After compaction, the decrease in volume of the waste was noted, and the density was recalculated. However, these density tests are not standard tests. They were developed specifically to characterize coal combustion wastes and have been used in previous research studies (1).

3.2.1.2 Compacted Density

The compacted density of a waste can be used to estimate the fill-space required for its ultimate disposal in a landfill and also to indicate the expected stability of the material after it has been placed and compacted at a disposal site.

ASTM method D698-78, "Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using a 5.5-lb Rammer and 12-in Drop," was used to determine the maximum compacted densities for the waste materials.

This method requires the preparation of a series of waste cylinders with different moisture contents and use of standard Proctor compaction.

The characteristic moisture-density relationship for a fine-grained, cohesive material is one where the density initially increases as the moisture content is increased until a maximum compacted density is reached. The moisture content at which the maximum compacted density occurs is called the "optimum" moisture content. When the moisture content is increased above the optimum value, the density will begin to decrease. A plot of compacted density versus moisture content has a characteristic inverted-U shape and is referred to as the moisture-density curve.

For some of the waste materials, there was not enough sample to fully define the moisture-density relationship with standard 4-inch-diameter specimens as specified by ASTM method D698-78. In these cases, some additional 1.25-inch-diameter "Harvard miniature" specimens were prepared to fill out the moisture density curve. The Harvard miniature procedure is designed to approximate standard Proctor compaction.

In a few cases, the waste materials did not produce a normal moisture-density curve. These particular wastes were granular, noncohesive materials which did not display a distinct maximum compacted density.

3.2.1.3 Specific Gravity

Specific gravity is defined as the ratio of the dry weight of a unit volume of waste particles to the unit weight of distilled water at 4°C. Specific gravity differs from bulk density because the unit volume which is measured does not include the volume of the voids between the particles. Thus the specific gravity actually indicates the average mass per unit volume of the solid particles contained in the waste.

ASTM method C188, "Standard Test Method for Density of Hydraulic Cement," was used to determine the specific gravities of the coal-utilization wastes. The test is conducted by adding a known weight of the waste to kerosene contained in a special graduated flask. The volume of kerosene displaced is recorded and used to calculate the specific gravity.

ASTM method C188 is routinely used to measure specific gravities of fly ashes. This method is particularly useful for testing samples that contain a significant amount of water-soluble material.

3.2.1.4 Particle-Size Analysis

Particle-size analysis was used to determine a weight distribution of the various particle-size fractions contained in the coal-utilization wastes. Particle-size data are useful for evaluating a number of handling and disposal-related properties of the wastes such as dusting potential, compactability, self-cementing behavior, and potential pozzolanic activity.

ASTM method D422-63, "Method of Particle-Size Analysis of Soils," was used to determine the particle-size distribution of the wastes. The method involves passing a dried sample through a set of sieves and recording the weight of the material retained on each sieve. The sieve series used for the waste analyses included 3/4-inch, 3/8-inch, No. 4, No. 10, No. 40, No. 100,

and No. 200 sieves. If more than a few percent of waste sample passed the No. 200 sieve, a hydrometer analysis was conducted to measure the weight distribution of the minus-200 fraction.

The hydrometer analysis involves measuring the settling rates of the minus-200 waste particles in water. The settling rates can be related to particle sizes because smaller particles have a lower ratio of weight-to-drag resistance than larger particles; therefore, the smaller particles settle more slowly than the larger particles. The analysis is performed by inserting a hydrometer into a well-mixed particle slurry, recording the reduction in the specific gravity of the slurry over time, and then calculating a particle-size distribution based on the specific gravity data.

3.2.1.5 Specific Surface Area

The specific surface area of a waste is important because it may affect its leaching behavior. Usually, the larger the surface area of the waste, the more contact there will be between the water-soluble inorganic compounds contained in the waste and the aqueous leaching phase. Specific surface area is also a key indicator of how easily a waste can be fluidized in an airstream. Material fluidization is necessary for certain types of pneumatic transfer equipment to operate properly.

The specific surface areas of the coal-utilization wastes were measured with a Quantachrome, single-point, monosorb instrument, using the BET liquid nitrogen adsorption principle.

3.2.1.6 Blaine Fineness

Blaine fineness is useful for indicating the potential pozzolanic activity of a material. ASTM method C204-84, "Test Method for Fineness of Portland Cement by Air Permeability Apparatus," was used to determine the Blaine fineness of the coal-utilization waste samples. The test uses an air permeability apparatus to measure the specific surface area of cement and other fine pozzolanic materials such as fly ash. Blaine fineness is calculated by relating the number and size of pores in the sample to the particle size and rate of airflow through the sample.

Since Blaine fineness relates specifically to pozzolanic activity, only those samples which were expected to be reactive were tested. The characteristics which indicated potential pozzolanic activity were a high percentage of material passing the No. 200 sieve, a high specific surface area, and high silica and alumina contents.

3.2.1.7 Moisture Content

The moisture content of each advanced process waste was measured when the sample container was first opened at the Energy and Environmental Research Center (EERC). The analysis was performed using ASTM method D2216-80, "Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures." The procedure involves weighing a sample of as received fly ash, drying the sample at 110°C, and then reweighing the sample to determine the moisture loss.

Most of the wastes were fairly dry when received, some had a significant moisture content, and a few had standing water in the container. No attempt was made to measure the moisture content of the samples which had standing water.

3.2.1.8 Heat of Hydration

Some coal-utilization wastes release significant amounts of heat when conditioning water is added. The heat is generated as a result of hydration reactions which occur when the water reacts with compounds such as calcium oxide contained in the waste. Some of the wastes actually released enough heat to generate steam.

The heats of hydration of the advanced process wastes were measured with a modified version of ASTM method C110-87, "Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone." The standard procedure is designed to test quicklime, and it calls for the addition of 400 mL of water to 100 g of quicklime in an insulated flask. The mixture is stirred, and the temperature rise is recorded. For the modified procedure, the temperature increase was measured when the optimum moisture content for maximum compacted density was added to 500 g of waste material. The objective of the modified test was to evaluate the heating behavior of the waste under typical conditioning and disposal conditions.

3.2.1.9 Pozzolan Reactivity Test

Pozzolan materials are usually composed of finely divided particles which contain a high total percentage of silica, alumina, and iron oxide. These materials react with lime in the presence of moisture to form cementitious interparticle bonds. Pozzolan reactions, in contrast to hydraulic cementitious reactions, often occur slowly and continue for an extended time period.

The method used to test the coal-utilization wastes for pozzolan reactivity is contained in ASTM C311-87, "Method for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete." To perform the pozzolan reactivity test, the waste material is mixed with Portland cement in a sand-mortar mix and then cast into 2-inch cubes. After curing, the cubes are tested for unconfined compressive strength. The pozzolan reactivity of the waste was evaluated by comparing the strength of the cubes containing the waste to a set of control cubes which contained only Portland cement.

Since pozzolan materials must be composed of very fine particles, coarse wastes such as spent bed materials from atmospheric fluidized-bed combustion were not tested for pozzolan reactivity.

3.2.1.10 Unconfined Compressive Strength

The unconfined compressive strength of a compacted and cured waste gives an indication of the expected load-bearing capacity and general stability of the material after disposal. Typically, the greater the unconfined compressive strength of the material, the higher it can be stacked at a disposal site, and the steeper the side slopes on the pile can be.

A high unconfined compressive strength is caused by cementitious and pozzolanic chemical reactions in the waste. If the reactions are hydraulic, they may take place in a relatively short time period (a matter of hours to days). However, if the reactions are pozzolanic and there are no hydraulic reactions, they may take longer to occur (a matter of weeks to months or longer).

ASTM method D2166-66(79), "Test Methods for Unconfined Compressive Strength of Cohesive Soil," was used to prepare the advanced process waste specimens for unconfined compressive strength tests. The specimens were compacted in a 1.25-inch-diameter by 3-inch-long cylindrical mold, and they were cured in sealed plastic bags for 7, 14, and 28 days at 70°F before testing. All of the specimens were prepared at their optimum moisture contents as defined by the compacted density tests described above. The different curing times were used to determine how the unconfined compressive strength increased during the initial curing period.

The strengths of the cured-waste cylinders were measured by applying a gradual compressive load until failure occurred. The load was applied with a hydraulic table, and it was measured with a proving ring and an indicating dial.

Only those wastes which displayed significant self-cementing behavior after curing were fully evaluated for unconfined compressive strength.

3.2.1.11 Angle of Internal Friction

Even if a waste has a low unconfined compressive strength, it can still develop a high load-bearing capacity if it is securely held in place by well-consolidated surrounding material. If the compacted waste materials did not display significant unconfined compressive strength, their load-bearing capacities were tested while the specimens were confined in a triaxial chamber.

The function of the triaxial chamber is to confine the waste cylinder with an evenly applied pressure while a separate axial load is applied. Inside the chamber, the waste cylinder is enclosed in a rubber membrane, and water is used to transmit the confining pressure to the specimen.

ASTM method D2850-87, "Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression," was used as a general guide for the tests. However, the procedure was altered so that the specimens were allowed to drain while they were being loaded. This was done to more closely simulate the type of loading conditions to which the wastes would be subjected in the field. The waste specimens for the triaxial strength tests were prepared in a 1.25-inch-diameter by 3-inch-long mold, and they were compacted at their optimum moisture content.

The data generated from the triaxial strength test were used to determine an angle of internal friction for the compacted waste. This parameter indicates the degree to which the waste particles consolidate and interlock to resist shearing under a load. In general, the higher the angle of internal friction, the higher the load-bearing capacity of the waste will be.

3.2.1.12 Permeability

The permeability (also referred to as hydraulic conductivity) of a waste is an important property because it indicates how rapidly water can move through a waste deposit and thus generate a waste leachate.

The permeability of a waste is usually related to a number of factors such as its particle-size distribution, self-cementing behavior, and degree of compaction. A poorly graded material containing mostly sand- and gravel-sized particles will typically have a high permeability in the range of 10^{-3} to 10^{-4} cm/sec. A well-graded material containing a large fraction of very fine particles will tend to have a moderately low permeability in the range of 10^{-5} to 10^{-6} cm/sec. If the waste is actively self-cementing, the permeability of the material will tend to further decrease after it has been conditioned and allowed to cure, due to the occurrence of cementitious chemical reactions in the voids between the particles. Permeabilities of self-cementing wastes may decrease to below 10^{-7} cm/sec after conditioning, compaction, and curing.

In the laboratory, permeabilities can be measured by several different methods. For this project, a constant-head permeability test was done while the sample was confined with a rubber membrane inside a triaxial cell. The advantage of this type of sample confinement is that it eliminates the possibility of sidewall leakage. The pressure head used for the permeability tests was approximately 5 psi, and the confining pressure was approximately 10 psi.

The waste specimens for the permeability tests were compacted at optimum moisture in a 1.25-inch-diameter by 3-inch-long mold. If the waste was actively self-cementing, it was cured for 28 days at 70°F before it was tested.

The permeability measurements obtained in the laboratory for the advanced process wastes may not necessarily be representative of the permeabilities that these wastes will exhibit in the field. The in-field permeabilities of these wastes will depend on a number of factors, the most important of which are usually the degree of compaction used to place the waste at the disposal site, the moisture content of the compacted waste, and possibly the age of the waste deposit.

Generally, if the compacted density obtained in the field for a specific advanced process waste is lower than the compacted density used to prepare the waste specimens tested in the laboratory, then the in-field permeability of the advanced process waste will tend to be higher than the values measured in the laboratory. Further, if the moisture content of the waste in the field is significantly lower than the moisture content of the specimens tested in the laboratory, then the in-field permeabilities will also tend to be higher than the values measured in the laboratory.

For those advanced process wastes that are either self-cementing or pozzolanic, their in-field permeabilities may decrease over time after they have been placed at a disposal site. This is because the continuing cementitious chemical reactions that occur in these types of wastes tend to clog the internal pores in the waste deposit. Thus for both the self-cementing wastes and the pozzolanic wastes, their in-field permeabilities may eventually be lower than the values reported from the laboratory tests.

3.2.1.13 Compressibility/Consolidation

When waste is stacked at a disposal site, it will gradually settle under its own weight. The rate of consolidation depends on both the load applied and the rate of migration of water out of the particle voids.

The test method used to measure waste compressibility/consolidation is described in ASTM D2435-80, "Test Method for One-Dimensional Consolidation Properties of Soil." No attempt was made to measure the rebound characteristics of the waste.

The consolidation test is performed by placing a waste specimen in a special apparatus called a consolidometer. The specimen is loaded under compression, and the vertical deflection is measured as a function of time with an indicating dial gage. The test data are used to determine a coefficient of consolidation (C_v) for the waste. The C_v represents the material properties that control the consolidation process.

Since C_v tends to vary with the load applied, several different C_v values were determined for each waste over a range of different loadings. The results of the consolidation test are presented as a plot of C_v versus the log of applied pressure.

3.2.1.14 Angle of Repose

Angle of repose is the angle formed between the side-slope and bottom of the pile when a dry waste is slowly poured onto a flat horizontal surface. The magnitude of the angle of repose, which is measured with a protractor, indicates how easily a material will flow by gravity. Generally, the lower the angle, the more readily the waste tends to flow when in a dry, loose state.

3.2.2 Chemical and Mineral Characterization Methods

3.2.2.1 Bulk Chemical Composition

The chemical composition of a waste material can influence many important handling and disposal-related properties such as self-heating potential, self-hardening potential, pozzolanic reactivity, permeability, and leachate-production potential. The usual method for determining the chemical composition of coal-utilization wastes is to perform a bulk chemical analysis. A standard bulk chemical analysis includes the following elements (all reported as oxides):

- Silicon, SiO_2
- Aluminum, Al_2O_3
- Iron, Fe_2O_3
- Calcium, CaO
- Magnesium, MgO
- Sodium, Na_2O
- Potassium, K_2O
- Titanium, TiO_2
- Phosphorous, P_2O_5
- Sulfur, SO_3

To perform bulk chemical analyses, the coal-utilization waste samples were fused with lithium metaborate and then dissolved in dilute nitric acid. Silicon, aluminum, iron, calcium, magnesium, sodium, potassium, titanium, and phosphorous were analyzed from the dilute acid solution. Inductively coupled argon plasma (ICAP) spectrometry was used to determine the concentrations of titanium and phosphorous, and the remaining elements were determined by flame atomic absorption (AA) spectrometry. Matrix-matched standards were used for both spectrophotometric methods. Duplicate analyses were performed. The results were reported as oxides on a weight percent basis in accordance with standard bulk chemical reporting conventions.

Although the elements determined for a bulk chemical analysis are conventionally reported as oxides, it must be remembered that these elements may or may not actually be present as oxides. For example, calcium in coal combustion wastes may be present as calcium oxide, calcium sulfate, calcium carbonate, and many other forms.

In order to give a more complete description of the chemical composition of each advanced process waste, additional compounds that could not be detected directly with the bulk chemical analysis were listed separately as "other constituents." The other waste constituents included compounds such as calcium carbonate, water of hydration, unburned carbon, anionic sulfur forms, and chloride. The amounts of these other constituents in a specific waste sample were determined by comparing the results of the bulk chemical analysis, mineralogical analysis, and thermogravimetric analysis.

3.2.2.2 Sulfur Forms

The total sulfur content of each advanced process waste was analyzed with a LECO induction furnace. The acid-labile sulfur was determined by extracting the sample with 40% hydrochloric acid and measuring the sulfur concentration of the extract by ICAP spectrometry. The acid extraction will liberate nonpyritic sulfide as hydrogen sulfide and will solubilize the sulfite and sulfate that are not present as an insoluble calcium or barium salt. Most of the hydrogen sulfide will escape to the atmosphere and thus be only a minor interference in the determination. The difference between the total sulfur value and the sulfate/sulfite value represents the acid-insoluble sulfide, such as pyrite, plus the acid-insoluble sulfate/sulfite such as the Ca/Ba salts.

3.2.2.3 Chloride Content

The chloride content of the advanced process wastes was determined by extracting the chloride with distilled-deionized water and then measuring the chloride concentration of the extract using ion chromatography.

3.2.2.4 X-Ray Diffraction Analysis

Qualitative x-ray powder diffraction analysis was used to identify the crystalline phases present in the advanced process wastes. The mineral composition of a waste is important because crystalline phases such as lime, tricalcium aluminate, and calcium sulfate can greatly affect the self-hardening and self-heating properties of the wastes.

To perform the x-ray diffraction analysis, a representative aliquot of each waste was ground with ethyl alcohol and smeared onto a single-crystal, "zero"-background, quartz plate for subsequent analysis. Diffraction data were collected in 0.02° steps for a one-second dwell time using a Philips automated diffractometer equipped with a copper tube, theta-compensating slit, graphite-diffracted beam monochromator, and scintillation detector. A new set of software programs on a CD ROM supplied by Materials Data Incorporated was used for data collection, data reduction, and phase identification.

3.2.2.5 Scanning Electron Microscope Point Count

The scanning electron microscope point count (SEMP) analysis technique was used to quantify the various mineral phases in the advanced process wastes. The SEMPC analysis is a valuable supplement to the x-ray diffraction analysis for determining the mineral composition of the wastes.

The SEMPC analysis was performed by collecting quantitative chemical composition data using a microprobe at a large number of different points across the surface of a waste sample.

The data were collected using a stage automation system programmed according to operator-selected parameters to move in a raster pattern over a representative area of the sample. The system was programmed to halt the movement of the stage at regular intervals and collect an energy-dispersive spectrum for eight seconds. After eight seconds, the spectrum was integrated to determine the total number of x-ray counts collected. If the x-ray count was below a threshold selected by the operator, the computer moved the sample to the next point.

The chemical composition data were used to identify the mineral composition corresponding to each point. The mineral composition was determined by use of a computer program that compared the chemical composition data obtained at each point to various molar weight ratios for 43 different crystalline or amorphous phases which are known to be present in many coal-utilization wastes.

The SEMPC technique is based on the point-count technique used in quantitative optical mineralogy. In the optical technique, the sample is overlain with a grid graticule. The mineral at each intersection of the grid is then classified and counted. By classifying a statistically significant number of grains, the mineral composition of the sample is determined. The SEMPC technique uses the same procedure, except the grid pattern is replaced by a programmed rastering of the electron microscope beam, and the optical identification is replaced by classification based on chemical composition.

3.2.2.6 Thermogravimetric Analysis

Thermogravimetric analysis (TGA) was used to evaluate the thermal stability of the advanced process wastes. The analysis was also useful for identifying certain mineral phases in the wastes. For example, certain carbonate phases which cannot be identified with either bulk chemical or SEMPC analyses can be semiquantitatively identified by TGA because they decompose when heated between 600° and 900°C .

The instrument used for TGA analysis of the wastes was a DuPont Model 951 module interfaced with a DuPont 1090 thermoanalyzer and data processor. The instrument has a 100-mg capacity and a maximum heatup rate of 100°C/min.

To perform the TGA analysis, the waste sample was heated to 1075°C while the weight, time, and temperature were logged by a computer. Based on this data, a plot of sample weight versus time (or temperature) was prepared for each sample. The loss of weight from the sample corresponded to dehydration, decomposition, or volatilization of various constituents as the temperature increased. Depending on the temperature range where the weight loss occurred, the particular mineral phase affected may be identified.

3.2.2.7 Coal Analysis

Proximate analysis of the coal samples was performed using an automated coal analyzer. Sulfur content was determined using a LECO induction furnace, and the remaining parameters for the ultimate analysis were determined using an automated carbon-hydrogen-nitrogen analyzer. The heating value was determined by adiabatic calorimetry. Representative aliquots of the coal samples were ashed, and elemental concentrations of the major cations were determined using the analytical methods outlined in the section on bulk chemical analysis.

Samples of the coal were digested with sulfuric and nitric acids for the determination of arsenic, barium, cadmium, chromium, mercury, lead, selenium, and silver. Barium, cadmium, and chromium were determined by ICAP. Arsenic and selenium were determined using hydride-generation AA. Cold vapor-generation AA was used to determine mercury, and graphite-furnace AA was used to determine lead and silver.

4.0 DATA

The data collected for the 34 advanced process wastes and the eight coals that were characterized for this project are contained in a set of 11 appendices. The appendices included with this report are listed as follows:

- Appendix 1 - Summary of the Waste Physical Property Data
- Appendix 2 - Summary of the Waste Chemical and Mineral Compositions
- Appendix 3 - Waste Moisture-Density Curves
- Appendix 4 - Waste Particle-Size Distribution Curves
- Appendix 5 - Waste Consolidation Curves
- Appendix 6 - Waste Scanning Electron Microscope Photographs
- Appendix 7 - Waste Bulk Chemical Composition Data
- Appendix 8 - Waste Scanning Electron Microscope Point Counts
- Appendix 9 - Waste X-Ray Diffraction Analyses
- Appendix 10 - Waste Thermogravimetric Analyses
- Appendix 11 - Coal Bulk Chemical Composition Data

5.0 RESULTS AND DISCUSSION

The advanced coal-utilization processes currently being developed in the U.S. will be part of the next generation of energy production technology.

These processes are expected to produce large amounts of solid wastes. In order to minimize the costs and potential adverse environmental impacts associated with the disposal of wastes from advanced processes, appropriate waste management techniques must be developed.

Although waste management systems for advanced processes will be similar in many respects to those now being used for conventional coal combustion wastes, some modifications will be necessary in some cases to accommodate the unique properties of the advanced process wastes. In this section, the geochemical and geophysical properties of 34 different advanced process wastes are discussed, and the impacts of these properties on waste handling, transport, and disposal operations are evaluated. The evaluation was done by examining the properties of the wastes and comparing them to the specified ranges of relevant properties that are generally considered acceptable for the various waste management operations, and by identifying waste characteristics such as extreme abrasiveness or corrosiveness, which might pose special problems for the various operations.

5.1 Solid Waste Management Systems

Waste management systems for coal-fired power plants usually consist of the following five principal subsystems (2):

1. A transfer subsystem to remove the waste from the primary collection device and transfer it to storage.
2. A storage subsystem to equalize the waste flow at the plant.
3. A conditioning subsystem to prepare the waste for transport and disposal.
4. A transport subsystem to convey the waste to an ultimate disposal site.
5. A disposal subsystem to ultimately contain the waste.

In addition to these subsystems, if the waste has value as a by-product, it may be profitable to include additional handling and storage facilities so that it can be sold as the demand arises.

5.2 Transfer Subsystems

Waste transfer involves in-plant movement of the waste from an initial collection point such as an electrostatic precipitator or a baghouse to some type of short-term storage facility. Waste-transfer subsystems usually consist of feeder and transport components. The feeder removes the waste from the initial collection point, and the transport component moves it around the plant.

The selection of a transfer subsystem for an advanced process waste should be based on the physical and chemical properties of the waste, the volume of material to be handled, and the distances the material must be moved. For the following analysis, the only information available was the physical and chemical property data generated during the testing phase of the project. Therefore, the conclusions drawn from the analysis will be limited

to making general recommendations that concern the suitability of different transfer options for the advanced process wastes and to identifying specific transfer mechanisms which are clearly not compatible with certain wastes.

Transfer subsystems can be designed to handle wastes in a dry form or as a wet slurry. Most of the advanced process wastes, however, will require dry transfer due to their self-hardening and/or self-heating behaviors. For this reason, only dry transfer subsystems will be discussed in this section. Since wet handling of some of the wastes may be more appropriate for transport subsystems, which usually move materials over longer distances than transfer subsystems, a discussion of wet-handling systems will be included in the section on transport subsystems.

Dry transfer subsystems are classified as either pneumatic or mechanical processes. The most widely used pneumatic transfer processes are dilute-phase vacuum conveyors, dilute-phase positive-pressure conveyors, dilute-phase vacuum/positive-pressure conveyors, dense-phase vacuum conveyors, and air-activated gravity conveyors. The most widely used mechanical transfer processes are belt, screw, chain, and vibrating conveyors and bucket elevators.

5.2.1 Dilute-Phase Pneumatic Conveyors

Dilute-phase pneumatic conveyors use high-velocity air to move materials through a system of pipes. They are usually used in a power plant to transfer wastes over relatively short distances. The airstream for the pneumatic conveyor can be produced by either drawing air through the pipes under a vacuum or by pumping air through the system using positive-pressure. Also, for certain applications, vacuum and positive-pressure air movement can be used in different sections of the same transfer subsystem. Dilute-phase pneumatic conveyors are the most commonly used types of fly ash transfer subsystems in U.S. power plants.

Materials conveyed with dilute-phase systems must be dry and relatively fine. Vacuum and positive-pressure conveyors can handle materials with particle sizes ranging from about 1 μm to 0.64 cm, with bulk densities ranging from 1 to 200 lb/ft³. Generally, materials with a particle size of about 50 μm are easiest to transfer with these systems. The material being transferred should be kept dry, or it may cause a serious problem with clogging in the pipes (2).

5.2.2 Dense-Phase Pneumatic Conveyors

Dense-phase pneumatic conveyors operate in a manner similar to dilute-phase systems, but use a higher material-to-air ratio. Dense-phase systems have been used in Europe with good results for handling fly ash, and they may be useful for transferring some of the advanced process wastes.

Dense-phase conveyors can only be used for transferring fine, dry wastes because the material must be fluidized for the conveyor to operate properly. Generally, dense-phase conveyors cannot handle quite as broad a range of particle sizes as dilute-phase systems.

5.2.3 Air-Activated Gravity Conveyors

Air-activated gravity conveyors transfer materials pneumatically through a rectangular duct. This type of conveyor works by fluidizing the waste with an airstream directed up through the porous bottom of the duct. When the duct is inclined slightly, the fluidized waste flows by gravity. Air-activated gravity conveyors are usually used for relatively short transfer distances.

Since material movement depends on fluidization, many of the same requirements apply to an air-activated gravity conveyor as apply to a dense-phase conveyor. Air-activated systems generally require that 100% of the material being conveyed pass through a #20 sieve (which has 841- μm openings) and that 20% to 60% pass through a #200 sieve (which has 74- μm openings). The material must also be dry for the conveyor to work properly. Usually the moisture content should be less than 1% (2).

5.2.4 Belt Conveyors

Belt conveyors use a continuous belt loop supported by rollers to transfer material. If dusting is expected to be a problem, the belt can be enclosed. Sticky materials can cause problems for belt conveyors because they are difficult to unload. The temperature of materials being transferred with a belt conveyor should not exceed 300°F. Also, materials being transferred by a belt conveyor should have a particle size greater than 0.125 inches (2).

5.2.5 Screw Conveyors

A screw conveyor consists of a long steel auger supported in a U-shaped trough. The turning of the auger moves the material through the trough. Materials to be transferred with a screw conveyor must be free flowing, with particle sizes ranging from very fine to 4 inches in diameter.

5.2.6 Chain Conveyors

Chain conveyors use a heavy steel chain to move materials through a trough. The chain is connected to a power drive and often has some type of blade attached for moving the materials. Various types of free-flowing materials can be transferred with chain conveyors. Generally, materials with particle sizes ranging from very fine to granular can be moved with some type of chain conveyor. Hot materials can also be handled with chain conveyors, although very hot spent bed materials from fluidized-bed combustors may have to be cooled somewhat before being transferred. Generally, the temperature of wastes being transferred by chain or screw conveyors should not exceed 900°F. Abrasive materials may be difficult to handle with chain conveyors because they can cause excessive wear.

5.2.7 Vibrating Conveyors

Vibrating conveyors usually consist of a steel pan which is mounted on springs and vibrated by an electric motor. The vibration causes the material being transferred to move along the pan in a series of short hops. Vibrating conveyors are best suited to moving granular materials rather than fine powders. Hot materials can be transferred with this type of conveyor, but abrasive materials may cause problems.

5.2.8 Bucket Elevators

Bucket elevators move materials up an incline or vertically with a series of buckets attached to a chain or belt. The elevator is usually enclosed to contain the material being conveyed. Bucket elevators having the proper bucket configuration can move almost any type of material with a maximum particle size up to about 6 inches. If belts are used for the elevator, the temperature of the material should not exceed about 600°F.

5.2.9 Criteria for Selecting Appropriate Waste-Transfer SubSystems

The main waste characteristic that was used to decide whether a specific waste was compatible with the different transfer subsystems was particle-size distribution. Bulk density and specific surface area were also considered in some cases to estimate the porosity of the waste, which is important if the material must be fluidized for proper movement. Table 4 summarizes some of the physical property data that can be useful for selecting appropriate waste transfer subsystems.

Table 5 contains qualitative estimates of the abrasiveness and corrosiveness of the advanced process wastes. If the waste produced an aqueous slurry with a pH >11.5 or <4.5, it was classified as potentially corrosive. Although the slurry pH is a useful indicator of waste corrosiveness, the actual corrosive behavior of a specific waste will also depend on other factors such as the amount of free-moisture in the waste and the presence of soluble anions such as chloride and sulfate in the free-moisture phase.

The abrasiveness of each waste was rated as either high, moderate, or low based on the amounts of quartz determined in the mineralogical analysis and the total SiO_2 and Al_2O_3 determined in the bulk chemical analysis. Generally, quartz is the most abrasive form of silicon oxide in the wastes. Other forms such as silicon oxide contained in glassy phases may not be as abrasive as quartz.

The properties listed in Table 5 do not necessarily indicate whether a specific transfer subsystem can or cannot handle a particular waste, but they may indicate that special precautions should be taken in the construction of equipment to minimize future maintenance problems. For example, if a waste is extremely abrasive, a chain conveyor may still be used to transfer the material, but it may be necessary to use a special abrasion-resistant steel alloy for the conveyor parts that will come into contact with the waste.

Table 6 shows the results of a compatibility analysis that was done by comparing the physical properties of the advanced process wastes to the various limitations specified for each type of transfer subsystem. According to each subsystem's ability to handle a particular waste, either a "y" (for yes) or an "n" (for no) was placed in the column designated for that transfer subsystem.

TABLE 4
Important Physical Properties for Selection of Transfer Subsystems

<u>Sample No.</u>	<u>Maximum Particle Diameter* (mm)</u>	<u>Mean Particle Diameter (D₅₀, mm)</u>	<u>Specific Surface Area (m²/g)</u>	<u>Loose Dry Bulk Density (lb/ft³)</u>
102	0.16	0.018	2.47	60.9
104	5.0	0.85	0.1	89.2
202	0.16	0.022	0.92	62.2
203	5.0	0.28	2.0	93.0
302A	25.4	1.7	0.76	38.5
403A	0.16	0.03	2.82	51.8
502A	19.0	1.7	0.91	62.5
503	19.0	0.6	4.02	54.0
602A	19.0	2.3	3.46	75.3
603A	0.16	0.014	1.71	57.0
702A	19.0	2.5	0.88	57.4
703A	0.16	0.032	2.38	54.6
1202	5.0	0.47	6.43	78.1
1203	0.16	0.013	7.18	46.5
1204	5.0	0.48	5.68	82.3
1204A	0.16	0.07	10.02	41.4
1205A	0.16	0.088	10.08	50.3
1302A	19.0	0.48	1.12	89.6
1304A	0.16	0.035	3.78	42.6
1305A	0.16	0.005	11.64	28.0
2002	5.0	2.2	ND**	53.7
2102A	9.5	0.6	0.2	69.3
2201	5.0	0.8	0.44	50.9
2201A	9.5	0.9	21.64	60.3
2302A	19.5	0.9	2.25	75.9
2303A	5.0	0.21	3.68	71.7
2304A	0.16	0.03	13.04	42.6
2402A	19.0	0.51	0.77	97.1
2403A	0.16	0.04	3.26	63.5
2404	0.16	0.018	25.05	18.9
2404A	0.16	0.027	6.85	43.5
2503A	0.16	0.07	10.49	39.7
2504A	0.16	0.029	13.33	26.9
EER	75.0	3.5	0.09	86.4

* Maximum particle diameter was estimated from the sieve analysis.

** No data. It was not possible to accurately measure the specific surface area of this sample.

TABLE 5
Estimated Abrasiveness and Corrosiveness of the
Advanced Process Wastes

<u>Sample No.</u>	<u>Waste Abrasiveness¹</u>	<u>Waste Corrosiveness²</u>
102	Moderate	Potentially Corrosive
104	High	--
202	High	Potentially Corrosive
203	High	--
302A	High	--
403A	High	--
502A	High	--
503	Moderate	--
602A	High	--
603A	Moderate	--
702A	High	--
703A	High	Potentially Corrosive
1202	Moderate	--
1203	Low	Potentially Corrosive
1204	Moderate	--
1204	Moderate	Potentially Corrosive
1205A	Moderate	Potentially Corrosive
1302A	High	Potentially Corrosive
1304A	Moderate	Potentially Corrosive
1305A	Moderate	Potentially Corrosive
2002	High	--
2102A	Low	Potentially Corrosive
2201	High	--
2201A	High	Potentially Corrosive
2302A	Low	Potentially Corrosive
2303A	Moderate	Potentially Corrosive
2304A	Low	Potentially Corrosive
2402A	Low	Potentially Corrosive
2403A	Low	Potentially Corrosive
2404	High	Potentially Corrosive
2404A	High	Potentially Corrosive
2503A	High	Potentially Corrosive
2504A	High	Potentially Corrosive
EER	High	--

^{1,2} Basis for ranking:

Abrasiveness:	Low	Moderate	High
Quartz Content	<5%	5% to 10%	>10%
or			
Total SiO ₂ + Al ₂ O ₃ Content	<30%	30% to 50%	>50%

Corrosiveness: Wastes were listed as "potentially corrosive" if the pH of a 50% aqueous slurry was either >11.5 or <4.5.

5.3 Storage Subsystems

Storage facilities for advanced process wastes will normally be necessary to equalize the flow of waste to the conditioning, transport, and disposal subsystems. If the waste is transferred in a dry form, it can normally be stored in a bin or silo. These types of vessels are usually cylindrical or square in cross-section, enclosed, and may have a lowerfunnel-like section called a hopper. The purpose of the hopper is to control the discharge flow from the storage vessel.

Design considerations for storage facilities include the rate at which the waste will be produced, the amount of time that it may have to be stored, and the physical and chemical properties that control its flow characteristics. Since only physical and chemical property data are available for the advanced process wastes, the analysis of storage subsystems will be limited to a discussion of some pertinent waste characteristics. These include the angle of repose, packed dry bulk density, self-heating potential, self-hardening potential, abrasiveness, corrosiveness, and utilization potential of the advanced process wastes.

Angle of repose is the angle formed between the side-slope and bottom of the pile formed when dry waste is poured on a flat surface. Angle of repose is an important consideration for the design of a storage system because, generally, the smaller this angle, the more easily the dry material will tend to flow by gravity. The packed dry bulk density indicates how much waste can be placed in a unit volume of the storage facility. The possible self-heating and/or self-hardening of a waste are important considerations because these properties can lead to troublesome clogging in the discharge hopper if the material is allowed to get wet.

The utilization potential of a waste is another important design consideration for the storage subsystem. If a waste has a high utilization potential, it may be desirable to build enough storage capacity to hold some of the waste until it can be sold. The amount of storage capacity that is needed will depend on the local coal combustion by-product market. Also, if utilization of a waste depends on its chemical activity, as is the case with many types of fly ash, it will be important to keep the waste dry while it is being stored in order to maintain its chemical activity.

One of the most profitable uses for coal combustion wastes is as a concrete additive. Fly ash can be used to replace some of the Portland cement in a concrete mix if it meets the specifications listed in ASTM C618, "Specification for Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete." Several of the parameters needed to evaluate the advanced process wastes in terms of these specifications were measured for this study. Based on a comparison between these data and the specifications, the potential utilization of the advanced process wastes was evaluated. Only one of the 34 wastes studied appeared to meet the specification. This was sample 202, an ash produced by a fluidized-bed gasifier. The full results of this evaluation are contained in Table 7.

Other markets for coal combustion wastes include uses as fill materials for construction sites, sandblasting grit, road deicer, and asphalt additives. Generally, wastes that have a high pentage of inert oxides (i.e., SiO_2 , Al_2O_3 , and Fe_2O_3) are useful for these applications. See Table 8 for a listing

TABLE 6

Suitability of Pneumatic Systems for Transferring Advanced Process Wastes

Sample No.	Pneumatic Systems					Comment
	Vacuum	Positive Pressure	Vacuum/Positive Pressure	Dense Phase	Air-Activated Gravity	
102	Y	Y	Y	Y	Y	
104	Y	Y	Y	N	N	Waste difficult to fluidize
202	Y	Y	Y	Y	Y	
203	Y	Y	Y	N	N	Waste difficult to fluidize
302A	N	N	N	N	N	Waste too coarse to transfer pneumatically
403A	Y	Y	Y	Y	Y	
502A	N	N	N	N	N	Waste too coarse to transfer pneumatically
503	N	N	N	N	N	Waste too coarse to transfer pneumatically
602A	N	N	N	N	N	Waste too coarse to transfer pneumatically
603A	Y	Y	Y	Y	Y	Waste too coarse to transfer pneumatically
702A	N	N	N	N	N	Waste too coarse to transfer pneumatically
703A	Y	Y	Y	Y	Y	
1202	Y	Y	Y	N	N	Waste difficult to fluidize
1203	Y	Y	Y	Y	Y	
1204	Y	Y	Y	N	N	Waste difficult to fluidize
1204A	Y	Y	Y	Y	Y	
1205A	Y	Y	Y	N	N	Waste difficult to fluidize
1302A	N	N	N	N	N	Waste too coarse to transfer pneumatically
1304A	Y	Y	Y	Y	Y	
1305A	Y	Y	Y	Y	Y	
2002	N	N	N	N	N	Waste too coarse to transfer pneumatically
2102A	N	N	N	N	N	Waste too coarse to transfer pneumatically
2201	Y	Y	Y	N	N	Waste difficult to fluidize
2201A	N	N	N	N	N	Waste too coarse to transfer pneumatically
2302A	N	N	N	N	N	Waste too coarse to transfer pneumatically
2303A	Y	Y	Y	N	N	Waste too coarse to transfer pneumatically
2304A	Y	Y	Y	Y	Y	Waste difficult to fluidize
2402A	N	N	N	N	N	Waste too coarse to transfer pneumatically
2403A	Y	Y	Y	N	N	Waste difficult to fluidize
2404	Y	Y	Y	Y	Y	
2404A	Y	Y	Y	Y	Y	
2503A	Y	Y	Y	Y	Y	
2504A	Y	Y	Y	Y	Y	
EER	N	N	N	N	N	Waste too coarse to transfer pneumatically

(continued)

TABLE 6 (continued)

Suitability of Various Mechanical Systems for Transferring Advanced Process Wastes

Sample No.	Mechanical Systems					Comment
	Belt* Conveyor	Screw Conveyor	Chain Conveyor	Vibrating Conveyor	Bucket Elevator	
102	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
104	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
202	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
203	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
302A	N	Y	Y	Y	Y	
403A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
502A	N	Y	Y	Y	Y	
503	N	Y	Y	Y	Y	
602A	N	Y	Y	Y	Y	
603A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
702A	N	Y	Y	Y	Y	
703A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
1202	N	Y	Y	Y	Y	
1203	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
1204	N	Y	Y	Y	Y	
1204A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
1205A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
1302A	N	Y	Y	Y	Y	
1304A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
1305A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2002	Y	Y	Y	Y	Y	
2102A	Y	Y	Y	Y	Y	
2201	N	Y	Y	Y	Y	
2201A	Y	Y	Y	Y	Y	
2302A	N	Y	Y	Y	Y	
2303A	N	Y	Y	Y	Y	
2304A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2402A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2403A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2404	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2404A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2503A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
2504A	N	N	Y	N	Y	Waste too fine for screw and vibrating conveyors
EER	N	Y	Y	Y	Y	

* Abrasive properties of most advanced process wastes make belt transfer difficult.

The self-hardening and self-heating behaviors of the advanced process wastes are indicated in Table 9. The self-hardening potential of each waste was rated as either high, moderate, or low based on the 7-day unconfined compressive strengths measured. The self-heating potential was rated as either high, moderate, low, or none based on the temperature rise recorded for each waste when it was mixed with water. Other important properties of 34 advanced process wastes which relate to the design of storage facilities are listed in Table 10.

Abrasiveness and corrosiveness are important considerations for selecting suitable materials for constructing storage facilities. If a waste is corrosive, it may be necessary to construct the silos and hoppers from concrete or stainless steel rather than mild steel, and if the waste is abrasive, it may necessary to construct some parts of the storage system from abrasion-resistant steel alloys.

5.4 Conditioning Subsystems

Conditioning is usually accomplished by mixing the waste with just enough water to produce a moist, cohesive product. The purpose of waste conditioning is to improve the handling properties of the material prior to transport to an ultimate disposal site and to facilitate proper placement of the waste at the disposal site. Conditioning the waste helps to control dusting, increase cohesiveness, and increase maximum compacted density. As an alternative to adding water to the waste, conditioning is sometimes done by mixing a dry waste with a relatively wet scrubber sludge to produce a moist product. Either method is acceptable, but scrubber sludge may not be available at a plant that is producing an advanced process waste.

The amount of water used to condition coal combustion wastes is usually just enough to keep them from dusting. This is typically between 10 and 15 percent on a dry weight basis for a conventional fly ash. Most coal combustion plants try to keep the amount of added water low so that the waste does not become tacky and cause handling problems.

With most coal-utilization wastes, there is a specific water addition level called the optimum moisture content which produces the maximum compacted density when the waste is placed at a disposal site. Conditioning the waste to its optimum moisture content is beneficial because good compaction tends to reduce waste permeability, increase load-bearing capacity, and permit the maximum amount of material to be placed in a unit volume at the disposal site. Normally, adding the optimum moisture level to the waste will not cause handling problems, but most combustion plants still tend to keep the conditioning moisture level below the optimum.

It is recommended for the advanced process wastes that the amount of conditioning moisture being added be kept as close to the optimum as possible for the sake of the benefits stated above. Table 11 lists the optimum moisture determined for the 34 advanced process wastes along with the maximum dry densities determined for each using a standard Proctor compactive effort. Some of the advanced process wastes had unusually high optimum moisture and low maximum compacted densities.

TABLE 7

Comparison of Waste Properties to ASTM C618 Specifications

Sample No.	Total SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ Content (wt%)	SO ₃ Content (wt%)	Pozzolanic Activity Index (% of control)	% Retained ¹ on a #325 Sieve (wt%)
102	53.2	6.8	82	32
104	72.8	0.2	ND ²	95
202	79.8	1.1	118	25
203	78.5	4.3	ND	92
302A	97.1	0.2	ND	93
403A	89.0	0.6	73	28
502A	95.1	0.2	ND	91
503	36.0	8.5	ND	82
602A	76.2	0.5	ND	96
603A	52.0	5.9	110	11
702A	82.3	0.3	ND	97
703A	81.4	0.8	73	40
1202	74.8	1.4	ND	94
1203	10.2	3.7	37	75
1204	66.1	1.4	ND	92
1204A	20.1	11.0	73	62
1205A	10.3	16.2	27	75
1302A	62.8	12.6	ND	98
1304A	54.6	10.9	42	45
1305A	55.8	5.6	48	5
2002	69.2	0.75	42	98
2102A	30.9	0.6	48	100
2201	86.5	0.2	ND	100
2201A	74.2	0.2	ND	97
2302A	2.6	6.5	ND	100
2303A	5.8	9.6	ND	96
2304A	27.4	8.7	56	43
2402A	8.1	6.6	ND	99
2403A	22.9	4.4	37	48
2404	71.8	0.4	70	12
2404A	34.4	6.4	76	24
2503A	35.6	3.7	31	60
2504A	32.6	2.3	31	25
EER	76.1	0.4	ND	100

¹ Percent waste retained on a #325 sieve was estimated from the particle-size analysis.

² No data. These wastes were not tested for pozzolanic activity.

Note: Some requirements to meet ASTM C618 specifications include:

- Total SiO₂ + Al₂O₃ + Fe₂O₃ content must be >70% for Class F ash and >50% for Class C ash.
- SO₃ content must be <5%.
- Pozzolanic activity index (for cement) must be >75% of control after a 28-day cure.
- Percent retained on a #325 sieve cannot exceed 34%.

TABLE 8

Major Element Composition* of the Advanced Process Wastes

Sample No.	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O
102	30.7	13.0	9.5	20.4	6.3	6.0	1.7
104	44.4	16.9	11.5	18.2	6.5	2.4	1.3
202	51.8	21.5	6.5	14.6	4.8	0.5	0.8
203	42.6	12.4	23.5	9.7	2.0	0.3	0.4
302A	54.5	31.6	11.0	2.1	0.6	0.7	0.4
403A	54.4	22.4	12.2	2.7	1.2	0.5	2.5
502A	55.1	18.8	21.2	4.0	1.1	0.8	2.3
503	20.8	6.1	9.1	25.3	0.7	0.3	1.1
602A	45.1	13.8	8.3	15.3	6.1	5.2	1.0
603A	35.2	12.1	4.7	20.0	6.0	6.3	1.0
702A	60.8	17.8	3.7	11.3	3.0	2.7	0.8
703A	56.7	20.0	4.7	11.2	2.2	4.0	0.9
1202	35.6	13.7	25.5	2.9	0.8	0.3	1.3
1203	5.2	2.0	3.0	45.7	0.5	0.1	0.2
1204	32.3	12.7	21.1	2.6	0.7	0.3	1.2
1204A	11.5	3.5	5.1	35.9	0.4	0.2	0.4
1205A	6.2	2.2	1.9	45.9	0.3	0.1	0.2
1302A	40.2	19.2	3.4	21.2	1.8	0.2	2.5
1304A	30.8	17.2	6.6	19.5	1.6	0.2	2.2
1305A	29.4	18.4	8.0	11.9	1.3	0.2	2.0
2002	39.6	15.4	14.2	5.3	1.0	0.6	1.6
2102A	17.7	6.0	7.2	52.8	7.0	0.1	0.5
2201	79.7	5.7	1.1	2.3	0.7	0.9	2.4
2201A	40.4	17.6	16.2	7.0	1.0	0.7	1.2
2302A	1.5	0.6	0.5	69.4	0.8	0.0	0.1
2303A	3.4	1.6	0.8	63.5	0.8	0.0	0.1
2304A	16.0	6.6	4.8	32.7	0.8	0.1	0.8
2402A	6.0	1.1	1.0	50.0	0.7	0.1	0.1
2403A	12.5	4.2	6.2	45.9	0.8	0.1	0.4
2404	39.5	20.5	11.8	0.7	0.7	1.2	1.6
2404A	19.9	6.2	8.3	33.2	0.8	0.2	0.8
2503A	27.7	7.0	0.9	32.3	0.5	0.5	0.2
2504A	24.6	7.0	1.0	14.7	0.3	0.5	0.2
EER	33.4	22.9	19.8	26.0	1.3	0.1	0.2

* All elements are reported as oxides on a weight percent basis.

TABLE 9

**Estimated Self-Heating and Self-Hardening
Potentials of the Advanced Process Wastes**

<u>Sample No.</u>	<u>Waste Self-Heating Potential¹</u>	<u>Waste Self-Hardening Potential²</u>
102	Low	Moderate
104	None	None
202	Low	High
203	None	None
302A	None	None
403A	None	None
502A	None	None
503	None	Low
602A	Low	None
603A	None	High
702A	None	None
703A	None	Low
1202	None	None
1203	Moderate	High
1204	None	None
1204A	Moderate	Moderate
1205A	High	Moderate
1302A	Low	None
1304A	Low	Moderate
1305A	None	High
2002	None	None
2102A	None	None
2201	None	None
2201A	None	None
2302A	High	Low
2303A	High	Moderate
2304A	Moderate	None
2402A	High	None
2403A	High	High
2404	None	None
2404A	Moderate	High
2503A	Moderate	Moderate
2504A	Low	Moderate
EER	None	None

¹ Self-heating potential was estimated from the maximum waste temperature after the waste was mixed with water. None: <70°F, Low: 70°F to 100°F, Moderate: 100° to 200°F, and High: >200°F.

² Self-Hardening potential was estimated from the 7-day compressive strength of the wastes. None: <5 psi, Low: 5 to 10 psi, Moderate: 10 to 50 psi, and High: >50 psi.

TABLE 10

Angle of Repose and Packed Dry Bulk Density of the
Advanced Process Wastes

Sample No.	Angle of Repose (°)	Packed Dry Bulk Density (lb/ft ³)
102	43	79.1
104	38	99.1
202	33	80.7
203	34	102.2
302A	35	46.4
403A	25	71.0
502A	38	71.8
503	44	66.7
602A	38	83.6
603A	IS*	86.4
702A	35	68.4
703A	24	81.4
1202	IS	91.9
1203	38	57.0
1204	38	95.7
1204A	37	55.9
1205A	37	59.2
1302A	35	97.4
1304A	35	60.0
1305A	35	50.5
2002	34	60.3
2102A	IS	77.9
2201	37	74.8
2201A	37	64.1
2302A	34	81.6
2303A	38	99.2
2304A	38	67.6
2402A	34	103.3
2403A	IS	85.7
2404	27	33.2
2404A	36	68.0
2503A	36	50.2
2504A	34	35.9
EER	35	108.0

* Insufficient sample to do the test.

For those wastes which undergo hydration reactions (i.e., self-heating wastes), it may be necessary to add significantly more than the optimum moisture content to allow for moisture losses as the material hydrates and steams. For very reactive wastes, such as some of the FBC spent bed materials, an additional 30 percent moisture (or more) over and above the optimum moisture content may be needed to satisfy the hydration reactions.

Some of the advanced process wastes tend to be noncohesive, even after they have been conditioned. Noncohesive wastes are undesirable because they do not form stable side slopes when they are stacked at a disposal site. For noncohesive wastes, it may be desirable to blend them with other wastes to produce a cohesive mixture. Generally, the simplest way to increase the cohesiveness of a waste is to extend its particle-size distribution by blending it with a fine material such as fly ash.

For example, spent bed materials from FBC processes are usually granular materials that do not contain many fine particles. However, if a spent bed material is blended with a fly ash, enough fine particles will usually be added to make the mixture cohesive. Further, if the fly ash is either a self-cementing or a pozzolanic material, the stability of the waste may be further increased due to the occurrence of cementitious chemical reactions in the conditioned mixture.

If an advanced process waste is mixed with a self-cementing fly ash, care must be taken that the mixture does not set up too quickly. Some types of cementitious fly ashes will set up as rapidly as a few minutes after being mixed with water. When this happens, the waste is very difficult to handle, and it is impossible to place and compact at the disposal site before it hardens.

Various types of mixers are used to condition conventional coal combustion wastes. These include both continuous mixers such as pug mills and horizontal rotary drum mixers, or batch mixers such as turbine mixers.

A pug mill contains one or two shafts to which are attached short, heavy paddles. The shafts rotate in a horizontal trough. The water and dry waste enter continuously at one end of the trough, and the conditioned mixture is extruded at the other end. These mixers are efficient, durable, and relatively easy to clean. They work best when a fairly dry mixture is desired. For the advanced process wastes, pug mill mixers are best suited to the finer materials that are more difficult to wet and thus require more mixing energy.

A horizontal rotary drum mixer is simply a large diameter steel drum with some internal baffles. The water and dry waste enter one end of the drum and are mixed as it rotates. The baffles move the mixture continuously through the drum, and the conditioned waste exits at the other end. Rotary drum mixers do not supply as much mixing energy as pug mills, but they are durable and very easy to clean out. For the advanced process wastes, rotary drum mixers are probably best suited to the coarser materials which are easier to wet.

A turbine mixer consists of a circular trough with a housed shaft in the center from which projects a set of radial arms that reach down into the trough. A blade is attached to each arm to scrape the bottom of the trough.

TABLE 11

Optimum Moisture Content and Maximum Compacted Density of the
Advanced Process Wastes

Sample No.	Optimum* Moisture Content (% of dry wt)	Maximum Compacted Density* (lb/ft ³)
102	11.6	119.2
104	15.6	104.9
202	17.2	105.5
203	19.2	103.0
302A	34.8	68.0
403A	28.5	76.0
502A	20.0	83.0
503	21.0	93.0
602A	12.2	102.0
603A	18.5	107.8
702A	22.0	72.0
703A	22.5	83.8
1202	18.0	98.0
1203	36.0	60.2
1204	13.5	103.4
1204A	45.3	62.5
1205A	27.0	77.0
1302A	13.0	99.2
1304A	37.0	70.3
1305A	53.0	58.0
2002	27.5	73.0
2102A	16.7	79.2
2201	10.3	100.8
2201A	32.6	66.0
2302A	29.0	84.0
2303A	30.5	77.8
2304A	31.0	73.5
2402A	19.6	101.5
2403A	23.3	84.2
2404	76.6	47.0
2404A	30.2	76.4
2503A	42.5	62.5
2504A	76.1	38.0
EER	5.0	117.7

* Optimum moisture and maximum compacted density were determined with standard Proctor compaction.

The dry waste and water are added to the trough and mixed by the rotating by opening the bottom of the trough and letting the contents fall through. For the advanced process wastes, a turbine mixer would work well for mixing fine materials to a relatively dry consistency.

Mixers used to condition conventional coal combustion wastes may not be appropriate for all types of advanced process wastes. Wastes which are self-heating, for example, may require much additional water just to satisfy hydration reactions and steam releases. In order to fully condition a highly exothermic waste to the optimum moisture, it will probably be necessary to initially mix it in the form of a slurry. Then as the waste hydrates and heats up, it will spontaneously stiffen to a suitable hardness and dry out somewhat. Usually it takes about 20 minutes after mixing for the waste to dry to its optimum moisture content.

A number of different commercially available mixers were evaluated to determine if they would be suitable for conditioning a self-heating FBC ash. The best piece of equipment identified for this particular application was the Scott Model 2072 high-production/high-speed continuous blender. This piece of equipment is capable of mixing an ash slurry with a moisture content of 50 to 60 percent of dry weight in a matter of seconds, and it can process up to 60 tons of dry ash per hour.

5.5 Transport Subsystems

The purpose of a waste-transport subsystem is to convey waste from a plant to a long-term storage facility or an ultimate disposal site. The waste can be transported as a wet slurry, in a moist conditioned form, or in a dry form. A waste slurry may contain 100 percent moisture or more on a dry weight basis, a moist conditioned waste would normally contain between 10 and 30 percent moisture, and a dry waste should not contain more than about 1 percent moisture.

A wet slurry will normally be hydraulically transported from the plant to a sedimentation basin. Dry or moist conditioned waste can be transported from the plant to the disposal site by truck, railroad, barge, belt conveyor, or aerial tram. Dry waste can also be transported by pneumatic conveyor.

5.5.1 Wet Transport

Wet ash transport of conventional coal combustion waste typically involves transfer of the material to a central location in the plant where it is collected for sluicing. A waste slurry is then hydraulically transported to a settling basin where the solids are removed. The slurry water can be recycled to the plant, stored, discharged, or evaporated. The waste can be left in the settling basin, sent to a long-term storage facility, or sent to a permanent disposal site. Fly ash and bottom ash can be transported with the same system or using separate systems. Transport distances from the plant to the settling pond are not usually more than one mile (2).

Wet transport subsystems have several advantages compared to moist conditioned or dry transport subsystems. They are not usually affected by transportation strikes or rising fuel costs. There is less noise, dust, and traffic associated with wet transport. They also tend to be less expensive than the other types of transport.

The disadvantages of wet transport include higher site development costs, larger quantities of water to control, a larger disposal site for a given mass of waste, a possible reduction of the utilization potential of the waste, and less flexibility to change the system in the future.

Conventional fly ash and bottom ash are often transported as slurries, and so it is probable that at least some of the advanced process wastes can also be transported in this manner. However, several characteristics of the advanced process wastes will present special problems for a wet transport. Wastes that display high levels of self-heating and self-hardening activity may be difficult to handle, and the high pH associated with most of the advanced process waste slurries may cause corrosion problems.

The heat and steam released by some of the advanced process wastes could be controlled by slaking the materials under controlled conditions before they are sluiced into the transport system. Cementitious wastes present a more difficult problem for wet transport because they may set up while in transit. If this happens, the waste can plug the transport lines, and the necessary repairs could be very expensive. Various additives have been used with wet transport systems to retard the set of cementitious wastes, but continuous use of chemical additives will increase the waste-handling costs. If the waste slurry has a high pH, the transport system will have to be constructed with special corrosion resistant materials, and this may significantly increase construction costs.

There is a general trend away from the use of wet transport in waste management systems for new power plants because of the problems associated with managing the water used to sluice the wastes. If it is necessary to discharge excess water from the system, a discharge permit will be needed, and these are becoming more difficult to obtain. There is also the possibility that an episode of high precipitation would cause the settling pond to flood. If this happens, it may be necessary to discharge quickly a large amount of water from the pond. Since many of the advanced process wastes produce a high pH, an uncontrolled discharge from such a system could cause serious environmental damage. Further, controlling the movement of leachate to the groundwater is much more difficult with ponds than with dry disposal sites.

5.5.2 Dry and Conditioned Transport

Similar types of equipment can be used to transport dry or conditioned wastes, although if the waste is not conditioned before it is transported, the containers must be tightly sealed so that the dry waste does not leak out. Also, the waste cannot be transported pneumatically if it has been fully conditioned.

5.5.2.1 Trucks

Trucks are the most widely used equipment for transporting dry or conditioned wastes. Truck transport is very flexible because it can be done with utility-owned or private contractor-owned equipment, and thus the number of trucks being used can be quickly increased if greater transport capacity is needed. Another attractive feature of truck transport is that if an alternate disposal site is being used, the trucks can be rerouted to the new site with little disruption to the system. If the waste is conditioned at the plant, it is usually hauled in dump trucks. If the waste is to be conditioned at the

disposal site or if it is to be transported to an alternate site for utilization, it is usually transported in pneumatic tank trucks or covered, sealed dump trucks.

One disadvantage of truck transport is the relatively high operational cost. If the haul distance is long, fuel and personnel costs will be high. For this reason, truck transport may be better suited to short haul distances. Also, if the trucks must travel on public roads, spillage of waste may cause a public relations problem (2).

5.5.2.2 Railroads

Railroad cars have not been widely used to transport coal-utilization wastes, although rail transport would certainly be feasible in situations where long haul distances are required. Construction of a railroad system is expensive, and, once constructed, the system is not very flexible. It may be possible to use a common carrier system and existing track which would minimize construction costs. But even when a common carrier is used, special loading and unloading facilities will need to be constructed at the plant and the disposal sites.

There is a growing trend in the utility industry to ship wastes back to the coal mine for disposal. This approach is attractive because it greatly reduces the waste disposal burden for the utility. Mine disposal is particularly attractive when the coal is supplied to the plant by rail, in which case the same railroad cars that brought the coal can be used to transport the waste back to the mine. Since mine disposal appears to be increasing, railroads may be an important means of transportation for future utility plants which produce advanced process wastes.

5.5.2.3 Barges

In situations where both the waste-generating plant and the disposal site are located close to navigable waterways, barge transport may be feasible. Transportation by barge requires construction of special loading and unloading facilities, but it offers the advantages of large capacity and low operational costs. If barges are used to transport advanced process wastes, care will have to be taken to avoid large waste spills into the waterway. And there is always the possibility that a barge might sink and create a major pollution threat to the waterway.

5.5.2.4 Belt Conveyors

The use of belt conveyors for transporting coal utilization wastes is feasible, but has not been widely used at power plants, although in other industries belt conveyors are used to transport materials over long distances. They are typically best-suited to situations where the waste flow is constant, and the discharge point is stationary.

The advantages of belt conveyors include low maintenance and operational costs. The disadvantages are that they have relatively high construction costs and it is difficult to change the system once it is built. Also, conveyors cannot handle very hot materials. If the waste is conditioned before transport, it should not be so wet that it sticks to the belt, or it

will be difficult to unload. If the waste is transported dry, the conveyor should be enclosed to prevent problems with dust release.

5.5.2.5 Aerial Trams

An aerial tram is a set of cars that travel above the ground suspended from a cable. Aerial trams are not widely used in the utility industry, but are used at some mining operations to transport waste. The advantages and disadvantages of aerial trams for transporting wastes are similar in many respects to those of belt conveyors. However, aerial trams have some advantages over belt conveyors. If the waste is contained in a tram car, there is less chance for it to cause abrasive wear on the moving parts of the system. Also, a tram system can travel up steep slopes, through rough terrain, and over long distances.

5.5.2.6 Pneumatic Conveyors

The use of pneumatic conveyors for transporting coal combustion wastes is limited because they are not economical for moving wastes more than about 7500 feet (2). However, if the transport distance is relatively short, pneumatic conveyors may be an excellent means of transporting dry, unconditioned waste to a disposal site.

5.5.3 Criteria for Selecting Appropriate Waste-Transport Subsystems

The physical and chemical properties of the advanced process wastes must be carefully considered when selecting an appropriate transport subsystem. Many of these wastes produce high-pH slurries when mixed with water, which may cause corrosion problems for the transportation equipment. Some of the advanced process wastes also appear to be quite abrasive, judging from their quartz contents and chemical compositions. The corrosive and abrasive tendencies of the advanced process wastes were examined in Section 5.2.9 for transfer subsystems, and the results are listed in Table 5. The same information can be used to assess the compatibility of the wastes with the various transportation subsystems. Generally, if a waste is expected to be highly corrosive or abrasive, the transportation equipment must be constructed with special materials that can resist the adverse conditions.

The particle-size distribution and bulk density data summarized in Table 4 are also useful information for selection of appropriate transportation subsystems for the advanced process wastes.

For belt conveyors and pneumatic conveyors, the assessment done for transfer subsystems which was summarized in Table 6 will also apply, with a few exceptions, to transportation subsystems. Although very fine materials cannot be transported in a dry form with a belt conveyor, they can be if they are first conditioned with water to reduce dusting. If wastes are to be transported pneumatically, they must be in a loose, dry form; therefore, they should not be conditioned before transport.

For truck, railroad, barge, and aerial tram transport, there are no prohibitive particle-size restrictions. However, if the waste is very fine and in a dry form, any type of container in which it is being transported must be enclosed to prevent leakage and dusting. If the waste is conditioned

before transport, the waste can be carried in an open container for short distances. However, if there is a chance that the material will dry out during transport, some type of a closed container should be used.

For railroad and barge transport, in particular, it may not be possible to ship the waste in a closed container. If the waste is to be shipped for a long distance in an open container, precautions will have to be taken to ensure that the waste does not leak out of, or blow away from, the container. One such precaution may be to spray the top of the waste with a membrane-forming chemical.

If a waste is self-heating, appropriate precautions should be taken to keep the waste dry during transport or else to expend the heat to a manageable level before the material is transported to the disposal site. If a waste is self-hardening, it must not be allowed to harden while being transported. None of the advanced process wastes are flash-setting materials that could harden during a short haul, but for railroad or barge transportation, where the waste might be in a container for several days, self-hardening could present a problem. The self-heating and self-hardening potentials of the advanced process wastes are listed in Table 9.

5.6 Waste Disposal Subsystems

Ultimate disposal of a coal-utilization waste requires that it be placed at a permanent location which has been designed to contain the waste and protect the surrounding groundwater. Disposal can be done by either depositing the waste in a settling pond, placing it in a landfill, or returning it to the original mine site.

Coal combustion wastes that are transported by wet sluicing are usually sent to a pond where the solids settle out and the free water is removed. Depending on how the system is operated, the waste can be periodically dredged from the pond and moved to a different site for disposal, or it can be left in the pond. When the pond is full, the decision may be made to close the pond and make it the ultimate disposal site for the waste.

Landfilling a solid waste is accomplished by spreading the material on the ground and compacting it in thin layers. A landfill must contain the waste within defined boundaries and also restrict the movement of leachate from the waste into the surrounding groundwater. Landfills can be designed for heaped, sidehill, or valley fill. In some cases these different configurations can be combined to suit the topography of the site and the properties of the waste. For a heaped fill configuration, the waste is simply stacked on a level surface. To build the stack, the waste is spread out and compacted in lifts. Each lift is usually between 6 inches and 1 foot thick. For a sidehill fill configuration, the waste is placed and compacted along the side of a hill or valley, and for a valley fill configuration, the waste is deposited in a valley (2).

Mine disposal of coal-utilization wastes is becoming increasingly popular because the waste is returned to the mine; therefore, the use of undisturbed land is not required for a disposal site. This option is particularly attractive for mine-mouth operations where the distance between the plant and the mine is relatively short. Even in situations where the waste must be transported fairly long distances, mine disposal still may be

done economically if the same railcars or trucks that bring the coal to the plant are used to transport the waste back to the mine.

5.6.1 Disposal-Related Waste Properties

A number of different waste properties are useful for evaluating disposal options for the advanced process wastes. These include shear strength, permeability, maximum compacted density, optimum moisture content, particle-size distribution, and consolidation. Optimum moisture and maximum compacted densities for the advanced process wastes are listed in Table 11. Particle-size data can be found in Appendix 4, and consolidation data can be found in Appendix 5. The strength and permeability data for the advanced process wastes are summarized in Table 12.

5.6.1.1 Shear Strength

The shear strength that a coal combustion waste develops after it has been placed at a disposal site is important because it influences the stability of the waste deposit. For example, shear strength will be an extremely important factor in designing a disposal site if the waste is to be placed in a heaped or sidehill landfill. In these configurations, shear strength will determine how much material can be placed at a particular site because it limits how high the waste can safely be stacked and how steep the side slopes can be constructed. High shear strength also indicates that the waste deposit will be resistant to erosion and freeze-thaw damage.

For self-hardening wastes, shear strength results from the development of interparticle cementitious bonds. The strength of a self-hardening waste is measured by applying an unconfined compressive load on a prepared specimen. The shear strength is usually assumed to be about 20 percent of the compressive strength.

For wastes that are nonself-hardening, shear strength results mainly from the interlocking of individual particles, and these types of wastes only exhibit significant shear strength when they are confined by the surrounding waste in a deposit. The shear strength of a waste that does not self-harden is usually measured by confining a specimen in a triaxial cell and then loading it to failure. The strength is indicated by the angle of internal friction. The higher the angle of internal friction, the greater the shear strength of the waste when it is in a confined state.

Of the 34 wastes that were tested, 16 exhibited some degree of self-hardening behavior. Generally, the self-hardening wastes tended to be fine-grained materials with a high calcium content. Twenty-eight-day unconfined compressive strengths for compacted self-hardening wastes ranged from 25 to 661 psi.

The nonself-hardening wastes tended to be the more granular materials. Angles of internal friction for compacted noncementitious waste specimens ranged from 29° to 49°. These values are very similar to values reported in previous studies for conventional coal combustion wastes (3).

TABLE 12

Strength and Permeability Data for the
Advanced Process Wastes

Sample No.	Angle of Internal Friction (degrees)	Unconfined Compressive Strength (psi at 28 days)	Permeability Coefficient ^a (cm/sec)
102	NA ^b	51	9.8×10^{-5}
104	41	NA	1.8×10^{-3}
202	NA	661	2.0×10^{-7}
203	43	NA	3.2×10^{-3}
302A	42	NA	1.4×10^{-3}
403A	49	NA	7.0×10^{-3}
502A	44.5	NA	1.5×10^{-3}
503	NA	25	5.3×10^{-5}
602A	43	NA	3.9×10^{-4}
603A	NA	392	2.0×10^{-6}
702A	34	NA	6.8×10^{-5}
703A	NA	27	1.9×10^{-5}
1202	43	NA	6.1×10^{-5}
1203	NA	220	1.8×10^{-4}
1204	40	NA	4.7×10^{-5}
1204A	NA	164	1.1×10^{-4}
1205A	NA	169	5.3×10^{-5}
1302A	41	NA	4.7×10^{-4}
1304A	NA	275	1.7×10^{-4}
1305A	NA	311	7.2×10^{-5}
2002	43.5	NA	3.0×10^{-4}
2102A	39.5	NA	5.7×10^{-5}
2201	38	NA	3.1×10^{-5}
2201A	40	NA	6.0×10^{-5}
2302A	NA	26	9.0×10^{-5}
2303A	NA	463	6.5×10^{-5}
2304A	37	NA	6.6×10^{-5}
2402A	29	NA	1.7×10^{-4}
2403A	NA	338	ND ^c
2404	45	NA	6.0×10^{-5}
2404A	NA	572	8.0×10^{-5}
2503A	NA	66.2	3.4×10^{-4}
2504A	NA	83.4	2.3×10^{-4}
EER	ND	NA	3.0×10^{-4}

^a Cementitious samples were cured for 28 days before permeability tests were run.

^b The test was not applicable to the sample.

^c No data were obtained for the sample.

5.6.1.2 Permeability

Waste permeability is an important factor in determining how rapidly water will pass through a waste deposit and how much leachate it will produce. Waste permeability is indicated by a permeability coefficient. Permeability coefficients were measured in the laboratory for all of the advanced process wastes, and the values typically ranged between 10^{-3} and 10^{-6} cm/sec. These values indicate high to moderate permeabilities, respectively, for the advanced process wastes. The permeability coefficients measured for the advanced process wastes are very similar to coefficients measured in other studies for conventional coal combustion wastes (3). When evaluating the laboratory permeabilities measured for the advanced process wastes, it should be noted that permeabilities exhibited in the field may differ significantly from the laboratory values. The actual in-field permeabilities will depend on factors such as the compacted density, moisture content, and age of the waste deposit. Generally, in-field permeabilities tend to be higher than permeabilities measured in the laboratory.

5.6.1.3 Maximum Compacted Density and Optimum Moisture Content

The maximum compacted density of a waste indicates how much dry material can be placed in a unit volume at the disposal site using a standard compactive effort. The actual compacted density that can be achieved for a waste will be influenced by its moisture content. Typically, the compacted density will increase as the moisture content is increased up to some maximum density, and then the density will begin to decrease as more moisture is added to the waste. The specific moisture content that produces the maximum compacted density for a waste is referred to as its optimum moisture.

The maximum compacted densities of the advanced process wastes were measured using a standard Proctor compactive effort, and the values ranged from 38 to 117 pounds per cubic foot on a dry weight basis. Most of the maximum compacted densities measured for the advanced process wastes are similar to densities that have been measured for conventional coal combustion wastes, although the lowest densities obtained for a few of the advanced process wastes were significantly lower than typical values reported for conventional wastes (3). Moisture-density curves for the advanced process wastes are contained in Appendix 3.

5.6.1.4 Particle-Size Distribution

In general, wastes with a broad particle-size distribution tend to compact better and have lower permeabilities than wastes with narrow particle-size distributions. This is because the smaller particles will tend to fill the spaces between the larger particles and produce a more compact matrix.

The particle-size distributions of the advanced process wastes are represented by their uniformity coefficients (C_u). The uniformity coefficient is the ratio between the particle size which 60 percent of the waste particles are smaller than and the particle size which 10 percent of the particles are smaller than. The particle-size distribution curves and the uniformity coefficients determined for the advanced process wastes can be found in Appendix 4. The C_u values ranged from 1.05 to 112.5.

5.6.1.5 Waste Consolidation

The consolidation properties of a coal combustion waste deposit will control the rate and extent of settlement of the deposit under an applied load. For the advanced process wastes, only the nonself-hardening materials were tested because the cementitious materials would not be expected to undergo significant compression under normal loads.

The consolidation test is done by loading a waste specimen and measuring the compression of the specimen over time. The data are then analyzed to calculate a coefficient of consolidation (C_v). The C_v values measured for the advanced process wastes generally ranged between 1 and 7 in²/minute. The results of the consolidation tests are contained in Appendix 5.

The consolidation properties of the nonself-hardening advanced process wastes were quite similar and appeared to be controlled by their highly glassy compositions. Typically, when a load was applied, the waste consolidated very quickly, but after the initial reaction there was very little additional consolidation. The initial consolidation was apparently caused by crushing of the material. When a higher load was applied to the waste, some additional consolidation occurred, but again the materials stabilized quickly.

5.6.2 Disposal Options for Advanced Process Wastes

5.6.2.1 Pond Disposal

When a settling pond is to serve as an ultimate disposal site, steps must be taken to ensure the long-term stability of the deposit. To close a pond, the standing water must be drained, the waste must be dewatered, and the deposit must be capped. Dewatering is necessary to stabilize the waste. The waste can be dewatered to some extent by driving wells into the deposit and then pumping out the free water. Once the waste has been stabilized, the deposit can be sealed with a soil cap. The purpose of the cap is to confine the waste and to limit the infiltration of water into the deposit.

The procedures for closing a pond will be much the same for an advanced process waste as they are for conventional coal combustion wastes. There may be opportunities, however, for utilizing additional quantities of advanced process wastes for the closure process. For example, large quantities of self-heating wastes may possibly be used to partially dewater a disposal pond. This could be done by hauling the self-heating waste in a dry form to the pond, spreading it on the surface, and then tilling it into the deposit. The hydration reactions will chemically bind some of the free moisture in the pond, and some of the moisture will simply be absorbed by the dry waste. If the advanced process waste being used is also self-hardening, it could help to stabilize the surface of the waste deposit by increasing its shear strength.

Self-hardening wastes could also be used to form part of the cap for a pond. This would require that the waste be placed and compacted over the surface of the deposit. A cap formed in this manner would have to meet the same permeability criteria specified for a conventional soil cap, but this may be possible if the waste is well compacted.

Another waste-utilization option may be to stabilize the surface of a pond using an advanced process waste and then to convert it to a landfill by

stacking additional waste on top of the pond. The advantage of this approach is that if the pond already has a good liner system, a new liner will not be needed for the landfill.

It should be possible to dispose of any of the advanced process wastes in a pond if the site is properly designed. A chief drawback of pond disposal is that the waste cannot be compacted as it is placed. The relatively low density of pond-disposed waste means that less material can be placed in a given disposal volume compared to landfilled waste. Another potential problem associated with pond disposal is the difficulty of obtaining environmental permits for constructing new ponds. In general, state regulatory agencies are requiring more stringent environmental controls for new ash disposal ponds and in some cases suggesting that alternate disposal methods be used.

5.6.2.2 Landfill Disposal

It should be possible to dispose of the advanced process wastes with either a heaped, sidefill, or valley landfill. If the waste is to be disposed of in a heaped or sidefill landfill, it is usually beneficial if it is self-hardening because it will develop long-term strength and create a stable deposit. However, a valley landfill configuration can probably be used for any of the advanced process wastes because the sides of the valley will serve to confine the deposit even if it is not a self-hardening material.

An advantage of the sidefill and valley fill configurations over the heaped fill configuration is that they usually blend in better with the surrounding terrain once they have been capped and revegetated; however, sidefill and valley landfills are usually more difficult to construct because the natural drainage in the area has to be rerouted around the landfill site (2).

5.6.2.3 Mine Disposal

Active surface coal mines are the best candidates for in-mine waste disposal because the disposal activities can be incorporated into the overall operation of the mine. This can be done in several ways. The simplest method is to place the waste in a worked-out section of the pit bottom. Another possibility is to place the waste in the vee-notches of the spoil banks. Placing the waste in the vee-notches is usually more difficult than placing it on the pit bottom, but waste placed in the vee-notches usually has the advantage of being well above the groundwater table. Another alternative is to place the waste in the spoil bank with the overburden.

One aspect of mine disposal that could present a problem is the containment of leachate since it may be difficult or even impossible to construct a liner at the site. Constructing a liner may not be a problem for pit-bottom placement, but if the pit bottom is below the groundwater table, the liner may not be effective. For vee-notch placement, it may be possible to use a liner, but it would be difficult. And for placement in the overburden, it probably would not be possible to use a liner.

Mine disposal can probably be used for any of the advanced process wastes assuming that the site design provides sufficient protection for the groundwater.

5.7 Utilization Potential of the Advanced Process Wastes

One of the most profitable by-product utilization markets for coal combustion wastes is as a concrete admixture. The fly ash is usually added to a concrete mix to replace some of the Portland cement or to act as a pozzolan. In order for a fly ash to be used as a concrete additive, it must meet the specifications listed in ASTM C618, "Specification for Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete."

Several of the key waste properties included in the ASTM C618 specifications were measured for this study. These properties are listed in Table 7. Based on a comparison between these data and the specifications, the potential for utilization of the advanced process wastes as concrete admixtures was evaluated. Only one of the 34 wastes examined appeared to meet the specifications. This was Sample 202, a fine ash produced by a fluidized-bed coal gasifier.

Since the rest of the advanced process wastes did not appear to meet the specification for concrete admixtures, the most promising utilization markets for these materials will probably be high-volume applications such as use for construction fills, soil-stabilization additives, soil-amendment additives, landfill cover material, waste-stabilization additives, and pavement base course (4). Conventional coal combustion ashes are currently being used for all of these applications, but it appears that the advanced process wastes may be as good as or better than conventional ashes for many of these high-volume applications.

In addition to the high-volume markets listed above, there are several other markets for which significant amounts of the advanced process wastes might be used. These include utilization as aggregate for asphalt paving, blasting grit, and road deicer.

5.7.1 Waste Utilization for Construction Fills

Fill materials are used to create a level surface and a stable foundation for a construction site. Construction fills may be either compacted or uncompacted depending on the type of structure being placed on the site. Fly ash has been extensively used as a fill material in situations where natural soil was either unavailable or too expensive. Fly ash can be compacted using equipment and procedures similar to those used for natural soils.

Coal combustion wastes have several characteristics which make them good fill materials. Large amounts of these wastes are available at low cost in many areas of the United States. Coal combustion wastes usually have a lower compacted unit weight than soil, and so they can be used to advantage in situations where the underlying soil has a low bearing capacity. Self-hardening wastes are particularly useful because they develop a relatively high shear strength when they are compacted with an appropriate moisture content.

Some important physical properties which indicate whether an advanced process waste can be used as a fill material are its particle size, maximum compacted density, unconfined compressive strength, pozzolanic activity, angle

of internal friction, compressibility/consolidation, and permeability. This information is summarized in Appendix 1 for the advanced process wastes.

Generally, a good fill material will be well-graded (i.e., have a relatively broad particle-size distribution), have a medium to high maximum compacted density, a high unconfined compressive strength if it is self-hardening or pozzolanic, or a high angle of internal friction if it is noncohesive. Low compressibility/consolidation is important if a large structure is going to be constructed on the site, and moderate to high permeability is required if the fill is to have good drainage properties.

Some important chemical properties of the advanced process wastes are total silicon, aluminum, and iron oxide content; SO_3 content; free lime content; and leachate composition. Data on the chemical composition of the advanced process wastes are contained in Appendix 2. No leachate data, except for pH, were generated for this study.

A finely divided material with a high total silicon, aluminum, and iron oxide content will usually be pozzolanic. A pozzolanic waste used as a fill material will usually gain significant shear strength over an extended time period when free lime and moisture are also present. A high SO_3 content (as determined from a bulk chemical analysis) and high corrosivity (as indicated by an acidic or basic leachate pH) are both undesirable for a fill material because these properties may promote rapid corrosion of concrete or steel structures buried in the fill.

Considering the advanced process wastes as a group, it appears that the major drawback to using many of these as fill materials is their typically high leachate pH values and SO_3 contents. (See Table 5 for a listing of potential waste corrosiveness and Table 7 for a listing of the waste SO_3 contents.) These characteristics would not only tend to cause damage to buried concrete pipes and footings, but might degrade the quality of the surrounding groundwater.

Samples 104, 203, 302A, 2002, and 2201 appear to be acceptable fill materials based on their relatively low corrosiveness and SO_3 contents. All of these are coal gasification wastes. The more corrosive advanced process wastes appear to be the FBC ashes and bed materials which contain spent limestone sorbents. Although the FBC wastes are corrosive, it may still be possible to use them as fill materials if they are blended with soils or other wastes which can neutralize some of the lime and thus reduce their corrosiveness.

Another potential problem associated with the use of high lime content FBC wastes for fill materials may occur if the waste tends to expand as it hydrates. If the waste does expand after it has been placed, it will heave and destroy the integrity of the fill. To avoid this, enough water must be added to the waste to fully prehydrate the oxides, and enough residual moisture must be left in the hydrated material to facilitate compaction. Also, the hydrated waste should be allowed to cool before it is placed and compacted as a fill.

5.7.2 Waste Utilization for Soil Stabilization

A combination of lime and fly ash is often used to stabilize soil for the construction of pavement subgrades. The lime serves to improve the mechanical properties of fine-grained soils by decreasing their plasticity and increasing their shear strength. The fly ash promotes cementitious reactions which also increase the shear strength of the soil. Further, if the fly ash contains free lime, the amount of additional commercial lime required for stabilization will be reduced. In some cases, when the fly ash contains a high percentage of free lime (typically this would be a Class C fly ash), no additional lime needs to be added to stabilize the soil.

In order for an advanced process waste to be an effective soil-stabilization additive, either it should have significant pozzolanic and/or self-hardening properties so that it can be used in place of the fly ash, or it should have a sufficiently high free-lime content so that it can be used as a substitute for commercial lime.

Pozzolanic and/or self-hardening wastes stabilize the soil by cementing the soil particles together. Pozzolanic materials require the addition of lime and water to initiate cementitious reactions which then occur at a relatively slow rate. Self-hardening materials do not require the addition of lime and react rapidly when mixed with water.

The pozzolanic activities of selected advanced process wastes were measured using the procedure contained in ASTM C311. The pozzolanic activity indexes of the advanced process wastes are listed in Table 7. The indexes are reported as the ratio (expressed as a percentage) of the compressive strength developed by a mixture of waste and lime divided by the compressive strength developed by a standard control mix.

The self-hardening properties of selected advanced process wastes were determined by measuring the 7-day unconfined compressive strengths of compacted and cured waste specimens. The self-hardening potentials of the wastes are listed in Table 9.

The free-lime content of each of the advanced process wastes was estimated by comparing acid titration data, bulk chemical data, and thermogravimetric data obtained for each of the wastes. Estimates of the waste free-lime contents are summarized in Appendix 2.

Based on an examination of the pozzolanic activities, self-hardening properties, and free-lime contents of the advanced process wastes, it was determined that 16 of the 34 wastes were potentially useful soil-stabilization additives. Those 16 wastes are listed in Table 13 along with the reasons they were considered useful soil-stabilization additives.

Typically, only 5 to 15 percent fly ash by weight is required to stabilize a soil. Since the amount of waste used for soil stabilization will be small compared to the amount of soil with which it is mixed, many of the problems associated with the use of advanced process wastes as fill materials, such as corrosiveness, will not occur when the waste is used for soil stabilization. Further, the high lime contents of the FBC wastes will actually be a benefit for soil stabilization because little or no additional

lime will have to be added to the soil. This fact is significant since lime is usually the most expensive additive in the stabilization process.

5.7.3 Waste Utilization for Soil Amendment

Coal combustion wastes can be used for soil-amendment additives to raise soil pH, eliminate trace element deficiencies, and increase the moisture-holding capacity of soil. The most common use for these types of wastes, however, has been to neutralize acidic soils when reclaiming strip-mined lands in the eastern United States (4).

Acid-buffering capacity is an important property for determining whether an advanced process waste can be used to neutralize soil acidity. The acid-buffering capacities of the advanced process wastes were measured by titrating 10 grams of the waste with a sulfuric acid solution to an end-point pH of 5.0. The buffering capacities thus determined are listed in Appendix 1. From an examination of those data, it appears that many of these materials would be effective soil-neutralizing additives.

Table 14 lists fourteen advanced process wastes which neutralized at least 0.1 gram of sulfuric acid per gram of waste. Thirteen of these wastes were ashes and spent bed materials produced from FBC processes which used limestone injection for SO₂ capture, and the other waste was an ash from a fluidized-bed gasifier that used a limestone sorbent.

5.7.4 Waste Utilization as Landfill Cover Material

Coal combustion fly ash has been used as cover material at several landfills in the United States. Fly ash makes a good cover material because it has a moderately low permeability when compacted at optimum moisture content, it does not shrink appreciably when it dries out, and many types of fly ash develop significant shear strength after they have been placed (4).

Generally the same advanced process wastes that were designated as acceptable fill materials would also make good landfill cover materials. One potential drawback to the use of an advanced process waste for cover material is the possibility that it would contribute significant levels of regulated trace elements to the landfill leachate. However, there is no reason to expect that the advanced process wastes would release higher levels of trace elements than conventional fly ashes.

The advanced process wastes that have high free-lime contents may not be suitable cover materials if they produce an unacceptably high leachate pH. A high leachate pH could be corrosive to the leachate collection system at the landfill or possibly degrade the quality of the surrounding groundwater. Also if the landfill design includes a system for collecting methane, a high pH would tend to inhibit methane production.

In some situations, however, a high leachate pH may be an advantage. For example, if the material being placed in the landfill contains trace metals such as lead and cadmium, which are more soluble at low pH, an advanced process waste that contains free lime would serve to stabilize the trace metals and reduce their concentrations in the leachate. For situations such as these, the wastes produced from the FBC processes might make excellent cover materials.

TABLE 13

**Summary of the Advanced Process Wastes that are Potentially Useful
Soil-Stabilization Additives**

<u>Sample No.</u>	<u>Waste Type¹</u>	<u>Useful Soil-Stabilization Properties²</u>
102	CGA	Moderately Pozzolanic
202	CGA	Self-Hardening and Highly Pozzolanic
403A	CCFA	Moderately Pozzolanic
603A	CCFA/SS	Self-Hardening and Highly Pozzolanic
703	CCFA	Moderately Pozzolanic
1203	FBC CA	Self-Hardening and High Free-Lime Content
1204A	FBC BFA	Moderately Pozzolanic and High Free-Lime Content
1205A	FBC SA	High Free-Lime Content
1305A	FBC BFA	Self-Hardening
2302A	FBC SB	High Free-Lime Content
2303A	FBC EA	High Free-Lime Content
2402A	FBC SB	High Free-Lime Content
2403A	FBC EA	Self-Hardening and High Lime Content
2404	FBC BFA	Moderately Pozzolanic
2404A	FBC BFA	Self-Hardening, Moderately Pozzolanic, and High Free-Lime Content
2503A	FBC BFA	High Free-Lime Content

¹ CGA - Coal Gasification Ash, CCFA - Fly Ash, CCFA/SS - Mixture of Fly Ash and Scrubber Sludge, FBC - Fluidized-Bed Combustion, CA - Cyclone Ash, BFA - Baghouse Fly Ash, SA - Superheater Ash, SB - Spent Bed Material, EA - Economizer Ash

² Moderately Pozzolanic - the pozzolanic activity index was between 70% and 100% of control.

Highly Pozzolanic - the pozzolanic activity index was greater than 100% of control.

Self-Hardening - the 7-day unconfined compressive strength was greater than 50 psi.

High Free-Lime Content - Free-lime content estimated to be greater than 20% of the dry weight.

TABLE 14

Summary of the Advanced Process Wastes that have
High Acid-Neutralizing Capacities

<u>Sample No.</u>	<u>Waste Type¹</u>	<u>Sulfuric Acid-Neutralizing Capacity (g H₂SO₄/g waste)</u>
1203	FBC CA	0.54
1204A	FBC BFA	0.39
1205A	FBC SA	0.53
1302A	FBC SB	0.13
1304A	FBC EA	0.10
2102A	CGA	0.49
2302A	FBC SB	0.77
2303A	FBC EA	0.65
2304A	FBC BFA	0.36
2402A	FBC SB	0.21
2403A	FBC EA	0.28
2404A	FBC BFA	0.30
2503A	FBC BFA	0.43
2504A	FBC BFA	0.16

¹ CGA - Coal Gasification Ash, FBC - Fluidized-Bed Combustion
CA - Cyclone Ash, BFA - Baghouse Fly Ash, SA - Superheater
Ash, SB - Spent Bed Material, EA - Economizer Ash

If an advanced process waste is being considered for use as a landfill cover material, it will be necessary to evaluate the chemical compatibility between the waste being placed in the landfill and waste being considered as a cover material. This should be done on a specific case-by-case basis since the chemical interactions between the two materials can be very complex.

5.7.5 Waste Utilization for Sludge Stabilization

Coal combustion fly ash has been used to stabilize sludges produced from both industrial and municipal wastewater treatment systems. Waste stabilization usually involves mixing a dry stabilizing agent with a wet sludge to improve its handling properties, to increase its compacted density and shear strength, to reduce its permeability, and possibly to reduce the amounts of trace metals which leach out (4).

Many of the advanced process wastes appear to have properties that would make them valuable waste-stabilization additives. For example, all of the wastes listed in Table 13 with self-hardening and/or pozzolanic properties should be excellent additives for reducing the permeability and increasing the shear strength of stabilized sludges.

The FBC wastes listed in Table 13 which have high free-lime contents should be particularly effective additives for dewatering sludges because, as the lime hydrates, it will remove some of the free moisture from the sludge. The FBC wastes should also be good for stabilizing sludges which contain trace metals that are soluble at low pH because the lime will tend to raise the pH of the leachate. The lime in the FBC wastes would also be useful when applied at fairly high admixture ratios for disinfecting sewage sludge because the pathogenic microorganisms in the sludge are killed at high pH. At lower admixture ratios, the FBC wastes could be used as an additive for composting operations to neutralize the acidic by-products of microbial degradation and thus maintain a favorable pH for the composting process.

5.7.6 Waste Utilization for Pavement Base Course

The base course of a highway is the foundation for the paved surface. The base course must have sufficient bearing capacity to support the traffic load, and it also must be sufficiently durable to withstand weather-related stresses such as freezing and thawing cycles. Mixtures of coal combustion fly ash, lime or Portland cement, and aggregate are commonly used for constructing base courses. In a few cases, fly ash alone, without any added aggregate, has also been used to construct base courses. If the fly ash is not self-hardening, lime or cement must be added to achieve the necessary strength. However, if the fly ash is self-hardening, it may be possible to use it without adding any lime or cement (4).

All of the advanced process wastes identified in Table 13 as either pozzolanic or self-hardening should be good candidate materials for base course construction. The wastes that are pozzolanic but not highly self-hardening will require the addition of either lime or cement to develop strength in a reasonable time period.

A few of the wastes that are listed as self-hardening in Table 13 may be usable for base course without adding lime or cement. For a self-hardening waste to be used without lime or cement addition, the material should probably attain a minimum 7-day unconfined compressive strength of about 400 psi. This is a standard "rule-of-thumb" strength criterion used for designing soil-cement mixtures. Based on the 28-day compressive strengths listed in Table 12, it appears that wastes 202, 603A, 2303A, and 2404A may be usable without lime or cement addition.

The FBC wastes which have high free-lime contents could potentially be useful for constructing base course even if they are not pozzolanic or self-hardening. These materials could possibly be used as a substitute for the commercial lime which must be added to pozzolanic materials such as fly ash. All of the advanced process wastes listed in Table 13 as having high free-lime contents should be useful substitutes for commercial lime in base course construction.

5.7.7 Other Utilization Markets

Boiler slag from wet-bottom coal combustion processes is a granular material produced when molten slag from a boiler is quenched in a water tank.

The material has a glassy composition and a black color. Boiler slag is commonly marketed as an aggregate for bituminous pavement, a blasting grit, and a road deicing material.

Two of the advanced process wastes have compositions similar to conventional boiler slags: Sample 104 (a coal gasification slag), and sample EER (origin unknown). Sample 104 appears to be usable for all of the markets normally associated with boiler slag. The EER sample, however, has moderately high corrosiveness as defined in Table 5, which could make it unsuitable for some of these uses.

Bottom ash produced from dry-bottom coal combustion processes is a granular material which often has a porous cinder-like composition. Bottom ash is useful for some of the high-volume applications discussed above, and it is also widely used as a road deicer. In addition to the two samples studied that actually were coal combustion bottom ashes (502A and 702A), a number of the advanced process wastes were sandy or gravelly materials which could be useful road deicers. Some of these wastes, however, particularly the FBC spent bed materials, have moderate to high corrosiveness, as defined in Table 5, which probably makes them unacceptable road deicer materials. The remaining wastes that appear to be acceptable road deicer materials are Samples 104, 203, 302A, 502A, 503, 602A, and 2201.

5.8 Summary

In this section, the characteristics of the advanced process wastes will be evaluated on a site-by-site basis, and potential problems associated with the handling and disposal of these wastes will be discussed.

5.8.1 Site 1 - Coal Gasification

Two solid waste streams were sampled at the coal gasification plant located at Site 1. Sample 104 was a slag collected from the bottom of the gasifier, and Sample 102 was a fine ash collected from the product gas stream.

The gasifier slag is a black, glassy, granular material that appears to be very similar to a conventional boiler slag produced by a wet-bottom, pulverized-coal boiler. Therefore, it should be possible to dispose of the gasifier slag using procedures similar to those used for conventional boiler slags. This often involves sluicing the boiler slag to a settling pond and then transferring the material to a landfill. It should also be possible to utilize the gasifier slag for many of the same by-product applications for which conventional boiler slags are used.

For the fine gasifier ash, the most important considerations for selecting appropriate handling and disposal procedures are 1) that the material is self-hardening, and 2) that it produces a leachate with a relatively high pH. Although the material was self-hardening, it did not set up quickly and so would probably not pose any problems for the transfer or conditioning operations. Care should be taken not to let the conditioned waste sit for an extended time period and set up in a truck while being transported to a disposal site.

Since the fine gasifier ash produces a high pH leachate, it will probably be best to handle this material in as dry a form as possible. The

waste should, therefore, be transferred in a dry form and conditioned with just enough water to achieve its maximum compacted density.

5.8.2 Site 2 - Ash Agglomerating, Fluidized-Bed Coal Gasification

Two solid waste streams were sampled from the ash agglomerating, fluidized-bed coal gasification plant located at Site 2. During the run that produced these wastes, dolomite was injected into the gasifier. Sample 203 was a mixture of ash and spent dolomite collected from the bottom of the gasifier, and Sample 202 was a fine ash collected from the product gas stream. Although the two wastes had similar bulk chemical compositions, their physical properties were quite different.

The ash/spent-dolomite mixture collected from the bottom of the gasifier was a finer material than a conventional coal combustion bottom ash. This ash could be either sluiced or hauled to a disposal site. If it is to be hauled to a disposal site, it should probably be conditioned first to keep the dust down.

The most important consideration for selecting appropriate handling and disposal operations for the fine gasifier ash is the fact that it is a self-hardening material. Although the waste did not set up quickly, care should be taken while storing or transporting this material for an extended time period not to let it set up in a bin or container.

When the fine ash was compacted at optimum moisture content and cured for 28 days, it developed an unconfined compressive strength of 661 psi and a low permeability of 2.0×10^{-7} cm/sec. These properties indicate that the material should become quite stable after it has been placed and compacted at a landfill.

The fine ash from Site 2 met several of the ASTM C618 specifications for a concrete admixture, and it may be an acceptable material for this profitable utilization market. However, this ash did have a relatively high magnesium oxide content due to the dolomite injection. Since magnesium oxide tends to expand when moistened, this ash may cause a problem with expansion when it is added to concrete. This possibility can be checked by performing a test to evaluate expansive behavior in concrete.

5.8.3 Site 3 - Fixed-Bed Coal Gasification

One solid waste stream was sampled from the fixed-bed coal gasification plant located at Site 3. Sample 302A was a coarse ash collected from the bottom of the gasifier.

This waste was a noncohesive material with a particle-size distribution similar to a conventional pulverized-coal bottom ash. It could probably be disposed of with the same types of operations that are routinely used for conventional bottom ashes, and it could also be utilized for the same general applications as conventional bottom ashes.

This gasifier ash was unusual because it had a compacted density of 46.4 lb/ft³, which is quite low for a coal combustion waste. For this reason, the gasifier ash may be particularly useful as a low-density fill material or possibly as a low-density concrete aggregate.

5.8.4 Site 4 - Pulverized-Coal Combustion with Flue Gas Desulfurization

One solid waste stream was sampled from a pulverized-coal combustion plant located at Site 4. The plant used a spray tower with a limestone sorbent for SO₂ capture. Sample 403A was a conventional ESP fly ash. The waste was a very fine material composed of approximately 90 percent silicon, aluminum, and iron oxides and should not pose any unusual disposal problems. The waste was moderately pozzolanic, but it did not have a sufficiently high pozzolanic activity to meet the ASTM C618 specification for use as a concrete admixture.

5.8.5 Site 5 - Pulverized-Coal Combustion with Flue Gas Desulfurization

Two solid waste streams were sampled from a pulverized-coal combustion plant located at Site 5. The plant used a spray tower with a limestone sorbent for SO₂ capture. Sample 502A was a bottom ash, and Sample 503 was a flue gas desulfurization (FGD) sludge.

The bottom ash was a noncohesive material composed of approximately 97 percent silicon, aluminum, and iron oxides and should not pose any unusual disposal problems.

The FGD sludge sample was collected in the form of a wet, vacuum filter cake. The sludge contained large percentages of both calcium carbonate and calcium sulfate. The FGD sludge displayed an increased stability when it was compacted in the laboratory and allowed to cure for 28 days, because it gained 25 psi of unconfined compressive strength and exhibited a moderately low permeability of 5.3×10^{-5} cm/sec. The stability of the sludge could probably be increased further if it were blended with the ESP fly ash produced at Site 5 (although no sample of the fly ash was available for analysis).

5.8.6 Site 6 - Pulverized-Coal Combustion with Flue Gas Desulfurization

Two solid waste streams were sampled from a pulverized coal combustion plant located at Site 6. This plant used a spray dryer with a lime sorbent for SO₂ capture. Sample 602A was a bottom ash, and Sample 603A was a mixture of fly ash and spent lime sorbent collected in a baghouse.

The bottom ash was a noncohesive material that should not pose any unusual disposal problems.

The main considerations for selecting appropriate handling and disposal operations for the fly ash/spent-sorbent mix are 1) that this is a self-hardening material, and 2) that it produced a leachate with a high pH value. For these reasons, the same restrictions apply to the handling and disposal of this waste as are stated above for waste Sample 102.

When the fly ash/spent-sorbent mix was compacted at optimum moisture content and cured for 28 days, it developed an unconfined compressive strength of 392 psi and a low permeability of 2.0×10^{-6} cm/sec. This indicates that the material should become quite stable after it has been placed and compacted at a landfill.

5.8.7 Site 7 - Pulverized Coal Combustion with Flue Gas Desulfurization

Two solid waste streams were sampled from a pulverized coal combustion plant located at Site 7. This plant used a spray tower with a lime sorbent for SO₂ capture. Sample 702A was a bottom ash, and Sample 703A was a fly ash collected in an ESP.

Both the bottom ash and the fly ash were conventional coal combustion wastes and should not present any unusual handling or disposal problems.

5.8.8 Site 12 - Fluidized-Bed Combustion

Five solid waste streams were sampled from an FBC plant located at Site 12. This plant used limestone injection into the boiler for SO₂ capture. Samples 1202 and 1204 were spent-bed materials from the boiler. Sample 1205A was a superheater ash, sample 1203 was an economizer ash collected in a cyclone, and Sample 1204A was a fly ash collected in a baghouse.

The two samples of spent bed material from the FBC boiler were very similar in their chemical compositions and physical properties. They were composed principally of silicon, aluminum, and iron oxides. The spent bed materials had the consistency of a very fine sand, and they did not display either self-heating or self-hardening properties. Although limestone was injected into the boiler, the bed materials only contained small amounts of calcium, which indicates that most of the sorbent was carried out of the boiler with the ash.

The superheater ash, economizer ash, and baghouse fly ash also had similar chemical compositions and physical properties. These ashes all contained high calcium contents, were self-heating and self-hardening materials, and produced high pH leachates. These ashes did not set up quickly, but since they are self-hardening, they should not be permitted to set up while they are being transported.

The baghouse fly ash displayed a particularly vigorous self-heating behavior. For this reason, it may pose a potential safety hazard when being conditioned, and special precautions should be taken to allow it to hydrate under controlled conditions. It is particularly important not to place the hydrating waste in a sealed container where the steam being released can build to a dangerously high pressure.

Since the spent bed materials are not self-heating, while the ashes are self-heating, it may be more economical to handle the spent bed material separately rather than to blend it with the ash prior to disposal.

5.8.9 Site 13 - Fluidized-Bed Combustion

Three solid waste streams were sampled from an FBC plant located at Site 13. This plant used limestone injection into the boiler for SO₂ capture. Sample 1302A was a spent bed material from the boiler. Sample 1304A was an economizer ash, and Sample 1305A was a fly ash collected in a baghouse.

The chemical compositions of the spent bed material and the two ashes from this FBC boiler were similar, and all three had relatively high calcium

contents. The bed material had a consistency similar to coarse sand, while the two ashes were much finer. The spent bed material and the economizer ash were slightly self-heating, and the economizer and baghouse ashes were self-hardening. All of the wastes produced high-pH aqueous slurries.

Although the spent bed material and the economizer ash were slightly self-heating, the amount of heat released was not great enough to require any special precautions during the conditioning operation. The economizer ash and the baghouse fly ash were both self-hardening materials. Although they did not set up quickly, they should not be permitted to set up if they are being transported for an extended time period.

Since self-heating is not a serious problem for these wastes, the spent bed material and the ashes can probably be blended before disposal without significantly increasing handling problems, although blending the wastes will probably make the entire mixture self-hardening.

5.8.10 Site 20 - Fixed-Bed Coal Gasification

One solid waste stream was sampled from the fixed-bed coal gasification plant located at Site 20. Sample 2002 was a coarse gasifier ash collected from the bottom of the gasifier. The waste was composed of approximately 70 percent silicon, aluminum, and iron oxides and had an unburned carbon content of 21 percent.

This waste was a noncohesive material with a particle-size distribution similar to a conventional pulverized coal bottom ash. It could probably be disposed of with the same types of operations that are routinely used for conventional bottom ashes. The only unusual feature of this waste is its high unburned-carbon content. It is uncertain whether the unburned carbon in the waste presents any special problems for disposal, but it would almost certainly reduce the utilization potential of the waste.

5.8.11 Site 21 - Agglomerating-Ash, Fluidized-Bed Coal Gasification

One solid waste stream was sampled from an agglomerating-ash, fluidized-bed coal gasification plant located at Site 21. For this particular process, limestone was injected into the gasifier for sulfur capture. Sample 2102A was a mixture of gasifier ash and spent-limestone collected from the bottom of the gasifier. The ash/spent-limestone mixture contained a high percentage of calcium sulfide which was apparently produced by reaction between limestone and sulfur in the gasifier.

The high calcium sulfide content of this material is very unusual for a coal-utilization waste. In order to safely dispose of this waste, a processing operation will probably be necessary to convert the sulfide to a more highly oxidized sulfur form. If this were not done, the waste deposit could potentially generate dangerous amounts of hydrogen sulfide gas. Another possibility may be to recover the sulfur from this waste as a valuable by-product.

5.8.12 Site 22 - Fluidized-Bed Coal Gasification

Two solid waste streams were sampled from the fluidized-bed coal gasification plant located at Site 22. Samples 2201 and 2201A were ashes

collected from the bottom of the gasifier. Sample 2201 contained approximately 80 percent silicon oxide and no detectable unburned carbon. Sample 2201A had a dramatically different composition since it contained 21 percent unburned carbon.

Both wastes were noncohesive materials with particle-size distributions similar to fine sand. Sample 2201 could probably be disposed of in a manner similar to a conventional pulverized-coal bottom ash, and it could be utilized for many of the same applications as bottom ash. Sample 2201A may be more difficult to dispose of or to utilize due to its high unburned-carbon content.

5.8.13 Site 23 - Fluidized-Bed Combustion

Three solid waste streams were sampled from an FBC plant located at Site 23. This plant used limestone injection into the boiler for SO_2 capture. Sample 2302A was a spent bed material from the boiler. Sample 2303A was an economizer ash, and Sample 2304A was a fly ash collected in a baghouse.

The spent bed material and the economizer ash both had very high calcium contents and were vigorously self-heating materials. When these wastes were mixed with water, they reacted in a few minutes with a violent release of heat and steam. The baghouse fly ash had a lower calcium content than either the spent bed material or the economizer ash, and it had a much lower self-heating potential than the other two wastes.

The spent bed material and the economizer ash may pose a potential safety hazard when they are being conditioned; therefore, special precautions should be taken to allow them to hydrate under controlled conditions after they have been mixed with water. It is particularly important not to place the hydrating waste in a sealed container where the steam being released can build to a dangerously high pressure.

The economizer ash and the baghouse fly ash were both self-hardening materials, but it took several hours before they gained significant strength. Transporting these wastes after they have been conditioned should not be a problem unless they are allowed to remain in the transport container for an extended time period.

All three FBC wastes produced aqueous slurries with high pH values.

5.8.14 Site 24 - Fluidized-Bed Combustion

Three solid waste streams were sampled from an FBC plant located at Site 24. This plant used limestone injection into the boiler for SO_2 capture. Sample 2402A was a spent bed material from the boiler. Sample 2403A was an economizer ash, and Samples 2404A and 2404 were fly ashes collected in a baghouse. Sample 2404 was collected from the same baghouse as Sample 2404A, but apparently it was collected during a period when limestone was not being injected into the boiler because it contained almost no calcium.

Samples 2402A, 2403A, and 2404A were similar to the FBC spent bed material, economizer ash, and baghouse fly ash produced from Site 23, except that they had lower calcium contents and did not heat up as quickly when they were mixed with water.

Although the spent bed material and economizer ash produced at Site 24 were both self-heating materials and did release steam after they were mixed with water, they should not be too difficult to handle because it took more than 30 minutes for the temperature to rise to the point where steam was produced, and then it was released gradually. Both of these wastes are also self-hardening, and so care should be taken not to allow them to set up if they are being transported for a long time period.

5.8.15 Site 25 - Fluidized-Bed Combustion

Two solid waste streams were sampled from an FBC plant located at Site 25. This plant used limestone injection into the boiler for SO₂ capture. Sample 2503A was an economizer ash, and Sample 2504A was a fly ash collected in a baghouse.

The economizer ash and baghouse fly ash had only moderately high calcium contents compared to the FBC wastes produced at Sites 23 and 24. These wastes were moderately self-heating, and the economizer ash was slightly self-hardening, but these properties were not extreme enough to pose any significant handling problems during the disposal process.

5.8.16 Site EER - Slagging Combustor with Limestone Injection

One waste stream was sampled from Site EER. This was a coarse black slag with an appearance similar to a slag from a conventional, wet-bottom pulverized-coal boiler. The waste was composed almost entirely of silicon, aluminum, iron, and calcium oxides. The calcium was not in the form of free lime, but rather appeared to be mixed with the other oxides in the slag.

It should be possible to handle and dispose of the EER slag in much the same manner as a conventional coal combustion boiler slag and to utilize it for many of the same by-product applications.

6.0 CONCLUSIONS

Thirty-four waste materials produced from coal gasification, fluidized-bed combustion, and advanced flue gas scrubbing processes were characterized for this project. The advanced process wastes were a diverse group of materials ranging from relatively coarse slags to very fine ashes. Their chemical and mineral compositions also varied depending mainly on what types of scrubber materials were used in the processes. The wastes that were produced from FBC processes that used limestone injection, for example, tended to have high lime and calcium sulfate contents, while the processes that did not use scrubber materials tended to be predominantly composed of silica- and alumina-containing compounds.

Based on the results of the waste characterizations, an analysis of appropriate waste management practices for the advanced process wastes was performed. The analysis indicated that it should be possible to use conventional waste management technology to handle and dispose of the advanced process wastes. However, some of wastes did possess properties which would present special problems for conventional waste management systems. Chief of these was the vigorous self-heating behavior exhibited by many of the FBC

process wastes and their potential corrosivity. Additionally, the by-product-utilization potentials for the advanced process wastes were also evaluated.

Waste self-heating is caused by the exothermic hydration of lime, which occurs when the waste is mixed with conditioning water. If enough lime is present, the temperature of the waste will rise until the water begins to boil and steam is produced. It was recommended that the self-heating wastes be conditioned under controlled conditions so that the heat and steam can be safely dissipated before the material is transported to an ultimate disposal site. In order to get the self-heating wastes wet enough to fully hydrate when they are conditioned, they must be initially mixed to the consistency of a wet slurry. As the lime hydrates, the waste will gradually dry out. The process takes about twenty minutes. Conditioning the self-heating wastes in this manner will probably require some different mixing equipment than the type normally required for conventional wastes.

The Scott Model 2072 mixer was identified as a good choice for conditioning self-heating ashes. This piece of equipment appears to be capable of mixing ash slurries with moisture contents in the range of 50%-60% of dry weight. Further, it is a continuous-flow type mixer with a relatively short residence time and can process up to 50 tons of dry ash per hour.

The potentially corrosive behavior of many of the advanced process wastes can be dealt with by constructing equipment that will handle wet wastes with special corrosion-resistant materials.

The utilization potentials of the advanced process wastes were also evaluated based on their physical properties, bulk chemical compositions, and mineral compositions. Waste utilization is important because if the waste is sold it will not require ultimate disposal. Only one of the thirty-four materials studied appeared to be suitable for use as a pozzolanic concrete additive. However, many of the wastes appeared to be suitable for other less-profitable uses such as blasting grit, fine aggregate for asphalt concrete, road deicer, structural fill material, soil-stabilization additives, waste-stabilization additives, landfill cover material, and pavement base course construction.

7.0 REFERENCES

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2. Electric Power Research Institute, 1988, Atmospheric fluidized-bed combustion waste management design guidelines, EPRI CS-6053.
3. Electric Power Research Institute, 1981, Coal ash disposal manual, EPRI CS-2049.
4. Electric Power Research Institute, 1984, Coal combustion by-products utilization manual, EPRI CS-3122, Vol. 1.

APPENDIX 1

Sample 102 - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- Wet (standing water)
pH of 50% Slurry	- 11.3
Acid-Neutralizing Capacity (to pH 5.0)	- 635 meq/lb
Particle-Specific Surface Area	- 2.47 m ² /g
Particle-Specific Gravity	- 2.85
Dry Bulk Density (poured)	- 60.9 lb/ft ³
Dry Bulk Density (packed)	- 79.1 lb/ft ³
Blaine Fineness	- 5413 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.018 mm
Uniformity Coefficient $\frac{(D_{60})}{(D_{10})}$	- 30
Maximum Compacted Dry Density (standard proctor)	- 119.2 lb/ft ³
Optimum Moisture Content	- 11.6% dry wt
Pozzolanic Activity Index (28 day w cement)	- 82% of control
Self-Cementing Behavior	- Slightly cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 105 psi 14 day - 89 psi 28 day - 51 psi
	NOTE: MATERIAL TENDED TO EXPAND AS IT CURED
Angle of Repose	- 43° (dry)
Self-Heating Behavior	- Slightly exothermic, the temperature of the material increased 6°F in 30 minutes.
Permeability Coefficient	- 9.8 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 104 - Physical Data Summary

Color:Consistency	- Black Granules
Initial Moisture Content	- 0.02%
pH of 50% Slurry	- 9.1
Acid-Neutralizing Capacity (to pH 5.0)	- 4.5 meq/lb
Particle-Specific Surface Area	- 0.1 m ² /g
Particle-Specific Gravity	- 2.83
Dry Bulk Density (poured)	- 89.2 lb/ft ³
Dry Bulk Density (packed)	- 99.1 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.85 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 2.8
Maximum Compacted Dry Density (standard proctor)	- 104.9 lb/ft ³ , (material was noncohesive)
Optimum Moisture Content	- 15.6% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 41° (at optimum moisture)
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 1.8 x 10 ⁻³ cm/sec
Compressibility (at 8000 PSF)	- 7.8 in ² /min

NA - Test was not applicable to this sample.

Sample 202 - Physical Data Summary

Color:Consistency	- White Powder
Initial Moisture Content	- 0.0%
pH of 50% Slurry	- 11.8
Acid-Neutralizing Capacity (to pH 5.0)	- 91 meq/lb
Particle-Specific Surface Area	- 0.92 m ² /g
Particle-Specific Gravity	- 2.41
Dry Bulk Density (poured)	- 62.2 lb/ft ³
Dry Bulk Density (packed)	- 80.7 lb/ft ³
Blaine Fineness	- 3333 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.022 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 2.7
Maximum Compacted Dry Density (standard proctor)	- 105.5 lb/ft ³
Optimum Moisture Content	- 17.2%
Pozzolanic Activity Index (28 day w cement)	- 118% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 550 psi 14 day - 611 psi 28 day - 661 psi
Angle of Repose	- 33° (dry)
Self-Heating Behavior	- Slightly exothermic, the temperature of the material increased 7.5°F in 30 minutes.
Permeability Coefficient	- 2.0 x 10 cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 203 - Physical Data Summary

Color:Consistency	- Grey-black Granules
Initial Moisture Content	- 2.9%
pH of 50% Slurry	- 7
Acid-Neutralizing Capacity (to pH 5.0)	- 14 meq/lb
Particle-Specific Surface Area	- 2.0 m ² /g
Particle-Specific Gravity	- 2.68
Dry Bulk Density (poured)	- 93 lb/ft ³
Dry Bulk Density (packed)	- 102.2 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.28 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 5.5
Maximum Compacted Dry Density (standard proctor)	- 103 lb/ft ³
Optimum Moisture Content	- 19.2% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 43° (at optimum moisture)
Angle of Repose	- 34° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 3.2 x 10 ⁻³ cm/sec
Compressibility (at 8000 PSF)	- 5.1 in ² /min

NA - Test was not applicable to this sample.

Sample 302A - Physical Data Summary

Color:Consistency	- Tan Granules
Initial Moisture Content	- 51% dry wt
pH of 50% Slurry	- 6.0
Acid-Neutralizing Capacity (to pH 5.0)	- 0.0 meq/lb
Particle-Specific Surface Area	- 0.76 m ² /g
Particle-Specific Gravity	- 2.20
Dry Bulk Density (poured)	- 38.5 lb/ft ³
Dry Bulk Density (packed)	- 46.4 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 1.7 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 66.7
Maximum Compacted Dry Density (standard proctor)	- 68 lb/ft ³ (material was noncohesive)
Optimum Moisture Content	- 34.8% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 42° (at optimum moisture)
Angle of Repose	- 35° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 1.4 x 10 ⁻³ cm/sec
Compressibility (at 8000 PSF)	- 7.8 in ² /min

NA - Test was not applicable to this sample.

Sample 403A - Physical Data Summary

Color:Consistency	- Grey Granules
Initial Moisture Content	- 0.28%
pH of 50% Slurry	- 10.4
Acid-Neutralizing Capacity (to pH 5.0)	- 110 meq/lb
Particle-Specific Surface Area	- 2.82 m ² /g
Particle-Specific Gravity	- 2.22
Dry Bulk Density (poured)	- 51.8 lb/ft ³
Dry Bulk Density (packed)	- 71.0 lb/ft ³
Blaine Fineness	- 3171 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.029 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 9.7
Maximum Compacted Dry Density (standard proctor)	- 76 lb/ft ³
Optimum Moisture Content	- 28.5% dry wt
Pozzolanic Activity Index (28 day w cement)	- 73% of control
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 49° (at optimum moisture)
Angle of Repose	- 25° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 7.0 x 10 ⁻³ cm/sec
Compressibility (at 8000 PSF)	- 2.4 in ² /min

NA - Test was not applicable to this sample.

Sample 502A - Physical Data Summary

Color:Consistency	- Grey-black Granules
Initial Moisture Content	- 32.3%
pH of 50% Slurry	- 9.3
Acid-Neutralizing Capacity (to pH 5.0)	- 91 meq/lb
Particle-Specific Surface Area	- 0.91 m ² /g
Particle-Specific Gravity	- 2.34
Dry Bulk Density (poured)	- 62.5 lb/ft ³
Dry Bulk Density (packed)	- 71.8 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 1.7 mm
Uniformity Coefficient $\frac{(D_{60})}{(D_{10})}$	- 48
Maximum Compacted Dry Density (standard proctor)	- 83 lb/ft ³ (material was noncohesive)
Optimum Moisture Content	- 20% of dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 44.5° (at optimum moisture)
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 1.5 x 10 ⁻³ cm/sec
Compressibility (at 8000 PSF)	- 6.5 in ² /min

NA - Test was not applicable to this sample.

Sample 503 - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0.0%
pH of 50% Slurry	- 8.7
Acid-Neutralizing Capacity (to pH 5.0)	- 209 meq/lb
Particle-Specific Surface Area	- 4.02 m ² /g
Particle-Specific Gravity	- 2.39
Dry Bulk Density (poured)	- 54 lb/ft ³
Dry Bulk Density (packed)	- 66.7 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.6 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 112.5
Maximum Compacted Dry Density (standard proctor)	- 93 lb/ft ³
Optimum Moisture Content	- 21% of dry wt
Self-Cementing Behavior	- Low
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 25 psi 14 day - 17 psi 28 day - 25 psi
Angle of Repose	- 44° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 5.3 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test not applicable to this sample.

Sample 602A - Physical Data Summary

Color:Consistency	- Black Granules
Initial Moisture Content	- 19.1%
pH of 50% Slurry	- 9.7
Acid-Neutralizing Capacity (to pH 5.0)	- 159 meq/lb
Particle-Specific Surface Area	- 3.46 m ² /g
Particle-Specific Gravity	- 2.48
Dry Bulk Density (poured)	- 75.3 lb/ft ³
Dry Bulk Density (packed)	- 83.6 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 2.3 mm
Uniformity Coefficient $\frac{(D_{60})}{(D_{10})}$	- 13
Maximum Compacted Dry Density (standard proctor)	- 102 lb/ft ³
Optimum Moisture Content	- 12.2% of dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 43° (at optimum moisture)
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- Slightly exothermic, the temperature of the material increased 10°F in 2 minutes.
Permeability Coefficient	- 3.9 x 10 ⁻⁴ cm/sec
Compressibility (at 80000 PSF)	- 4.3 in ² /min

NA - Test not applicable to this sample.

Sample 603A - Physical Data Summary

Color:Consistency	- White Powder
Initial Moisture Content	- 0.93%
pH of 50% Slurry	- 11.3
Acid-Neutralizing Capacity (to pH 5.0)	- 73 meq/lb
Particle-Specific Surface Area	- 1.71 m ² /g
Particle-Specific Gravity	- 2.7
Dry Bulk Density (poured)	- 57 lb/ft ³
Dry Bulk Density (packed)	- 86.4 lb/ft ³
Blaine Fineness	- 5025 m ² /g
Particle-Size Data:	
D ₅₀	- 0.014
Uniformity Coefficient $\frac{D_{60}}{D_{10}}$	- 2.0
Maximum Compacted Dry Density (standard proctor)	- 107.8 lb/ft ³
Optimum Moisture Content	- 18.5% dry wt
Pozzolanic Activity Index (28 day w cement)	- 110% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 160 psi 14 day - 262 psi 28 day - 392 psi
Angle of Repose	- NS
Self-Heating Behavior	- None
Permeability Coefficient	- 2 x 10 ⁻⁶ cm/sec
Compressibility	- NA

NA - Test not applicable to this sample.

NS - Not enough sample available to perform this test.

Sample 702A - Physical Data Summary

Color:Consistency	- Grey-black Granules
Initial Moisture Content	- 24.5%
pH of 50% Slurry	- 9.6
Acid-Neutralizing Capacity (to pH 5.0)	- 41 meq/lb
Particle-Specific Surface Area	- 0.88 m ² /g
Particle-Specific Gravity	- 2.39
Dry Bulk Density (poured)	- 57.4 lb/ft ³
Dry Bulk Density (packed)	- 68.4 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 2.5 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 13
Maximum Compacted Dry Density (standard proctor)	- 72 lb/ft ³ (material was noncohesive)
Optimum Moisture Content	- 22% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 34° (at optimum moisture)
Angle of Repose	- 35° (dry)
Self-Heating Behavior	- NA
Permeability Coefficient	- 6.8 x 10 ⁻⁵ cm/sec
Compressibility	- 3.4 in ² /min

NA - Test was not applicable to this sample.

Sample 703A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0.08%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 68 meq/lb
Particle-Specific Surface Area	- 2.38 m ² /g
Particle-Specific Gravity	- 2.22
Dry Bulk Density (poured)	- 54.6 lb/ft ³
Dry Bulk Density (packed)	- 81.4 lb/ft ³
Blaine Fineness	- 2314 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.032 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 5.5
Maximum Compacted Dry Density (standard proctor)	- 83.8 lb/ft ³
Optimum Moisture Content	- 22.5% dry wt
Pozzolanic Activity Index (28 day w cement)	- 3698 psi
Self-Cementing Behavior	- Very slight
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 16 psi 14 day - 20 psi 28 day - 27 psi
Angle of Repose	- 24° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 1.9 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 1202 - Physical Data Summary

Color:Consistency	- Red-brown Powder
Initial Moisture Content	- 32.8%
pH of 50% Slurry	- 5.5
Acid-Neutralizing Capacity (to pH 5.0)	- 0 meq/lb
Particle-Specific Surface Area	- 6.43 m ² /g
Particle-Specific Gravity	- 2.85
Dry Bulk Density (poured)	- 78.1 lb/ft ³
Dry Bulk Density (packed)	- 91.9 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.47 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 7.3
Maximum Compacted Dry Density (standard proctor)	- 98 lb/ft ³
Optimum Moisture Content	- 18% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 39.5° (at optimum moisture)
Angle of Repose	- NS
Self-Heating Behavior	- NA
Permeability Coefficient	- 6.1 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.
NS - Not enough sample to perform this test.

Sample 1203 - Physical Data Summary

Color:Consistency	- White Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.8
Acid-Neutralizing Capacity (to pH 5.0)	- 5085 meq/lb
Particle-Specific Surface Area	- 7.18 m ² /g
Particle-Specific Gravity	- 2.81
Dry Bulk Density (poured)	- 46.5 lb/ft ³
Dry Bulk Density (packed)	- 57 lb/ft ³
Blaine Fineness	- 2314 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.013 mm
Uniformity Coefficient $\frac{(D_{60})}{(D_{10})}$	- 2.1
Maximum Compacted Dry Density (standard proctor)	- 60.25 lb/ft ³
Optimum Moisture Content	- 36 dry wt
Pozzolanic Activity Index (28 day w cement)	- 37% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 88.3 psi 14 day - 180 psi 28 day - 220 psi
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- Moderately exothermic, the temperature of the material increased 108°F in 8 minutes.
Permeability Coefficient	- 1.8 x 10 ⁻⁴ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 1204 - Physical Data Summary

Color:Consistency	- Red-brown Granules
Initial Moisture Content	- 30.7%
pH of 50% Slurry	- 5.3
Acid-Neutralizing Capacity (to pH 5.0)	- 0 meq/lb
Particle-Specific Surface Area	- 5.68 m ² /g
Particle-Specific Gravity	- 2.75
Dry Bulk Density (poured)	- 82.3 lb/ft ³
Dry Bulk Density (packed)	- 95.7 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.48 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 9.6
Maximum Compacted Dry Density (standard proctor)	- 103.4 lb/ft ³
Optimum Moisture Content	- 13.5% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 40° (at optimum moisture)
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- NA
Permeability Coefficient	- 4.7 x 10 ⁻⁵ cm/sec
Compressibility (at 8000 PSF)	- 4.1 in ² /min

NA - Test not applicable to this sample.

Sample 1204A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 3859 meq/lb
Particle-Specific Surface Area	- 10.02 m ² /g
Particle-Specific Gravity	- 2.55
Dry Bulk Density (poured)	- 41.4 lb/ft ³
Dry Bulk Density (packed)	- 55.9 lb/ft ³
Blaine Fineness	- 2314 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.07 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 1.05
Maximum Compacted Dry Density (standard proctor)	- 62.5 lb/ft ³
Optimum Moisture Content	- 45.3% dry wt
Pozzolanic Activity Index (28 day w cement)	- 73% of control
Self-Cementing Behavior	- Slightly cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 30 psi 14 day - 106 psi 28 day - 164 psi
Angle of Repose	- 37° (dry)
Self-Heating Behavior	- Moderately Exothermic, the temperature of the material increased 95° in 15 minutes.
Permeability Coefficient	- 1.1 x 10 ⁻⁴ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 1205A - Physical Data Summary

Color:Consistency	- White-Black Powder
Initial Moisture Content	- 0.06%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 5130 meq/lb
Particle-Specific Surface Area	- 10.08 m ² /g
Particle-Specific Gravity	- 2.88
Dry Bulk Density (poured)	- 50.3 lb/ft ³
Dry Bulk Density (packed)	- 59.2 lb/ft ³
Blaine Fineness	- 2005 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.088 mm
Uniformity Coefficient $\frac{(D_{50})}{(D_{10})}$	- 5
Maximum Compacted Dry Density (standard proctor)	- 77 lb/ft ³
Optimum Moisture Content	- 27% dry wt
Pozzolanic Activity Index (28 day w cement)	- 27% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 20 psi 14 day - 51 psi 28 day - 169 psi
Angle of Repose	- 37° (dry)
Self-Heating Behavior	- Highly exothermic, the temperature of the material increased to 210°F in 7 minutes.
Permeability Coefficient	- 5.3 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 1302A - Physical Data Summary

Color:Consistency	- Brown Granules
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 1226 meq/lb
Particle-Specific Surface Area	- 1.12 m ² /g
Particle-Specific Gravity	- 2.7
Dry Bulk Density (poured)	- 89.6 lb/ft ³
Dry Bulk Density (packed)	- 97.4 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.48 mm
Uniformity Coefficient $\frac{(D_{60})}{(D_{10})}$	- 3.25
Maximum Compacted Dry Density (standard proctor)	- 99.2 lb/ft ³
Optimum Moisture Content	- 13% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 41° (at optimum moisture)
Angle of Repose	- 35° (dry)
Self-Heating Behavior	- Slightly exothermic, the temperature of the material increased 13°F in 45 minutes.
Permeability Coefficient	- 4.7×10^{-4} cm/sec
Compressibility	- NS

NA - Test was not applicable to this sample.

NS - Not enough sample available to perform this test.

Sample 1304A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 12
Acid-Neutralizing Capacity (to pH 5.0)	- 1022 meq/lb
Particle-Specific Surface Area	- 3.78 m ² /g
Particle-Specific Gravity	- 2.58
Dry Bulk Density (poured)	- 42.6 lb/ft ³
Dry Bulk Density (packed)	- 60 lb/ft ³
Blaine Fineness	- 2244 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.035 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 14
Maximum Compacted Dry Density (standard proctor)	- 70.3 lb/ft ³
Optimum Moisture Content	- 37% dry wt
Pozzolanic Activity Index (28 day w cement)	- 42% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 34 psi 14 day - 128 psi 28 day - 275 psi
Angle of Repose	- 35° (dry)
Self-Heating Behavior	- Slightly exothermic, the temperature of the material increased 5°F in 30 minutes.
Permeability Coefficient	- 1.7 x 10 ⁻⁴ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 1305A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0.2%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 726 meq/lb
Particle-Specific Surface Area	- 11.64 m ² /g
Particle-Specific Gravity	- 2.22
Dry Bulk Density (poured)	- 28 lb/ft ³
Dry Bulk Density (packed)	- 50 lb/ft ³
Blaine Fineness	- 6483 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.0051 mm
Uniformity Coefficient ($\frac{D_{50}}{D_{10}}$)	- 1.5
Maximum Compacted Dry Density (standard proctor)	- 58 lb/ft ³
Optimum Moisture Content	- 53% dry wt
Pozzolanic Activity Index (28 day w cement)	- 48% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 104 psi 14 day - 270 psi 28 day - 311 psi
Angle of Repose	- 35° (dry)
Self-Heating Behavior	- None
Permeability Coefficient	- 7.2 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 2002 - Physical Data Summary

Color:Consistency	- Black Granules
Initial Moisture Content	- 0.75%
pH of 50% Slurry	- 8.1
Acid-Neutralizing Capacity (to pH 5.0)	- 18.1 meq/lb
Particle-Specific Surface Area	- No Data
Particle-Specific Gravity	- 2.07
Dry Bulk Density (poured)	- 53.7 lb/ft ³
Dry Bulk Density (packed)	- 60.3 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 2.2 mm
Uniformity Coefficient	- 8.75
Maximum Compacted Dry Density (standard proctor)	- 73 lb/ft ³ (material was noncohesive)
Optimum Moisture Content	- 73% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 43.5° (at optimum moisture)
Angle of Repose	- 34° (dry)
Self-Heating Behavior	- NA
Permeability Coefficient	- 3.0 x 10 ⁻⁴ cm/sec
Compressibility (at 8000 PSF)	- 6.1 in ² /min

NA - Test was not applicable to this sample.

Sample 2102A - Physical Data Summary

Color:Consistency	- Black-brown Granules
Initial Moisture Content	- 0%
pH of 50% Slurry	- 12
Acid-Neutralizing Capacity (to pH 5.0)	- 7718 meq/lb
Particle-Specific Surface Area	- 0.2 m ² /g
Particle-Specific Gravity	- 2.76
Dry Bulk Density (poured)	- 69.3 lb/ft ³
Dry Bulk Density (packed)	- 77.9 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.6 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 1.3
Maximum Compacted Dry Density (standard proctor)	- 79.2 lb/ft ³
Optimum Moisture Content	- 16.7% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 39.5° (at optimum moisture)
Angle of Repose	- NS
Self-Heating Behavior	- NA
Permeability Coefficient	- 5.7 x 10 ⁻⁵ cm/sec
Compressibility (at 8000 PSF)	- 6.1 in ² /min

NA - Test was not applicable to this sample.

NS - Not enough sample available to perform this test.

Sample 2201 - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 5.6%
pH of 50% Slurry	- 8.2
Acid-Neutralizing Capacity (to pH 5.0)	- 159 meq/lb
Particle-Specific Surface Area	- 0.44 m ² /g
Particle-Specific Gravity	- 2.07
Dry Bulk Density (poured)	- 50.9 lb/ft ³
Dry Bulk Density (packed)	- 74.8 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.8 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 1.6
Maximum Compacted Dry Density (standard proctor)	- 100.8 lb/ft ³
Optimum Moisture Content	- 10.3% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction	- 38° (at optimum moisture)
Angle of Repose (confined and drained)	- 37° (slightly moist)
Self-Heating Behavior	- NA
Permeability Coefficient	- 3.1 x 10 ⁻⁵ cm/sec
Compressibility (at 8000 PSF)	- 2.4 in ² /min

NA - Test not applicable to this sample.

Sample 2201A - Physical Data Summary

Color:Consistency	- Black Granules
Initial Moisture Content	- 0.3%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 195 meg/lb
Particle-Specific Surface Area	- 21.64 m ² /g
Particle-Specific Gravity	- 2.2
Dry Bulk Density (poured)	- 60.3 lb/ft ³
Dry Bulk Density (packed)	- 64.1 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.9 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 2.1
Maximum Compacted Dry Density (standard proctor)	- 66 lb/ft ³ (material was noncohesive)
Optimum Moisture Content	- 32.6% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 40° (at optimum moisture)
Angle of Repose	- 37° (dry)
Self-Heating Behavior	- NA
Permeability Coefficient	- 6.0 x 10 ⁻⁵ cm/sec
Compressibility	- NS

NA - Test was not applicable to this sample.

NS - Not enough sample available to perform the test.

Sample 2302A - Physical Data Summary

Color:Consistency	- Tan Granules
Initial Moisture Content	- 0 mg/l
pH of 50% Slurry	- 12
Acid-Neutralizing Capacity (to pH 5.0)	- 7491 meq/lb
Particle-Specific Surface Area	- 2.25 m ² /g
Particle-Specific Gravity	- 3.43
Dry Bulk Density (poured)	- 75.9 lb/ft ³
Dry Bulk Density (packed)	- 81.6 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.9 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 1.7
Maximum Compacted Dry Density (standard proctor)	- 84 lb/ft ³
Optimum Moisture Content	- 29% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- Slightly cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 21.3 psi 14 day - 28.2 psi 28 day - 26 psi
Angle of Repose	- 34° (dry)
Self-Heating Behavior	- Highly exothermic, the temperature of the material increased to 212°F in 5 minutes.
Permeability Coefficient	- 9 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 2303A - Physical Data Summary

Color:Consistency	- Brown-white Granules
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.7
Acid-Neutralizing Capacity (to pH 5.0)	- 6129 meq/lb
Particle-Specific Surface Area	- 3.68 m ² /g
Particle-Specific Gravity	- 3.19
Dry Bulk Density (poured)	- 71.7 lb/ft ³
Dry Bulk Density (packed)	- 99.2 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.21 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 1.4
Maximum Compacted Dry Density (standard proctor)	- 77.8 lb/ft ³
Optimum Moisture Content	- 30.5% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 54.3 psi 14 day - 152 psi 28 day - 463 psi
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- Highly exothermic, the temperature of the material increased to 212°F in 4 minutes.
Permeability Coefficient	- 6.5 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 2304A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.7
Acid-Neutralizing Capacity (to pH 5.0)	- 3541 meq/lb
Particle-Specific Surface Area	- 13.04 m ² /g
Particle-Specific Gravity	- 2.6
Dry Bulk Density (poured)	- 42.6 lb/ft ³
Dry Bulk Density (packed)	- 67.6 lb/ft ³
Blaine Fineness	- 5651 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.03 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 7.1
Maximum Compacted Dry Density (standard proctor)	- 73.5 lb/ft ³
Optimum Moisture Content	- 31% dry wt
Pozzolanic Activity Index (28 day w cement)	- 56% of control
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 37° (at optimum moisture)
Angle of Repose	- 38° (dry)
Self-Heating Behavior	- Moderately exothermic, the temperature of the material increased 107°F in 20 minutes.
Permeability Coefficient	- 6.6 x 10 ⁻⁵ cm/sec
Compressibility	- NS

NA - Test not applicable to this sample.

NS - Not enough sample available for this test.

Sample 2402A - Physical Data Summary

Color:Consistency	- Tan Granules
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.8
Acid-Neutralizing Capacity (to pH 5.0)	- 2134 meq/lb
Particle-Specific Surface Area	- 0.77 m ² /g
Particle-Specific Gravity	- 2.94
Dry Bulk Density (poured)	- 97.1 lb/ft ³
Dry Bulk Density (packed)	- 103.3 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 0.51 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 3.2
Maximum Compacted Dry Density (standard proctor)	- 101.5 lb/ft ³
Optimum Moisture Content	- 19.6% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- 29° (at optimum moisture)
Angle of Repose	- 34° (dry)
Self-Heating Behavior	- Highly exothermic, the temperature of the material increased to 212°F in 60 minutes.
Permeability Coefficient	- 1.7 x 10 ⁻⁴ cm/sec
Compressibility	- NS

NA - Test was not applicable to this sample.

NS - Not enough sample available to perform this test.

Sample 2403A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.7
Acid-Neutralizing Capacity (to pH 5.0)	- 2815 meq/lb
Particle-Specific Surface Area	- 3.26 m ² /g
Particle-Specific Gravity	- 2.9
Dry Bulk Density (poured)	- 63.5 lb/ft ³
Dry Bulk Density (packed)	- 85.7 lb/ft ³
Blaine Fineness	- 1180 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.04 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 5.4
Maximum Compacted Dry Density (standard proctor)	- 84.2 lb/ft ³
Optimum Moisture Content	- 23.2% dry wt
Pozzolanic Activity Index (28 day w cement)	- 37% of control
Self-Cementing Behavior	- Moderately exothermic
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 138 psi 14 day - 178 psi 28 day - 338 psi
Angle of Repose	- NS
Self-Heating Behavior	- Highly exothermic, the temperature of the material increased to 212°F in 72 minutes.
Permeability Coefficient	- NS
Compressibility	- NA

NA - Test was not applicable to this sample.

NS - Not enough sample available to perform the test.

Sample 2404 - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0.9%
pH of 50% Slurry	- 4.3
Acid-Neutralizing Capacity (to pH 5.0)	- 0 meq/lb
Particle-Specific Surface Area	- 25.05 m ² /g
Particle-Specific Gravity	- 2.25
Dry Bulk Density (poured)	- 18.9 lb/ft ³
Dry Bulk Density (packed)	- 33.2 lb/ft ³
Blaine Fineness	- 11,455 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.018 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 2.9
Maximum Compacted Dry Density (standard proctor)	- 47 lb/ft ³
Optimum Moisture Content	- 72.6% dry wt
Pozzolanic Activity Index (28 day w cement)	- 70% of control
Self-Cementing Behavior	- NA
Angle of Internal Friction (confined and drained)	- 45° (at optimum moisture)
Angle of Repose	- 27° (dry)
Self-Heating Behavior	- NA
Permeability Coefficient	- 6 x 10 ⁻⁵ cm/sec
Compressibility (at 8000 PSF)	- 2.3 in ² /min

NA - Test not applicable to this sample.

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Sample 2404A - Physical Data Summary

Color:Consistency	- Grey Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.7
Acid-Neutralizing Capacity (to pH 5.0)	- 2951 meq/lb
Particle-Specific Surface Area	- 6.85 m ² /g
Particle-Specific Gravity	- 2.87
Dry Bulk Density (poured)	- 43.5 lb/ft ³
Dry Bulk Density (packed)	- 68 lb/ft ³
Blaine Fineness	- 3824 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.027 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 2.9
Maximum Compacted Dry Density (standard proctor)	- 76.4 lb/ft ³
Optimum Moisture Content	- 30.2% dry wt
Pozzolanic Activity Index (28 day w cement)	- 76% of control
Self-Cementing Behavior	- Moderately cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 451 psi 14 day - 483 psi 28 day - 572 psi
Angle of Repose	- 36° (dry)
Self-Heating Behavior	- Moderately exothermic, the temperature of the material increased 91°F in 100 minutes.
Permeability Coefficient	- 8 x 10 ⁻⁵ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 2503A - Physical Data Summary

Color:Consistency	- Black Powder
Initial Moisture Content	- 0%
pH of 50% Slurry	- 11.7
Acid-Neutralizing Capacity (to pH 5.0)	- 4131 meq/lb
Particle-Specific Surface Area	- 10.49 m ² /g
Particle-Specific Gravity	- 2.45
Dry Bulk Density (poured)	- 39.7 lb/ft ³
Dry Bulk Density (packed)	- 50.2 lb/ft ³
Blaine Fineness	- 2926 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.07 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 11.9
Maximum Compacted Dry Density (standard proctor)	- 62.5 lb/ft ³
Optimum Moisture Content	- 42.5% dry wt
Pozzolanic Activity Index (28 day w cement)	- 31% of control
Self-Cementing Behavior	- Slightly cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 25.5 psi 14 day - 27.8 psi 28 day - 66.2 psi
Angle of Repose	- 36° (dry)
Self-Heating Behavior	- Moderately exothermic, the temperature of the material increased 59°F in 60 minutes.
Permeability Coefficient	- 3.4 x 10 ⁻⁴ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample 2504A - Physical Data Summary

Color:Consistency	- Black Powder
Initial Moisture Content	- 0.07%
pH of 50% Slurry	- 11.9
Acid-Neutralizing Capacity (to pH 5.0)	- 1816 meq/lb
Particle-Specific Surface Area	- 13.33 m ² /g
Particle-Specific Gravity	- 1.84
Dry Bulk Density (poured)	- 26.9 lb/ft ³
Dry Bulk Density (packed)	- 35.9 lb/ft ³
Blaine Fineness	- 3122 cm ² /g
Particle-Size Data:	
D ₅₀	- 0.029 mm
Uniformity Coefficient ($\frac{D_{60}}{D_{10}}$)	- 3.6
Maximum Compacted Dry Density (standard proctor)	- 38 lb/ft ³
Optimum Moisture Content	- 76.1% dry wt
Pozzolanic Activity Index (28 day w cement)	- 31% of control
Self-Cementing Behavior	- Slightly cementitious
Unconfined Compressive Strength (at optimum moisture)	- 7 day - 19.8 psi 14 day - 43.8 psi 28 day - 83.5 psi
Angle of Repose	- 34° (dry)
Self-Heating Behavior	- Slightly exothermic, the temperature of the material increased 19°F in 20 minutes.
Permeability Coefficient	- 2.3 x 10 ⁻⁴ cm/sec
Compressibility	- NA

NA - Test was not applicable to this sample.

Sample EER - Physical Data Summary

Color:Consistency	- Black Granules and Chunks
Initial Moisture Content	- 49.7%
pH of 50% Slurry	- 9.9
Acid-Neutralizing Capacity (to pH 5.0)	- 9.1 meq/lb
Particle-Specific Surface Area	- 0.09 m ² /g
Particle-Specific Gravity	- 3.08
Dry Bulk Density (poured)	- 86.4 lb/ft ³
Dry Bulk Density (packed)	- 108 lb/ft ³
Blaine Fineness	- NA
Particle-Size Data:	
D ₅₀	- 3.5 mm
Uniformity Coefficient $\frac{(D_{60})}{(D_{10})}$	- 7.8
Maximum Compacted Dry Density (standard proctor)	- 117.7 lb/ft ³ (material was noncohesive)
Optimum Moisture Content	- 5% dry wt
Pozzolanic Activity Index (28 day w cement)	- NA
Self-Cementing Behavior	- None
Angle of Internal Friction (confined and drained)	- NT
Angle of Repose	- 35° (dry)
Self-Heating Behavior	- NA
Permeability Coefficient	-
Compressibility (at 8000 PSF)	- 4.1 in ² /min

NA - Test was not applicable to this sample.

NT - Sample was not tested due to technical difficulty.

Chemical Composition

Sample No. 102

Mineral Composition

Sample No. 102

Chemical Composition

Sample No. 104

Mineral Composition

Sample No. 104

Chemical Composition

Sample No. 202

Mineral Composition

Sample No. 202

Chemical Composition

Sample No. 203

Mineral Composition

Sample No. 203

Chemical Composition

Sample No. 302A

Mineral Composition

Sample No. 302A

Chemical Composition

Sample No. 403A

Mineral Composition

Sample No. 403A

Chemical Composition

Sample No. 502A

Mineral Composition

Sample No. 502A

Chemical Composition

Sample No. 503

Mineral Composition

Sample No. 503

Chemical Composition

Sample No. 602A

Mineral Composition

Sample No. 602A

Chemical Composition

Sample No. 603A

Mineral Composition

Sample No. 603A

Chemical Composition

Sample No.702A

Mineral Composition

Sample No.702A

Chemical Composition

Sample No. 703A

Mineral Composition

Sample No. 703A

Chemical Composition

Sample No. 1202

Mineral Composition

Sample No. 1202

Chemical Composition

Sample No. 1203

Mineral Composition

Sample No. 1203

Chemical Composition

Sample No. 1204

Mineral Composition

Sample No. 1204

Chemical Composition

Sample No. 1204A

Mineral Composition

Sample No. 1204A

Chemical Composition

Sample No. 1205A

Mineral Composition

Sample No. 1205A

Chemical Composition

Sample No. 1302A

Mineral Composition

Sample No. 1302A

Chemical Composition

Sample No. 1304A

Mineral Composition

Sample No. 1304A

Chemical Composition

Sample No. 1305A

Mineral Composition

Sample No. 1305A

Chemical Composition

Sample No. 2002

Mineral Composition

Sample No. 2002

Chemical Composition

Sample No. 2102A

Mineral Composition

Sample No. 2102A

Chemical Composition

Sample No. 2201

Mineral Composition

Sample No. 2201

Chemical Composition

Sample No. 2201A

Mineral Composition

Sample No. 2201A

Chemical Composition

Sample No. 2302A

Mineral Composition

Sample No. 2302A

Chemical Composition

Sample No. 2303A

Mineral Composition

Sample No. 2303A

Chemical Composition

Sample No. 2304A

Mineral Composition

Sample No. 2304A

Chemical Composition

Sample No. 2402A

Mineral Composition

Sample No. 2402A

Chemical Composition

Sample No. 2403A

Mineral Composition

Sample No. 2403A

Chemical Composition

Sample No. 2404

Mineral Composition

Sample No. 2404

Chemical Composition

Sample No. 2404A

Mineral Composition

Sample No. 2404A

Chemical Composition

Sample No. 2503A

Mineral Composition

Sample No. 2503A

Chemical Composition

Sample No. 2504A

Mineral Composition

Sample No. 2504A

APPENDIX 3

SAMPLE #102

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
8.5	112.9
10.28	118.1
12.43	118.6
13.76	114.2

MOISTURE-DENSITY RELATION

SAMPLE #104

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
7.34	99.7
11.96	104
13.7	104.7
18.29	104.3

MOISTURE-DENSITY RELATION

SAMPLE #202

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
13.3	101.2
14.63	102.9
16.67	105

MOISTURE-DENSITY RELATION

SAMPLE #302A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
20.98	59.6
25.31	63
29.04	66.3
33.5	67.9

MOISTURE-DENSITY RELATION

SAMPLE #403A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
6.16	68.2
13.98	71.9
29.97	76.1
34.94	75.4

MOISTURE-DENSITY RELATION

SAMPLE #502A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
17.06	78.7
23.32	82.2
25.84	80.2

MOISTURE-DENSITY RELATION

SAMPLE #503

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
5.58	89.6
12.81	89.9
20.73	93
26.9	89.9

MOISTURE-DENSITY RELATION

SAMPLE #602A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
9.96	98.6
15.08	99.6
17.69	95.9
18.07	95.6

MOISTURE-DENSITY RELATION

SAMPLE #603A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
14.46	104.6
18.23	107.9
19.57	107.1

MOISTURE-DENSITY RELATION

SAMPLE #702A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
14.19	70.7
18.44	72
22.91	71.6
31.31	70.3

MOISTURE-DENSITY RELATION

SAMPLE #703A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
6.03	76.4
15.09	81
22.4	83.07
27.11	81.9

MOISTURE-DENSITY RELATION

SAMPLE #1202

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
14.09	94
15.96	96.8
17.95	98.3

MOISTURE-DENSITY RELATION

SAMPLE #1203

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
6.35	58.2
28.85	60.1
53.21	59.8

MOISTURE-DENSITY RELATION

SAMPLE #1204

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
5.57	99.1
10.43	102.7
17.64	101.9
22.71	95.7

MOISTURE-DENSITY RELATION

SAMPLE #1204A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
28.92	61.7
39.54	61.2
48.88	62.5
73.75	53.8

MOISTURE-DENSITY RELATION

SAMPLE #203

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
12.35	100.2
14.48	100.8
16.65	102.3
18.64	103.7
21.42	102.7

MOISTURE-DENSITY RELATION

SAMPLE #1205A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
3.36	63.8
7.36	61.3
44.24	66.3
54.84	47.9

MOISTURE-DENSITY RELATION

SAMPLE #1302A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
2.34	97.6
13.13	99.2
21.02	97.7

MOISTURE-DENSITY RELATION

SAMPLE #1304A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
10.96	63.1
20.11	66.3
38.49	70.3
54.64	63.5

SAMPLE #1305A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
14.35	49.5
27.25	55.2
53.95	58.5
65.68	57.6

MOISTURE-DENSITY RELATION

SAMPLE #2002

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
14.87	69.5
18.04	70.7
26.32	72
34.04	72
35.2	71.7

MOISTURE-DENSITY RELATION

SAMPLE #2102A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
4.81	78.2
8.77	77.9
17.67	79.2
33.09	75.2

MOISTURE-DENSITY RELATION

SAMPLE #2201

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
4.35	95.7
9.69	100.7
14.78	97.8
18.66	90

MOISTURE-DENSITY RELATION

SAMPLE #2201A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
19.37	62.6
22.7	63.4
27.45	65
31.98	66
36.46	65.6

MOISTURE-DENSITY RELATION

SAMPLE #2302A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
25.04	73.7
28.25	83.7
31.25	82.7
32.59	80.1

3 of 6

SAMPLE #2303A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
19.26	71.8
26.16	77
34.67	77.1
48.12	68.9

SAMPLE #2304A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
18.47	67.4
24.25	67.7
30.57	73.5
41.12	70.7

MOISTURE-DENSITY RELATION

SAMPLE #2402A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
12.57	94.7
18.35	100.5
19.56	101.7

MOISTURE-DENSITY RELATION

SAMPLE #2403A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
4.94	76.6
9.04	79.8
16.53	83
32.54	83.1

MOISTURE-DENSITY RELATION

SAMPLE #2404

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
51.33	40.6
71.41	46.3
109.31	32.6

MOISTURE-DENSITY RELATION

SAMPLE #2404A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
6.84	67.9
22.29	74.1
35.21	76.2
37.74	75.2

MOISTURE-DENSITY RELATION

SAMPLE #2503A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
9.73	53.7
16.78	55
31.77	59.6
42.21	62.6
53.26	59.4

MOISTURE-DENSITY RELATION

SAMPLE #2504A

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
31.43	34.4
43.52	35.7
56.46	37.3
70.97	38.1

MOISTURE-DENSITY RELATION

SAMPLE EER

MOISTURE-DENSITY RELATION

MOISTURE DENSITY (%Dry Wt.)	DRY DENSITY (lbs/cu. ft.)
3.93	112.8
4.68	117.5
6.23	115.3

MOISTURE-DENSITY RELATION

APPENDIX 4

Sample 102 - Particle Size Distribution

Sample 104 - Particle Size Distribution

Sample 202 - Particle Size Distribution

Sample 203 - Particle Size Distribution

Sample 502A - Particle Size Distribution

Sample 503 - Particle Size Distribution

Sample 602A - Particle Size Distribution

Sample 603A - Particle Size Distribution

Sample 702A - Particle Size Distribution

Sample 703A - Particle Size Distribution

Sample 1202 - Particle Size Distribution

Sample 1203 - Particle Size Distribution

Sample 1204 - Particle Size Distribution

Sample 1204A - Particle Size Distribution

Sample 1205A- Particle Size Distribution

Sample 1302A - Particle Size Distribution

Sample 1304A - Particle Size Distribution

Sample 1305A - Particle Size Distribution

Sample 2002 - Particle Size Distribution

Sample 2102A - Particle Size Distribution

Sample 2201 - Particle Size Distribution

Sample 2201A - Particle Size Distribution

Sample 2302A - Particle Size Distribution

Sample 2303A - Particle Size Distribution

Sample 2304A - Particle Size Distribution

Sample 2402A - Particle Size Distribution

Sample 2403A - Particle Size Distribution

Sample 2404 - Particle Size Distribution

Sample 2404A - Particle Size Distribution

Sample 2503A - Particle Size Distribution

Sample 2504A - Particle Size Distribution

Sample EER - Particle Size Distribution

APPENDIX 5

CALCULATED C_v VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 104

<u>LOAD (PSF)</u>	<u>C_v (SQ. IN/MIN)</u>
2000	17.8
4000	17.8
8000	7.8
16000	5.7
32000	7.7

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 203

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	7.89
4000	5.71
8000	5.6
16000	5.46
32000	5.3

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 302A

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
1000	14.1
8000	7.85
16000	9.6

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 403A

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
1000	3.5
8000	2.4
16000	3.1

CALCULATED C_v VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 502A

<u>LOAD (PSF)</u>	<u>C_v (SQ. IN/MIN)</u>
1000	9.3
8000	6.5
16000	3

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 602A

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	7.9
4000	5
8000	4.3
16000	7.5
32000	5.3

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 702A

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
1000	1.9
4000	6.2
8000	3.4
16000	7.5
32000	3.2

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 1204

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	5.1
4000	6.2
8000	4.1
16000	6.1
32000	4.8

CALCULATED C_v VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 2002

<u>LOAD (PSF)</u>	<u>C_v (SQ. IN/MIN)</u>
2000	6.3
4000	4.1
8000	6.1
16000	3.4
32000	7.4

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 2102A

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	10.3
4000	7.8
8000	6.1
16000	4.9
32000	2.8

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 2201

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	0.9
4000	1.5
8000	2.4
16000	0.9
32000	1.6

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - 2404

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	3
4000	2.5
8000	2.3

CALCULATED Cv VALUES Vs. APPLIED LOAD CURVES

SAMPLE - EER SLAG

<u>LOAD (PSF)</u>	<u>Cv (SQ. IN/MIN)</u>
2000	3.5
4000	3.5
8000	4.1
16000	4.9
32000	5.8

APPENDIX 6

Sample No. 102 - Scanning Electron Micrographs

X 50

X 500

Sample No. 104 - Scanning Electron Micrographs

X 50

X 500

Sample No. 202 - Scanning Electron Micrographs

X 50

X 500

Sample No. 203 - Scanning Electron Micrographs

X 50

X 500

Sample No. 302A - Scanning Electron Micrographs

X 50

X 500

Sample No. 403A - Scanning Electron Micrographs

X 50

X 500

Sample No. 502A - Scanning Electron Micrographs

X 50

X 500

Sample No. 503 - Scanning Electron Micrographs

X 50

X 500

Sample No. 602A - Scanning Electron Micrographs

X 50

X 500

Sample No. 603A - Scanning Electron Micrographs

X 50

X 500

Sample No. 702A - Scanning Electron Micrographs

X 50

X 500

Sample No. 703A - Scanning Electron Micrographs

X 50

X 500

Sample No. 1202 - Scanning Electron Micrographs

X 50

X 500

Sample No. 1204 - Scanning Electron Micrographs

X 50

X 500

Sample No. 1204A - Scanning Electron Micrographs

X 50

X 500

Sample No. 1205A - Scanning Electron Micrographs

X 50

X 500

Sample No. 1302A - Scanning Electron Micrographs

X 50

X 500

Sample No. 1304A - Scanning Electron Micrographs

X 50

X 500

Sample No. 1305A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2102A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2201 - Scanning Electron Micrographs

X 50

X 500

Sample No. 2201A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2302A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2303A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2304A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2402A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2403A - Scanning Electron Micrographs

X 50

X 500

Sample No. 2404 - Scanning Electron Micrographs

X 50

X 500

Sample No. EER - Scanning Electron Micrographs

X 50

X 500

APPENDIX 7

REQUESTOR

Ed Olson

PROJ. #

5420

SAMPLE INFO

UFDA Waste Ash Samples

DATE SUBMITTED

4-20-90

SAMPLE ID.

EER SLAG	102	104	202	203	302A	403A
	90-571	90-572	90-573	90-574	90-575	90-576
1	2	3	4	5	6	7

LAB #

39840	39603	39604	39605	39606	39607	39608
-------	-------	-------	-------	-------	-------	-------

PARAMETER

OXIDES

[illegible]

DATE REPORTED 1-15-90
REPORTED BY E. H. HARRIS
DISTRIBUTION 11-19-90

ANALYSIS REPORT FORM

REQUESTOR

Ed Olson

PROJ. #

5420

SAMPLE INFO

UFDA Waste Ash Samples

DATE SUBMITTED

4-20-90

SAMPLE ID.

502A	503	602A	603A	702A	703A	1202
90-577	90-578	90-579	90-580	90-581	90-582	90-583

1	2	3	4	5	6	7
39609	39610	39611	39612	39613	39614	39615

PARAMETER

OXIDES

%

Si

55.1

20.8

45.1

35.2

60.8

56.7

35.6

Al

18.8

6.1

13.8

12.1

17.8

20.0

13.7

Fe

21.2

9.1

8.3

4.7

3.7

4.7

25.5

Ca

4.0

25.3

15.3

20.0

11.3

11.2

2.9

Mg

1.1

0.7

6.1

6.0

3.0

2.2

0.8

Na

0.8

0.3

5.2

6.3

2.7

4.0

0.3

K

2.3

1.1

1.0

1.0

0.8

0.9

1.3

P

0.17

0.04

0.21

0.25

0.12

0.26

0.22

Ti

0.83

0.31

0.61

0.50

0.79

1.03

0.65

Sulfate

0.2

10.2

0.6

7.1

0.3

0.9

1.7

Sulfide

<0.1

1.2

1.0

2.0

<0.1

0.2

Chloride

26

340

17

460

41

39

300

DATE REPORTED 11-15-98REPORTED BY D. HARRISDISTRIBUTION 11-19-98

8376

ANALYSIS REPORT FORM

Ed Olson

5420

UFDA Waste Ash Samples

4-20-90

1204	1204A	1205A	1302A	1304A	1305A	2102A
90-584	90-585	90-586	90-587	90-588	90-589	90-590

39616	39617	39618	39619	39620	39621	39622
39616	39617	39618	39619	39620	39621	39622

OXIDES

[illegible]

72339	7039	763
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1048	92%	78.9
------	-----	------

DATE REPORTED

REPORTED BY: S. H. K. A. T. A.

DISTRIBUTION 11-19-96 c

REQUESTOR

Ed Olson

PROJ.

5420

SAMPLE INFO

UFDA Waste Ash Samples

DATE SUBMITTED

4-20-90

SAMPLE ID.

2201	2201A	2302A	2303A	2304A	2402A	2403A
90-591	90-592	90-593	90-594	90-595	90-596	90-597
1	2	3	4	5	6	7

LAB

39623	39624	39625	39626	39627	39628	39629
-------	-------	-------	-------	-------	-------	-------

PARAMETER

OXIDES

Si	79.7	40.4	1.5	3.4	16.0	6.0	12.5
Al	5.7	17.6	0.6	1.6	6.6	1.1	4.2
Fe	1.1	16.2	0.5	0.8	4.8	1.0	6.2
Ca	2.3	7.0	69.4	63.5	32.7	50.0	45.9
Mg	0.7	1.0	0.8	0.8	0.8	0.7	0.8
Na	0.9	0.7	0.0	0.0	0.1	0.1	0.1
K	2.4	1.2	0.1	0.1	0.8	0.1	0.4
P	0.03	0.55	0.01	<0.01	0.04	0.07	0.02
Ti	0.19	0.68	0.02	0.02	0.31	0.06	0.23
Sulfate	0.2	0.2	7.8	11.6	10.5	7.9	5.3
Sulfide	0.2	4.0	3.6	3.2	0.7	10.5	7.4
Chloride	**	13	23	16	40	30	52

** Insufficient sample size.

DATE REPORTED 11-19-90

REPORTED BY E. Hansen

DISTRIBUTION 11-19-90 el

ANALYSIS REPORT FORM

REQUESTOR

Ed Olson

PROJ. #

5420

SAMPLE INFO

UFDA Waste Ash Samples

DATE SUBMITTED

4-20-90

SAMPLE ID.

2404	2404A	2504A	2503A	12032	20022
90-598	90-599	90-600	90-601	90-602	90-603

1	2	3	4	5	6	7
39630	39631	39632	39633	39634	39635	

PARAMETER

OXIDES

%

Si

39.5

19.9

24.6

27.7

5.2

39.6

%

Al

20.5

6.2

7.0

7.0

2.0

15.4

%

Fe

11.8

8.3

1.0

0.9

3.0

14.2

%

Ca

0.7

33.2

14.7

32.3

45.7

5.3

%

Mg

0.7

0.8

0.3

0.5

0.5

1.0

%

Na

1.2

0.2

0.5

0.5

0.1

0.6

%

K

1.6

0.8

0.2

0.2

0.2

1.6

%

P

0.12

<0.01

0.23

0.14

0.02

0.25

%

Ti

0.87

0.30

0.27

0.21

0.06

0.06

%

Sulfate

0.5

7.7

2.8

4.4

4.1

0.9

%

Sulfide

0.3

3.4

0.4

0.5

4.7

1.5

%

Chloride

16

460

38

37

470

17

DATE REPORTED

11-15-90

REPORTED BY

Ed Olson

DISTRIBUTION

11-19-90

APPENDIX 8

102 2633 90-0571 54201230

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.8
% GEHLENITE	=	.8
% ANORTHITE	=	.8
% ALBITE	=	2.1
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.4
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	1.2
% IRON OXIDE	=	.4
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.8
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.4

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	1.2
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.8
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	87.7
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	1.2
% ILLITE (AMORP)	=	.8
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.4
-------------------	---	----

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O		K2O	SO3	BAO	MN2O7	CLO
BULK	34.3	12.0	8.3	.8	.0	20.3	5.1	5.2	2.0	10.4	.8	.3	.5	
AMORP.	38.3	13.8	9.3	1.0	.0	22.4	5.7	6.0	2.3	.0	.9	.3	.0	

1.2 1.7 .3 15.6 4.7 5 1.9 .7 .3

5.5
C03

104 2634 90-0572 54201231

TOTAL NUMBER OF POINTS = 243.0
 SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.8
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	7.4
% IRON OXIDE	=	.0
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	91.8
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.0
% ILLITE (AMORP)	=	.0
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O		K2O	SO3	BAO	MN2O7	CLO
BULK	45.7	13.5	11.9	.8	.0	19.0	5.0	2.0	1.3	.1	.4	.2	.1	
AMORP.	44.1	14.3	12.6	.9	.0	18.9	5.3	2.1	1.3	.0	.4	.2	.0	

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	4.9
% ANORTHITE	=	3.7
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.4
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	16.5
% IRON OXIDE	=	1.2
% CALCIUM OXIDE	=	4.5
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
. DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	43.6
% PURE KAOLINITE (AMORP)	=	13.6
% KAOLINITE DERIVED	=	10.3
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
-----------	---	----

CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
-------------------	---	----

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O		K2O	SO3	BAO	MN2O7	CLO
BULK	54.7	21.6	3.3	.9	.2	12.4	3.0	.5	.9	1.2	.4	.3	.7	
AMORP.	49.2	29.1	2.4	1.0	.2	11.9	3.6	.7	1.2	.0	.4	.2	.0	

203 2636 90-0574 54201233

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.4
% ANORTHITE	=	7.4
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	13.2
% IRON OXIDE	=	13.6
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	11.1
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	44.9
% PURE KAOLINITE (AMORP)	=	1.2
% KAOLINITE DERIVED	=	6.2
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
CALCIUM DERIVED POINTS		
% CALCIUM DERIVED	=	.8

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O		K2O	SO3	BAO	MN2O7	CLO
BULK	44.0	11.6	20.4	.7	.1	11.9	1.6	.3	.6	8.1	.4	.2	.1	
AMORP.	54.9	19.6	9.1	1.1	.2	9.8	2.8	.4	1.1	.0	.6	.3	.0	

302A 2637 90-0575 54201234

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	1.2
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	2.1
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	6.6
% IRON OXIDE	=	4.1
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.4
DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	50.2
% PURE KAOLINITE (AMORP)	=	17.3
% KAOLINITE DERIVED	=	16.9
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
-----------	---	----

CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
-------------------	---	----

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O		K2O	SO3	BAO	MN2O7	CLO
BULK	50.0	31.3	10.7	2.3	.0	3.0	.8	.5	.5	.3	.3	.1	.1	
AMORP.	50.8	34.4	7.7	2.1	.0	2.5	.8	.6	.6	.0	.3	.1	.0	

403A 2638 90-0576 54201235

TOTAL NUMBER OF POINTS = 158.0

SILICATE AND OTHER CRYSTALLINE PHASES

% AKERMANITE	=	.0
% GEHLENITE	=	1.3
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	12.0
% IRON OXIDE	=	2.5
% CALCIUM OXIDE	=	1.9
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	55.7
% PURE KAOLINITE (AMORP)	=	8.2
% KAOLINITE DERIVED	=	10.8
% ILLITE (AMORP)	=	7.6
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	55.9	23.4	9.4	1.1	.2	4.0	1.1	.5	3.1	.5	.2	.2	.5
AMORP.	53.6	28.2	9.0	1.3	.2	1.7	1.3	.6	3.7	.0	.2	.2	.0

502A 2639 90-577 54201236

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE = .0
 % GEHLENITE = .4
 % ANORTHITE = 3.3
 % ALBITE = .0
 % NEPHELINE = .0
 % LEUCITE = .0
 % POTASSIUM FELDSPAR = .0
 % PYROXENE = .0
 % MULLITE = .0
 % MERWINITE = .0
 % CALCIUM SILICATE = .0
 % (CA,MG,FE)SIO3 = .0
 % DICALCIUM SILICATE = .0
 % SPURRITE = .0
 % NA2CASIO4 = .0
 % HAUYNE = .0
 % CALCIUM ALUMINATE = .0
 % SPINEL = .0
 % CALCIUM TITANATE = .0

OXIDE OR CARBONATE PHASES

% QUARTZ = 11.1
 % IRON OXIDE = 7.0
 % CALCIUM OXIDE = 1.6
 % MAGNESIUM OXIDE = .0
 % ANKERITE (CA,MG,FE)CO3 = .0
 % ALUMINUM OXIDE = .0
 % RUTILE = .0
 % DOLOMITE = .0

SULFATE AND SULFIDE PHASES

% BARITE = .0
 % ANHYDRITE = .0
 % SULFATED DOLOMITE = .0
 % SULFATED ANKERITE = .0
 % SODIUM SULFATE = .0
 % SODIUM CALCIUM SULFATE = .0
 % FERRIC SULFATE = .0
 % PYRRHOTITE = .0
 % PYRITE = .0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED = 45.7
 % PURE KAOLINITE (AMORP) = 4.1
 % KAOLINITE DERIVED = 2.9
 % ILLITE (AMORP) = 8.2
 % MONTMORILLONITE (AMORP) = 15.6

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE = .0
 CALCIUM DERIVED POINTS
 % CALCIUM DERIVED = .0

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	55.1	17.7	16.0	.7	.1	5.7	.9	.6	2.4	.3	.1	.2	.1
AMORP.	55.5	21.8	10.2	.9	.1	6.4	1.1	.7	3.0	.0	.1	.1	.0

503

2640 90-0578 54201237

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE = .0
 % GEHLENITE = 1.2
 % ANORTHITE = .4
 % ALBITE = .0
 % NEPHELINE = .0
 % LEUCITE = .0
 % POTASSIUM FELDSPAR = .0
 % PYROXENE = .0
 % MULLITE = .0
 % MERWINITE = .0
 % CALCIUM SILICATE = .4
 % (CA,MG,FE)SIO3 = .0
 % DICALCIUM SILICATE = .4
 % SPURRITE = .0
 % NA2CASIO4 = .0
 % HAUYNE = .0
 % CALCIUM ALUMINATE = .0
 % SPINEL = .0
 % CALCIUM TITANATE = .0

OXIDE OR CARBONATE PHASES

% QUARTZ = 6.6
 % IRON OXIDE = .4
 % CALCIUM OXIDE = 28.4
 % MAGNESIUM OXIDE = .0
 % ANKERITE (CA,MG,FE)CO3 = .0
 % ALUMINUM OXIDE = .0
 % RUTILE = .0
 % DOLOMITE = .0

SULFATE AND SULFIDE PHASES

% BARITE = .0
 % ANHYDRITE = 7.4
 % SULFATED DOLOMITE = .0
 % SULFATED ANKERITE = .0
 % SODIUM SULFATE = .0
 % SODIUM CALCIUM SULFATE = .0
 % FERRIC SULFATE = .0
 % PYRRHOTITE = .0
 % PYRITE = .0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED = 50.6
 % PURE KAOLINITE (AMORP) = .0
 % KAOLINITE DERIVED = .0
 % ILLITE (AMORP) = 1.2
 % MONTMORILLONITE (AMORP) = 2.9

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE = .0

CALCIUM DERIVED POINTS

% CALCIUM DERIVED = .0

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	37.2	8.0	11.0	.6	.1	32.5	.7	.6	1.5	7.4	.1	.2	.2
AMORP.	48.9	13.1	17.9	.8	.1	14.6	1.1	.8	2.4	.0	.1	.3	.0

602A 2641 90-0579 54201238

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0	
% GEHLENITE	=	12.8	34.1
% ANORTHITE	=	1.6	4.3
% ALBITE	=	3.7	10%
% NEPHELINE	=	.0	
% LEUCITE	=	.0	
% POTASSIUM FELDSPAR	=	.0	
% PYROXENE	=	7.4	19.7
% MULLITE	=	.0	
% MERWINITE	=	.0	
% CALCIUM SILICATE	=	.8	2.1
% (CA,MG,FE)SIO3	=	.0	
% DICALCIUM SILICATE	=	.0	
% SPURRITE	=	.0	
% NA2CASIO4	=	.0	
% HAUYNE	=	.4	1.1
% CALCIUM ALUMINATE	=	.0	
% SPINEL	=	.0	
% CALCIUM TITANATE	=	.0	

OXIDE OR CARBONATE PHASES

% QUARTZ	=	7.8	20.8
% IRON OXIDE	=	1.2	3.2
% CALCIUM OXIDE	=	1.6	4.3
% MAGNESIUM OXIDE	=	.0	
% ANKERITE (CA,MG,FE)CO3	=	.0	
% ALUMINUM OXIDE	=	.0	
RUTILE	=	.0	
DOLOMITE	=	.0	

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	51.4
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.4
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	9.5

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	49.6	12.6	6.5	.8	.1	18.4	4.5	3.7	1.2	1.1	1.1	.1	.1
AMORP.	49.2	14.9	6.2	.9	.1	16.1	4.7	4.8	1.6	.0	1.4	.1	.0

603A 2642 90-0580 54201239

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.8	4.2
% GEHLENITE	=	2.5	13.2
% ANORTHITE	=	1.2	6.3
% ALBITE	=	2.9	15.2
% NEPHELINE	=	.0	
% LEUCITE	=	.0	
% POTASSIUM FELDSPAR	=	.0	
% PYROXENE	=	.8	4.2
% MULLITE	=	.0	
% MERWINITE	=	.0	
% CALCIUM SILICATE	=	.0	
% (CA,MG,FE) SIO3	=	.0	
% DICALCIUM SILICATE	=	.0	
% SPURRITE	=	.0	
% NA2CASIO4	=	.0	
% HAUYNE	=	.0	
% CALCIUM ALUMINATE	=	.0	
% SPINEL	=	.0	
% CALCIUM TITANATE	=	.0	

OXIDE OR CARBONATE PHASES

% QUARTZ	=	2.5	13.1
% IRON OXIDE	=	.0	
% CALCIUM OXIDE	=	.4	2.1
% MAGNESIUM OXIDE	=	.0	
% ANKERITE (CA,MG,FE) CO3	=	.0	
% ALUMINUM OXIDE	=	.0	
RUTILE	=	.0	
DOLOMITE	=	.4	2.1

SULFATE AND SULFIDE PHASES

% BARITE	=	.0	
% ANHYDRITE	=	7.4	39
% SULFATED DOLOMITE	=	.0	
% SULFATED ANKERITE	=	.0	
% SODIUM SULFATE	=	.0	
% SODIUM CALCIUM SULFATE	=	.0	
% FERRIC SULFATE	=	.0	
% PYRRHOTITE	=	.0	
% PYRITE	=	.0	

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	76.5	
% PURE KAOLINITE (AMORP)	=	.0	
% KAOLINITE DERIVED	=	.8	
% ILLITE (AMORP)	=	.4	
% MONTMORILLONITE (AMORP)	=	2.9	

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0	
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.4	
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	35.0	10.5	3.7	.6	.1	23.3	4.3	4.4	1.1	15.3	.7	.3	.5
AMORP.	41.0	12.8	4.8	.8	.1	27.1	5.2	5.6	1.3	.0	.8	.4	.0

702A 2643 90-0581 54201240

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	2.1
% ANORTHITE	=	18.9
% ALBITE	=	2.9
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	2.1
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	21.0
% IRON OXIDE	=	.0
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.4
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.4
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	27.6
% PURE KAOLINITE (AMORP)	=	8.2
% KAOLINITE DERIVED	=	4.1
% ILLITE (AMORP)	=	.0
% MONTMORILLONITE (AMORP)	=	12.3

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	62.9	16.7	4.6	.9	.1	10.1	1.4	2.1	.6	.4	.1	.1	.1
AMORP.	56.8	21.6	5.2	1.1	.0	10.2	1.5	2.5	.9	.0	.1	.1	.0

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	1.6
% ANORTHITE	=	6.6
% ALBITE	=	1.2
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.4
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.8
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	14.0
% IRON OXIDE	=	.4
% CALCIUM OXIDE	=	4.1
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	2.1
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	48.6
% PURE KAOLINITE (AMORP)	=	5.8
% KAOLINITE DERIVED	=	8.2
% ILLITE (AMORP)	=	1.6
% MONTMORILLONITE (AMORP)	=	4.5

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	57.3	18.9	4.5	1.2	.2	12.0	1.3	2.5	1.1	.7	.1	.1	.2
AMORP.	55.4	24.5	3.6	1.4	.1	8.7	1.4	3.2	1.5	.0	.1	.1	.0

1202 2645 90-0583 54201242

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	.4
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	4.1
% IRON OXIDE	=	30.9
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.4
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	1.2
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	60.5
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.8
% ILLITE (AMORP)	=	.4
% MONTMORILLONITE (AMORP)	=	1.2

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	32.1	10.9	46.2	.7	.2	3.6	.6	.3	1.5	3.1	.1	.3	.3
AMORP.	47.6	18.6	24.3	1.2	.2	3.8	1.0	.4	2.4	.0	.1	.2	.0

1203 2664 90-0602 54201261 8/6/90

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.4
% ANORTHITE	=	.4
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	1.6
% IRON OXIDE	=	4.5
% CALCIUM OXIDE	=	63.8
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	15.6
% PURE KAOLINITE (AMORP)	=	2.5
% KAOLINITE DERIVED	=	.0
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	9.9
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	7.9	2.8	5.6	.5	.1	63.4	.2	.1	.4	18.5	.0	.2	.2
AMORP.	49.0	22.7	3.8	.8	.0	18.5	.9	.5	3.3	.0	.3	.3	.0

MORETT 1204 2646 90-0584 54201243

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	2.5
% IRON OXIDE	=	15.6
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	73.7
% PURE KAOLINITE (AMORP)	=	.4
% KAOLINITE DERIVED	=	1.2
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	5.3

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	42.6	16.0	32.7	1.0	.1	3.0	.7	.3	2.1	.9	.1	.2	.2
AMORP.	49.7	19.9	21.9	1.3	.1	3.1	.9	.4	2.6	.0	.1	.2	.0

1204A 2647 90-0585 54201244

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	.8
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	7.0
% IRON OXIDE	=	2.9
% CALCIUM OXIDE	=	31.7
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	39.5
% PURE KAOLINITE (AMORP)	=	2.9
% KAOLINITE DERIVED	=	1.2
% ILLITE (AMORP)	=	1.2
% MONTMORILLONITE (AMORP)	=	2.1

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	10.7
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	22.9	6.5	5.4	.6	.1	46.3	.4	.4	.9	15.8	.1	.2	.6
AMORP.	49.1	21.3	6.3	1.4	.1	16.9	1.0	.9	2.6	.0	.2	.2	.0

1205A 2648 90-0586 54201245

TOTAL NUMBER OF POINTS = 255.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
GEHLENITE	=	.8
% ANORTHITE	=	.4
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	7.8
% IRON OXIDE	=	2.7
% CALCIUM OXIDE	=	39.2
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	1.6
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	27.5
% PURE KAOLINITE (AMORP)	=	1.2
% KAOLINITE DERIVED	=	.4
% ILLITE (AMORP)	=	2.0
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	16.5
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	15.7	2.8	4.0	.5	.0	54.4	.3	.2	.4	21.3	.0	.2	.4
AMORP.	47.3	16.5	2.2	.7	.0	29.3	.7	.8	2.0	.0	.1	.3	.0

1302A 2649 90-0587 54201246

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
GEHLENITE	=	.8
% ANORTHITE	=	.8
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	6.2
% IRON OXIDE	=	.8
% CALCIUM OXIDE	=	22.2
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	3.3
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	34.6
% PURE KAOLINITE (AMORP)	=	.4
% KAOLINITE DERIVED	=	1.2
% ILLITE (AMORP)	=	20.6
% MONTMORILLONITE (AMORP)	=	.8

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	8.2
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	36.7	15.0	4.7	.8	.0	28.0	1.0	.2	2.9	10.5	.1	.1	.1
AMORP.	49.4	23.8	6.4	1.1	.0	12.8	1.4	.2	4.6	.0	.1	.1	.0

1304A 2650 90-0588 54201247

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	1.2
% ANORTHITE	=	.8
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.4
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUZYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	7.0
% IRON OXIDE	=	1.6
% CALCIUM OXIDE	=	7.4
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	2.5
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	42.8
% PURE KAOLINITE (AMORP)	=	2.5
% KAOLINITE DERIVED	=	4.5
% ILLITE (AMORP)	=	24.3
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	4.9
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	41.8	18.8	5.6	.9	.1	18.7	1.3	.2	3.1	9.0	.1	.2	.4
AMORP.	49.1	26.5	5.0	1.1	.1	11.5	1.7	.3	4.4	.0	.1	.2	.0

1305A 2651 90-0589 54201248

TOTAL NUMBER OF POINTS = 243.0
 SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.8
% ANORTHITE	=	.8
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	2.1
% IRON OXIDE	=	1.2
% CALCIUM OXIDE	=	4.1
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	2.5
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	65.0
% PURE KAOLINITE (AMORP)	=	4.5
% KAOLINITE DERIVED	=	3.7
% ILLITE (AMORP)	=	14.8
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.4
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	41.4	22.4	7.5	1.1	.1	14.9	1.4	.3	2.8	6.7	.1	.2	1.1
AMORP.	47.5	27.2	7.3	1.2	.1	11.2	1.4	.3	3.5	.0	.2	.2	.0

2002 2665 90-0603 54201262 8-8-90

TOTAL NUMBER OF POINTS = 225.0

SILICATE AND OTHER CRYSTALLINE PHASES

% AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	11.6
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	3.6
% IRON OXIDE	=	2.7
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
ANKERITE (CA,MG,FE) CO3	=	.0
ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.4
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	70.7
% PURE KAOLINITE (AMORP)	=	.4
% KAOLINITE DERIVED	=	.9
% ILLITE (AMORP)	=	3.1
% MONTMORILLONITE (AMORP)	=	6.2

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.4
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
JLK	51.8	16.5	15.7	1.0	.2	7.3	.9	.5	2.5	3.1	.1	.2	.2
AMORP.	55.5	16.8	17.2	1.4	.3	3.5	1.0	.5	3.3	.0	.1	.3	.0

2102A 2652 90-0590 54201249

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	9.1
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.8
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	6.6
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	.4
% IRON OXIDE	=	.4
% CALCIUM OXIDE	=	7.8
% MAGNESIUM OXIDE	=	.4
% ANKERITE (CA,MG,FE)CO3	=	2.5
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
• DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	30.9
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	36.2
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.0
% ILLITE (AMORP)	=	.8
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	4.1
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	11.8	3.0	4.7	.4	.0	45.6	2.8	.1	.2	31.1	.0	.1	.1
AMORP.	22.6	5.4	10.4	.7	.0	54.0	5.9	.1	.6	.0	.0	.1	.0

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2201 2653 90-0591 54201250

TOTAL NUMBER OF POINTS = 243.0
 SILICATE AND OTHER CRYSTALLINE PHASES

% AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	4.5
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.4
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	53.9
% IRON OXIDE	=	.4
% CALCIUM OXIDE	=	2.1
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.4
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	33.7
% PURE KAOLINITE (AMORP)	=	.4
% KAOLINITE DERIVED	=	.4
% ILLITE (AMORP)	=	3.7
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	84.3	6.3	1.4	.1	.0	2.2	.4	.6	3.6	.6	.1	.1	.1
AMORP.	64.8	17.8	2.5	.4	.0	2.5	.6	2.0	9.0	.0	.2	.2	.0

2201A 2654 90-0592 54201251

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

. AKERMANITE = .0
% GEHLENITE = .8
% ANORTHITE = 11.1
% ALBITE = .0
% NEPHELINE = .0
% LEUCITE = .0
% POTASSIUM FELDSPAR = .0
% PYROXENE = .4
% MULLITE = .0
% MERWINITE = .0
% CALCIUM SILICATE = .0
% (CA,MG,FE) SIO3 = .0
% DICALCIUM SILICATE = .0
% SPURRITE = .0
% NA2CASIO4 = .0
% HAUYNE = .0
% CALCIUM ALUMINATE = .0
% SPINEL = .0
% CALCIUM TITANATE = .0

OXIDE OR CARBONATE PHASES

% QUARTZ = 7.4
% IRON OXIDE = 2.1
% CALCIUM OXIDE = .8
% MAGNESIUM OXIDE = .0
% ANKERITE (CA,MG,FE) CO3 = .0
% ALUMINUM OXIDE = .0
% RUTILE = .0
% DOLOMITE = .0

SULFATE AND SULFIDE PHASES

% BARITE = .0
% ANHYDRITE = .4
% SULFATED DOLOMITE = .0
% SULFATED ANKERITE = .0
% SODIUM SULFATE = .0
% SODIUM CALCIUM SULFATE = .0
% FERRIC SULFATE = .0
% PYRRHOTITE = 3.3
% PYRITE = .0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED = 60.9
% PURE KAOLINITE (AMORP) = 1.2
% KAOLINITE DERIVED = .8
% ILLITE (AMORP) = 4.9
% MONTMORILLONITE (AMORP) = 4.5

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE = .0

CALCIUM DERIVED POINTS

% CALCIUM DERIVED = 1.2

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	44.9	16.4	17.6	1.2	.5	9.7	.8	.5	1.7	6.3	.1	.2	.1
AMORP.	47.9	18.9	19.2	1.6	1.1	7.4	.9	.5	2.3	.0	.1	.2	.0

2302A 2655 90-0593 54201252 8\6\90

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.8
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	.0
% IRON OXIDE	=	.0
% CALCIUM OXIDE	=	86.8
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	4.9
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.0
% ILLITE (AMORP)	=	.0
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	7.4
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	1.2	.4	.4	.5	.1	82.9	.5	.1	.1	13.6	.0	.1	.2
AMORP.	17.8	7.6	9.3	1.2	.1	61.4	1.0	.2	.8	.0	.2	.3	.0

2303A 2656 90-0594 54201253 8\6\90

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	.0
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	.4
% IRON OXIDE	=	.4
% CALCIUM OXIDE	=	83.1
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	8.6
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.4
% ILLITE (AMORP)	=	.8
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	6.2
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	2.5	.8	.7	.5	.1	75.2	.6	.1	.1	19.0	.0	.2	.2
AMORP.	55.6	21.5	4.1	.7	.1	13.1	.8	.3	3.1	.0	.1	.6	.0

mouth

2304A 2657-90-0595 54201254

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

% AKERMANITE	=	.0
% GEHLENITE	=	2.9
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.4
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	3.7
% IRON OXIDE	=	2.5
% CALCIUM OXIDE	=	28.8
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO3	=	.4
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	46.9
% PURE KAOLINITE (AMORP)	=	2.1
% KAOLINITE DERIVED	=	2.5
% ILLITE (AMORP)	=	4.1
% MONTMORILLONITE (AMORP)	=	.8

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	4.9
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	25.5	8.7	5.8	.6	.1	43.4	.6	.2	1.6	12.2	.1	.2	.9
AMORP.	49.6	22.6	4.4	.9	.1	16.5	.9	.3	4.3	.0	.1	.3	.0

2402A 2658 90-0596 54201255

TOTAL NUMBER OF POINTS = 243.0
SILICATE AND OTHER CRYSTALLINE PHASES

% AKERMANITE	=	.0
% GEHLENITE	=	.4
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.4
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	1.6
% IRON OXIDE	=	.4
% CALCIUM OXIDE	=	44.9
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	4.5
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	9.5
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.0
% ILLITE (AMORP)	=	.0
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	38.3
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	4.0	.6	.8	.4	.0	58.7	.4	.1	.2	34.3	.0	.3	.1
AMORP.	31.8	9.3	2.7	1.3	.1	49.6	.6	.4	4.0	.0	.1	.1	.0

2403A 2659 90-0597 5420156 8/6/90

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
% GEHLENITE	=	2.9
% ANORTHITE	=	.4
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.4
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	4.5
% IRON OXIDE	=	5.3
% CALCIUM OXIDE	=	28.8
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.4
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	23.5
% PURE KAOLINITE (AMORP)	=	.4
% KAOLINITE DERIVED	=	2.1
% ILLITE (AMORP)	=	1.6
% MONTMORILLONITE (AMORP)	=	.4

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	29.2
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	12.9	3.3	7.4	.5	.0	49.3	.5	.2	.5	24.7	.0	.3	.4
AMORP.	38.5	16.6	8.5	1.1	.1	30.8	1.4	.5	2.4	.0	.1	.1	.0

2404 2660 90-0598 54201257 8/6/90

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
GEHLENITE	=	.0
% ANORTHITE	=	.0
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	5.3
% IRON OXIDE	=	1.6
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	73.7
% PURE KAOLINITE (AMORP)	=	5.8
% KAOLINITE DERIVED	=	5.8
% ILLITE (AMORP)	=	7.8
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	54.7	24.5	11.7	.9	.1	1.2	.6	.9	2.5	1.7	.2	.2	.8
AMORP.	54.3	28.3	9.7	1.0	.2	1.5	.7	1.0	2.9	.0	.2	.3	.0

2404A 2661 90-0599 54201258 8/6/90

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0
GEHLENITE	=	1.6
% ANORTHITE	=	.4
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.4
% (CA,MG,FE)SIO3	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% NA2CASIO4	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	11.5
% IRON OXIDE	=	2.9
% CALCIUM OXIDE	=	26.3
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE)CO3	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	41.6
% PURE KAOLINITE (AMORP)	=	1.6
% KAOLINITE DERIVED	=	1.2
% ILLITE (AMORP)	=	3.7
% MONTMORILLONITE (AMORP)	=	.8

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	7.8
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	25.3	6.3	5.8	.6	.1	42.2	.6	.3	1.1	16.9	.3	.2	.4
AMORP.	47.2	20.5	6.7	.9	.1	17.2	1.8	.7	3.7	.0	1.0	.2	.0

2503A 2663 90-0601 54201260 8/6/90

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE	=	.0	
% GEHLENITE	=	.8	1.1
% ANORTHITE	=	.8	1.1
% ALBITE	=	.0	
% NEPHELINE	=	.0	
% LEUCITE	=	.0	
% POTASSIUM FELDSPAR	=	.0	
% PYROXENE	=	.0	
% MULLITE	=	.0	
% MERWINITE	=	.0	
% CALCIUM SILICATE	=	.0	
% (CA,MG,FE) SIO3	=	.0	
% DICALCIUM SILICATE	=	.0	
% SPURRITE	=	.0	
% NA2CASIO4	=	.0	
% HAUYNE	=	.0	
% CALCIUM ALUMINATE	=	.0	
% SPINEL	=	.0	
% CALCIUM TITANATE	=	.0	

OXIDE OR CARBONATE PHASES

% QUARTZ	=	11.9	17
% IRON OXIDE	=	1.2	1.7
% CALCIUM OXIDE	=	55.6	79.5
% MAGNESIUM OXIDE	=	.0	
% ANKERITE (CA,MG,FE) CO3	=	.0	
% ALUMINUM OXIDE	=	.0	
% RUTILE	=	.0	
% DOLOMITE	=	.0	

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	16.0
% PURE KAOLINITE (AMORP)	=	9.5
% KAOLINITE DERIVED	=	.8
% ILLITE (AMORP)	=	1.6
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	1.6
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CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	29.5	8.2	1.9	.6	.2	50.7	.5	.3	.3	7.4	.0	.1	.2
AMORP.	54.2	31.4	.8	1.1	.4	8.7	1.2	.9	1.0	.0	.1	.2	.0

2504A 2662 90-0600 54201259 8/6/90

TOTAL NUMBER OF POINTS = 219.0

SILICATE AND OTHER CRYSTALLINE PHASES

AKERMANITE = .0
GEHLENITE = 3.2 2.1
% ANORTHITE = .0
% ALBITE = .5 .3
% NEPHELINE = .0
% LEUCITE = .0
% POTASSIUM FELDSPAR = .0
% PYROXENE = .0
% MULLITE = .0
% MERWINITE = .0
% CALCIUM SILICATE = .5 .3
% (CA,MG,FE)SIO3 = .0
% DICALCIUM SILICATE = .5 .3
% SPURRITE = .5 .3
% NA2CASIO4 = .0
% HAUYNE = .0
% CALCIUM ALUMINATE = .0
% SPINEL = .0
% CALCIUM TITANATE = .0

OXIDE OR CARBONATE PHASES

% QUARTZ = 16.9 11.3
% IRON OXIDE = .5 .3
% CALCIUM OXIDE = 31.1 20.8
% MAGNESIUM OXIDE = .0
% ANKERITE (CA,MG,FE)CO3 = .5 .3
% ALUMINUM OXIDE = .0
% RUTILE = .0
% DOLOMITE = .0

SULFATE AND SULFIDE PHASES

% BARITE = .0
% ANHYDRITE = .0
% SULFATED DOLOMITE = .0
% SULFATED ANKERITE = .0
% SODIUM SULFATE = .0
% SODIUM CALCIUM SULFATE = .0
% FERRIC SULFATE = .0
% PYRRHOTITE = .0
% PYRITE = .0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED = 33.8
% PURE KAOLINITE (AMORP) = 8.7
% KAOLINITE DERIVED = .9
% ILLITE (AMORP) = 1.8
% MONTMORILLONITE (AMORP) = .9

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE = .0
CALCIUM DERIVED POINTS
% CALCIUM DERIVED = .0

CHEMICAL COMPOSITION WT %

	SIO2	AL2O3	FE2O3	TIO2	P2O5	CAO	MGO	NA2O	K2O	SO3	BAO	MN2O7	CLO
BULK	46.9	10.7	1.8	.7	.3	33.3	.6	.5	.4	3.8	.1	.2	.7
AMORP.	52.7	27.3	1.8	1.3	.2	13.1	1.1	1.0	1.1	.0	.2	.3	.0

Mineral Point Count

EER 2632 90-0570 54201229

TOTAL NUMBER OF POINTS = 243.0

SILICATE AND OTHER CRYSTALLINE PHASES

% AKERMANITE	=	.0
% GEHLENITE	=	10.3
% ANORTHITE	=	1.2
% ALBITE	=	.0
% NEPHELINE	=	.0
% LEUCITE	=	.0
% POTASSIUM FELDSPAR	=	.0
% PYROXENE	=	.0
% MULLITE	=	.0
% MERWINITE	=	.0
% CALCIUM SILICATE	=	.0
% (CA,MG,FE) SiO ₃	=	.0
% DICALCIUM SILICATE	=	.0
% SPURRITE	=	.0
% Na ₂ CASiO ₄	=	.0
% HAUYNE	=	.0
% CALCIUM ALUMINATE	=	.0
% SPINEL	=	.0
% CALCIUM TITANATE	=	.0

OXIDE OR CARBONATE PHASES

% QUARTZ	=	4.9
% IRON OXIDE	=	.0
% CALCIUM OXIDE	=	.0
% MAGNESIUM OXIDE	=	.0
% ANKERITE (CA,MG,FE) CO ₃	=	.0
% ALUMINUM OXIDE	=	.0
% RUTILE	=	.0
% DOLOMITE	=	.0

SULFATE AND SULFIDE PHASES

% BARITE	=	.0
% ANHYDRITE	=	.0
% SULFATED DOLOMITE	=	.0
% SULFATED ANKERITE	=	.0
% SODIUM SULFATE	=	.0
% SODIUM CALCIUM SULFATE	=	.0
% FERRIC SULFATE	=	.0
% PYRRHOTITE	=	.0
% PYRITE	=	.0

UNCLASSIFIED AND DESIGNATED AMORPHOUS PHASES

% UNCLASSIFIED	=	83.5
% PURE KAOLINITE (AMORP)	=	.0
% KAOLINITE DERIVED	=	.0
% ILLITE (AMORP)	=	.0
% MONTMORILLONITE (AMORP)	=	.0

THE FOLLOWING ARE ODD CRYSTALLINE PHASES

% APATITE	=	.0
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CALCIUM DERIVED POINTS

% CALCIUM DERIVED	=	.0
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CHEMICAL COMPOSITION WT %

	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	P ₂ O ₅	CaO	MgO	Na ₂ O	K ₂ O	SO ₃	BAO	Mn ₂ O ₇	ClO
BULK	31.9	25.3	11.4	1.0	.3	27.7	1.2	.2	.2	.2	.0	.3	.1
AMORP.	30.5	26.0	12.0	1.0	.3	28.1	1.3	.2	.2	.0	.0	.4	.0

APPENDIX 9

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-13-90

ICG# 54201230 .XRD

SAMPLE DESCRIPTION:

102?

MAJOR PHASES:

Glass	
$\text{Ca}_2\text{Al}_2\text{SiO}_7$	Gelinite
MgO	Periclase
CaSO_4	Anhydrite

MINOR PHASES:

Na_2SO_4	Sodium Sulfate
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COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 4/90 S= .02 I= 1.0 54201230 2633-90-0571 102

0 6- 4-90 54201230 2633-90-0571 102
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=1.50 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	6.361	13.8831	.0052	41.	7.	9.	.188	.180
2	18.741	4.7311	.0447	24.	5.	9.	.235	.216
3	20.039	4.4274	.0510	25.	7.	10.	.282	.276
4	22.720	3.9108	.0654	51.	8.	10.	.164	.159
5	23.940	3.7141	.0725	40.	8.	8.	.211	.203
6	25.480	3.4930	.0820	69.	15.	39.	.235	.216
7	26.740	3.3312	.0901	44.	16.	24.	.376	.354
8	28.820	3.0953	.1044	46.	9.	9.	.211	.204
9	30.840	2.8971	.1191	58.	10.	8.	.188	.178
10	31.399	2.8467	.1234	78.	22.	46.	.305	.279
11	32.640	2.7413	.1331	47.	10.	7.	.211	.205
12	33.440	2.6775	.1395	60.	12.	8.	.211	.204
13	35.660	2.5158	.1580	51.	10.	12.	.211	.202
14	37.178	2.4164	.1713	30.	7.	9.	.235	.225
15	37.559	2.3927	.1747	35.	9.	17.	.258	.243
16	38.401	2.3422	.1823	34.	7.	8.	.235	.218
17	39.217	2.2953	.1898	30.	5.	10.	.188	.182
18	42.959	2.1037	.2260	62.	13.	36.	.235	.214
19	44.600	2.0300	.2427	46.	12.	21.	.282	.265
20	54.318	1.6875	.3512	27.	7.	9.	.282	.268
21	57.279	1.6071	.3872	31.	6.	7.	.211	.202
22	62.279	1.4896	.4507	46.	9.	16.	.211	.199
23	62.880	1.4768	.4585	31.	8.	8.	.282	.272
24	64.059	1.4524	.4740	25.	4.	7.	.164	.155
25	64.319	1.4472	.4775	27.	4.	8.	.164	.156
26	65.259	1.4286	.4900	27.	7.	9.	.258	.249
27	67.038	1.3949	.5139	26.	5.	8.	.188	.181

542012 6/ 4/90 S= .02 T= 1.0 54201230 2633-90-0571 102 Gehlenite 1035, 755

542012 6/ 4/90 S= .02 I= 1.0 54201230 2633-90-0571 102
 Anhydrite 1) 37, 1496
 MgO 2) 4, 829

542012 6/ 4/90 S= .02 T= 1.0 54201230 2633-90-0571 102
Sodium Sulfate 1025.1111

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C- Movetti DATE 6-18-90

ICG# 54201231 .XRD

SAMPLE DESCRIPTION:

2634-90-0572 104

MAJOR PHASES: Glass (peak from 20-35°)

α -Fe Iron

MINOR PHASES:

possibly Al and/or Ni

COMMENTS:

Analyzed by D. Burke

revised 5/90

542012 6/ 4/90 S= .02 I= 1.0 54201231 2634-90-0572 104

0 6- 4-90 54201231 2634-90-0572 104
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=25 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=1.50 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	13.039	6.7841	.0217	21.	7.	10.	.352	.324
2	26.240	3.3936	.0868	41.	8.	6.	.211	.203
3	26.620	3.3460	.0893	43.	10.	6.	.235	.229
4	29.820	2.9938	.1116	50.	11.	12.	.235	.225
5	38.360	2.3446	.1819	32.	8.	14.	.282	.264
6	41.180	2.1904	.2084	26.	7.	6.	.282	.266
7	42.860	2.1083	.2250	27.	7.	7.	.282	.267
8	44.599	2.0300	.2427	46.	12.	22.	.282	.266
9	50.278	1.8132	.3041	24.	6.	7.	.258	.250
10	62.281	1.4896	.4507	26.	7.	6.	.282	.266
11	69.581	1.3500	.5487	22.	6.	8.	.282	.258

542012 6/ 4/90 S= .02 T= 1.0 54201231 2634-90-0572 104

Fe 1) 6, 696

542012 6/ 4/90 S= .02 T= 1.0 54201231 2634-90-0572 104

AI 10 4, 787

542012 6/ 4/90 S= .02 I= 1.0 54201231 2634-90-0572 104

Ni 1) 4, 850

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Morvett DATE 6-18-90

ICC# 54201232 .XRD

SAMPLE DESCRIPTION:

2635-90-0573 202

MAJOR PHASES:

SiO_2

quartz

CaO

MINOR PHASES:

CaSO_4

anhydrite

$\alpha\text{-Fe}_2\text{O}_3$

hematite

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 4/90 S= .02 T= 1.0 54201232 2635-90-0573 202

0 6- 4-90 54201232 2635-90-0573 202
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSpace	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.120	17.2475	.0034	51.	7.	7.	.141	.130
2	6.119	14.4317	.0048	37.	10.	10.	.282	.269
3	19.940	4.4493	.0505	28.	4.	9.	.164	.156
4	20.899	4.2471	.0554	95.	18.	71.	.211	.189
5	24.241	3.6687	.0743	39.	8.	7.	.211	.202
6	25.540	3.4849	.0823	58.	14.	26.	.258	.242
7	26.040	3.4191	.0855	69.	11.	13.	.164	.157
8	26.280	3.3884	.0871	89.	14.	14.	.164	.157
9	26.680	3.3386	.0897	432.	80.	376.	.211	.186
10	27.500	3.2408	.0952	42.	8.	8.	.188	.179
11	28.321	3.1487	.1009	38.	7.	7.	.188	.179
12	30.219	2.9551	.1145	45.	8.	9.	.188	.184
13	31.099	2.8735	.1211	46.	14.	13.	.329	.314
14	32.300	2.7693	.1304	60.	13.	29.	.235	.215
15	33.240	2.6931	.1379	63.	18.	36.	.305	.281
16	35.301	2.5405	.1549	51.	10.	13.	.211	.195
17	35.639	2.5171	.1578	55.	10.	11.	.188	.181
18	36.540	2.4571	.1656	48.	11.	12.	.235	.223
19	37.479	2.3977	.1739	91.	21.	84.	.258	.227
20	38.738	2.3226	.1854	29.	6.	10.	.235	.220
21	39.498	2.2796	.1924	51.	15.	38.	.329	.294
22	40.919	2.2037	.2059	52.	15.	35.	.329	.297
23	42.501	2.1253	.2214	46.	7.	10.	.164	.157
24	42.600	2.1206	.2224	49.	8.	9.	.164	.157
25	42.960	2.1036	.2260	54.	12.	28.	.235	.220
26	44.399	2.0387	.2406	29.	6.	13.	.235	.219
27	44.739	2.0240	.2441	28.	6.	9.	.235	.224
28	45.780	1.9804	.2550	34.	8.	16.	.258	.241
29	50.139	1.8180	.3026	77.	22.	66.	.329	.281
30	54.001	1.6967	.3474	68.	20.	55.	.329	.298
31	54.860	1.6721	.3576	35.	6.	9.	.188	.179
32	55.338	1.6588	.3634	29.	7.	8.	.258	.246
33	57.159	1.6102	.3857	29.	8.	10.	.305	.287
34	59.938	1.5420	.4205	54.	12.	24.	.235	.222
35	60.799	1.5222	.4315	34.	9.	9.	.282	.263
36	62.420	1.4866	.4525	40.	13.	17.	.352	.327
37	64.638	1.4408	.4817	38.	6.	10.	.164	.155
38	66.819	1.3990	.5110	25.	7.	9.	.282	.269
39	67.562	1.3854	.5210	42.	6.	7.	.164	.150
40	67.720	1.3825	.5232	52.	9.	9.	.188	.182
41	68.259	1.3729	.5305	49.	10.	9.	.211	.195

542012 6/ 4/90 S= .02 T= 1.0 54201232 2635-90-0573 202

Hematite 1)33, 664
anhydrite 2)37,1496

542012 6/ 4/90 S= .02 T= 1.0 54201232 2635-90-0573 202

SiO₂ 1033,1161

CaO 2037,1497

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 6-18-90

ICC# 54201233 .XRD

SAMPLE DESCRIPTION:

2636-90-0574 203

MAJOR PHASES:

$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

Gypsum

SiO_2

Quartz

MINOR PHASES:

COMMENTS:

Analyzed by O. Buehler

revised 5/90

542012 6/ 4/90 S= .02 T= 1.0 54201233 2636-90-0574 203

0 6- 4-90 54201233 2636-90-0574 203
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	7.080	12.4756	.0064	34.	10.	9.	.305	.297
2	11.720	7.5449	.0176	307.	49.	303.	.188	.158
3	13.960	6.3385	.0249	20.	8.	10.	.399	.378
4	20.860	4.2550	.0552	111.	24.	91.	.235	.213
5	23.461	3.7888	.0697	121.	22.	107.	.211	.184
6	26.681	3.3384	.0897	432.	86.	430.	.235	.200
7	27.980	3.1863	.0985	56.	10.	17.	.188	.179
8	29.179	3.0581	.1069	85.	19.	67.	.258	.227
9	31.179	2.8663	.1217	56.	11.	27.	.211	.196
10	32.080	2.7878	.1287	30.	8.	9.	.282	.269
11	33.400	2.6806	.1392	54.	20.	50.	.423	.371
12	35.560	2.5226	.1571	61.	23.	49.	.423	.382
13	36.560	2.4558	.1658	40.	12.	24.	.329	.300
14	38.420	2.3411	.1825	25.	5.	10.	.211	.200
15	39.459	2.2818	.1921	30.	7.	11.	.235	.226
16	40.342	2.2339	.2004	92.	20.	91.	.258	.218
17	40.939	2.2027	.2061	30.	8.	11.	.258	.251
18	42.460	2.1273	.2210	44.	14.	36.	.352	.322
19	47.940	1.9961	.2782	45.	13.	43.	.329	.297
20	50.180	1.8166	.3030	54.	12.	30.	.235	.214
21	54.920	1.6705	.3584	36.	11.	25.	.329	.309
22	59.981	1.5410	.4211	82.	24.	80.	.329	.291
23	60.659	1.5254	.4297	26.	6.	11.	.258	.241
24	62.700	1.4806	.4562	31.	10.	16.	.329	.316
5	68.300	1.3722	.5311	54.	12.	22.	.235	.217

542012 6/ 4/90 S= .02 T= 1.0 54201233 2636-90-0574 203

Gypsum 1>33, 311
Quartz 2>33,1161

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moratti DATE 7-13-90

ICC# 54201234 .XRD

SAMPLE DESCRIPTION:

2037 -90 - 0575 302A

MAJOR PHASES: $\text{SiO}_2 \cdot x\text{H}_2\text{O}$ Opal
 $\text{Al}_6\text{Si}_2\text{O}_{13}$ Mullite

MINOR PHASES: SiO_2 Quartz

COMMENTS:

Analyzed by Di Brette

revised 5/90

542012 6/ 4/90 S= .02 T= 1.0 54201234 2637-90-0575 302A

0 6- 4-90 54201234 2637-90-0575 302A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.841	15.1193	.0044	40.	8.	8.	.211	.203
2	16.499	5.3686	.0347	42.	10.	29.	.258	.237
3	17.039	5.1997	.0370	22.	6.	9.	.282	.267
4	20.060	4.4228	.0511	26.	7.	10.	.305	.288
5	20.579	4.3124	.0538	31.	6.	8.	.211	.195
6	20.880	4.2509	.0553	40.	8.	13.	.211	.200
7	21.720	4.0884	.0598	133.	47.	149.	.399	.350
8	23.678	3.7546	.0709	42.	9.	13.	.211	.205
9	25.300	3.5174	.0808	38.	9.	7.	.235	.227
10	26.019	3.4218	.0854	108.	21.	44.	.211	.194
11	26.318	3.3836	.0873	140.	30.	75.	.235	.217
12	26.661	3.3409	.0896	135.	26.	90.	.211	.190
13	27.499	3.2409	.0952	43.	10.	14.	.235	.223
14	27.920	3.1930	.0981	51.	10.	16.	.211	.201
15	29.819	2.9939	.1116	30.	9.	14.	.305	.296
16	30.160	2.9607	.1141	35.	7.	9.	.211	.198
17	30.460	2.9323	.1163	38.	10.	10.	.282	.264
18	30.980	2.8842	.1202	45.	14.	24.	.329	.304
19	33.240	2.6931	.1379	93.	26.	79.	.305	.278
20	34.481	2.5990	.1480	26.	5.	8.	.211	.199
21	35.260	2.5433	.1546	91.	22.	54.	.258	.238
22	35.740	2.5103	.1587	74.	24.	36.	.352	.330
23	37.038	2.4252	.1700	39.	10.	17.	.282	.267
24	38.257	2.3507	.1810	22.	4.	9.	.211	.204
25	39.260	2.2929	.1902	39.	9.	18.	.235	.221
26	40.860	2.2068	.2053	89.	28.	80.	.352	.311
27	42.579	2.1216	.2222	44.	16.	31.	.399	.360
28	48.140	1.8887	.2803	28.	6.	8.	.235	.217
29	49.421	1.8427	.2945	37.	7.	8.	.188	.176
30	50.139	1.8180	.3026	32.	6.	11.	.188	.175
31	50.779	1.7965	.3098	23.	6.	11.	.282	.258
32	54.180	1.6915	.3495	46.	12.	15.	.282	.266
33	57.440	1.6030	.3892	42.	17.	31.	.446	.414
34	60.640	1.5259	.4295	70.	22.	55.	.352	.312
35	63.219	1.4697	.4630	28.	7.	7.	.258	.248
36	64.499	1.4436	.4799	47.	13.	21.	.305	.285
37	65.159	1.4305	.4887	26.	6.	9.	.235	.221
38	67.740	1.3822	.5235	29.	7.	10.	.258	.237

542012 6/ 4/90 S= .02 I= 1.0 54201234 2637-90-0575 302A Mullite 1)15, 776

542012 6/ 4/90 S= .02 T= 1.0 54201234 2637-90-0575 302A

Opal 1>38, 448

Quartz 2>33,1161

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-13-90

ICC# 54201235 .XRD

SAMPLE DESCRIPTION:

2638 - 90 - 0576 403 A

MAJOR PHASES:

SiO_2

Quartz

MINOR PHASES:

$\text{Al}_6\text{Si}_2\text{O}_{13}$

Mullite

possibly MgFe_2O_4

Spinel

COMMENTS:

Analyzed by D. Brakke

revised 5/90

542012 6/ 5/90 S= .02 I= 1.0 54201235 2638-90-0576 403A

0 6- 5-90 54201235 2638-90-0576 403A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
-1	16.480	5.3747	.0346	35.	8.	12.	.258	.240
2	20.841	4.2589	.0551	64.	14.	25.	.235	.219
3	21.760	4.0809	.0600	47.	9.	9.	.211	.200
4	26.020	3.4217	.0854	77.	14.	12.	.188	.178
5	26.241	3.3935	.0868	94.	13.	14.	.141	.136
6	26.619	3.3460	.0893	227.	52.	185.	.258	.228
-7	30.320	2.9456	.1153	44.	13.	9.	.305	.290
-8	33.239	2.6932	.1379	56.	22.	40.	.446	.396
-9	35.259	2.5434	.1546	56.	11.	23.	.211	.198
-10	35.600	2.5199	.1575	59.	13.	12.	.235	.226
-11	36.480	2.4611	.1651	43.	9.	9.	.211	.198
-12	37.381	2.4038	.1731	32.	7.	8.	.235	.221
13	39.321	2.2895	.1908	43.	14.	33.	.352	.318
14	40.121	2.2457	.1983	27.	7.	8.	.258	.242
-15	40.859	2.2068	.2053	51.	14.	37.	.305	.278
-16	44.600	2.0300	.2427	43.	14.	26.	.352	.331
17	48.580	1.8726	.2852	23.	7.	9.	.305	.295
18	50.039	1.8213	.3015	48.	16.	33.	.376	.330
-19	54.039	1.6956	.3478	36.	8.	10.	.235	.228
20	59.879	1.5434	.4198	39.	6.	9.	.164	.155
-21	60.581	1.5272	.4288	42.	8.	17.	.211	.199
22	63.519	1.4635	.4669	35.	9.	11.	.258	.250
23	64.500	1.4435	.4799	36.	10.	12.	.282	.267
-24	65.140	1.4309	.4884	28.	6.	9.	.235	.220
5	67.800	1.3811	.5243	42.	10.	10.	.258	.247

2.344

30

542012 6/ 5/90 S= .02 T= 1.0 54201235 2638-90-0576 403A
 Quartz 1>33,1161
 Mullite 2>15, 776

542012 6/ 5/90 S= .02 T= 1.0 54201235 2638-90-0576 403A 1)17, 464
 Spinel

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moratti DATE 6-26-90

ICC# 54201236 .XRD

SAMPLE DESCRIPTION:

2639-90-0577 502A

MAJOR PHASES:

SiO_2

quartz

Fe_2O_3

hematite

MINOR PHASES:

$\text{Al}_6\text{Si}_2\text{O}_{13}$

mullite

$\text{CaAl}_2\text{Si}_2\text{O}_8$

anorthite

COMMENTS:

Analyzed by J. Breckle

revised 5/90

542012 6/ 5/90 S= .02 I= 1.0 54201236 2639-90-0577 502A

0 6- 5-90 54201236 2639-90-0577 502A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	11.960	7.3936	.0183	17.	4.	7.	.235	.217
2	16.519	5.3620	.0348	23.	6.	8.	.258	.240
3	20.940	4.2389	.0557	60.	12.	35.	.211	.192
4	23.679	3.7545	.0709	41.	7.	9.	.188	.181
5	26.261	3.3909	.0870	64.	12.	16.	.188	.181
6	26.719	3.3338	.0900	247.	45.	214.	.211	.182
- 7	27.940	3.1908	.0982	56.	18.	31.	.352	.324
- 8	29.580	3.0176	.1098	50.	11.	15.	.235	.218
9	31.540	2.8343	.1245	34.	7.	7.	.211	.205
10	31.939	2.7998	.1276	32.	9.	7.	.282	.276
11	33.378	2.6823	.1390	74.	20.	56.	.305	.276
12	35.280	2.5419	.1548	40.	16.	20.	.446	.405
* 13	35.821	2.5048	.1594	90.	21.	63.	.258	.234
14	36.579	2.4546	.1660	56.	13.	34.	.258	.236
15	40.859	2.2068	.2053	39.	6.	9.	.164	.159
16	42.558	2.1226	.2220	32.	7.	12.	.235	.224
17	49.639	1.8351	.2970	40.	12.	20.	.329	.309
18	50.179	1.8166	.3030	35.	6.	10.	.188	.181
19	54.280	1.6886	.3507	41.	8.	13.	.211	.196
20	57.618	1.5985	.3914	31.	5.	7.	.164	.159
21	64.219	1.4492	.4762	36.	7.	8.	.188	.181

4.06 34
 2.93 38

542012 6/ 5/90 S= .02 I= 1.0 54201236 2639-90-0577 502A

Quartz 1>33.1161
Mullite 2>15. 776

542012 6/ 5/90 S= .02 T= 1.0 54201236 2639-90-0577 502A Hematite 1033, 664

542012 6/ 5/90 S= .02 T= 1.0 54201236 2639-90-0577 502A Anorthite 20, 20

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Morvett DATE 6-26-90

ICC# 54201237 .XRD

SAMPLE DESCRIPTION:

2640-90-0578 503

MAJOR PHASES:

CaCO_3	Calcite
$\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$	Bassanite

MINOR PHASES:

SiO_2	Quartz
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COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 5/90 S= .02 I= 1.0 54201237 2640-90-0578 503

0 6- 5-90 54201237 2640-90-0578 503
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	14.780	5.9890	.0279	51.	12.	32.	.258	.232
2	20.899	4.2472	.0554	33.	9.	18.	.282	.261
3	22.139	4.0119	.0621	27.	5.	8.	.188	.178
4	23.139	3.8408	.0678	54.	9.	31.	.188	.175
5	25.738	3.4585	.0836	66.	17.	49.	.282	.253
6	26.660	3.3410	.0896	94.	18.	63.	.211	.188
7	27.759	3.2112	.0970	27.	6.	8.	.211	.206
8	28.320	3.1488	.1009	46.	10.	20.	.235	.220
9	29.461	3.0294	.1090	528.	96.	497.	.211	.182
10	29.716	3.0040	.1108	119.	13.	8.	.117	.107
11	30.620	2.9174	.1175	35.	6.	7.	.188	.178
12	31.501	2.8378	.1242	38.	6.	11.	.164	.155
13	31.940	2.7998	.1276	96.	22.	83.	.258	.224
14	34.239	2.6168	.1460	25.	6.	10.	.258	.242
15	35.560	2.5225	.1572	45.	13.	20.	.305	.286
16	36.039	2.4901	.1613	68.	13.	45.	.211	.189
17	38.401	2.3422	.1823	24.	8.	16.	.352	.316
18	39.461	2.2817	.1921	110.	24.	109.	.258	.218
19	42.399	2.1301	.2204	34.	15.	26.	.470	.428
20	43.202	2.0924	.2284	116.	28.	127.	.282	.244
21	44.600	2.0300	.2427	36.	8.	14.	.235	.214
22	47.239	1.9226	.2705	46.	12.	24.	.282	.254
23	47.579	1.9096	.2742	116.	27.	104.	.258	.230
24	48.579	1.8726	.2852	127.	32.	150.	.282	.250
25	49.379	1.8442	.2940	57.	19.	33.	.352	.325
26	54.158	1.6921	.3492	31.	8.	14.	.282	.262
27	55.041	1.6671	.3598	29.	5.	11.	.188	.172
28	56.542	1.6263	.3781	28.	4.	8.	.164	.154
29	57.441	1.6030	.3892	65.	17.	58.	.305	.265
30	60.681	1.5249	.4300	43.	11.	28.	.282	.259
31	61.059	1.5164	.4349	34.	7.	9.	.211	.199
32	62.700	1.4806	.4562	30.	7.	8.	.235	.222
33	64.699	1.4396	.4825	39.	7.	15.	.138	.178
34	65.659	1.4208	.4953	30.	5.	12.	.188	.178

542012 6/ 5/90 S= .02 T= 1.0 54201237 2640-90-0578 503

Calcite 1) 5, 586

542012 6/ 5/90 S= .02 T= 1.0 54201237 2640-90-0578 503

Bassanite 1)33, 310
Quartz 2)33,1161

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Monetti DATE 7-13-90

ICC# 54201238 .XRD

SAMPLE DESCRIPTION:

2641-90-0579 602A

MAJOR PHASES:

Gehlenite

Diopside, aluminous

MINOR PHASES:

Quartz

possible

Maghemite

COMMENTS:

Analyzed by D. Bruck

revised 5/90

542012 6/27/90 S= .02 I= 1.0 54201238 2641-90-0579 602A

0 6-27-90 54201238 2641-90-0579 602A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.138	17.1859	.0034	62.	13.	14.	.211	.203
2	19.479	4.5535	.0482	29.	8.	10.	.305	.291
3	19.859	4.4672	.0501	35.	6.	10.	.188	.181
4	20.879	4.2512	.0553	42.	8.	13.	.211	.202
5	23.100	3.8472	.0676	52.	17.	36.	.376	.329
6	23.998	3.7052	.0728	54.	10.	17.	.188	.182
7	26.640	3.3434	.0895	69.	17.	44.	.282	.252
8	27.299	3.2642	.0939	51.	11.	15.	.235	.221
9	27.661	3.2224	.0963	55.	12.	16.	.235	.222
10	29.061	3.0702	.1061	62.	11.	19.	.188	.178
11	29.859	2.9899	.1119	125.	27.	83.	.235	.213
12	30.340	2.9437	.1154	71.	17.	35.	.258	.242
13	30.919	2.8898	.1197	71.	19.	31.	.282	.262
14	31.301	2.8554	.1226	133.	33.	100.	.282	.252
15	33.040	2.7090	.1363	53.	11.	11.	.211	.199
16	35.260	2.5434	.1546	63.	13.	16.	.211	.205
17	35.661	2.5156	.1580	81.	21.	51.	.282	.260
18	36.680	2.4481	.1669	46.	7.	10.	.164	.158
19	37.480	2.3977	.1740	45.	11.	9.	.258	.247
20	39.160	2.2986	.1893	45.	10.	10.	.235	.227
21	40.879	2.2058	.2055	42.	10.	10.	.235	.229
22	42.120	2.1436	.2176	42.	12.	15.	.305	.291
23	42.439	2.1282	.2208	48.	13.	19.	.282	.261
24	42.900	2.1064	.2254	47.	9.	12.	.211	.199
25	43.201	2.0925	.2284	48.	10.	11.	.211	.203
26	44.138	2.0502	.2379	52.	14.	23.	.282	.273
27	44.500	2.0343	.2416	61.	15.	22.	.258	.245
28	45.999	1.9715	.2573	34.	11.	10.	.329	.321
29	47.440	1.9149	.2727	40.	7.	9.	.188	.175
30	49.740	1.8316	.2981	41.	15.	16.	.376	.359
31	50.080	1.8200	.3019	41.	7.	9.	.188	.176
32	52.000	1.7572	.3239	56.	13.	14.	.235	.226
33	54.919	1.6705	.3584	41.	10.	14.	.258	.242
34	56.261	1.6338	.3746	57.	11.	17.	.211	.193
35	61.418	1.5084	.4395	44.	8.	9.	.188	.181
36	66.400	1.4068	.5053	46.	8.	9.	.188	.179
37	67.718	1.3826	.5232	42.	9.	11.	.211	.207

542012 6/27/90 S= .02 T= 1.0 54201238 2641-90-0579 602A
 Gehlenite 135, 755

542012 6/27/90 S= .02 I= 1.0 54201238 2641-90-0579 602R
Diopside, aluminian 1038, 466

542012 6/27/90 S= .02 T= 1.0 54201238 2641-90-0579 602A 1)33,1161
 Quartz

542012 6/27/90 S= .02 T= 1.0 54201238 2641-90-0579 602A
 Maghemite 1025,1402

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-3-90

ICC# 54201239 .XRD

SAMPLE DESCRIPTION:

2642-90-0580 G03A

MAJOR PHASES: $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ Gypsum
 $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ Bassanite
 MgO Periclase

MINOR PHASES: $\text{Ca}(\text{OH})_2$ Portlandite
Fe Iron

COMMENTS:

Analyzed by D. Buekle

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201239 2642-90-0580 603A
P(29)=62.2806 D= 1.4895 P(30)=64.8606 D= 1.4364

0 6- 5-90 54201239 2642-90-0580 603A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	6.240	14.1535	.0050	44.	14.	13.	.329	.315
2	11.699	7.5579	.0175	112.	18.	97.	.188	.160
3	14.741	6.0047	.0277	37.	8.	17.	.235	.212
- 4	18.159	4.8814	.0420	34.	6.	12.	.188	.179
5	20.820	4.2630	.0550	48.	10.	25.	.235	.216
6	23.441	3.7921	.0695	72.	15.	46.	.235	.210
7	25.500	3.4903	.0821	55.	9.	9.	.164	.159
8	25.719	3.4611	.0835	54.	10.	9.	.188	.180
9	26.679	3.3387	.0897	49.	8.	9.	.164	.161
-10	28.380	3.1423	.1013	68.	16.	12.	.235	.230
11	29.180	3.0580	.1069	78.	15.	33.	.211	.197
12	29.739	3.0017	.1110	90.	18.	34.	.211	.199
13	31.801	2.8117	.1265	77.	22.	32.	.305	.288
14	32.660	2.7397	.1332	50.	13.	10.	.258	.252
15	33.479	2.6744	.1398	58.	16.	16.	.282	.271
-16	34.159	2.6228	.1454	57.	9.	10.	.164	.162
17	35.480	2.5281	.1565	38.	8.	9.	.235	.221
18	35.979	2.4941	.1608	37.	6.	8.	.164	.157
19	38.360	2.3446	.1819	35.	7.	10.	.211	.197
20	40.319	2.2351	.2002	32.	7.	9.	.235	.228
21	42.979	2.1027	.2262	60.	13.	33.	.235	.218
22	43.659	2.0715	.2330	34.	8.	9.	.235	.227
-23	44.580	2.0309	.2425	52.	15.	31.	.329	.292
24	46.599	1.9475	.2637	35.	11.	12.	.329	.320
5	47.900	1.8976	.2777	35.	9.	10.	.258	.244
26	48.659	1.8697	.2860	38.	6.	8.	.164	.156
27	49.200	1.8504	.2920	46.	15.	20.	.352	.334
28	51.280	1.7802	.3156	32.	6.	9.	.211	.196
29	62.281	1.4895	.4507	38.0				
30	64.861	1.4364	.4847	31.0				

542012 6/ 5/90 S= .02 T= 1.0 54201233 2642-90-0580 603A

Gypsum 1) 33, 311
Bassanite 2) 33, 310
MgO 3) 4, 829

542012 6/ 5/90 S= .02 T= 1.0 54201239 2642-90-0580 603A
 Portlandite 1> 4, 733
 Iron 2> 6, 696

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moratti DATE 7-3-90

ICC# 54201240 .XRD

SAMPLE DESCRIPTION:

2643-90-0581 702 A

MAJOR PHASES:

SiO_2	Quartz
$\text{NaAlSi}_3\text{O}_8$	Albite

MINOR PHASES:

COMMENTS:

Analyzed by O. Breckle

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201240 2643-90-0581

0 6- 5-90 54201240 2643-90-0581
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	20.920	4.2430	.0555	69.	15.	46.	.235	.214
2	22.100	4.0190	.0619	74.	15.	35.	.211	.197
3	22.820	3.8937	.0660	46.	8.	11.	.188	.178
4	23.739	3.7451	.0713	73.	16.	39.	.235	.218
5	24.559	3.6219	.0762	67.	15.	32.	.235	.225
6	26.720	3.3336	.0900	275.	51.	220.	.211	.187
7	27.899	3.1953	.0979	172.	37.	87.	.235	.218
8	28.018	3.1821	.0988	133.	17.	14.	.141	.129
9	28.558	3.1231	.1025	74.	13.	31.	.188	.177
10	29.560	3.0195	.1097	55.	14.	17.	.258	.249
11	29.959	2.9802	.1126	63.	17.	25.	.282	.268
12	30.400	2.9380	.1159	67.	22.	32.	.352	.323
13	31.059	2.8771	.1208	46.	8.	9.	.188	.182
14	31.598	2.8292	.1249	50.	11.	18.	.235	.220
15	35.280	2.5419	.1548	45.	9.	8.	.211	.205
16	35.701	2.5130	.1584	68.	26.	59.	.423	.377
17	36.640	2.4507	.1665	46.	12.	26.	.282	.263
18	39.520	2.2785	.1926	39.	7.	10.	.188	.179
19	42.540	2.1234	.2218	52.	9.	16.	.188	.176
20	43.079	2.0981	.2272	37.	10.	12.	.282	.267
21	44.959	2.0146	.2464	42.	7.	9.	.188	.175
22	45.780	1.9804	.2550	34.	10.	8.	.305	.285
23	48.519	1.8748	.2845	30.	7.	10.	.258	.244
24	49.700	1.8330	.2976	41.	11.	14.	.282	.268
25	50.139	1.8179	.3026	51.	10.	20.	.211	.197
26	51.599	1.7699	.3192	37.	7.	7.	.211	.199
27	52.898	1.7294	.3343	27.	7.	8.	.282	.274
28	59.999	1.5406	.4213	42.	15.	25.	.399	.366
29	67.539	1.3858	.5207	36.	8.	9.	.235	.224
30	67.959	1.3783	.5264	41.	11.	15.	.282	.267
31	68.240	1.3733	.5303	50.	11.	23.	.235	.223

542012 6/ 5/90 S= .02 T= 1.0 54201240 2643-90-0581

Albite 1>20, 572

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-3-90

ICC# 5420 1241 .XRD

SAMPLE DESCRIPTION:

2044-90-0582 703A

MAJOR PHASES: SiO_2 Quartz

MINOR PHASES:

CaO Lime
possibly Fe_2O_3 Hematite

COMMENTS:

the hematite appears to be poorly crystallized.

Analyzed by D. Brekke

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201241 2644-90-0582 703A

0 6- 5-90 54201241 2644-90-0582 703A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

	N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
	1	11.641	7.5959	.0173	24.	6.	10.	.258	.238
	2	15.639	5.6617	.0312	25.	6.	9.	.258	.250
	3	20.020	4.4316	.0509	41.	9.	9.	.235	.225
	4	20.880	4.2510	.0553	86.	17.	48.	.211	.196
	5	22.860	3.8870	.0662	51.	9.	12.	.188	.177
	6	26.080	3.4140	.0858	67.	9.	9.	.141	.136
	7	26.639	3.3435	.0895	293.	55.	236.	.211	.189
	8	27.200	3.2759	.0932	51.	12.	9.	.235	.226
	9	28.081	3.1751	.0992	48.	10.	8.	.211	.205
	10	29.279	3.0478	.1077	45.	11.	11.	.258	.252
	11	29.739	3.0017	.1110	45.	9.	10.	.211	.207
-	12	32.319	2.7677	.1305	63.	14.	28.	.235	.224
-	13	33.260	2.6915	.1380	55.	11.	9.	.211	.202
-	14	35.319	2.5392	.1551	47.	9.	10.	.188	.182
	15	36.539	2.4572	.1656	65.	13.	32.	.211	.194
-	16	37.441	2.4000	.1736	73.	17.	57.	.258	.237
	17	39.441	2.2828	.1919	40.	12.	22.	.305	.289
	18	40.280	2.2372	.1998	37.	9.	13.	.258	.243
	19	40.899	2.2048	.2057	43.	12.	24.	.305	.289
	20	41.561	2.1712	.2121	32.	8.	10.	.258	.241
	21	42.440	2.1282	.2208	46.	16.	28.	.352	.338
-	22	43.000	2.1018	.2264	40.	9.	9.	.235	.225
-	23	44.620	2.0292	.2429	52.	13.	29.	.282	.258
-	24	45.839	1.9780	.2556	35.	9.	12.	.258	.244
	25	47.680	1.9058	.2753	28.	6.	8.	.235	.219
	26	50.041	1.8213	.3015	56.	20.	56.	.399	.357
	27	50.740	1.7978	.3094	28.	9.	9.	.329	.308
-	28	53.960	1.6979	.3469	53.	15.	35.	.305	.278
	29	58.279	1.5819	.3996	29.	7.	9.	.258	.254
	30	60.680	1.5249	.4300	37.	13.	25.	.399	.364
	31	64.519	1.4432	.4801	40.	10.	15.	.258	.245
	32	65.601	1.4220	.4946	32.	6.	10.	.188	.177

542012 6/ 5/90 S= .02 I= 1.0 54201241 2644-90-0582 703A Hematite 1)33, 664

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-3-90

ICC# 54201242 .XRD

SAMPLE DESCRIPTION:

2045-90-0583 12023

MAJOR PHASES: SiO_2 Quartz
 Fe_2O_3 Hematite

MINOR PHASES:

COMMENTS:

Hematite is poorly crystallized

Analyzed by D. Brekke

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201242 2645-90-0583 1202

0 6- 5-90 54201242 2645-90-0583 1202
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.240	16.8517	.0035	43.	8.	8.	.188	.182
2	6.778	13.0296	.0059	32.	5.	8.	.164	.159
3	7.220	12.2342	.0067	29.	11.	12.	.376	.363
4	8.020	11.0158	.0082	27.	7.	10.	.258	.245
5	20.939	4.2390	.0556	66.	11.	45.	.188	.171
6	23.580	3.7699	.0704	30.	5.	8.	.164	.154
7	24.298	3.6602	.0746	31.	7.	9.	.235	.230
8	26.701	3.3360	.0899	207.	38.	201.	.211	.182
9	32.420	2.7593	.1313	27.	8.	10.	.305	.283
10	33.301	2.6884	.1384	57.	10.	17.	.188	.179
11	35.780	2.5076	.1590	67.	22.	38.	.352	.328
12	36.621	2.4519	.1663	37.	11.	9.	.305	.287
13	40.119	2.2458	.1983	20.	5.	7.	.282	.275
14	40.901	2.2047	.2057	27.	7.	11.	.282	.257
15	42.520	2.1244	.2216	85.	17.	89.	.235	.204
16	43.161	2.0943	.2280	23.	6.	8.	.258	.240
17	50.160	1.8172	.3028	48.	12.	47.	.282	.259
18	53.539	1.7102	.3419	25.	6.	8.	.258	.244
19	54.199	1.6910	.3497	33.	9.	14.	.282	.258
20	54.859	1.6722	.3576	26.	4.	7.	.164	.159
21	57.198	1.6092	.3862	25.	4.	7.	.164	.159
22	64.220	1.4492	.4762	28.	7.	7.	.258	.242
23	67.439	1.3876	.5194	19.	4.	7.	.211	.197
24	68.319	1.3719	.5314	45.	6.	10.	.141	.135
5	69.580	1.3501	.5487	19.	4.	7.	.211	.198

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-12-90

ICC# 54201261 .XRD

SAMPLE DESCRIPTION:

2664-90-0602 1203

MAJOR PHASES:

CaO

Lime

CaSO_4

Anhydrite

MINOR PHASES:

SiO_2

Quartz

$\text{Ca}(\text{OH})_2$

Portlandite

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201261 2664-90-0602 12032

L

0 6- 7-90 54201261 2664-90-0602 12032
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.380	16.4144	.0037	46.	7.	5.	.164	.160
2	5.959	14.8186	.0046	42.	11.	6.	.258	.251
3	6.459	13.6725	.0053	42.	6.	7.	.141	.133
4	12.119	7.2971	.0188	20.	4.	5.	.235	.222
5	17.159	5.1636	.0375	19.	4.	6.	.211	.204
6	17.779	4.9848	.0402	25.	5.	6.	.235	.220
7	20.898	4.2473	.0554	24.	4.	8.	.188	.182
8	21.900	4.0552	.0608	19.	8.	12.	.423	.405
9	22.961	3.8702	.0668	29.	10.	17.	.399	.358
10	24.120	3.6867	.0736	24.	7.	9.	.305	.296
11	25.521	3.4875	.0822	253.	52.	238.	.235	.204
12	26.678	3.3388	.0897	57.	11.	39.	.211	.194
13	28.619	3.1166	.1030	27.	5.	7.	.188	.180
14	29.421	3.0334	.1087	54.	12.	31.	.235	.214
15	31.341	2.8518	.1230	81.	19.	54.	.258	.234
16	32.260	2.7727	.1301	167.	37.	166.	.258	.223
17	33.238	2.6933	.1379	33.	6.	17.	.211	.195
18	33.840	2.6467	.1427	30.	5.	6.	.188	.176
19	35.719	2.5117	.1585	28.	6.	17.	.235	.219
20	37.419	2.4014	.1734	446.	100.	473.	.258	.223
21	38.659	2.3272	.1846	54.	11.	24.	.211	.195
22	39.499	2.2796	.1924	20.	6.	12.	.305	.288
23	40.878	2.2058	.2055	50.	12.	28.	.258	.244
24	41.360	2.1812	.2102	30.	7.	17.	.282	.250
5	43.458	2.0807	.2310	33.	9.	18.	.282	.269
26	44.619	2.0292	.2429	27.	8.	12.	.305	.288
27	47.400	1.9164	.2723	28.	5.	6.	.188	.179
28	48.719	1.8676	.2867	52.	20.	50.	.446	.387
29	49.458	1.8414	.2949	22.	4.	8.	.211	.203
30	50.160	1.8172	.3028	18.	4.	6.	.211	.200
31	51.038	1.7880	.3128	20.	5.	7.	.235	.225
32	52.340	1.7466	.3278	35.	12.	37.	.399	.352
33	53.901	1.6996	.3462	223.	70.	272.	.352	.313
34	55.779	1.6468	.3688	33.	9.	13.	.305	.283
35	64.181	1.4500	.4756	75.	27.	81.	.423	.360
36	67.401	1.3883	.5188	70.	22.	65.	.352	.314

542012 6/ 7/90 S= .02 I= 1.0 54201261 2664-90-0602 12032
 CaO 1>37.1497
 Anhydrite 2>37.1496

542012 6/ 7/90 S= .02 T= 1.0 54201261 2664-90-0602 12032
 Quartz 1>33,1161
 Portlandite 2> 4, 733

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Monetti DATE 7-5-90

ICC# 54201243 .XRD

SAMPLE DESCRIPTION:

2646-90-0584 1204

MAJOR PHASES:

SiO_2

Quartz

MINOR PHASES:

Fe_2O_3

Hematite

COMMENTS:

Hematite appears to be poorly crystallized

Analyzed by D. Brucke

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201243 2646-90-0584 1204

0 6- 5-90 54201243 2646-90-0584 1204
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
				50.	10.	8.	.211	.206
1	5.419	16.2938	.0038	46.	9.	8.	.211	.200
2	5.800	15.2244	.0043	21.	8.	10.	.399	.386
3	14.119	6.2676	.0255	37.	6.	8.	.164	.160
4	20.859	4.2553	.0552	33.	8.	7.	.258	.246
5	21.300	4.1682	.0576	30.	8.	10.	.282	.269
6	23.279	3.8181	.0686	34.	8.	12.	.258	.243
7	24.318	3.6572	.0748	434.	69.	428.	.188	.160
8	26.682	3.3383	.0897	31.	9.	10.	.305	.291
9	28.740	3.1038	.1038	31.	7.	7.	.235	.230
10	30.479	2.9305	.1164	53.	14.	24.	.282	.261
11	33.280	2.6900	.1382	41.	7.	10.	.188	.177
12	35.299	2.5406	.1549	68.	23.	43.	.376	.343
13	35.760	2.5089	.1589	26.	7.	12.	.282	.259
14	40.880	2.2057	.2055	27.	6.	16.	.235	.219
15	42.578	2.1216	.2222	34.	7.	18.	.211	.197
16	44.579	2.0309	.2424	16.	4.	8.	.305	.279
17	47.641	1.9073	.2749	25.	7.	13.	.305	.278
18	49.500	1.8399	.2954	32.	6.	8.	.211	.201
19	54.061	1.6950	.3481	58.	9.	31.	.164	.147
20	54.860	1.6721	.3576	22.	7.	7.	.329	.307
21	59.100	1.5619	.4099	23.	4.	8.	.188	.176
22	67.720	1.3825	.5232

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-5-90

ICC# 54201244 .XRD

SAMPLE DESCRIPTION:

2647-90-0585 1204 A

MAJOR PHASES:

CaO

Lime

CaSO_4

Anhydrite

MINOR PHASES:

SiO_2

Quartz

Fe_2O_3

Hematite

CaCO_3

Calcite

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201244 2647-90-0585 1204A

0 6- 5-90 54201244 2647-90-0585 1204A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.580	15.8258	.0040	41.	7.	6.	.188	.179
2	5.901	14.9654	.0045	38.	6.	6.	.164	.156
3	7.399	11.9386	.0070	29.	7.	9.	.235	.230
4	7.699	11.4738	.0076	30.	5.	7.	.188	.183
5	9.080	9.7310	.0106	20.	3.	6.	.164	.151
6	20.899	4.2470	.0554	42.	9.	27.	.235	.213
7	22.040	4.0298	.0616	25.	5.	10.	.211	.200
8	22.440	3.9588	.0638	25.	7.	8.	.305	.287
9	22.941	3.8735	.0666	32.	6.	8.	.188	.179
10	24.240	3.6688	.0743	38.	9.	15.	.258	.247
11	25.540	3.4850	.0823	226.	50.	231.	.258	.221
12	26.380	3.3759	.0877	37.	5.	6.	.141	.136
13	26.680	3.3385	.0897	148.	30.	147.	.235	.200
14	29.442	3.0314	.1088	66.	13.	35.	.211	.194
15	31.379	2.8485	.1232	78.	23.	68.	.329	.291
16	32.279	2.7711	.1302	129.	30.	119.	.258	.230
17	33.221	2.6947	.1377	67.	15.	55.	.258	.231
18	33.921	2.6406	.1434	35.	5.	7.	.164	.154
19	34.240	2.6167	.1460	37.	10.	14.	.282	.260
20	34.779	2.5774	.1505	24.	4.	8.	.188	.175
21	35.699	2.5131	.1583	52.	10.	35.	.211	.194
22	36.518	2.4585	.1654	36.	6.	15.	.188	.176
23	37.439	2.4002	.1736	322.	78.	357.	.282	.242
24	38.640	2.3283	.1845	50.	13.	36.	.282	.256
25	39.499	2.2796	.1924	28.	4.	8.	.164	.155
26	40.340	2.2340	.2004	22.	7.	12.	.329	.310
27	40.879	2.2058	.2055	58.	13.	35.	.235	.217
28	41.359	2.1813	.2102	26.	7.	11.	.282	.262
29	43.500	2.0788	.2314	33.	13.	27.	.423	.398
30	45.840	1.9779	.2556	21.	6.	15.	.329	.304
31	46.801	1.9395	.2658	27.	8.	9.	.305	.286
32	48.740	1.8668	.2869	47.	17.	38.	.423	.370
33	49.499	1.8400	.2954	32.	6.	13.	.211	.200
34	50.140	1.8179	.3026	27.	5.	9.	.188	.173
35	50.780	1.7965	.3098	24.	5.	8.	.211	.203
36	52.320	1.7472	.3276	32.	10.	21.	.329	.312
37	53.920	1.6991	.3464	177.	59.	201.	.376	.331
38	55.840	1.6451	.3695	34.	5.	7.	.164	.154
39	57.679	1.5969	.3921	19.	5.	10.	.282	.267
40	59.861	1.5438	.4196	19.	4.	6.	.235	.218
41	62.520	1.4844	.4538	31.	15.	37.	.540	.489
42	64.160	1.4504	.4754	66.	24.	57.	.423	.364
43	67.419	1.3880	.5191	53.	9.	19.	.188	.176

542012 6/ 5/90 S= .02 I= 1.0 54201244 2647-90-0585 1204R

CaO 1)37,1497

Anhydrite 2)37,1496

5 of 6

542012 6/ 5/90 S= .02 I= 1.0 54201244 2647-90-0585 1204R

Hematite 1>33, 664
Calcite 2>5, 586

542012 6/ 5/90 S= .02 T= 1.0 54201244 2647-90-0585 1204A
 Quartz 133,1161

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-5-90

ICC# 54201245 .XRD

SAMPLE DESCRIPTION:

2648-90-0586 1205A?

MAJOR PHASES:

CaO

Lime

CaSO_4

Anhydrite

MINOR PHASES:

CaCO_3

Calcite

Fe_2O_3

Hematite

SiO_2

Quartz

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 5/90 S= .02 T= 1.0 54201245 2648-90-0586 1205A

0 6- 5-90 54201245 2648-90-0586 1205A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	7.361	12.0004	.0069	36.	7.	7.	.188	.181
2	11.200	7.8941	.0160	20.	4.	6.	.211	.202
3	12.838	6.8899	.0211	19.	4.	5.	.235	.230
4	15.118	5.8556	.0292	18.	4.	7.	.235	.221
5	16.239	5.4539	.0336	18.	5.	8.	.305	.296
6	17.961	4.9347	.0411	28.	5.	11.	.211	.192
7	18.598	4.7671	.0440	20.	4.	5.	.211	.198
8	19.139	4.6336	.0466	19.	5.	6.	.258	.244
9	20.898	4.2473	.0554	24.	4.	6.	.188	.181
10	22.998	3.8640	.0670	29.	7.	15.	.258	.245
11	24.219	3.6720	.0742	28.	7.	12.	.282	.257
12	25.520	3.4876	.0822	260.	53.	246.	.235	.205
13	26.200	3.3987	.0866	26.	5.	5.	.211	.201
14	26.660	3.3410	.0896	67.	14.	54.	.235	.207
15	28.060	3.1774	.0991	19.	3.	5.	.164	.157
16	29.438	3.0317	.1088	56.	11.	32.	.211	.195
17	29.880	2.9879	.1120	19.	4.	5.	.235	.220
18	30.238	2.9533	.1147	17.	2.	6.	.141	.134
19	31.360	2.8502	.1231	94.	24.	86.	.282	.250
20	32.260	2.7727	.1301	166.	37.	168.	.258	.223
21	33.181	2.6978	.1374	42.	10.	36.	.282	.240
22	34.239	2.6168	.1460	23.	7.	9.	.329	.321
23	35.699	2.5131	.1583	39.	8.	29.	.235	.216
24	37.401	2.4025	.1732	456.	101.	481.	.258	.222
25	38.659	2.3272	.1846	58.	16.	37.	.305	.271
26	40.800	2.2099	.2048	55.	20.	60.	.399	.359
27	41.338	2.1823	.2100	34.	8.	23.	.282	.246
28	43.419	2.0824	.2306	37.	13.	34.	.399	.347
29	44.541	2.0325	.2421	27.	9.	30.	.376	.334
30	45.359	1.9978	.2506	22.	6.	9.	.282	.265
31	46.878	1.9365	.2667	23.	4.	5.	.188	.180
32	48.120	1.8894	.2801	18.	5.	7.	.282	.261
33	48.758	1.8662	.2871	50.	15.	39.	.329	.300
34	50.220	1.8152	.3035	17.	4.	7.	.258	.242
35	52.359	1.7460	.3280	33.	12.	33.	.399	.367
36	53.919	1.6991	.3464	245.	79.	307.	.376	.322
37	55.759	1.6473	.3685	43.	9.	20.	.235	.218
38	59.179	1.5600	.4109	17.	5.	9.	.305	.282
39	62.399	1.4870	.4522	31.	9.	20.	.329	.294
40	64.199	1.4496	.4759	76.	24.	67.	.352	.322
41	67.420	1.3880	.5191	70.	23.	58.	.376	.323

542012 6/ 5/90 S= .02 T= 1.0 54201245 2648-90-0586 1205A

CaO 1)37,1497
Anhydrite 2)37,1496

542012 6/ 5/90 S= .02 T= 1.0 54201245 2648-90-0586 1205A

Calcite 1) 5, 586

Hematite 2) 33, 664

542012 6/ 5/90 S= .02 T= 1.0 54201245 2648-90-0586 1205A
Quartz 1)33,1161

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moratti DATE 7-5-90

ICC# 54201246 .XRD

SAMPLE DESCRIPTION:

2649-90-0587 1302A

MAJOR PHASES: SiO_2 Quartz
 CaSO_4 Anhydrite

MINOR PHASES:

CaO Lime
Trace Fe_2O_3 Hematite
possibly $\text{NaAlSi}_3\text{O}_8$ Albite (or other
composition)

COMMENTS:

unknown peak at 4.47 Å

Analyzed by D. Brekke

revised 5/90

542012 6/ 6/90 S= .02 T= 1.0 54201246 2649-90-0587 1302A

0 6- 6-90 54201246 2649-90-0587 1302A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	19.838	4.4717	.0500	39.	11.	22.	.305	.287
2	20.900	4.2469	.0554	76.	14.	52.	.211	.187
3	22.900	3.8804	.0664	34.	8.	9.	.235	.221
4	24.219	3.6719	.0742	31.	6.	9.	.211	.197
5	25.520	3.4876	.0822	228.	43.	193.	.211	.187
6	26.660	3.3409	.0896	365.	75.	347.	.235	.205
7	27.519	3.2386	.0953	34.	7.	9.	.211	.203
8	27.939	3.1908	.0982	46.	9.	14.	.211	.199
9	28.600	3.1187	.1028	31.	10.	12.	.352	.335
10	31.400	2.8467	.1234	104.	25.	64.	.258	.236
11	32.260	2.7727	.1301	59.	14.	37.	.258	.232
12	33.239	2.6932	.1379	32.	6.	10.	.188	.182
13	34.180	2.6212	.1455	37.	8.	10.	.235	.223
14	34.580	2.5918	.1489	35.	7.	10.	.211	.197
15	35.660	2.5157	.1580	39.	14.	19.	.376	.355
16	36.539	2.4572	.1656	52.	16.	26.	.329	.301
17	37.420	2.4014	.1734	123.	28.	105.	.258	.226
18	38.660	2.3271	.1847	50.	16.	35.	.376	.320
19	39.499	2.2796	.1924	40.	11.	29.	.305	.270
20	40.340	2.2340	.2004	31.	6.	8.	.188	.180
21	40.860	2.2068	.2053	58.	17.	45.	.329	.300
22	42.498	2.1254	.2214	45.	11.	32.	.258	.235
23	43.400	2.0833	.2304	32.	8.	15.	.258	.241
24	45.500	1.9919	.2520	37.	7.	11.	.211	.200
25	48.739	1.8669	.2869	43.	9.	17.	.235	.217
26	50.160	1.8172	.3028	63.	17.	55.	.305	.268
27	52.360	1.7459	.3281	39.	9.	17.	.258	.237
28	53.939	1.6985	.3466	71.	19.	56.	.305	.272
29	54.919	1.6705	.3584	42.	10.	23.	.258	.235
30	55.779	1.6468	.3688	43.	8.	14.	.188	.176
31	59.940	1.5420	.4206	54.	18.	49.	.376	.341
32	62.260	1.4900	.4504	28.	7.	9.	.282	.267
33	65.859	1.4170	.4980	30.	5.	8.	.164	.155
34	67.699	1.3829	.5229	45.	7.	8.	.164	.159
35	68.100	1.3757	.5284	44.	7.	10.	.164	.157

542012 6/ 6/90 S= .02 I= 1.0 54201246 2649-90-0587 1302A Hematite 1033, 664

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Maret DATE 7-5-90

ICC# 54201247 .XRD

SAMPLE DESCRIPTION:

2050-90-0588 1304A

MAJOR PHASES:

CaSO_4	Anhydrite
SiO_2	Quartz
CaO	Lime

MINOR PHASES:

Fe_2O_3	Hematite
possibly $\text{NaAlSi}_3\text{O}_8$	Albite (or like feldspar)

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 6/90 S= .02 T= 1.0 54201247 2650-90-0588 1304A

0 6- 6-90 54201247 2650-90-0588 1304A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSpace	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	17.620	5.0294	.0395	25.	7.	12.	.305	.288
2	19.879	4.4626	.0502	31.	8.	8.	.282	.274
3	20.939	4.2391	.0556	40.	10.	23.	.282	.258
4	23.080	3.8506	.0674	41.	6.	8.	.164	.157
5	25.522	3.4873	.0822	220.	49.	210.	.258	.224
6	26.681	3.3384	.0897	180.	37.	140.	.235	.207
7	27.980	3.1864	.0985	50.	18.	19.	.376	.351
8	28.780	3.0996	.1041	36.	7.	8.	.188	.182
9	29.399	3.0356	.1085	38.	6.	7.	.164	.159
10	31.400	2.8466	.1234	102.	22.	62.	.235	.214
11	32.280	2.7710	.1302	53.	14.	24.	.282	.258
12	33.278	2.6901	.1382	64.	14.	42.	.235	.216
13	35.681	2.5143	.1582	62.	12.	31.	.211	.194
14	36.460	2.4624	.1649	41.	12.	19.	.329	.303
15	37.458	2.3990	.1738	106.	29.	103.	.305	.271
16	38.719	2.3237	.1852	52.	13.	29.	.258	.241
17	39.479	2.2807	.1922	28.	8.	9.	.305	.295
18	40.300	2.2361	.2000	25.	7.	7.	.282	.276
19	40.881	2.2057	.2055	65.	18.	48.	.305	.278
20	41.398	2.1793	.2106	35.	6.	10.	.164	.159
21	43.440	2.0815	.2308	35.	10.	15.	.305	.295
22	46.918	1.9350	.2671	28.	7.	11.	.258	.244
23	48.740	1.8668	.2869	49.	12.	26.	.258	.238
24	49.559	1.8379	.2961	33.	10.	17.	.329	.303
25	50.179	1.8166	.3030	34.	7.	13.	.211	.201
26	52.398	1.7448	.3285	39.	7.	14.	.188	.181
27	53.999	1.6967	.3473	70.	20.	35.	.305	.280
28	54.098	1.6939	.3485	61.	10.	7.	.188	.166
29	55.858	1.6446	.3697	37.	10.	16.	.282	.263
30	60.018	1.5402	.4216	27.	6.	9.	.235	.229
31	61.260	1.5119	.4375	28.	5.	9.	.211	.196
32	64.199	1.4496	.4759	39.	10.	16.	.282	.263
33	65.459	1.4247	.4927	26.	7.	7.	.282	.274
34	67.560	1.3854	.5210	38.	7.	8.	.188	.179

542012 6/ 6/90 S= .02 I= 1.0 54201247 2650-90-0588 1304R Hematite 1033, 664

542012 6/ 6/90 S= .02 I= 1.0 54201247 2650-90-0588 1304R
 Albite 1) 9. 466

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-5-90

ICC# 54201248 .XRD

SAMPLE DESCRIPTION:

2054-90-0589 1305A?

MAJOR PHASES:

SiO_2

Quartz

CaSO_4

Anhydrite

Fe_2O_3

Hematite

CaO

Lime

MINOR PHASES:

Trace $\text{NaAlSi}_3\text{O}_8$

Albite

(or other feldspar)

COMMENTS:

Analyzed by D. Buekle

revised 5/90

542012 6/11/90 S= .02 T= 1.0 54201248 2651-90-0589 1305A

0 6-11-90 54201248 2651-90-0589 1305A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	6.400	13.7986	.0053	47.	14.	17.	.329	.307
2	7.060	12.5115	.0064	39.	8.	9.	.211	.204
3	7.958	11.1003	.0081	36.	10.	13.	.282	.271
4	20.861	4.2548	.0552	54.	14.	26.	.282	.254
5	24.219	3.6720	.0742	63.	13.	22.	.211	.201
6	25.501	3.4902	.0821	162.	34.	116.	.235	.211
7	26.659	3.3411	.0896	174.	33.	110.	.211	.190
8	27.959	3.1886	.0984	56.	15.	11.	.282	.265
9	31.341	2.8519	.1230	81.	21.	51.	.282	.257
10	32.298	2.7695	.1304	48.	8.	19.	.188	.175
11	33.201	2.6962	.1376	87.	22.	72.	.282	.250
12	34.898	2.5689	.1515	34.	5.	9.	.164	.160
13	35.680	2.5144	.1582	76.	18.	48.	.258	.236
14	36.539	2.4572	.1656	45.	11.	16.	.258	.243
15	37.420	2.4014	.1734	78.	18.	48.	.258	.235
16	38.600	2.3306	.1841	44.	11.	17.	.282	.259
17	39.439	2.2829	.1919	33.	8.	11.	.258	.244
18	40.881	2.2057	.2055	57.	12.	26.	.235	.218
19	42.458	2.1273	.2210	33.	7.	10.	.211	.200
20	43.461	2.0805	.2310	35.	12.	12.	.376	.354
21	44.639	2.0283	.2431	44.	10.	19.	.235	.223
22	48.758	1.8662	.2871	39.	11.	21.	.305	.287
23	49.559	1.8379	.2961	41.	14.	24.	.352	.332
24	50.119	1.8186	.3023	34.	7.	15.	.235	.217
25	52.340	1.7466	.3278	31.	8.	12.	.282	.267
26	54.020	1.6962	.3476	63.	23.	42.	.399	.372
27	55.700	1.6489	.3678	35.	6.	11.	.188	.179
28	62.421	1.4865	.4525	40.	14.	25.	.376	.348
29	64.078	1.4520	.4743	47.	10.	21.	.235	.219

542012 6/11/90 S= .02 T= 1.0 54201248 2651-90-0589 1305A

Hematite 1)33, 664
CaO 2)37,1497

542012 6/11/90 S= .02 T= 1.0 54201248 2651-90-0589 1305A
 Quartz 1>33.1161
 Anhydrite 2>37.1496

542012 6/11/90 S= .02 T= 1.0 54201248 2651-90-0589 1305A
Albite 1> 9, 466

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-12-90

ICG# 54201202 .XRD

SAMPLE DESCRIPTION:

2065-90-0603 2002

MAJOR PHASES: SiO_2 Quartz
 $(\text{Ca}, \text{Na})(\text{Si}, \text{Al})_4\text{O}_8$ Anorthite

MINOR PHASES: $\text{Ca}(\text{OH})_2$ Portlandite
 FeS Troilite
possible Fe Iron

COMMENTS:

Minor phase ID is tentative for Troilite & Iron.

Analyzed by D. Brekke

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201262 2665-90-0603 20022

0 6- 7-90 54201262 2665-90-0603 20022
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	19.119	4.6383	.0465	25.	8.	11.	.352	.339
2	21.118	4.2035	.0566	39.	6.	11.	.164	.157
3	22.040	4.0298	.0616	54.	11.	23.	.211	.197
4	22.840	3.8904	.0661	40.	11.	11.	.282	.268
5	23.661	3.7572	.0708	59.	11.	28.	.211	.192
6	24.541	3.6245	.0761	55.	11.	14.	.211	.201
7	25.121	3.5421	.0797	46.	7.	8.	.164	.160
8	25.560	3.4823	.0825	47.	12.	8.	.258	.250
9	26.639	3.3436	.0894	117.	28.	85.	.258	.236
10	27.500	3.2408	.0952	62.	11.	22.	.188	.176
11	27.980	3.1863	.0985	112.	40.	115.	.399	.354
12	28.520	3.1272	.1023	50.	12.	20.	.258	.245
13	29.480	3.0275	.1091	45.	13.	17.	.305	.291
14	29.920	2.9839	.1123	44.	7.	10.	.164	.157
15	30.460	2.9323	.1163	42.	8.	9.	.188	.180
16	31.000	2.8824	.1204	39.	12.	16.	.329	.304
17	31.580	2.8308	.1248	40.	7.	7.	.188	.180
18	33.761	2.6528	.1421	45.	8.	10.	.188	.179
19	35.180	2.5490	.1539	35.	7.	7.	.211	.203
20	35.740	2.5103	.1587	49.	10.	11.	.211	.197
21	36.579	2.4546	.1660	41.	13.	25.	.352	.329
22	37.479	2.3977	.1739	31.	10.	14.	.352	.330
23	40.341	2.2340	.2004	27.	7.	10.	.258	.241
24	40.919	2.2037	.2059	27.	8.	12.	.305	.287
25	42.220	2.1388	.2186	37.	7.	13.	.188	.177
26	43.222	2.0915	.2286	75.	19.	57.	.282	.256
27	44.700	2.0257	.2437	55.	12.	20.	.235	.215
28	45.639	1.9862	.2535	30.	5.	9.	.188	.180
29	48.319	1.8821	.2823	27.	5.	11.	.211	.199
30	49.440	1.8420	.2947	29.	8.	9.	.282	.268
31	50.121	1.8186	.3024	31.	6.	8.	.211	.201
32	51.581	1.7705	.3190	39.	8.	18.	.235	.215
33	53.199	1.7204	.3379	30.	8.	7.	.258	.251
34	67.099	1.3938	.5147	22.	4.	8.	.211	.203
35	67.699	1.3829	.5229	30.	7.	12.	.235	.221
36	68.240	1.3733	.5303	34.	8.	8.	.235	.226

542012 6/ 7/90 S= .02 T= 1.0 54201262 2665-90-0603 20022

Quartz 1)33,1161

542012 6/ 7/90 S= .02 T= 1.0 54201262 2665-90-0603 20022
Anorthite 1>18.1202

542012 6/ 7/90 S= .02 T= 1.0 54201262 2665-90-0603 20022
Portlandite 1> 4, 733

542012 6/ 7/90 S= .02 I= 1.0 54201262 2665-90-0603 20022 Troilite 1)24, 80

542012 6/ 7/90 S= .02 I= 1.0 54201262 2665-90-0603 20022 Fe 1> 6, 696

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-13-90

ICC# 54201249 .XRD

SAMPLE DESCRIPTION:

2652-90-0590 2102A

MAJOR PHASES:

CaS

Oldhamite

MINOR PHASES:

probably $\text{Na Mg Si}_2\text{O}_4$ or $\text{Na Al Si}_2\text{O}_4$

COMMENTS:

Halite has basically the same pattern as oldhamite.

Analyzed by D. Brekke

revised 5/90

542012 6/11/90 S= .02 T= 1.0 54201249 2652-90-0590 2102A

0 6-11-90 54201249 2652-90-0590 2102A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.080	17.3826	.0033	53.	4.	5.	.070	.067
2	7.479	11.8110	.0072	31.	6.	5.	.188	.183
3	7.739	11.4152	.0077	29.	5.	6.	.164	.158
4	8.020	11.0152	.0082	26.	5.	5.	.211	.203
5	9.958	8.8751	.0127	16.	3.	5.	.188	.179
6	18.198	4.8709	.0421	18.	3.	5.	.164	.157
- 7	20.960	4.2350	.0558	44.	7.	32.	.188	.168
8	24.057	3.6963	.0732	18.	3.	6.	.164	.159
- 9	26.717	3.3340	.0900	36.	8.	21.	.235	.214
- 10	27.238	3.2714	.0934	28.	6.	20.	.235	.220
- 11	27.599	3.2295	.0959	25.	6.	12.	.235	.226
- 12	29.198	3.0561	.1071	20.	4.	6.	.188	.183
- 13	29.840	2.9918	.1117	22.	4.	8.	.211	.189
14	31.164	2.8676	.1216	67.	8.	5.	.141	.112
15	31.480	2.8396	.1240	630.	126.	669.	.235	.200
- 16	32.220	2.7760	.1298	58.	17.	35.	.305	.289
- 17	32.679	2.7380	.1334	55.	13.	26.	.258	.240
18	32.939	2.7171	.1355	40.	6.	8.	.164	.154
- 19	33.500	2.6729	.1400	37.	12.	35.	.352	.328
- 20	34.361	2.6078	.1470	32.	7.	17.	.235	.209
21	36.719	2.4456	.1672	42.	9.	19.	.235	.219
- 22	37.500	2.3964	.1741	31.	10.	26.	.376	.328
23	38.341	2.3457	.1817	14.	3.	8.	.282	.235
24	39.500	2.2795	.1924	25.	6.	16.	.282	.250
- 25	41.240	2.1873	.2090	37.	12.	34.	.352	.311
26	41.720	2.1632	.2137	18.	3.	5.	.164	.154
27	42.659	2.1178	.2230	95.	20.	62.	.235	.212
28	45.061	2.0103	.2474	360.	94.	442.	.305	.262
29	46.723	1.9426	.2650	16.	2.	5.	.164	.153
30	50.218	1.8153	.3035	18.	4.	9.	.235	.224
31	50.817	1.7953	.3103	15.	3.	6.	.235	.227
32	52.079	1.7547	.3248	20.	7.	14.	.352	.325
33	53.398	1.7144	.3402	24.	6.	13.	.258	.239
34	55.940	1.6424	.3707	110.	29.	117.	.305	.261
35	59.700	1.5476	.4175	16.	4.	9.	.282	.261
36	61.840	1.4991	.4450	49.	11.	28.	.235	.215
37	65.580	1.4224	.4943	88.	26.	116.	.352	.291

542012 6/11/90 S= .02 T= 1.0 54201249 2652-90-0590 2102A
CaS Oldhamite 1> 8, 464

542012 6/11/90 S= .02 I= 1.0 54201249 2652-90-0590 2102A NaCl Halite 1> 5, 628

542012 6/11/90 S= .02 T= 1.0 54201249 2652-90-0590 2102A
Sodium Magnesium Silicate 19.1216

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-5-90

ICC# 54201250 .XRD

SAMPLE DESCRIPTION:

2653-90-0591 2201

MAJOR PHASES:

SiO₂ Quartz

MINOR PHASES:

KAlSi₃O₈ Orthoclase

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/11/90 S= .02 T= 1.0 54201250 2653-90-0591 2201

0 6-11-90 54201250 2653-90-0591 2201
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU L
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID=

N	2THETA	DSpace	(1/D**2)	HEIGHT	AREA	P	
1	12.519	7.0647	.0200	26.	8.	11.	.
2	20.600	4.3082	.0539	50.	6.	15.	.
3	20.900	4.2469	.0554	680.	124.	742.	.
4	23.119	3.8441	.0677	45.	9.	25.	.
5	23.639	3.7606	.0707	58.	10.	36.	.
6	24.261	3.6657	.0744	130.	24.	124.	.
7	25.640	3.4716	.0830	48.	11.	21.	.
8	26.495	3.3614	.0885	135.	20.	21.	.
9	26.682	3.3383	.0897	1890.	367.	2204.	.
10	27.141	3.2828	.0928	85.	13.	38.	.
11	27.521	3.2384	.0954	636.	130.	671.	.
12	28.020	3.1819	.0988	195.	40.	146.	.
13	29.501	3.0254	.1093	93.	19.	81.	.
14	29.880	2.9879	.1120	38.	8.	9.	.
15	30.999	2.8826	.1203	56.	18.	48.	.
16	35.139	2.5518	.1536	38.	9.	13.	.
17	35.560	2.5226	.1571	32.	8.	17.	.
18	36.040	2.4901	.1613	27.	7.	12.	.
19	36.600	2.4532	.1662	178.	36.	201.	.
20	37.101	2.4213	.1706	28.	5.	8.	.
21	38.399	2.3424	.1823	23.	4.	8.	.
22	39.519	2.2785	.1926	147.	32.	165.	.
23	40.321	2.2350	.2002	74.	15.	67.	.
24	41.821	2.1583	.2147	34.	7.	16.	.
25	42.500	2.1253	.2214	187.	41.	213.	.
26	44.560	2.0317	.2422	34.	7.	10.	.
27	45.822	1.9787	.2554	115.	27.	126.	.
28	47.199	1.9241	.2701	35.	11.	23.	.
29	49.199	1.8505	.2920	40.	9.	16.	.
30	50.160	1.8173	.3028	213.	55.	271.	.
31	50.658	1.8005	.3085	47.	9.	13.	.
32	51.100	1.7860	.3135	31.	8.	14.	.
33	54.498	1.6824	.3533	24.	5.	11.	.
34	54.899	1.6711	.3581	94.	27.	117.	.
35	55.400	1.6571	.3642	36.	10.	23.	.
36	58.721	1.5711	.4051	36.	6.	13.	.
37	59.979	1.5411	.4211	193.	61.	293.	.
38	61.740	1.5013	.4437	25.	4.	7.	.
39	63.999	1.4536	.4732	61.	9.	16.	.
40	65.800	1.4181	.4972	33.	12.	31.	.
41	67.740	1.3822	.5235	186.	28.	90.	.
42	68.181	1.3743	.5295	162.	15.	10.	.
43	68.280	1.3726	.5308	188.	29.	62.	.

542012 6/11/90 S= .02 T= 1.0 54201250 2653-90-0591 2201
Quartz 1)33,1161

542012 6/11/90 S= .02 T= 1.0 54201250 2653-90-0591 2201
 Orthoclase feldspar 1019, 932

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-9-90

ICC# 54201251 .XRD

SAMPLE DESCRIPTION:

2654-90-0592 2201A

MAJOR PHASES:

SiO_2

Quartz

$(\text{Ca}, \text{Na})(\text{Si}, \text{Al})_4 \text{O}_8$

Anorthite

MINOR PHASES:

Fe_{1-x}S

Pyrrhotite

COMMENTS:

Analyzed by D. Burke

revised 5/90

542012 6/ 6/90 S= .02 T= 1.0 54201251 2654-90-0592 2201A

0 6- 6-90 54201251 2654-90-0592 2201A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.319	16.6009	.0036	51.	11.	13.	.211	.207
2	9.840	8.9819	.0124	21.	7.	10.	.329	.320
3	14.979	5.9099	.0286	22.	6.	10.	.282	.256
4	18.259	4.8549	.0424	28.	10.	14.	.376	.357
5	20.898	4.2473	.0554	47.	10.	27.	.235	.215
6	22.059	4.0264	.0617	43.	9.	18.	.211	.203
7	23.699	3.7513	.0711	47.	9.	15.	.211	.197
8	24.539	3.6248	.0761	42.	10.	16.	.258	.244
9	25.159	3.5368	.0799	40.	9.	13.	.235	.227
10	26.659	3.3411	.0896	193.	47.	192.	.282	.244
11	27.539	3.2363	.0955	49.	9.	11.	.188	.181
12	27.940	3.1908	.0982	92.	33.	93.	.399	.361
13	28.539	3.1252	.1024	39.	8.	12.	.211	.204
14	29.099	3.0663	.1064	30.	6.	8.	.188	.184
15	29.940	2.9820	.1125	51.	9.	18.	.188	.178
16	31.440	2.8431	.1237	45.	15.	23.	.352	.329
17	33.779	2.6514	.1423	62.	21.	44.	.376	.337
18	35.660	2.5157	.1580	43.	9.	18.	.235	.218
19	36.580	2.4546	.1660	41.	11.	24.	.282	.264
20	37.418	2.4014	.1734	37.	7.	12.	.188	.179
21	39.497	2.2797	.1924	35.	6.	14.	.188	.179
22	40.861	2.2067	.2054	28.	7.	11.	.258	.238
23	42.320	2.1340	.2196	34.	11.	20.	.352	.329
4	43.360	2.0852	.2300	64.	19.	33.	.329	.302
25	43.678	2.0707	.2332	48.	8.	8.	.164	.158
26	44.660	2.0274	.2433	41.	14.	28.	.376	.348
27	47.140	1.9264	.2695	29.	7.	9.	.258	.245
28	47.818	1.9006	.2768	21.	6.	9.	.305	.293
29	50.119	1.8186	.3023	38.	8.	11.	.211	.205
30	53.101	1.7233	.3367	45.	17.	37.	.423	.369
31	54.039	1.6956	.3478	28.	9.	11.	.329	.313
32	59.860	1.5439	.4195	30.	9.	10.	.305	.285
33	68.179	1.3743	.5294	34.	7.	8.	.211	.203

542012 6/ 6/90 S= .02 I= 1.0 54201251 2654-90-0592 2201A
 Quartz 1)33,1161

542012 6/ 6/90 S= .02 I= 1.0 54201251 2654-90-0592 2201A
 Pyrrhotite 1)29, 725

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-9-90

ICC# 54201252 .XRD

SAMPLE DESCRIPTION:

2655-90-0593 2302A

MAJOR PHASES:

CaO

lime

MINOR PHASES:

CaSO_4

anhydrite

Trace Ca(OH)_2

Portlandite

COMMENTS:

Analyzed by D. Buehler

revised 5/90

542012 6/ 6/90 S= .02 T= 1.0 54201252 2655-90-0593 2302A

0 6- 6-90 54201252 2655-90-0593 2302A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.080	17.3828	.0033	45.	6.	5.	.141	.139
2	5.980	14.7679	.0046	41.	7.	5.	.164	.159
3	6.399	13.8013	.0053	36.	9.	7.	.258	.248
4	7.879	11.2115	.0080	28.	6.	7.	.211	.198
5	8.198	10.7760	.0086	22.	3.	5.	.164	.157
6	13.600	6.5058	.0236	15.	3.	5.	.211	.199
7	17.075	5.1886	.0371	13.	2.	5.	.164	.159
8	19.099	4.6431	.0464	14.	3.	6.	.235	.216
9	21.476	4.1343	.0585	11.	3.	9.	.305	.284
10	22.919	3.8772	.0665	15.	2.	5.	.141	.135
11	25.540	3.4850	.0823	150.	30.	154.	.235	.201
12	26.699	3.3362	.0898	17.	3.	7.	.188	.174
13	29.437	3.0318	.1088	16.	3.	7.	.188	.175
14	30.861	2.8951	.1193	15.	2.	5.	.164	.147
15	31.378	2.8485	.1232	58.	16.	54.	.305	.274
16	32.261	2.7726	.1301	303.	61.	315.	.235	.201
17	33.479	2.6744	.1390	17.	4.	7.	.258	.246
18	36.360	2.4689	.1641	24.	5.	11.	.211	.196
19	37.420	2.4014	.1734	835.	182.	984.	.258	.218
20	38.601	2.3306	.1841	37.	13.	38.	.423	.359
21	40.820	2.2088	.2050	35.	10.	28.	.305	.272
22	43.038	2.1000	.2268	13.	2.	5.	.188	.181
23	43.480	2.0797	.2312	20.	7.	20.	.376	.339
24	45.499	1.9920	.2520	15.	2.	5.	.164	.149
25	46.840	1.9380	.2662	17.	3.	7.	.211	.188
26	48.720	1.8675	.2867	33.	10.	26.	.329	.295
27	52.420	1.7441	.3287	25.	8.	23.	.352	.308
28	53.900	1.6996	.3462	417.	119.	544.	.329	.285
29	55.838	1.6452	.3695	26.	8.	19.	.329	.295
30	62.359	1.4879	.4517	17.	5.	16.	.352	.315
31	63.840	1.4569	.4711	19.	4.	5.	.211	.198
32	64.200	1.4496	.4759	123.	39.	168.	.376	.319
33	67.383	1.3886	.5186	123.	21.	64.	.188	.173
34	67.477	1.3869	.5199	99.	12.	13.	.141	.122

542012 6/ 6/90 S= .02 T= 1.0 54201252 2655-90-0593 2302A CaO 1037.1497

542012 6/ 6/90 S= .02 I= 1.0 54201252 2655-90-0593 2302R
Anhydrite 1037.1496

542012 6/ 6/90 S= .02 T= 1.0 54201252 2655-90-0593 2302A
Portlandite 1> 4, 733

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-7-90

ICC# 54201253 .XRD

SAMPLE DESCRIPTION:

2656-70-0594 2303 A

MAJOR PHASES:

$$CaO$$

Line

$$\text{CaSO}_4$$

Anhydrite

MINOR PHASES:

BASES: *Trace* $\text{Ca}(\text{OH})_2$

Portland, Me

Trace. SiO_2

Quantz

possibly CaCO_3

Calcule

COMMENTS:

~~CONFIDENTIAL~~

Analyzed by D. Birckke

revised 5/90

542012 6/ 6/90 S= .02 I= 1.0 54201253 2656-90-0594 2303A

0 6- 6-90 54201253 2656-90-0594 2303A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.680	15.5459	.0041	45.	10.	7.	.235	.229
2	7.018	12.5846	.0063	36.	9.	10.	.258	.251
3	7.461	11.8399	.0071	34.	6.	5.	.188	.179
4	7.779	11.3559	.0078	32.	6.	6.	.188	.181
5	8.199	10.7750	.0086	30.	6.	7.	.211	.204
6	10.759	8.2166	.0148	18.	4.	5.	.235	.226
7	11.399	7.7564	.0166	20.	4.	6.	.188	.180
8	12.358	7.1566	.0195	20.	4.	7.	.211	.197
9	12.700	6.9648	.0206	19.	4.	6.	.235	.215
10	16.018	5.5287	.0327	18.	3.	6.	.164	.155
11	17.178	5.1577	.0376	17.	3.	5.	.188	.184
-12	18.319	4.8391	.0427	22.	4.	6.	.211	.201
13	18.699	4.7416	.0445	19.	4.	5.	.211	.195
14	20.840	4.2590	.0551	18.	4.	6.	.211	.197
15	22.998	3.8640	.0670	21.	6.	12.	.305	.286
16	25.309	3.5162	.0809	35.	4.	6.	.141	.126
17	25.521	3.4875	.0822	243.	50.	250.	.235	.204
18	26.659	3.3411	.0896	31.	7.	21.	.235	.214
19	27.838	3.2022	.0975	15.	4.	6.	.258	.246
20	28.819	3.0954	.1044	22.	4.	5.	.188	.179
-21	29.401	3.0354	.1085	25.	5.	10.	.211	.193
22	31.340	2.8520	.1229	82.	19.	61.	.258	.235
23	32.260	2.7727	.1301	220.	49.	232.	.258	.222
24	33.200	2.6963	.1376	21.	5.	8.	.258	.244
5	34.201	2.6197	.1457	33.	5.	6.	.164	.158
26	36.381	2.4675	.1642	27.	5.	10.	.211	.200
27	37.419	2.4014	.1734	593.	131.	666.	.258	.221
28	38.601	2.3306	.1841	50.	17.	49.	.399	.343
29	40.818	2.2089	.2049	48.	16.	44.	.376	.334
30	41.400	2.1792	.2106	26.	6.	13.	.235	.215
31	43.000	2.1018	.2264	15.	4.	7.	.329	.293
32	43.480	2.0797	.2312	26.	6.	12.	.258	.238
33	44.619	2.0292	.2429	25.	8.	26.	.376	.336
34	45.438	1.9945	.2514	17.	3.	6.	.188	.181
35	46.718	1.9428	.2649	21.	3.	7.	.164	.157
36	47.318	1.9196	.2714	21.	3.	8.	.164	.155
37	48.700	1.8682	.2865	46.	13.	34.	.329	.284
38	50.997	1.7894	.3123	18.	3.	6.	.188	.184
39	52.399	1.7447	.3285	33.	10.	30.	.329	.294
40	53.900	1.6996	.3462	307.	88.	367.	.329	.288
41	54.821	1.6733	.3572	13.	2.	5.	.211	.190
42	55.779	1.6467	.3688	38.	7.	14.	.188	.180
43	57.578	1.5995	.3909	10.	2.	5.	.211	.195
44	62.419	1.4866	.4525	20.	7.	11.	.352	.328
45	64.199	1.4496	.4759	91.	31.	121.	.399	.342
46	67.380	1.3887	.5186	85.	30.	107.	.399	.356

542012 6/ 6/90 S= .02 I= 1.0 54201253 2656-90-0594 2303A
Anhydrite 1037.1496

542012 6/ 6/90 S= .02 T= 1.0 54201253 2656-90-0594 2303A CaO 1)37.1497

542012 6/ 6/90 S= .02 T= 1.0 54201253 2656-90-0594 2303A
Portlandite 1) 4, 733

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moratti DATE 7-10-90

ICG# 54201254 .XRD

SAMPLE DESCRIPTION:

2657-90-0595 2304 A

MAJOR PHASES:

CaO

Lime

CaSO_4

Anhydrite

SiO_2

Quartz

MINOR PHASES:

Fe_2O_3

Hematite

$\text{Ca}(\text{OH})_2$

Portlandite

COMMENTS:

Analyzed by D. Brucke

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201254 2657-90-0595 2304A

0 6- 7-90 54201254 2657-90-0595 2304A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.519	16.0006	.0039	51.	11.	9.	.211	.207
2	6.919	12.7656	.0061	36.	7.	8.	.211	.206
3	7.600	11.6231	.0074	37.	7.	10.	.188	.181
4	13.100	6.7528	.0219	22.	6.	9.	.282	.259
5	15.639	5.6617	.0312	21.	4.	6.	.211	.197
6	18.000	4.9241	.0412	36.	8.	10.	.235	.226
7	19.818	4.4762	.0499	27.	7.	9.	.258	.249
8	20.900	4.2469	.0554	45.	13.	34.	.329	.291
9	21.499	4.1299	.0586	25.	7.	9.	.282	.270
10	24.299	3.6600	.0747	37.	11.	12.	.305	.291
11	25.539	3.4851	.0823	198.	41.	167.	.235	.205
12	26.661	3.3408	.0896	165.	33.	156.	.235	.203
13	27.259	3.2689	.0936	31.	7.	10.	.235	.229
14	27.639	3.2248	.0962	31.	8.	10.	.282	.268
15	28.779	3.0996	.1041	35.	9.	10.	.258	.248
16	29.518	3.0237	.1094	34.	5.	6.	.164	.153
17	31.360	2.8502	.1231	77.	30.	81.	.470	.392
18	32.260	2.7727	.1301	118.	27.	99.	.258	.225
19	33.239	2.6932	.1379	61.	14.	45.	.258	.237
20	34.141	2.6241	.1452	53.	20.	35.	.423	.382
21	35.700	2.5130	.1583	49.	10.	25.	.211	.194
22	36.598	2.4533	.1661	33.	7.	9.	.235	.226
23	37.420	2.4013	.1734	280.	63.	285.	.258	.225
24	38.580	2.3317	.1839	44.	13.	24.	.329	.302
25	39.559	2.2763	.1930	29.	8.	17.	.282	.264
26	39.941	2.2554	.1966	21.	4.	6.	.211	.196
27	40.320	2.2351	.2002	25.	5.	6.	.188	.181
28	40.879	2.2058	.2055	53.	21.	51.	.470	.399
29	41.260	2.1863	.2092	28.	7.	6.	.258	.237
30	42.479	2.1263	.2212	26.	6.	15.	.258	.236
31	42.939	2.1046	.2258	21.	4.	7.	.211	.205
32	43.500	2.0788	.2314	33.	11.	16.	.352	.322
33	44.660	2.0274	.2433	35.	12.	28.	.376	.333
34	47.019	1.9311	.2682	33.	5.	6.	.164	.159
35	47.498	1.9127	.2733	27.	7.	7.	.258	.245
36	48.719	1.8676	.2867	40.	12.	21.	.329	.310
37	49.518	1.8393	.2956	31.	7.	17.	.258	.239
38	50.220	1.8152	.3035	35.	9.	22.	.305	.271
39	50.799	1.7959	.3101	30.	5.	8.	.164	.154
40	52.480	1.7422	.3294	30.	5.	6.	.188	.175
41	53.920	1.6990	.3464	156.	49.	163.	.352	.316
42	54.999	1.6683	.3593	22.	5.	8.	.258	.244
43	55.860	1.6446	.3697	34.	6.	8.	.188	.179
44	59.980	1.5411	.4211	29.	10.	21.	.376	.339
45	62.459	1.4857	.4530	33.	9.	13.	.282	.268
46	64.160	1.4504	.4754	58.	13.	19.	.235	.216
47	64.259	1.4484	.4767	53.	9.	7.	.188	.171
48	67.498	1.3865	.5202	53.	14.	27.	.282	.265
49	68.218	1.3736	.5300	27.	7.	10.	.282	.272

542012 6/ 7/90 S= .02 T= 1.0 54201254 2657-90-0595 2304R

CaO 1)37.1497
Quartz 2)33.1161

542012 6/ 7/90 S= .02 I= 1.0 54201254 2657-80-0595 2304R
Anhydrite 1037.1496

542012 6/ 7/90 S= .02 I= 1.0 54201254 2657-90-0595 2304R

Hematite 1033. 664

L

542012 6/ 7/90 S= .02 I= 1.0 54201254 2657-90-0595 2304R
Portlandite 1> 4, 733

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Monetti DATE 7-10-90

ICC# 54201255 .XRD

SAMPLE DESCRIPTION:

2658-90-0596 2402A

MAJOR PHASES:

CaSO_4

Anhydrite

CaO

Lime

MINOR PHASES:

SiO_2

Quartz

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201255 2658-90-0596 24020

0 6- 7-90 54201255 2658-90-0596 2402A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	5.900	14.9673	.0045	46.	12.	12.	.282	.263
2	6.420	13.7571	.0053	42.	14.	22.	.352	.333
3	7.179	12.3043	.0066	34.	5.	6.	.164	.160
4	8.159	10.8282	.0085	28.	5.	5.	.164	.162
5	11.580	7.6357	.0172	19.	4.	6.	.235	.221
6	14.179	6.2414	.0257	16.	4.	6.	.235	.228
7	14.598	6.0631	.0272	18.	3.	6.	.164	.157
8	18.879	4.6969	.0453	17.	3.	5.	.188	.175
9	19.340	4.5859	.0475	19.	3.	5.	.188	.174
10	20.957	4.2356	.0557	21.	4.	9.	.188	.182
11	22.420	3.9623	.0637	16.	3.	6.	.211	.197
12	22.980	3.8671	.0669	29.	7.	20.	.258	.234
13	25.539	3.4850	.0823	463.	94.	471.	.235	.204
14	26.698	3.3364	.0898	73.	14.	59.	.211	.189
15	28.561	3.1228	.1025	22.	3.	6.	.164	.154
16	31.380	2.8484	.1233	177.	47.	162.	.305	.266
17	32.279	2.7710	.1302	124.	28.	113.	.258	.229
18	36.441	2.4636	.1648	38.	11.	23.	.305	.281
19	37.440	2.4001	.1736	297.	77.	345.	.305	.258
20	38.639	2.3284	.1845	89.	29.	94.	.376	.325
21	39.498	2.2796	.1924	16.	3.	5.	.211	.207
22	40.839	2.2078	.2051	88.	22.	62.	.282	.250
23	41.399	2.1793	.2106	45.	11.	27.	.258	.241
24	42.519	2.1244	.2216	14.	2.	5.	.141	.131
25	43.459	2.0806	.2310	44.	15.	50.	.399	.336
26	44.620	2.0291	.2429	29.	8.	18.	.305	.282
27	45.440	1.9944	.2514	26.	5.	6.	.188	.173
28	46.859	1.9373	.2665	25.	4.	6.	.188	.178
29	48.739	1.8668	.2869	81.	21.	61.	.282	.257
30	50.179	1.8166	.3030	19.	8.	17.	.446	.405
31	52.399	1.7447	.3285	55.	19.	59.	.399	.348
32	53.921	1.6990	.3464	163.	47.	154.	.329	.289
33	55.819	1.6457	.3692	67.	14.	22.	.211	.202
34	55.838	1.6451	.3695	61.	9.	7.	.164	.149
35	60.660	1.5254	.4298	21.	4.	5.	.211	.197
36	60.818	1.5218	.4318	22.	5.	5.	.211	.205
37	62.339	1.4883	.4515	30.	9.	15.	.329	.308
38	64.181	1.4499	.4757	49.	20.	54.	.470	.411
39	65.101	1.4317	.4879	23.	4.	6.	.188	.175
40	65.438	1.4251	.4924	21.	3.	6.	.164	.158
41	67.500	1.3865	.5202	49.	17.	36.	.376	.351
42	68.160	1.3747	.5292	16.	3.	5.	.188	.178
43	69.758	1.3470	.5511	8.	2.	5.	.211	.200

542012 6/ 7/90 S= .02 T= 1.0 54201255 2658-90-0596 2-02A
Anhydrite 1037.1496

542012 6/ 7/90 S= .02 T= 1.0 54201255 2658-90-0596 2402A

CaO 1>37,1497
Quartz 2>33,1161

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-10-90

ICC# 54201256 .XRD

SAMPLE DESCRIPTION:

2659-90-0597 2403 A

MAJOR PHASES:

CaSO_4

Anhydrite

CaO

Cime

MINOR PHASES:

SiO_2

Quartz

Fe_2O_3

Hematite

COMMENTS:

Analyzed by D. Buehler

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201256 2659-90-0597 2403A

0 6- 7-90 54201256 2659-90-0597 2403A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	6.499	13.5888	.0054	35.	9.	13.	.282	.271
2	20.899	4.2471	.0554	26.	6.	18.	.258	.238
3	22.940	3.8736	.0666	26.	5.	11.	.188	.177
4	24.201	3.6746	.0741	27.	5.	12.	.211	.197
5	25.541	3.4848	.0823	301.	66.	327.	.258	.219
6	26.679	3.3387	.0897	124.	23.	115.	.211	.184
7	28.138	3.1688	.0996	21.	4.	6.	.211	.205
8	28.720	3.1058	.1037	22.	4.	6.	.188	.179
9	29.419	3.0337	.1087	28.	7.	10.	.258	.245
10	31.361	2.8501	.1231	130.	39.	141.	.352	.302
11	32.299	2.7695	.1304	100.	21.	75.	.235	.212
12	33.219	2.6948	.1377	55.	12.	39.	.235	.209
13	34.140	2.6241	.1452	28.	9.	13.	.329	.314
14	35.680	2.5144	.1582	44.	10.	35.	.258	.230
15	36.420	2.4649	.1646	32.	14.	26.	.470	.440
16	37.441	2.4001	.1736	250.	65.	266.	.305	.261
17	38.679	2.3260	.1848	61.	22.	72.	.423	.368
18	39.501	2.2795	.1925	23.	5.	8.	.211	.196
19	40.860	2.2068	.2053	70.	24.	70.	.399	.346
20	41.340	2.1822	.2100	33.	9.	16.	.282	.258
21	42.599	2.1206	.2224	17.	5.	9.	.352	.321
22	43.480	2.0797	.2312	36.	6.	9.	.188	.180
23	45.059	2.0104	.2474	24.	6.	6.	.258	.235
24	45.439	1.9945	.2514	24.	5.	6.	.211	.194
5	46.860	1.9372	.2665	24.	8.	16.	.376	.349
26	47.200	1.9241	.2701	22.	4.	6.	.188	.177
27	48.759	1.8661	.2872	57.	18.	51.	.352	.320
28	50.159	1.8173	.3028	29.	7.	21.	.258	.235
29	52.420	1.7441	.3287	44.	12.	27.	.305	.275
30	53.199	1.7204	.3379	16.	4.	6.	.235	.220
31	54.000	1.6967	.3474	137.	53.	161.	.446	.385
32	54.900	1.6710	.3581	18.	5.	10.	.305	.275
33	55.762	1.6472	.3685	53.	12.	25.	.235	.220
34	59.979	1.5411	.4211	20.	7.	17.	.376	.337
35	62.400	1.4870	.4523	36.	6.	12.	.188	.177
36	64.180	1.4500	.4756	49.	23.	65.	.517	.468
37	67.499	1.3865	.5202	43.	14.	20.	.376	.330
38	67.599	1.3847	.5215	40.	8.	6.	.211	.190

542012 6/ 7/90 S= .02 I= 1.0 54201258 2658-90-0597 2403R
 Anhydrite 1037.1496

L

542012 6/ 7/90 S= .02 T= 1.0 54201256 2659-90-0597 2403A

1)37.1497

CaO

2)33.1161

Quartz

542012 6/ 7/90 S= .02 T= 1.0 54201256 2659-90-0597 2403R

Hematite 1033, 664

X= -1.64 Y= -11.63

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Monetti DATE 7-10-90

ICC# 54201257 .XRD

SAMPLE DESCRIPTION:

2060-90-0598 2404

MAJOR PHASES:

SiO_2	Quartz
Fe_2O_3	Hematite

MINOR PHASES:

$\text{Al}_2\text{Si}_2\text{O}_5$	Mullite
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COMMENTS:

Analyzed by D. Burke

revised 5/90

542012 6/ 7/90 S= .02 I= 1.0 54201257 2660-90-0598 2404

0 6- 7-90 54201257 2660-90-0598 2404
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	7.898	11.1851	.0080	35.	5.	10.	.164	.152
- 2	16.420	5.3941	.0344	36.	14.	21.	.423	.400
3	20.878	4.2513	.0553	74.	16.	44.	.235	.219
4	24.200	3.6748	.0741	60.	18.	27.	.329	.307
5	24.601	3.6158	.0765	50.	9.	9.	.188	.182
6	25.480	3.4930	.0820	56.	17.	12.	.329	.310
7	26.639	3.3436	.0895	315.	65.	287.	.235	.206
8	27.361	3.2569	.0943	47.	8.	8.	.188	.180
- 9	30.220	2.9551	.1145	50.	13.	19.	.282	.266
-10	30.921	2.8896	.1198	42.	9.	10.	.211	.204
11	33.200	2.6963	.1375	84.	23.	58.	.305	.276
12	35.620	2.5184	.1577	98.	29.	57.	.329	.296
13	36.539	2.4572	.1656	50.	16.	37.	.352	.324
14	38.379	2.3435	.1821	29.	7.	10.	.235	.226
15	39.381	2.2862	.1913	44.	9.	17.	.211	.199
16	40.299	2.2362	.2000	32.	9.	11.	.282	.270
17	40.860	2.2068	.2053	55.	11.	21.	.211	.200
18	42.458	2.1273	.2210	45.	8.	15.	.188	.180
19	44.599	2.0300	.2427	42.	9.	20.	.235	.218
20	45.720	1.9829	.2543	33.	7.	9.	.211	.201
21	49.480	1.8406	.2952	37.	7.	9.	.211	.201
22	50.060	1.8206	.3017	56.	17.	45.	.329	.303
23	57.161	1.6102	.3857	37.	11.	10.	.329	.303
24	57.560	1.6000	.3906	39.	13.	16.	.352	.335
5	59.900	1.5429	.4201	45.	13.	21.	.305	.291
26	62.621	1.4823	.4551	44.	11.	11.	.258	.247
27	68.139	1.3751	.5289	50.	11.	17.	.235	.225
3 39								

542012 6/ 7/90 S= .02 T= 1.0 54201257 2660-90-0598 2404

Quartz 1>33, 1161
Hematite 2>33, 664

542012 6/ 7/90 S= .02 I= 1.0 54201257 2660-90-0598 2404 Mullite 1>15. 776

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Morretti DATE 7-10-90

ICC# 54201258 .XRD

SAMPLE DESCRIPTION:

2661-90-0599 2404 A

MAJOR PHASES:

CaO

Lime

CaSO_4

Anhydrite

SiO_2

Quartz

MINOR PHASES:

Fe_2O_3

Hematite

CaCO_3

Calcite

COMMENTS:

Analyzed by D. Brakke

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201258 2661-90-0599 2404A

0 6- 7-90 54201258 2661-90-0599 2404A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	20.900	4.2470	.0554	53.	12.	49.	.258	.221
2	22.959	3.8706	.0667	29.	5.	9.	.188	.178
3	24.238	3.6690	.0743	35.	8.	17.	.235	.220
4	25.000	3.5590	.0789	28.	6.	6.	.211	.202
5	25.540	3.4850	.0823	208.	50.	223.	.282	.241
6	26.681	3.3385	.0897	214.	39.	197.	.211	.182
7	29.459	3.0296	.1089	37.	16.	36.	.470	.431
8	31.360	2.8502	.1231	90.	28.	83.	.352	.307
9	32.261	2.7726	.1301	90.	24.	83.	.305	.269
10	33.220	2.6947	.1377	69.	13.	51.	.211	.193
11	35.680	2.5143	.1582	60.	16.	63.	.305	.267
12	36.540	2.4571	.1656	37.	8.	14.	.235	.215
13	37.440	2.4001	.1736	220.	62.	249.	.329	.280
14	38.640	2.3283	.1845	45.	16.	38.	.399	.359
15	39.519	2.2785	.1926	30.	8.	29.	.305	.279
16	40.879	2.2058	.2055	57.	19.	45.	.376	.338
17	42.480	2.1263	.2212	23.	5.	11.	.258	.233
18	43.419	2.0824	.2306	29.	9.	14.	.329	.308
19	48.700	1.8682	.2865	42.	8.	10.	.211	.197
20	48.760	1.8661	.2872	43.	7.	8.	.164	.155
21	49.558	1.8379	.2960	33.	8.	18.	.258	.243
22	50.159	1.8173	.3028	44.	10.	33.	.258	.225
23	52.419	1.7441	.3287	34.	12.	26.	.376	.345
24	53.979	1.6973	.3471	135.	43.	107.	.352	.318
5	54.822	1.6732	.3572	20.	5.	9.	.282	.256
26	55.799	1.6462	.3690	35.	8.	10.	.235	.227
27	57.658	1.5975	.3919	20.	4.	7.	.211	.197
28	59.899	1.5430	.4200	27.	5.	11.	.188	.177
29	60.740	1.5236	.4308	19.	8.	16.	.423	.402
30	61.539	1.5057	.4411	14.	3.	7.	.258	.238
31	62.458	1.4857	.4530	36.	6.	12.	.188	.178
32	64.100	1.4516	.4746	51.	10.	13.	.211	.194
33	64.219	1.4492	.4762	50.	12.	13.	.282	.241
34	67.620	1.3843	.5218	44.	7.	9.	.164	.152

542012 6/ 7/90 S= .02 T= 1.0 54201258 2661-90-0589 2404R
 Anhydrite 1037.1496

542012 6/ 7/90 S= .02 T= 1.0 54201258 2661-90-0599 2404A

Quartz 1)33,1161
CaO 2)37,1497

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Monetti DATE 7-12-90

ICG# 54201260 .XRD

SAMPLE DESCRIPTION:

2663-90-0601 2503A

MAJOR PHASES:

SiO_2

Quartz

CaO

Lime

MINOR PHASES:

CaSO_4

Anhydrite

$\text{Ca}(\text{OH})_2$

Portlandite

COMMENTS:

Analyzed by D. Buckle

revised 5/90

6 of 6

542012 6/ 7/90 S= .02 T= 1.0 54201260 2663-90-0601 2503A

0 6- 7-90 54201260 2663-90-0601 2503A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
		11.2115	.0080	30.	10.	18.	.352	.332
1	7.879			41.	16.	27.	.423	.393
2	18.080	4.9024	.0416	45.	7.	19.	.164	.154
3	18.479	4.7977	.0434	88.	14.	68.	.188	.161
4	20.901	4.2468	.0554	115.	22.	87.	.211	.192
5	25.520	3.4876	.0822	50.	9.	10.	.188	.180
6	26.160	3.4038	.0863	473.	92.	550.	.235	.194
7	26.662	3.3408	.0896	38.	9.	15.	.258	.242
8	28.641	3.1142	.1031	68.	16.	46.	.258	.232
9	29.439	3.0316	.1088	25.	8.	12.	.352	.332
10	30.759	2.9045	.1185	48.	11.	24.	.235	.220
11	31.360	2.8502	.1231	146.	30.	143.	.235	.206
12	32.241	2.7743	.1299	72.	10.	9.	.141	.133
13	34.001	2.6346	.1441	76.	18.	20.	.258	.242
14	34.160	2.6227	.1454	60.	12.	40.	.235	.207
15	36.580	2.4545	.1660	353.	78.	378.	.258	.222
16	37.400	2.4026	.1732	31.	6.	10.	.211	.201
17	38.639	2.3284	.1845	47.	12.	38.	.282	.251
18	39.519	2.2785	.1926	27.	6.	16.	.258	.234
19	40.320	2.2351	.2002	30.	9.	19.	.329	.300
20	40.761	2.2119	.2044	48.	11.	43.	.258	.233
21	42.498	2.1254	.2214	29.	6.	7.	.211	.205
22	43.379	2.0843	.2302	31.	7.	16.	.235	.218
23	45.819	1.9788	.2554	49.	15.	32.	.329	.298
24	47.501	1.9126	.2734	34.	8.	13.	.235	.223
25	48.619	1.8712	.2856	80.	21.	92.	.305	.268
26	50.160	1.8172	.3028	38.	8.	12.	.211	.201
27	50.839	1.7945	.3105	199.	56.	214.	.329	.284
28	53.899	1.6997	.3462	29.	4.	7.	.164	.152
29	54.919	1.6705	.3584	25.	5.	8.	.211	.203
30	55.779	1.6468	.3688	67.	11.	38.	.188	.168
31	59.939	1.5420	.4206	54.	7.	6.	.141	.124
32	59.997	1.5407	.4213	74.	25.	64.	.376	.333
33	64.180	1.4500	.4756	61.	15.	33.	.258	.243
34	67.439	1.3876	.5194	51.	9.	16.	.188	.178
35	68.260	1.3729	.5305					

542012 6/ 7/90 S= .02 T= 1.0 54201260 2663-90-0601 2503A
 Quartz 1)33,1161
 CaO 2)37,1497

542012 6/ 7/90 S= .02 T= 1.0 54201260 2663-90-0601 2503A

1) 37.1496

Anhydrite

2) 4. 733

portlandite

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Monetti DATE 7-11-90

ICC# 54201259 .XRD

SAMPLE DESCRIPTION:

2662-90-0600 2504A

MAJOR PHASES:

SiO_2

Quartz

MINOR PHASES:

CaO

Lime

CaSO_4

Anhydrite

$\text{Ca}(\text{OH})_2$

Portlandite

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 7/90 S= .02 T= 1.0 54201259 2662-90-0600 2504A

0 6- 7-90 54201259 2662-90-0600 2504A
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=2.00 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
				45.	9.	12.	.211	.204
1	6.459	13.6744	.0053	41.	7.	19.	.188	.176
2	15.919	5.5628	.0323	31.	7.	10.	.235	.227
3	16.759	5.2859	.0358	44.	9.	11.	.211	.202
4	17.779	4.9847	.0402	54.	11.	14.	.211	.204
5	18.099	4.8974	.0417	170.	31.	150.	.211	.185
6	20.917	4.2435	.0555	48.	14.	15.	.305	.294
7	22.300	3.9834	.0630	50.	9.	9.	.188	.179
8	22.680	3.9175	.0652	60.	13.	14.	.235	.223
9	24.260	3.6659	.0744	106.	21.	43.	.211	.197
10	25.519	3.4877	.0822	657.	120.	632.	.211	.183
11	26.681	3.3385	.0897	91.	19.	54.	.235	.211
12	29.441	3.0315	.1088	75.	18.	48.	.258	.234
13	32.240	2.7744	.1299	72.	15.	13.	.211	.206
14	34.160	2.6227	.1454	37.	12.	19.	.329	.313
15	35.619	2.5185	.1577	92.	19.	72.	.235	.208
16	36.580	2.4545	.1660	157.	36.	148.	.258	.230
17	37.400	2.4026	.1732	64.	13.	38.	.211	.196
18	39.498	2.2796	.1924	47.	11.	28.	.258	.237
19	40.379	2.2319	.2007	82.	17.	59.	.235	.212
20	42.479	2.1263	.2212	40.	8.	10.	.211	.203
21	43.299	2.0879	.2294	51.	16.	28.	.329	.305
22	44.620	2.0291	.2429	51.	13.	33.	.258	.245
23	45.858	1.9772	.2558	48.	10.	9.	.211	.206
24	47.040	1.9302	.2684	107.	28.	93.	.305	.265
5	50.160	1.8172	.3028	44.	17.	22.	.423	.398
26	50.839	1.7945	.3105	94.	35.	96.	.423	.374
27	53.919	1.6991	.3464	46.	13.	25.	.305	.280
28	54.880	1.6716	.3579	26.	6.	9.	.258	.245
29	57.638	1.5980	.3916	71.	20.	57.	.329	.288
30	59.940	1.5420	.4206	54.	18.	39.	.376	.328
31	64.179	1.4500	.4756	22.	6.	9.	.282	.265
32	66.500	1.4049	.5066	65.	13.	20.	.211	.201
33	67.701	1.3829	.5229	58.	13.	15.	.235	.219
34	68.260	1.3729	.5305					

542012 6/ 7/80 8= .02 T= 1.0 54201258 2662-80-0600 2504R
 Quartz 1>33.1161
 CaO 2>37.1497

L

542012 6/ 7/90 S= .02 T= 1.0 54201259 2662-90-0600 2504R
 Anhydrite 137.1496

542012 6/ 7/80 S= .02 I= 1.0 54201259 2662-90-0600 2504R
Portlandite 1> 4, 733

X-RAY DIFFRACTION REPORT

UND Energy & Environmental Research Ctr

P.I. C. Moretti DATE 7-13-90

ICC# 54201229 .XRD

SAMPLE DESCRIPTION:

2032-90-0570 EEER

MAJOR PHASES:

$\text{Na Ca AlSi}_2\text{O}_7$ melilite
also glassy material

MINOR PHASES:

$\text{Fe Al}_2\text{O}_4$ Hercynite
or $\text{Mn Al}_2\text{O}_4$ Galaxite
or $\text{Mg (Al, Fe)}_2\text{O}_4$ Spinel, Ferric

COMMENTS:

Analyzed by D. Brekke

revised 5/90

542012 6/ 4/90 S= .02 T= 1.0 54201229 2632-90-0570 EER

0 6- 4-90 54201229 2632-90-0570 EER
 START ANGLE= 5.000 DELTA 2THETA= .020 TIME= 1.0 TUBE=CU LAMDA= 1.541
 SM=19 BKGR= 0 0 0 KA2=0 TUBE=CU SCH= 9 SENS=1.50 CENTROID= 7 NTP= 5

N	2THETA	DSPACE	(1/D**2)	HEIGHT	AREA	P	W2	W4
1	6.419	13.7590	.0053	36.	7.	9.	.211	.203
2	7.379	11.9705	.0070	31.	6.	7.	.211	.202
3	13.581	6.5148	.0236	18.	3.	6.	.188	.176
4	17.697	5.0076	.0399	23.	4.	9.	.188	.177
5	20.520	4.3248	.0535	19.	5.	9.	.258	.242
6	24.079	3.6930	.0733	34.	7.	14.	.211	.196
7	24.439	3.6394	.0755	27.	6.	6.	.235	.230
8	24.959	3.5647	.0787	29.	7.	7.	.235	.230
9	25.601	3.4768	.0827	31.	10.	14.	.352	.338
10	26.300	3.3860	.0872	33.	5.	6.	.164	.158
11	27.240	3.2711	.0935	36.	7.	7.	.211	.205
12	27.779	3.2089	.0971	37.	9.	9.	.235	.230
13	29.220	3.0539	.1072	48.	7.	8.	.141	.136
14	31.479	2.8397	.1240	90.	15.	49.	.188	.171
15	35.619	2.5185	.1577	37.	10.	15.	.282	.270
16	36.259	2.4755	.1632	50.	17.	30.	.352	.335
17	37.500	2.3964	.1741	35.	9.	20.	.282	.255
18	40.240	2.2393	.1994	23.	7.	8.	.305	.289
19	41.819	2.1584	.2147	23.	5.	6.	.235	.222
20	43.180	2.0934	.2282	24.	5.	6.	.211	.200
21	43.680	2.0706	.2332	33.	10.	17.	.329	.305
22	47.298	1.9203	.2712	26.	7.	9.	.258	.250
23	50.180	1.8166	.3030	24.	4.	6.	.188	.178
24	50.840	1.7945	.3105	29.	5.	6.	.164	.158
25	51.498	1.7731	.3181	25.	5.	7.	.211	.200
26	52.081	1.7546	.3248	30.	10.	20.	.376	.339
27	53.179	1.7210	.3376	25.	7.	8.	.282	.261
28	58.679	1.5721	.4046	25.	4.	7.	.188	.179
29	62.999	1.4743	.4601	24.	4.	7.	.164	.158
30	64.119	1.4512	.4748	30.	6.	6.	.211	.204
31	69.839	1.3457	.5522	26.	2.	7.	.117	.085

542012 6/ 4/90 S= .02 I= 1.0 54201229 2632-90-0570 EER Melilite 1026,1371

542012 6/ 4/80 8= .02 T= 1.0 54201228 2832-80-0570 EER
 Hercynite 1034. 192

APPENDIX 10

Sample: GEOTECH #102

Size: 50.45 mg

Rate: 20C/50C/10C/MIN

Program: TGA Analysis V2.0

TGA

Date: 5-Jun-90 Time: 10:52:31

File: GED/TGA.05 MISC.#15

Operator: KULAS

Plotted: 19-Jul-91 8:20:52

Sample: GEOTECH#2002

Size: 51.3720 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#20022

TGA

File: A:GT20022.01

Operator: KULAS

Run Date: 14-Jun-90 11:37

Sample: GEOTECH#1203

Size: 47.5680 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#12032

TGA

File: A:GT12032.01

Operator: KULAS

Run Date: 13-Jun-90 08:18

Sample: GEOTECH #104

Size: 57.33 mg

Rate: 20C/50C/10C/MIN

Program: General Analysis V1.0

TGA

Date: 4-Jun-90 Time: 14:11:55

File: GEO/TGA.02 MISC.#15

Operator: KULAS

Plotted: 4-Jun-90 15:37:24

Sample: GEOTECH #202

Size: 54.87 mg

Rate: 20C/50C/10C/MIN

Program: General Analysis V1.0

TGA

Date: 5-Jun-90

Time: 7:05:01

File: GEO/TGA.03 MISC.#15

Operator: KULAS

Plotted: 5-Jun-90 8:35:00

Sample: GEOTECH #203
Size: 57.11 mg
Rate: 20C/50C/10C/MIN
Program: General Analysis V1.0

Date: 5-Jun-90 Time: 8:51:22
File: GEO/TGA.04 MISC.#15
Operator: KULAS
Plotted: 5-Jun-90 10:30:48

TGA

Sample: GEOTECH #302A REPEAT#2

Size: 48.6850 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH #302A

TGA

File: A:GT302A.02

Operator: KULAS

Run Date: 20-Jun-90 13:07

Sample: GEOTECH#403A

Size: 46.3890 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#403A

TGA

File: A:GT403A.01

Operator: KULAS

Run Date: 11-Jun-90 09:58

Sample: GEOTECH #502A REPEAT#3

Size: 48.1400 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH #502A

TGA

File: A:GT502A.03

Operator: KULAS

Run Date: 20-Jun-90 11:25

Sample: GEOTECH#503
Size: 50.7330 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#503

TGA

File: A:GT503.01
Operator: KULAS
Run Date: 11-Jun-90 13:13

Sample: GEOTECH #602A REPEAT#4
Size: 48.5600 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH #602A

TGA

File: A:GT602A.04
Operator: KULAS
Run Date: 20-Jun-90 08:29

Sample: GEOTECH#603A
Size: 46.8600 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#603A

TGA

File: A: GT603A.01
Operator: KULAS
Run Date: 12-Jun-90 06:54

Sample: GEOTECH#702A REPEAT UNGROUNDED TGA

Size: 42.8520 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#702A

File: A:GT702A.02

Operator: KULAS

Run Date: 12-Jun-90 10:52

Sample: GEOTECH#703A
Size: 47.5170 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#703A

TGA

File: A:GT703A.04
Operator: KULAS
Run Date: 12-Jun-90 14:36

Sample: 6E0TECH#1202

Size: 56.5740 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#1202

TGA

File: A:6T1202.01

Operator: KULAS

Run Date: 13-Jun-90 06:37

Sample: GEOTECH#1204
Size: 60.7440 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#1204

TGA

File: A:GT1204.01
Operator: KULAS
Run Date: 13-Jun-90 10:01

Sample: GEOTECH#1204A

Size: 47.4030 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#1204A

TGA

File: A:GT1204A.01

Operator: KULAS

Run Date: 13-Jun-90 11:39

TGA V4.0D DuPont 2100

Sample: GEOTECH#1205A
Size: 50.8480 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#1205A

TGA

File: A:6T1205A.01
Operator: KULAS
Run Date: 13-Jun-90 13:35

Sample: GEOTECH#1302A

Size: 60.6120 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#1302A

TGA

File: A:GT1302A.01

Operator: KULAS

Run Date: 14-Jun-90 06:39

Sample: GEOTECH#1304A

Size: 51.2780 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#1304A

TGA

File: A:GT1304A.01

Operator: KULAS

Run Date: 14-Jun-90 08:20

Sample: GEOTECH#1305A
Size: 43.0270 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#1305A

TGA

File: A:GT1305A.01
Operator: KULAS
Run Date: 14-Jun-90 10:00

Sample: GEOTECH#2102A
Size: 56.7520 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#2102A

TGA

File: A:GT2102A.01
Operator: KULAS
Run Date: 14-Jun-90 13:19

Sample: GEOTECH#2201

Size: 56.3460 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#2201

TGA

File: A:GT2201.01

Operator: KULAS

Run Date: 14-Jun-90 14:59

Sample: GEOTECH#2201A

Size: 64.1700 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#2201A

TGA

File: A:GT2201A.02

Operator: KULAS

Run Date: 15-Jun-90 08:32

Sample: GEOTECH#2302A

Size: 49.5860 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#2302A

TGA

File: A:GT2302A.02

Operator: KULAS

Run Date: 18-Jun-90 07:19

Sample: GEOTECH#2303A
Size: 49.0220 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#2303A

TGA

File: A:GT2303A.01
Operator: KULAS
Run Date: 18-Jun-90 09:00

Sample: GEOTECH#2304A
Size: 47.0000 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#2304A

TGA

File: A:GT2304A.01
Operator: KULAS
Run Date: 18-Jun-90 11:49

Sample: GEOTECH#2402A

Size: 56.0840 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#2402A

TGA

File: A:GT2402A.01

Operator: KULAS

Run Date: 18-Jun-90 13:31

Time (min)

TGA V4.0D DuPont 2100

Sample: GEOTECH#2403A
Size: 47.6670 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#2403A

TGA

File: A:GT2403A.01
Operator: KULAS
Run Date: 19-Jun-90 06:50

Sample: GEOTECH#2404
Size: 61.2920 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#2404

TGA

File: A:GT2404.01
Operator: KULAS
Run Date: 15-Jun-90 10:59

Time (min)

TGA V4.0D DuPont 2100

Sample: GEOTECH#2404A

Size: 45.1580 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#2404A

TGA

File: A:GT2404A.01

Operator: KULAS

Run Date: 19-Jun-90 08:29

Sample: GEOTECH#2503A
Size: 45.3460 mg
Method: MORETTI
Comment: PROXIMATE ANALYSIS OF GEO TECH#2503A

TGA

File: A:GT2503A.01
Operator: KULAS
Run Date: 19-Jun-90 10:15

Sample: GEOTECH#2504A

Size: 47.7910 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH#2504A

TGA

File: A:GT2504A.01

Operator: KULAS

Run Date: 19-Jun-90 11:53

Sample: GEOTECH EER-SLAG

Size: 50.5200 mg

Method: MORETTI

Comment: PROXIMATE ANALYSIS OF GEO TECH EER-SLAG

TGA

File: A:GTSLAG.01

Operator: KULAS

Run Date: 19-Jun-90 13:36

APPENDIX 11

ANALYSIS REPORT FORM

REQUESTOR

Ed Olson

PROJ. #

5420

SAMPLE INFO

UFDA Coal Samples

AS RECEIVED VALUES REPORTED

DATE SUBMITTED

4-20-90

SAMPLE ID.

2489	2490	2491	2492	2493	2494	2495
DOE 0101	DOE 0201	DOE 0301	DOE 0601	DOE 0701	DOE 1001	DOE 1301
1	2	3	4	5	6	7

LAB #

39205	39206	39207	39204	39208	39209	39210
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PARAMETER

PROXIMATE

%

Moisture

%

Volatile Matter

%

Fixed Carbon (IND)

%

Ash

%

ULTIMATE

%

Hydrogen

%

Carbon

%

Nitrogen

%

Sulfur

%

Oxygen (IND)

%

HEATING VALUE

BTU/LB

24.10	18.40	6.70	14.50	12.30	4.50	12.30
32.36	32.00	33.71	29.78	31.30	29.86	30.02
33.72	40.18	49.68	47.67	46.64	52.62	48.51
9.80	9.40	9.89	8.04	9.75	13.00	9.15
6.21	5.62	4.87	6.21	5.42	4.83	5.71
46.07	54.29	63.58	62.19	59.37	69.23	61.31
0.72	0.82	1.19	1.39	1.09	1.36	1.37
0.84	0.57	3.35	2.35	3.05	0.98	2.44
36.33	29.28	17.09	19.80	21.30	10.58	19.99
7787	9415	11235	10796	10304	12354	10751

DATE REPORTED October 22, 1990

REPORTED BY D. H. Amick

DISTRIBUTION 10/22/90 DCH

DATE REPORTED October 22, 1990
REPORTED BY J. Harvath
DISTRIBUTION 15/22/90 JEPH

REQUESTOR
PROJ. #
SAMPLE INFO
DATE SUBMIT

10/90

SAMPLE ID.

1 2 3 4 5 6 7

LAB #

39841					
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PARAMETER OXIDES

% % % % % % % % %

[illegible]

DISTRIBUTION - 11-21-90

REQUESTOR	<u>Ed Olson</u>
PROJ. #	5420
SAMPLE INFO	<u>UFDA Bulk Grab Raw Coal</u>
DATE SUBMITTED	10/90

10/90

3109

1

11

6/61A
6/61A
6/61A
6/61A
6/61A
6/61A
6/61A

DISTRIBUTION 11-19-90

**DATE
FILMED**

10/25/93

END