INVESTIGATION OF MUSCOVITE MICA IN GREISEN, SIMS GRANITOID INTRUSIVE, WILSON COUNTY, NORTH CAROLINA

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Investigation of Muscovite Mica in Greisen, Sims Granitoid Intrusive Wilson County, North Carolina

by

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ABSTRACT

Field and laboratory studies were conducted to evaluate the commercial muscovite potential of greisen associated with the Sims granitoid pluton. A zone of greisen-bearing granitoid, approximately 2 miles in length, was delineated in the southwestern portion of the pluton. An occurrence of greisen boulders, comprising an area of about 2.5 acres near the eastern end of the zone of greisen-bearing granitoid (Zone B), is estimated to contain possible reserves of 230,000 - 240,000 short tons of muscovite to a depth of 100 feet. The estimated mica content of the boulders is >75 wt. %. Quartz and feldspar are possible by-products.

Mineral beneficiation studies indicate that muscovite recovery exceeds 90 wt.%. The grade of mica in concentrates exceeds 98 wt.%. Muscovite concentrates contain an extremely high K_2O *content* (10.81% K_2O). Consequently, the mica would make an excellent material in the flux coating of welding rods. Low brightness and yellowish coloration may limit use of the greisen-mica in joint cements and textural paints. Bulk density of the muscovite is also higher than that of most commercial mica products. However, with proper grinding techniques, bulk density may be reduced to acceptable levels.

INTRODUCTION

Greisen, a rock comprised mainly of muscovite and quartz, is associated with the Sims granitoid intrusive in Nash and Wilson Counties, North Carolina (Figure 1). This report is a preliminary evaluation of muscovite in the greisen as a commercial mineral resource. It is a joint study between the North Carolina Geological Survey (NCGS) and the Minerals Research Laboratory (MRL). Field studies and sample collections were conducted by NCGS personnel. Ore dressing studies were performed by MRL.

Almost 25 years ago, these agencies cooperated in a statewide investigation of mica resources (Lewis and others, 1971). In the eastern Piedmont, muscovite associated with greisen was found to have the highest quality. Lewis and others (1971) recommended that ..."future investigations should be devoted to finding greisen of wide extent". The present study of greisen associated with the Sims intrusive is in keeping with these earlier findings and recommendations.

1 North Carolina Geological Survey
2 N. C. Minerals Research Laboratory
3 Mineralogical Society of America

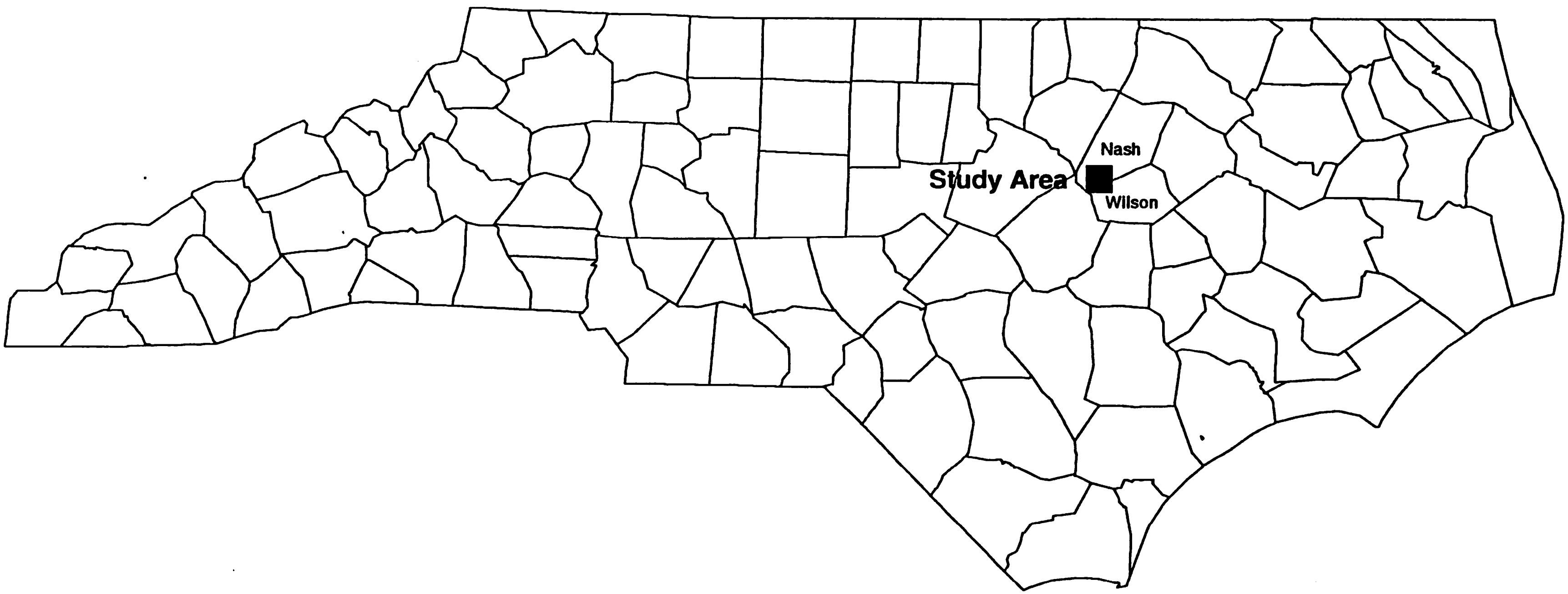

Figure 1. Map showing location of study area in Nash and Wilson Counties, North Carolina.

OCCURRENCES AND USES OF MUSCOVITE MICA

Muscovite mica, commonly referred to as potassium mica, is generally colorless to pale green in color. A summary of the muscovite mica industry has been presented by Tanner (1994). In the United States, muscovite is mined from pegmatite, alaskite, and muscovite mica schist. North Carolina is the leading U.S. producer and accounts for approximately 60% of U.S. mica production. Production is mainly from alaskite deposits in the Spruce Pine area where mica is mined as a byproduct, or coproduct, with feldspar or kaolin. Muscovite is also produced as a by product of spodumene mining near Kings Mountain, North Carolina

According to the U.S. Bureau of Mines (Davis, 1994a,1994b), the two most important categories of mica are "scrap and flake mica" and "sheet mica". Sheet mica is produced from large "books", or mica crystals, which occur mainly in pegmatites. Scrap and flake mica include mica wastes from sheet mica operations, as well as muscovite mined from other types of occurrences in pegmatite, alaskite, or mica schist. Although greisen is not currently mined for muscovite in the U.S., the size of contained muscovite crystals is consistent with that in scrap and flake mica deposits.

In 1993, the U.S. consumed 98,000 tons of scrap and flake mica in a variety of products (Davis, 1994a). Properties of muscovite that account for its wide usage include chemical inertness, prominent basal cleavage, transparency, luster, sheen, high aspect ratio, high electrical resistivity, high thermal resistivity, excellent mechanical and thermal strength, and low moisture absorption. Product uses depend largely on processing procedures (Tanner, 1994). Wet ground mica is used in rubber products, outside house paint, sealers, and plastics. Dry ground mica is used in welding rod flux, roofing felt and shingles, and in oil well drilling muds. Very fine-particle dry ground mica (micronized mica) is used in cosmetic applications such as nail varnishes, lipsticks, and eye shadow.

Sheet mica is widely used in the electrical and electronic industries because of its high dielectric strength, unform dielectric constant, and low temperature coefficient. In 1993, the U.S. consumed 2,450 tons of sheet mica (Davis, 1994b). Almost all of the sheet mica consumed was imported.

GEOLOGY

The Sims pluton is one of a number of Alleghanian granitoids of the southern Appalachians (Figure 2a). The age of the pluton is 287 ± 9 Ma (Wedemeyer and Spruill, 1980). It is a composite body with two major and several minor dike facies. The major lithologies are both coarse-grained biotite granitoids that differ in the appearance of the alkali feldspars, color, degree of alteration, accessory mineralogy, and mineral compositions. The contact between the two is gradational and it is concluded that both facies formed from the same magma, but crystallized under different conditions.

The Conner granitoid occurs in the western and southern sides of the pluton (Figure 2b). It is a

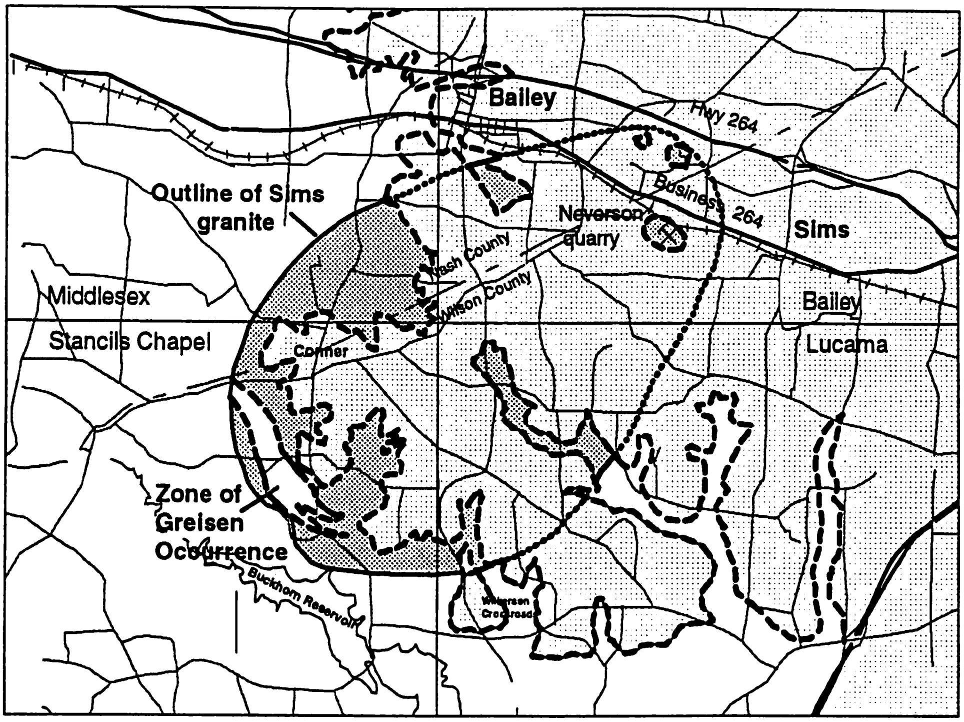

Figure 2a. Scale 1 inch = 2 miles. Geologic map showing outline of Sims granite, zone of greisen occurrence and boundaries of the Middlesex, Stancils Chapel, Bailey and Lucama 7.5-minute quadrangles. Granitic rock (dense pattern), Coastal Plain sediment (light stippled pattern), and country rocks of the eastern Slate belt (no pattern). Adapted from Speer (1991), Hoffman and Carpenter (1992), and Carpenter and others (1994).

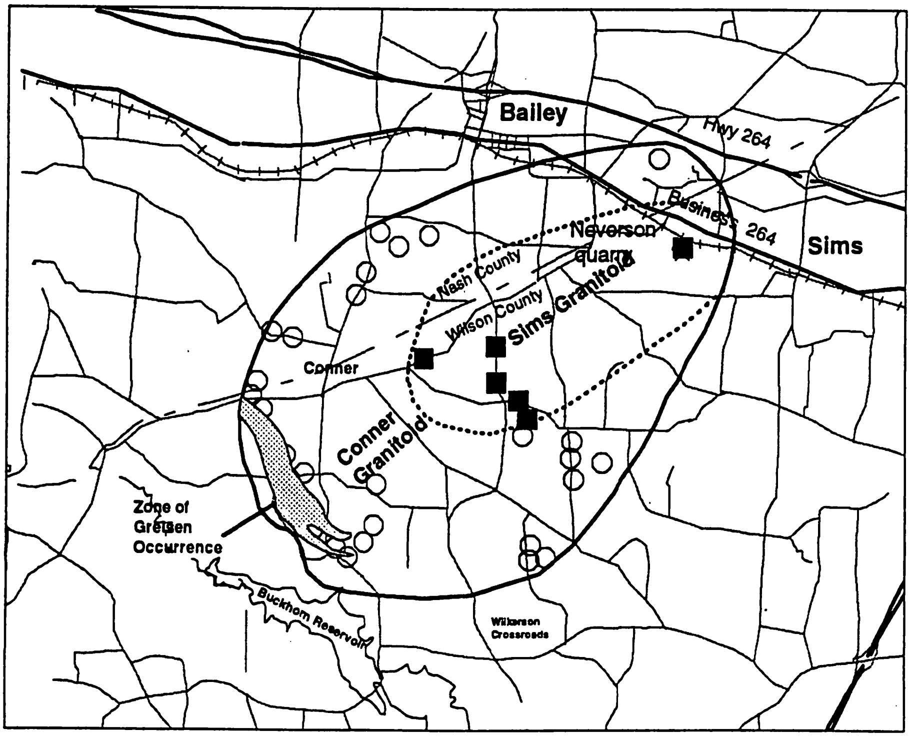

Figure 2b. Scale 1 inch = 2 miles. Map showing Connor granitoid (megacrystic phase) and Sims granitoid (equigranular phase) of Sims intrusive. Principal outcrops are shown by open circles (Connor granitoid) and closed squares (Sims granitoid). Adapted from Speer (1991) and Carpenter and others (1994).

coarse-grained, inequigranular biotite granitoid containing abundant subhedral to euhedral, orange pink alkali feldspars up to 5 cm (2 inches) across in a light gray matrix of grains less than 1 cm in size. Modal analysis shows these rocks are monzogranites with a color index (CI) <5. Biotite is the only varietal mineral and has Fe/(Fe + Mg) = 0.60. Magmatic accessory minerals include apatite, monazite, zircon, magnetite, exsolved hemo-ilmenite, columbite, pyrite, chalcopyrite, and pyrrhotite. Calcite, chlorite, epidote, fluorite, Nb-rutile, and muscovite are secondary accessory minerals. The greisen is restricted to the Conner granitoid (Figure 2b).

The Sims granitoid occurs in the center and northeastern corner of the pluton (Figure 2b). It is also coarse-grained biotite granitoid, but it is equigranular. The mineral grains, including the alkali feldspars, are less than 1.4 cm in size. Modal analysis show that the rocks are monzogranites with a color index (CI) < 5. Contrasting colors of the major minerals give the rock a mottled appearance, but overall the rock is pale red to grayish red. Biotite is the varietal mineral and has Fe/(Fe + Mg) = 0.46. Magmatic accessory minerals include allanite, apatite, columbite, zircon, magnetite, coarsely exsolved hemo-ilmenite, chalcopyrite, pyrite, and pyrrhotite. Magnetite is relatively abundant as compared to the Conner granitoid. Secondary accessory minerals are calcite, fluorite, epidote, hematite, muscovite, Nb-bearing rutile, and titanite.

Greisen associated with the Sims pluton was first identified in the late 1960's in a mineral exploration program described by Cook (1972). It has subsequently been studied by Farrar (1985), who described these rocks as quartz-muscovite hornfels. More recently, Speer (1991) has investigated the mineralogy of the greisen.

Exposures of greisen are restricted mainly to boulders ranging from over 10 feet in maximum dimension to fragments less than an inch in size. In rare outcrops, northwest-trending veins of greisen cut megacrystic granitoid (Connor granitoid). Muscovite occurs as pale yellow-brown, unoriented crystalline aggregates up to 5 mm in diameter. Locally the muscovite is color zoned, with darker interior bands paralleling the crystal boundaries. Muscovite:quartz ratios of boulders range from approximately 90:10 to 10:90. On average, muscovite comprises over 50% of the mineral assemblage. Irregular masses of limonite-after-pyrite are locally present. Other sulfides identified in greisen include chalcopyrite and molybdenite (Cook, 1972). Weathering of sulfide minerals has resulted in staining of surfaces of muscovite grains by red iron oxide. Black organic growth (lichen ?) commonly encrusts muscovite on some of the larger boulders giving the mica a black appearance in contrast to whitish quartz which is not encrusted to the same degree. Feldspar is rare in greisen. In some exposures, quartz appears as rectangular masses enclosed by muscovite. These masses are comparable in size and shape to feldspar crystals in the megacrystic granitoid. This relationships suggests that some greisen may have formed by replacement of granite.

Figure 3 is a map showing the distribution of greisen-bearing boulders. Within the zone containing greisen, boulders of granitoid rock are also common. In two areas, the relative proportion

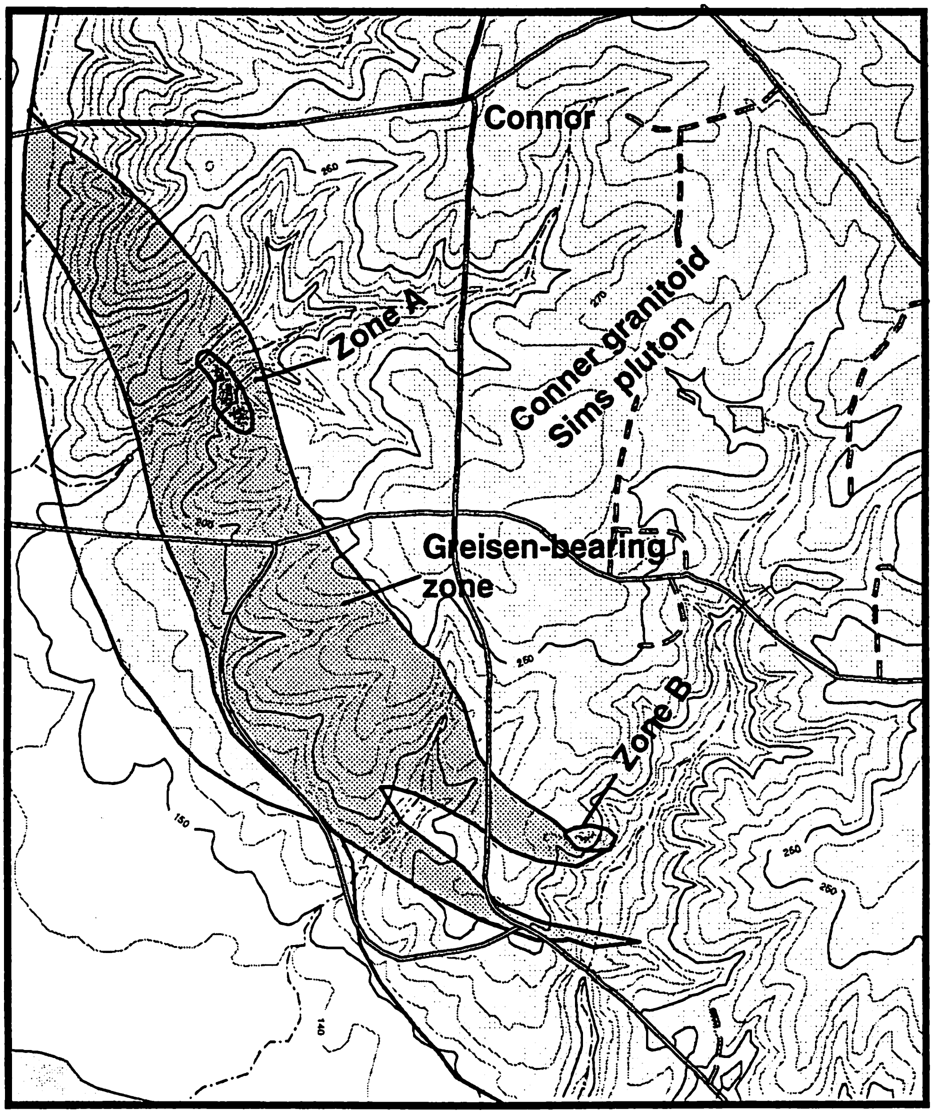

Figure 3. Scale 1 inch = 2000 ft. Geologic map showing greisen-bearing zone, Zone A, Zone B, the Conner granitoid (light stippled pattern).

of greisen:granitoid boulders is high, and the size of greisen boulders is considerably larger, commonly exceeding 10 feet in maximum dimension. These are shown as Zones A and B (Figure 3).

A large boulder from Zone A was the source of greisen used in ore dressing tests. Although it was the freshest sample identified in the area, some red stains of iron oxide are present on surfaces of muscovite crystals. Thus the iron content, as well as the brightness measurements of muscovite, may not be representative of fresh, unweathered, greisen at depth.

The distribution of greisen and granitoid boulders in Zone A suggests a series of northwest trending veins of greisen, possibly 5 to 10 feet thick, separated by zones of granitoid rock 20 to 30 feet thick. In the widest portion of Zone A, 4 or 5 veins of greisen comprise the zone.

Zone B is approximately 500 feet in length and 225 feet in average width. The northern contact with granitoid rock is fairly sharp. This zone consists almost entirely of greisen boulders, most of which appear to contain more than 75% muscovite. Many boulders are over 10 feet long. Unlike Zone A, alternating zones of granite and greisen are not indicated. The relative proportion of greisen:granitoid appears to be much higher for Zone B. However, it is not possible to determine the actual proportion of greisen to granitoid rock in the subsurface. Greisen is more resistant than granite. Consequently, its relative abundance in residual boulders is enhanced.

ORE DRESSING STUDIES

Summary of Tests

The sample provided by NCGS weighed 8399 grams. A flowsheet of bench tests used in processing the sample is presented in Figure 4. Summary tables for bench tests and details of laboratory procedures are presented in Appendix 1. Major processing steps included crushing, grinding, and froth flotation.

The mica content of the sample determined magnetically is 81.2% (Table 1, Appendix 1). An independent determination by grain counting of a representative sample is 83% (Merschat, written communication). In several tests, mica recovery ranged from 88% to 99.5%. The grade of mica in concentrates produced by flotation exceeded 98%.

CONCLUSIONS

Evaluation of Test Results

Compared to mica products currently being supplied in the U.S., muscovite in the greisen sample contains an extremely high potassium content (Table 9, Appendix 1). Consequently, it would make an excellent material in the flux coating of welding rods. The mica might also be suitable for dusting rubber compounds. Some drawbacks to the greisen mica include high grinding hardness, low brightness, and high bulk density. Grinding characteristics may be satisfactory in a fluid energy mill (not available for these tests) which would yield a higher proportion of fine mica. Some improvement in brightness is expected with finer grinding. Bulk

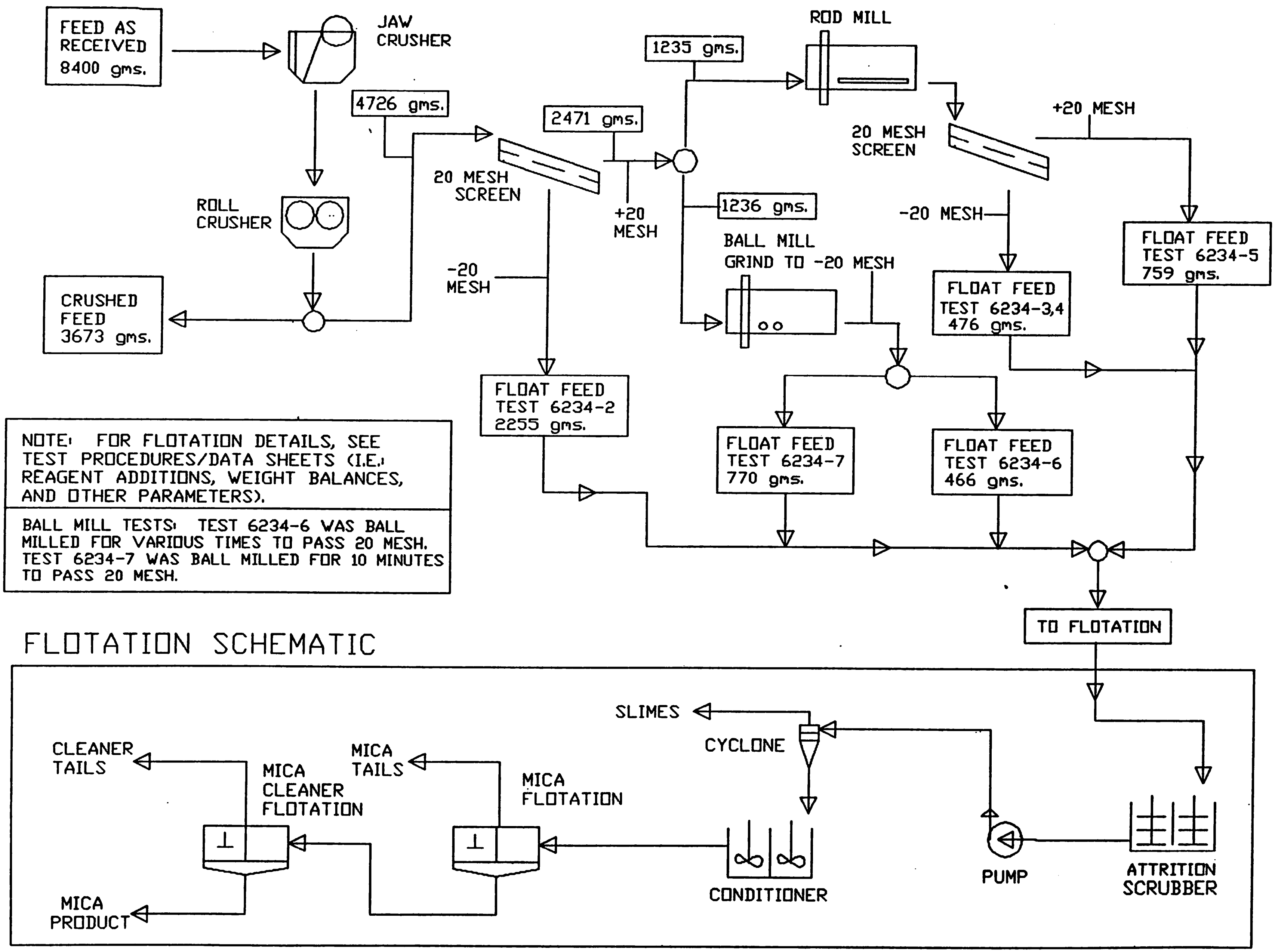

Figure 4. Beneficiation of greisen mica bench test - flowsheet

density will probably be reduced to acceptable levels by proper grinding techniques. For important uses in joint cement, plastic fillers and extenders, and textural paint, greisen mica could be mixed with higher brightness mica to meet specifications of these products.

Procedures used in Test 7 (Table 7, Appendix 1), with some refinement, would make an excellent production process.

Reserve Estimates - Zone B

Zone B (Figure 3) is considered to be the best commercial prospect because of the high mica content of the boulders, and the general lack of granite boulders within the deposit. The following assumptions are used in calculating possible reserves to a depth of 100 feet from the base of the regolith cover:

Area - 2.58 acres

Average Density - 2.7 gm/cubic cm. (168.75 lbs/cubic ft., 11.85 cubic ft/short ton)

Weight % Muscovite - 25% [Assumes average mica content of greisen is 75 wt. % which is reduced to 25% by dilution of granitic rock]

Calculated reserves of muscovite to a depth of 100 feet is 237,098 short tons (215,092 metric tons). Losses in mining and milling could be between 5% and 10%.

Considering that annual U.S. production of scrap and flake mica ranged from 89,000 to 119,000 metric tons (98,106 to 131,175 short tons) between 1989 and 1993 (U.S. Bureau of Mines, 1994), the calculated reserve base of Zone B is adequate to sustain a major operation.

Potential by-product minerals include quartz from greisen and granitoid rocks, and feldspar from granitoid rocks.

ACKNOWLEDGEMENTS

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APPENDIX 1

PROCEDURE AND TEST RESULTS
GREISEN MICA SAMPLE

Procedure

The total sample received from the NCGS (8399 grams) was crushed in a laboratory 6-inch jaw crusher. It was then crushed in a 6-inch double roll crusher to about 1/4 inch. The sample was split on a riffle splitter into two halves. Sample 1 (4726) grams was screened on a 20 mesh Tyler sieve and Sample II was set aside for further work. The -20 mesh fraction (2255 grams) of Sample 1 was prepared for flotation by further splitting out 500 gram samples for froth flotation. The samples were floated on a 2-liter Denver cell at 1200 RPM shaft speed (942 ft/min. tip speed) and approximately 25% solids. The details follow:

1. A 500 gram sample of -20 mesh material was scrubbed in a hexagonal pot using a three-tier impeller whose blades were pitched at 45°, and then deslimed twice on a 100 mesh Tyler sieve. The sample was conditioned (with rosin amine acetate, sulfuric acid, and a frother) at 50% solids in a 1000 ml beaker using a shaft with a single impeller at 700 RPM. The pH was adjusted to 2.5. The conditioning step was followed by flotation in a 2-liter Denver cell. The flotation impeller shaft speed was 1200 RPM (single impeller). One rougher and one cleaner float was employed. (See Table 2 for further details.)

2. The +20 mesh material from Sample 1 was split in half. A 1235 gram sample of the +20 mesh product was added to a 8.5" diameter x 9" long rod mill containing eleven rods weighing 13 kilograms. Enough water was added to bring the percent solids to 40%. The slurry was milled for two minutes at 55 RPM. The contents of the mill were wet screened on a 20 mesh Tyler sieve and both fractions were filtered on a Denver vacuum filter. The filter cakes were dried at 110° C in a laboratory size electric oven. The -20 mesh fraction from this procedure was then floated (Table 3).

A 500 gram sample from the +20 mesh fraction from the mill fraction was split out for flotation. A small amount of fuel oil was added to "pull" the coarse mica fraction (see Table 5). A rougher tail developed from this float that had a large percent of mica present. Therefore, these tailings were further ground in a ball mill using the ball charge shown in Table 10. The ground slurry was deslimed two times on a 100 mesh sieve. The -20 +100 mesh concentrate was given one rougher and one cleaner float.

Two more 500 gram samples were split out of the other half of the +20 mesh fraction. The first sample was ball milled for various times, up to 6 minutes (shown in Table 6), in order to determine the grinding time necessary to liberate most of the quartz. The slurry was then screened on a 20 mesh sieve and the -20 mesh fraction was floated.

The second sample was ball milled for 10 minutes in order to reduce the amount of +20 mesh material. The -20 mesh fraction of this sample was floated (see Table 7). Additional amine was used to increase recovery.

Discussion of results

The mica content of the head feed sample was determined magnetically to be 81.2% (Table I). An independent analysis of a representative sample by point counting indicated a muscovite content of 83% (Merschat, written communication). The muscovite content of the greisen is extremely high even when compared to mica schist (40 - 60% mica).

The flotation test shown in Tables 2 - 7 were all performed using -20 + 100 mesh material, except Test 5 which was performed using +20 mesh mica and was a failure. Minus 20 mesh is the maximum size at which mica is liberated from the gangue minerals (mainly quartz), and is also the particle size amenable to flotation. Most mica operations deslime at either 80 or 100 mesh to free the mica pulp of unwanted clays and fine silica that will float with the concentrate. Slight changes were made in each of the flotation tests in an effort to improve grade and recovery.

The test shown in Table 2 shows a good recovery of 88% of the float feed and an excellent grade of over 98%. The grade was determined on a Frantz Isodynamic magnetic separator. The slimes were not considered in calculating the overall recovery in order to better highlight grade and recovery of mica produced from the flotation process. Moreover, the mineral content of the slimes could not be determined with the equipment on hand.

Slightly more amine collector was added in Test 3, and this extra addition resulted in an excellent recovery of 99.5%, with the grade remaining the same as Test 2. Both the grade and recovery shown in this test are about the maximum that can be expected.

The concentrate from Test 2 and 3 were ground in a "coffee grinder" to minus 100 mesh (see Table 4). This proved to be extremely difficult because the mica is hard and "booky". As noted in Table 4, the particle size is not nearly as fine as a typical commercial fine ground mica product. However, the commercial mica was ground in a fluid energy mill, and it is assumed that an equivalent size product could be made from greisen-mica using the same method.

As a partial result of the coarse grind, the brightness was much lower than commercial fine ground mica. Brightness improved greatly when just the minus 325 mesh fraction was measured, although it is still below commercial mica standards.

The bulk density is also much higher than the bulk density of commercial fine mica although this property also improved with finest of grind (Table 4). The bulk density will probably improve more if ground in a fluid energy mill.

The color of the mica had a slightly yellow hue as shown in Table 4. A plus 20 mesh fraction was ground in a ball mill in Test 6 in an effort to determine the mica content and grade possible with this fraction of the head feed. As will be noted, the scrubbing step was not used because this fraction appeared to be extremely clean. The ground material was screened on a 20 mesh sieve and the -20 mesh was floated. The plus 20 mesh remaining was examined for grit. The flotation grade obtained in Test 6 was excellent, however, the recovery was low. A high percentage of mica reported to the cleaner tails indicating insufficient reagent dosage. Both the slimes and +20 mesh fraction did not enter into the grade or recovery calculations shown. The slimes were not considered for the reasons already stated, and the +20 mesh was not considered because there was an abundance of sand still present, indicating the need to reprocess this fraction. As is noted in Test 6, several ball mill grinding times were used in an effort to determine where the point of complete liberation of sand and mica occurred, and at the same time creating a minimum amount of slimes. The optimum grinding time was not achieved even though a total of 6 minutes was used.

Test 7 was a repeat of Test 6 except that a grinding time of 10 minutes was arbitrarily chosen. As can be seen in Table 7, this amount of grinding time seemed to be sufficient to achieve complete liberation. The +20 mesh fraction appeared to be free of gangue minerals. It must also be noted that twice as much slime was created. However, the grade was extremely high and the overall recovery was almost 95%, excluding the slimes. The process in this test is considered almost optimal. It might be possible, if a continuation of this investigation is desired, to use less (between 6 and 10 minutes) grinding time and produce the same results while at the same time reducing the slimes.

The results of grinding the +20 mesh products in a rod mill is shown in Table 8. This test illustrates the resistance to grinding inherent with this product.

The wet chemical analysis is shown in Table 9. Compared to other commercial muscovite products, the K_2O content is extremely high. Consequently, greisen-mica would be an excellent material in the flux coating of welding rods. The screen size of the concentrate shown in Table 10 indicates a possible application in oil well drilling or asphalt roofing shingles. However, the bulk density would be too high for these purposes. Bulk density might decrease upon hammer milling.

Conclusions from tests

1. The greisen-mica is much harder to grind than normal muscovite obtained from either "hard rock" alaskite or weathered alaskite.

2. The mica should grind to commercial sizes in a fluid energy mill.

3. Neither the brightness nor bulk density compared with commercially used joint cement and textured paint micas. However, the brightness improved with finest of grind as did the bulk density.

4. The bulk density will probably be reduced to acceptable levels by proper grinding techniques.

5. The greisen-mica will make an excellent welding rod mica because of its high K_2O content.

6. The greisen mica might be mixed with better brightness mica for joint cement, plastic fillers and extenders, and textured paints.

7. Greisen mica might be suitable for dusting rubber compounds.

8. The procedure used in Test 7 is almost optimal, and with some refinement, would make an excellent production process.

Table 1. Determination of % mica in head feed sample determined in Frantz using 1.5 amps

Test No. 1 Lab No. 6234 Operator: Grotto Date: 1/31/95

		% Wt.
Mica		81.2
Sand		18.8
	Total	100.0
% Magnetic= (0.5 amps)		1.60%

Procedure:

1. Sample crushed in a mortar with a pestle to pass 20 mesh Tyler sieve. This procedure was required to liberate sand.
2. Minus 20 mesh feed through a Frantz Isodynamic separator at 1.5 amps to seperate mica from sand (approximately 7500 guass field strength).

Table 2. ***Float Greisen mica from -20 mesh ore (See Figure 4)***
Test No. 2 Lab No. 6234 Operator: Grotto Date: 1/4/95

	Wt. %	Units Mica	% Dist.	Units Sand	% Dist.	Units Mag.	% Dist.	Grade	Recov.
Float Product	68.7	67.6	88.1	0.9	4.8			98.4	88.1
Rougher Tails	25.4	7.1	9.1	16.9	71.8	1	100		
Cleaner Tails	0.6			0.6	3.4				
Slimes (-100 mesh)	5.3	ND							
Total	100.0		100.0		100.0				

	Conditions			Reagents (lbs. per ton)				
Process	Time Min.	% Solids	pH	2.5% NaOH	2.5% H_2SO_4	2.5% Arm-T	F-65 Froth	RPM
Scrub	10	70	9.5	0.5				1000
Deslime 100M	2X							
Condition	3	50	2.5		0.65	0.50	0.1	700
Rougher Flot	1X					0.05		1200
Cleaner Flot	1X					0.50		1200

Note: Recovery and grade represent -20 mesh fraction only (see Fig. 1).

	Frantz Analysis		Frantz Analysis (0.5 amps) Stained Mica and Magnetics	
	Float Product	Rougher Tails	Float Product	Rougher Tails
Mica	98.4%	35.6%	Mica = 0.00	stained 4.00
Sand	1.6%	64.4%		
Total	100.0	100.0		

Note: Dist = distribution

100% non-stained mica

Table. 3 Float mica from rod milled -20 mesh ore (see Figure 4)

Test No. 3 Lab No. 6234-3 Operator: Grotto Date: 1/5/95

	Wt. %	Units Mica	% Dist.	Units Sand	% Dist.	Units Mag.	% Dist.	Grade	Recov.
Float Product	83.20	81.80	99.5	1.70	12.7	trace		98.3	99.5
Rougher Tails	11.90	0.44	0.5	11.46	85.1			98.3	99.5
Cleaner Tails	0.30			0.30	2.2				
Slimes (-100 mesh)	4.60	4.60							
Total			100.0		100.0				

	Conditions			Reagents (lbs. per ton)				
Process	Time Min.	% Solids	pH	2.5% NaOH	2.5% H_2SO_4	2.5% Arm-T	F-65 Froth	RPM
Scrub	10	70	10.6	0.5				1000
Deslime 100M	2X							
Condition	3	50	2.5		0.52	0.5	0.1	700
Rougher Flot								1200
Cleaner Flot						0.5		1200

Remarks:

Frantz Analysis (1.5 amps)

	Float Product	Rougher Tails
Mica	98.3%	3.7%
Sand	1.7%	96.3%
Total	100.0	100.0

Frantz Analysis (0.5 amps) stained Mica and Magnetics

Float Product Rougher Tails

Mica = 0.00 stained 3.6% stained

100% non-stained mica

Table. 4 Physical properties from a ground cleaner float product from Test 3, bulk density, brightness, screen analysis

Test No. 4 Lab No. 6234 Operator: Grotto Date: 1/9/95

Tyler Sieve Sizes	Retained % Weight	Commercial Joint Cement Mica % Weight
+60	0	0
-60 +100	0.2	1.5 max
-100 +140	22.1	
-140 +200	12.8	10 min
-200 +270	12.7	
-270 +325	24.1	
-325	28.1	50 min 70 typical
Total	100.0	

Remarks:	Commercial Mica
1. Bulk Density of Float Concentrate = 72.4 lbs./cu. ft.	25-35 lbs./cu. ft.
2. Bulk Density of -100 mesh product = 27.1 lbs./cu. ft.	13-16 lbs./cu. ft.
3. Brightness (Photovoltmeter Model 670) -100 mesh	
a. W search unit (paper brightness) = 56.5	
b. Y search unit = 1. Green Filter = 55	70-75
2. Amber Filter = 55.8	
3. Blue Filter = 50.0	
4. Degree of Yellowness = 0.11	
4. Brightness - Y search unit	
(-325 Mesh) 1. Green Filter = 65.5	70-75
2. Amber Filter = 67.9	
3. Blue Filter = 61.5	
4. Degree of Yellowness = 0.10	
Bulk Density = 20.6 lbs./ft3	

Table. 5 Float rod milled (2 min) +20 mesh material

Test No. 5 Lab No. 6234 Operator: Grotto Date: 1/9/95

	Wt (g)	Wt. %			Wt (g)	Wt. %
Ro-Tails	364.20	73.0	Rougher 2 Tails		195.3	54.7
Cleaner Tails	11.70	2.3	Cleaner 2 Tails		5.6	1.6
Cleaner F.P.	109.50	21.9	Cleaner 2 F.P.		140.0	39.2
Slimes (-100 Mesh)	13.50	2.8	Slimes 2 (-100)		16.1	4.5
Total	498.90	100.0		Total	357.0	100.0
St. Wt.	502.60		Start Wt.		364.2	
% Loss	0.74					

	Conditions			Reagents (lbs. per ton)					
Process	Time Min.	% Solids	pH	RPM	NaOH	H_2SO_4	ARM-T	F-65 Froth	Fuel Oil
Scrub	10	70	10.3	1000	0.5				
Deslime 100M	2X								
Cond/Beaker	3	50	2.5	700		0.95	0.50	0.1	3 drops
Float-Rougher				1200					
Cond. in Cell	1						0.05		
Float-Cleaner				1200					
Filter & Dry									
Grind Ro-tails in ball mill	2								
Deslime 100M	2X								
Cond. in Beaker	3	50	2.5	700		0.5	0.50	0.1	3 drops
Flot-Rougher 2				1200					
Cond. in Cell	1			1200			0.05		
Flot-Cleaner 2				1200					

Table. 6 ***Ball Mill +20 Mesh Material - Screen and Float -20 Mesh***

Test No. 6 Lab No. 6234 Operator: Grotto Date: 1/11/95

	Wt. %	Wt. % Float	Units Mica	% Dist.[1]	Units Sand	% Dist.[1]	Grade	Recov.
+20 Mesh	18.3							
Float Product	45.5	60.3	59.9	70.4	0.42	2.8	99.3	70.4
Rougher Tails	12.5	16.6	4.6	5.4	12.0	80.4		
Cleaner Tails	17.4	23.1	20.6	24.2	2.5	16.8		
Slimes	6.3							
Total	100.0	100.0		100.0		100.0		

	Conditions			Reagents (lbs. per ton)			
Process	Time Min.	% Solids	pH	2.5% H_2SO_4	2.5% Arm-T	F-65 Froth	RPM
Grind-Balls	2	40					
Add'l. Grind	2						
	1						
	1						
Screen 20M					0.05		1200
Deslime 100M	2X						
Condition	3	50	2.5	0.85	0.50	0.1	700
Rougher Flot							1200
Cond. in Cell	1				0.05[2]		1200
Cleaner Flot							1200

Remarks:

Frantz Analysis (1.5 amps)

	Float Prod.	Cleaner Tails	Rougher Tails
Mica	99.3	89.3	27.6
Sand	0.7	10.7	72.4
Total	100.0	100.0	100.0

Frantz Analysis (0.5 amps) & Mags.

	Float Prod.	Cleaner Tails	Rougher Tails
Mica =	83.0	67.6	72.7
Sand =	17.0	32.4	27.3
Total =	100.0	100.0	100.0

Note 1: Recovery and grade of float product only

Note 2: Not enough amine - increased to 0.15#/ton Test 7

Table. 7 Ball Mill +20 Mesh Material - Screen on 20 Mesh Tyler sieve
Float -20 Mesh Size Fraction -10 Minute Grind

Test No. 7 Lab No. 6234 Operator: Grotto Date: 1/4/95

	Wt. %	Wt. % Float	Units Mica	% Dist.[1]	Units Sand	% Dist.[1]	Overall Grade[2]	Grade[1]	Recov.[2]
+20 Mesh	9.3						98.5		
Float Product	65.3	83.2	81.5	93.8	1.7	12.9	Over-	98	93.8
Rougher Tails	9.2	11.7	1.3	1.5	10.4	78.8	all		
Cleaner Tails	4.0	5.1	4.1	4.7	1.1	8.3	Rec.		
Slimes	12.2						94.6		
Total		100.0		100.0		100.0			

	Conditions			Reagents (lbs. per ton)			
Process	Time Min.	% Solids	pH	2.5% H_2SO_4	2.5% Arm-T	F-65 Froth	RPM
Grind-Balls	10	40					
Screen 20M							
Desl. -20 on 100M	2X						
Dry & Weigh +20M							
Cond. -20 in Beaker	3	50	2.5	1	0.50	0.1	700
Rougher Float							1200
Cond. in Cell	1				0.15		1200
Cleaner Float							1200

Remarks:

Frantz Analysis (1.5 amps)

	Float Prod.	Cleaner Tails	Rougher Tails
Mica	98.0	79.5	11.0
Sand	2.0	20.5	89.0
Total	100.0	100.0	100.0

Frantz Analysis (0.5 amps) & Mags.

	Float Prod.	Cleaner Tails	Rougher Tails
Mica	84.1	52.1	79.5
Sand	15.9	47.9	20.5
Total	100.0	100.0	100.0

Note 1: Grade and recovery of float product only.
Note 2: Calculated excluding slimes.

Table. 8 ***Rod Milling of +20 Mesh Material to Liberate Mica/Sand for Tests 3 and 5***

Test No. 8 Lab No. 6234 Operator: Grotto Date: 1/4/95

Starting weight = 1235 grams of +20 mesh material (see Figure 1)

+20 Mesh	62%
-20 Mesh	38%

	Conditions		
Process	Time Min.	% Solids	pH
Rod Mill	2	40	
Screen Tyler 20 Mesh			
Filter & Dry +20 Mesh and -20 Mesh			

Table. 9 ***Chemical Analysis of Greisen Mica Concentrate***

Test No. 9 Lab No. 6234 Operator: Tanner Date: 1/25/95

OXIDES	Percent by Weight
A1203	30.25
Si02	45.77
Fe203	4.91
Na20	1.98
K20	10.81
Ca0	<.002
Mg0	1.08
Ti02	0.49
LOI	4.62
Total	99.92

Note: Chemistry determined by atomic absorption.

Table. 10 Ball Charges for Small Mill

No.	Size of Mill
14	1.25 inches
41	1.00 inches
99	0.75 inch
178	0.50 inch
Total Weight	9.9 kilograms
RPM of Mill = 55	

Table. 11 Physical Properties from a Ground Cleaner Float Product from Test 7 - Bulk Density, Brightness, Screen Analysis

Test No. 10 Lab No. 6234 Operator: Grotto Date: 2/27/95

Tyler Sieve Sizes	Retained % Wt.	Commercial Joint Cement Mica % Wt.
+60	0.0	0
-60 + 100	1.2	1.50 Max
-100 + 140	28.7	
-140 + 200	29.7	10.0 Max
-200 + 270	18.1	
-270 + 325	5.1	50.0 Min
-325	17.2	70.0 Typical
Total	100.0	

Remarks:	Commercial Mica
1. Bulk Density of Float Concentrate = 43.8 lb./cu. ft.	25-35 lbs./cu. ft.
2. Bulk Density of -100 Mesh Mica Product = 18.7 lbs./cu.ft.	13-16 lbs./cu. ft.
3. Brightness (Photovoltmeter Model 670) -100 Mesh Prod.	
a. Search Unit (Paper Brightness) =	
b. Y Search Unit = 1. Green Filter = 55.0	70 - 75
2. Amber Filter = 57.5	
3. Blue Filter = 54.1	
4. Degree of Yellowness = +0.06	
4. Brightness - Y Search Unit	
(-325 Mesh) 1. Green Filter = 61.0	70 - 75
2. Amber Filter = 63.2	
3. Blue Filter = 59.9	
4. Degree of Yellowness = +0.05	
Bulk Density = 15.6 lbs./cu. ft.	

Table. 12 Screen Analysis of Mica at Various Points in Test 7 Circuit

Tyler Sieve Sizes	Roll Crushed	-20 Mesh Roll Crushed	Cleaner Float Product
+6 Mesh	3.8		
-6 + 16 Mesh	39.7		
-16 + 20 Mesh	7.4	0.8	
-20 + 35 Mesh	18.2	39.0	15.0
-35 + 60 Mesh	18.6	37.1	43.6
-60 + 100 Mesh	6.6	17.5	22.8
-100 Mesh	5.7	10.6	18.6
Total	100.0	100.0	100.0
Bulk Density = lbs./cu. ft.			43.8