69-1-P

CONSERVATION OF NONMETALLIC MINERALS THROUGH IMPROVED PROCESSING

by

Immo H. Redeker
Mineral Dressing Engineer

North Carolina State University
Minerals Research Laboratory

Asheville, North Carolina

This paper is to be presented at the Annual Meeting of the American Institute of Mining, Metallurgical and Petroleum Engineers, Washington, D.C., February 16-20, 1969.

I N D E X

CONSERVATION OF NONMETALLIC MINERALS THROUGH IMPROVED PROCESSING

Immo H. Redeker

Introduction

The Asheville Minerals Research Laboratory is a member of the Engineering Research Department of North Carolina State University. The Laboratory is engaged mainly in applied nonmetallic mineral processing research to assist the North Carolina mining industry. A few out of state projects are handled at times. The Laboratory helped to bring the flotation process to North Carolina feldspar, spodumene, mica and phosphate producers and maintains versatile batch and pilot plant facilities at Asheville. It is of interest that North Carolina has now one of the newest and largest flotation plants at Lee Creek where Texas Gulf Sulphur Company produces 10,000 tons of phosphate concentrate per day, and one of the smallest flotation plants at Pittsburgh Plate Glass Company's fiberglass plant in Shelby, North Carolina where $50,000 per year of platinum-rhodium metal is reclaimed from wasted fiberglass furnace refractories in a tiny flotation operation of pilot plant size. The conservation of mineral resources through improved processing methods has been the object of most of the Laboratory's projects. This work has been extremely interesting and rewarding in many instances.

On the example of projects for Kings Mountain Mica Company it will be demonstrated how waste could be reduced step by step from 20 tons of waste per ton of product to 20 tons of product per ton of waste by improved processing methods. Brick, high grade potash feldspar, and silica sand are now produced from formerly wasted materials.

At this time Laboratory work sponsored by three feldspar companies, the State of North Carolina, and the U. S. Bureau of Mines, is aimed at reducing the amounts of feldspar tailings in the Spruce Pine area. Mineral dressing techniques are applied to reclaim saleable mineral products such as feldspar, mica, quartz, and to make more uniform material for possible ceramic and other applications. Processes to produce new products such as sand-lime brick, and lightweight foamed autoclaved calcium silicate building products will be tested.

The Case of Kings Mountain Mica Company

Mica is produced in North Carolina as a by-product from the feldspar flotation plants and clay plants in the Spruce Pine area, mica is produced as by-product at Foote Mineral Company's spodumene plant, and as a main product from weathered pegmatite ore bodies. At Kings Mountain Mica Company's Moss Plant in Kings Mountain, North Carolina, a weathered pegmatite consisting, in the order of abundance,

of quartz, clay, feldspar and mica is exploited by open pit mining methods. About 500 tons of ore per day are slurried up and reduced in size by rod-milling primarily for mica recovery. The mica is recovered by screening, as 1/4-inch mesh oversize, by Humphrey Spirals in the minus 1/4-inch plus 80 mesh size range and by flotation in the minus 80 plus 200 mesh size range. Clay for brick making is recovered by settling, filtering and drying. Feldspar, quartz and fine mica is recovered by high intensity scrubbing, followed by desliming, mica flotation, iron mineral flotation and feldspar-quartz flotation separation.

The different processes were developed step by step for this particular deposit and will be explained in chronological order.

Mica Recovery by Screening

In 1945 Kings Mountain Mica Company, then Hendricks Construction Company, started to recover scrap mica from weathered pegmatite near Kings Mountain, North Carolina. Basically, crushing by rolls crushers, followed by screening on 1/8-inch, was employed. The plus 1/8-inch material was recovered mica. Everything minus 1/8-inch was wasted, and at a weight recovery of five percent for every ton of mica 20 tons of waste had to be impounded or piled on waste dumps.

Mica Recovery by Spiralling

The Asheville Laboratory developed a process using the Humphrey Spiral for recovery of mica finer than was formerly recovered.[1] The unique principle of separation is that granular feldspar and quartz is removed from the inside ports of the Spiral while the flaky mica particles stay on the outside of the Spiral. The 5-turn Spiral can handle about two tons of material per hour. Kings Mountain Mica Company expanded during the 1950's and installed Humphrey Spirals. Existing screen plant tailings were first treated and when treating fresh ore approximately ten percent of the ore was then recovered as mica and only ten tons had to be disposed of per ton of product. Because of increased production rates, sizable waste piles and ponds grew steadily. About 200,000 tons of coarse waste material was sold during 1962 to 1965 as drainage material for the sides of Interstate Highway 85. Limitations on impounding areas forced the Company to look at other ways to dispose of waste.

---

[1] "New Method for Recovery of Flake Mica", by R. Adair, W. T. McDaniel, and W. R. Hudspeth. Mining Engineering, March 1951, p. 252-254

Bricks from Mica Plant Tailings

North Carolina is a major clay brick producing state; about 12 percent of the nation's clay bricks are produced in North Carolina, which amounts to approximately 900 million per year. Studies to supply this industry with mica plant waste materials were undertaken. Sizing, thickening and filtering tests at the Laboratory and continuous pilot plant testing at Kings Mountain produced samples for testing by the Department of Engineering Research of North Carolina State University and for testing by industry. High quality white clay bricks could be produced from a mixture of 80 to 85 percent Kings Mountain waste clay and 15 to 20 percent plastic clay from other locations. Kings Mountain Mica Company installed sizing, thickening and filtering for the fine clays in 1963. As well as processed material, this brick raw material is of very uniform quality. Kings Mountain Brick Company was formed and a modern 20-million brick per year plant started production in 1966. For every ton of mica produced, only two tons of waste were left for stockpiling for the next phase of mineral recovery.

Mica Recovery by Flotation

Intensive batch and continuous pilot plant studies at Asheville demonstrated to Kings Mountain Mica Company that additional mica and high potash feldspar together with pure quartz sand could be recovered from the sands. The key to the process was high-intensity attrition scrubbing, followed by desliming.(2) By using a flotation procedure employing anionic and cationic reagents in the mica float, a procedure developed by the U. S. Bureau of Mines in Tuscaloosa, Alabama, high grade fine mica is recovered.(3)

Feldspar and Quartz Recovery by Flotation

Test work at the Minerals Research Laboratory delineated the optimum conditions for removal of iron minerals, dark mica and iron-stained minerals by a petroleum sulfonate flotation step before final separation of feldspar and quartz with the hydrofluoric acid amine flotation system.

---

(2)"Flotation of Weathered Wilicates", by Dean Van Dyk, Foote Mineral Co., Kings Mountain, N. C. - presented to Carolinas Section of AIME in Gastonia, N. C., May 5, 1967.

(3)"Anionic-Cationic Flotation of Mica Ores from Alabama and North Carolina", by James Browning, Frank W. Millsaps and Paul E. Bennett. U. S. Bureau of Mines Report of Investigation No. 6589

Kings Mountain Silica Company was formed and a mica-feldspar flotation plant was erected in 1965. The modern plant is operated with a minimum of manpower and is a show piece of our feldspar industry in North Carolina.[4] [5] The feldspar produced has the highest potash content (12 to 13 percent K_2O) of any feldspar produced by flotation in the United States. The feldspar produced has also a low iron content (0.05 percent Fe_2O_3).

Nearly all mineral matter has so been put to profitable use by Kings Mountain Mica, Silica, and Brick Companies.

Figure 1 shows in a schematic flowsheet how through different mineral dressing processes the raw materials for Kings Mountain Mica Company, Kings Mountain Silica Company and Kings Mountain Brick Company are produced.

Figure 2 demonstrates how the amount of waste material at Kings Mountain Mica Company was reduced through improved recovery methods.

Mineral Conservation in the Feldspar Plants at Spruce Pine, North Carolina

Feldspar Production and Tailings Problems in the Spruce Pine Area

In the Spruce Pine area there are three feldspar flotation plants which produce feldspar, quartz and mica from hard rock, coarse-grained alaskite ore bodies. A three-step flotation process is used after grinding to minus 20 to 28 mesh and desliming at about 200 mesh. Mica is recovered by flotation with cationic amine in acid circuit, iron minerals and garnet are removed by anionic petroleum sulfonate flotation in an acid circuit, and finally feldspar and quartz is separated by flotation with cationic amine and hydrofluoric acid. The ore as fed to the mill contains about 65 percent feldspar, 25 to 30 percent quartz, five percent muscovite-mica and some garnet. The three feldspar companies[6] mill a total of 2500 tons of ore per day and have to dispose of about a thousand tons of tailings per day. Until 1964 all tailings were disposed of in the North Toe River which carried the material into the TVA river system. Stream pollution laws forced each company to install approximately $100,000 worth of dewatering facilities. The clean water is discharged into the river and the solids

---

[4] "Flowsheet and Production of Kings Mountain Silica, Inc.", by Hugh A. Lancaster, Kings Mountain Silica, Inc. - presented at Carolinas Section of AIME, May 5, 1967, in Gastonia, N. C.

[5] "The Kings Mountain Mica Story", by P. N. Sales, Southeastern Section American Ceramic Society, Gatlinburg, Tenn., July 1, 1966

[6] The Feldspar Corporation; Lawson-United Feldspar & Mineral Company; International Minerals & Chemical Corporation (all of Spruce Pine, N. C.)

are trucked to mined out dump areas. The cost of tailings disposal added about ten percent to the feldspar production costs. A few scrap mica producers which had to dispose of 20 tons of waste or more per ton of mica had to terminate operations because of tailings disposal costs.

The Tailings Project at the Laboratory

In 1966 the three feldspar producers approached the Laboratory and asked for assistance with their tailings problems. A project sponsored by the three companies, the State of North Carolina and the U. S. Bureau of Mines was proposed by the Laboratory and started in early 1968.

Sampling of Tailings

The Laboratory has sampled all tailings as produced by the companies on a day-to-day basis and on a week-to-week basis to determine variations in quantity and quality and to obtain representative samples for test work in Asheville.

Flotation Testing Results - Feldspar and Quartz

Preliminary results show that we can recover about 300 to 350 tons per day of high quality, low-iron, saleable feldspar and about 300 tons per day of high grade quartz from the combined tailings material. A small tonnage of fairly good scrap mica can also be obtained. A central waste products flotation plant, similar to the one erected by Kings Mountain Mica Company with high intensity scrubbing equipment followed by desliming and mica flotation, iron flotation or eventual high-intensity wet magnetic separation, and feldspar quartz flotation separation could be employed.

Bricks From Secondary Slimes

There would be still 300 to 350 tons of fine slimes and this material will be more suitable for brick making than any of the tailings now because of finer size and higher clay mineral content. White clay bricks can probably be manufactured from the fine slimes with mixtures of other plastic clays after thickening, filtering and drying.

Quartz Uses

The quartz sand can be used as a glass melting or grinding sand or would make excellent raw material for sand-lime bricks or foamed calcium silicate building materials.

Sand-Lime Bricks. Sand-lime bricks are calcium silicate building products consisting of high-silica quartz sand bonded by hydrated calcium silicates. These hydrated calcium silicates, similar to the bonding agents in Portland cement are formed by the reaction of the cationic lime with the anionic quartz under steam pressure. Sand-lime bricks can be made with high compressive strength, low absorption, freeze and thaw resistance, in colors of natural silver-gray or colored as desired. Mineral and metal oxide pigments give weather-resistant and reproducible colors. The brick can be split for a textured surface.

The general manufacturing process consists of mixing ground quicklime or hydrate with high silica sands in ratios of 85 to 90 percent sand to 15 to 10 percent lime, and adjusting of moisture content for easy pressing and forming. The mixture is pressed at 4000 to 8000 psi and steam cured in autoclaves at pressures of 150 to 250 psi for four to eight hours. The bricks retain their exact dimensions during curing and can be shipped immediately after removal from the pressure vessel. The sand-lime brick manufacturing process can be completely automated and is practiced at a high state of perfection in Europe where close to 50 percent of the bricks consumed are sand-lime bricks in Holland and Germany.[7] [8] [9]

Attractive test bricks meeting ASTM Specifications have been made from other Spruce Pine area quartz material at the Asheville Laboratory.

Foamed Sand-Lime Building Products. Foamed, lightweight, calcium silicate products are produced by pouring a mixture of silica and lime with water together with an expanding agent, usually aluminum powder, into forms for initial setting. After removal from the forms, the pieces are cured in autoclaves for final tricalcium silicate bond formation.[10] It is hoped that Spruce Pine tailings quartz can be used in this way.

---

(7) "Fully Automatic Plants for the Production of Pressed Bricks", Atlas-MaK Maschinenbau GmbH. Bremen, Germany.

(8) "Pressed Bricks in Modern Architecture", Atlas-MaK Maschinenbau GmbH. Bremen, Germany.

(9) "A Pre-Investment Study of the Calcium Silicate Bonded Brick Industry", by G. E. Bessey. United Nations, Dept. of Economic and Social Affairs. Center for Industrial Development. 3 March 1966. CID/VI/Background Paper 6.

(10) "Hebel-Informationsbuch" 2. Auflage - Hebel-Gasbetonwerk GmbH. 8080 Emmering-Fuestenfeldbruck, Germany.

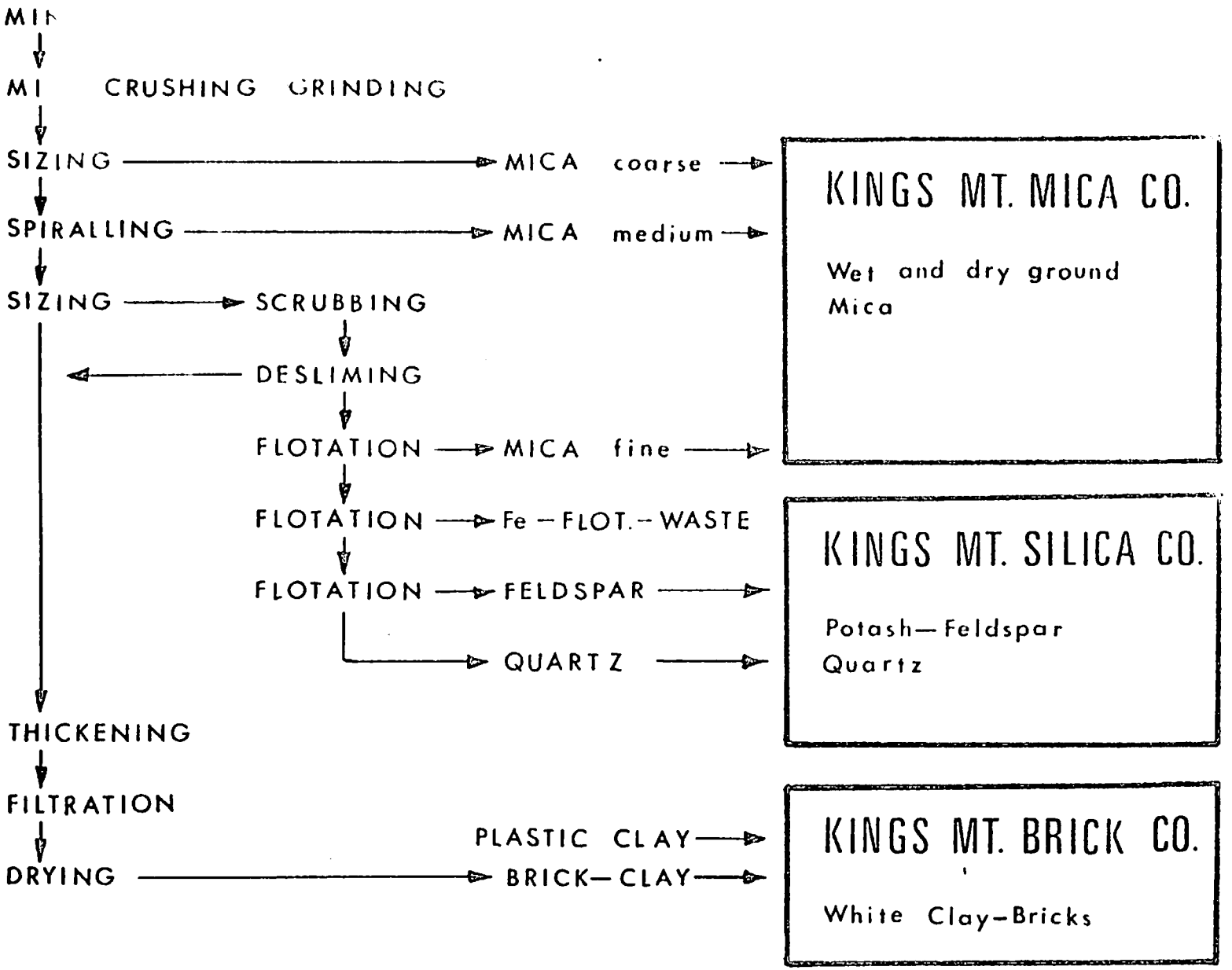
Feldspar Flotation Pilot Plant

It is planned to set up a 250 to 500 pounds per hour flotation pilot plant at Asheville to treat composite and single tailing streams of Spruce Pine tailings materials to verify that high grade feldspar and quartz can be produced reliably under varying tailings feed conditions, as would be encountered where tailings from three different flotation plants are treated together. The pilot plant will also produce tonnage samples of feldspar, quartz, mica, and slimes for customer evaluation and testing, as well as data for plant design.

It will be difficult to find a solution as complete as in the Kings Mountain Mica Company project. A later report will present the results of the Spruce Pine tailings project.

Figure 3 demonstrates the feldspar tailings problems on examples of mineral content of the ore and recoveries of feldspar, quartz and mica in plant and laboratory.

Figure 4 presents a schematic flowsheet of a flotation plant for the recovery of feldspar and quartz from Spruce Pine tailings.



FLOWSHEET OF KINGS MT. MICA-SILICA-BRICK COMPANIES

FIGURE 1

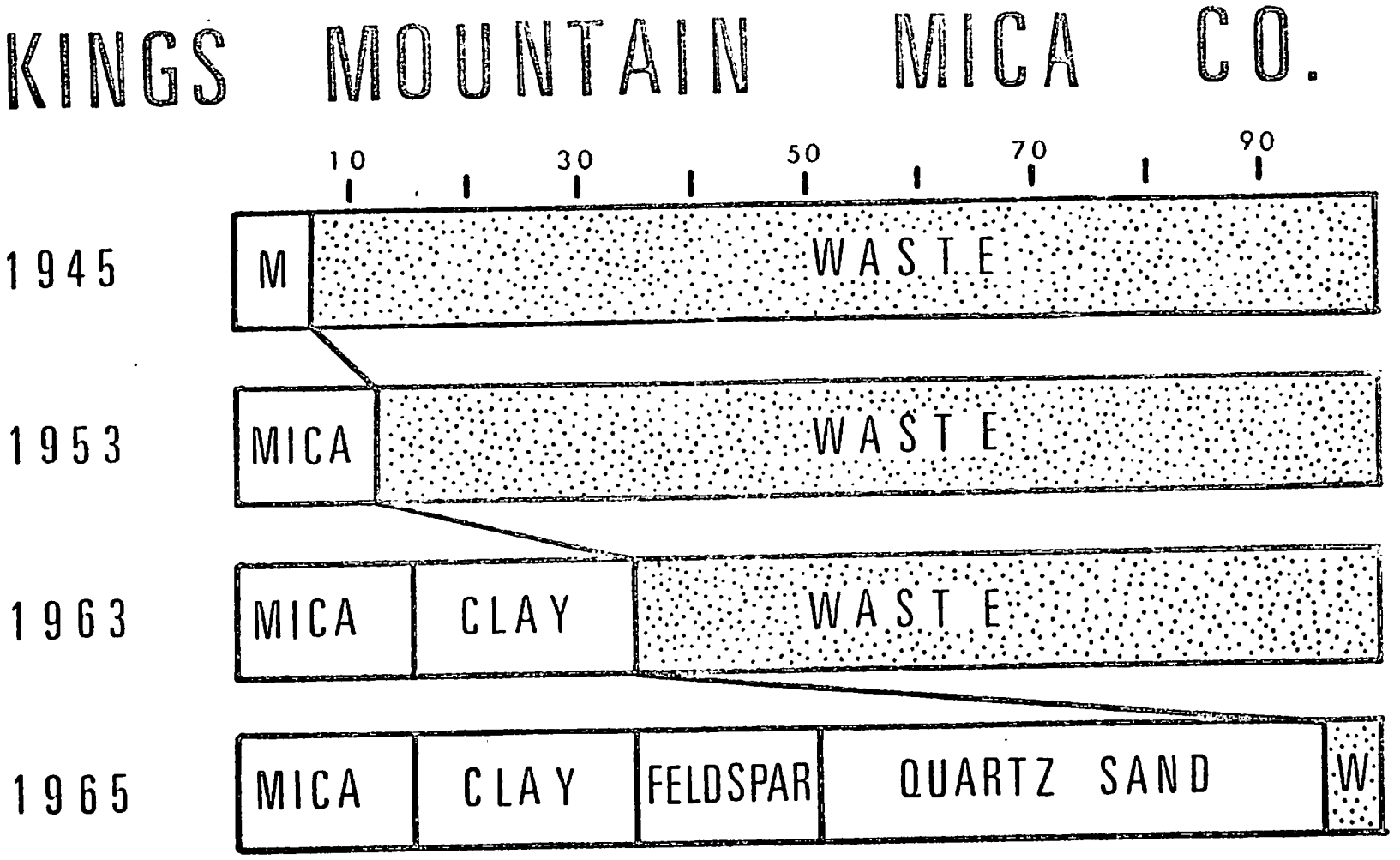

KINGS MOUNTAIN MICA CO.
10
30
50
70
90
1945
M
WASTE
1953
MICA
WASTE
1963
MICA
CLAY
WASTE
1965
MICA
CLAY
FELDSPAR
QUARTZ SAND
W

FIGURE 2

FELDSPAR TAILINGS PROBLEMS

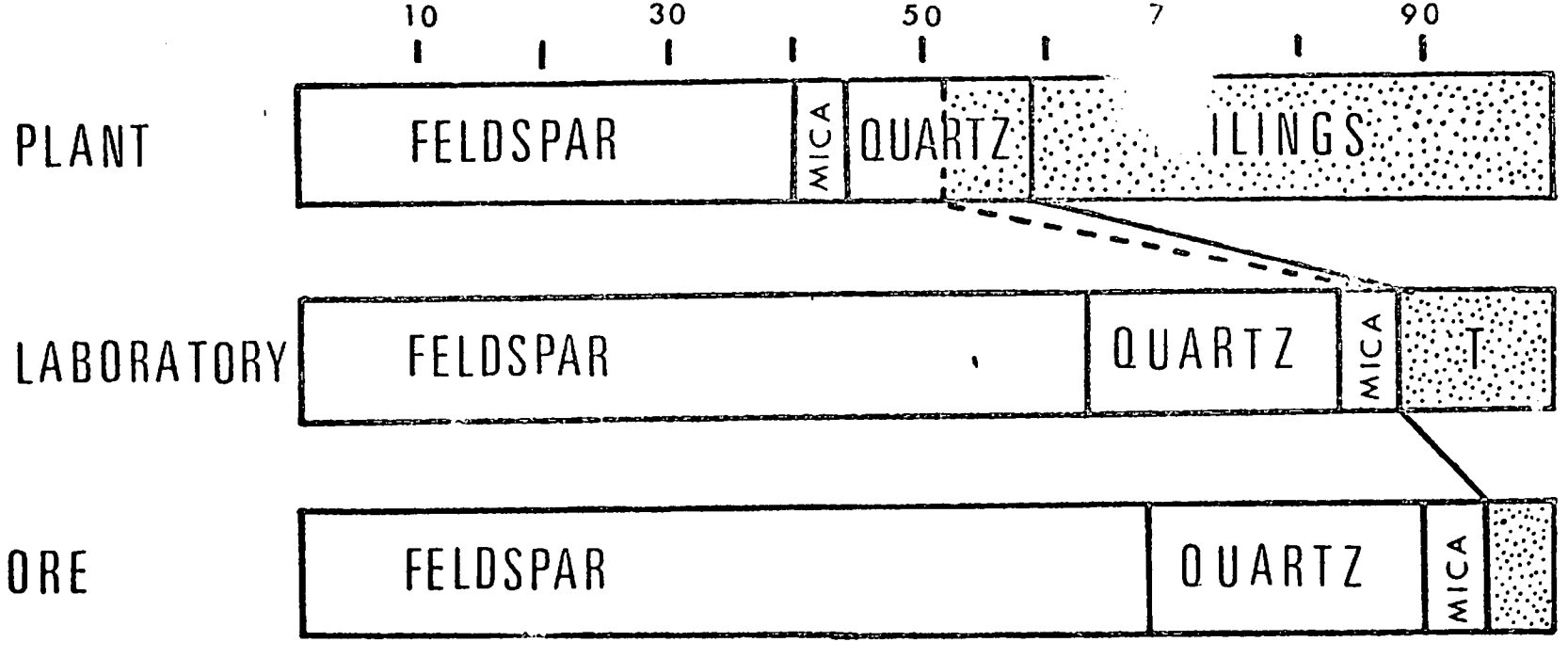
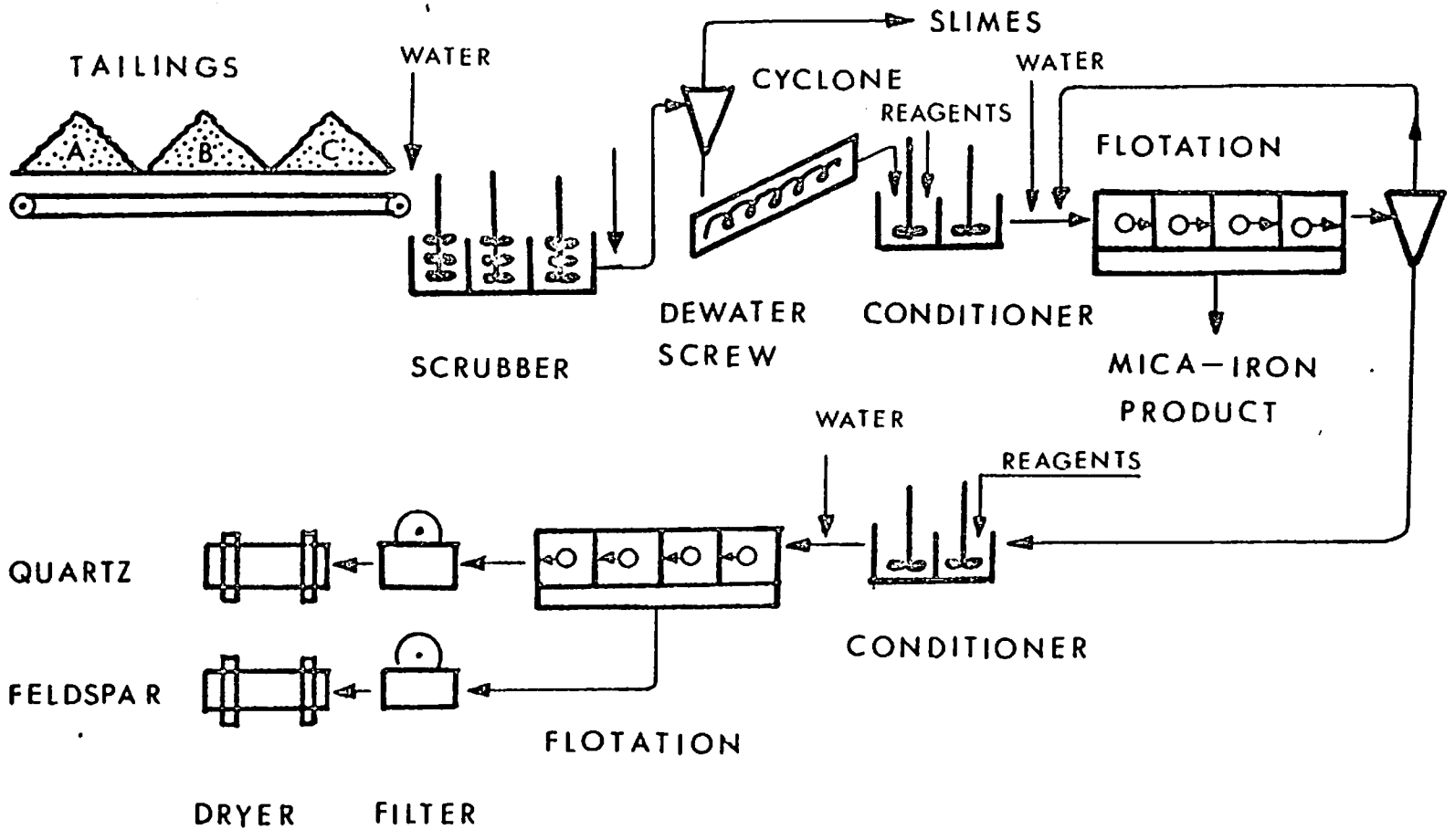


FIGURE 3



FLOWSHEET OF PROPOSED TAILINGS PLANT

FIGURE 4