Approximately 250,000 tons per year of tailings were generated by the feldspar producers in the Spruce Pine area of North Carolina. Disposal of these tailings involved hauling them to dumping areas at a cost of about fifty cents per ton. The first phase of an investigation to alleviate the disposal problem consisted of determining the physical, chemical, and mineralogical composition of the tailings. It was found that the tailings contained approximately 100,000 tons per year of feldspar and 80,000 tons per year of fine quartz which could be recovered by reprocessing. The three principal feldspar producers in the area have instituted programs to reprocess the tailings or to increase initial recovery from the ore. The reduction in the amount of tailings will reduce disposal costs significantly, and sale of the additional feldspar and quartz without additional mining costs should have a marked effect on the profitability of the feldspar mining operations.

A limited program to find uses for the tailings revealed possible applications in structural ceramics and highway construction.
INTRODUCTION

The North Carolina feldspar producers process huge quantities of ores and generate large quantities of tailings (waste products) each day. The problem of disposing of the tailings becomes more acute as more and more emphasis is placed on environmental control. For example, the major portion of North Carolina's feldspar industry is concentrated in and around Spruce Pine, a small mountain village. Three major producers of feldspar have production facilities in this locality, and disposal of the wastes from these three plants is a major problem. All three companies have been hauling their tailings to abandoned open pit mines or other land-fill locations. Disposal of the wastes in this manner costs about fifty cents per ton for haulage alone.

In 1968 the three Spruce Pine feldspar companies, the U. S. Bureau of Mines, and North Carolina State University agreed to sponsor research to find uses for feldspar tailings. An advisory committee consisting of a representative from each of the three sponsoring feldspar companies and two technical personnel from the University was organized to guide the research. This committee recommended that the first phase of the research be characterization of the tailings from the three Spruce Pine plants. This recommendation was accepted, and the University's Minerals Research Laboratory in Asheville, North Carolina, conducted this part of the investigation.

TAILINGS CHARACTERIZATION

All three plants process alaskite ores, but their flotation plants are somewhat different. One plant has a single waste stream, whereas each of the other two plants has a coarse tailings stream and a filter cake waste product. Each of these five tailings streams was sampled initially on a daily basis and then at longer time intervals, so that variabilities in compositions and amounts could be determined.

The results of the analyses of these samples revealed that each plant produced between 235 and 310 tons of tailings each day or a combined total of about 250,000 tons per year. Furthermore, these tailings consisted largely of feldspar and quartz, as shown in Figure 1. The "other" minerals in the ore are clays and iron bearing minerals such as garnet. The Minerals Research Laboratory developed special processing techniques whereby the yields of minerals could be increased substantially either by reprocessing the tailings or by revising the primary processing circuit. These new processes should permit yields of minerals to be increased as follows: feldspar from 40 to about 63%, quartz from 8 to about 20%, and mica from 6 to about 5%. It is estimated that each year an additional 100,000 tons of commercial grade feldspar and 60,000 tons of fine quartz can be recovered by these three plants from the ore at the current rate at which it is mined.

ECONOMICS OF HIGHER MINERAL RECOVERIES

The economic aspects of reprocessing the tailings are quite promising. For example, for each ton of feldspar recovered from tailings costs are estimated to be $1.50 for reagents, $1.50 for processing, and $3.00 for plant amortization which is a total cost of $5.00 per ton of feldspar. This cost is low because mining, crushing, and grinding of the ore are not involved. Minimum estimated sale price for this feldspar is $8.00 per ton F.O.B. Spruce Pine. This represents a profit of about $300,000 on the feldspar; furthermore, savings in haulage fees would be about $50,000. Additional profits could accrue from sale of the quartz reclaimed from the tailings, but markets must be developed for this additional supply of sand. The economic advantages of obtaining higher mineral yields by improving the primary processing circuits are considered to be at least as favorable as those of reprocessing the tailings.

As a result of this investigation, one feldspar producer has built a new facility to recover feldspar and quartz from tailings by flotation. The other two producers are making major changes in their primary processing so that higher percentages of feldspar and quartz will be obtained from the primary flotation circuits. These actions are expected to reduce the amount of tailings by at least 60% of the original amounts.

PRELIMINARY EVALUATION OF USES FOR TAILINGS

The preliminary evaluation of uses for tailings was initiated before the feldspar producers decided to change their processing of the ore. Since the character of the tailings will change, the results of this phase of the research can be used only as a guide to future research on the new tailings. However, the information presented here should be very useful in predicting uses for the new tailings. This is true because a large portion of the new tailings will likely be quite similar to the filter cake tailings evaluated.
Also, the quartz product will be similar in many ways to the material from the two coarse tailings streams. The feldspar producers desired to find uses for the tailings as they are produced or with a minimum of subsequent processing.

Utilization for Construction Purposes

An evaluation of the potential of the sands and filter cake materials for use as construction materials was conducted in the Civil Engineering Department of North Carolina State University. Emphasis was placed on use of the materials as fine aggregates for Portland cement mortars and bituminous concrete mixtures and for stabilization of base-course foundation materials. The results of this investigation may be summarized as follows: 1. The coarse tailings can be used to make mortars of acceptable strength and workability. However, the water and cement requirements are such that they are marginal competitors with natural sands.

2. The coarse tailings can be used to make asphalts of acceptable strength and stability. Asphalt cement requirements are near normal, and this potential use should be developed further.

3. The fine tailings (filter cake materials) can be stabilized with Portland cements or a mixture of Portland cement, lime, and flyash. The fine tailings so stabilized could be used as foundation layers for structures and low cost roads. The use in combination with flyash, another waste product of industry, is of special interest; and comprehensive studies to develop specific guidelines for this application are warranted.

Utilization in Brick and Glass Production

This part of the investigation was conducted by the University's Department of Engineering Research. Both applications are attractive in that large volumes of materials are used in these products. It was found that the filter cake materials probably could be used as brick raw materials if a plasticizer such as 2 or 3% of ball clay were added. However, the preliminary work indicated that process variables such as kiln atmosphere and kiln temperature gradients would have to be controlled very carefully. Since the percentage of clay will probably be appreciably higher in the new tailings, they are even more likely to be useful for brick production.

The results of this investigation indicate that a glass of commercial value cannot be produced from any of the tailings without additional processing. Beneficiation to remove such things as mica and iron minerals and the addition of alkali metal oxide fluxes to the tailings might permit production of low grade glasses. This does not appear to be economically feasible.

Utilization in Calcium-Silicate Building Materials

The University's Minerals Research Laboratory demonstrated that sand-lime bricks meeting A.S.T.M. S17 (severe weathering) strength specifications could be made by using various combinations of the materials from the five tailing streams. Promising samples of lightweight, foamed calcium-silicate building materials were produced in the laboratory also.
TRANSPORTATION OF TAILINGS OR PRODUCTS

Although some of the potential uses look very promising, there is still a major problem to be overcome. That is, the tailings are generated in a rather remote mountain area, and the nearest metropolitan area (Charlotte, North Carolina) is 115 miles away. Only one railroad serves Spruce Pine, and this railroad has been reluctant to quote favorable rates for shipment of the tailings. The railroad personnel think of the tailings as processed minerals rather than waste products; and, therefore, the quoted freight rates virtually prohibit shipment of the tailings to be processed in large market areas. It is assumed that this problem could be resolved, if necessary.

CONCLUSION

Final solutions for the problem of disposal of the remaining tailings must await completion of the process changes in the feldspar plants. With the information already developed it should be possible to determine applications for the new tailings rapidly.

In any investigation involving utilization of waste, characterization of the material should be considered as a first step. In this investigation, determination of the mineral constituents in the tailings immediately presented a solution to the major portion of the tailings problem. Since this solution would increase the profitability of the feldspar plants, they initiated action to make the necessary process changes as rapidly as possible. Two plants have completed the changes already.