

Process and Methodology of Creating a Glaze from Crystalline Feldspar ($\text{NaAlSi}_3\text{O}_8 - \text{CaAl}_2\text{Si}_2\text{O}_8$)

Ashby Gale

Abstract. This paper covers the manner in which glazes are created—from collecting the specimens in situ, through the process of calcination, ball milling, and testing for color responses and application properties. All feldspar used in this analysis was obtained at the Ray Mica Mine in Burnsville, NC. Testing was performed on Phoenix clay and fired at Cone 10 ($\Delta 10$) reduction.

INTRODUCTION

Feldspar's mineralogical origins date to bodies of rocks called pegmatites—intrusive igneous rock that cools at rates slow enough to create crystals of sizes ranging from 5cm to 20cm in diameter. Feldspar for analysis was collected from a pegmatite body called the Spruce Pine Pegmatite, in Burnsville, North Carolina. This particular intrusion formed between 320 and 390 million years ago during the Alleghenian orogeny, as the continental plates reversed direction. Figure 1 shows a reconstructed cross section of the Ray Mine Pegmatite, which was mined for its mica and feldspar from 1869 until 1944 [1]. The feldspar present in this formation is sodium plagioclase feldspar, $\text{NaAlSi}_3\text{O}_8 - \text{CaAl}_2\text{Si}_2\text{O}_8$.

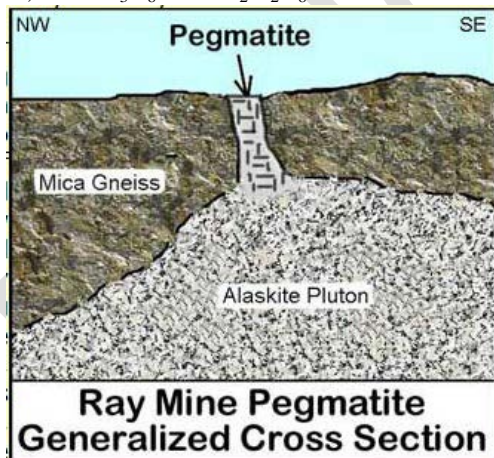


FIGURE 1. Sketch of the Ray Mine Pegmatite in cross section. Note the surrounding mica gneiss that the pegmatite intrudes.

The history of feldspar glazes is relatively new and close to home. The earliest known accounts of feldspar used in ceramic use date back prior to 1744 when the Cherokee Indians sold partially kaolinized feldspar to the European settlers for shipment back to England for use in ceramics [2].

The first locations in the U.S. that saw mining of feldspar were recorded in Avery, Mitchell, and Yancey counties by the mid-19th century. This area is currently the Spruce Pine district of North Carolina; the leading producer of feldspar in the United States. At the time, feldspar had to be shipped to New Jersey and Ohio for grinding and processing, but in 1914, a grinding mill was constructed in Erwin, Tennessee, and processing plants now reside in Spruce Pine.

As of 2012, 30% of feldspar production is used in ceramics [2]. Feldspar is an essential resource in the ceramics industry and for potters as it strengthens pieces and glazes, acting as a flux from $\Delta 6$ to $\Delta 10$.

METHODS

The general procedure for creating a glaze from feldspar involves procurement of the mineral from a site where collection is legal; calcining the reduced crystals; further size reduction after calcination; ball milling; and sieving after drying of the ball milled powder.

On Site Collection

As stated, the Ray Mine Pegmatite was selected for collection due to the high quality feldspar present, and permitted collection of minerals within the National Forest. Figure 2a is the tailings site where feldspar was collected for this research. Approximately 20 lbs of feldspar was collected and brought back to Appalachian State University's campus for calcining. Some reduction of the feldspar was performed in the field by means of an Estwing rock hammer.



FIGURE 2a.

FIGURE 2b.

FIGURE 2c.

FIGURE 2a. Mine tailings pile at Ray Mica Mine where feldspar was collected. Only specimens absent of any accessory minerals were selected for calcining.

FIGURE 2b. After calcining, feldspar was placed in a constructed rock crusher consisting of a wooden board surrounded by cardboard siding. Further reduction of crystal sizes was aided by use of a large iron pipe as a pulverizing implement.

FIGURE 2c. Small scale ball mill used in reducing crystalline feldspar to fine powder. Ball mill operation ran for 96 hours.

Calcining Process

The process of calcining involves thermal decomposition of the material being calcined. Bonds are broken in the feldspar (for this case), which allows the crystals to be crushed with greater ease. For this experiment, the feldspar was calcined at $\Delta 6$ during a normal $\Delta 6$ firing. Figure 2b shows the process of further reducing the feldspar crystals. A large iron pipe served as the means to pulverize the feldspar into pieces fine enough to be put through the ball mill.

Ball Milling

In one of the final stages of converting crystalline feldspar to a powdered state, the crushed and calcined feldspar is loaded into a ball mill. Addition of water is important to expedite the time needed to mill the fragments. In this study, the feldspar was milled for 96 hours; the ball mill utilized can be found in Figure 2c. Other individuals opt to grind the feldspar dry, without use of a ball mill; however, the time required to complete this step can be accelerated through ball milling.

One important note on ball milling: *Once a satisfactory grain size is achieved, immediately remove the mill from the conveyor system and unload the contents into a drying apparatus. If the system is left unattended and motionless, the feldspar will settle between the porcelain balls and necessitate an unnecessary amount of work to remove all of the settled feldspar. In order to prevent settling, transfer*

all saturated feldspar powder to a sieve immediately after removing the ball mill from the conveyor belt.

The ratio of feldspar:water:balls utilized was 1.5:1:1.5, and could be adjusted according to the model of ball mill used and quantity of porcelain grinding balls.

Drying and Screening

Once the feldspar is unloaded from the ball mill, there are two states in which workable material exists: suspended powder and saturated powder (Figure 3a). Suspended powder was poured into a five gallon bucket to allow settling and separation of feldspar from the water used in the milling process. Saturated powder was placed on cheesecloth suspended above the bucket so that any draining water that contained powder could settle in the bucket.

After enough settling occurred in the suspended powder bucket, water was skimmed off to advance the drying process. Once dry, the powder was able to be chiseled out, as seen in Figure 3b. This powder was then added to the dried powder in the cheesecloth shown in Figure 3c.



FIGURE 3a.

FIGURE 3b.

FIGURE 3c.

FIGURE 3a. Saturated feldspar powder in the cheesecloth suspended above a capture bucket. Note the large lumps present in the powder: unreduced crystalline feldspar.

FIGURE 3b. Suspended powder after skimming of water, drying, and chiseling.

FIGURE 3c. Previously saturated powder in the dry state.

The combined dry powders then required screening through a sieve as seen in Figure 4a; the process of screening removes larger particles from the desired glaze powder. Powder to be screened was loaded into the sieve and sifted until only large particles remained in the top screen. Ultimately, 625 grams of feldspar was obtained after screening. At this point, the feldspar was tested as a glaze.



FIGURE 4a.

FIGURE 4b.

FIGURE 4a. Rotating sieve for processing of powdered glazes and reducing the particle size.

FIGURE 4b. Final 600+ grams of produced feldspar glaze powder, taken from the crystalline state to the powdered state.

TESTING AND RESULTS

The first glaze test involved adding varying amounts of flint and EPK kaolin to the feldspar. A comparison of pre- and post-firing surfaces is displayed in Figure 5, with *application* on top, and *fired* on the bottom.



FIGURE 5. Results from the first round of testing. Applied before firing is on top, and post-firing is on bottom. Testing values increase in ascending order with Test #1 on left, and Test #5 on far right.

TEST #1

100 Feldspar

COMMENTS:

TEST #2

80 Feldspar
15 EPK
5 Flint

COMMENTS:

TEST #3

80 Feldspar
10 EPK
10 Flint

COMMENTS:

TEST #4

75 Feldspar
15 EPK
10 Flint

COMMENTS:

TEST #5

70 Feldspar
20 EPK
10 Flint

COMMENTS:

After the first round of testing was completed, the pure feldspar was chosen as the desired glaze based on appearance and texture. From this point, the second round of testing focused on achieving a preferred spectrum of colors. The following colorants were selected for testing:

COLORANTS SELECTED (Used separately)

Tile 1	4	CuCO ₃
Tile 2	0.25	CoCO ₃
Tile 3	10	Lavender Stain
Tile 4	3	Rutile
Tile 5	10	Florentine Green Stain
Tile 6	4, 0.25	CuCO ₃ , CoCO ₃
Tile 7	4, 0.25, 10	CuCO ₃ , CoCO ₃ , Lavender Stain
Tile 8	3, 10	Rutile, Florentine Stain



FIGURE 6a. Tiles 1 – 4, from left: copper carbonate, cobalt carbonate, lavender stain, rutile. Glaze applied over black and white slip on each tile.



FIGURE 6b. Tiles 5 – 8, from left: Florentine green stain, combined copper and cobalt carbonates, combined lavender stain and copper and cobalt carbonates, combined rutile and Florentine green stain. Glaze applied over black and white slip on each tile.

Noted observations about the pure feldspar glaze were as follows: the cobalt carbonate tile was involved in more fluxing than all of the other tiles—the surface was much smoother, and crazed. A similar occurrence happened on Tile 8, the combined rutile and Florentine green; its overall qualities were much smoother than Tile 5, and held a depth that the stain lacked. Tile 1 of copper carbonate captured the copper red, and in subsequent tests, more variations of copper red should be attempted.

Overall, the process of creating glaze from crystalline feldspar yielded pleasing results. On its own, feldspar acts as an adequate glaze for high fire works, but should not be used on its own for $\Delta 6$ pieces. One test did not reach $\Delta 10$ and the glaze did not engage in enough of a melt to cover the area of clay. Recommendations for future studies could

involve feldspar as a supplementary element in other glaze bodies, and testing purchased feldspar against personally produced feldspar powder. Another test could involve adding other naturally occurring elements to the feldspar—beryl, magnetite, muscovite/biotite, fluorescent minerals, clay sediment from a stream; the possibilities are numerous.

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Thanks to you all!

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