Elizabethtown College SCARP Series:

Investigating Ancient and Contemporary Celadon Glazes and their Application on Contemporary Ceramic Objects

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Abstract

This research investigates the chemical limits of ancient and contemporary Celadon glazes, starting with ancient Chinese formulas from around 960 AD and progressing to modern formulas used by contemporary ceramic artists. By analyzing the chemistry of these glazes, including silica, alumina, feldspars, calcium, and iron as the chromophore, the study aims to establish chemical limits for calculating new Celadon formulas. Initial tests assess the performance of the glazes, allowing for adjustments to enhance their aesthetic and functional compatibility with various clay bodies, including iron-bearing clay, white stoneware, and iron-free porcelain. The project involves making twenty finished ceramic objects to observe how the glazes interact with different clay types, affecting color and appearance, as well as over 150 test tiles.

The overall goal is to create a light blue celadon glaze with a glossy surface and crazing texture. Our successful glazes will be added to Elizabethtown College's glaze pallet for use within the ceramics department.

Feldspar Substitutions

FELDSPARS TO LOWER FIRING TEMPERATURES

Our initial goal was to substitute the feldspars in preexisting **Cone 10 (2284°-2381°F)** glaze recipes, to lower the temperature to **Cone 6 (2165°-2269°F)**. These cone 10 recipes were primarily sourced from Robert Tichane and Nelson Burkett.

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The initial felspar, **Custer Potash Feldspar**:

Sodium to Potassium Ratio	Silica to Alumina Ratio
1:3	4:1

Our Substitutions:

Kona F-4:

Sodium to Potassium Ratio	Silica to Alumina Ratio
1.4:1	3.4:1

Nepheline Syenite:

Sodium to Potassium Ratio	Silica to Alumina Ratio
1:3	4:1

The relative fluxing power of the varying feldspars, due to their differences in sodium and potassium, determines that both Kona F-4 and Nepheline Syenite were successful in lowering the firing temperatures of the glazes.

Lithium can be added to recipes with a Custer feldspar base to add fluxing power and brilliance, which has been proven to successfully lower the firing temperature.

Identical recipes with Feldspar substitutions, illustrating both the differences in hue and fluxing power.

From left to right: Custer Potash, Kona F-4, Nepheline Syenite.

FELDSPARS PROMOTING CELADON BLUES

Historically, glazes containing higher levels of potassium were used to get blue Celadons, rather than the traditional grey/green colors, however introducing feldspars with higher levels of sodium has proved to produce more pure blue colors (closer on the color wheel to a true blue than a green blue). Nepheline Syenite and Kona F-4 were successful in promoting these true-blue colors, with minimal differences between the two feldspars.

Bone Ash

SOURCE OF PHOSPHOROUS TO PROMOTE BLUES

On left: Original Shoji Celadon on 182 Clay Body

On right: Shoji Celadon with 1% Bone Ash on 182 Clay Body

The addition of bone ash to our test recipes met the requirement as a source of phosphorous in our glazes. As discovered in Tichane's *Celadon Blues*, these Ancient Sung Dynasty glazes contained a small percentage of phosphorus, likely sourced from wood ash. Bone ash is a hard flux, it melts at higher temperatures, meaning it can act as an opacifier in glazes. Opacifiers can create a cloudy appearance in the glaze, as the particles are becoming suspended in the glaze, which can assist our goal of a lighter, powdery color.

As proven by adding 1% bone ash to our preexisting Shoji Celadon glaze, the addition of a small percentage of bone ash (1-2%) is successful in creating a pale blue hue.

TSP VS. BONE ASH

Trisodium phosphate can be used as an artificial alternative to bone ash. In terms of color and surface texture, the TSP tests were incredibly similar to their original bone ash counterparts. They produced very similar blue hues and glossy surfaces. The TSP recipes did however produce more crazing. Crazing is caused by a difference in the thermal expansion between the clay body and the glaze, causing hairline cracks along the surface. These cracks are very desirable for our intended appearance. Overall, there was not enough of a discernable difference between recipes using bone ash and TSP to continue this line of experimentation.

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Clay Bodies

IRON AND TITANIUM IN CLAY BODIES

Historical findings show that better blues appear on clay bodies that are low in iron and titanium, for example porcelain.

Shoji Celadon with 1% Bone Ash on four different clay bodies, illustrating the varying levels of iron within the clay bodies.

From left to right: Porcelain, B-Mix, 182, Soldate-60.

We tested each recipe on four separate clay bodies with varying levels of iron to test its effect on the appearance of each glaze, confirming that porcelain was most conducive to our desired blue colors. Higher iron content in the clay body can create either more yellowish/orange hues in the glaze, giving a greener appearance, or darker grey hues.

Molecular Amounts of Each Oxide

Chemical Limits

Findings from Batch to Formula calculations are used to establish limits of each oxide within the glaze recipes. These limits are used to create new empirical calculations to create an original Celadon Blues recipe.

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RO-R2O	
CaO	0.003-0.25
K_2O	0.02-0.58
Li_2O	0.00-0.06
MgO	0.002-0.03
Na_2O	0.04-0.33
P_2O_5	0.003-0.005

R2O3	
Al_2O_3	**0.10-1.38**
B_2O_3	0.00-0.05
Fe_2O_3	0.001-0.01

RO2	
SiO_2	**0.709-3.81**
TiO_2	0.0003-0.05

These limits provide the guidelines for the chemical amounts that can go into our future recipe calculations. We then used these limits to calculate formula to batch. Formula to batch calculations give you the exact amounts of each raw formula needed to satisfy the chemical requirements for each glaze.

Our Successful Blue Celadons

100-gram Batch Formulas (excluding chromophores):

Dove Blue Celadon (F3-A calculated by Milt Friedly)

- Cone 6 recipe, produces better blues with thicker application

Custer Potash Feldspar	59.9
Lithium	1.6
Grolleg	4.6
Whiting	9.0
Flint	20.5
Pearl Ash	3.5
Bone Ash	1.0
Red Iron Oxide	0.75

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F6-C (Calculated by Milt Friedly)

- Cone 6, visually similar to F3-A, slightly more pale blue

Kona F-4	41.2
Whiting	17.0
Grolleg	8.8
Flint	28.3
Pearl Ash	3.9
Bone Ash	1
Red Iron Oxide	.75

15B4 (Modified Recipe from Robert Tichane)

- Substitution of TSP for Bone Ash, crazing surface

Nepheline Syenite	50
Silica	30
Whiting	20
Grolleg	10
TSP	1
Red Iron Oxide	0.5

17B2 (Modified Recipe from Robert Tichane)

- Substitution of Nepheline Syenite for Kona F-4

Nepheline Syenite	60
Silica	30
Whiting	20
Grolleg	10
Bone Ash	1
Red Iron Oxide	0.5

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BODY OF WORKS

Influences in Design, Motif, and Form on Ceramic Design

The aesthetic influences in this body of work have been heavily influenced by Chinese, Japanese, and Korean works in form and in theme. Especially work from the Sung Dynasty, which originated the Celadon glaze.

Gienah Sonnema:







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Milt Friedly:

Personal Reflections

Throughout the eight weeks of this project, I have learned completely new and valuable skills. Through formulating these recipes, I have learned how each raw material affects glaze appearance through its chemical composition. I have learned how to calculate batch to formula, as well as formula to batch, and how to fulfill the chemical requirements of glazes using raw materials. I gained experience in mixing and measuring glazes, which I will continue to do throughout the fall and spring semesters for the ceramics department.

I was able to develop myself as an artist through this project, as well. I improved my skills in trimming and carving. I also was given the opportunity to work with porcelain for the first time and overcame the initial learning curve of throwing with such a soft clay body.

Overall, I was able to improve both technically and intellectually as a ceramic artist and to explore themes in my works which I may continue in future semesters.

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References

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