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# Three basic stoneware glazes for cone six oxidation which may be changed in color or texture by the addition of common materials such as sand, clay soil, crushed gravel, or metal filings

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AN ABSTRACT OF THE THESIS OF

Carol Hilda Balsiger for the Master of Science in Teaching in Ceramics  
(Name) (Degree) (Major)

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Title THREE BASIC STONEWARE GLAZES FOR CONE SIX OXIDATION WHICH MAY  
BE CHANGED IN COLOR OR TEXTURE BY THE ADDITION OF COMMON MATERIALS  
SUCH AS SAND, CLAY SOIL, CRUSHED GRAVEL, OR METAL FILINGS.

Abstract approved

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(Major/Professor)

This thesis maintains that glazes may be colored or textured by the addition of common substances such as metal filings, gravels, sands, or local clays.

Three basic glazes were chosen: one transparent, one mat, and one semi-mat. To these basic glazes more than fifty inorganic materials were added in separate test batches. A diversity of results was produced, ranging from a glossy, sand-speckled glaze to a rough glaze made with aluminum shavings; from a white, iridescent glaze made with gypsum to a dull, gun-metal black glaze made with brass shavings; from a transparent colorless glaze made with aspirin tablets to a dark green translucent glaze made with copper filings.

This study can be used as the basis for a unit on glazes in a secondary school classroom; its purpose is to serve as an introduction to glazes, while teaching the students an appreciation of some of the earth's abundant raw materials and how they can be used in ceramic glazes.

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by

CAROL HILDA BALSIGER

A THESIS

submitted to

PORTLAND STATE COLLEGE

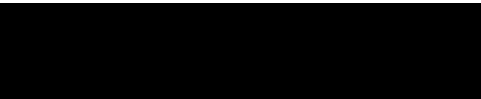
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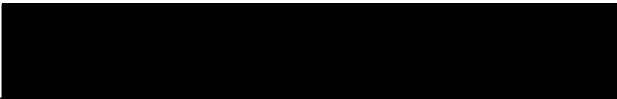
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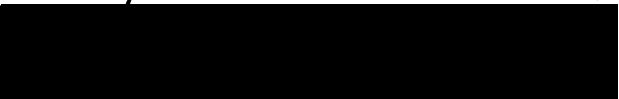
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THREE BASIC STONEWARE GLAZES FOR CONE SIX  
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CLAY SOIL, CRUSHED GRAVEL, OR METAL FILINGS.

INTRODUCTION

The problem considered in this thesis is to investigate what significant changes in the color or texture of a glaze can be gained by adding to it various common inorganic substances.

The purpose of the study is to emphasize the importance of seemingly insignificant sources of materials which can alter the color or texture of a glaze, and to provide the basis for developing a glaze study project suitable for use in a secondary school art class. There is little information concerning the addition of common ingredients to glazes.

In our affluent society many persons seldom consider making an article if it can be purchased at a store. We have become so sophisticated that we tend to overlook the usefulness of common materials. Our young people need to gain an awareness of what can be done with simple substances. A study such as this will help to overcome this prejudice, because the study focuses on the use of humble materials such as beach sand or soils in glazes. Some of the materials used for the glazes are waste products. For example, the slag tailings from a steel mill, disposed of in unsightly heaps along the riverbank, can be used. This slag creates a rich lustrous brown glaze which belies its beginnings. Common substances such as this, often overlooked, can be used to enrich and fulfil our lives

through the creation of esthetic forms.

The whole field of ceramics, including pottery, brick and tile, structural clay products, firebrick, porcelain, and sanitary wares, comprises a large portion of our country's industries. These products are all made from the simple, inexpensive raw materials, silica and alumina, the two most common ingredients on the surface of the earth. These two oxides together comprise about three-fourths of the earth's crust. (Green, 1963).

"Clay may be defined as an earthy mineral substance, composed largely of a hydrous silicate of alumina, which becomes plastic when wet, and hard and rock-like when fired." (Rhodes, 1957). The chemical formula for clay is  $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ . Clay found in nature, however, is seldom pure. It is combined with other minerals, such as iron, magnesium, calcium, and sodium, all in oxide form.

Glazes are formed from various materials, the chief one being silica (flint). The other important ingredient, alumina, is a refractory which resists the effects of high temperatures, has a high melting point, and helps to keep the glaze from running off the pot. It is used in small amounts in the glaze formula.

Most of the other ingredients of glazes serve as fluxes, because they melt at relatively low temperatures and help to lower the melting temperature of the silica.

In addition to the silica and alumina, there are only about fourteen oxides used in hundreds of combinations to produce thousands of basic glazes. These glazes are all essentially colorless, but many colors can be produced by the addition of small amounts of

coloring oxides.<sup>1</sup>

"A glaze may be defined as a glassy coating melted in place on a ceramic body, which may render the body smooth, non-porous, and of a desired color or texture." (Rhodes, 1957).

This glaze, which can enhance the pot, may get its "desired color or texture" from very humble sources, and it is these humble sources that we wish to recognize--the significant contribution of insignificant materials.

<sup>1</sup> See Table 1, Appendix, p. 23.



## II. AREA OF STUDY

Twenty-eight different glaze recipes for Cone six<sup>2</sup> were tested to choose the three most suitable for the project. These three were chosen because they were dissimilar, thus offering a variety of glaze types. One is a dry mat glaze, which is referred to as Glaze "A"; one is a transparent crackle glaze, which is referred to as Glaze "B"; and one is a semi-mat glaze, which is labeled Glaze "C".

Another qualification was to use as few ingredients as possible so that secondary school pupils could mix the glazes from a small supply of stock. Eleven ingredients are required. It is less expensive to buy the supplies and mix the glazes than to purchase prepared glazes.

The recipes follow:

GLAZE A  
(M Mat Dry Opaque, Cone 5-6)  
(F. Carlton Ball)

	Percent
Feldspar (Kingman)	44.3
Ball clay	1.5
Whiting	5.6
Barium carbonate	6.6
Zinc oxide	19.5
Flint	16.0
Rutile	6.5
	<u>100.0</u>

GLAZE B  
(Glaze #16 Cone 3-6 Transparent  
(F. Carlton Ball)

	Percent
Feldspar (Kingman)	44
Flint	24
Ball clay	1
Colemanite	20
Whiting	2
Zinc oxide	3
Barium carbonate	6
	<u>100</u>

<sup>2</sup> Cone six is 1255°C. and 2291°F.

## GLAZE C

(Semi-mat Glaze, Cone 6)  
(Glenn C. Nelson)

	Percent
Whiting	9.8
Talc	2.1
Barium carbonate	11.0
Zinc oxide	4.3
Soda feldspar (Del Monte)	42.5
Kaolin	8.3
Ball clay	8.0
Flint	14.0
	<u>100.0</u>



Photograph No. 1

Test pots showing basic glazes A, B, and C.

To these three basic glazes common substances were to be added to see how they would affect the color or texture of the basic glaze. Refined chemicals were not used, since these were available in the ceramics laboratory and presented no challenge.

### III. THE ADDITION OF COMMON MATERIALS

Various kinds of materials were used: beach sand, river sand, four different kinds of sand from a foundry, several types of gravel and rocks from gravel companies, local clays from road cuts and slide areas, slag tailings from a steel mill, metal filings from a metals company, kitty-litter, vermiculite, and gypsum wall board. The gravel, rocks, and kitty-litter were made useable by smashing them with a hammer on a piece of steel until they were about as fine as table salt. The vermiculite, gypsum wallboard, and clay soils were made finer with a mortar and pestle. Many of the items were sifted through a flyscreen. Several of the waste products from Albina Engine and Machine Works had to be washed to remove sand and dirt particles. Some of the metal shavings and the steel wool pad were cut into approximately one-fourth-inch pieces with scissors. The smaller the size the more likely the additive would become imbedded in the glaze; coarse additives made coarse-textured glazes.

To determine whether the metal filings were likely to melt or to remain intact and become imbedded in the glaze, the melting point of the metal had to be known.<sup>3</sup> Not all of the waste metals could be identified; some were a mixture of more than one metal and other substances.

The items had to be inorganic, since organic materials would burn out during the firing.

<sup>3</sup> See Table 2, Appendix, p. 23.

The test samples for this study were made on bisque-fired clay tiles about one-and-one-half-inches square and one-eighth-inch thick. Most of the samples were weighed out in ten-gram batches, with ten percent (one gram) of additive. Ten percent was used because smaller amounts might not make a significant change in the glaze, and larger amounts could change the glaze so greatly that it was no longer a glassy coating on the ware.

One teaspoonful of the mixture was moistened with water to make a creamy paste which was then brushed onto a labeled sample tile with a one-fourth-inch paintbrush. Sometimes the additive settled to the bottom of the paste so that the mixture had to be stirred each time before painting it onto the test tile. This settling happened with the sand, the gravels, the crushed rocks, the metal filings, and the vermiculite. The steel wool clung to itself after cutting and was difficult to work with.

When larger amounts of the glazes were used to decorate some test pots, the settling became more of a problem. In one instance during the glazing application process, the glaze solution was poured into the bowl and quickly emptied, but a surplus of sand remained deposited inside the bowl.

The coarser sands and gravels settled to the bottom of the liquid glaze mixture. After the glaze was poured over the pot, more sand was added by dipping into the bottom of the glaze batch with a fingertip and retouching the glazed pot. The vermiculite was thick and poured unevenly. These problems could probably be corrected by using smaller

amounts of additive in order to reproduce the texture and control the results.

The following tables list the materials used, the source of the materials, a brief description of each of the three glazes, and an indication of its possibilities as a useful glaze.

TABLE 1.-TEST RESULTS USING SAND

Description of material	Source	Glaze A	Results in Glaze B	Glaze C	Useable <sup>4</sup>
White fine-grain sand Zirconite	Foundry	Smooth, white	Fine white bubbles	White	ABC
Fine black sand	Foundry	Lt. blue, black	Clear with black particles		ABC
Fine white sand	Foundry	White	Clear bubbles	Clear	ABC
Gray sand	Foundry	Blue particles	Clear with gray particles salt and pepper		ABC
Black sand	Indian Beach	Blue particles	Clear with gray particles salt and pepper		ABC
Black coarse sand	Albina Engine	Large black particles in all three			ABC
White sandblasting sand	Northwest Copper	Smooth white	Smooth white	Rough white	ABC
Black sand	Gravel company	White glaze, black particles	Clear with large black particles		ABC
Beige sand	Cape Lookout	White with blue particles	Tan with brown particles		ABC

<sup>4</sup> The letters indicate the basic glaze in which the additive is useable.

TABLE 2.--TEST RESULTS USING GRAVEL AND CRUSHED ROCKS

Description of material	Source	Glaze A	Results in Glaze B	Glaze C	Useable
Fine gravel	Empire Lite Rock	Light blue glaze, purple particles	Fine red salt and pepper		ABC
Red gravel	Empire Lite Rock	White with brown particles	Translucent brown particles		ABC
Pea gravel	Willamette Gravel	White with coarse blue particles	Clear, brown particles	Translucent, red and black particles	ABC
Black rock with holes	Willamette Gravel	Pink with blue particles	Clear with brown particles	Translucent, red and black particles	ABC
Red rock	Willamette Gravel	Cream with purple particles	Clear with red particles	Translucent, red particles Rough	ABC
Yellow rock	Willamette Gravel	Red and blue particles	Clear with red particles	Translucent, red particles	ABC
Gravel	Pioneer Gravel	Lt. blue, brown particles	Clear, brown and black particles	Translucent, brown and black particles	ABC

TABLE 3.--TEST RESULTS USING CLAYS AND SOILS

Description of material	Source	Results in			Useable
		Glaze A	Glaze B	Glaze C	
Brown soil	Road cut Saddle Mt. St. Park	Blue with brown specks	Clear with red particles	Translucent Red-brown par- ticles; rough	ABC
Gray clay	Empire Lite Rock	Cream, with brown particles	Clear with brown particles	Translucent Red-brown par- ticles; smooth	ABC
Red clay soil	Slide area, Ecola State Park	Blue-white with brown particles	Clear with brown particles	Translucent Red-brown par- ticles; rough	ABC
Red clay soil	Slide area, Ecola State Park	Blue-white with blue and brown particles	Clear with brown particles	Translucent Red-brown par- ticles; rough	ABC
Green clay	Core sample Tektronix	Lt. blue with brown particles	Unchanged	Very few particles	A



TABLE 4.--TEST RESULTS USING SLAG TAILINGS

Description of material	Source	Results in			Useable
		Glaze A	Glaze B	Glaze C	
Gray gravel-like slag	Oregon Steel Mill	White glaze, blue speckles	Clear with brown spots	Clear with rough gray spots	ABC
Black gravel-like slag	Oregon Steel Mill	White glaze, blue speckles	Clear with brown spots	Clear with rough gray spots	ABC
Dull black powdered slag	Oregon Steel Mill	Dark brown	Rich lustrous brown	Dark gray shiny	B
Rough black metallic slag	Oregon Steel Mill	White glaze blue speckles	Clear with brown spots	Clear, rough gray spots	ABC
Red rock	Oregon Steel Mill	Same as above	Clear, rough	Rough pink	AC
Firebrick	Oregon Steel Mill	Same as above	Same as above	Rough gray	AC

TABLE 5.--TEST RESULTS USING METAL FILINGS

Description of material	Source	Glaze A	Glaze B	Glaze C	Useable
Brass, other metals	Albina Engine	Metallic black spots; large rough particles			ABC
Rusty brown unknown	Albina Engine	Blue-black	Brown, rough	Black, rough	ABC
Metal shavings	Albina Engine	Metallic black with green			B
Stainless steel slag	Albina Engine	Large rough black particles			ABC
Aluminum shavings	Tektronix	Dark gray, rough craters			B
Manganese and steel	Foundry	Black particles	Brown and black transparent		ABC
Steel wool pad	Home	Blue "wool", white glaze	Transparent, brown "wool"	Transparent, black "wool"	ABC
Coin silver	Jewelry lab.	Dull gray	Marbelized blue and green	Transparent green	B
Copper filings	Reynolds Metals	Gun-metal black	Same as above	Gun-metal black	B
Ferro-manganese	Reynolds Metals	Splotchy brown	Marbelized blue and red-purple	Rough black and purple	B
Silica tailings	Reynolds Metals	Blue textured	Black craters	Rough gray	ABC
Aluminum sawdust	Reynolds Metals	Dry, blue	Black craters	Rough gray	B
Iron shavings	Reynolds Metals	Rough black on white	Trans. brown	Transparent, black	ABC
Brass shavings	Tektronix	White; retest	Metallic black, green	Transparent, green	B

TABLE 6.--TEST RESULTS USING MISCELLANEOUS ITEMS

Description of material	Source	Results in			Useable
		Glaze A	Glaze B	Glaze C	
Aspirin	Home	No change in any of the glazes			None
Bicarbonate of soda	Home	No change in any of the glazes			None
Borateem	Home	No change in any of the glazes			None
Epsom salts	Home	No change in any of the glazes			None
Gypsum wallboard	Home	White iridescent	Translucent white	No change	AB
Sand dollars	Beach	Same as above	Same as above	Dry white spots	A
Kitty litter	Neighbor	Rough tan	Rough white	Rough pink and white spots	ABC
Vermiculite	Cone boxes	Tan and blue fairly smooth, bulky appearing	Clear with brown spots	Clear with brown spots	A

#### IV. ESTHETIC APPLICATION OF GLAZE TO CERAMIC POTS

In choosing a particular glaze for a particular pot, the foremost characteristics considered were the visual lightness or heaviness of the pot, and the fineness or coarseness of the texture of the glaze. Also considered was whether or not a piece of ware would contain food as some of the glazes would not be compatible with food.

All of the pottery shapes are simple and straightforward, and some are primitive in feeling. These pots were made to provide appropriate vehicles for glazes made from common raw materials.

The bowl in Photograph No. 2 is strong in feeling, showing the clay it came from and the fingermarks of the potter. Therefore, it could be enhanced by a bright, colorful glaze. The glaze, made from copper filings, is a smooth, glossy blue-green, with metallic highlights in the center of the bowl caused by an oversupply of copper. The outside of the bowl, where the glaze was poured thinner, has a green salt-and-pepper effect.



Photograph No. 2  
Cylinder, bowl and covered jar.

The cylinder, primitive in form, provides a compatible base for the bulky brown and blue-white textured glaze made from vermiculite. The small covered jar is more refined, making a harmonious combination with the iridescent elegance of the gypsum glaze.

Photograph No. 3 shows two entirely different results achieved by adding two different scrap metals to different batches of the same basic glaze. The low bowl has a glossy, marbelized blue and red-purple glaze, highlighted with metallic black areas. This glaze is made from a metal called ferro-manganese. In contrast, the small bottle has an extremely rough, sharp-edged texture, colorless except for the dark gray of the aluminum sawdust. This glaze may be suitable for large ceramic sculptures which require a visual, rather than a tactile, texture.



Photograph No. 3  
Bowl and small bottle.



In Photograph No. 4, there are neutral colors; the covered jar shows a unity of the clay with the sand in the glaze, providing a subtle overall texture. The small bottle has a delicate texture throughout the glaze, produced by fine particles of the sand. Coarser sand highlights the curved edges of the piece.

The plate has some coarse particles, as well as green and metallic black decoration made by pieces of an unknown metal, possibly brass, found in the waste bins of a machine company. The black area was made by allowing a large concentration of the additives to remain on the plate during the glazing process to see what effect they would have on the finished glaze.



Photograph No. 4  
Covered jar, plate, and small bottle.

The bowl in Photograph No. 5 has beach sand in the glaze, which appears as blue particles, and gives the glaze a texture which feels dry.

The covered jar has brass shavings in the glaze, which made the green and black markings where the brass melted and ran. These accentuate the curve of the jar. The vase has a rich brown glaze, resulting from the iron in the slag tailings from which it was made. This lustrous glaze enhances the curved shape, making a decorative vase.



Photograph No. 5  
Vase, bowl, and covered jar.

## V. APPLICATION TO SECONDARY SCHOOL TEACHING

This project can form the basis for a unit on glaze study for a secondary school classroom ceramics program. The unit can excite the pupils to use their imagination and search the countryside for suitable materials to add to the glazes. The pupils would need to discuss the difference between organic and inorganic matter and suggest sources of ingredients.

Although there are only three basic glazes, the students would have a wide variation in them because of the great number of changes that additions can produce. The students would have the opportunity to mix the basic glazes themselves, which would involve the careful weighing, straining, and mixing of the glaze ingredients. Then the students would add their found materials and test them in varying amounts. The pupil could experiment to determine how coarse or fine the materials need to be to give the results he likes the best. Although the teacher would know in most cases what the approximate results of the additives will be, he would let the student discover them for himself. For those students who may wish to study glazes more fully, this experience could serve as an introduction.

The actual building and decorating of the ware could lead to discussions of design, proportion, and applied design. One student could pursue that aspect of ceramics which most appealed to him, or a group might work on a common problem. Hopefully, the students would branch out into areas not covered here, depending upon their interests.

In a general art program, the student would be allowed and encour-



aged to pursue the medium in which he is most interested after an initial experience in various media. Some students may be involved in a ceramics project at the same time that others may be painting, others building three-dimensional structures, while others are doing research in the field of art history, and the like. Each student would be encouraged to make a study in depth in his area of interest, of which there may be several during the year.

## VI. SUMMARY AND CONCLUSIONS

This study has shown that the color and texture of a good basic glaze can be changed by adding such items to it as vermiculite, copper filings, or crushed rocks. The basic glazes were colorless. Of fifty-two ingredients tested, forty-six of these ingredients effected a change in the color or texture, or both, in at least one of the three basic glazes.

Several of the glaze mixtures show promise and could be tested and developed into good, useable, colorful glazes: specifically, the copper filings, the ferro-manganese, and the slag tailings from the steel mill. For textured glazes, additional studies could be developed on several of the sands using lesser amounts and on the gravels using finer particles.

In a classroom without adequate ventilation, it would be unwise to fire in an electric kiln anything which is in any way questionable. Plastics should not be used because they create an obnoxious odor which is perhaps toxic. Salt (sodium chloride) produces chlorine gas, which is poisonous. It also creates a salt-glaze on the inside of the kiln, which would salt-glaze any subsequent firings. All organic materials would burn out during the firing.

This practical use of common ingredients provides many opportunities to interest secondary school students in the study of glazes.

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## APPEND IX

TABLE 1

## METALLIC OXIDES USED TO PRODUCE COLORS IN GLAZES

Oxide	Percent
Cobalt carbonate $\text{CoCO}_3$ . . . . .	1
Copper carbonate $\text{CuCO}_3$ . . . . .	6
Ferric oxide (Red iron) $\text{Fe}_2\text{O}_3$ . . . . .	10
Manganese dioxide $\text{MnO}_2$ . . . . .	5
Tin oxide $\text{SnO}_2$ . . . . .	7
Titanium dioxide (Rutile) $\text{TiO}_2$ . . . . .	10

TABLE 2

## MELTING POINTS OF SELECTED COMPOUNDS AND METALS

	Degree F
Alumina . . . . .	3722
Aluminum . . . . .	1214
Brass (copper) . . . . .	1981
(zinc) . . . . .	787
Copper . . . . .	1981
Copper oxide ( $\text{Cu}_2\text{O}$ ) . . . . .	2210
( $\text{CuO}$ ) . . . . .	1947
Ferrous oxide . . . . .	2586
Flint . . . . .	3119
Gypsum (calcium) . . . . .	1652
Iron . . . . .	2795
Manganese . . . . .	2268
Silica . . . . .	3119
Silver . . . . .	1761
Sodium chloride . . . . .	1458
Stainless steel (Carbon) . . . . .	--
(Chromium) . . . . .	2822
(Nickel) . . . . .	2646
Zircon . . . . .	3452-4172