

Portland State University

PDXScholar

Dissertations and Theses

Dissertations and Theses

5-23-1968

Color in Salt Glaze

Daniel Lee Stevens

Portland State University

Follow this and additional works at: https://pdxscholar.library.pdx.edu/open_access_etds



Part of the [Art and Design Commons](#)

Let us know how access to this document benefits you.

Recommended Citation

Stevens, Daniel Lee, "Color in Salt Glaze" (1968). *Dissertations and Theses*. Paper 561.

<https://doi.org/10.15760/etd.561>

This Thesis is brought to you for free and open access. It has been accepted for inclusion in Dissertations and Theses by an authorized administrator of PDXScholar. Please contact us if we can make this document more accessible: pdxscholar@pdx.edu.

AN ABSTRACT OF THE THESIS OF

Daniel Lee Stevens for the Master of Science in Teaching in
Ceramics presented on August 7, 1967.

Title: COLOR IN SALT GLAZE.

Abstract approved:


Raymond M. Grimm

This thesis endeavors to bring a brief history of salt glaze to the reader, following its genesis in Germany to England and the American colonies and its continuation to the present day.

In order to conduct research on color in salt glaze, a kiln had to be built for this purpose, meeting all the requirements that this technique demands.

Studies were made on clay bodies to determine their throwing qualities as well as their ability to take a salt glaze.

Finally, research was carried out in many series of tests studying the reactions of various engobes and other coloring materials when fired in the salt glaze kiln.

COLOR IN SALT GLAZE

by

Daniel Lee Stevens

A THESIS

submitted to

Portland State College

in partial fulfillment of

the requirements for the

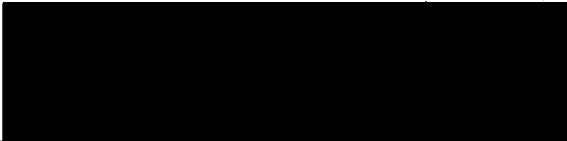
degree of


Master of Science in Teaching

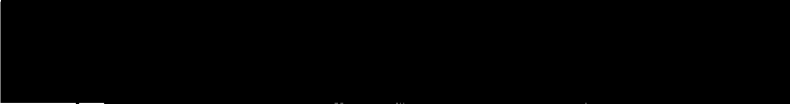
August 1967

PORTLAND STATE COLLEGE
LIBRARY

APPROVED:


Raymond M. Grimm, Associate Professor of Art


Head of Art Department


Dean of Graduate School

Date of Presentation May 23, 1968

TABLE OF CONTENTS

I. INTRODUCTION	1
A. History	1
B. Definition of Salt Glaze	3
II. THE KILN: ITS CONSTRUCTION	5
III. CLAYS AND THEIR EFFECT ON COLOR	14
A. Individual Clays Tested	14
B. Compounded Clays Tested	16
IV. COLORING AGENTS FOR SALT GLAZE	19
A. Native Clays	19
B. Engobes	20
C. Metallic Oxides	23
V. SUMMARY AND CONCLUSIONS	33
BIBLIOGRAPHY	34

I. Introduction

A. History. It is not known how the first salt glaze came about, but it is generally thought that it originated in the vicinity of Cologne, Germany, where natural clay deposits led to the development and production of stoneware.¹ This stoneware, in some unknown way, became salt glazed. Salt glaze is a vitreous coating formed on the surface of clay wares by subjecting them to the fumes of common salt at high temperatures during the firing of the kiln. The kilns that were being used at that time were all wood-fired and if for some reason the wood supply became depleted before the end of the firing, the potters, in desperation, would have probably used any available wood in order to complete the firing. Perhaps at this time old wooden pickling barrels or the hull of an old ship saturated with a salt brine might have been used for fuel. If this wood, saturated with salt had been used near the end of the firing when the kiln was the hottest, near 2000°F., enough salt combined with the moisture of the wood could have been introduced to give the pots a thin coating of salt glaze.² The follow-up and analysis of the accidental glazing, supplemented by further experiments, could have led to the eventual development of the salt glazing technique.

The technique grew rapidly and Cologne seems to have been the marketing center for all of the ware produced along the Rhine River Valley. Parmelli (1948) gives the earliest date of the production during the

¹Angelo Garzio, "German Salt Glazing," Craft Horizons, XXIII, (March-April 1963), pp. 20-22.

²F. Carleton Ball, "Salt Glazed Stoneware," Ceramics Monthly, X (February 1962), p. 26.

12th Century,³ but other authorities put the date as late as the 15th Century.

It was in 1671, that the Englishman John Dwight of Fulham applied for a patent and was granted the exclusive right to manufacture salt glazed pottery in England.⁴ Stoneware, at this time, was synonymous with the technique referred to as salt glazed ware, and can further be described as pottery fired at a high temperature to the point of great hardness and vitrification. Before this time, no stoneware had been made in England.⁵ It is not known for certain whether Dwight invented the technique through experimentation or whether he learned the technique from German immigrant potters. In any case, salt glazed pottery was in England to stay, and when Dwight's patent expired in 1699, numerous commercial potteries began producing stoneware.⁶

Although the potters of England were restricted by Dwight's patent, American potters began making salt glazed utilitarian ware as early as 1684 when Daniel Coxe established a pottery in Burlington, New Jersey. Other potters are known to have lived and produced salt glazed ware in New York, Massachusetts and Virginia before that date, but the ware was never produced in these areas on a commercial scale.⁷

³Cullen W. Parmelli, Ceramic Glazes, (Chicago Industrial Publications, Inc., 1948), p. 175.

⁴W.B. Honey, English Pottery and Porcelain, (London: Adam and Charles Black, 1962), p. 54.

⁵Ibid., p. 54.

⁶Daniel Rhodes, Stoneware and Porcelain, (New York: Chilton Company, 1959), p. 28.

⁷John Ramsey, American Potters and Pottery, (Clinton, Mass.: Columbia Press, 1939), pp. 39-40.

As the pioneers moved West, they brought with them the knowledge of salt glazing. In Oregon and in the Northwest in general, many potteries were established to meet the needs of the growing population. Most of these were located at the sites of natural clay deposits. Like the Germans three hundred years before them, the potters used native materials to produce salt glazed utilitarian ware. The pioneer potters, however, never developed the high quality of stoneware that the Germans did, and with the introduction of a harder and more resistant ware called Ironstone from the East, easily transported by the newly built railways, many Western potters were put out of business by 1880. The railroad and mass production of ironstone ware limited any existing Western potteries to the making of heavy, Bristol glazed items such as crocks, churns, bottles and lidded jars. Although the production of salt glazed pottery for utilitarian ware died out, the demand for salt glazed items such as chemical stoneware, sewer pipes, conduits and hollow building blocks has continued to the present day.⁸

The technique of salt glazing for aesthetic purposes in fine ceramics has only recently been revived by the studio potter who strives for new and varying techniques to express his art through pottery and sculptural forms.

B. Definition of Salt Glaze. Salt glaze can be explained as follows: To make a glaze three materials must be present, Silicon oxide, or acid element; alumina oxide, or neutral element, and the

⁸Ball, p. 27.

third or alkaline element, which acts as a flux. The theoretical formula of clay is $\text{Al}_2\text{O}_3 - 2\text{SiO}_2 - 2\text{H}_2\text{O}$. These components are present in these proportions in the pots that are put into the salt kiln. To make a glaze, however, the flux must be added in the form of sodium.

In salt glaze, the sodium enters into the glaze by means of common salt (usually in the form of rock salt introduced into the loaded kiln during firing). When green pots are put into the kiln and heated to stoneware temperature, 2300°F. , salt is thrown into the kiln. The salt decomposes rapidly into sodium and chlorine vapors and passes into the hot kiln full of ware. The chlorine combines with hydrogen from ever-present water vapor and then passes out of the kiln as hydrochloric acid. The sodium vapor is oxidized and then attacks the alumina and silica of the clay ware to form a sodium-aluminum-silicate glaze. The longer the concentration of sodium vapors is maintained, the thicker the glaze obtained.⁹ No matter how thick, however, salt-glaze is perfectly transparent, and does not obliterate the finest scratch on the body. On some old German salt glazed steins, fingerprints of the potter can be distinguished.

⁹H.D. Foster, "Salt Glaze for Structural Building Units," Journal of the American Ceramics Society, XXVI. (1943) pp. 660-667.

II. The Kiln: Its Construction

Most commercial ceramic kilns are constructed of soft brick (insulating brick). However, they cannot be used for salt glazing because of the corrosive action of the salt and moisture on them. Electric kilns cannot be used for salt glazing because the same action will destroy the heating elements in a very short time. It was found that a salt glaze kiln must be fired with natural gas, coal, oil, or wood, and must be made out of hard brick (fire brick). Fire brick is nothing more than a clay itself, and melts at a very high temperature (around 2700°F.). The fire brick then forms a high silica inner lining of the kiln. As stated earlier, the reaction between the sodium (salt) and the silica in the clay body forms the sodium silicate glaze on the surface of the fired ware. It also glazes the entire interior of the kiln and renders it unsuitable for normal glaze firings.

Before testing could be carried out in the salt glazing technique, it was necessary to build a kiln for this purpose. The kiln was designed on a downdraft principle, to burn natural gas. Because of the toxic fumes (hydrochloric acid) caused by the volatilizing of salt, it is important that salt glaze kilns have adequate ventilation. Unlike the updraft kiln, which creates its own draft and functions on the principle that heated air will rise naturally through the flue openings, the downdraft kiln (Diagram 1) requires a chimney or stack to pull the flame through the bottom of the kiln. In salt glazing, a downdraft kiln forces the flame and the volatilized salt down through the ware bringing it in contact with all surfaces. This is one of the major controlling factors in producing good quality ware.

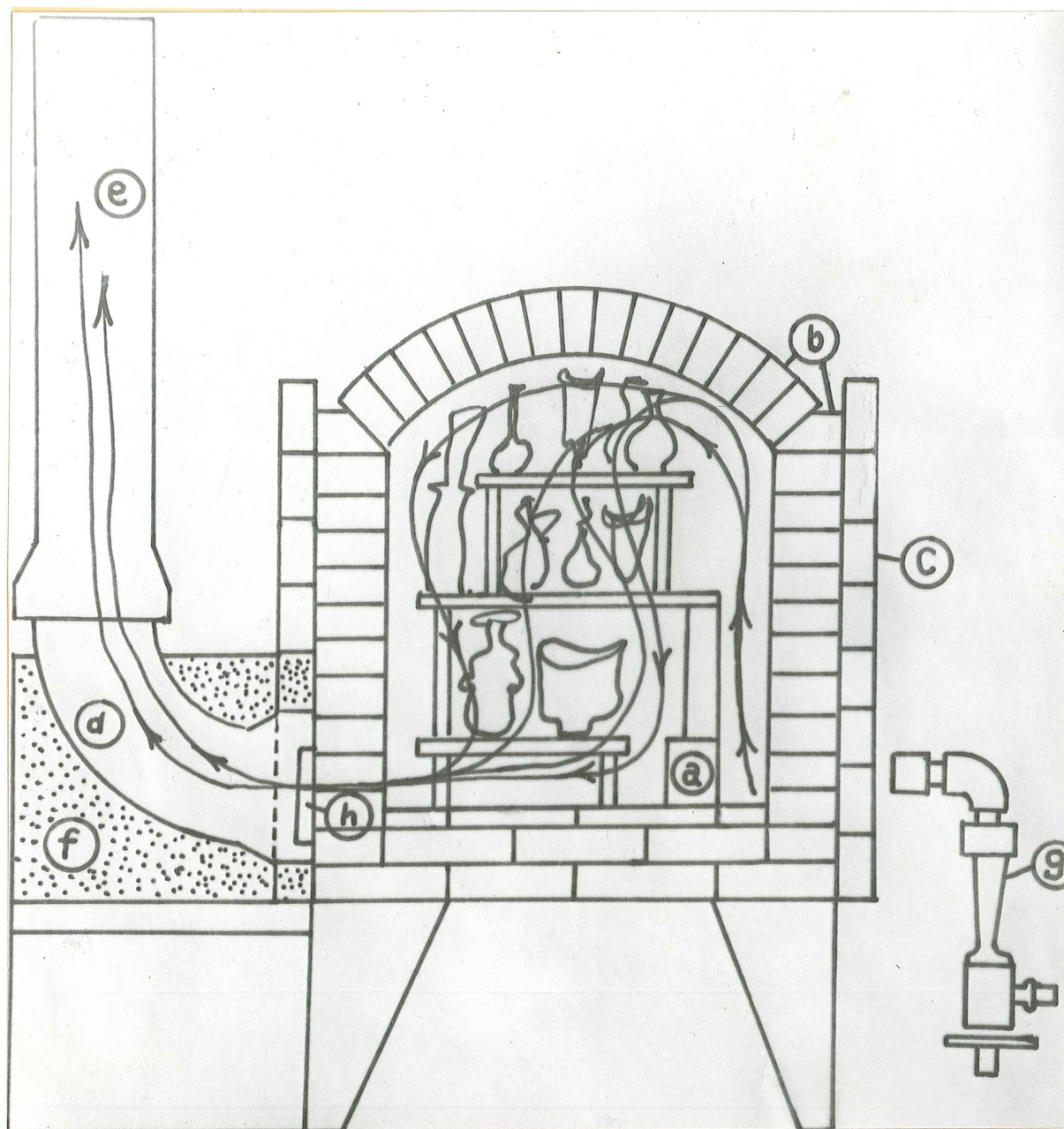


Diagram I. Downdraft Kiln Showing Movement of Air Through Ware and Out Through Flue.

- | | |
|---------------------|--------------------|
| a. Bag Wall | e. Chimney |
| b. Fire Brick | f. Refracrete |
| c. Insulating Brick | g. Venturi Burners |
| d. Flue | h. Damper |

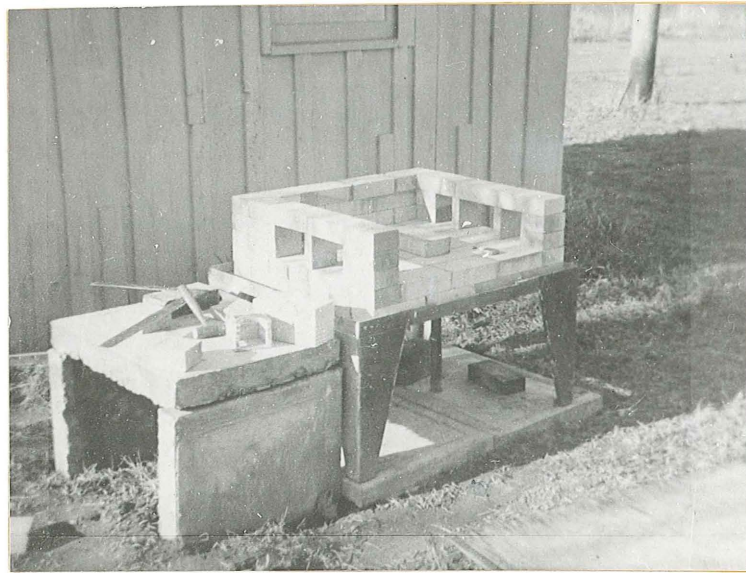


Photo A. Kiln Foundation and Flue Support.

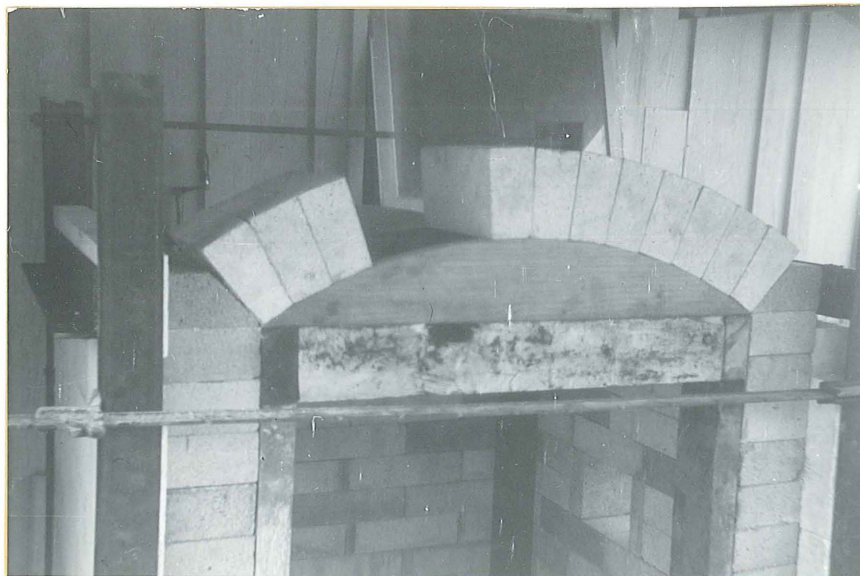


Photo B. Arch Construction.

To hold the walls erect and to keep the weight of the kiln from settling unevenly, a solid foundation was constructed of a heavy steel plate and angle iron set onto a four-inch slab of concrete. (Photo A) Four-inch blocks were constructed to support the base of the flue.

All bricks on the inner layer of the firing chamber were laid in a horizontal or stringer position. After the walls of fire brick were raised, a template of plywood was made for the construction of the arch. (Photo B) The bricks of the outer layer and of the arch were laid in a vertical or soldier position.

The flue was then constructed of a right angle eight-inch ceramic sewer pipe, imbedded in a thick layer of refractory material, Refracrete*. (Photo C) A four foot length of eight-inch sewer pipe was installed for the chimney. A notch was cut into the bell of the ceramic flue so that a damper could slide between the insulating and fire bricks. A piece of ceramic shelf was cut for the damper, threaded with an I-screw for easy opening and closing. (Photo D)

To facilitate repair to the kiln floor, a layer of fire brick splits (9" x 4½" x 1½") were laid flat on the existing floor. Four inches from the inside wall, a bag wall was placed on the floor. The bag wall was designed to deflect the flames upward, and was originally constructed of five 1½" fire brick splits placed vertically. The corrosive action of the salt and the excessive heat in this area had destroyed the original and two successive bag walls before the present design was used. The latter design consists of three standard fire bricks placed horizontally on the kiln floor, with five 1 3/4" fire

*Trade name for a refractory casting material.



Photo C. Flue
Construction



Photo D. Damper

brick splits placed on them vertically. (Diagram 1,a.)

A five inch by six inch salting port was constructed directly above the burners so that when salt is dropped into the kiln, between the bag wall and the burner ports, the volatilized salt is drawn upward, following the curve of the arch, and travels down through the ware.

The burner system is perhaps the most important factor in controlling and holding the temperature within the kiln. The three Venturi burners are successful because the manner in which they induce oxygen into the kiln atmosphere. (Photo E) Primary air is mixed with the gas in the lower stem (Photo E,a.), and secondary air is drawn at the burner tips (E,b.). Pressure indicators were installed on the input pipe of each burner. These indicator tubes were filled with water and marked at one inch intervals. (E,c.)

The door, constructed of an angle iron frame and of the same thickness and materials as the kiln, pivots at the bottom and is lowered and raised by pulleys and cables controlled by a reduction gear motor. (Photo F) This door, when open, provides a good table area for stacking and unloading of the kiln. Observation ports (Photo F,a.) were placed on two levels with bricks fitted for closings.

When the door was in place and all was in readiness for the first firing, a paste of aluminum oxide was painted on the kiln shelves, the bag wall, shelf supports and around all openings where the formation of salt glaze would impair the function of the kiln. This substance is the most effective in repelling the action of salt glaze during the firing of the kiln.

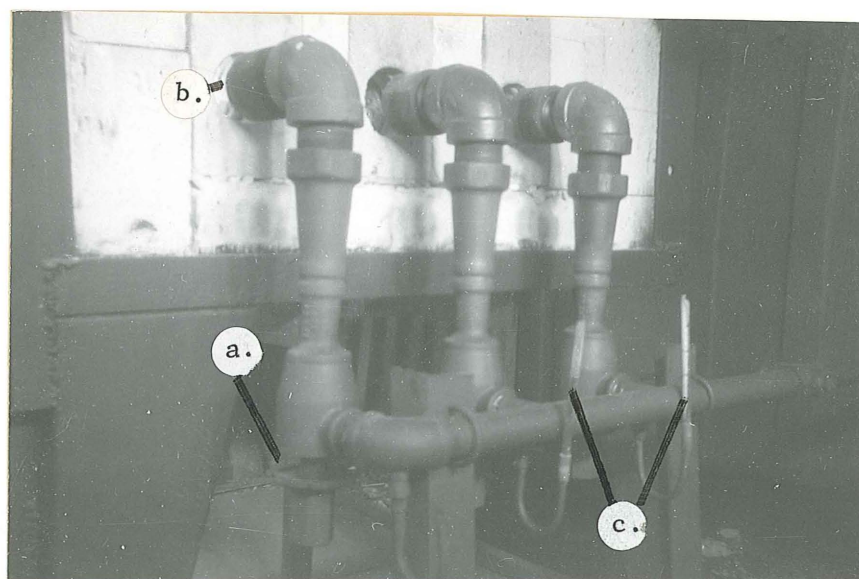


Photo E. Venturi Burners. (a.) Primary Air and (b.) Secondary Air.
(c.) Pressure Indicators.

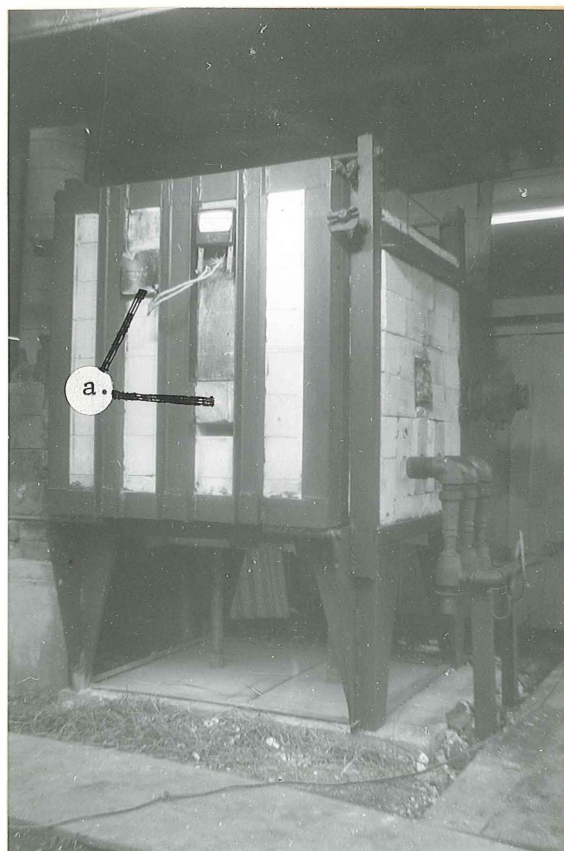


Photo F. Kiln Door
(a.) Observation Ports.

The first few firings of the kiln were designed to "ripen" the interior and with each successive firing, the salt glaze became more thickly coated. To speed up this process, old bricks and discarded pots were stacked into the kiln to take up some of the volume. It was only after about fifteen firings that consistently glazed ware came from the kiln.

The pottery was placed in the kiln with adequate space between the pieces to facilitate the proper circulation of the salt fumes. To keep the ware from sticking to the shelves, rings or small balls of clay high in alumina were placed under them.

Silicon carbide shelves can be used in the salt kiln, but must be covered with a thick layer of aluminum oxide before each firing. Alumina mullite shelves, which repel all action of the salt glaze, were found to be more successful.

On the average, one pound of salt per cubic foot of kiln capacity will give the best glaze results. Water is mixed with the salt to form a thick brine. When the kiln has reached the required temperature, about 2300¹⁰F., a small scoop of brine is thrown into the kiln through the salting port directly above the burners. Immediately after throwing the salt into the kiln, the damper is closed to one-quarter opening to hold the gases within the chamber causing dense white smoke to pour out of the chimney. The unburned gas, reacting with the oxygen, ignites outside of the kiln through cracks and small openings.

The damper is opened after about five minutes. It then takes approximately twenty minutes for the kiln to regain the temperature

¹⁰ A pyrometric cone can be used to determine the temperature but is of no use after the salting begins.

lost during the salting process. At this time, the process is repeated, until ample glaze is accumulated on the ware. To check for glaze thickness, clay test rings which were in the chamber during firing, are taken from the kiln through a port in the door with a long rod, cooled in water and examined. If the glaze is not thick enough, salting is resumed. The average firing time is eighteen to twenty hours with about five to eight pounds of salt being used. However, as the salt layer becomes thicker on the interior of the kiln, less salt is required because some of the previous salt volatilizes to form a glaze before the actual salting takes place.

III. Clays and Their Effect on Color

A. Individual Clays Tested: Color in salt glaze is determined by the clay's ability to take a good glaze. Some clay bodies will take a salt glaze while others will not. This depends mainly on the silica content and the maturing temperature of the clay. H.G. Schurecht found that the silica content of the body should be between 4.6 and 12.5 molecules to each molecule of alumina oxide (Al_2O_3). Bodies which over-fire at cone 1 usually cannot be salt glazed because higher temperatures are necessary for reaction with the body.¹¹

Schurecht has reported on the relations between the content of iron oxide, alumina, and silica in clays, and their effect on the formation of color in a good salt glaze. He summarizes the relationship as follows:

White to tan, if the ferric oxide content is not above 1% and the silica is low; or up to 2.19% ferric oxide if the silica is high. (The ferric oxide content is calculated on the basis of calcined clay.)

Light brown, if the silica is low and the ferric oxide does not exceed $3\frac{1}{2}\%$; or with ferric oxide 2.19 to 3.5%, if the silica is high.

Brown, if the iron oxide lies between 3.5 and 4.75%.

Mahogany, if the iron oxide exceeds 4.75% but is less than 8.2%.

Black, if the content of iron oxide is greater than 8.2%.¹²

The same investigator found that ferruginous clays high in lime produce greenish-yellow glazes, but a lime content as low as 1% may

¹¹ H.G. Schurecht, "Salt Glazing of Ceramic Ware," Bull. American Ceramic Society, XXII, (1943), p. 45.

¹² H.G. Schurecht, "Clay Sewer Pipe Manufacture," Journal of American Ceramic Society. (Abstract) 6:717 1961.

prevent development of bright glaze at low temperatures. High lime clays can be salted best at high temperatures. One and one-half to three per cent magnesium oxide (MgO) improves the ability of the clay to take a glaze but more than 3% dulls the glaze. Clays high in MgO tend to produce crystalline salt glazes at cone 10.* A more brilliant glaze may be obtained if clay contains 1 to 5% titanium dioxide (TiO_2). The addition of 0.1% to 0.3% of barium carbonate ($BaCO_3$) to the clay is recommended to eliminate objectionable soluble sulphates.¹³

In order to develop a clay with a good throwing body as well as one that would take a good salt glaze, it was necessary to test many clay bodies and single natural clays in the salt kiln. The results of these tests are given here as a guide for others preparing a salt glaze body. The results may help in controlling, to a small degree, the color, the amount of glaze and temperatures required of a salt glaze body.

The following clays, salted and fired to cone 8 in a reduction atmosphere, gave the listed results:

Beuna Vista Clay - Smooth, very little texture, reddish brown.

Denver Formart Clay - Good transparency, bright orange-peel textured glaze; light gray with dark specks.

Edgar Plastic Kaolin - Slight glaze, appeared as a layer of orange-tan stain.

Georgia Kaolin - Dry; no layer of glaze. In some areas a slightly glossy layer of orange color.

*2381°F.

¹³Ibid.

A.P. Green Flint Fire Clay - Good satin glaze; good orange-peel texture, brown color.

Indian Hill Fire Clay - Smooth satin glaze, no texture. Buff to gray color.

Jordan Stoneware Clay - Good layer of glaze; bright, with an orange-peel texture.

Kentucky Ball Clay - Thin, smooth satin glaze with an orange-tan color.

Lincoln Plastic Fire Clay - Good satin glaze, orange-peel texture; rich mahogany color.

Masons Blend - Took a thin satin glaze, very little texture; brown color.

Microblend Fire Clay - Took a thin satin glaze; very little texture, brown color.

Spinks Clay - Good texture; satin finish, light gray color.

Tennessee Ball Clay #1 - Took a thin, smooth satin glaze with a strong orange color.

Troy Fire Clay - No glaze; light orange to white.

By compounding the individual clays in different proportions, it was possible to develop clays that have good throwing characteristics, plus influencing the color to some degree.

B. Compounded Clays Tested: Following are some clay bodies for salt glazing that proved to be successful. Research was directed toward developing a light colored stoneware body that would be a good base for decorating oxides and engobes.

Clay Body I:

Indian Hill Fire Clay	15%
Edgar Plastic Kaolin	20%
Flint	20%
Feldspar	28%
Troy Fire Clay	17%
	<u>100%</u>

This is a white body beneath the glaze. It produces a clear, bright glaze and a large orange-peel texture that has a fine crackle pattern.

Clay Body II.

Lincoln Fire Clay	15%
Tennessee Ball Clay #1	20%
Troy Fire Clay	17%
Flint	20%
Feldspar	<u>28%</u>
	100%

This is a white body beneath the glaze. It produces a clear, bright, smooth glaze that has a fine crackle.

Clay Body III.

Edgar Plastic Kaolin	45%
Silspar	25%
Flint	25%
Bentonite	<u>5%</u>
	100%

This is a white body with a transparent glaze, a slight texture, and a small crackle.

Clay Body IV.

Tennessee Ball Clay #1	26.9%
Edgar Plastic Kaolin	26.9%
Feldspar	26.9%
Flint	<u>19.5%</u>
	100.0%

This clay gives a beautiful, finely textured glaze with a small crackle where the glaze is thick.

Clay Body V.

Indian Hill Fire Clay	40.2%
Troy Clay	40.2%
Nepheline Syenite	<u>19.6%</u>
	100.0%

This clay body has a light gray body under the salt glaze. The glaze is enriched by a heavy orange-peel texture and some iron-red color areas at the texture tips. This is a good body for salt glazing at cone 8.

Clay Body VI:

Indian Hill Fire Clay	26%
Troy Fire Clay	26%
Tennessee Ball Clay #1	26%
Nepheline Syenite	<u>22%</u>
	100%

This finely textured, light colored body is light gray and was used in most tests. The glaze is clear with iron-red spots at the tip of a prominent orange-peel texture.

Clay Body VII:

Spinks Clay	28%
Troy Fire Clay	28%
Tennessee Ball Clay #1	28%
Nepheline Syenite	<u>16%</u>
	100%

This body appears gray beneath the glaze. It produces an attractive orange-peel texture with a small crackle.

IV. Coloring Agents for Salt Glaze

A. Native Clays: For colors other than those derived from the iron or other impurities in the clay body, it is best to use a clay body that has very little iron in it. Only in this way will the glaze be clear and colorless, allowing in turn the true development of the coloring technique. A good throwing body, light in color, with a good orange-peel texture is Clay Body VI, and one that was used for the majority of the tests made.

The simplest and most direct way of applying color to ware is to make a clay slip and brushing it on the green ware. A slip of dark shale or dark-firing clay applied to a light body can be as successful as a light slip being applied to a dark clay body.

By making slips of many Oregon clays, it was possible to arrive at a variety of colors and textures. Using Clay Body VI, the prepared slips were applied. However, it was found that Oregon clays are predominately iron-bearing and the range of colors is from a light brown, indicating 3.5 to 4.75% of iron present, to a dark black, indicating the iron percentage to be in excess of 8.2%. Plate I shows the results of the testing.

Troutdale Clay and Gresham Slip are low-firing brick clays and tend to flux out under the influence of the salt kiln. (Plate I, i-j). The green color in the two clays is caused by a small percentage of iron in the body or the reduction of small iron pyrite crystals which are visible when the clay is in slip form. The varying percentages of iron in the other clay slips are obvious. (Plate I)

Another native material which was used successfully is volcanic

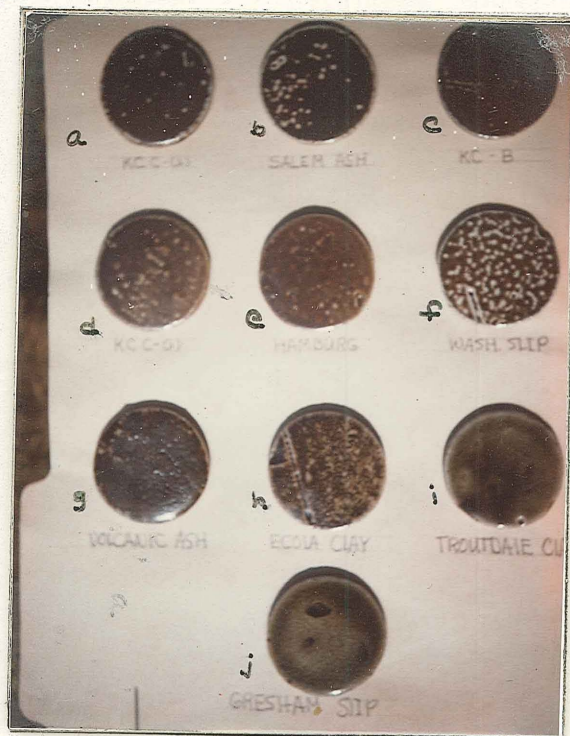
ash (pumice). This material was ground and sifted through a 60-mesh screen, mixed with water and applied to the ware. The pumice itself does not mature but its surface is glazed by the salt action. This material appeared to be a part of the design of the pot itself and did not appear to be painted-on. Also interesting areas are formed in the spaces between the raised surface of the pumice. (Photo G)

B. Engobes: A great range of color can be obtained by adding different amounts of coloring oxides to the clay body itself and by using it as the basic engobe or prepared slip material. If the clay body is high in iron, however, this technique does not work as well because of the dark color. A more flexible technique can be employed by preparing an engobe from basic materials, clay, feldspar, flint and flux. To this clear slip, different percentages of colorants can be added and the slip applied directly to the wet or dry ware. This type of engobe works well on either dark or light clay bodies.

Circular tiles were used to test the engobes. A clear slip was prepared from the following formula:

Tennessee Ball Clay #1	15%
Kaolin	15%
Calcined Kaolin	20%
Flint	20%
Zircopax	5%
Borax	5%
	<hr/> 80%
Coloring Agents	20%
	<hr/> 100%

To the basic mixture, percentages of various materials were added, as shown in Plate II, figures (a.) through (f.) For salt glazing, these techniques could not be considered to be successful, in that the colors were either washed out or appeared to be painted on. These



- a. Kings Clay - White Ash
- b. Salem Ash, found in road cuts south of Salem on Highway 5, between Salem and Albany.
- c. Kings Clay - Brown Ash, and
- d. Kings Clay - Gray Ash (also a.) were found in road cuts south of Kings, Oregon.
- e. Hamburg Clay - Stoneware Clay mixed by John Hamburg, Beaverton, Oregon.
- f. Washington Slip - Dug from Cowlitz, Wash. Brick Co.'s clay pit, just north of city.
- g. Volcanic Ash - Widely found in Eastern Oregon; light in color, commonly referred to as pumice.
- h. Ecola Clay - Found at cliffs of Ecola Park, Oregon.
- i. Troutdale Clay - Dug from road cut south of Wood Village, Oregon.
- j. Gresham Slip - A brick clay used by Columbia Brick Works, Gresham, Oregon.

Plate I. Color in Native Clays.

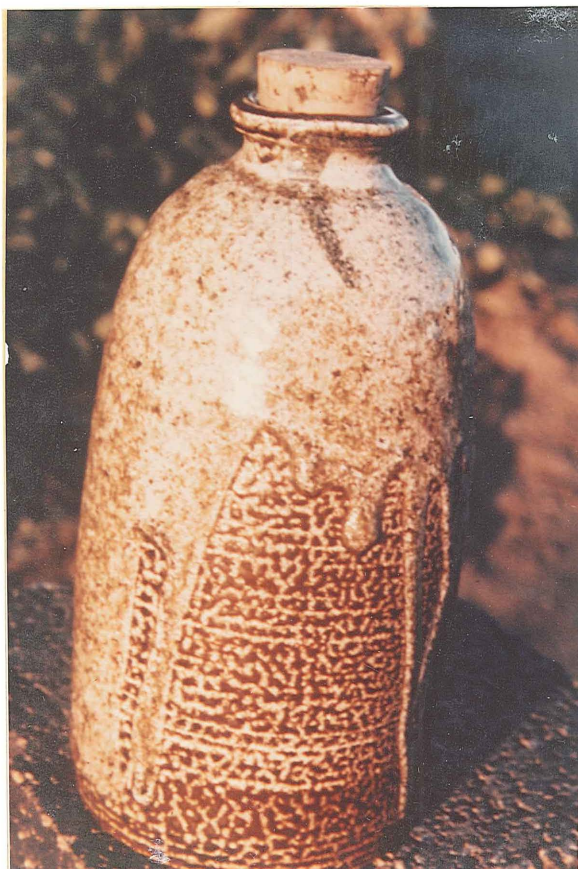


Photo G. Example of Pumice Used
with Salt Glaze.



Photo H. Use of Prepared Glaze
with Salt Glaze.

engobes obliterate the formation of good orange-peel texture, but if used correctly as a decorating agent, there can be an interesting play between the glossy areas of the glazed engobe and the textured area of the salt glaze.

Regular glazes can be used with salt glaze but most of them tend to flux out and be glossy. (Plate II, Fig. h.) They, like engobes, can be used to create textural differentiation or special decorating effects. (Photo H)

Glazes high in barium withstand the action of the salt very well and produce an opaque surface. One of these found to be quite successful was Lib Barium Mat; the formula is as follows:

(Plate II, Fig. g.)

Nepheline Syenite	57.3%
Barium	26.3%
Ball Clay	7.6%
Flint	7.6%
Bentonite	.6%
Magnesium Carbonate	.6%
	<u>100.0%</u>

C. Metallic Oxides: The most successful method for painting glaze on greenware was to mix the raw elements with water and apply them directly to the ware. Of all the metallic oxides available, cobalt oxide and manganese dioxide were the most satisfactory. When these are painted on the raw ware and fired in the salt kiln, the color becomes a part of the pot and does not have a painted-on appearance as does that of the engobes.

Cobalt is the most versatile of the coloring agents, ranging from black to light blue. (Plate III) Black cobalt oxide is the darkest



Plate II. Engobes and Prepared Glazes.

- a. White 1% Cobalt Oxide
- b. Gray 2% Iron Oxide
- c. Brown 4% Iron Oxide
- d. Blue 1% Cobalt Oxide
- e. Green 3% Copper Oxide
- f. Black 3% Iron Oxide
2% Cobalt Oxide
2% Manganese Dioxide
- g. Lib Blue - See Test for Formula
- h. Transparent Matte - Fluxed out by salt action.
- i. Colemanite - Formed semi-matte blues, no salt glaze texture.

of the cobalts and forms a metallic surface when heavily applied. If applied thinly, the light body is allowed to show through. (Photo I)

Cobalt sulphate is most attractive when applied in large areas. The edges of the design blur and form attractive abstract shapes.

(Plate III, Fig. f.) Cobalt carbonate is the weakest of the three and forms an interesting texture when the light body shows through. (Plate III, Fig. g.)

Manganese dioxide and manganese carbonate are harder to work with than the cobalts. If the kiln reduces while it is being salted, which it very often does, the manganese color disappears. Manganese is not very strong in coloring power and it has a tendency to blur under the salt glaze, just as the cobalt oxides do. To be successful, the decoration must have the appearance of being just barely black. When decorated with the proper amount of manganese and then salted, manganese produces a beautiful, rich black color with some fascinating white specks, caused by the eruption of the orange-peel texture. (Plate III, Fig. k.)

Although manganese forms a rich color when applied in small areas, strongly colored manganese dioxide slip, painted all over a leather-hard pot does not give as pleasing an effect. (Plate II, Fig. f.)

Chromium produces a deep black and retards the formation of any salt glaze on the surface. The chromium, when used with a wax resist technique, forms a sharp line and adds interest between the textured and non-textured areas. (Photo J) The wax resist technique is a liquid wax emulsion painted on the greenware, in areas where the decorating oxide is not wanted.

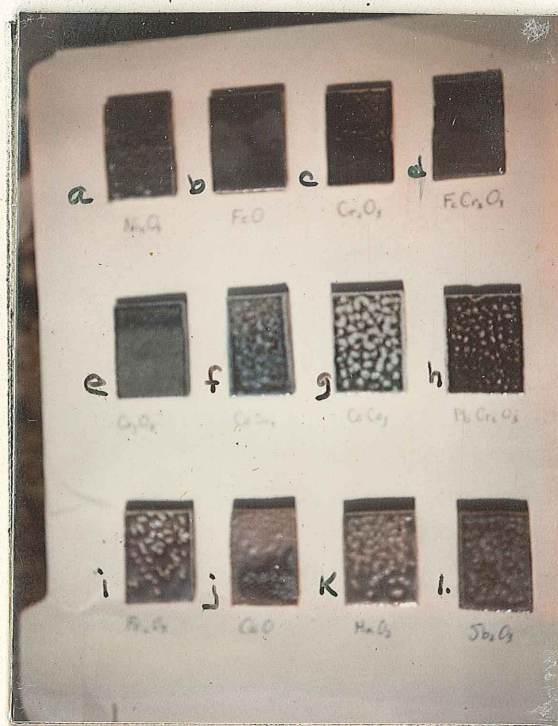


Plate III. Coloring Agents

- | | |
|------------------------------|------------------------|
| a. Ni_2O_3 | - Black Nickel Oxide |
| b. FeO | - Black Iron Oxide |
| c. Cr_2O_3 | - Green Chromium Oxide |
| d. FeCr_2O_3 | - Iron Chromate |
| e. Co_3O_4 | - Black Cobalt Oxide |
| f. CoSO_4 | - Cobalt Sulphate |
| g. CoCO_3 | - Cobalt Carbonate |
| h. PbCrO_3 | - Lead Chromate |
| i. Fe_2O_3 | - Red Iron Oxide |
| j. CuO | - Black Copper Dioxide |
| k. MnO_2 | - Manganese Dioxide |
| l. Sb_2O_3 | - Antimony Oxide |

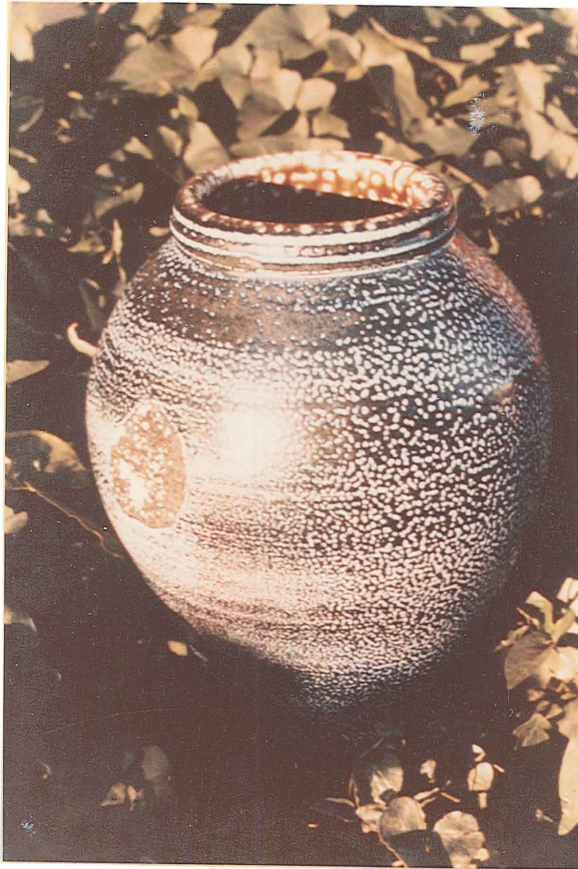


Photo I. Cobalt Oxide Applied Thinly
Over Light Body.

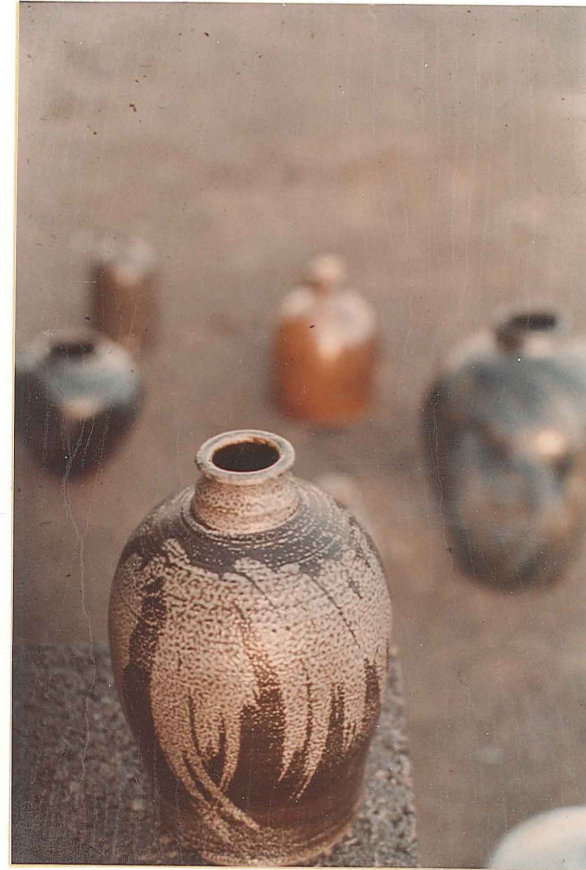


Photo J. Chromium Applied With Wax Resist
Technique.

When chromium oxide is used with cobalt oxide, it tends to temper the color. Another colorant that can be used to temper the blue of cobalt is red iron oxide. Iron can be used by itself, but is a fugitive color and useful only on very light bodies, where it produces rich red metallics with light and dark areas. (Plate III, Fig. i.) Unlike chromium that retards the action of salt, lead chromate produces a good black color and allows an excellent orange-peel texture to develop. (Plate III, Fig. h.)

Rutile is an impure form of titanium dioxide, contained in iron oxide.¹⁴ When rutile is added to the surface of a clay body high in iron, the result is an intense ochre or light brown. (Photos K and L), but when it is added to a light body such as that of Clay Body VI, the rutile takes on a silver appearance. (Photo M) Also, when rutile comes in contact with cobalt oxide, various shades of green are produced. (Photo M, Foreground)

Copper was tried many times under various circumstances but because of the thin quality of the glaze, only one test using copper oxide produced a clear copper red. (Plate IV, Fig. i.)

Some materials not generally explored by the ceramist were found to be very useful as decorating agents in salt glazing. Among these materials are uranyl nitrate, (uranium) ammonium molybdate, and cerium nitrate. (Plate IV)

Uranyl nitrate is one of the most interesting materials used. On Clay Body VI, fired to cone 8*, it forms a deep black beneath an orange-

¹⁴ Glenn C. Nelson, Ceramics - A Potter's Handbook. 2nd ed., (New York: Holt, Rinehart and Winston), p. 215.

*2300°F.

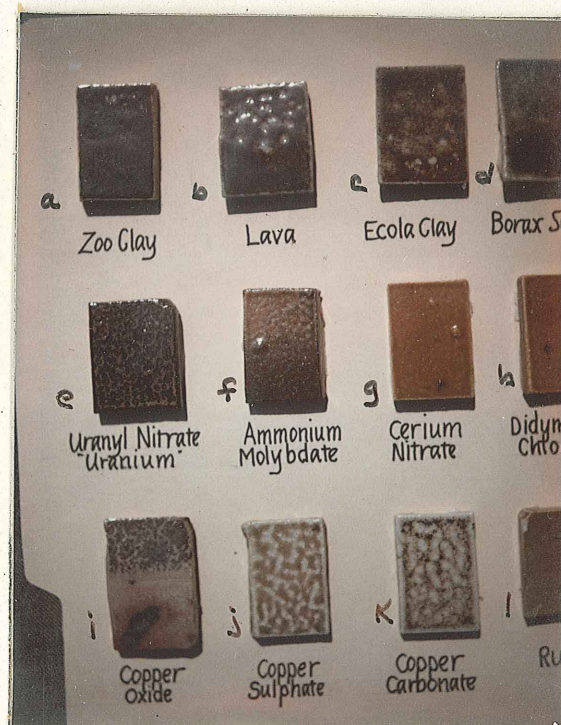


Plate IV. Coloring Agents

- a. Zoo Clay
- b. Lava
- c. Ecola Clay (Duplicate)
- d. Borax Salt
- e. Uranyl Nitrate ("Uranium")
- f. Ammonium Molybdate
- g. Cerium Nitrate
- h. Didymium Chloride
- i. Copper Oxide
- j. Copper Sulphate
- k. Copper Carbonate
- l. Rutile



Photo K. Rutile Applied to Body High in Iron.

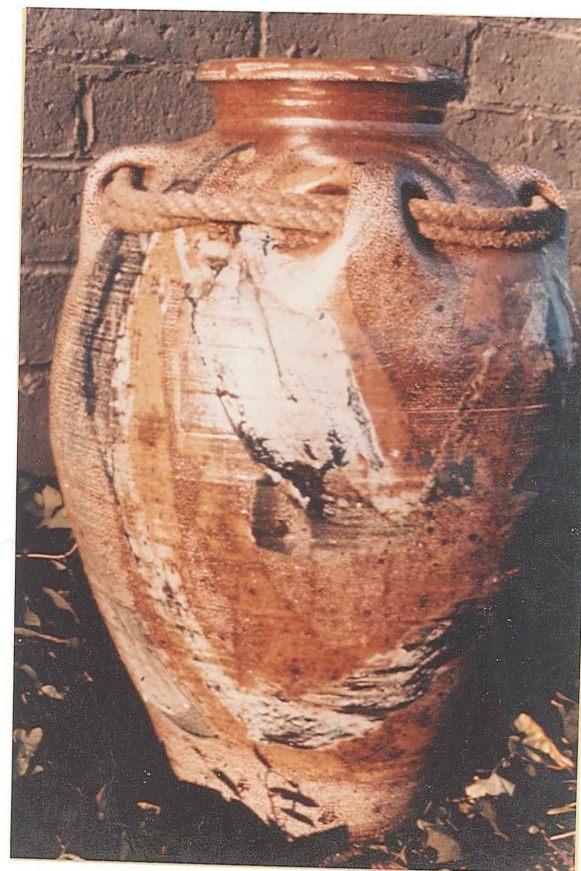


Photo L. Rutile Used in Combination with Engobes.

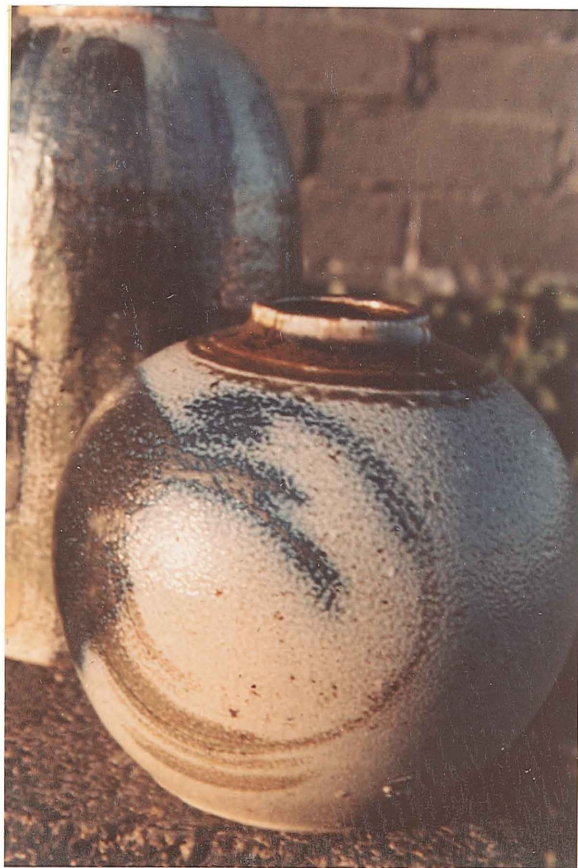


Photo M. Rutile Applied to Light Body
Resulting in Silver Effects; See Back-
Ground Pot. Green Effects on Fore-
Ground Piece Where Rutile and Cobalt
Meet.



Photo N. Salt Glaze Used on Sculptured
Plaque.

peel texture of metallic gold. (Plate IV, F g. e.)

Ammonium molybdate, although not a strong colorant, produced light blues with diffused edges and developed a medium orange-peel texture.

A strong orange color was obtained from the use of cerium nitrate. Its lack of texture allows it to be used in the same way as chromium to create differentiation between textured and non-textured areas.

Other materials were tested. However, those which lent themselves best to the salt glaze technique have been discussed.

V. Summary and Conclusions

In the research done for this thesis it was found that there are many native (Oregon) clays that will give color in salt glaze, but their colors are confined to the brown range because of the high iron content of the clay. However, most of these clays form interesting textures when used with salt glaze.

Prepared slips and engobes do not seem to have the wide range of possibilities that native clays and raw elements do as a decorating technique for salt glazing. Engobes often have an applied appearance, and with salt glaze forming in the manner it does, do not adapt readily to this glazing technique unless handled very carefully.

On the other hand, oxides, when applied to greenware, penetrate and become part of the clay itself. They allow one to create spontaneous designs, which is a most important factor in freedom of expression.

Building a kiln becomes a part of the total process in producing salt glaze ceramics. In this case the studio potter must control all factors--the selection of clays, coloring agents, and the kiln itself. Thus there is total involvement in the art-craft by the artist which opens up avenues of technical and aesthetic experiences to him.

BIBLIOGRAPHY

Ball, F. Carleton, "Salt Glazed Stoneware," Ceramics Monthly, X, 26-27, (February 1962).

Barringer, L.E., "The Relation Between the Constitution of Clay and its Ability to Take a Good Salt Glaze," Trans. American Ceramic Society, IV, 211-229 (1902).

Driscoll, H. "Salt Glaze Firing," Ceramic Age, 56 (4), 66-68. (1950).

Everhart, J.O., "Production of Salt Glaze by the Application of Slip to the Ware," Journal of American Ceramic Society, XIII (6) 399-403 (1930).

Foster, H.D., "Resume of Technical Studies of Salt Glazing," Bulletin of American Ceramic Society, XX (7) 239-241. (1941).

_____, "Salt Glazes for Structural Building Units," Journal of American Ceramic Society, XXVI (2) 660-667 (1943).

Garzio, Angelo, "German Salt Glazing," Craft Horizons, XXIII, 20-22 (March - April 1963).

Honey, W.B., English Pottery and Porcelain, London: Adam and Charles Black, 1962. 284 p.

Nelson, Glenn C., Ceramics - A Potter's Handbook, 2nd ed., New York: Holt, Rinehart and Winston. 1966. 329 p.

Parmelli, Cullen W., Ceramic Glazes, Chicago: Industrial Publications, Inc. 1951. 230 p.

Rhodes, Daniel, Stoneware and Porcelain, New York: Chilton Co. 1959. 217 p.

Schurecht, H.G., "Salt Glazing of Ceramic Ware," Bulletin of American Ceramic Society, XXII, (1943).

_____, "Clay Sewer Pipe Manufacture," (An Abstract) Journal of American Ceramic Society. 6:717. (1961).

OTHER REFERENCES

Anonymous, "Borax-Salt Mixture Improves the Appearance of Salt Glaze Ware," Brick and Clay Records, 95 (1) 30. (1939). (Also in Ceramic Observer, 1940)

Fosdick, M.L., "Salt Glazing at Cone 02 by Slip Application," Journal of American Ceramic Society, XXVII (7), 219-220 (1934).

Longnecker, W.L., "Vapor Glazing and Color Flashing of Pre-Cambrian Shales," Journal of American Ceramic Society, XIII (11) 794-804 (1930).

Schurecht, H.G., "Influence of Carrying Lime Content in Clays Upon Some Properties of Salt Glazes Produced at Different Temperatures," Journal of American Ceramic Society, VII, p539. (1924).