AN EXPLORATION OF THE DEVELOPMENT AND USE OF COLORED CLAY IN RAKU FIRING

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We hereby recommend that the thesis prepared under our supervision by Michael Haley

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AN EXPLORATION OF THE DEVELOPMENT AND USE OF COLORED CLAY IN RAKU FIRING

I. Introduction

Statement of the Problem

The problem was to develop a palette of colored clays from metallic oxides and salts commonly used by studio potters for use in the raku process, and to execute a series of works using those colored clays either structurally or as plastic decoration.

Purpose of the Study

The purpose of the study was to explore through experimentation the possibility of using colored clays as an additional tool for achieving unique chromatic effects when used in conjunction with the raku firing process.

Justification

While work had been done using colored clays at various temperature ranges, there was little published material on the use of colored clay and raku. Preliminary experiments indicated a unique quality of color emitted by the colored clay beneath a glaze which appeared to be unattainable through the use of slips, glazes, and other coloring methods.

The expressive nature of the raku process was given another dimension through the integration of raku and

colored clay by providing a significant color element to act as a counterpoint to the traditional white-on-black dichotomy of raku.

Many subtle variations of value, hue, and intensity were thought to be possible through alterations in the compositions of the colored clays, thus providing a color technique with greater controlled variety than other coloring methods will allow.

A large degree of control was possible in color juxtapositions, but at the same time, a spontaneous appearance was achievable through manipulation of the clay surface by paddling, incising, etc.; thereby giving the artist another technique for achieving a sense of structure while enabling him to obscure this sense of structure at his discretion.

Background

The technical side of contemporary raku has an unbroken lineage which goes back to 16th century Japan and the spread of Zen Buddhism in that country. Its techniques have literally been handed down from father to son since then with relatively few changes (Tyler, 1975).

The intuitive side, on the other hand, involves an approach to art that also passes through 16th century Japan,

although it probably did not begin there. Some of the characteristics of this approach include economy of means, assertion of the expressive qualities of the medium, emphasis on the creative act, and a liberation from tradition. This intuitive approach followed a somewhat erratic path through modern art in the essence of such artists as Van Gogh, Gaugin, also the Fauves; from them into such movements as the German Expressionism and Dadaism and Surrealism; and eventually, into the expressionistic and abstract movements. Expressionistic and abstract art attacked the barriers to expression: the rules and conventions in the art world. One result of this confrontation was the elevation of the media referred to as the "decorative arts" to a level of equality with the "fine arts." This, in turn, attracted more serious artists to these media, which, in its turn, resulted in an extensive exploration of the expressive qualities of these heretofore lightly regarded materials (Guggenheim, 1961).

Clay was one of those materials, and raku was a clay process which was little known or explored in this country prior to the middle 1950's. The expressive quality of clay combined with the nature of the raku process and the philosophy behind it made it a natural selection for artists who were trying to express themselves in a similar manner to the Abstract Expressionists and the Action Painters, but in a

more plastic medium; and several artists did begin to work very expressively in raku. Largely through the influence of these artists and the publication in English of more literature on raku technique and philosophy, the spread of raku has reached unprecedented proportions.

What we are seeing in contemporary raku is a continuation of that search to better understand the expressive aspects of clay and glazes. And with virtually all restraints to artistic freedom of expression destroyed, we need no longer feel tied to tradition, although the intuitive approach to art, as epitomized by traditional raku, is invaluable in our search for spontaneity.

The project was a further extension of that search as expressed in the attempts of one artist to achieve a sense of unity through the exploitation of certain color elements and the expressive qualities of a medium.

Delimitations

(1) Colored clay tests were limited to approximately 6-8 different coloring compounds, including the following:

(a) Red Iron Oxide

(b) Rutile

(c) Cobalt Carbonate

(d) Copper Carbonate

(e) Manganese Dioxide

(f) Nickel Oxide

(2) All works were raku fired

(3) All works involved the use of colored clay

(4) Works could be made of clay manipulated in any manner and could combine any forming methods

(5) Works included any glazing, firing, or post-firing techniques deemed necessary to achieve desired or unexpected results.

II. Methodology

Review of Relevant Literature

The author reviewed literature in the following areas:

(1) Reference works:

(a) Art Encyclopedias

(b) Ceramics Encyclopedias

(c) Ceramic Dictionaries

(2) Books, Periodicals, and Journals:

(a) Art Index

(b) Ceramics Abstracts

(c) Essay and General Literature Index

(3) Unpublished Works:

(a) Comprehensive Dissertation Index

(b) Dissertation Abstracts International

(c) Master's Abstracts

As a result of the literature search, the author found nothing pertaining directly to colored clay used in the raku firing process. The following sources were helpful in compiling the background information, disclosing the history of raku and the philosophy behind it, and in testing procedures and forming techniques.

(1) Finding One's Way With Clay by Paulus Berensohn.

Although Berensohn does not deal specifically with raku, his approach to clay is similar to the traditional Zen

approach in its acceptance and utilization of the unexpected events the earth has to offer. His results of using colored clay at various temperatures would be beneficial to anyone working with colored clay.

(2) Ceramic Formulas: The Complete Compendium by Joseph Conrad.

Conrad's book was useful in the area of testing the various oxides and oxide combinations. He has done fairly extensive research on colored clays at different temperatures, although none specifically concerning raku. The book is a handy reference text for clay and glaze formulas as well.

(3) The Penland School of Crafts Book of Pottery, John Coyne, editor.

This book from the Penland School is comprised of a series of articles by reknowned teachers of clay who are associated in some way with the Penland School. The article by Jane Peiser on a forming technique for colored clay proved to be helpful in creating serial images.

(4) Raku by Hal Reigger

Hal Reigger experimented with post firing in the late 1940's and taught a course in raku at the Haystack School in the 1950's. His book was the first on the subject of raku published in English. It was useful as an historical reference.

(5) Techniques for Contemporary Potters: Raku by Christopher Tyler and Richard Hirsch.

The Tyler and Hirsch book was useful in the areas of technique, history, and philosophy of raku. This is a comprehensive text that should prove useful to anyone beginning a study of raku.

(6) Abstract Expressionist Ceramics, University of California at Irvine.

This is a catalogue from a show of early west coast abstract expressionist ceramics and includes works by Peter Voulkos, John Mason, et al. It proved helpful in outlining the recent history of raku at the beginning of its exploration by American artists in the 1950's and 60's.

Definition of Terms

(1a) Raku - Raku refers to,

> . . . a low-fired earthenware which is made of clay with a high content of grof and generally covered with a soft borax/lead glaze, after which it is fired by a special process in which the biscuit-fired glazed article is placed in a red-hot kiln--(750-850°C)--and taken out again in a few minutes as soon as the glaze has melted. The actual word raku comes from a Chinese ideogram, the meaning of which covers such concepts as enjoyment, ease, pleasure, quiet, and happiness. (The word can also be used as a professional title.) (Lyngaard, 1973).

(1b) Though in a strict sense, there may be no true definition for the body of work usually termed "raku," the work created in the evolving process known by the term

probably has its essential nature in an attitude. This attitude has close connections with the ability to accept and utilize the unexpected events the earth can offer (Tyler, 1975).

(2) Colored clay - As it was used in this study, colored clay referred to any of a number of mixtures of white-burning clay and various coloring compounds which were utilized for their fired color rather than for other attributes they may have possessed (e.g., plasticity, resistance to thermal shock, etc.) (Haley, 1977).

(3) Significant color statement - As it was used in this study, a significant color statement was defined as an expressive use of the colored clay, either bold or subtle (Haley, 1977).

(4) Expressive qualities of a medium - Those attributes or characteristics inherent in a medium which are capable of suggesting symbolic meaning or significance (Haley, 1977).

(5) Coloring compounds - The coloring compounds used in this exploration (see Delimitations) were fairly pure grades of insoluble metallic oxides and carbonates commonly used as colorants by studio potters (Haley, 1977).

(6) In-kiln reduction - Referred to an atmosphere during the

firing cycle which contained a surplus of unburned gases, or conversely, a lack of oxygen for complete combustion (Haley, 1977).

(7) Post-firing reduction - When the piece was removed from the kiln with the glaze still hot enough to be in a molten state, it was immediately plunged into an air-tight container of combustible material. The heat of the piece ignited the combustible which consumed all available oxygen thus creating a reduction atmosphere in which the glaze cooled.

(8) Ground or field - As it was used in the investigation ground referred to that part of a piece upon which colored clay was applied as plastic decoration or slip decoration (Haley, 1977).

(9) Opacifier - A substance such as tin oxide which is added to make a glaze more white or opaque. The opacifier either remains suspended in the glaze or crystallizes out in cooling (Searles and Grimshaw, 1959).

III. Developing a Palette of Colored Clay

The compounds most often used in the coloration of clay and glazes are the insoluble metallic oxides and carbonates. The series of tests utilized some of those most commonly used as coloring compounds by studio potters (see Delimitations). They were tested in various combinations following the line blend technique outlined by Rhodes (1971).

A batch of clays was mixed for each coloring compound containing a high percentage of the coloring compound (20-30 percent in most cases). Weaker batches were made from these strong batches by mixing uncolored white-burning clay with the colored clay, resulting in scales of colored clays which diminished in strength in a geometric progression (see Appendix I).

Each test clay from these scales was then blended with each test clay of all the other scales. Theoretically this would result in a palette of colors progressively varying in hue, value, and intensity. Using 6-8 different coloring compounds, and preparing at least two samples for each test resulted in approximately 300 separate tests.

All tests were bisque-fired, glazed with the same glaze, and fired in a similar manner. The results of the tests were reviewed and additional tests were conducted when justified.

It was thought that it would not be possible to develop a palette of colored clays containing the full range of hues and intensities. It was believed, however, that the palette potentially available from the compounds being tested would provide ample color opportunity for an exploration of the hypothesis that colored clay may be successfully integrated with the raku process.

Results of Testing

The testing of the various oxides resulted in both negative and positive findings. The colors were not as exciting as was hoped due to the basic nature of the materials used and to a lack of visual texture, but exploring their possibilities proved to be an experiment which provided ample latitude for self-expression. Before presenting the recommendations for a palette, however, a few points should be noted.

(1) The relatively low temperature of the raku process resulted in colors which were, with the exception of the copper tests, quite bland in texture and earthy in color, lacking the brilliance and visual texture often found in colored clays fired to stoneware temperature (1225-1325°C).

(2) At the temperature involved, the colors formed by the iron and manganese oxides were so similar that they were virtually indistinguishable, and most of the colored clays required such a strong mixture to produce any perceivable color that they were impractical to use. Rhodes (1971) has suggested the use of an opacifier in order to lighten the colors when using coloring oxides at stoneware temperature, but the colors at Raku temperate were so light that no opacifier was deemed necessary in most cases.

(3) All the oxides tested, with the exception of cobalt, required so high a percentage of oxide that their structural and handling qualities were adversely affected.

(4) And finally, in conjunction with the high percentages necessary, the high cost of the oxides made the use of colored clays for structural purposes undesirable except for relatively small or unique pieces where materials cost is not so much of a factor as in production ware.

Recommended Palette

The results of mixing the various oxides was not as positive as was hoped due to the previously mentioned lack of chemical changes taking place at raku temperature and the bland and earthy colors which resulted; and in general,

it was found that by using only a single coloring oxide in a given colored clay the resulting color was more likely to be saturated (i.e., less muddy) than if two or more oxides were mixed. The major exception was in the case of cobalt carbonate, which, being a very strong coloring agent, lent itself to more subtle color variations when mixed with an opacifier and/or certain other oxides.

The chart presented on the following page lists briefly some of the more significant tests. The descriptions of the colors are very generalized and one is advised to test all colors before using them due to the many variables involved.

Color	Composition[1] %	Oxide
Light green to lustrous red	1-3	Copper Carbonate[2]
Dark green to shiny copper	5-19	Copper Carbonate[2]
Pastel green	1 4-8	Copper Carbonate[2] Nickel Carbonate
Yellow to orange with flashes of green and red	1-3 1-3	Copper Carbonate[2] Manganese Dioxide
Blue-green	1 1/2 1 1/2	Cobalt Oxide Chrome Oxide
Light blue	1/2-2	Cobalt Oxide
Medium blue	3-5	Cobalt Oxide
Dark blue to black	6-10	Cobalt Oxide
Light to medium yellow	5-20	Rutile[3]
Ochne	40	Rutile
Flesh tones	5-10 5-10	Rutile Manganese Dioxide
Flesh tones	5-10 2-5	Rutile Red Iron Oxide
Rich, yellow-brown	40 5-10	Rutile Manganese Dioxide
Buff to light pink	1-3	Red Iron Oxide
Warm, light brown	5	Red Iron Oxide
Light brown	10	Manganese Dioxide
Medium to dark brown	10-20	Red Iron Oxide
Medium to dark brown	20-40	Manganese Dioxide

[1]The percentages given should be added to 100 grams of white-burning clay.

[2]The color copper clays varies considerably with kiln atmosphere.

[3]Rutile is the ore commonly used by studio potters as a source of titanium dioxide. It contains a large amount of iron as well.

Recommendations for Further Study

Two other oxides which were not tested extensively but which provided interesting results in preliminary testing were antimony oxide, which produced a gold color when used with nickel oxide; and chromium oxide, which resulted in greens and blue-greens when mixed with a small quantity of cobalt oxide.

Also, a naturally occurring iron-bearing clay provided one of the most exciting colors discovered during the course of the investigation and, although this project did not set out to explore the possibility, an interesting palette could conceivably be developed from naturally occurring clays, which often contain a mixture of coloring compounds difficult or impossible to duplicate by a synthetic process such as the one used in this investigation.

IV. Execution of Works

Approximately 40 pieces were completed during the course of this investigation, several of which are shown on the following pages. Forming methods, problems encountered, and observations are presented in Chapter V along with a summation of the project.

Figure 1. Thrown and paddled vase with serial images. Colorants in serial images are cobalt and iron. Body of the piece has a small amount of iron for a warmer appearance.

Figure 2. Thrown jar with applied coils of cobalt, rutile, and white clay. Body has a small amount of iron.

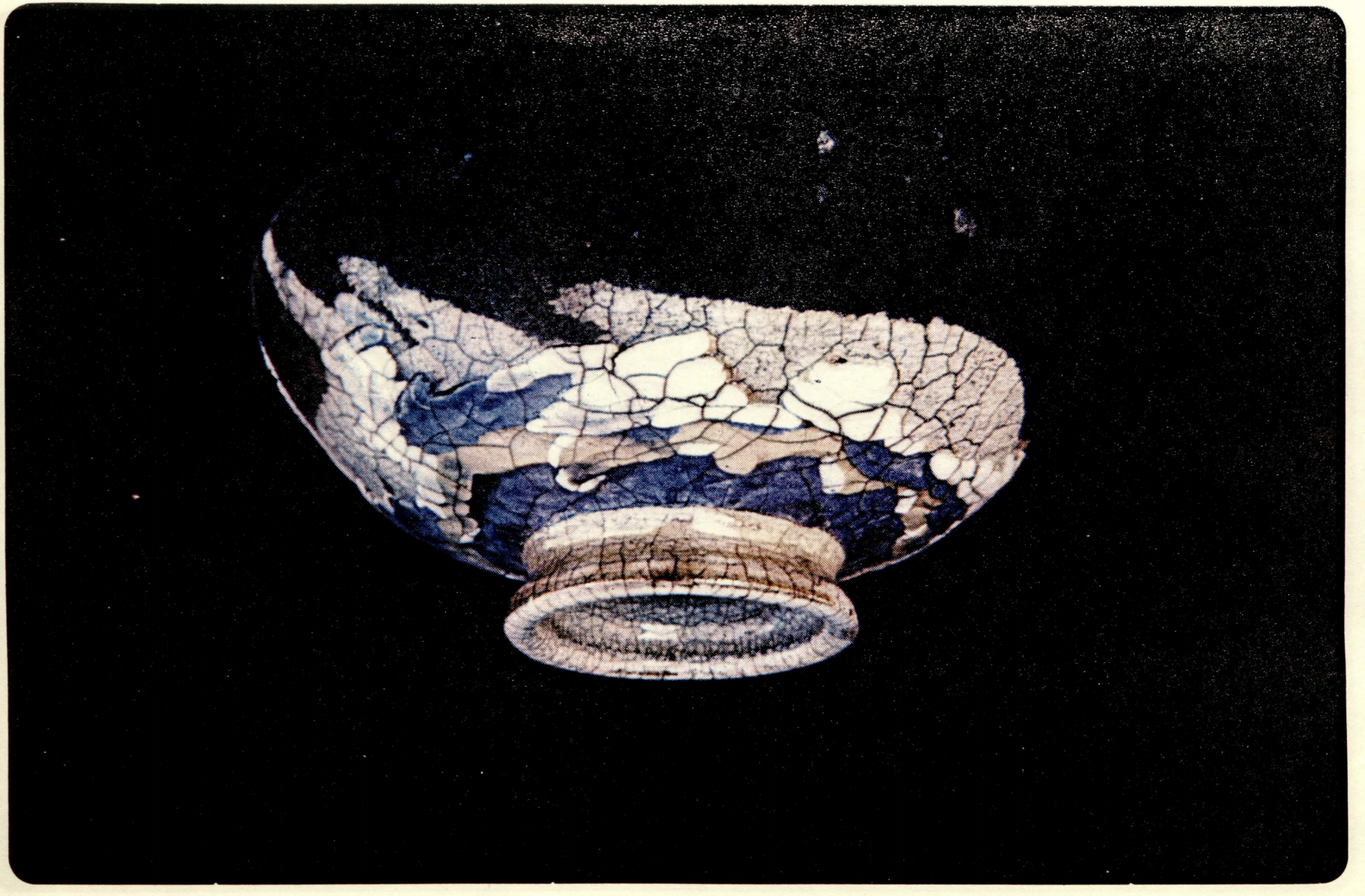

Figure 3. Thrown and hand built jar with applied serial images of cobalt and iron. Height 30 inches. Notice running of colors utilized in design.

Figure 4. Thrown and carved lidded jar with brushed decoration of chrome and cobalt and applied coils of rutile. Height 15 inches.

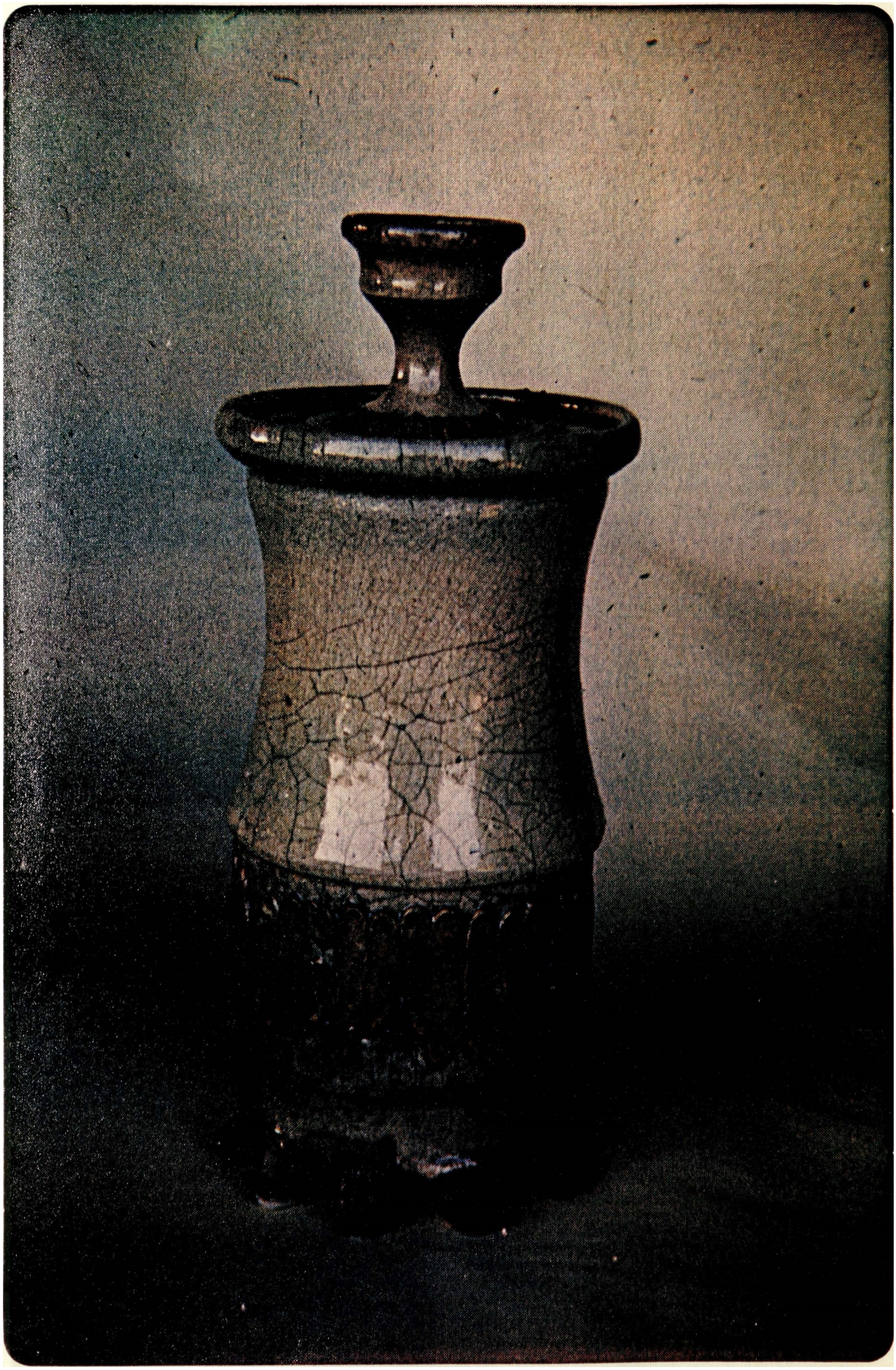

Figure 5. Test slab. Width 18 inches.

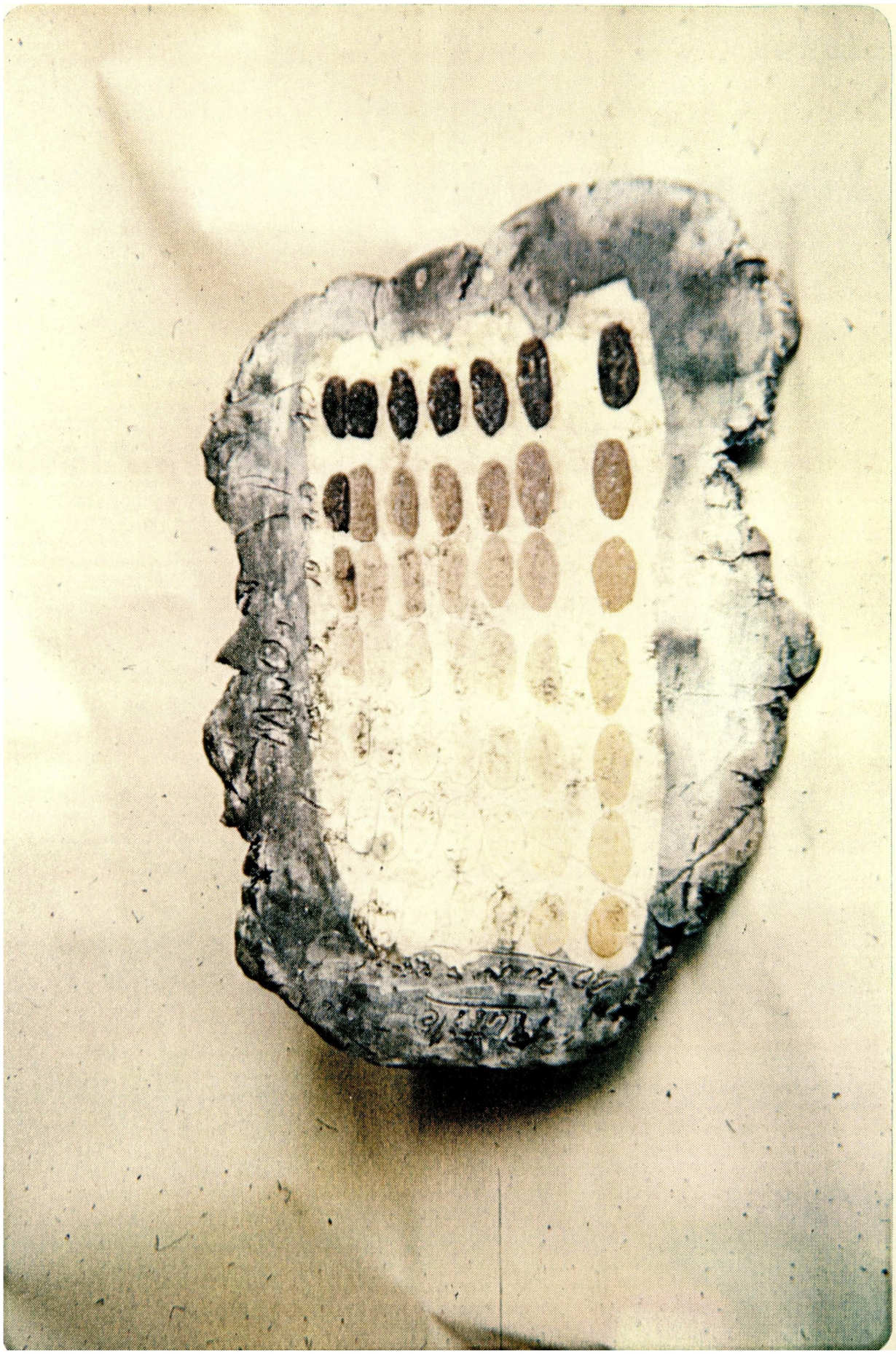

Figure 6. Thrown jar with brushed slip decoration of cobalt, chrome, rutile, manganese, and nickel. Height 18 inches.

Figure 7. Slab platter with serial image of rutile and iron-bearing natural clay. Width 20 inches.

V. Results and Observations

The works were executed using coil and slab building, wheel throwing, and slip painting. Various combinations of these forming methods utilized the colored clay structurally and as plastic decoration.

The project started with an exploration of coils and slabs impressed into thrown forms, then dealt briefly with thrown colored clay forms, which led to an exploration of colored clay used as slip decoration and, finally involved forms combining any or all of these methods. Observations concerning the problems encountered in handling colored clay will be covered in the following section.

The results of this phase of the investigation along with the author's observations are divided into three sections: (1) Color, (2) Texture, and (3) Recommendations for Further Study, with a summation of the project concluding the investigation. It should be remembered that color is determined by the size and quality of the metallic oxides, the method of introduction, the duration and temperatures of the bisque firing, the composition of the clay, the duration, temperature, and character of the glaze firing, and the composition of the glaze, to name some of the variables involved. One is advised to conduct his own tests to more closely determine what to expect from a given colored clay.

Color

(1) The colored clay was used both with and without glaze, and often, both ways on a single piece. The resulting colors were a product not only of what oxides were used and how they were used, but also when they were used. In the case of colored clay slips, for instance, a slip applied before the bisque firing would take the smoke of post-firing more readily than the same slip applied during the glazing step, due to the variation in the porosity or openness of the resulting surface.

(2) The colored clay under a thin clear glaze resulted in bright colors with relatively small increments of change in value being readily discernable. The unglazed clay, on the other hand, was muted and, although upon close examination the colors were discernable, to the casual glance they appeared as shades of grey.

(3) It was noted that when the design formed by the colored clay was partially covered by glaze, "ghosts" would sometimes form at the juncture of the glazed and unglazed areas especially when using copper. And in the case of using the colored clay as slip decoration the unglazed portion would maintain the definition of its brush strokes while the glazed portion took on the appearance of a wet-in-wet water-color wash.

(4) A problem arose due to a change in value that the uncolored body and the colored clays underwent from the wet state to the glazed state. Some clays became lighter in

value and some became darker, and a few stayed the same. This unpredictability created a problem in design because even though a particular color and value combination might work successfully in the wet state, the combination might have a different feel or might not work at all when the piece was glazed and fired. The problem could be overcome by experience in handling and glazing the colored clays. Great latitude was possible by glazing more or less of the colored or uncolored areas according to the needs of the particular piece, with changes being possible up to the moment of firing and even after the firing in the case of unglazed areas which could be glazed and refired.

Constructing the body of the piece out of colored clay with the uncolored clay being used as a decoration was also explored with positive results. The only problem encountered was when clays with very different shrinkage rates were joined, as in slab pieces, they sometimes experienced bonding problems.

Along the same lines, pieces were constructed of uncolored clay and then slip-painted with colored clay before adding colored clay decoration. As mentioned before, the colored clay slip took on a watercolor quality when covered with glaze and was quite unlike the visual texture of the glazed colored clay body due to variations in thickness of application, amount of grog, and differing tendencies to run.

(5) By using the colored clay as a plastic decoration juxtaposition of color could be controlled to a large degree. Coils and slabs were applied directly to the surface of the piece or were pounded into a bar and sliced with a cheese cutter before being applied. The latter method proved useful in creating serial images due to a similarity between the slices. The thickness of the slices could be easily controlled which also enabled control of the amount of basrelief of the finished piece. The best method found for applying the colored pieces to the body was that of using a small brayer and covering the clay with thin plastic or newspaper to avoid contamination of the colors and to prevent the clay from sticking to the roller. (See Pizer's article in Coyne's Penland book for a more thorough discussion of this technique.)

(6) It has been previously indicated that high percentages of the oxides were necessary to attain satisfactory colors with most of the oxides tested. Aside from this added cost factor, the high percentage of oxide affected the shrinkage rates and handling qualities of the clays, especially when used structurally. As mentioned before, the different shrinkage rates caused bonding problems between the different clays, especially in slab pieces in which the clays could not be wedged together before being rolled into a slab.

The addition of more grog helped alleviate the problem, but in larger pieces it would be advisable to run tests of the various bodies to be used with different amount of grog in order to match more closely the shrinkage rates.

(7) In the use of colored clay as plastic decoration, the addition of grog to the colored clays was avoided whenever possible because it was found that the grog affected both the color and texture of the colored clay somewhat adversely. Lack of visual texture of most of the colored clays gave them a sense of purity that was lost with the addition of grog. It was found that if the color areas were fairly small and well impressed into the surface of the piece no grog was necessary.

(8) The smoothness and narrow range of the colors imposed a limitation on what could be expected from the colored clays, but these limitations were accepted and presented no great problems. Many variations of value were found to be discernible within the rather limited range of hues. One observation was that the clay with no colorant took on the appearance of a very pure white when used on a ground or field containing a small percentage of coloring oxide. By using the uncolored clay in this manner, the available palette was given greater range and contrast. The

ground could be made to appear warmer or cooler, depending on the oxide selected, which subsequently affected the mood of the piece.

(9) One final problem in the area of color was the tendency of some colors (especially those colors derived from cobalt and copper) to run and mute lighter colors. This problem was either circumvented by placing the colors likely to run at the bottom of the design where they would be least likely to run into other colors, or by incorporating the running colors in such a way that their running would complement the design. One other solution was to design pieces that used the running colors in slip form and the stable colors in plastic form.

Texture

(1) A bas-relief effect was achieved by paddling or pressing the colored clay into the surface of the piece. The height of the relief was easily controlled by manipulating the thickness of the applied piece and the amount of pressure used to apply it. The thicker the applied piece the more shadow it cast, and consequently, the more it visually separated itself from the body of the piece. But even when an applied piece was pressed flush with the surface the difference in the shrinkage rates invariably gave it a shadow line. However, too much shrinkage differential in some cases caused applied

pieces to curl and become susceptible to being knocked off. As mentioned earlier, due to the fact that the addition of grog affected both color and texture, it was not used except when needed for structural purposes.

(2) The crackle inherent in the raku process due to the rapid cooling had a tendency to be an integrating factor by acting as a matrix which enclosed the surface of the piece and obscured the colored clay enough to give it more subtlety. Even though the crackle pattern of the colored clay had a tendency to be slightly different from that of the uncolored body, the suggestion of the crackle was enough to integrate the surface of the piece in most instances. The combination of the colored clay with the crackle and the rough unglazed surfaces tended to give the pieces a sense of aesthetic unity.

(3) The nature of the post-firing reduction process used in raku requires that almost all pieces be scrubbed with an abrasive cleanser to remove discolorations and flashes caused by the cooling process. This necessity presented a problem when dealing with highly textured surfaces because getting them clean became almost impossible. The colored clays which were given an impressed texture proved to be so hard to clean that they were not feasible unless designs could be conceived in which the textured areas need not be cleaned. The effect of the color was lost on all but the highlights of

the piece, and although this could conceivably be used to advantage, preliminary results were less than pleasing.

(4) The unglazed areas of a piece reduced in combustible material take on more or less of a smoked appearance, depending on the manner of the reduction process. In addition the lack of glaze allows the unglazed area to retain its coarse texture, which in the investigation was used as a counterpoint to the smooth texture of the glazed colored clay areas. By glazing more or less of the uncolored areas of the subject, the nature of the piece could be radically altered, it was observed.

Other Problems Encountered

There were a few problems other than those already mentioned, most of which were technical considerations.

(1) The thickness of the glaze application affected the brilliance of the colors and the texture of the finished piece. Too thick an application, especially on bowls and other concave surfaces, caused the glaze to become opaque and obscured the colors. On the other hand, too thin an application resulted in a rough surface. Brushing several thin coats proved to be the best solution for local glazing, and soaking the piece in water just prior to glazing seemed to work best for pieces on which the glaze was to be poured or dipped.

(2) Maintaining the purity of the colors posed another problem, not only in handling the clays, as previously mentioned, but in storing them as well. With 40 or 50 clay bodies that all required labeling and air-tight storage, the best solution seemed to be to use large plastic buckets with sealing lids in which plastic freezer boxes were stored. This plan enabled all the clays of one type to be stored together, thereby simplifying classification and storage while helping to expedite the time needed to locate a desired color.

(3) The plasticity of the clay was lowered considerably by the addition of large amounts of oxide, but aging helped increase the plasticity to an acceptable level. Freezing of the colored clay also was found to have increased the plasticity. For a more complete discussion of the factors affecting plasticity see Searles and Grimshaw (1959).

Recommendations for Further Study

The testing of additional oxides and naturally occurring clays has been recommended in Phase II. In addition, the author would recommend further experimentation with other forming methods such as slip casting, ram casting, extruding, and pouring of thick slips on formed pieces.

One anticipated problem in all these areas is the large amount of grog required for raku firing. In plastic decoration the grog can often be eliminated; but for

structural use, the clay bodies must have grog to counter the thermal shock of cooling. In slip casting, the grog may be found difficult to keep in suspension. In the extruding process the grog may cause unpleasantly rough surfaces. And in attempting to use poured slips on previously formed pieces, the shrinkage rate (largely determined by the amount of grog) would be a critical factor.

VI. Summary and Conclusions

The investigation began with the development of a palette of colored clays to be used in the raku firing process. The resulting palette was not as broad as was hoped due to the self-imposed limit of coloring materials that were to be used. The palette proved to be broad enough for an exploration of the hypothesis, however, and provided many values and easily discernible value changes within its limited range of colors.

The study then moved to the execution of works using the colored clays structurally or as plastic decoration. Approximately 40 pieces were completed, many of which were less than successful due to several problems encountered. These problems were investigated and either overcome, circumvented, or accepted. The results and observations were divided into three parts: (1) Color, (2) Texture, and (3) Other Problems Encountered. These may be summarized as follows:

Color

(1) Colors vary according to when, where, and what oxides are used.

(2) Thickness of glaze affects colors.

(3) Glazed and unglazed areas affect color differently.

(4) Changes in color value from the wet to the glazed state make design conception difficult.

(5) Color juxtaposition control and serial images are possible.

(6) High oxide content affects shrinkage rates which may result in both positive and negative aspects.

(7) Grog affects color and texture.

(8) Colors are earthy and smooth, and subtle variations in value are readily discernable.

(9) Some colors are prone to run.

Texture

(1) Bas-relief is possible and a shadow line usually accompanies colored pieces which have been applied to a ground.

(2) The crackle inherent in raku tends to unify various components of a piece.

(3) Textured areas of colored clay are more difficult to clean.

(4) Varying the size relationship between the glazed and unglazed areas may change the mood of a piece due to the difference in texture and color of glazed and unglazed areas.

Other Problems Encountered

(1) Glazing technique affects the color quality.

(2) Maintaining purity of colors depends on careful handling and storage.

(3) Plasticity of the clay is lowered by the addition of high percentages of oxides.

Recommendations for further study in both the area of developing a color palette and in exploring the use of colored clay with other forming methods were suggested.

The author believes that he has proved his hypothesis that unique chromatic effects can be achieved through the integration of colored clay and the raku firing process. However, just as in any medium of expression, much experience would be necessary before one possessed the skill to combine raku and colored clay into works of a consistently high quality, yet which maintained a spontaneous nature. The problems encountered were minor for the most part, and the author encourages further exploration of the possibilities of these two processes.

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APPENDIXES

Appendix I: Sample Test Slab

Appendix II: Time-Line Matrix

Appendix III: Methodology Flow Chart

APPENDIX I

The scale of colored clays for each coloring compound will be blended with the scales of each of the other coloring compounds as shown in this sample test slab:

Cobalt Carbonate		%	1.25	2.5	5.0	10.0	20.0	40.0%
Iron Oxide	%							
	1.25							
	2.5							
	5.0							
	10.0							
	20.0							
	40.0							

Test slabs will be imprinted slabs of raku clay onto which tiles of the colored clay tests have been impressed.

APPENDIX II

TIME-LINE MATRIX
TIME SEQUENCE SHOWN DURING INVESTIGATION

November 1976 through April 1977

	Jan.	Feb.	Mar.	Apr.	May	June	1977
Phase I 11/76-4/77	Review of Relevant Literature						
Phase II 11/76-2/77	Developing a Palette of Colored Clays						
Phase III 12/76-3/77	Execution of Works						
Phase IV 2/76-4/77				Presentation of Findings and Preparation of Manuscript			
Phase V 5/77-6-77				Exhibition of work and completion of thesis			

APPENDIX III

Methodology Flow Chart

I. Literature Search

II. Developing a Palette of Colored Clays

- A. Preparation of Materials
  1. Mixing and drying of colored clays
  2. Blending of clays
  3. Bisque firing of tests
- B. Conducting of Tests
  1. Glazing
  2. Firing
- C. Review of Results
- D. Additional Testing

III. Execution of Works

- A. Construction of Works
- B. Firing
- C. Selection for Presentation of Manuscript

IV. Preparation of Manuscript and Presentation of Findings

- A. Presentation of Data from Tests
  1. Summation
  2. Recommendations for Further Research
- B. Presentation of Selected Works
  1. Technical Considerations
  2. Aesthetic Considerations
  3. Recommendations for Further Study