In Search of High Fired, Oxidation Glazes

Diane King

University Wisconsin-Whitewater

Table of Contents

Artist Statement

My work represents an indirect response to the tactile and visual sensations of the natural world. Of particular interest to me are the reproductive privities of flowers as their forms are both erotically familiar, yet strangely ambiguous when isolated as single specimens. The overlap between the known and the unknown; between what is human and what is flora, is a theme that continues to fascinate me as I consider issues of life and its cycles. Close inspection of flora reveals a rich and varied body of information that is otherwise overlooked by the casual observer. Contrasts of texture and surface detail are hence indicative to my work as referenced by the obsessively carved porcelain as opposed to the coarseness of the terra cotta. A forced intimacy exists between viewer and object due to the diminutive scale of the work.. Therefore interpretation and response is personal, analogous to one's own visceral reactions to the natural world.

Purpose

The purpose of this inquiry is to discover suitable glaze coatings that will complement my ceramic work. Due to the delicacy of the forms and the erotic nature of the content, the pieces are constructed from porcelain clay and fired to 2350 degrees Fahrenheit, which in ceramic terms, is referred to as cone 10. Porcelain is a coarse grained, white clay that is very soft and slippery in its moist state. When fired to cone 10, it tightens and approaches a glassy condition known as vitrification (Rhodes, 1998). Consequently, the properties of high-fired porcelain complement both the visual and physical qualities that I seek in my work. However, finishing the pieces with a glaze coating has been difficult. While there are hundreds of cone 10 glazes available to ceramicists, I am specifically searching for glazes that further reveal the texture and sensuality of the work, rather than ones that would completely cover the work. I envision the completed pieces to be subtle in color, with a minimum amount of reflected light. However, most cone 10 glazes are fired in a reduction atmosphere kiln, whereas my work will be fired in an oxidation atmosphere kiln due to studio limitations. Although this is not necessarily problematic, it is an important point to consider when researching glazes. Reduction firing is a process whereby there is a reduced amount of oxygen in the kiln to adequately combust the available fuel. Therefore, any free carbons in the kiln will seize oxygen from any source, including the oxygen present in glaze colorants. The resulting effect is a rich surface in both color and texture. However, in oxidation firing, there is enough oxygen in the kiln to properly combust all of the available fuel. Thus, the colorants or oxides in the glazes are not affected. In the case of oxidation, it is the combination of oxides and fluxes that will cause any variation. Often times, these glazes are not as active or interesting as those of reduction fired glazes (Peterson, 2001; Rhodes, 1998; Rowe, 1985). Given these factors, the inquiry into finding appropriate glazes is clear and succinct. I am searching for cone 10, oxidation glazes that are subtle in both color and texture.

Definitions

Operational

Matte: A non-reflective, opaque surface.

Mottled: Color variations within one glaze.

Textured: A visual quality of a surface that suggests a tactile quality, but it may not have one.

Constitutive (Hamer, 1991; Rhodes, 1998)

Bisque Firing: The firing of ceramic pieces up to 1800 degrees Fahrenheit prior to glazing, which then allows for ease of glaze application.

Cone 10: A high temperature in which glazes melt at 2350 degrees Fahrenheit.

Flux: A material that reduces the melting point of another ceramic material and promotes fusion of a clay or glaze.

Frit: A combination of raw materials that are mixed, fired, melted, crushed and ground into a powder. Frits can render soluble materials insoluble.

Mason Stain: Combinations of oxides, fritted to ensure uniformity of color.

Oxidation firing: A sufficient amount of oxygen within a kiln environment to properly combust all of the available fuel. Consequently, the colorants in a glaze are not affected.

Oxide: A chemical combination of oxygen with another element. Metal oxides form the fluxes, colorings and opacifiers within a glaze.

Pyrometric cones: Small and triangular in shape, cones are made of ceramic materials that melt at specific temperatures. Various cones are made to lay over, or slump, at different melting or maturation points. Cones are numbered to correspond to a particular temperature.

Reduction firing: A process whereby an insufficient amount of oxygen is present within the kiln environment to adequately combust the available fuel. Consequently any free carbons will seize oxygen from any source, including the oxygen present in glaze colorant.

Refractory: A material that is resistant to high temperatures ranging from 2372 degrees Fahrenheit to 3092 degrees Fahrenheit. Silica is an example of a refractory.

Soak: Maintaining the melting point of a glaze for an extended period of time to ensure proper melting and smoothness.

Viscosity: A ceramic material that promotes stiffness and density in a glaze so that it does not run off the surface of a piece.

Glaze Make Up

In looking at glaze recipes, it is imperative to begin with a basic understanding or glaze components. While there is usually an array of ingredients in any glaze, every glaze requires three crucial parts. The most important ingredient to any glaze is silica, which is the abundant element on earth. It is the glass former in a glaze and, when fired by itself, melts at a temperature or 3110 degrees Fahrenheit. Due to its high melting point, or refractoriness, a flux is added. Fluxes aid in reducing the melting point of silica. Lastly, there is alumina. This element increases the glaze's durability, opacity and viscosity (Daly, 1997; Pitelka, 2001; Rhodes, 1998). However, the earth minerals or materials found in glaze recipes do not directly equate to any one of the aforementioned glaze components. For example, kaolin is a type of pure clay used in the making of porcelain. It is also used in glazes, as it contains a significant amount of alumina, as well as silica. Similarly, feldspars are the main source of fluxes in any glaze. Yet they, too, have the elements of alumina and silica in them. According to Meinssen (2000), there are ten top glaze materials. They are as follows: silica, clay, binders and deflocculants, feldspars, alkaline earth materials, alumina, opacifiers, pigments, frits and water. As previously mentioned, silica is a glass former. However, since it is readily available in other minerals, it is not always present in its pure form within a glaze recipe. Although clays are a diverse group, from pure kaolin to ball clay, they are composed mainly of silica and alumina. Used in glazes as a suspending agent, they also "provide plasticity to the coating and serve to provide a mechanical bond to the substrate" (p. 100). Binders and deflocculants affect the smoothness and ease of application of a glaze, while feldspars are a main source of fluxes in a glaze. Alkaline earth minerals area another type of flux, although they area considered to be secondary fluxes, such as calcium carbonate, barium carbonate and talc. Secondary fluxes also cause surface variations ranging from matt to glossy.

Alumina supplies a glaze with durability and viscosity, while opacifiers, like tin oxide, "provide opacity by scattering and reflecting light" (p. 102) within a glaze structure. Pigments provide color to a glaze. They may be in form of oxides, salts or prepared (man-made) stains, such as frits. Frits easily reduce the melting point of silica. Finally, water is used to mix the glaze materials, thus allowing for ease of application. All of these components contribute to the performance of a glaze. Consequently knowledge of basic glaze chemistry is essential to deciphering the wide range of glaze recipes.

Procedure

Ceramic literature offers an infinite variety of glaze recipes for the ceramic researcher to test. Hence any limitations to this type of testing are partially driven by time and vision, as there can be no definitive answer as in other, more concrete types of analysis. I began with 12 recipes that in written form, appeared to offer the qualities I desire in a glaze. Additionally, I experimented with combinations of frits and Mason stains. While the stain tests were not found in ceramic literature, I knew from previous experience that a frit fluxes out a stain, depending on the amount of frit used. All glaze and stain formulas used in this procedure are listed in Appendix A. Both glazes and stains were applied to porcelain clay tiles, measuring 2" x 6" x 1/2" that were bisque fired to 1800 degrees Fahrenheit. The porcelain clay body recipe used is as follows:

Grolleg	50
Potash Feldspar	30
Silica	20
Macaloid	2%

Both the glaze tiles and the stain tiles had at one end a smooth surface and at the other end an incised surface, similar to the marks carved into my pieces. This type of surface treatment was important so that I could discern how each glaze and stain would respond to a texture. Glaze materials were weighed on a gram scale, with each batch weighing a total of 100 grams. However, the stain and frit materials were weighed to a total of only 10 grams due to the costliness of the stains. Ingredients were measured into numbered cups and dry mixed before the addition of water. Dry mixing is necessary so that the fine particles are thoroughly mixed with the more coarse particles, thus preventing any settling or clumping of some materials. Water was then added to the glazes and stains using a graduated cylinder until a smooth consistency was obtained. The glaze recipes required 50 milliliters of water, while the stain recipes required five milliliters of water. Each tile had a number that corresponded to the number of each glaze and stain test cup. Tiles and cups each totaled 25. Using a brush application, tiles received one full coat of glaze. Approximately 2/3 of each tile then received a second coat, and the remaining 1/3 of each tile received a third coat. To verify an appropriate glaze thickness, it was necessary to apply multiple layers of glaze. Stains were applied in the same procedure, however they were wiped back with a damp sponge so that the stain would only remain in the crevices of the texture. Here I wanted to test out how incised color would visually compare with the remaining smooth surface of the tile. All tiles were placed in a Bailey Electric Programmable kiln, Model P, and fired to 2350 degrees Fahrenheit. A cone, melting at the same temperature (cone 10), was placed in the kiln setter. Additionally the digital thermometer was programmed to reach that temperature so that the kiln would not shut off prematurely. During early firing stages, the kiln was programmed to increase in temperature 100 to 212 degrees Fahrenheit per hour. As the kiln neared the melting point of the glazes, the rate of climb was slowed down, allowing the glazes to smooth out. Once reaching the melting point, the kiln soaked for one half hour to ensure the complete melting and smoothing out of the glazes. The kiln then shut off and cooled for about 12 hours before unloading.

Results

While this experimental procedure was precise at its core, the analysis of it was not. Resulting glazes and stains were deemed successful only by personal judgment and opinion. Therefore, while many of the recipes fired to interesting surfaces, they nonetheless appeared to be either too harsh or too opaque for the delicacy of the porcelain forms. For example, the Bright Yellow-Cream Glaze (Cooper, 1980) resulted in a chalky matt surface that clearly was not yellow, but more of a white with speckles of brown. Variegated Green (Cooper, 2001) was described as a semi-matt green that “breaks to flecks of violet and pale blue-gray when thicker” (p. 138). However, my test revealed a light blue, mottled surface that completely covered all underlying detail. Barium Matt (Cooper, 2001) yielded a white matt glaze with flecks of blue. This glaze did not entirely erase surface detail, but the flecks of blue became a visual distraction to the detail. Matt Glaze (Speight and Toki, 1999) fired to a suitable matt white, but was quite thick in texture. Opaque Gray-Blue Matt (Chapell, 1999) resulted in almost the exact description of the title, only with a much darker blue than anticipated. And similar to the Barium Matt, it was speckled with a dark blue fleck. Purple Satin Matt (Rowe, 1985) fired to a dull, blue gray with no hint of purple whatsoever. Clear Mottled (Peterson, 2001) revealed a matt white, with minute dots of brown that visually overwhelmed the porcelain. Celestial Pink Glaze (Creber, 1997) exhibited a creamy white to light pink, matt surface. However due to its opaqueness, it wiped out all surface texture.

Yet despite these results, four glazes proved to be subtle enough to visually fit my work. White Speckle Matt Glaze and White Opaque Matt Glaze (Cooper, 1980) both fired to white surfaces that did not mask the delicacy of the underlying texture. The former glaze was more opaque, while the later glaze was semi-transparent. High Lime (C. M. Olson, personal interview, March 2006) resulted in a clear, glossy glaze that did not erase the incised lines, but rather it melted into them, resulting in a highly refined, finished look. As a consequence, I used the High Lime as a base glaze to which I added small percentages of Mason stains in order to widen my color palette (see Appendix A). Additional test tiles were then fired using the same procedures as previously described. These tests produced the same clarity as that of the base glaze, yet with the color range of pink, magenta, turquoise, and yellow. While much shinier than I had originally foresaw, I applied them only in certain areas of a given piece as a means of emphasizing an area.

Perhaps the most surprising glaze result was that of Patina Green (Coleman, 2000). This fired to a completely opaque surface that masked all detail. Yet it was creamy in texture and colors ranged from yellows to dark greens. While this glaze would overwhelm the smaller pieces, it was applied to a larger piece that had less textural detail.

Similar to the glaze tests, the stain and frit tests also had mixed outcomes. While they all sufficiently revealed the underlying textured surface, several of the colors were heavy and chalky, thus opposing my vision of delicacy and subtlety. These Mason Stain colors included: Buttercup 640; Celedon 6201; Celeste 6207; Victoria 6264: Blue Willow 6360; Blackberry Wine 6381; Old Gold 6471; and Deep Salmon 6031. However, Shell Pink 6000, Chartreuse 6236, Vanadium 6440 and Saturn Orange 6121 all fired light enough to use in small areas as a means of visual accent.

As an outcome of this research, I applied the three aforementioned white glazes on three different pieces. Each of these pieces also received one additional glaze or stain for variation. Those glazes included the High Lime shell pink and crimson; as well as the stains saturn orange, vanadium and chartreuse. The pieces were fired to cone 10, just as the tiles were, with a soaking time of one half hour. Here the glazes developed the same surface as that of the test tiles, yet none of them appeared cohesive to the piece. Hence I sandblasted the glaze off of these pieces and began experimenting with a variety of other materials, including non-ceramic media such as designer inks, acrylic paints and melted wax. Again, the appearance of these surfaces was not quite the vision I had anticipated. Consequently I began leaving the clay completely unglazed with the exception of applying the High Lime clear glaze only in the smallest of areas. The quality of the porcelain, when fired to cone 10, was so vitreous, it seemed to reveal the purity of the form and texture rather than superficially coloring it. After firing, the pieces were lightly sanded which then revealed a subtle sheen and tactile softness.

Discussion

The purpose of this inquiry was to discover interesting, but unassuming glazes to complement my ceramic work. Due to the small scale and intricacy of the pieces, a delicate coating was a visual necessity. Through research and discovery, I do not feel that I achieved my purpose. Although I experimented with of variety of cone 10 oxidation glazes and stains, they ultimately concealed the detail carved into the forms. Similarly, the non-ceramic materials did not appear to be a part of the pieces, but rather a false, prescribed coating. As a result, I left the majority of my work unglazed, revealing instead only the purity of the porcelain. Despite the setback, I did gain a vast knowledge concerning glaze chemistry. Ceramic research never reaches an absolute. In other words, there are no definitive answers as to applying the correct glaze formula, as every artist’s vision is personal. Therefore, my exploration into the possibilities of glazes is not final. Future research will involve mixing Mason Stains directly into the clay body to create colored clays. Consequently a variety of colors could be used without sacrificing any detail. China paints are another possibility as there is more control with this type of application as compared to the unpredictability of glazes. China paints are low fire colorants that are applied to cone 10, fired pieces and then re-fired to cone 021, or 1050 degrees Fahrenheit. In their unfired state, these paints look quite similar to their fired state, thus the results are more obvious prior to firing. While this type of glazing is quite laborious due to the necessity for multiple firings, it does hold promise.

In failing to ascertain suitable glazes for my work, I did instead succeed in solidifying my rationales for leaving the majority of my work unglazed. Because my interest lies in both the visual and tactile qualities of texture and the work is quite small, it seems obvious to me now that the work had to be left uncolored or naked in order to reveal the sensual quality of the pieces. However, had I not gone through this research, I would not have come to that conclusion as I would still be of the mind set that ceramic work must be colored. While abandoning the search for glazes and colorants is not a future consideration; neither is the idea that unglazed porcelain is unfinished. Hence the work continues.

References

Chappel, J. (1991). *The potter's complete book of clay and glazes* (rev.ed.). New York: Watson-Guptill.

Coleman, T (2000). *With a little help from my friends* (rev. ed.). Self-published.

Cooper, E. (1980). *The potter's book of glaze recipes*. New York: Charles Scribner's Sons.

Cooper, E. (Ed.). (2001). *Clay and glazes* (3rd ed.). London: Ceramic Review.

Creber, D. (1997). *Crystalline glazes*. Philadelphia: University of Pennsylvania Press.

Daly, G. (1997). A balancing act. *Ceramics Technical,5*, 90-96.

Hamer, F. & J. (1991). *The potter's dictionary of materials and techniques* (3rd ed.). Philadephia: University of Pennsylvania Press.

Meinssen, K. (2000, November). The top ten glaze materials. *Ceramics Monthly*, 100-104.

Peterson, S. (2001). *Smashing glazes*. Madison, WI: Guild.

Pitelka, V. (2001). *Clay*. *A studio handbook*. Westerville, OH: The American Ceramic Society.

Rhodes, D. (1998). *Clay and glazes for the studio potter* (rev. ed.). Iola, WI: Krause.

Rowe, M.D. (1985, February). Converting to oxidation glazes. *Ceramics Monthly*, 50-51.

Speight, C.F. & Toki, J. (1999). *Hands in clay* (4th ed.). Mountain View, CA: Mayfield.

Appendix A

White Speckle Matt Glaze (Cooper, 1980)

Feldspar (soda)	35
Whiting (calcium carbonate)	28
Kaolin	28
Silica	9

White Opaque Matt Glaze (p. 155)

Feldspar	28
Nepheline syenite	32
Dolomite	9
Barium Carbonate	11
Kaolin	12
Silica	8

Bright Yellow-Cream Glaze (p. 53)

Nepheline syenite	45
Whiting (calcium carbonate)	18
Talc	5
Colemanite	2

Add:
Red Iron oxide 2

Variegated Green (Cooper, 2001)

Cornwell Stone (feldspar)	443
Whiting (calcium carbonate)	22
Kaolin	23
Silica	3
Red iron oxide	1
Cobalt oxide	.6
Titanium oxide	7

Barium Matt (p. 138)

Potash Feldspar	28
Kaolin	20
Barium Carbonate	44
Silica	8

Matt Glaze (Speight and Toki, 1999)

Kaolin	28
Silica	13
Feldspar	35
Whiting (calcium carbonate)	24

Opaque Gray-Blue Matt (Chapell, 1999)

Feldspar	48.4
Kaolin	23.7
Dolomite	21.2
Whiting (calcium carbonate)	2.4
Gertsley Borate	1.5
Add:	
Cobalt oxide	.6
Chromium oxide	.2

Purple Satin Matt (Rowe, 1985)

Barium carbonate	7.05
Dolomite	8.81
Whiting (calcium carbonate)	18.10
Custer Feldspar	31.80
Ball Clay	16.14
Silica	18.10
Cobalt carbonate	.50
Manganese carbonate	2.45
Bentonite	1.96

Clear Mottled (Peterson, 2001)

Potash felspar	50.0
Whiting (calcium carbonate)	16.7
Talc	2.3
Lithium Carbonate	1.0
Zinc oxide	1.0
Silica	29.0

Celestial Pink (Creber, 1997)

Nepheline syenite	40.47
Barium carbonate	30.95
Whiting (calcium carbonate)	9.53
Ballclay	7.14
Titanium dioxide	7.14
Tin oxide	4.76

High Lime (C.M. Olson)

Potash feldspar	31
Whiting (calcium carbonate)	26
EPK Kaolin	13
Silica	30
Add: Bentonite	1

Additional Mason stains added, one color per test tile:

Rose Pink 6002: 8%
Crimson 6003: 4%
Turquoise 6364: 4%
Vanadium 6464: 4%

Patina Green (Coleman, 2000)

Custer Feldspar	52
EPK Kaolin	10
Barium carbonate	38
Add: Rutile	8
Copper carbonate	4

Mason Stain/ Frit 3124 Percentages

Buttercup 6401: 80/20
Celedon 6201: 80/20
Celeste 6207: 85/15
Victoria 6264: 85/15
Blue Willow 6360: 75/25
Blackberry Wine: 6381: 80/20
Old Gold 6471: 80/20
Deep Salmon 6031: 75/25
Shell Pink 6000: 75/25
Chartreuse 6236: 85/25
Vanadium 6440: 80/20
Saturn Orange 6121: 85/25

Appendix B

Extrorous

2.5" w x 2.5" d x 6"h

Porcelain, Terra Cotta
2006

Extrorse detail

Psuedocopulation, 5" w x 7" d x 3.5" h

Porcelain, Terra Cotta, 2006

Psuedocopulation detail

Didymous, 7" w x 10.5 d x 3.5h

Porcelain, Terra cotta, 2006

Didymous detail

Polygeniculate, 2.5" w x 4.5" d x 4" h

Porcelain, Terra Cotta, 2006

Calcicole, 2.5w x 10.5d x 3.5 h

Porcelain, Terra Cotta, 2006

Calcicole detail

Porose

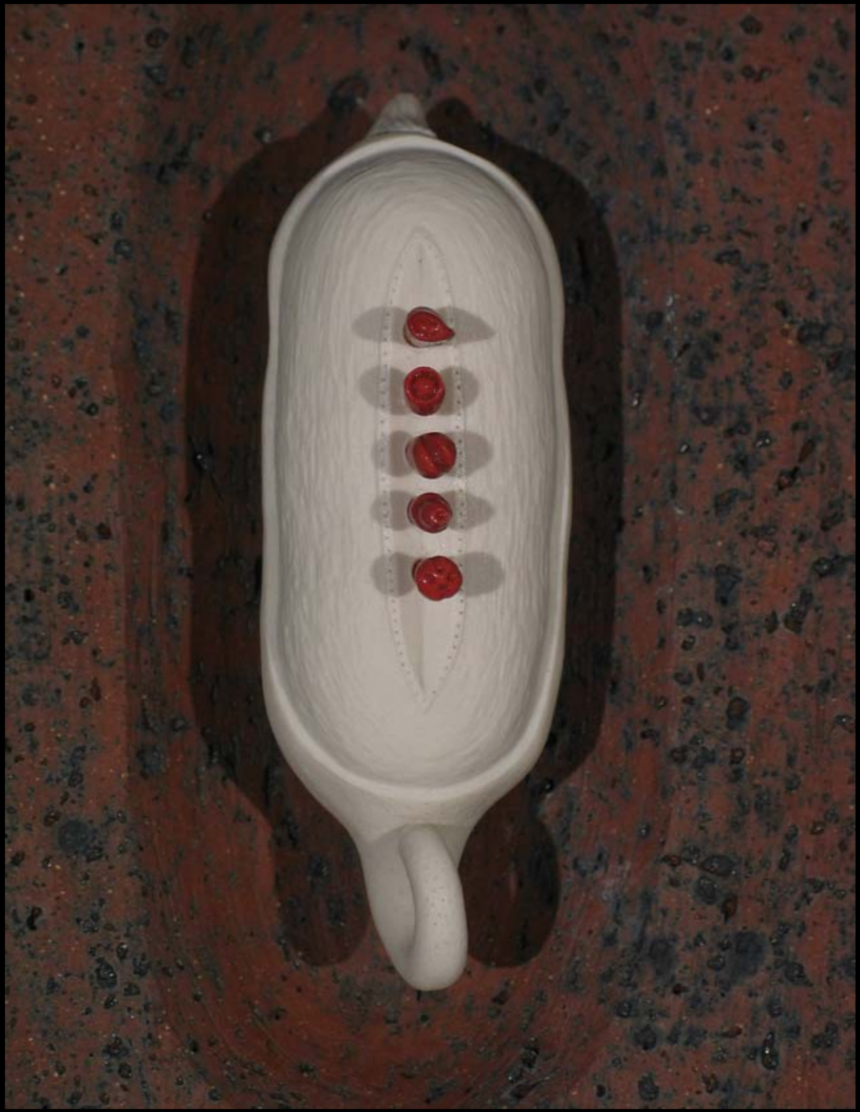
5.5 w x 2.5 d x 13 h

Porcelain, Terra cotta

2006

Porose detail

Protandrous
5.5 w x 3.5 d x 8.5 h
Porcelain, Terra Cotta, 2006



Protandrous detail

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Unwhorled, 16" w x 3.5" d x 13.5"h

Porcelain, Terra cotta, 2006

Unwhorled detail

DIANE KING
Thesis Exhibition

October 16 - October 28, 2006

Gallery on the Main
208 South Main Street
Fort Atkinson, WI
920.563.9959

Opening Reception
Saturday, October 21
6:00 - 8:00 P.M.

Gallery Hours
Tuesday, Wednesday, Friday
10:00 A.M. - 5:30 P.M.
Thursday
10:00 A.M. - 8:00 P.M.
Saturday
10:00 A.M. - 4:00 P.M.

"Extrorous", 2 .5"w x 2 .5"d x 6"h
Porcelain, Terra Cotta, 2006

Appendix C