Glazes: Materials, Recipes and Techniques
CONTENTS

INTRODUCTION
by Anderson Turner.................................................................1

1 MATERIALS
Color and the Ceramic Surface:
Alchemy or Science?, by Robin Hopper ....................................3
Ordering Raw Materials, by Jeff Zamek....................................17
Additives for Glazes, by Jeff Zamek........................................19
Glaze Material Substitutions, by Jeff Zamek............................23
Gerstley Borate and Colemanite, by Jeff Zamek.......................27
Substitutions for Gerstley Borate, by Jeff Zamek......................30
Is Barium Carbonate Safe?, by Jeff Zamek...............................33
Using Rare Earth Colorants, by David Pier..............................36
Using Soluble Colorants at Stoneware Temperatures, by Kurt Wild .................................................................39
Formulating Glazes, by Richard A. Eppler..............................41

2 RECIPES
Versatile Cone 06-6 Clays and Engobes, by Gerald Rowan.........46
Cone 06-6 Vitreous Engobes, by Gerald Rowan........................48
Variation with One Base Glaze, by Melvin D. Rowe..................50
Electric Kiln Copper Reds, by Robert S. Pearson
    and Beatrice I. Pearson...................................................52
More Electric Kiln Copper Reds, by Robert S. Pearson
    and Beatrice I. Pearson...................................................55
Cone 5 Blue Glazes, by Dwain Naragon..................................56
Cone 5 White Glazes, by Dwain Naragon................................57
Cone 5 Oxidation Glazes, by Anthony Bellesorte......................58
Hobart Cowles White Glazes, by Lili Krakowski......................59
Hobart Cowles Tan and Brown Glazes, by Lili Krakowski........60
Hobart Cowles Blue and Green Glazes, by Lili Krakowski........61
Black Friday, by Jeff Zamek...............................................62
Cone 6 Oxidation Slips and Glazes, by Gerald Rowan..............64
A Palette of Cone 6 Oxidation Glazes, by Jeff Dietrich .......................66
Cone 08-6 Self-Glazing Clays, by Gerald Rowan ..................................67
Cone 5-6 Reduction Glazes, by Paul Woolery .....................................68
Cone 6 Reduction: Great Glazes and Smart Savings, by Rick Malmgren ........70
Cone 3-6 Data Bank Glazes, by Harold J. McWhinnie ............................74
Cone 4-6 Oxidation Glazes, by Harold J. McWhinnie ............................75
A Cone 6-10 Glaze Palette, by Harold J. McWhinnie ............................76
Cone 3-8 Rutile Glazes, by Harold J. McWhinnie ..................................78
Lichenlike Surfaces, by Lana Wilson ....................................................79
The Fugitive Blue Chun, by Emman Okunna .......................................80
Awka Oil-Spot Glaze, by Emman Okunna ...........................................82
Converting to Oxidation Glazes, by Melvin D. Rowe .........................84

3  TECHNIQUES

Converting to Oxidation Glazes, by Melvin D. Rowe ............................84
Glaze Dipping: Tubs and Tongs, by Bennett Welsh ...............................90
Bob Reed: Landscape and Motion, by Von D. Allen .............................92
China Paint: The Ultimate Low Fire, by Paul Lewing ............................96
Old Glazes, New Words, by John Chalke ..........................................100
Layered Cone 6 and Cone 06 Glazes, by Lana Wilson ...........................101
When Bad Glazes Happen to Good Potters:
An Unsolved Mystery, by Cynthia Spencer ........................................105
Jim Koudelka’s Layered Contraptions, by Daniel Duford ......................108
Five Steps to Stop Glaze Shivering, by Jeff Zamek .............................113
A Garden Niche, by Trevor E. Youngberg .........................................114
Wood-Ash Glazing at Cone 6, by Harry Spring ..................................116
Kathleen Guss and Stephen Robison, by Clive Clintonson ..................118
George McCauley, by Peter Held .....................................................122
Wayne Bates, by Sandy Miller Sasso .................................................126
Eight Steps to Stop Crazing, by Jeff Zamek ......................................132
Glaze Crawling: Causes and Corrections, by Jeff Zamek ....................134
A Wood-Fired Look from an Electric Kiln, by Richard Busch ...............136
3 TECHNIQUES

Converting to Oxidation Glazes, by Melvin D. Rowe ......................... 84
Glaze Dipping: Tubs and Tongs, by Bennett Welsh .......................... 90
Bob Reed: Landscape and Motion, by Von D. Allen .......................... 92
China Paint: The Ultimate Low Fire, by Paul Lewing ...................... 96
Old Glazes, New Words, by John Chalke ....................................... 100
Layered Cone 6 and Cone 06 Glazes, by Lana Wilson ..................... 101
When Bad Glazes Happen to Good Potters:
An Unsolved Mystery, by Cynthia Spencer .................................... 105
Jim Koudelka’s Layered Contraptions, by Daniel Duford .................. 108
Five Steps to Stop Glaze Shivering, by Jeff Zamek ............................ 113
A Garden Niche, by Trevor E. Youngberg ...................................... 114
Wood-Ash Glazing at Cone 6, by Harry Spring ............................... 116
Kathleen Guss and Stephen Robison, by Clive Clintonson ............... 118
George McCauley, by Peter Held .................................................. 122
Wayne Bates, by Sandy Miller Sasso ............................................ 126
Eight Steps to Stop Crazing, by Jeff Zamek .................................. 132
Glaze Crawling: Causes and Corrections, by Jeff Zamek .................. 134
A Wood-Fired Look from an Electric Kiln, by Richard Busch ............. 136
INTRODUCTION

The ceramic artist is capable of doing many things when driven by the desire to clearly communicate an idea or produce a work of art using clay. Many pieces, though, skillfully crafted in the forming stage, can be ruined with an inappropriate glaze. And while there are many mysteries involved in this final act of creation, many have been solved over the years through diligent research and painstaking trial and error.

Since its inception, *Ceramics Monthly* has provided a forum for artists to share their findings on all aspects of the medium, not the least of which are the glaze recipes and information on how to formulate new ones. It is ironic that information such as this, once guarded so closely that revealing any of these secrets could bring about severe punishment, is now freely given knowing that everyone benefits from the sharing. By looking over the past issues of CM, the wealth of solid technological information on glaze chemistry, formulation and recipes is astounding.

We are fortunate that the authors represented in this book have shared their work, so now we can take the next step and push beyond. The information contained here is a starting point, and you’ll find a world of mysteries unfold as you alter percentages, swap out ingredients, overlap glazes, use different application techniques, or come up with something entirely new. And through this process—that of working from the premise of “what happens when I do this?”—we are better able to achieve our main goal—to express ourselves clearly with clay.—Anderson Turner
MATERIALS
To a potter or ceramic sculptor, what is it that represents the most important aspect of his or her work after developing the form? The usual answer is color or surface quality.

The preconceived idea usually combines form, surface and color as an integrated whole. When a clayworker has arrived at the point where he or she is technically able to make the forms that are visualized, the development of an individual palette of color and surface is next in importance. It makes little difference whether one is producing functional work, one-of-a-kind ware or sculpture; ceramic development is basically the same. It requires testing and observation, and, through what is essentially a process of elimination, narrowing the field until the required result is achieved.

Perhaps the most common method is to find a glaze recipe that sounds more or less suitable in a book or magazine, make a batch and test fire it. In the long run, this is probably the least satisfactory method. Unless one compromises one’s ideas to suit the glaze at hand, or makes many adjustments to that glaze, that is usually second best to coming up with one’s own original recipes or formulas.

Original glazes are produced either by empirical methods (trial and error) or by glaze calculation. The latter is a somewhat abstract concept, foreign to most artistic minds. Glaze calculation makes glazemaking possible through mathematical formulas achieved by developing and understanding the ratios of different materials that are likely to be incorporated into glazes. Since the original development of the system, limit formulas have been established which show the high and low extents to which any chemical may be normally used in developing a glaze for a given temperature. The limit formula sets up a basic structure from which one can work. The formula is mathematically converted to produce a glaze from available ceramic materials. In order to work efficiently, calculation is dependent on direct prior experience with the behavior of ceramic materials. One needs this to make an educated guess at the suitability of raw materials. There are various methods of calculation, the most recent of which use computer software programs. They essentially remove the drudgery of doing the math involved in calculating the formula and conversions to batch recipes, and vice versa.

Calculation has some very useful attributes, but, for the artist, it also has some great deficiencies. Have you ever realized that glaze calculation can’t tell you the things that you most want to know about glazes? Have you ever wondered why specific color development and control seems to be such an elusive activity? Or why commercially prepared colors and stains often don’t come out the way that you think they should? Have you ever wondered why we learn how to calculate glaze formulas by mathematical means? Or why, for the studio potter or individual ceramic artist, this process is largely redundant? Are you prepared to accept what happens with a glaze or color rather than exert control to gain just what you want?

To downplay glaze calculation, perhaps, appears regressive and seems to be going against long-standing scientific principles. But my reasons for both using and teaching the empirical approach are that the majority of people are inhibited from doing much individual glaze exploration by an imposed semiscientific system which has its own built-in deficiencies. As students, or as self-taught clayworkers, we are not usually made aware of those deficiencies, and often struggle in the misguided belief that a scientific approach will open the door to marvels. From my experience over 40 years of teaching and making pots, I can honestly say that I have almost never seen a calculated glaze that was better than those produced by a solid, sensitive, empirical understanding of the materials we use. The only possible exception to this is in the area of industrial dinnerware and sanitary ware.

Scientifically based glaze calculation has a history of about 125 years, although ceramic glazes have been with us for approximately 4500 years. Prior to the development of mathematical calculation, all glaze development was done empirically and information was passed down through family tradition, more often than not with great secrecy, for such knowledge represented livelihood. Glazemaking throughout the great and innovative ceramic-producing cultures of China, Islam, Korea and Japan evolved in this way. With the exception of the German salt-glazing process, all glaze development in Europe and later in the colonized Western Hemisphere was based on earlier Middle Eastern or Oriental examples. Very often this was “stolen” information, and is among the first occurrences of industrial espionage. When European ceramic industry really “took off” with the likes of Wedgwood, Spode and the many court-based European centers such as Sèvres, Limoges, Meissen and Vienna, it was obvious that something more than alchemy was needed to standardize fine quality wares. Hundreds of years of trial-and-error finally gave way to calculation, a scientific approach based on the individual weights of molecules composing compounds of materials used in a glaze.

Glaze calculation was eventually developed in the last quarter of the 19th century by the renowned German ceramic chemist Hermann Seger, as a
means of developing and comparing glaze formulas for ceramic industry. This industry is understandably concerned with product regularity and quality control, characteristics which calculation of formulas from mineral analysis can achieve quite efficiently. From an industrial standpoint, a properly calculated and formulated glaze is one which is usually clear, fully melted and attached to the clay body in a fault-free coating. It is interesting to note that if calculation had preceded the empirical methods of glazemaking, most of the glaze types that potters hold in high esteem would have been outside these acceptable parameters. It is difficult to imagine ceramic history without ash glazes, or glazes that flow, crackle, curl, crystallize or crater-by-industrial standards all unacceptable. It is also interesting to note that much current European and Japanese industrial pottery incorporated impurities, such as granular iron, rutile, ilmenite or manganese, into the glazes to emulate the reduction-fired qualities that have been admired by potters and connoisseurs for centuries. Some factories work extremely hard at trying to industrially reproduce qualities that can only come from hand making.

So why should today’s clayworkers use glaze calculation? First, through its mathematical process, it can offer a basic understanding of mineral fusion principles. Second, it establishes the ratios of chemical molecules required to develop a glaze at a given temperature. Third, through the use of limit formulas, it establishes the normal extents of volume in chemical use for a given temperature range. Fourth, it makes possible easy comparison between formulas. Fifth, it affords understanding of information in technical ceramic books and journals. And sixth, it can be useful in pinpointing what may be causing glaze problems.

But what is it that calculation does not tell us? First, what the quality of the surface will be: glassy, glossy, satin, vellum, matt, crystalline or dry. Second, which raw materials to use in a glaze to obtain a specific color or color range. Third, how colorants or opacifiers or their combinations will behave in a given glaze. And fourth, how the glaze will vary in different kilns and firing conditions. It seems to me that the qualities and colors of ceramic surfaces are what we find most appealing, and therefore a calculation method which, though undeniably has validity in certain areas, falls far short in those very places which are our greatest concern.

What should our concerns be in selecting materials for glazes? This is dependent on a number of factors: desired firing temperature; type of firing (electric, gas, raku, etc.); surface wanted; colors or color ranges; and finally, materials available.

Every glaze is composed of three types of material: bases or fluxes, neutrals or amphotericis; and acids. In a very simplistic view, the acid is the glassformer, usually silica. It is melted at a variety of temperatures by the addition of a flux or mixture of fluxes; and made to satisfactorily adhere to the surface of the clay object by the neutral, usually alumina or clay. All glazes at all temperatures basically follow this structure.

For convenience in calculation, materials are listed in three columns with bases (flux) on the left, the neutrals (alumina) in the center and the acids (silica, the glassformer) on the right. It is the ratio between the three material types which determines firing range, but primarily the fluxes which control color development.

Color and surface in any glaze are dependent on three variables: the raw materials that make up the glaze; the temperature to which the glaze is fired; and the atmosphere (oxidation or reduction) in which it is fired. To this we have to also add the selection of colorant(s) and opacifier(s), if used.

For color, the basic raw materials not included in the glaze are often as important as those which are, as some materials greatly inhibit the development of some colors. Most colorants vary considerably in their capabilities.

Books usually tell us about color in very generalized terms; for instance, that iron compounds will give brown or green and copper compounds red or green. Iron can certainly give us brown and green, but it can also give us yellow, red, gold, gray, pink, black, orange or purple. Similarly, copper can give green and red, but it can also produce turquoise, purple, orange, blue, gray, pink and occasionally yellow. The controlling factors are the three variables. Iron and copper are the most versatile colorants, but all have multiple possibilities.

Because commercial underglaze colors and glaze stains are manufactured from premixed and sometimes prefired colorants and opacifiers, they too are dependent on the three variables for color responses. The wrong choice of materials, temperature or atmosphere can radically change the colors that they ought to achieve.

In theory then, glaze calculation sounds very convenient, but it leaves a lot to be desired as it cannot indicate surface or color potential, the tactile and visual qualities most desired. If, for example, one was looking for a glaze that would be satin-surfaced and crimson in color, the only way that one could find it would be through a published recipe, or by trial and error, which is what invariably has to be done in the long term anyway. Unless one is a ceramic chemist continually making and comparing glazes, one tends to seldom use calculation, and consequently one often needs to relearn the process at each use. From my observations, most ceramists learn it and then forget it. There is no doubt that the system works and has some benefits, and is even more or less understandable, but what do we lose by using it?

From a personal view, I don’t feel that glazes developed since the advent of calculation are in any way an improvement upon those achieved by the great ceramic-producing cultures of the past, where purely empirical methods were used. Unfortunately, we have generally lost the intuitive sense of our materials which was so strong in potters of the past. Intuition derives from an innate understanding coming
from experience and observation: it is the direct learning or knowledge of something without conscious reasoning. In its place we’ve largely gained a dependence either on published recipes or on questionable scientific principles, which neither tell us the whole story nor give us real comprehension to base our work on.

Why do I say questionable scientific principles? Because the analyses of ceramic minerals supplied by mining companies are averages of the compounds that form the basic raw materials supplied by their mines, and those certainly change from one part of a mine to another. Such is the nature of Nature. Not every bag will be identical, and the same raw material purchased over an extensive period of time is likely to alter considerably. So our science is based on a changeable generality and not on established fact.

How does one go about learning to understand the nature of ceramic

Part 2: A State of Flux

When developing color, the most important ingredient in a glaze is the flux or mixture of fluxes. By changing the fluxes within any glaze, complete changes in color range and surface quality are both possible and probable. From a learning point of view, it is quite instructive to take any glaze—one that you have developed or one that you have picked up in a book or magazine—and exchange one or more fluxes for others.

The materials that we call fluxes are calcium, alkalines or alkaline earths, lead, boron, magnesia, zinc, barium and strontium. Calcium, which is a vigorous flux at temperature ranges beyond Cone 4, has the least effect on color variation. The others may have a profound effect on both surface and color, depending on the other materials which make up the glaze, the firing temperature and atmosphere.

The alkaline fluxes (sodium, lithium and potassium) have particularly strong effects on glazes containing copper, manganese and nickel compounds. They are found in the following materials: nepheline syenite, soda feldspar, alkaline frits, borax, soda ash, cryolite, sodium nitrate, sodium chloride, sodium silicate, lithium carbonate, spodumene, lepidolite, petalite, potassium feldspar, pearl ash, niter, and most wood ashes.

Lead has strong and pleasant effects on most colorants, allowing pure colors to be developed; however, it is highly toxic, both in studio use and sometimes in the fired glaze; it therefore must be handled with great care. Lead is the only flux that can be used for achieving some colors, particularly bright yellow, orange and red from chromium or uranium, bright green from copper, and the sparkling, low-temperature aventurine or goldstone glazes employing iron. But because of their potential toxicity, lead glazes should be for decorative use only, never applied to functional objects—with special emphasis upon avoiding lead glazes on those objects made for storing acidic liquids. Still, for decorative purposes and vibrant color at low temperatures, lead glazes are unsurpassed.

Boron is usually supplied to a glaze by the inclusion of colemanite, Gerstley borate, boron frits, boric acid or borax. It can be the main flux in a glaze and is similar to lead and the alkalines in its power. It is likely to cause a streaked or cloudy quality, which is often mottled with colorants.

Magnesia has a strong effect on surface texture, particularly in giving smooth, buttery or sugary matte surfaces. It also has a profound effect on color, and can cause mauve, lilac and purple to develop from cobalt, salmon pink to gray from copper, and acid greens from nickel. In glaze batches, magnesia is provided by talc, dolomite or magnesium carbonate.
Zinc oxide is always used with other fluxes in a glaze, and usually causes opaque and sometimes matt surfaces. Its effect on colorants is quite strong, giving pastels from most colorants.

Barium is a strong flux, usually producing soft, silky or frosty matts. When mixed with boron in a glaze, it usually turns to a more fluid, glassy state. It has a profound effect on most colorants, producing vibrant turquoise and blue from copper, red to purple from nickel, brilliant blue from cobalt and mellow yellow from iron. The possibility of barium leaching from a glaze makes it a potentially hazardous material for functional ware; but for sculpture or nonutilitarian ware, it can produce magnificently rich colors.

Strontium is similar to barium in fluxing and color-development effect. It is nontoxic, however, and can be used in place of barium when functional concerns have to be met.

In the following glaze approaches, materials are measured by weight. Any feldspar, kaolin or ball clay can be used. They will all vary compositionally to some extent, but this doesn't particularly affect the general result.

The first approach, flux variations, is a system of glaze development study that I originated many years ago to give students a better understanding of the role that fluxes play. It is also the basis from which the second approach developed, and therefore is included here as foundation material. Besides, it still produces very interesting glazes and has great color potential. The system was formed by averaging the contents of 50 Cone 8-10 glazes from various books and publications, then separating the major color-affecting fluxes from the rest of the recipe. The general average of these 50 glazes produced the following base:

**Partial Glaze Base**
(Cone 8-10)

<table>
<thead>
<tr>
<th>Material</th>
<th>Matt</th>
<th>Gloss</th>
<th>Gloss to Matt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whiting</td>
<td>12</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Feldspar</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Ball Clay</td>
<td>17</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Kaolin</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Flint</td>
<td>7</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>83</td>
<td>83</td>
<td>83</td>
</tr>
</tbody>
</table>

The average of the prime color-affecting fluxes filled the remaining 17%, making a total of 100%. In this method, as long as the amount of base glaze is kept at 83%, the remaining 17% can be made up of any single flux or any mixture of fluxes. This allows simple alterations of the glaze to be made and makes it possible to easily add some of the materials that are usually used in small amounts for their special effects, such as cryolite, fluor spar, bone ash or any highly fusible materials that may have been found in the single materials fusion tests mentioned last month in the first article in this series.

To gain the most information on how any glaze test will respond to color, paint thin lines of iron, copper, cobalt, and manganese, or your favorite stains, on the glaze before firing.

The initial testing was done primarily for matt glazes fired in both oxidation and reduction, and proved so successful that it was further developed for Cone 8-10 gloss glazes and for both gloss and matt glazes at Cone 6. This was done by slightly altering the original average-removing the kaolin and adding its volume (12%) to make the flint 19% for the gloss variation; removing 5% ball clay, and adding its volume to the calcium, thus decreasing the alumina and increasing the flux, for the Cone 6 variation.

![Table](image)

To complete the glaze, add any flux or mixture of fluxes equal to 17%, depending on the desired color and surface qualities. It is often confusing for the novice to know which fluxes to select, as knowledge of color and surface reactions generally comes from experience. The only way to gain the necessary experience is by experimenting, and learning from observation of the results.

If it is a learning process that is desired, it doesn't matter which fluxes and mixtures are selected, because whatever the results, you will learn something about material behavior. Many glazes created through this system have been part of my own work for years. The following list gives some of the fluxes and mixtures of fluxes that have been used, but almost any inter-mixtures can be made:

1) 17% Zinc Oxide
2) 17% Barium Carbonate
3) 17% Colemanite or Gerstley Borate
4) 17% Dolomite
5) 17% Talc
6) 17% Wood Ash
7) 17% Lithium Carbonate
8) 17% Any Frit
9) 17% Zircopax
10) 17% Soda Ash
11) 17% Volcanic Ash
12) 17% Bone Ash
13) 10% Colemanite or Gerstley Borate, 7% Barium Carbonate
14) 12% Colemanite or Gerstley Borate, 5% Bone Ash
15) 7% Colemanite, 5% Cryolite, 5% Fluorspar
16) 7% Talc, 5% Bone Ash, 5% Any Frit
17) 10% Wood Ash, 7% Lithium Carbonate
18) 7% Barium, 5% Cryolite, 5% Fluorspar
19) 5% Colemanite, 7% Cryolite, 5% Amblygonite
20) 10% Wollastonite, 7% Barium
21) 5% Barium, 5% Lithium, 7% Zinc
22) 7% Barium, 7% Zinc, 3% Lithium
23) 5% Fluorspar, 10% Barium, 2% Lithium
24) 10% Any Frit, 5% Cryolite, 2% Lithium
25) 7% Colemanite, 7% Barium, 3% Lithium

In a way similar to the method of triaxial glaze development using three
materials, one can also use one base glaze with a variable flux component. The following is a combination of triaxial and flux variations, which has produced some very interesting glazes at Cone 6, and at Cones 8-10.

With this approach, it is good to keep the mathematics simple—80% base mix; 20% fluxes. The following shows what the base mix should be comprised of:

The fluxes are best selected by considering their color-affecting properties. Some selections that have yielded interesting results are given below as examples; but the principle allows great flexibility, and I feel that the more individual decisions one makes, the more satisfying are the results:

Cone 6 Flux Variations Triaxial

1) A=Li $\quad$ B=Wollastonite $\quad$ C=Wood Ash
2) A=Al $\quad$ B=Albany Clay $\quad$ C=Gerstley Borate
3) A=Any Frit $\quad$ B=Barnard Clay $\quad$ C=Barium
4) A=Zn $\quad$ B=Lithium $\quad$ C=Gerstley Borate
5) A=Barium $\quad$ B=Dolomite $\quad$ C=Gerstley Borate

Cone 8-10 Flux Variations Triaxial

6) A=Zn $\quad$ B=Barium $\quad$ C=Gerstley Borate
7) A=Lithium $\quad$ B=Dolomite $\quad$ C=Barium
8) A=Wood Ash $\quad$ B=Talc $\quad$ C=Gerstley Borate
9) A=Barium $\quad$ B=Spodumene $\quad$ C=Barnard Clay
10) A=Petalite $\quad$ B=Barium $\quad$ C=Albany Slip or Local Red Clay

Initially it may sound confusing, but it is really very easy. From each set of tests there will be 21 glaze variations. The 21 boxes shown on the traxial chart below each represent a glaze which has a constant 80% base mix, and a changing amount of the fluxes.

The three fluxes to be used in each triaxial are listed as A, B and C. You can also add more fluxes (particularly if you want smaller amounts of extremely active ones, such as cryolite, fluorspar and bone ash) by simply dividing the amounts in each angle and adjusting the mathematics, so that points A, B and C could each be made up of equal or differing ratios of two fluxes. Remember, the major decisions are all yours, and as long as you get the mathematics right it should all work out quite nicely. The possibilities are limitless. Each box numbered 1-21 represents 80% glaze base and 20% variable flux. In box 9, for instance, you should have 80% glaze base, 8% flux A, 4% flux B, and 8% flux C. In box 13, the mix would be 80% glaze base, 4% flux A, 8% flux B, and 8% flux C.

The third glaze approach involves flux saturation. Many spectacular effects and brilliant colors may be achieved in glazes which use abnormally high amounts of fluxes. Such glazes may not be particularly suitable for dinnerware, but can be quite wonderful when used for decorative effect. Most of these glazes are for Cone 8-10, but many can be used at Cone 6 or adapted to Cone 6 by the addition of 5%-10% Colemanite or Gerstley borate. Most include between two and four ingredients. Because they contain such heavy saturations of fluxes, the effect on colorants can be wild. Those containing barium and lithium can produce turquoise to purple from copper, yellows and from copper, dove-grays to mushroom from manganese, and soft greens to brown from small amounts of nickel. Glazes high in calcium may be quite similar to ash glazes in the way that they run in rivulets and form islands of glass surrounded by drier surfaces. Those containing combinations of zinc and barium are likely to form crystals. These glazes can produce rich colors from almost any colorants. The colors will change to some extent dependent on atmosphere, but less than with a more normal balanced glaze. As with all glazes, they need testing in your own studio to develop their potential.

Flux Saturation Glaze 1
(Cone 8-10)

<table>
<thead>
<tr>
<th>Flux Saturation Glaze 1</th>
<th>Cone 8-10</th>
</tr>
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<tbody>
<tr>
<td>Dolomite................</td>
<td>25 %</td>
</tr>
<tr>
<td>Feldspar................</td>
<td>50 %</td>
</tr>
<tr>
<td>Kaolin...................</td>
<td>25 %</td>
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<tr>
<td>100 %</td>
<td></td>
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Flux Saturation Glaze 2
(Cone 8-10)

<table>
<thead>
<tr>
<th>Flux Saturation Glaze 2</th>
<th>Cone 8-10</th>
</tr>
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<tbody>
<tr>
<td>Wood Ash...............</td>
<td>50 %</td>
</tr>
<tr>
<td>Kaolin................</td>
<td>50 %</td>
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<tr>
<td>100 %</td>
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Flux Saturation Glaze 3
(Cone 8-10)

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<thead>
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<th>Flux Saturation Glaze 3</th>
<th>Cone 8-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whiting................</td>
<td>35 %</td>
</tr>
<tr>
<td>Albany Slip Clay......</td>
<td>50 %</td>
</tr>
<tr>
<td>Ball Clay...............</td>
<td>15 %</td>
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<tr>
<td>100 %</td>
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Flux Saturation Glaze 4
(Cone 8-10)

<table>
<thead>
<tr>
<th>Flux Saturation Glaze 4</th>
<th>Cone 8-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amblygonite...........</td>
<td>80 %</td>
</tr>
<tr>
<td>Feldspar...............</td>
<td>10 %</td>
</tr>
<tr>
<td>Kaolin................</td>
<td>10 %</td>
</tr>
<tr>
<td>100 %</td>
<td></td>
</tr>
</tbody>
</table>

Flux Saturation Glaze 5
(Cone 8-10)

<table>
<thead>
<tr>
<th>Flux Saturation Glaze 5</th>
<th>Cone 8-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barium Carbonate......</td>
<td>50 %</td>
</tr>
<tr>
<td>Nepheline Syenite.....</td>
<td>50 %</td>
</tr>
<tr>
<td>100 %</td>
<td></td>
</tr>
</tbody>
</table>

Flux Saturation Glaze 6
(Cone 8-10)

<table>
<thead>
<tr>
<th>Flux Saturation Glaze 6</th>
<th>Cone 8-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolomite (or Talc).....</td>
<td>35 %</td>
</tr>
<tr>
<td>Feldspar...............</td>
<td>35 %</td>
</tr>
<tr>
<td>Kaolin................</td>
<td>30 %</td>
</tr>
<tr>
<td>100 %</td>
<td></td>
</tr>
</tbody>
</table>
Flux Saturation Glaze 7
(Cone 8-10)
Barium Carbonate .....................25 %
Lithium Carbonate ....................  3
Zinc ..........................................20
Feldspar .....................................35
Kaolin .......................................  2
Flint ..........................................15
100 %

Flux Saturation Glaze 8
(Cone 8-10)
Barium Carbonate .....................20 %
Whiting ....................................10
Zinc ..........................................10
Feldspar .....................................60
100 %

Flux Saturation Glaze 9
(Cone 8-10)
Wood Ash .................................50 %
Feldspar .....................................25
Kaolin .......................................  25
100 %

Flux Saturation Glaze 10
(Cone 8-10)
% Dolomite.................................20
Talc .............................................10
Feldspar .....................................60
Kaolin .......................................  10
100 %

Flux Saturation Glaze 11
(Cone 8-10)
Whiting .....................................10
Zinc .............................................30
Feldspar .....................................50
Flint ..........................................10
100 %

Flux Saturation Glaze 12
(Cone 8-10)
Barium Carbonate .....................40 %
Zinc .............................................15
Feldspar .....................................35
Kaolin .......................................  10
Flint ..........................................  5
100 %

Flux Saturation Glaze 13
(Cone 8-10)
% Barium Carbonate ....................30
dolomite .....................................30
Nepheline Syenite .....................60
Flint ..........................................  5
100 %

Flux Saturation Glaze 14
(Cone 8-10)
% Barium Carbonate ....................35
dolomite .....................................20
Red Clay ...................................45
100 %

Flux Saturation Glaze 15
(Cone 8-10)
Talc .............................................30
Zinc .............................................10
Feldspar .....................................50
Kaolin .......................................  10
Flint ..........................................  5
100 %

Part 3: Hot to Trot

Artists who choose to work in clay are at a great disadvantage. Not only has biased tradition largely relegated the clayworker to the lowly position of artisan, but the medium's nature makes it the most complex of any in the art world. The clayworker must make a “canvas,” and usually all the “paints” as well. It is a tenuous balance of art and science, where, for production of much meaningful work, the ceramist must have an intimate knowledge of materials and their reaction with each other under variations of heat and kiln atmosphere. I am convinced that it is partly due to the medium's complexity that most clayworkers tend to stay within a comparatively narrow framework of expression. Sometimes it is called developing an individual style; sometimes it is simply fear of the world beyond that which is known and safe.

With few exceptions, squeezing paint out of a tube then mixing desired colors by sight is a luxury not available to ceramists. Most of the time we are working either blind or in the half-visible state. Glazemakers see what has been mixed only when glazes emerge from the kiln. There are methods available, however, that enable the margin of error to be narrowed somewhat. The knowledge that three variables-glaze makeup, temperature and atmosphere-control all color development is the foundation stone on which all ceramic color and surface understanding is based. One's grasp of the complexities of material interaction has to come from acute observation, plus a little logic. In the past, it might have taken a generation for new developments to occur; but for us, in our instant society, time becomes all important, so we take many shortcuts that may lead us down blind alleys. Glaze recipes found in books and magazines are an example of this. It often seems much quicker and easier to use somebody else's recipe to clothe a form than to spend time working to make one's own from scratch. But how often do published recipes and formulas really
satisfy? It doesn’t take long to begin to formulate intuitive understanding, and every series of tests one fires and analyzes helps build the foundation for complete understanding. Glazemaking is a creative act in itself, and an integral part of the overall creative statement.

The potter’s palette can be just as broad as the painter’s. When one combines vast surface enrichment techniques and the variables of kilns and firing, ceramics is easily as expressive as the gamut of painting and printmaking methods. Different techniques can be closely equated to working in any of the two-dimensional media, such as pencil, pen and ink, pastel, watercolor, oils, encaustics or acrylics. We also have an advantage in that the fired clay object is permanent, unless disposed of with a blunt instrument! Our works may live for thousands of years.

Because a number of colors can only be achieved at low temperatures, clayworkers have, during the last thousand years or so, developed a series of layering techniques in order to have the fired strength of stoneware or porcelain and the full palette range of the painter. To accomplish this, low-temperature glazes or overglazes are made to adhere to a higher-fired glazed surface, and can be superimposed over already existing decoration. To gain the full measure of color, one has to fire progressively down the temperature range so as not to burn out heat-sensitive colors that can’t be achieved any other way. Usually the lowest and last firing is for precious metals: platinum, palladium and gold.

For the hot side of the spectrum-red, orange, and yellow-there are many commercial body and glaze stains, in addition to the usual mineral colorants. Because commercial products are variable from one company and one country to another, I prefer to explore the potential of basic mineral colorants. However, ceramists looking for difficult-to-achieve colors might want to consider prepared stains, particularly in the yellow, violet and purple ranges. These colors are often quite a problem with standard minerals, be they in the form of oxides, carbonates, nitrates, sulfates, chlorides or even the basic metal itself.

Minerals that will give reds, oranges and yellows are copper, iron, nickel, chromium, uranium, cadmium-selenium, rutile, antimony, vanadium, and praseodymium. Variations in glaze makeup, temperature and atmosphere profoundly affect this particular color range, probably more than any other. The only materials which will produce red at high temperature are copper, iron and nickel. The reds they produce are more muted usually in the oxblood, crimson and plum variations. Reds in the scarlet to vermilion range can only be achieved at low temperatures.

On the opposite page, a chart shows 17 colors and 49 variations which should help pinpoint mineral choices for desired colors. This is the sort of listing that one finds for watercolors, oils or acrylics, and is often readily available at art stores. In this way, it is probably easier to recognize the colors that one is searching for, and to be able to work on glaze development for a given hue. Colors are listed with the minerals needed to obtain them, approximate temperatures, atmosphere, saturation percentage needed, and comments on enhancing/inhibiting factors. Because of the widely variable nature of ceramic color, there are many generalities here. Where the word “vary” occurs in the column under Cone, it signifies that the intended results could be expected most of the time at various points up to Cone 10 on the Orton scale.

Without doubt, this “hot-to-trot” section of the ceramic color range is the most elusive and difficult to control. Some colorants, like copper and cadmium-selenium stains, are, for various reasons, likely to volatilize and disappear in firing. Others, like chromium, may make abrupt color changes as kiln temperature rises. That is why most times when these colors are required, they are achieved with overglaze enamels or china paints. At the low-firing range (Cone 022-018) of enamels, both lead- and alkaline-fluxed mixtures can provide much more stability than can be had at higher temperatures. Small amounts of iron in lead-fluxed enamels will give the imperial yellows of Ming dynasty China. Large amounts of iron can give Indian red colors. Gold in the same sort of bases will give a range of pinks through to maroon. These are generally known as famille rose.