33 tried & true glaze recipes

recipe cards for our favorite pottery glazes
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Glazes are Good

If you’ve downloaded this free recipe book, you agree that glazes are good. And it’s true, these glazes are good. But, when you are looking at all the wonderful surfaces on all the wonderful forms, don’t make the mistake of thinking you should mix up a 5-gallon bucket of one of these glazes, plunge an entire kiln load of work into it, planning all the while to go sell the whole load and get rich. Yes, these glazes have been proven by those who submitted them to Ceramics Monthly as part of feature articles, but every one of those very accomplished artists will tell you that you will need to prove these recipes yourself, under your own firing conditions.

All of these glazes come from different kilns, different firing cycles, different altitudes and indeed, different attitudes toward glazing and firing. You will undoubtedly be approaching your work with your own set of requirements—you own attitude. I suggest that, regardless of the recipe, you mix up a small batch to begin with, say 500 grams. Heck, mix up several of them. You may find that a few work “right out of the box.” We all love it when that happens. But let’s say, for the sake of argument, that your clay or your forms or your firing schedule causes your results to vary from those pictured; what does this mean? It could mean you have a wonderful glaze that happens to look slightly different than what you expected. Or it could mean that you have been hooked, because you must discover the secrets of achieving the exact results you want. You will have begun your journey through the world of glaze calculation and chemistry. Don’t worry, it’s not as scary as it sounds. To help you along this path, we’ve included several useful references at the end of this book:

“Glazes: Materials, Mixing, Testing and Firing,” by Jeff Zamek (see page 23), is an overview of the things you need to keep in mind when assessing and testing new glazes. Who knew that the size of a kiln or the rate of cooling could matter so much in the success of a glaze? Okay, maybe you knew that, but there are many factors necessary to successful glaze testing and firing, and Zamek explains many of them in order to keep us on the path to successful glazes.

“The Potter’s Palette,” by Robin Hopper (see page 26), is a reference you can use to begin altering the color of a glaze. Let’s say you see a glaze surface you love, you’ve tested it and it works wonderfully on your favorite bowl form, but it would just blow you away if it were red. And not just any red, but that perfect red that would make your famous pea soup even more famous. Well, Hopper’s years of innovation and testing provide a great place to start.

“Primary Function of Common Ceramic Materials in Clay Bodies and Glazes,” on page 29, is an overview of what different materials contribute to glazes and clay bodies. If you see a glaze you like, but you haven’t worked with one of more of the materials before, this chart will list the main reason it is included in a glaze or clay body, and will help you decide whether or not a given recipe is formulated to suit your work and firing methods.

Taken together, these references will illuminate the recipes in this book beyond the images, as well as other recipes not included here. You will be able not only to assess the glazes in terms of their suitability for your studio and your work, but you will begin to learn about how different glaze materials behave. You will discover that you have favorites, as well as enemies, and you may even decide that it is time to begin formulating your own glazes. Here’s to those glazes being good!

Sherman Hall
Ceramics Monthly magazine,
Ceramic Arts Daily
Majolica Glaze
(Cone 04)

Linda Arbuckle's

Frit 3124 (Ferro) .......................... 65.72 %
Kona F-4 Feldspar ....................... 17.23
Nepheline Syenite ....................... 6.24
Edgar Plastic Kaolin ................. 10.81
100.00 %

Add: Tin Oxide ...................... 5.00 %
Zircopax ............................. 10.00 %
Bentonite ......................... 2.00 %

From Steve Davis-Rosenbaum,
This recipe is for the stiff base glaze,
over which stains are applied.

Matt Glaze
(Cone 06–06,)

Gerstley Borate ......................... 38 %
Lithium Carbonate .................... 10
Nepheline Syenite ....................... 5
Grolleg Kaolin ......................... 5
Flint ....................................... 42
100 %

Add 15% glaze stain for bright pinks and
reds; for other bright colors, add 10% glaze
stain. Greens require low chrome stains, or
bubbling may occur. To get opaque pastels,
add 0.5%–2% glaze stain and 8–9.5% Zir-
copax to total 10%.

Majolica Overglaze
(Cone 06–04)

Frit 3124 (Ferro) ....................... 50 %
Wollastonite .......................... 10
Glaze Stain .......................... 40
100 %

Can be used over a similarly colored Matt
Glaze (above) to intensify the color while
retaining the matt surface.
From Sandra Luehrsen,
Ceramics Monthly, June 2002.
Crater Underglaze
(Cone 08–04)
Borax (powder) .................................. 5 %
Talc .................................................. 15
Frit 3269 ........................................... 25
EPK .................................................. 15
Kentucky Ball Clay (OM 4) ............... 15
Silica (Flint) ........................................ 25
100 %
Add: Silicon Carbide (100 mesh) ........ 2 %

Top Crater Glaze
(Cone 08–04)
Frit 3134 ........................................... 52.1 %
EPK .................................................. 11.1
Silica (Flint) ........................................ 36.8
100.0 %
Add: Silicon Carbide (100 mesh) ........ 1 %
From James Haggerty,

White Crackle Glaze
(Cone 06)
Frit 3134 ........................................... 85 %
Kaolin .............................................. 15
100 %

Whitten Sculpture Body
(up to Cone 10)
F-1 Wollastonite .................................. 6.25 %
6-Tile Clay ........................................ 15.63
Edgar Plastic Kaolin ......................... 31.25
Kentucky Ball Clay (OM 4) ............. 15.62
Kyanite (35 mesh) .......................... 12.50
Extra-Fine Grog .............................. 6.25
Fine Grog ........................................ 6.25
Medium Grog .................................. 6.25
100.00 %
Stir Wollastonite into the mixing water and
screen. Though somewhat expensive, this body
is practically immune to thermal shock.
From George Whitten,
Ceramics Monthly, April 2000.

Red Green Glaze
(Cone 06)
Frit 3134 (Ferro) ................................. 50.0 %
Custer Feldspar ................................. 50.0
100.0 %
Add: Copper Carbonate .................. 3.2 %
From Ramon Camarillo
Ceramics Monthly, April 2002.
Blue-Green / Copper Red Glaze
(Cone 6, oxidation or reduction)
Talc .......................... 3.30 %
Whiting ........................ 14.29
Frit 3134 (Ferro) .................. 13.33
Kona F-4 Feldspar .............. 46.16
Edgar Plastic Kaolin ............. 6.40
Flint ............................. 16.52
100.00 %
Add: Tin Oxide ....................... 2.24 %
Zinc Oxide ...................... 4.37 %
Black Copper Oxide .......... 1.07 %
Covering with clear glaze helps reduce burning out of red.
From Rick Malmgren,
Ceramics Monthly, October 2000.

Wright’s Water Blue Glaze
(Cone 1–6, oxidation)
Lithium Carbonate .............. 3 %
Strontium Carbonate .......... 9
Frit 3110 .......................... 59
Edgar Plastic Kaolin .......... 12
Flint .............................. 17
100 %
Add: Bentonite ................. 2 %
Copper Carbonate ........... 5 %
From David Wright,
Ceramics Monthly, April 1998.
Fake Ash
(Cone 6, reduction)

- Bone Ash: 5%
- Dolomite: 25%
- Lithium Carbonate: 2%
- Strontium Carbonate: 9%
- Frit 3134 (Ferro): 10%
- Kentucky Ball Clay (OM 4): 24%
- Cedar Heights Redart: 23%
- Silica (Flint): 2%

100% 

This is a beautifully variegated fake ash glaze. It is a brighter yellow on porcelain with hints of green where thicker and terra cotta-colored where thin. It is not stable because it is low in silica, but to alter it would change the ash effect. While it does not meet strict requirements of stability, I use it anyway because I substituted strontium for barium.

From Diana Pancioli,

Matt “B” Glaze
(Cone 6, oxidation)

- Lithium Carbonate: 2.7%
- Strontium Carbonate: 26.5%
- Nepheline Syenite: 57.5%
- Kentucky Ball Clay (OM 4): 6.2%
- Flint: 7.1%

100.0% 

Add: Bentonite: 3.0%

The matt quality of this glaze is easily affected by colorants, so variations have different surface qualities as well as colors.

Dark Green:
- Copper Carbonate: 3%
- Nickel Oxide: 2%

Orange:
- Encapsulated Orange Stain: 5%
- Zirconium Yellow Stain: 5%

From Geoffrey Wheeler,

Rob’s/G.A. Blend Glaze
(Cone 6)

- Gerstley Borate: 2.9%
- Lithium Carbonate: 1.7%
- Strontium Carbonate: 9.3%
- Whiting: 8.4%
- Cornwall Stone: 34.6%
- Frit 3110(Ferro): 10.6%
- Kona F-4 Feldspar: 23.2%
- Flint: 9.3%

Add: Bentonite: 3.0%

Warm Pink:
- Coral Stain: 5%
- Rutile: 3%

Apple Green:
- Green Stain: 5%

From Diana Pancioli,
Floating Blue Glaze
(Cone 6, oxidation)
Gerstley Borate ................. 26 %
Nepheline Syenite .............. 48
Edgar Plastic Kaolin (EPK) .... 6
Flint (325 mesh) ............... 20
100 %
Add: Cobalt Oxide ............. 1 %
Light Rutile ................... 4 %
Red Iron Oxide ................. 2 %
From Jeff Zamek,

Frasca Wood Ash Glaze
(Cone 6, oxidation or reduction)
Whiting ......................... 11.36 %
Wood Ash (unwashed) ........ 54.56
Potash Feldspar ............... 11.36
Ball Clay ...................... 11.36
Silica (Flint) .................. 11.36
100.00 %
Green:
Copper Carbonate ............ 4 %
Blue:
Cobalt Carbonate ............ 2 %
From Harry Spring,
Ceramics Monthly, October 2002.
Temmoku Glaze
(Cone 6, reduction)

- Whiting: 20%
- Custer Feldspar: 35%
- Kentucky Ball Clay (OM 4): 15%
- Flint: 30%
- Add: Red Iron Oxide: 10%

A cone 10 that works equally well at cone 6; yields yellow “tea dust” crystals in reduction. Not as interesting in oxidation; just lies there and looks brown.

From Rick Malmgren, Ceramics Monthly, October 2000.

Marilee’s Lava Glaze
(Cone 6, oxidation or reduction)

- Whiting: 23.91%
- Custer Feldspar: 49.73%
- Edgar Plastic Kaolin: 13.18%
- Flint: 13.18%
- Add: Titanium Dioxide: 11.29%
- Silicon Carbide: 34.00%

A very rough glaze; not intended for food surfaces. Fine silicon carbide seems to work best. For a gray to black variation, add 70% Mason stain 6600.

From Rick Malmgren, Ceramics Monthly, October 2000.
Eggshell Glaze
(Cone 6, oxidation)

Whiting .......................... 9.5%
Zinc Oxide ......................... 5.5
Ferro Frit 3124 ..................... 44.5
Custer Feldspar .................... 20.0
Bentonite .......................... 7.5
EPK Kaolin ........................ 5.0
Silica .............................. 8.0

100.0 %

Add: Tin Oxide .................... 9.0%
Red Iron Oxide .................... 3.0%

From Central Carolina Community College,

Textured Blue
(Cone 6, reduction)

Talc ................................. 17.0 %
Whiting ............................ 10.0
Frit 3134 (Ferro) .................. 20.0
Nepheline Syenite ................. 30.0
EPK ................................. 13.0
Silica .............................. 10.0

100.0 %

Add: Zircopax ...................... 10.0 %
Cobalt Carbonate ................. 0.5 %
Copper Carbonate ............... 1.0 %
Rutile ............................. 3.0 %

This is Marcia Selsor's Waxy White base with a
number of colorants added. This variation was
derived from a 50/50 color blend with rutile
incorporated in the base for texture. Goes
glossy on interiors and breaks beautifully over
textures.

From Diana Pancioli,
Val's Satin Black Glaze (Variation)  
(Cone 10, reduction)

Dolomite ............................. 15 %
Talc ................................. 13
Whiting ............................. 2
Custer Feldspar ................. 20
Soda Feldspar ................. 20
Kentucky Ball Clay (OM 4) .... 10
Flint ................................. 20

100 %

Add: Cobalt Carbonate .......... 3 %
Red Iron Oxide ............... 9 %

Breaks black brown metallic with soda.

From Fred Herbst, 
Ceramics Monthly, October 2000.

Malcolm Davis Shino Glaze  
(Cone 10, reduction)

Soda Ash ............................. 17.27 %
Kona F-4 Feldspar .............. 9.82
Nepheline Syenite .............. 40.91
Edgar Plastic Kaolin ........... 18.18
Kentucky Ball Clay (OM 4) .... 13.82

100.00 %

For use on porcelain, add 6% Cedar Heights Redart
From Mel Jacobson, 
Hank’s Shino Glaze  
(Cone 10, reduction)

- Cryolite: 0.6%
- Nepheline Syenite: 55.4%
- Low-Melt Spodumene: 18.0%
- McNamee Kaolin: 26.0%
- Veegum T: 1.0%
- 100.0%

White where thick; red where thin. Best with early reduction and a long, concluding period of oxidation, or an oxidation soak during cooling. Yields a very soft and fat surface with crawling. Crawls more strongly if fired soon after glazing.

From Hank Murrow,  

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Mark Nafziger’s Gold Glaze  
(Cone 10, reduction)

- Bone Ash: 2%
- Dolomite: 22
- Whiting: 3
- Custer Feldspar: 48
- Kentucky Ball Clay (OM 4): 25
- Rutile: 8%
- 100%

Add: Cobalt Carbonate: 0.75%
- Rutile: 4.00%
- 100.00%

For use on green- or bisqueware

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Jim Brown’s Blue Glaze  
(Cone 10, reduction)

- Bone Ash: 2%
- Dolomite: 22
- Whiting: 3
- Custer Feldspar: 48
- Kentucky Ball Clay (OM 4): 25
- Rutile: 8%
- 100%

Add: Cobalt Carbonate: 0.75%
- Rutile: 4.00%
- 100.00%

From Tony Winchester,  
**Peach Black Temmoku Glaze**  
*Cone 10, reduction*

- Whiting: 17%  
- G-200 Feldspar: 50%  
- Edgar Plastic Kaolin (EPK): 10%  
- Flint: 23%  
- Add: Tin Oxide: 1%  
- Red Iron Oxide: 10%  
- Macaloid: 1%

**Tom Turner Porcelain Body**  
*Cone 10, reduction*

- Custer Feldspar: 23.5%  
- 6-Tile Clay: 29%  
- Kaopaque 20: 14.5%  
- Kentucky Ball Clay (OM 4): 4.5%  
- Flint: 27%  
- Veegum T: 1.5%  
- Total: 100%


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**Celadon Liner Glaze**  
*Cone 10, reduction*

- Dolomite: 4.7%  
- Whiting: 15.9%  
- G-200 Feldspar: 30.2%  
- Grolleg Kaolin: 18.9%  
- Flint: 30.3%  
- Add: Tin Oxide: 3.0%  
- North Fork Stone: 6.0%  
- Macaloid: 1.0%

**Magnesia Matt Glaze**  
*Cone 10, reduction*

- Dolomite: 4.7%  
- Lithium Carbonate: 2.0%  
- Talc: 8.0%  
- Whiting: 15.9%  
- G-200 Feldspar: 20.2%  
- Grolleg Kaolin: 18.9%  
- Flint: 30.3%  
- Add: Tin Oxide: 3.5%  
- Macaloid: 1.0%

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**Coleman Vegas Red Glaze**  
*Cone 8–10, reduction*

- Barium Carbonate: 2.55%  
- Dolomite: 5.61%  
- Gerstley Borate: 9.18%  
- Whiting: 8.68%  
- Custer Feldspar: 53.57%  
- EPK (Edgar Plastic Kaolin): 2.55%  
- Silica (Flint): 17.86%  
- Total: 100.00%

- Add: Copper Carbonate: 0.41%  
- Tin Oxide: 2.04%  
- Titanium Dioxide: 0.10%  
- Yellow Iron Oxide: 0.10%

- Oxblood with purple undertones

Green to Black
(Cone 10)

Bone Ash . . . . . . . . . . . . . . . . . . . . . . 5.5 %
Dolomite . . . . . . . . . . . . . . . . . . . . . . 17.3
Whiting . . . . . . . . . . . . . . . . . . . . . . . 7.0
Custer Feldspar . . . . . . . . . . . . . . . . . . . 35.1
EPK . . . . . . . . . . . . . . . . . . . . . . . . . . 35.1
100.0 %

Add: Copper Carbonate . . . . . . . . . . . 9.4 %
Tin Oxide . . . . . . . . . . . . . . . . . . . . . . . 3.4 %

The glaze will be matt black when applied thick and soda fired in oxidation or reduction. A thin application combined with light soda glaze coverage can produce pumpkin oranges next to olive greens.

From Ryan Mc kerley, Ceramics Monthly, March 2006.

Elaine’s Celadon Base Glaze
(Cone 8–11, reduction)

Whiting . . . . . . . . . . . . . . . . . . . . . . . 21.2 %
Zinc Oxide . . . . . . . . . . . . . . . . . . . . . . 2.7
Custer Feldspar . . . . . . . . . . . . . . . . . . . 24.9
Frit 3110 (Ferro) . . . . . . . . . . . . . . . . . 8.8
EPK (Edgar Plastic Kaolin) . . . . . . . . . . . 17.5
Silica (200-mesh Flint) . . . . . . . . . . . . . . . 24.9
100.0 %

White:
Tin Oxide . . . . . . . . . . . . . . . . . . . . . . . 0.7 %

Green:
Mason Stain 6201 . . . . . . . . . . . . . . . . . 0.9 %
Iron Blue:
Mason Stain 6391 . . . . . . . . . . . . . . . . . 1.6 %

Yields a smooth transparent glaze that is great over carved or incised decoration on porcelain.

From Tom & Elaine Coleman, Ceramics Monthly, January 2003.
How many times have you copied a glaze formula, only to find that it didn’t work as expected? It is not unheard of for glazes with the same formula to produce different results. While this may seem like a dead end, it does not have to be.

A high-temperature feldspathic green, transparent, gloss celadon glaze can be obtained with many different glaze formulas. The flexibility to know which formulas will produce the same glaze effect is a function of experience and the ability to interpret glaze tests. Adjusting glaze formulas requires a knowledge of how ceramic raw materials react in various combinations, temperatures, and kiln atmospheres. Taking a course in glaze calculation and raw materials is probably the most efficient way to learn about the “building blocks” of glazes. The lone ceramist in his or her studio, testing a small number of materials, cannot equal the multiplying effect of many students testing glazes with various raw materials and sharing the information. A narrow, limited education in ceramics can yield many areas for failure.

Raw Materials

When choosing glaze materials, the cost of the actual material is not the most important factor. Time, labor and a low defect rate should be more important. Every raw material should be considered for its technical and aesthetic benefit to the glaze. Some unique glazes are worth any irregularities of raw materials or difficulties with mixing, storage, application or firing.

The practice of using generic names for very specific raw materials creates challenges in choosing the appropriate ingredients when trying to duplicate glazes. Different ceramics suppliers use different manufacturers or distributors for the same raw materials. Each processor or wholesaler of raw materials can have several different manufacturers or distributors for the same raw materials.

Feldspars are grouped as potash, sodium or lithium. When making substitution materials in the glaze formula. If the glaze requires nepheline syenite, it is best not to substitute a potassium feldspar or a lithium feldspar. Clays are grouped as ball clays, bentonites, earthenwares, fireclays, kaolins and stoneware clays. Feldspars are grouped as potash, sodium or lithium. When making a substitution, always use a material from within the same group of clays, feldspars or raw materials.

Some glazes were developed using materials that are no longer in production. For example, Oxford feldspar, a potassium feldspar, is no longer being mined. If you have a container of Oxford feldspar in your studio and use it in a glaze, there might not be a readily available supply when you run out. Before mixing a glaze formula, make sure all of the materials are still in production.

In some instances, continually available materials may subtly change in chemical composition, particle size or organic content over time. All of these can alter the glaze. Often the supplier is unaware of changes in the raw materials they sell. The best course of action, though time consuming and inefficient, is to test raw materials before committing to a production glaze batch.

Particle Size

The particle size of a raw material is a critical factor in glaze melt. A smaller particle size means increased surface area for a given weight, and melting is more efficient. My ZAM Gloss Blue can drip or run on vertical surfaces if a finer mesh nepheline syenite, flint or whiting is used.

It is important to know the actual mesh size when trying to duplicate any glaze formula. Silica, a major component in any glaze, can be purchased in 60-, 100-, 200-, 325- and 400-mesh particle sizes. The larger mesh numbers indicate smaller particles. Frequently, a glaze formula will not specify a mesh size for silica. In such instances, use 325 mesh. Nepheline syenite, a common high-temperature glaze flux, is produced in 270 and 400 mesh. If the glaze formula does not specify a mesh size for nepheline syenite, use 270 mesh. Coarser mesh whiting can cause the solids in a glaze to sink to the bottom of the glaze bucket. It also can cause a transparent glaze to become semi-opaque when fired due to incomplete melting of the material in the glaze matrix. Unless otherwise noted, use 325-mesh whiting. When ordering any glaze material, always specify the mesh size where applicable.

Materials Substitution

Problems can occur when potters use inappropriate substitution materials in the glaze formula. If the glaze requires nepheline syenite, a sodium feldspar, it is best not to substitute a potassium feldspar or a lithium feldspar. Clays are grouped as ball clays, bentonites, earthenwares, fireclays, kaolins and stoneware clays. Feldspars are grouped as potash, sodium or lithium. When making a substitution, always use a material from within the same group of clays, feldspars or raw materials.

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Coloring Oxides/Carbonates

Metallic coloring oxides can differ in metal concentration, particle size and trace-element content. As with other raw materials, there are many processors of metallic coloring oxides. For example, cobalt oxide (CoO) is processed in three grades, 71.5%, 72.5% (ceramic grade) and 73.5%. The percentage represents the cobalt contained in the oxide. Each grade can affect the intensity of the blue that will be generated in a glaze. In addition, the quantity of trace elements in a metallic coloring oxide can influence its effect on the glaze color. For example, zinc oxide (French process) also can contain trace amounts of copper, lead, iron and manganese. Copper oxide also can have trace amounts of magnesium, sodium...
chloride, lead and other heavy metals. Use the same processor of metallic coloring oxides when ordering materials. When this is not possible, always test the oxide. While slight differences in trace metallic oxide content usually will not cause a radical color change, particle size can affect the look of a glaze. For example, a coarser particle size of cobalt oxide can cause larger blue specks in a glaze than a finer grind of the same oxide.

Clay Body/Glaze Interaction

The point at which the fired clay and glaze meet and fuse together in the ceramic structure plays an important role in the development of the fired glaze. Some clay bodies will draw part of the flux content from the forming glaze during the firing process. This can cause opacity or dry surface textures in the glaze. A light colored clay body, such as a white stoneware or porcelain, can have an intensifying affect on a colored glaze. ZAM Gloss Blue, when applied to a white clay body, will be light blue. The degree to which the clay body matures in the firing can promote or retard glaze maturation. Always consider the clay body.

Mixing Glazes

Every glaze will require different amounts of water, but it is best to use less water in initial mixing. It is easier to add water than remove it. If too much water is used in a glaze containing soluble materials and the excess water is poured off, it can change the glaze formula (solubles leave with the water). Glazes should be run through an 80-mesh sieve three times for final mixing.

Glaze Application

Ease of application is especially important in production situations where time-consuming touch-ups mean a decrease in profits. Some glazes will become soft, dusty and fragile when drying on bisqueware. Other glazes will drip and run down vertical surfaces or pool unevenly in horizontal areas. Glazes containing high percentages of clay or light-density materials such as magnesium carbonate can become fragile and loose on bisqueware. This can develop into crawling in the fired glaze. While there are several gums that can improve glaze application, it is often more efficient to choose glazes that do not need additives.

Generally, a spray application will impart a uniform glaze layer as opposed to a dipped or brushed application. However, much depends on the skill of the individual. Dipping the pot into the glaze can result in drips as the excess glaze runs off the surface. Brushing also can result in uneven glaze thickness.

Some glazes are especially sensitive to the way in which they are applied to the piece. Apply test glazes in varying thicknesses to determine the true glaze color and texture. The thinner the glaze application, the more the underlying color and texture of the clay body are likely to be revealed. Often, a thin glaze application can retard the development of color, texture and opacity in the fired glaze. A thick application can cause some glaze formulas to run and drip on vertical surfaces. ZAM Gloss Blue, when applied too thin, will not achieve a rich deep blue color. A great percentage of glazes can be applied slightly thinner than the thickness of a dime or about as thick as three business cards stacked together.

Glaze Testing Procedures

It is amazing that most glazes reproduce accurately with a minimum of additional information; however, it is always best to start a testing program with the knowledge that occasionally a glaze formula will not work as described. We all know of people who obtain a glaze formula and then mix up 30 gallons without considering that it might fail. Experimenting on such a large scale is not a good idea. Eventually, there will be a major glaze and/or kiln problem caused by a glaze failure.

One important, often-overlooked item required for testing glazes is a notebook. Writing down each step in the process and the results from each test is more effective than memory. While there is no single testing procedure that will suit all work habits and objectives, consistency of method will ensure greater accuracy in duplicating glazes.

It is important to know if a glaze will run or drip on vertical surfaces during firing. Vertical test tiles should be at least 4 inches in height and 2 inches wide. Tiles also must be of sufficient surface area to approximate the surface area of finished works. Many times, a small test tile will be successful because the weight of the molten glaze when heated is not enough to cause it to run down vertical surfaces. However, when larger areas are glazed, the increased weight of the fluid glaze might cause it to run.

Test tiles should have a smooth edge, a rough edge and any other textures likely to be used under the glaze, including throwing ridges. Some glazes can form razor-sharp edges on the fired clay. The testing stage is the time to find out if this is likely.

A gradual increase from a small test batch to the final large-volume glaze batch is important in ensuring a glaze formula’s reliability. A 500-gram test batch will allow you to glaze several test tiles, which should be placed in a number of different kiln firings. If the test glaze does not need an adjustment,
it is often a good policy to mix up a preproduction batch of 4000 grams (makes roughly 1 gallon). This larger batch will allow you to glaze several pieces and place them throughout the kiln. Many kilns do not transfer heat evenly throughout their interior space, and not every kiln fires consistently every time. There are always slight variations. If possible, test in several different kilns. Once you are confident with a glaze, larger batches can be mixed and slowly incorporated into your existing glaze palette.

Kiln Size

Kiln bricks, posts, shelves and stacked pots all radiate heat. Therefore, larger kilns have greater thermal mass, and will radiate more heat during their heating and cooling cycles than smaller kilns. Small test kilns are an inaccurate indicator of clay body and glaze reactions when compared to larger kilns. ZAM Gloss Blue can run or drip in a larger kiln due to prolonged heatwork on the glaze. Conversely, it can fire light blue with a satin-matt surface texture in a small kiln.

Firing Cycle

A kiln fired at a fast rate of heat increase can cause the clay body to remain more porous, causing crazing and a less durable clay. Glazes fired at a very slow rate of heat increase can run and drip due to the extra heatwork acting on the glaze. While there is no perfect rate for ZAM Gloss Blue, I recommended a 75–80°F (23–26°C) heat increase per hour from Cone 06 (1828°F/997°C) to Cone 9 (2300°F/1260°C), for this type of glaze.

Kiln Atmosphere

Whether the glaze is fired in an electric, wood, natural gas, propane or oil kiln (with or without soda or salt), the atmosphere affects the glaze color, texture and melting capacity. Electric kilns produce clean, repeatable neutral atmospheres. Carbon-based fuels such as natural gas, propane, wood, coal, oil and sawdust can produce oxidation, neutral and various intensities of reduction atmospheres. It is reduction that can be very difficult to reproduce, as one potter’s medium-reduction atmosphere can be another’s heavy-reduction atmosphere. Reduction atmospheres can cause greater melting due to the increased fluxing action of the metallic coloring oxides contained in the clay body and glaze.

The cobalt oxide in ZAM Gloss Blue will fire blue in almost any kiln atmosphere, but there can be variations in the intensity of the color due to the atmosphere in the kiln and the fuel used to maintain that atmosphere. In soda, salt or wood firings, it can run or drip on vertical surfaces or pool in horizontal areas because of the fluxing action of sodium vapor or the alkaline content of the wood ash. Pyrometric cones are also subject to the fluxing action of sodium vapor, giving an inaccurate indication of the kiln temperature. In most instances, the glaze reactions to salt and wood firing are aesthetically positive.

Cone Reading Position

The actual pyrometric cone reading is a difficult piece of information to obtain, because potters read pyrometric cones at different positions. Many potters consider the cone reaching maturity when it bends to the 3 o’clock or 9 o’clock position (bending over halfway in relation to the bottom of the cone pack). Other potters read the cone as being mature when it actually touches the cone pack. ZAM Gloss Blue has a two- to three-cone maturing range and will not change significantly when fired to Cone 8, 9 or 10. Some glazes are very sensitive to slight temperature variations. If you do not get a good glaze result, consider firing half a cone higher or lower.

Glazes with a wide maturing range are desirable, as not every kiln will fire evenly. While the glaze might not look the same at the lower end of the range as it does at the higher end, it should be functional, with a smooth nonpitted surface.

Soluble Materials

Whenever possible do not use soluble glaze materials. Borax, boric acid, colemanite, Gerstley borate, soda ash, wood ash, Gillespie borate, Borax, potassium bichromate and pearl ash (potassium carbonate) are the primary sources of solubility in glaze formulas. Other glaze materials such as lithium carbonate, magnesium carbonate, nepheline syenite, strontium carbonate, and some frits can have lesser degrees of solubility but generally they do not interfere with the glaze application or fired glaze effects.

Soluble materials can take on atmospheric water in storage. This can affect the accurate measurement of the materials when weighing them. These materials will leach into the water in the glaze, changing its chemical composition over time, which can result in several glaze defects. As water evaporates from the glaze during application, soluble materials travel in a wicking action, drawing higher concentrations of material to the ridges and edges of the pot. Essentially, in the elevated edges of the pot, the glaze formula is different due to the concentration of soluble materials. This can cause blisters, pinholes, dry surfaces or changes in color.

The use of soluble materials is required in some instances as they contribute distinctive characteristics to a glaze. For example, in Shino (a high temperature viscous, feldspathic glaze developed in Japan more than 400 years ago), the inclusion of soda ash causes the glaze to melt at lower temperatures, sealing in carbon produced during body reduction. The carbon remains in the surface of the fired glaze. When soluble materials are required in a glaze formula, they should be stored in waterproof plastic bags. A conservative approach is to mix only enough material for one glazing session as the stored liquid glaze can change over time.

the author A frequent contributor to CM, Jeff Zamek is a ceramics consultant in Southampton, Massachusetts. For further information, see www.fixpots.com.
The Potter’s Palette

Note: Colors bars are for visual reference only, and do not represent actual colors.

Red to Orange

The potter’s palette can be just as broad as the painter’s. 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—a sobering thought.

Because a number of colors can only be achieved at low temperatures, you need 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. 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 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. The only materials which produce red at high temperature are copper, iron and nickel—usually muted. Reds in the scarlet to vermillion range can only be achieved at low temperatures.

The chart should help pinpoint mineral choices for desired colors (note that the color bars are for guidance only and not representative of the actual colors—Ed.). 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.


<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS</th>
<th>%</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Vary</td>
<td>Red</td>
<td>0.5%-5%</td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Nickel</td>
<td>4-10</td>
<td>Ox.</td>
<td>5%-8%</td>
</tr>
<tr>
<td>Burgundy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>See Dark Red, Copper.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>See Dark Red, Copper.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maroon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrome-Tin Stains</td>
<td>Vary</td>
<td>Ox.</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Copper</td>
<td>Vary</td>
<td>Red</td>
<td>0.5%-5%</td>
</tr>
<tr>
<td>Crimson</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper + Titanium</td>
<td>8-10</td>
<td>Red.</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Calcium-Selenium Stains</td>
<td>O10-05</td>
<td>Ox.</td>
<td>0.5%-5%</td>
</tr>
<tr>
<td>Indian Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Brick Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Orange-Brown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron + Rutile</td>
<td>Vary</td>
<td>Both</td>
<td>1%-10%</td>
</tr>
<tr>
<td>Iron + Tin</td>
<td>Vary</td>
<td>Both</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Orange-Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadmium-Selenium Stains</td>
<td>O12-05</td>
<td>Ox.</td>
<td>1%-4%</td>
</tr>
<tr>
<td>Orange</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Rutile</td>
<td>Vary</td>
<td>Both</td>
<td>5%-15%</td>
</tr>
<tr>
<td>Copper</td>
<td>8-10</td>
<td>Both</td>
<td>1%-3%</td>
</tr>
<tr>
<td>Orange-Yellow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
<td>2%-5%</td>
</tr>
<tr>
<td>Rutile</td>
<td>Vary</td>
<td>Ox.</td>
<td>1%-10%</td>
</tr>
<tr>
<td>Yellow Ocher</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
<td>1%-10%</td>
</tr>
<tr>
<td>Iron + Tin</td>
<td>Vary</td>
<td>Ox.</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Iron + Rutile</td>
<td>Vary</td>
<td>Both</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Vanadium-Zirconian Stains</td>
<td>Vary</td>
<td>Ox.</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Lemon Yellow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phaseolodymium Stains</td>
<td>Vary</td>
<td>Both</td>
<td>1%-10%</td>
</tr>
<tr>
<td>Pale/Cream Yellow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron + Tin</td>
<td>Vary</td>
<td>Both</td>
<td>2%-5%</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Vary</td>
<td>Both</td>
<td>2%-5%</td>
</tr>
<tr>
<td>Rutile + Tin</td>
<td>Vary</td>
<td>Ox.</td>
<td>2%-5%</td>
</tr>
</tbody>
</table>
The Potter’s Palette

Yellow-Green to Navy Blue
The cool side of the glaze spectrum (from yellow-green to navy blue) is considerably easier, both to produce and work with, than the warm. In the main, colorants that control this range create far fewer problems than almost any of the red, orange and yellow range. Some are temperature and atmosphere sensitive, but that’s nothing compared to the idiosyncrasies possible with warm colors.

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATMOS.</th>
<th>%</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Green</td>
<td>Copper + Rutile</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Chromium</td>
<td>4-8</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Chromium</td>
<td>018-015</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Light Green</td>
<td>Copper</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Apple Green</td>
<td>Chromium</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>1%-2%</td>
<td></td>
</tr>
<tr>
<td>Celadon Green</td>
<td>Iron</td>
<td>Vary</td>
<td>Red.</td>
</tr>
<tr>
<td></td>
<td>Copper</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Grass Green</td>
<td>Copper</td>
<td>010-2</td>
</tr>
<tr>
<td></td>
<td>Chromium</td>
<td>018-04</td>
<td>Ox.</td>
</tr>
<tr>
<td>Olive Green</td>
<td>Nickel</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Iron</td>
<td>Vary</td>
<td>Red.</td>
</tr>
<tr>
<td>Hooker’s Green</td>
<td>Copper</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Chrome Green</td>
<td>Chromium</td>
<td>06-12</td>
<td>Both</td>
</tr>
<tr>
<td>Dark Green</td>
<td>Copper</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Chromium</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Teal Blue</td>
<td>Cobalt + Rutile</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Chromium</td>
<td>Vary</td>
<td>Both</td>
</tr>
</tbody>
</table>

The colorants known for creating cool hues are copper, chromium, nickel, cobalt, iron and sometimes molybdenum. For variations, some are modified by titanium, rutile, manganese or black stains. The usual three variables of glaze makeup, temperature and atmosphere still control the outcome, though it is less obvious in this range.

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATMOS.</th>
<th>%</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turquoise</td>
<td>Copper</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Copper + Rutile</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Copper + Tin</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td>Light Blue</td>
<td>Nickel</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Rutile</td>
<td>Vary</td>
<td>Red.</td>
</tr>
<tr>
<td></td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Celadon Blue</td>
<td>Iron</td>
<td>6-10</td>
<td>Red.</td>
</tr>
<tr>
<td>Wedgewood</td>
<td>Cobalt + Iron</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Manganese</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Nickel</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Cobalt</td>
<td>4-10</td>
<td>Both</td>
<td>0.5%-3%</td>
</tr>
<tr>
<td></td>
<td>Nickel</td>
<td>4-10</td>
<td>Ox.</td>
</tr>
<tr>
<td>Blue Gray</td>
<td>Nickel</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Rutile</td>
<td>Vary</td>
<td>Red.</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Manganese</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Vary</td>
<td>Ox.</td>
<td>0.5%-5%</td>
</tr>
<tr>
<td>Ultramarine</td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Cerulean Blue</td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Prussian Blue</td>
<td>Nickel</td>
<td>6-10</td>
<td>Ox.</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Manganese</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Cobalt + Manganese</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Navy Blue</td>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
</tbody>
</table>

Note: Colors bars are for visual reference only, and do not represent actual colors.
The Potter’s Palette

**Indigo to Purple**

The indigo-to-purple part of the color wheel is small but significant. The colorants that produce this range are nickel, cobalt, manganese, iron, chromium, rutile, ilmenite, copper, iron chromate, and black stains. In short, one could say that the colorants needed include just about the whole group that are used for all the other colors in the spectrum. The only ones I haven’t talked about previously in this articles series are amber, ilmenite, iron chromate and black stains.

**Black stains** Formulated from a variable mixture of other colorants, black stains are usually rather expensive due to their being saturations of colorant materials. Various companies produce black stains usually from a combination of iron, cobalt, chromium, manganese, iron chromate and sometimes nickel mixed with fillers and fluxes such as clay, feldspar and silica. I use the following recipe:

**Black Stain**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>Vary</td>
<td>8%-15%</td>
</tr>
<tr>
<td>Cobalt + Manganese</td>
<td>Vary</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Cobalt + Black Stain</td>
<td>Vary</td>
<td>5%-8%</td>
</tr>
</tbody>
</table>

**Violet**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>Vary</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Nickel</td>
<td>Vary</td>
<td>1%-10%</td>
</tr>
<tr>
<td>Manganese</td>
<td>Vary</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Copper</td>
<td>Vary</td>
<td>8%-10%</td>
</tr>
</tbody>
</table>

**Purple**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>6-10</td>
<td>Both</td>
</tr>
<tr>
<td>Copper</td>
<td>8-10</td>
<td>Red.</td>
</tr>
<tr>
<td>Nickel</td>
<td>Vary</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Vary</td>
<td>5%-10%</td>
</tr>
<tr>
<td>Manganese</td>
<td>04-10</td>
<td>Ox.</td>
</tr>
<tr>
<td>Iron</td>
<td>8-10</td>
<td>Red.</td>
</tr>
<tr>
<td>Copper + Cobalt</td>
<td>Vary</td>
<td>2%-8%</td>
</tr>
<tr>
<td>Chrome + Tin + Cobalt</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
</tbody>
</table>

**Mauve or Lilac**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>Vary</td>
<td>1%-5%</td>
</tr>
<tr>
<td>Nickel</td>
<td>Vary</td>
<td>1%-5%</td>
</tr>
</tbody>
</table>

**Pink**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt</td>
<td>Vary</td>
<td>1%-3%</td>
</tr>
<tr>
<td>Copper</td>
<td>Vary</td>
<td>Red.</td>
</tr>
<tr>
<td>Copper</td>
<td>6-10</td>
<td>Ox.</td>
</tr>
<tr>
<td>Copper</td>
<td>8-10</td>
<td>Red.</td>
</tr>
<tr>
<td>Chromium</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Ox.</td>
</tr>
<tr>
<td>Rutile</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Nickel</td>
<td>018-010</td>
<td>Ox.</td>
</tr>
<tr>
<td>Manganese</td>
<td>Vary</td>
<td>Both</td>
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</table>

**Brown**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Manganese</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Nickel</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Chromium</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Umber</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Rutile</td>
<td>Vary</td>
<td>Both</td>
</tr>
</tbody>
</table>

**Gray**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Red.</td>
</tr>
<tr>
<td>Iron Chromate</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Nickel</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Copper</td>
<td>8-10</td>
<td>Both</td>
</tr>
<tr>
<td>Cobalt + Nickel</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Cobalt + Manganese</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Black Stain</td>
<td>Vary</td>
<td>Both</td>
</tr>
</tbody>
</table>

**Black**

<table>
<thead>
<tr>
<th>COLORANT</th>
<th>CONE ATOMS. %</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Copper</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Vary</td>
<td>Both</td>
</tr>
<tr>
<td>Black Stain</td>
<td>Vary</td>
<td>Both</td>
</tr>
</tbody>
</table>

Note: Colors bars are for visual reference only, and do not represent actual colors.
# Primary Function of Common Ceramic Materials in Claybodies and Glazes

<table>
<thead>
<tr>
<th>CERAMIC MATERIAL</th>
<th>GLAZE FUNCTION</th>
<th>CLAYBODY FUNCTION</th>
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</thead>
<tbody>
<tr>
<td>Albany Slip clay</td>
<td>Glaze core</td>
<td>Colorant</td>
</tr>
<tr>
<td>Ball clay</td>
<td>Alumina Opacity</td>
<td>Plasticity</td>
</tr>
<tr>
<td>Barnard clay</td>
<td>Glaze core Color (ST, P)</td>
<td>Color</td>
</tr>
<tr>
<td>Bone ash</td>
<td>Opacifier</td>
<td>Melter (4–6)</td>
</tr>
<tr>
<td>Borax</td>
<td>Melter (5–6, E) Glassmaker</td>
<td>Melter (4–6, E)</td>
</tr>
<tr>
<td>Boric Acid</td>
<td>Melter (5–6, E) Glassmaker</td>
<td>Melter (4–6, E)</td>
</tr>
<tr>
<td>Boron Frits</td>
<td>Glaze core (5–6, E) Melter Colemanite (s) Gerstley Borate (s)</td>
<td>Melter (4–6, E)</td>
</tr>
<tr>
<td>Colemanite</td>
<td>Glaze core (5–6, E) Melter Gerstley Borate (s) Boron Frits (s)</td>
<td>Melter (4–6, E)</td>
</tr>
<tr>
<td>Cornwall Stone</td>
<td>Glaze core (ST, P) (Low melter, high SiO₂)</td>
<td>Melter (P)</td>
</tr>
<tr>
<td>Dolomite</td>
<td>Melter (ST) Opacifier Whiting (s)</td>
<td>Melter (ST)</td>
</tr>
<tr>
<td>EPK kaolin</td>
<td>Alumina Opacity (ST, P)</td>
<td>Core (P, W)</td>
</tr>
<tr>
<td>Flint (silica)</td>
<td>Glassmaker Glassmaker Glaze-fit</td>
<td>Glassmaker</td>
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<tr>
<td>Fluorspar</td>
<td>Melter</td>
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<tr>
<td>Gerstley Borate</td>
<td>Glaze core (4–6, E) Melter Colemanite (s) Boron Frits (s)</td>
<td>Melter (4–6, E)</td>
</tr>
<tr>
<td>Goldart clay</td>
<td>Core (ST)</td>
<td></td>
</tr>
<tr>
<td>Kentucky Stone</td>
<td>Core (ST)</td>
<td></td>
</tr>
</tbody>
</table>

### Key
- *(s)=substitute option*
- *(E)=earthenware claybody*
- *(ST)=stoneware claybody*
- *(P)=porcelain claybody*
- *(FL)=flameware claybody, c/9-10*
- *(W)=white-burning claybodies, c/4-10*

# Primary Function of Common Ceramic Materials in Claybodies and Glazes

<table>
<thead>
<tr>
<th>CERAMIC MATERIAL</th>
<th>GLAZE FUNCTION</th>
<th>CLAYBODY FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lepidolite</td>
<td>Lithium glaze core</td>
<td>Melter (FL)</td>
</tr>
<tr>
<td>Magnesium Carbonate</td>
<td>Melter (ST, P, W) Opacifier</td>
<td></td>
</tr>
<tr>
<td>Nepheline Syenite</td>
<td>Glaze core (low SiO₂) (high Na₂O) (high Al₂O₃)</td>
<td>Melter (ST, P)</td>
</tr>
<tr>
<td>Ocmulgee Red clay</td>
<td>Color (ST)</td>
<td>Color Melter Core (E 4-6)</td>
</tr>
<tr>
<td>Petalite</td>
<td>Lithium glaze core (ST 9-10)</td>
<td>Melter (FL)</td>
</tr>
<tr>
<td>Potash Spars</td>
<td>Glaze core (ST, P) G-200, K200 (s) Custer, K200 (s) Custer, G-200 (s)</td>
<td>Melter (ST, P)</td>
</tr>
<tr>
<td>Custer</td>
<td>Color</td>
<td>Melter Color Core (E)</td>
</tr>
<tr>
<td>G-200</td>
<td>Glaze core (ST, P)</td>
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</tr>
<tr>
<td>K200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redart</td>
<td>Color</td>
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</tr>
<tr>
<td>Rotten Stone</td>
<td>Glaze core (ST, P)</td>
<td>Melter Color Core (ST)</td>
</tr>
<tr>
<td>Soda Spars</td>
<td>Glaze core (ST, P) C-6 (s) Kona F-4 (s)</td>
<td>Melter (ST, P)</td>
</tr>
<tr>
<td>Kona F-4</td>
<td>Glaze core (ST, P)</td>
<td></td>
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<tr>
<td>C-6</td>
<td></td>
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<tr>
<td>Spodumene</td>
<td>Lithium glaze core (ST, P)</td>
<td>Melter (FL)</td>
</tr>
<tr>
<td>Talc</td>
<td>Melter Opacifier</td>
<td>Melter (E, 4-6, W)</td>
</tr>
<tr>
<td>Volcanic ash</td>
<td>Glaze core (ST, P) Cornwall Stone (s)</td>
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</tr>
<tr>
<td>Whiting</td>
<td>Melter (ST, P) Opacifier Wollastonite (s) Dolomite (s)</td>
<td>Melter (ST)</td>
</tr>
<tr>
<td>Wollastonite</td>
<td>Melter (ST, P) Opacifier Whiting (s) Dolomite (s)</td>
<td>Melter (ST, P)</td>
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<tr>
<td>Wood Ash</td>
<td>Glaze core (ST, P)</td>
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</tr>
<tr>
<td>Zinc</td>
<td>Melter (ST, P) Opacifier (ST, P)</td>
<td></td>
</tr>
</tbody>
</table>