10 BUYERS GUIDE TO

Ceramic Supplies

A Studio Reference on Purchasing and Using Ceramic Supplies and Pottery Tools

STUDIO REFERENCE

Technical Information

Buying Information

Glaze Recipes

Working with Texture

Materials Glossary

...and more!

WHERE TO FIND

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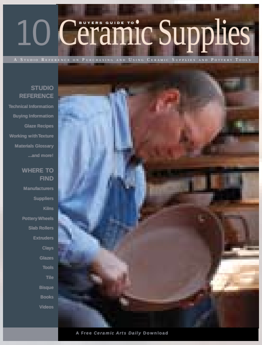

On the Cover: Potter Paul Eshelman, Elizabeth, Illinois.

Welcome to the 2010 Buyers Guide to Ceramic Supplies, a valuable resource you'll use throughout the coming year. This comprehensive studio reference contains information published in *Ceramics Monthly* and *Pottery Making Illustrated* as well as some of the books published by The American Ceramic Society.

Decisions, decisions

We have a dilemma each year as we put this free resource together in that we have to select what information goes into it. With all the information we've published in CM, PMI, and the books, that can be a tough call because there's so much to choose from. We think you'll enjoy this year's selection of a broad range of topics that includes ceramic glazes, ceramic raw materials, pottery equipment, and pottery studio supplies.

Glazes and Glazing

Glazing makes the piece, there's no doubt about that. As potters and ceramic artists, we have the ability to create anything our imagination can dream up. When you look at the list of ceramic colorants compiled by Robin Hopper or the glaze experiments of John Britt, you can really get excited about f ring effects, color and texture. Or if you want to simplify your life, there's Kristina Bogdanov's quest for the perfect glaze base that works over a range of temperatures.

Looking for Something?

Our Company Directory is the only complete listing of resources for the studio ceramic artist. This comprehensive directory provides complete contact information and descriptions of more than 285 companies and organizations involved in some way with meeting your studio needs. From the Geographic Locator, which lists companies and organizations by state and city, you may discover new resources near your own home. Or perhaps you'll locate three nearby suppliers where you can get cost estimates for your next major purchase. Whether you're looking for kilns, studio equipment, pug mills, slab rollers, glazes, clays, modeling tools or extruders, this directory of ceramic suppliers is a handy guide.

Enjoy!

Bill Jones
Editor
Pottery Making Illustrated

Sherman Hall
Editor
Ceramics Monthly

Buyers Guide to Ceramic Supplies

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DARREN EMENAU'S TEXTURE GLAZES
BY MANDY GINSON

Texture takes on an important role in Darren Emenau's work. Impurities, such as twigs and stones, are not removed but rather retained to effect unique markings and interesting surfaces. The roughed-up, worn exteriors convey a rich sense of history. This is not by chance. Individual works have been fired up to eight or nine times. History is not imitated but created. Emenau is a self-professed glaze fanatic. As he increasingly exploits this knowledge, the glaze is used not as mere surface decoration but the surface itself. Emenau experiments with applying successive layers of glaze and refiring. The results, he admits, might be irreproducible, but the intent here is not to make models but rather to unearth possibilities.

Bud vase, 5 in. (13 cm) in height, local earthenware, with MNO Lichen Glaze, fired to cone 06.

***Ellie Euer*, 4 in. (10 cm) in height, local earthenware, with MNO Lichen Glaze, fired to cone 06; detail below.**

***Ellie Euer*, detail, with MNO Lichen glaze, fired to cone 06.**

RECIPES

MNO Lichen
Cone 06

Borax	24.7 %
Lithium Carbonate	9.3
Magnesium Carbonate	39.2
Ferro Frit 3134	3.1
Nepheline Syenite	23.7
	100.0 %
Add: Copper Carbonate	5.2 %
Bentonite	3.1 %

This recipe was inspired by Lana Wilson's low-fire recipes. I brush it on in various thicknesses. Be aware that some of the glaze can flake off during firings, so use shelves that are coated with kiln wash. After firing, I scrape or sand blast the surface to remove any loose glaze. I rub beeswax into some areas and then torch it to remove most of the wax. Forms are often fired multiple times. A nepheline syenite wash will prevent flaking during firings. Additionally, my local clay contains a high percentage of iron oxide and salt crystals, which act as strong fluxes.

KENNY DELIO'S SUBTLE GLAZES

BY MYRA BELLIN

Kenny Delio glazes his work subtly. He thinks of glazes as a skin, choosing matt glazes that are soft and supple, or shiny surfaces that appear wet and visceral. Or he may choose to mimic scales and fur with multi-hued textures, an important consideration when glazing the legs for his tables and props for his shelves. The guiding consideration for his glazing choices is enticement. Delio wants people to interact with his work, to be drawn to touch it, and to use it.

Left: *Buddy Teapot*, 10 in. (25 cm) in height, thrown and altered white stoneware with White and Speckled glazes, fired to cone 6 in oxidation.

Teapot, 12 in. (30 cm) in height, thrown and altered white stoneware with a pulled handle, Brown Slip, and Black Glaze, fired to cone 6 in oxidation.

RECIPES

Brown Slip
Cone 6

Ferro Frit 3124	10 %
Nepheline Syenite	10
EPK Kaolin	40
Kentucky OM 4 Ball Clay	30
Silica	10
	100 %
Add: Red Iron Oxide	8 %

Olive Glaze
Cone 6

Barium Carbonate	7 %
Gerstley Borate	16
Whiting	7
Kona F-4 Feldspar	30
EPK Kaolin	9
Silica	31
	100 %
Add: Mason Stain #6503	2 %

White Glaze
Cone 6

Dolomite	23 %
Nepheline Syenite	72
Ball Clay	5
	100 %
Add: Tin Oxide	8 %
Red Iron Oxide	1 %
Bentonite	2 %

Black Glaze
Cone 6

Bone Ash	10 %
Whiting	15
Ferro Frit 3124	20
Nepheline Syenite	20
EPK Kaolin	18
Silica	17
	100 %
Add: Mason Stain #6616	12 %

Speckled Glaze
Cone 6

Gerstley Borate	59 %
Talc	41
	100 %
Add: Rutile	18 %

WEIGHTS AND MEASURES

BY ROBIN HOPPER

If you're doing repetitive throwing or production work, keep a chart of weights and measures showing the amount of clay needed and size of objects at the throwing stage. Here is a list of weights and measures of standard items produced in my studio. These are for an average throwing thickness of $^3/_{16}$ in. for smaller objects, and $^3/_8$ in. for larger objects. Adjust accordingly if throwing thinner or thicker.

Excerpted from Functional Pottery *by Robin Hopper and published by The American Ceramic Society.*

Weights and Measures for Basic Production Items

ITEM	WEIGHT Grams	lb./oz.	HEIGHT inches	cm	WIDTH inches	cm
Drinking vessels						
6 oz. coffee mug	275	10 oz.	3	7.5	3	7.5
8 oz. coffee mug	400	14 oz.	5	12.5	3	7.5
14 oz. beer mug	600	1 lb. 5 oz.	7	17.5	3.5	8.5
chalice (cup only)	500	1 lb. 2 oz.	4	10.0	4	10.0
goblet (cup only)	340	12 oz.	5	12.5	3	7.5
cup	300	11 oz.	2.75	7.0	3.75	9.5
saucer	350	13 oz.	1	2.5	5.5	13.5
large dinner plate	1800	4 lb.	1.25	3.0	11.5	29.0
medium dinner plate	1350	3 lb.	1	2.5	10	25.0
side plate	1000	2 lb. 3 oz.	1	2.5	8	20.0
bread and butter	600	1 lb. 5 oz.	.75	2.0	6.5	16.0
glutton plate	2300	5 lb. 2 oz.	1.25	3.0	14	35.0
Bowls						
large	2600	5 lb. 12 oz.	6	15.0	12	30.0
medium	1800	4 lb.	4.5	11.0	10	25.0
small	600	1 lb. 6 oz.	3	7.5	6	15.0
onion soup	600	1 lb. 5 oz.	3	7.5	6	15.0
large mixing bowl	1800	4 lb.	4.5	11	10	25.0
Casseroles						
4 quart	2600	5 lb. 12 oz.	8	20	12	30.0
lid	1600	3 lb. 8 oz.	-	-	-	-
2 quart	1800	4 lb.	4.5	11	8.5	21.0
lid	1000	2 lb. 3 oz.	-	-	-	-
1 quart	1000	2 lb. 3 oz.	4	10	6.5	16.0
lid	750	1 lb. 12 oz.	-	-	-	-
individual	600	1 lb. 6 oz.	3	7.5	5.5	13.5
lid	450	16 oz.	-	-	-	-
Pots for pouring						
cream pitcher	400	14 oz.	5	12.5	3	7.5
1 pint pitcher	675	1 lb. 8 oz.	6.5	16.5	4	10.0
4 pint pitcher	2600	5 lb. 12 oz.	14	35	6	15.0
coffee pot	1800	4 lb.	11	27.5	4.5	11.0
lid	400	14 oz.	-	-	-	-
large teapot	2000	4 lb. 6 oz.	8	20	8	20.0
lid	250	9 oz.				
medium teapot	1500	3 lb. 6 oz.	6	15	6	15.0
lid	200	7 oz.	-	-	-	-
small teapot	1000	2 lb. 3 oz.	4.5	11	5	12.5
lid	150	5 oz.	-	-	-	-
1 liter decanter	2000	4 lb. 6 oz.	12	30	6	20.0
small decanter	1200	2 lb. 11 oz.	8	20	5	12.5
liqueur or sake bottle	1000	2 lb. 3 oz.	-	-	-	-
Storage containers						
large storage jar	2250	5 lb.	12	30	5	12.5
medium storage jar	1500	3 lb. 6 oz.	10	25	4	10.0
small storage jar	800	1 lb. 12 oz.	7	17.5	3	7.5
jam or honey pot	450	16 oz.	3.5	8.5	4	10.0
Serving dishes						
large cooking/serving	2500	5 lb. 8 oz.	3.5	8.5	15	37.5
small cooking/serving	1350	3 lb.	2.25	6	10	25.0
cheese bell	2000	4 lb. 6 oz.	6	15	10	25.0
base	1500	3 lb. 6 oz.				
butter dish	600	1 lb. 5 oz.	3	7.5	5.5	13.5
base	600	1 lb. 5 oz.				
salt and pepper shakers	400	14 oz.	4.5	11	3	7.5
egg bakers	400	14 oz.	1.25	3	3.5	8.5

MID-RANGE REDUCTION GLAZES

BY JOHN BRITT

MudFire Clayworks and Gallery, a community ceramic art center in just outside of Atlanta offers studio space, workshops and a beautiful gallery. They also fre to cone 6 in reduction. Erik Haagensen and Luba Sharapan, the owners, started to fre cone 6 reduction because of a defect in the kiln they'd purchased, but after seeing the results they had no reason to change back, even after the kiln was repaired. Firing to cone 6 was cheaper, faster, and the results were almost indistinguishable from high fre.

e Project

Although they fre to mid-range reduction, Erik and Luba wanted me to give a workshop on the cost and time benefts of cone 6 reduction fring, as well as to explain the reasoning behind glaze recipes, fring cycles, and to show them how to bring glazes from cone 10 down to cone 6.

I normally work with, and teach about, high-fre glazes (cone 9–11), approximately 2350°F (1288°C), while mid-range, (cone 5–7), is about 2200°F (1204°C). Although this is only about a 150°F (66°C) temperature difference, raising the temperature 150°F at the peak of the fring takes quite a bit more energy and puts a lot of extra wear and tear on the kiln. It could easily take two to four more hours of fring to go from cone 6 to cone 10 with the gas on high, so fring to mid-range reduction would save considerable fuel if comparable glazes could be found.

At that time, I didn't have a lot of experience with mid-range reduction and I found it hard to believe that the results were "almost indistinguishable." I did have a good bit of experience fring mid-range oxidation in an electric kiln and the results are far from the look of cone 10 reduction. But the idea intrigued me, and the more I thought about it, the more I realized that the same principles of high fre reduction should apply to mid-range reduction. The key question would be if the oxides and materials needed to melt the glazes at a lower temperature would negatively affect the glaze colors. So I took the challenge, reasoning that I could use the same research methods I used for the high-fre glazes to explore these mid-range glazes.

Mid-range fring in both oxidation and reduction is a well researched area dating back before the energy crisis of the 1970s. There are also several college clay programs using mid-range reduction and have published their glazes. One notable example is Diana Pancioli, at Eastern Michigan University in Ypsilanti, MI, who started her "Glaze Forward" program. (For a small shipping fee, you could send for a list of cone 6 reduction recipes and test tiles of those glazes.) There are also organizations like the Clay Studio in Philadelphia, Pennsylvania that fre cone 6 reduction and have developed a wonderful palette.

Thrown and altered platter, 12 in. (30 cm) in diameter, stoneware with Cherry Blossom Shino and Woo Yellow glaze, fired in reduction to cone 6, by Barbara Morgenbesser.

e Research

My frst step is always completing an exhaustive survey of known glazes from books, the Internet and workshop handouts. Luba and Erik generously sent me all their recipes from MudFire [see selected recipes on page 15], and I pulled out my cone 6 glaze notebooks and began assembling recipe lists and fring instructions.

There is so much information available today that it is almost paralyzing; you don't know what to do with it all. So, in order to make it usable, I organized the recipes into types, like iron glazes (celadon, tenmoku, kaki, iron saturate, etc.), shino, copper red, oribe (copper green), magnesium matt, etc. Then, after eliminating all the duplicates, I looked for similarities and differences, and from those, selected enough glaze recipes to test that would show a broad range of possibilities within a type. Then I test those recipes in a variety of fring cycles, like heavy reduction, light reduction, early reduction, late reduction, and oxidation. This way, I can reveal a glaze's full potential.

Mugs, 4 in. (10 cm) in height, stoneware with Temmoku Gold, gas fired in reduction to cone 6, by Luba Sharapan.

Stoneware bowl with Malcolm Davis Shino Glaze, gas fired in reduction to cone 6, by Erik Haagensen.

Iron glazes are a great type to start with because you can see a wide range of colors by incrementally adding one colorant; iron oxide. For example, when fring in reduction using the same base glaze, adding 1% red iron creates a blue celadon, adding 2–4% iron oxide will give green to amber celadons, adding 5–10% iron oxide makes tenmokus, and 10–20% iron oxide gives iron saturates. Teadust tenmokus result from additions of magnesium carbonate to tenmokus with cooling soaks. Kakis, which are also part of the iron glaze type, are obtained with additions of bone ash and magnesium carbonate. Finally, oil spots result from stiff oxidized tenmokus with magnesium oxide. So you can see how one glaze type can show you a world of glaze colors.

Copper red glazes are generally low alumina and high alkaline bases with small amounts of copper carbonate (0.3%) and tin oxide (1%). Oribe glazes use copper to get greens while magnesium matt glazes yield satin whites and purples with cobalt oxide. You can try to reproduce these "types" at various cones and, as always, you may then have to make adjustments after you see the results.

The fnal type I concentrated on was shino glazes. Shinos are generally made with varying amounts of feldspar and clay. For example, you may have somewhere between 60–90% feldspar and 10–40% clay. A typical recipe would be 70% feldspar and 30% clay. This is the most diffcult glaze type to reproduce at mid-range because most feldspars melt around cone 9 and then with the added clay it is hard to melt much lower than cone 10. I started by using nepheline syenite, which is not a true feldspar but rather a feldspathoid (containing less silica than a true feldspar). It melts around cone 6. Because it is high in sodium oxide and lower in silica, the effects are not identical, but it was a good starting point and worth a try.

Firing

I loaded the kiln with these various glaze types and then flled the remainder with line blends within

Porcelain vase with Mint Julep Glaze, gas fired in reduction to cone 6, by Melissa Keen-Boggan.

these glaze types and a variety of other recipes, like blues, greens, yellows, blacks, etc., to see the overall effect of varying fring cycles across the board of glaze colors.

For frst fring, I started reduction at cone 010 and kept it heavy (0.65–0.72 on the oxygen probe) to cone 6 at 3 o'clock (cone melting position, not time of day). I had pretty good copper reds and iron glazes but the shinos were dull and washed out. For the next frings, I increased the fring temperature to cone 7 at 3 o'clock, which gave me about 25°F more and brightened up the glazes. I ran fve more frings to this cone, including full oxidation, light reduction, medium reduction, heavy reduction, and oxidation with reduction at peak temperature. I also tested numerous glazes with fux variations, exploring mid-range fuxes like boron oxide, sodium oxide, lithium oxide, calcium oxide, and zinc oxide. Adding fuxes and reducing alumina and silica affects the response of coloring oxides in glazes, so the trick was fnding suitable colors in properly melted glazes.

Results

The results were great for copper reds and iron glazes, as well as greens, blacks, blues, and carbon-trap shinos, which were very nice in heavy reduction. The carbon trap shinos worked because they contain soda ash, which melts very early, and with early reduction the carbon is already "trapped" below the soda layer so the peak temperature is not a factor. The only glaze type I could not achieve was traditional shinos, as I had expected. And I only had limited success with oil spots in the gas oxidation trials. This was also to be expected as iron oxide only starts to self reduce at 2250°F (1232°C) and that is about the peak temperature we reached. Soaking at cone 7 helped, but they were not as spectacular as a cone 13 oil-spot fring. Nevertheless, we did get spotting and some promising oil-spot recipes.

From all this testing, I came to the inescapable conclusion that Erik and Luba were correct. Ninety percent of the mid-range glazes were indistinguishable from their high-fre twins. This leads us to ask, why don't more potters fre to cone 6/7 in reduction?

Making the Switch

There seem to be a few obstacles in getting potters to convert to the idea of mid-range fring. First, there is the inertia of their current practice. Change is hard in spite of the obvious benefts, especially if you have been doing the same thing for 20 years and it is working.

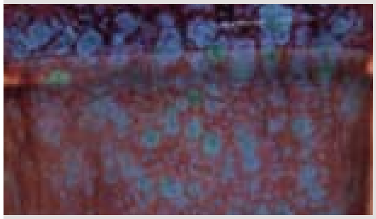
Also, there is an underlying belief, although it is completely incorrect, that cone 10 is superior to mid-range or low-fre, and changing this mind set is an educational challenge. I think that this comes from the long, historical European search to imitate Chinese, high-fre porcelain. The goal was always to achieve high fre, so it gained the psychological high ground.

When you mention mid-range, potters immediately think, as I initially did, of mid-range electric oxidation. But this is not the only way to fre mid-range. Mid-range reduction has a completely different look, as does mid-range oxidation soda fring or mid-range reduction soda fring.

And fnally, when you mention fring to mid-range, potters immediately want to change or convert their cone 10 glazes to this lower temperature. This is perceived as a signifcant challenge because it means that they will have to learn a glaze calculation software and unity molecular formulation. Most just want recipes that work. They know it will take time and effort to learn to convert all these recipes and they just don't want to spend their time doing that.

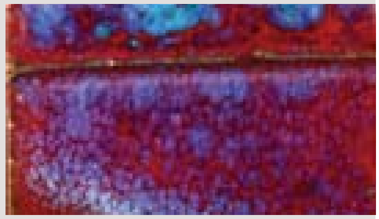
I don't recommend converting glazes to the lower temperature, because when you lower the fring temperature of a glaze you are using different fuxing oxides that have different color responses. So although it is possible to convert your glaze to the lower temperature, you will end up with a different glaze anyway. It is better to use the many tried and true mid-range glazes already in use and test them in your cycle. This is

RECIPES
SIDE BY SIDE



Jeff's Red
Cone 10 Reduction

Barium Carbonate	4.4%
Dolomite	8.7
Whiting	8.4
Zinc Oxide	1.7
Ferro Frit 3134	8.7
Custer Feldspar	41.9
Silica	26.2
	100.0%
Add: Tin Oxide	2.6%
Copper Carbonate	0.5%
Bentonite	1.0%

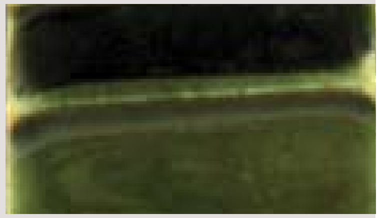


Panama Red
Cone 6 Reduction

Dolomite	7.8%
Gerstley Borate	10.7
Strontium Carbonate	4.2
Whiting	2.6
Zinc Oxide	2.6
Custer Feldspar	44.1
Ferro Frit 3110	9.7
EPK Kaolin	2.6
Silica	15.8
	100.0%
Add: Tin Oxide	2.6%
Copper Carbonate	1.8%

Shaner Oribe
Cone 10

Bone Ash	1.1%
Talc	7.9
Whiting	22.1
Custer Feldspar	31.0
Kaolin	12.6
Silica	25.3
	100.0%
Add: Copper Carbonate	5.2%



Selsor Oribe
Cone 6

Gerstley Borate	12.5%
Whiting	10.4
Nepheline Syenite	56.3
Silica	20.8
	100.0%
Add: Copper Carbonate	5.0%

This is a test I made with Selsor Copper Red and I removed the colorants and added copper carbonate, so I called it Selsor Oribe.

Coleman Teadust Tenmoku
Cone 10

Talc	7%
Whiting	16
Custer Feldspar	40
Ball Clay	12
Silica	25
	100%
Add: Red Iron Oxide	10%

Teadust Tenmoku
Cone 6

Whiting	10.5%
Pemco Frit P-25	26.3
Alberta Slip	63.2
	100.0%
Add: Red Iron Oxide	5.0%

Eggy Vase, 15 in. (38 cm) in height, John's Shino with decoration using Amaco Velvet underglaze, gas fired in reduction to cone 6, by Erik Haagensen.

the same way potters fnd high-fre glazes; they get glaze recipes from books or from friends and then vary the colorants and opacifers.

Although change is hard, potters should focus on the benefts of fring mid-range reduction. First, it saves fuel, reduces your carbon footprint, and costs less. Second, it saves time. It may take 2–4 hours to get the extra temperature of cone 10 and maybe longer depending on the size of the kiln. So rather than fring for 10–12 hours, you will be out in 8–10 hours. Firing to mid-range also reduces the wear and tear on your kiln, which means that it lasts longer. Finally, and most importantly, you get great results!

After all this testing, we discovered that the methods used to test high-fre glaze types also apply to mid-range types and, as a result, we found some very nice glazes. Erik, Luba, and the potters of MudFire Clayworks are proof of that. Hopefully, this will help other potters get started fring to mid-range reduction.

John Britt lives in Bakersville, NC, and is the author of The Complete Guide to High-Fire Glaze: Glazing & Firing at Cone 10. *For more information, go to www.johnbrittpottery.com.*

RECIPES

John's Shino
Cone 5–6

Gerstley Borate	5 %
Soda Ash	3
Nepheline Syenite	54
Spodumene	23
OM4 Ball Clay	15
	100 %

Malcolm Davis Shino
Cone 10

Soda Ash	16 %
Kona F-4 Feldspar	9
Nepheline Syenite	39
Cedar Heights Redart	6
EPK Kaolin	17
OM4 Ball Clay	13
	100 %

Cherry Blossom Shino
Cone 6

Soda Ash	10 %
Nepheline Syenite	40
Spodumene	40
EPK Kaolin	10
	100 %

Raw Sienna
Cone 6

Wollastonite	28 %
Ferro Frit 3195	23
Nepheline Syenite	4
EPK Kaolin	28
Silica	17
	100 %
Add: Red Iron Oxide	6 %
Rutile	6 %

Mint Julep
Cone 6

Gerstley Borate	3 %
Magnesium Carbonate	3
Whiting	22
Ferro Frit 3124	9
Nepheline Syenite	23
EPK Kaolin	20
Silica	20
	100 %
Add: Red Iron Oxide	1 %

Woo Yellow
Cone 6

Dolomite	15 %
Strontium Carbonate	24
Nepheline Syenite	43
Kaolin	9
Silica	9
	100 %
Add: Zircopax	19 %
Bentonite	5 %
Epsom Salt	1 %
Red Iron Oxide	4 %

Tenmoku Gold
Cone 6

Cornish Stone	67 %
Dolomite	8
Gerstley Borate	4
Lithium Carbonate	6
Whiting	9
Silica	6
	100 %
Add: Red Iron Oxide	11 %

Tumblers, 7 in. (18 cm) in height, stoneware with Gold Temmoku liner and Raw Sienna exterior glaze, gas fired in reduction to cone 6, by Erik Haagensen.

studio reference | colorants

THE POTTER'S PALETTE

BY ROBIN HOPPER

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. The results with nickel are usually muted. Reds in the scarlet to vermilion 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.

COLORANT	CONE	ATMOS.	%	COMMENTS
Dark Red				
Copper	Vary	Red.	0.5%-5%	Best in glazes containing less than 10% clay content, and a high alkaline content. Needs good reduction. In low temperatures it can be reduced during cooling. Good reds as low as cone 018.
Iron	Vary	Both	5%-10%	Good in many glaze bases at all temperatures. Can be improved with the addition of 2%-5% tin oxide.
Nickel	4-10	Ox.	5%-8%	Use in barium-saturated glazes.
Burgundy				
Iron				See Dark Red, Iron.
Copper	See Dark Red, Copper.			Owing to the unstable nature of copper, this colorant can produce a wide range of results. Very controlled reduction firing and cooling are important.
Maroon				
Chrome-Tin Stains	Vary	Ox.	1%-5%	Use in glazes with calcium. There should be no zinc in the glaze.
Copper	Vary	Red.	0.5%-5%	Best in high alkaline glazes.
Crimson				
Copper + Titanium	8-10	Red.	1%-5%	Try various blends of copper (1%-5%) and titanium (2%-5%).
Calcium-Selenium Stains	010-05	Ox.	0.5-5%	Best with special frits.
Indian Red				
Iron	Vary	Both	5%-10%	Best in high calcium glazes; small amount of bone ash helps. Tin addition up to 5% also helps. Also works well in ash glazes.
Brick Red				
Iron	Vary	Both	5%-10%	Similar to Indian Red. Tin to 2% helps.
Orange-Brown				
Iron + Rutile	Vary	Both	1%-10%	Various mixtures (up to 8% iron and 2% rutile) in most glaze bases.
Iron + Tin	Vary	Both	1%-5%	Various mixtures (up to 4% iron and 1% tin) in most glaze bases. Creamier than iron with rutile.
Orange-Red				
Cadmium-Selenium Stains	012-05	Ox.	1%-4%	Best with special frits such as Ferro 3548 or 3278 or both. Helps to opacify with zirconium.
Orange				
Iron	Vary	Both	1%-5%	Use in tin or titanium opacified glazes.
Rutile	Vary	Both	5%-15%	Many glaze types, particularly alkaline. More successful in oxidation.
Copper	8-10	Both	1%-3%	Use in high alumina or magnesia glazes. Addition of up to 5% rutile sometimes helps.
Orange-Yellow				
Iron	Vary	Both	2%-5%	With tin or titanium opacified glazes.
Rutile	Vary	Ox.	1%-10%	Best with alkaline glazes.
Yellow Ocher				
Iron	Vary	Both	1%-10%	Use in high barium, strontium or zinc glazes.
Iron + Tin	Vary	Ox.	1%-5%	Various mixtures (up to 3.5% iron and 1.5% tin) in many glaze bases.
Iron + Rutile	Vary	Both	1%-5%	Various mixtures (up to 2.5% iron and 2.5% rutile) in many glaze bases.
Vanadium-Zirconian Stains	Vary	Ox.		5%-10%Various mixtures in many Zirconium stain glaze bases.
Lemon Yellow				
Praseodymium Stains	Vary	Both	1%-10%	Good in most glazes. Best in oxidation.
Pale/Cream Yellow				
Iron + Tin	Vary	Both	2%-5%	Various mixtures (up to 3.5% iron and 1.5% tin) in high barium, strontium or zinc glazes. Titanium opacification helps.
Vanadium	Vary	Both	2%-5%	Use in tin-opacified glazes.
Rutile + Tin	Vary	Ox.	2%-5%	Various mixtures (up to 2.5% iron and 2% tin) in variety of glaze bases. Titanium opacification helps.

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

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.

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.

COLORANT	CONE	ATMOS.	%	COMMENTS
Yellow Green				
Copper + Rutile	Vary	Both	2%-10%	Various mixtures in a wide variety of glazes, particularly those high in alkaline materials. Almost any yellow glaze to which copper is added will produce yellow green.
Chromium	Vary	Both	0.5%-3%	In yellow glazes without tin or zinc.
Chromium	4-8	Ox.	0.25%-1%	In saturated barium glazes.
Chromium	018-015	Ox.	0-2%	In high alkaline glazes with no tin.
Cobalt	Vary	Both	0-1%	In any yellow glazes.
Light Green				
Copper	Vary	Ox.	0-2.5%	In various glazes except those high in barium or magnesium. Best in glazes opacified with tin or titanium.
Cobalt	Vary	Both	0-2%	In glazes opacified with titanium, or containing rutile.
Apple Green				
Chromium	Vary	Both	0-2%	In various glazes without zinc or tin. Good in alkaline glazes with zirconium opacifiers. Also use potassium dichromate.
Copper			1%-2%	See Light Green; use in non-opacified glazes.
Celadon Green				
Iron	Vary	Red	0.5%-2%	Best with high sodium, calcium or potassium glazes. Do not use with zinc glazes.
Copper	Vary	Ox.	0.5%-2%	Good in a wide range of glazes.
Grass Green				
Copper	010-2	Ox.	1%-5%	In high lead glazes; sometimes with boron.
Chromium	018-04	Ox.	1%-2%	In high alkaline glazes.
Olive Green				
Nickel	Vary	Both	1%-5%	In high magnesia glazes; matt to shiny olive green.
Iron	Vary	Red.	3%-5%	In high calcium and alkalines, usually clear glazes.
Hooker's Green				
Copper + Cobalt	Vary	Ox.	2%-5%	In a wide variety of glaze bases.
Cobalt +	Vary	Both	2%-5%	In a wide variety of glaze Chromium bases: no zinc or tin. Good opacified with zirconium or titanium.
Chrome Green				
Chromium	06-12	Both	2%-5%	In most glazes; no zinc or tin.
Dark Green				
Copper	Vary	Ox.	5%-10%	Many glaze bases, particularly high barium, strontium, zinc or alkaline with a minimum of 10% kaolin.
Cobalt + Chromium	Vary	Both	5%-10%	Blends of these colorants will give a wide range of dark greens.
Cobalt + Rutile	Vary	Both	5%-10%	Dark greens with blue overtones.
Teal Blue				
Cobalt + Rutile	Vary	Both	1%-5%	In a wide variety of glazes.
Cobalt + Chromium	Vary	Both	1%-5%	In most glazes without tin or zinc.

COLORANT	CONE	ATMOS.	%	COMMENTS
Turquoise				
Copper	Vary	Ox.	1%-10%	In high alkaline and barium glazes. Bluish with no clay content; tends toward greenish tint with added clay.
Copper + Rutile	Vary	Both	1%-5%	In high alkaline and barium glazes.
Copper + Tin	Vary	Ox.	1%-10%	In high alkaline and barium glazes; usually opaque.
Light Blue				
Nickel	Vary	Ox.	1%-2%	In high zinc or barium glazes.
Rutile	Vary	Red.	1%-5%	In a wide range of glazes; best with low (10% or less) clay content.
Cobalt	Vary	Both	0.25%-1%	Use in most glazes, particularly those opacified with tin. Also use mixed with small amounts of iron.
Celadon Blue				
Iron	6-10	Red.	0.25%-1%	In high alkaline or calcium clear glazes. Black iron is generally preferable to red iron.
Wedgewood Blue				
Cobalt + Iron	Vary	Both	0.5%-2%	In most glazes; small amounts of cobalt with iron, manganese or nickel yield soft blues. Added tin gives pastel blue.
Cobalt + Manganese	Vary	Both	0.5%-2%	
Cobalt + Nickel	Vary	Both	0.5%-2%	
Cobalt	4-10	Both	0.5%-3%	In high zinc glazes.
Nickel	4-10	Ox.	1%-3%	In high barium/zinc glazes; likely to be crystalline.
Blue Gray				
Nickel	Vary	Ox.	0.5%-5%	In high barium/zinc glazes.
Rutile	Vary	Red.	2%-5%	In a wide variety of glazes, particularly high alumina or magnesia recipes.
Cobalt + Manganese	Vary	Both	0.5%-2%	In most opaque glazes.
Cobalt	Vary	Ox.	0.5%-5%	In high zinc glazes.
Ultramarine				
Cobalt	Vary	Both	0.5%-5%	In high barium, colemanite, and calcium glazes; no zinc, magnesium or opacification.
Cerulean Blue				
Cobalt	Vary	Both	0.5%-5%	In glazes containing cryolite of fluorspar.
Cobalt + Chromium	Vary	Both	2%-5%	In most glazes except those containing zinc or tin.
Prussian Blue				
Nickel	6-10	Ox.	5%-10%	In high barium/zinc glazes.
Cobalt + Manganese	Vary	Both	5%-10%	In most glaze bases.
Cobalt + Manganese	Vary	Both	5%-10%	In most glazes; for example, cobalt 2%, chromium 2% and manganese 2%.
Navy Blue				
Cobalt	Vary	Both	5%-10%	In most glazes except those high in zinc, barium or magnesium.

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

THE POTTER'S PALETTE
BY ROBIN HOPPER

studio reference | colorants

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, umber, 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 umber, 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

Chromium Oxide	20 %
Cobalt Carbonate or Oxide	20
Manganese Dioxide	20
Red Iron Oxide	20
Feldspar (any)	8
Kaolin (any)	8
Silica	4
	100 %

This mixture is best ball-milled for a minimum of four hours to limit its tendency toward cobalt specking, and to make sure that the colorants are thoroughly mixed. Because any black stain is a very concentrated mixture, only small amounts are normally needed to cause a strong effect. In a clear glaze, a maximum of 5% should produce an intense black. In opaque glazes, more stain than that may be needed. Black stains and white opacifiers mixed together will produce a range of opaque grays. Stains, like other ceramic materials, are subject to the three variables of glaze makeup, temperature and atmosphere.

Outside the color wheel one finds tones of brown, gray, and black. These moderate other colors. A color wheel could, I suppose, include the range of opacifiers since they also have a strong role in affecting color. The toning influence of brown, gray, and black is just as much opacifying in result as are the white opacifiers such as tin, titanium, and zirconium compounds such as Zircopax, Opax, Superpax, and Ultrox. Slight additional increments of any of these colors will render most glazes, colored or not, progressively darker as they are added.

Excerpted from The Ceramic Spectrum: A Simplified Approach to Glaze and Color Development, *published by The American Ceramic Society*.

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

COLORANT	CONE	ATMOS.	%	COMMENTS
Indigo				
Nickel	Vary	Ox.	8%-15%	Use in high barium/zinc glazes. Also likely to crystallize.
Cobalt + Manganese	Vary	Both	5%-10%	Various mixtures in most glazes.
Cobalt + Black Stain	Vary	Both	5%-8%	Various mixtures in most glazes.
Violet				
Cobalt	Vary	Both	5%-10%	In high magnesium glazes.
Nickel	Vary	Ox.	1%-10%	In some saturated-barium glazes.
Manganese	Vary	Both	5%-10%	In high alkaline glazes.
Copper	Vary	Ox.	8%-10%	In some saturated-barium glazes.
Purple				
Copper	6-10	Both	8%-10%	In high barium and barium/zinc glazes.
Copper	8-10	Red.	1%-5%	In copper red glazes opacified with titanium.
Nickel	Vary	Ox.	5%-10%	In some high barium glazes.
Cobalt	Vary	Both	5%-10%	In high magnesium glazes.
Manganese	04-10	Ox.	5%-10%	In high alkaline and barium glazes.
Iron	8-10	Red.	8%-10%	In high calcium glazes; likely to crystallize.
Copper + Cobalt	Vary	Red.	2%-8%	Various mixtures in many glazes.
Chrome + Tin + Cobalt	Vary	Ox.	2%-8%	Various mixtures in many glazes.
Mauve or Lilac				
Cobalt	Vary	Both	1%-5%	In high magnesium glazes.
Nickel	Vary	Ox.	1%-5%	In some saturated-barium glazes.
Pink				
Cobalt	Vary	Ox.	1%-3%	In high magnesium glazes opacified with tin. Also in very low alumina content glazes.
Copper	Vary	Red.	0.2%-2%	In copper red glazes with titanium.
Copper	6-10	Ox.	0.2%-3%	In high magnesium or high alumina glazes.
Copper	8-10	Red.	5%-10%	In copper red glazes opacified w/min. 5% titanium.
Chromium	Vary	Ox.	1%-2%	In calcium glazes opacified with 5%-10% tin.
Iron	Vary	Ox.	1%-5%	In calcium glazes opacified with tin.
Rutile	Vary	Both	5%-10%	In high calcium and some ash glazes.
Nickel	018-010	Ox.	1%-3%	In high barium glazes with some zinc.
Manganese	Vary	Both	1%-5%	In alkaline glazes opacified with tin or titanium. Also in high alumina glazes.
Brown				
Iron	Vary	Both	3%-10%	In most glazes.
Manganese	Vary	Both	2%-10%	In most glazes.
Nickel	Vary	Both	2%-5%	In high boron, calcium, and lead glazes.
Chromium	Vary	Both	2%-5%	In high zinc glazes.
Umber	Vary	Both	2%-10%	In most glazes.
Ilmenite	Vary	Both	2%-10%	In most glazes. High calcium may yield bluish tint.
Rutile	Vary	Both	5%-10%	In most glazes; golden brown.
Gray				
Iron	Vary	Red.	2%-4%	In many glaze bases; gray brown.
Iron Chromate	Vary	Both	2%-5%	In most glaze bases without zinc or tin.
Nickel	Vary	Both	2%-5%	In most glaze bases; gray brown.
Copper	8-10	Both	3%-10%	In high magnesium glazes. Warm gray in reduction; cold gray in oxidation.
Cobalt + Nickel	Vary	Both	1%-5%	Blue gray in most glazes.
Cobalt + Manganese	Vary	Both	1%-5%	Blue gray to purple gray in most glazes.
Black Stain	Vary	Both	1%-5%	Shades of gray in most opacified glazes.
Black				
Iron	Vary	Both	8%-12%	In high calcium glazes—the temmoku range.
Copper	Vary	Both	8%-10%	In a wide range of glazes.
Cobalt	Vary	Both	8%-10%	Blue black in most glazes except those high in zinc and magnesium.
Black Stain	Vary	Both	3%-10%	In most zinc-free, non-opacified glazes.

VARIATIONS ON A GLAZE BASE

BY KRISTINA BOGDANOV

Imagine a glaze that fres perfectly at both cone 10 and cone 6, in reduction and oxidation, and in a soda fring, yet still produces a variety of exciting, stable colors. This idea intrigued me after realizing that one of the glazes in our studio fred well at cone 10 reduction in a gas kiln, cone 6 in an electric kiln, and cone 9 reduction in a soda kiln without any change in the recipe. The glaze—Turner's White—consists of common inexpensive ingredients that are easy to fnd.

Additionally, this glaze has very good properties—great viscosity but not runny; applies very well on bisque whether you spray, dip or pour; and doesn't settle out in the bucket over time so remixing is fairly easy.

Turner's White

Dolomite	10 %
Whiting	9
Soda Feldspar	25
Custer Feldspar	20
EPK Kaolin	18
Talc	6
Silica	12
	100 %
Add: Bentonite	2 %
Zircopax	8 %

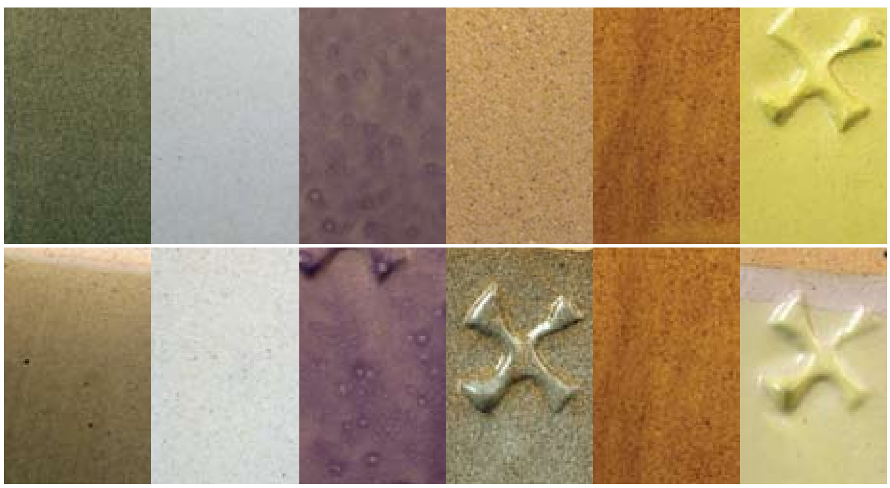
Color tests (right)

1 Copper Carbonate	4 %
2 Copper Carbonate	0.6 %
Tin Oxide	2 %
3 Cobalt Carbonate	4 %
Lithium Carbonate	2 %
4 Rutile	8 %
5 Red Iron Oxide	4 %
Rutile	4 %
6 Mason Stain 6405 (Naples Yellow)	4 %
Mason Stain 6433 (Praseodymium)	4 %

Note: Tests 3, 4, and 6 applied over Turner's White.

Feldspar EPK Silica Whiting Talc Dolomite Bentonite Zircopax

Altering a glaze: The top two rows above were fired to cone 10 reduction in a gas kiln and the bottom two rows were fired to cone 6 electric. Rows 1 and 3 contain 100 extra grams of the tested ingredient listed below each row, and rows 2 and 4 contain none of the tested ingredient.



1 2 3 4 5 6

The tiles above are examples of a single glaze base (Turner's White) used to obtain a variety of colors by adding coloring oxides. The top row was fired to cone 6 electric and the bottom row to cone 10 reduction in a gas kiln.

Testing the Base Glaze

My students and I decided to take two directions with the glaze—frst exploring Turner's White by changing the ingredients within the recipe, and the second exploring color development.

To explore the base, we made 500 gram test batches where we increased one ingredient by 100 grams and another test where we omitted the ingredient altogether. We did these two tests for each ingredient.

These tests did not require any glaze re-calculation but gave the students a better understanding of what certain chemicals do in a glaze. For example, Turner's White's original recipe produces a nice matt white surface fred to cone 6 electric. Adding silica, Turner's White fuxed more, and at the same temperature gave a more glossy, white surface, but was still very stable. Adding Zircopax and fring to cone 6 electric resulted in a superb white semigloss surface, and omitting Zircopax, produced a nice, light beige. Adding dolomite or talc also made Turner's White fux when fred to cone 6 electric, but adding EPK yielded a more textured, rough surface, like a slip or engobe.

In the cone 10 reduction tests, eliminating feldspars from the recipe gave a creamy matt surface. Eliminating silica from the recipe gave a stone white matt surface. Omitting Zircopax and fring to cone 10 reduction gave an interesting, celadon-like surface. Tests increasing either talc or dolomite at cone 10 reduction seemed to form a crystalline texture on the surface but were runny as well. Note: The brown specks on the cone 10 reduction tests were produced by iron in the stoneware clay body.

Color Development

The second part of our project was to use Turner's White as a base, but just exclude the Zircopax (an opacifer). We added a variety of colorants—copper carbonate, cobalt carbonate, rutile, red iron oxide, Mason stains, and others that are not shown here. We fred the tests to cone 6 in both electric and gas reduction. The test results were both interesting and disappointing as they yielded colors that we expected or did not.

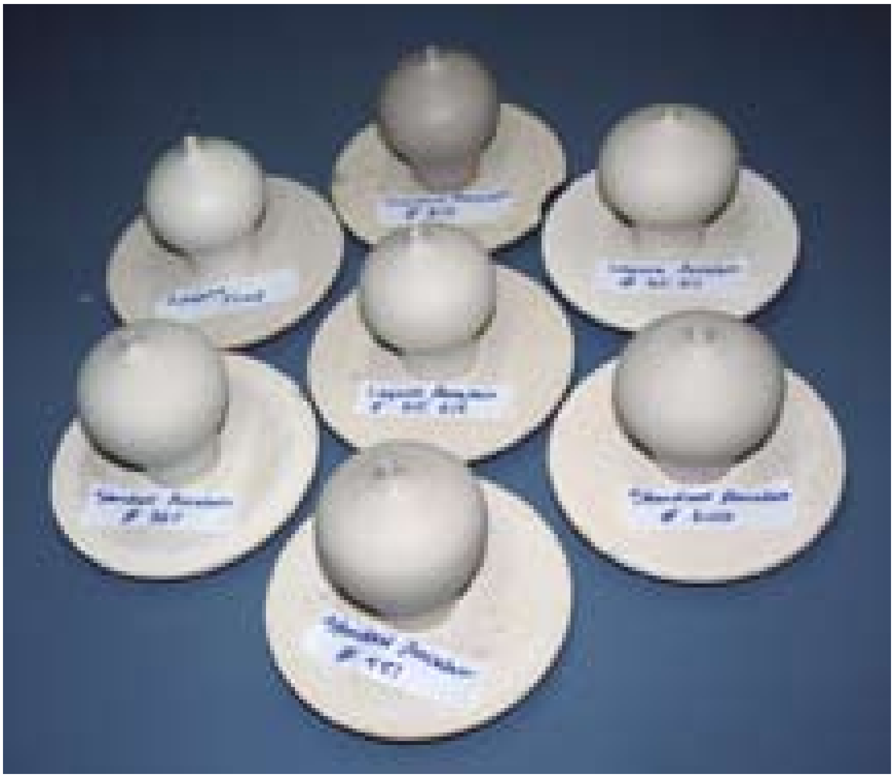
Copper carbonate gave light turquoise colors at 2% and at 4% it was dark green in electric frings. A combination of red iron oxide and rutile gave a buckwheat color when fred in electric. Adding 2% cobalt oxide and 4% manganese dioxide gave a nice purple both in oxidation and reduction. Nickel at 4% in oxidation gave a mustard colored matt surface but produced a chartreuse color and rough surface in reduction.

It is still a work in progress to fnd the "one glaze" for our studio. I wasn't keen on glaze testing until I stumbled upon Turner's White, which motivated me to explore the recipe. I encourage those of you who have one favorite glaze to try out one of the two directions and see what happens, maybe you'll discover some remarkable surface or color. In any case, you'll better understand the glaze.

Kristina Bogdanov teaches ceramics at Ohio Wesleyan University in Delaware, Ohio.

BUYING PORCELAIN

BY ANTOINETTE BADENHORST



Before making a large investment in porcelain, test several bodies to see which one best suits your needs.

If you've only worked with red, brown or buff clay in the past and you're looking for a change, maybe porcelain is the right clay for you. Planning, research, and evaluation are the best ways to assure any future success in making a switch from one clay body to another.

To determine if porcelain is what you're looking for, you'll need to evaluate where you want to go with your clay work, your skill level and your vision as a potter. Decide if you're happy with your current work, and if so, consider the effect that work will have if made with a white or porcelain clay body. Not all works in clay maximize the qualities that porcelain has to offer, so if you have to change your work in order to use porcelain, evaluate whether that's something you want to do.

In my own experience, I had a vision of pots dancing like ballerinas—soft fgurines moving around in bright colors against pure white backdrops. I also envisioned translucent light and instantly knew what to do, but it took some time to fnd the right porcelain and to develop a body of work.

Studio Setup and Working Methods

Do you have the right studio setup for porcelain and are you able to adjust your current workplace with ease? Can you work with precision and in a clean studio? Do you work with other clay bodies that might contaminate porcelain, or are there other potters working with you that might not respect a porcelain work station? Which techniques do you use most? For instance, if you work mostly with an extruder with a steel chamber and plunger, you'll need to replace it with a stainless steel or aluminum one to avoid possible rust contamination.

Skill Level

It's important to know your own abilities and skill level. If you're a beginner who wants to throw 20 inch pots, you'll have a lot of diffculty achieving your goals and there will be a whole lot of frustration, time and money wasted before you can reach them. In such a case, it's better to use white stoneware clay and gradually work your way frst through a semi-porcelain body and then eventually use pure porcelain as your skills improve.

Di erent Porcelains

If you want to become a porcelain production potter, you'll look at a different clay body than someone who wants to make one-of-a-kind porcelain pieces, porcelain sculptures or strictly handbuilt forms. Your working methods will differ dramatically from theirs. Maybe you need a clay body that combines some or all of the above mentioned clay techniques.

Once you decide that you want to take on the challenges that porcelain offer, you'll have to fnd the clay that suits your newly set goals. There are many different porcelain clay bodies available on the market.

I tested several commercially available cone 6 porcelain bodies and suggest you do the same before settling on one. Each clay had some special characteristic that I could use for my own work and could see used by anyone else. Commercial porcelain clay bodies meet almost all the needs of the potter, and there are some excellent throwing, handbuilding, and sculpture bodies available. The producers and suppliers know which one best suits each purpose, and they are an excellent resource when you are trying to fgure out what you need.

They develop some bodies to be more plastic and stretchable, but less white and translucent. These bodies can go further in height and thinner in walls than some others that might be pure white and translucent, but may be a little harder to throw.

If you choose to work with pure white, translucent clay, you can always throw thicker and trim thin afterward. If you need an all translucent, white and a non-warping clay body, it might cost a little more, but your ceramic supplier can recommend the right clay body for your purposes.

Amazingly, you will even find that some of the semi-porcelaneous clay bodies meet all the characteristics of porcelain and have the added green strength that is often missing in true porcelains. Add these qualities to the fact that you can save energy because many of the commercial clays are formulated for firing at cone 6 electric, and there are very few restrictions left that would limit you from working with this material.

Test several clay bodies for their ability to throw, trim, and to keep their shape when stretched beyond their limits. Also test them to see how they stand up to adjustments and attachments, then fire them to the proper cone in an electric kiln. Check them to see if shrinkage can cause problems. Compare the tests for shrinkage, color, and translucency.

Transition Carefully

It's always best to start by buying one bag of clay and testing it thoroughly. Then, even when you think you're satisfied with your choice, make the transition to your new style and clay body slowly and carefully. Porcelain is expensive but if you take a conservative approach, and do enough testing to make an informed decision, it will pay to make an investment in a large batch of clay.

A Final Word

I've seen porcelain clay bodies improve from one batch to another. Clay companies are constantly doing research to improve their clays. If you consult your clay company, they'll know what to recommend to you only if you understand your own needs and what you want. To us, as potters, that's good news, because it means that if we admire a specific clay body today, but it's not working for our circumstances, it's worth discussing that with our clay producer and retesting a body again to see if it has changed. Maybe your skills improve, perhaps the clay composition improves, or maybe you and that specific clay body simply get in sync with each other.

Read the literature available online, then talk to a sales representative and they'll be able to recommend the right clay body for your needs.

Thanks to T Robert at Laguna Clay and Carla Flati of Standard Ceramics. Antoinette Badenhorst has worked with translucent porcelain since the early 1990's.