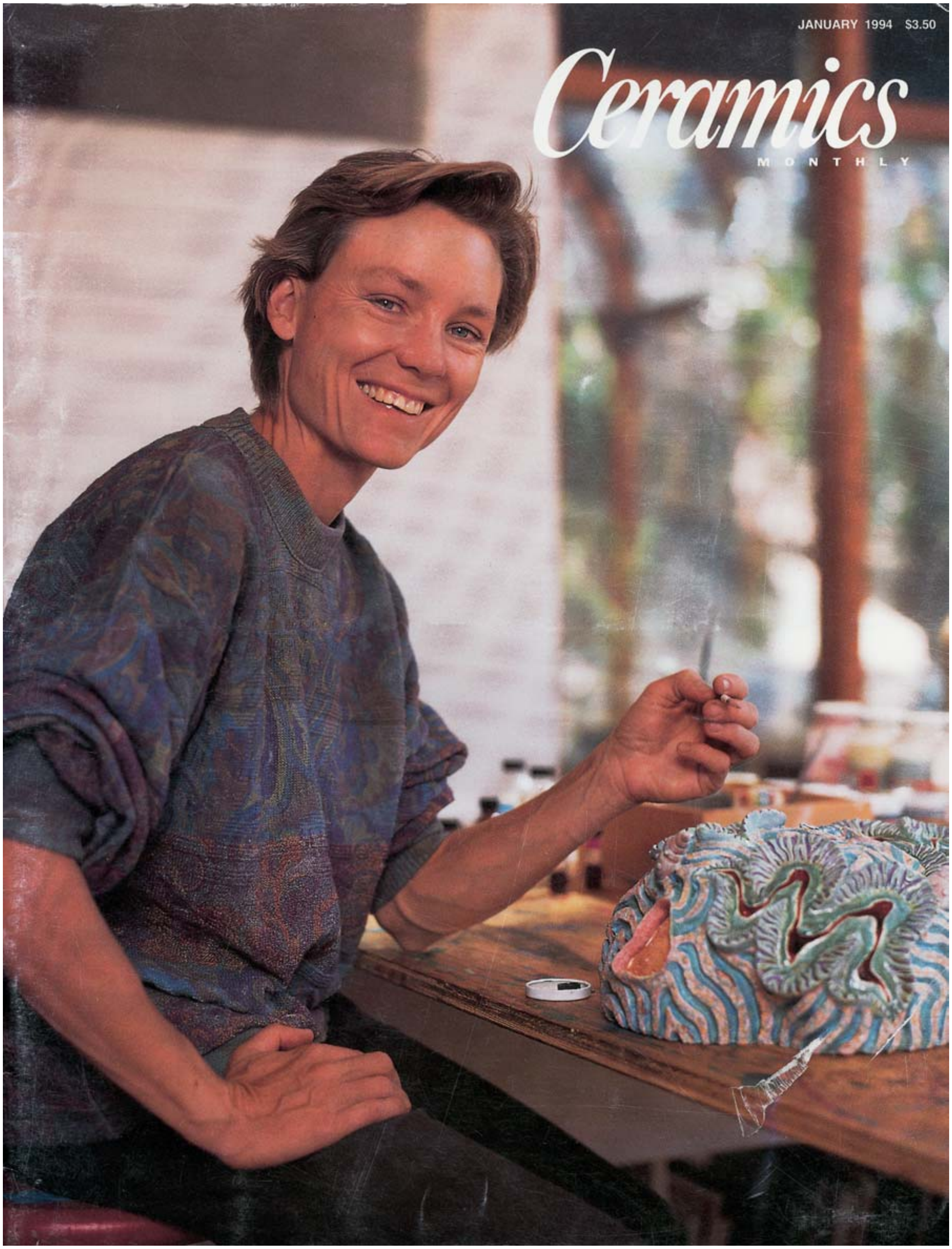
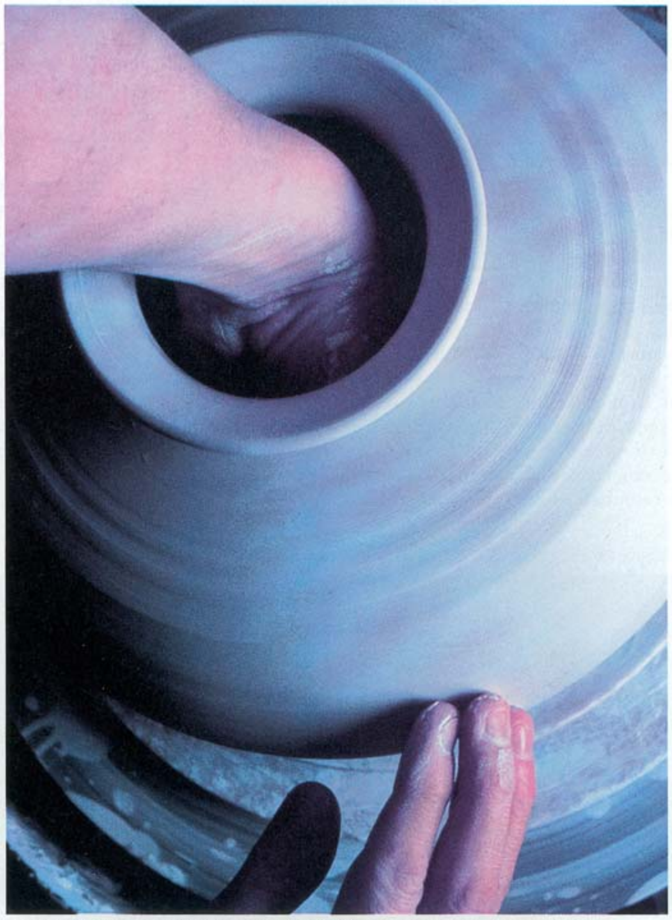


JANUARY 1994 $3.50
Ceramics
MONTHLY

Recipes, Testing and Mixing

Porcelain Bodies for Potters

by David Beumée



When evaluating a porcelain body, the first thing to consider is workability.

I remember my introduction to white clay. I was standing by my favorite wheel one day, near the end of my art schooling at Montana State, when I was given a ball of white stoneware to try. I threw a tumbler, decorated it with black slip, and later covered it with clear glaze. When I saw the black-and-white contrast on the fired piece, I was hooked. Ever since then, I have been working with porcelain fired to Cones 10 and 11 in reduction.

Forever fascinated by the clarity of glaze color achieved over porcelain, I have tested every body recipe I have come across. The following are particularly good for wheel throwing:

Dave Cornell's Porcelain Body
(Cone 10–11)

Custer Feldspar	20%
Grolleg Kaolin	55
Flint (200 mesh)	13
Pyrophyllite (Pyrax)	12
	100%
Add: Veegum T	2%

This is an excellent porcelain for dinnerware and ovenware; it also works well for larger forms, such as platters or vases. If necessary, add flint (in 5% increments) to lower the expansion of your glazes to match this low-expansion body.

Grolleg is a blended English kaolin, which combines good plasticity, low-titania content and relatively high-flux content, making it an excellent choice for a translucent throwing body.

Custer feldspar is also good for use in porcelains, as it produces the highest viscosity glass of any feldspar I have tested, thus reducing warping.

Pyrophyllite (Pyrax) decreases the thermal expansion of the clay, making ovenware less likely to crack; it also improves throwing characteristics and decreases warping.

In my experience, 200-mesh flint is best for all porcelains, adding the tooth and thixotropy missing with the use of 325-mesh flint. The larger particle size also decreases cracking.

Veegum T (available from R. T. Vanderbilt Company, 30 Winfield Street, Norwalk, Connecticut 06055) is a superb plasticizer that does not gray the body, as bentonite does. It has a very high (alkaline) pH of 8.5, yet acts as a flocculant, contributing to the workability of the porcelain.

Peter Pinnell's Porcelain Body
(Cone 10–11)

Custer Feldspar	20%
Alumina Hydrate (325 mesh)	2
Grolleg Kaolin	55
Flint (200 mesh)	23
	100%
Add: Veegum T	2%

Alumina hydrate reduces shrinkage, increases thixotropy and stiffens the clay at stoneware temperatures, minimizing warping and slumping. Alumina also benefits glaze fit and strengthens the fired porcelain considerably. The disadvantages are that alumina adds weight to the fired clay and reduces translucency. (I use C-33 Alumina Hydrate, a product of Alcoa, 1501 Alcoa Building, Pittsburgh, Pennsylvania 15219.)

Jeff Zamek's Original J Body
(Cone 10–11)

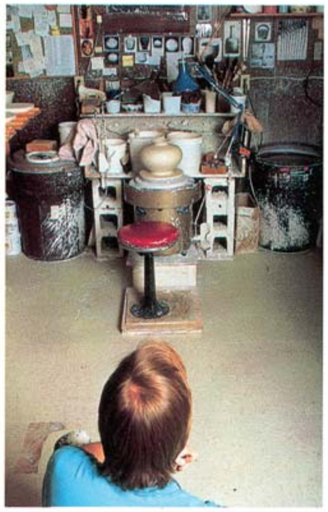
G-200 Feldspar	20 parts
Alumina Oxide (325 mesh)	3
Bentolite	3
Grolleg Kaolin	50
Macaloid	2
Flint (200 mesh)	30
	108 parts

An excellent all-purpose body.

G-200 feldspar is predominantly a potash feldspar, melting slightly faster and producing a more translucent glass than Custer feldspar. Potash feldspars are less prone to solubility than soda-based feldspars and produce a highly viscous glass; thus, warping is less likely.

Calcined alumina oxide is nearly twice as effective as alumina hydrate in helping to stiffen the clay and decrease warping at stoneware temperatures.

Bentolite is a bentonite produced by Southern Clay Products, 5775 Peachtree Dunwoody Road, Northeast, Atlanta, Georgia 30342.



Stepping back from the wheel helps Beumée see what the pots "contain."

Jeff Zamek's Revised J Body
(Cone 10–11)

G-200 Feldspar	19%
Alumina Oxide (325 mesh)	3
Grolleg Kaolin	49
Flint (200 mesh)	29
	100%
Add: Veegum T	2%

Jim Cooper's Translucent Porcelain
(Cone 10–11)

Custer Feldspar	12.5%
Kona F-4 Feldspar	12.5
Nepheline Syenite	5.0
Grolleg Kaolin	50.0
Flint (200 mesh)	15.0
Pyrophyllite	5.0
	100.0%
Add: Veegum T	2.0%
Epsom Salts	0.3%

Nepheline syenite is a sodium-based feldspar. All sodium-based feldspars, including Kona F-4, NC-4, Minspar and nepheline syenite, melt approximately twice as fast as potash-based feldspars such as Custer, G-200, K Spar, Norfloat and Primus. Sodium is a more active alkali than potassium and produces a lower viscosity glass, which takes other materials in the body into the melt somewhat faster than potash feldspars. (I have not had deflocculation problems using Cooper's recipe, perhaps because I use acidic water for mixing clay.)

There is less warping and slumping with Cooper's body in comparison with other highly fluxed porcelains containing 30% feldspar, yet even a lightweight handle attached to a thin cup will pull the wall out-of-round at Cone 10.

Porcelain Properties

When evaluating a porcelain body for possible use, the first thing to consider is workability—a combination of how well the clay throws (plasticity) and how well it stands up to use (thixotropy). Plasticity is a measure of how well the clay stretches, while thixotropy is a measure of the clay's ability to stay in place after it has been moved around. Bowls weighing ¾ pound were thrown as thin as possible from the porcelain bodies listed previously. When mixed using the wet method (described later), all five threw beautifully.

Translucency is another important factor in choosing a porcelain body. In general, to be translucent, a porcelain should contain a minimum of 20% feldspar in combination with 50% to 60% low-titania kaolins (e.g., Grolleg) plus a minimum of 20% flint. Pots should be thin walled (⅛ inch or less). Of course, that requires care in all parts of the making and firing process. But when tea colors the morning sunlight through the side of your favorite bowl, these efforts will have been rewarded.

If you fire in reduction and are concerned about whiteness, tests should be done in a reducing atmosphere as well. I line up my fired test bars side-by-side to make a color comparison by eye.

I prefer porcelains that have 0% water absorption at Cone 10. To check the absorption rate of the listed porcelains, fired test bars (still slightly warm from the firing) were first weighed to within a tenth of a gram. The bars were then pressure cooked in water for one-half hour at 15 psi, then weighed when all surface water had evaporated.

To determine the potential for slumping (bending or collapsing of the walls

Wheel-thrown porcelain covered jar with brushed glaze decoration, 7 inches in height, by David Beumée, Lafayette, Colorado.

Celadon-glazed porcelain covered jar, 11¾ inches high.

Crackle-glazed urn, approximately 11 inches in height, fired to Cone 10.

Vase with brushed slip and celadon glaze, approximately 6 inches in height.

of the pot during firing), press-molded test bars (4½×1¼×⅜ inches) were dried between plaster bats to keep them flat, bisqued, then fired spanning the edges of an altered softbrick. I used an old crosscut wood saw to narrow the width of a standard K-26 softbrick to 3¾ inches and to cut a wide groove down the middle of the brick. The test bars are made longer than the softbrick span to allow for 7%–12% shrinkage during a Cone 10 firing. Of the clay body recipes given, Zamek's Original J-Body showed the least slumping and shrinkage.

I used larger, thicker test bars for the porosity, shrinkage and warping/twisting tests. The degree of warping and twisting was gauged by eye.

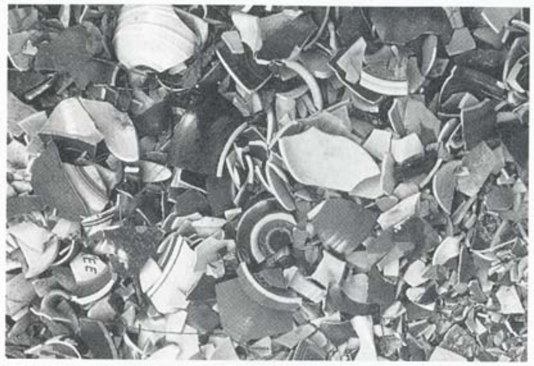
For shrinkage tests, all the bodies were mixed using the wet method, then dried to a similar throwing consistency. As each press-molded test bar was made, a 100-millimeter length was marked off with a razor blade; the bars were then dried (turning often) on a flat surface. After the Cone 10 firing, a second measurement was taken to determine the shrinkage. For example, if the distance between marks on the second reading is 83mm, the shrinkage would be 17%.

To test the ability of these bodies to fit glazes easily, I used ten glazes of high to low expansion (shown on the next page) adapted by Jim Robinson from R. R. West's data in *Ceramic Science for the Potter.* Almost no shivering occurred using the lowest expansion recipe of the Glaze Test Series (GTS); shivering occurs when the clay contracts faster than the glaze, causing the glaze to pop off the pot. Similarly, except for one or two of the highest expansion recipes in the series, crazing was not a problem; crazing occurs when the glaze contracts faster than the clay. The numbers in the Glaze Fit column of the Properties of Tested Clays chart denote glazes from the GTS that did not craze on the clay body tested.

Mixing Porcelain

A great porcelain body recipe is half the battle, but since white-firing clays are not as plastic as darker clays, you have to mix the body in a way that will encourage as much plasticity as possible. While the use of ball clay would increase plasticity, it would also darken the fired result.

The water used to mix your clay will make a tremendous difference in its throwing capabilities. City water in my area contains soda ash (water softener), which is highly alkaline and a strong deflocculant; therefore, its use in a porcelain body would decrease workability. Obtain information on water additives from your local water treatment plant.



Even when recipes are thoroughly tested, porcelain is an exacting taskmaster; witness Beumée's "million-dollar shard pile."

Another important factor is the water's pH. (I test my water with pHydrion paper, which comes in a dispenser and is easy to use. It is available from Micro Essential Laboratory, Inc., 4224 Avenue H, Brooklyn, New York.) The rainwater I collect from the roof of my house is an acidic pH 4.5, excellent for mixing clay (and a good use for acid rain). Pure water would be pH neutral (8). The higher (more alkaline) the pH, the more likely deflocculation will occur, so low pH (acidic) water is preferable, assuring maximum electrical attraction between clay particles (flocculation). Well water, because it contains valuable trace minerals and organisms, is preferable to distilled or city water.

Flat-bottomed, 30-gallon plastic barrels are recommended for mixing porcelain slurry. Fill each three-quarters full with water and add 125 pounds of dry materials. I use a 60-pound capacity dairy scale to weigh dry materials because the demarcations are in tenths of a pound. The scale was hung close to the floor to reduce back strain.

In the absence of a filter press, I pour the mixed slurry into a drying frame of 2×4 boards set on 24-inch-high legs also made of 2×4s. The dimensions of this drying frame are 29×92 inches. Attached to the bottom of the frame is ¼-inch hardware cloth, available in 3-foot-wide rolls. This left enough cloth to curl over the edge of the frame and be screwed to the sides between the 1×2-inch furring strips, ensuring that the hardware cloth will not detach from the weight of the clay.

After the hardware cloth was attached, the legs were screwed into the frame, three per side. A sheet of plastic attached below the hardware cloth catches drips and directs them to a collection bucket. Sheeting (old bed sheets) is placed on top of the hardware cloth.

Mixing Procedure

1. Attach the recipe to the side of the barrel. As each ingredient is added, mark it off your list.

2. Wearing a respirator, mix the plastic ingredients first: plasticizers (Veegum T, Bentolite, Macaloid) and clays (Grolleg). Do not add the Veegum or any montmorillonite directly to water. Weigh out 10 pounds of the clay to be added, then mix the Veegum and clay together dry. Add this mixture to the water and subtract these ingredients from your list. Mix thoroughly. I use a 24-inch-long mixer powered by a drill. Use a drill with high RPM; above 2000 is good. Hammer drills generally have up to 2500 RPM.

For Cooper's Translucent Porcelain Body, where the solubility of sodium feldspars is counteracted by Epsom salts, stir the Epsom salts into 1 quart water, allow a few minutes for the crystals to dissolve, then add to the barrel.

3. Weigh out the remaining clay in the recipe; add to the water and mix thoroughly, moving the mixer around in the barrel to avoid creating a vortex (which would pull air into the clay). Weigh out and add all remaining ingre-

Properties of Tested Porcelain Bodies

Clay Body	Workability	Translucency	Whiteness	Absorption at Cone 10	Slumping	Warping and Twisting	Shrinkage at Cone 10	Glaze Fit
Cornell Porcelain	Excellent	Very Little	Slightly Gray	0%	Very Slight	Very Slight	18.0%	GTS 3–10
Pinnell Porcelain	Excellent	Some	Excellent	0%	Slight	None	17.0%	GTS 3–10
Zamek J-Body	Excellent	Good	Excellent	0%	Almost None	None	14.0%	GTS 2–10
Revised J-Body	Excellent	Some	Excellent	0%	Very Slight	None	17.0%	GTS 3–10
Cooper Porcelain	Excellent	Excellent	Excellent	0%	Slight	Slight	17.5%	GTS 3–10

dients; mix thoroughly. Allow the mixture to stand for several days, then mix thoroughly once again.

4. Dip slurry from the barrels and pour through a 40-mesh screen into 5-gallon buckets. Mix the slurry thin enough so it can be pushed easily through the screen with a 3- or 4-inch paintbrush. Now pour the slurry into your drying frame.

The sheeting will hold the clay, while the water will drip through. Do not use this water again, as soluble alkalis will have been removed as water percolates through the slurry and drips through the sheeting. For the drying frame described, no more than two barrels (250 pounds dry materials) are poured in at one time. Any more than that will take an excessive amount of time for the clay to dry to throwing consistency.

When the clay has dried sufficiently, I remove softer clay for platters and plates, then allow the remainder to become slightly drier for use in vertical forms. Next, I run it through a deairing pug mill twice. The freshly pugged clay can be used immediately; aging will not appreciably help plasticity.

This is also an ideal system for reclaiming dried-out trimmings and scraps. I made a Formica-lined box for all my trimmings and set it in front of my wheel. When the box is full and the trimmings are completely dry, I weigh out 125 pounds, just as if it were new material, and add that to a 30-gallon barrel three-quarters full of water. The clay is allowed to slake a day or two, then mixed thoroughly until the lumps disappear. After screening, the slurry is ready to pour into the frame for drying to throwing consistency.

The author *David Beumée is a member of the Boulder Potters Guild.*

Cone 10 Glaze Test Series from High to Low Expansion

Molecular Formulas with Thermal Expansion Estimates*

Glaze Number	Oxide Equivalents							Thermal Expansion $\times 10^{-6}$in./°C
	KNaO	CaO	MgO	ZnO_2	Al_2O_3	B_2O_3	SiO_2	
Glaze 1	.46	.54	—	—	.50	—	4.00	8.40
Glaze 2	.30	.70	—	—	.50	—	4.00	7.84
Glaze 3	.30	.70	—	—	.50	.20	4.00	7.88
Glaze 4	.20	.80	—	—	.50	—	4.00	7.64
Glaze 5	.20	.60	.20	—	.50	—	4.00	6.87
Glaze 6	.20	.50	.20	.10	.50	—	4.00	6.81
Glaze 7	.20	.30	.50	—	.50	—	4.00	5.69
Glaze 8	.20	.10	.60	.10	.50	—	4.00	5.25
Glaze 9	.20	.10	.60	.10	.65	—	4.55	5.02
Glaze 10	.20	.10	.60	.10	.65	.20	4.55	5.05

*These thermal expansion estimates do not appear in exact descending order from Glaze 1 through Glaze 10 because these formulas are listed in empirical rather than theoretical order. While the thermal expansion figures are based on the best science available today, estimates of glaze expansion are not perfect.

Cone 10 Glaze Test Batch Recipes*

Materials	Glazes									
	1	2	3	4	5	6	7	8	9	10
Talc (Pfizer CP 96–30)	—	—	—	—	8.0	8.0	20.7	—	—	—
Talc (Pfizer MP 45–26)	—	—	—	—	—	—	—	21.2	18.4	17.8
Whiting	13.8	17.8	16.4	19.9	13.6	11.6	4.5	1.7	1.5	1.6
Zinc Oxide	—	—	—	—	—	2.1	—	2.3	2.0	1.9
Custer Feldspar	76.9	47.4	—	31.3	—	32.3	—	—	—	—
Frit 3185 (Ferro)	—	—	9.0	—	—	—	—	—	—	8.5
G-200 Feldspar	—	—	41.3	—	33.0	—	34.1	36.7	31.8	23.8
Bentonite	2.0	—	—	—	—	—	—	—	—	—
Edgar Plastic Kaolin	—	12.1	12.7	18.8	18.1	19.2	18.1	17.9	25.2	27.6
Flint (amorphous)	9.3	—	20.7	30.0	27.3	26.8	22.5	20.2	21.1	18.8
Flint (quartz)	—	22.6	—	—	—	—	—	—	—	—

*These batch recipes may change as their materials' actual contents change, requiring recalculation to approximate the molecular formulas above.