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Developing a Local Clay Body: Augusta County, Virginia

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Abstract:

Several samples of raw clay from Augusta County, Virginia were analyzed, and one was chosen to develop into a clay body that could successfully be thrown on the wheel, fired, and made into functional ware. The characteristics of plasticity, strength, absorption, and glaze effects were important when deciding what materials to add to the raw clay samples. Issues included low plasticity when throwing, cracking while drying, warping when firing, and pinholing in the glaze fire. A recipe was developed that worked well for the chosen clay, found in a roadside in Craigsville, Virginia.

Introduction:

Augusta County has an early history in developing ceramic ware; in 1863, the Virginia Porcelain Company operated in Lipscomb, Virginia and created tableware as “Rockingham Ware”, a popular style of ceramics at the time (6). They mined a white kaolin clay about 1.5 miles from the company in Porcelain, Virginia and mixed it with a bentonite clay from Bare Mountain, Virginia (6). Due to the addition of the kaolin clay, the pots’ strength and durability was praised by several critics of the time, as “the ware made from it is of very fine quality, equal to the best imported. . . Pots made from it proved better [stronger] than any [others] in use” (2). Soon after the completion of the Shenandoah Valley Railroad, the company was sold in 1879 to an English company and became the Virginia China Clay and Fire Brick Company (6). Production was focused on bricks and tile, and the company “washed eight tons of China clay to make 3000 bricks per day”, and employed around 50 workers, many of whom were newly emancipated African-Americans (5). The company dissolved sometime in the 1890s, and since that time, there has been no other recorded ceramic operations that have used local clay from

Augusta County. However, the area is currently home to several independent ceramists that produce and sell work.

Clay is composed of mainly silica, oxygen, alumina, and other elements. It is a unique mixture, made of thin platelets that are held tightly together by electrostatic attraction. With the addition of water, these platelets can move smoothly against one another, resulting in a plastic and malleable material. There are several important characteristics of clay that are directly related to the composition of the clay body. Plasticity describes the ability of the clay platelets to be able to stick to one another, and the surface tension of the water in the clay helps to hold the platelets together. Plasticity can also be improved by allowing the clay to mature so that the water can move through the clay to hold more platelets together (3, 9). In an acidic environment, the attraction of the clay platelets to one another increases, and the platelets are held tightly together producing a thicker clay mixture (flocculation); this can cause a clay body to be more plastic (3, 7). In an alkaline environment, the attraction weakens and creates a thinner consistency (deflocculation) (7). Related to plasticity is the thixotropy (strength) of a clay body. Thixotropy is the ability of a material to lose its shape and become less viscous when subject to stress. Some commercial porcelains are thixotropic, and care must be taken not to "overwork" the clay, as it can lose its ability to hold its shape quickly. The intended function of the clay body determines what kind of plasticity and strength a ceramist would require in their clay body. While flocculating a clay body to increase plasticity may help a wheel-throwing ceramist, deflocculating a clay may be better suited for ceramicist interested in slip casting or slip trailing.

There are three main kinds of ceramic ware: earthenware (cone 06-04), stoneware (cone 4-10), and porcelain (normally cone 9-13). Pyrometric cones, made of ceramic materials in a triangular shape, are placed inside the kiln when firing. They act as standards that provide a mechanical and/or visual indication of a specific time and temperature (Table 5). The samples I tested from Augusta County were all stoneware. A good stoneware clay body recipe has three basic parts: clay, flux, and filler (3, 7). Deciding which kinds of these three components to include in a clay recipe depends upon the method of production (e: wheel thrown, slab built, etc.), function (sculpture vs. functional ceramics), and firing atmosphere (oxidation vs. reduction) (7).

Clay refers to a group of materials including kaolin, bentonite, ball clay, and fire clay. Each of these sub groups have groups of their own. Ball clay is the most common type of clay to be used in stoneware and has many varieties such as Kentucky ball clay, OM4 ball clay, or Zamek ball clay. Many times, these ball clays can be substituted for one another as they have similar properties. Because of its fine particle size, the addition of ball clay can increase plasticity and strength, decrease warping when firing, and effect color (7, 8). However, ball clays can shrink excessively, as a finer particle size requires more water when in a workable state and can cause cracking when drying and firing (8).

Flux helps to lower the melting point of the stoneware, and is responsible for allowing the clay body to mature correctly at a specific temperature. Characteristics of correct maturation that are taken into consideration for functional ceramic ware are absorption, porosity, slumping, and shrinking. Adding too much flux into a body can cause the ware to slump or shrink excessively during firing, while a body with not enough flux may over-fire, or become so vitrified to not be absorptive at all, be brittle, or blister (8). Nepheline syenite and feldspars such as potash feldspar and soda feldspar are used as fluxing agents in clay bodies; when added with silica, fluxes can lower the melting point of the silica and strengthen the clay body (3, 8).

Fillers such as grog, flint, or silica are pre-fired sand-like materials. Because they are already fired, adding them to a clay body can increase porosity and offer a larger particle size to "open up" the clay body (7, 8). These characteristics help reduce unnecessary shrinkage and warping when firing and contribute to a more even drying to reduce cracking in greenware (7, 8).

It is important to note that commercial ceramic production requires consistent characteristics in both the clay body and glaze that allows for safe usage in a wide variety of thermal conditions. Functional use requires a specific clay body absorption, shrinkage, and glaze characteristics (must be immune to glaze defects). Glaze defects can include pinholing, crazing, dunting, and more. Crazing can mean that a pot has weak spots, and like pinholes, can harbor bacteria and germs. While the glaze itself on a pot can cause these defects, the clay under it can cause undesirable interactions with the glaze. Plasticity, strength, absorption, and glaze qualities were the characteristics I was most concerned about when trying to develop a workable and safe clay body for throwing on the wheel.

Experimental:

Procedures were adapted from Mason (1981) and Zakin (1990). During this process, it was important to wear a respirator mask.

Clay Body Preparation

Five samples from varying locations were dug and transported back to the studio. The clay was left to dry on sheets, broken up with a hammer into small chunks, left to dry completely, then broken up again. Small amounts of dry clay pieces were added to water while being mixed with an electric drill with mixer attachment. Additional amounts of dry clay were

Image 1: Slip was screened through a 18x16 mesh

added until a full bucket of clay was mixed into a slip consistency. This slip was then screened through an 18x16 mesh screen into another bucket to remove all leaves, rocks, etc. (Image 1). This slip was poured into pillowcases and hung in a warm area (sun or next to stove) until enough moisture was taken out of the clay for it to set up on plaster bats to remove the remaining moisture to become a workable consistency. The entire process could take as long as a week depending on how long it took to dry the clay.

Throwing Raw Clay Body

The five raw clays were thrown separately on the wheel to establish their characteristics to determine which clay bodies had a chance at being successfully developed.

Absorption and Shrinkage Testing

Test tiles from all five raw clays were made in triplicate using a slab roller set to 0.5 cm and then cut into 6x10 cm test tiles (Image 2). Tiles were left to dry and care was taken to ensure tiles dried flat and did not warp.

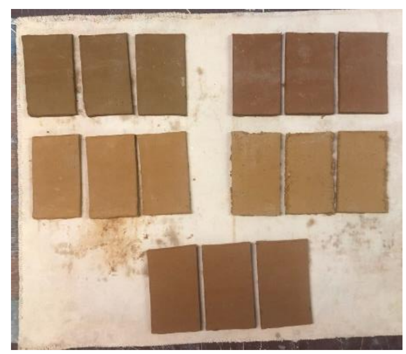

Image 2: Test tiles were created from raw clay

All firings were done using an electric programmable kiln. Clay test tiles were fired to cone 04, cooled to room temperature, weighed, submerged in room temperature water to absorb for 48 hours and weighed again. The same process was repeated at cone 6 and 10. Absorption was measured as

$$\frac{saturated\ weight - dry\ weight}{dry\ weight} * 100\%$$

Shrinkage of the fired bodies was measured similarly at cone 04, 6, and 10 and using the formula

$$\frac{original\ length - fired\ length}{original\ length} * 100\%$$

Developing Raw Clay Body

Two of the five raw clays were chosen to be developed further. Screened clay as prepared in the steps above was dried completely and pulverized to a powder (Image 3). Various dry components were added to the powdered clay samples to improve the clays' characteristics (Table 1). Dry materials added included grog, ball clay, silica, and soda feldspar. Materials were added as a percentage on top of 200 grams of powdered clay. Water was added to the powdered mixtures to rehydrate the clay. The samples sat for several days before being wedged and thrown (Image 4). Additionally, several tests included incorporating a percentage of vinegar on top of the water to flocculate the clay and increase plasticity.

Image 3: Dried clay was pulverized into a powder

Table 1: Mixtures of Components Tested

Trial	OM4 Ball Clay (%)	Soda Feldspar (%)	Silica (%)	Grog (60 mesh) (%)	Vinegar (%)
1	5	-	-	7	-
2	10	-	-	5	-
3	15	-	-	10	-
4	10	-	-	7	-
5	5	-	-	5	-
6	6	-	-	3	-
7	5	-	-	-	-
8	10	-	-	-	-
9	-	-	-	1	-
10	-	-	-	5	-
11	6	5	3	3	-
12	6	10	5	3	-
13	6	15	10	3	-
14	6	-	-	3	2
15	6	-	-	3	5

Image 4: Powdered clay with additives was rehydrated and allowed to mature before throwing

All 30, 200 gram samples were thrown into small cups to test for plasticity, strength, and water absorption. More successful mixtures were fired at cone 04 and 6.

Results/Discussion:

Five locations with promising clay deposits were found (Table 2). When throwing the raw samples, all the clays had varying throwing characteristics (Table 3) and different absorption, shrinkage, and warping percentages (Table 4). Samples #2 and #3 had the best properties for throwing, and when fired to cone 6, the absorption rates of #2 and #3 were acceptable for functional use. However, their shrinkage rates were high and #3 seemed to be prone to warping during firing, but the addition of grog combatted these issues. Unfortunately, no combinations of added materials seemed to prevent cracking in #2 while firing, so I chose #3 to work with when producing my ceramic pieces. For clay #3, small pieces such as cups and small bowls were able to be successfully thrown and fired without any additives, but failure rate was high. Handles could not be pulled, slabs could not be made and molded, thin pieces cracked while drying, and tall pieces and pieces subject to high stretching (large bowls) all split while throwing.

To ensure cracking while drying did not occur, grog was added to “open” the clay for more even drying, pieces were left to dry for 7-10 days and stored in cool environments. However, a large amount of grog caused the clay to be unworkable without a higher amount of water. The friction between my hands and the clay would become too much, and the clay would pull and create thin spots that could rip or warp. Additionally, the abrasiveness of the grog forced me to use more water while throwing, which caused splitting. At one time, with grog added, all of my pieces on a top shelf in the studio had cracked, but none of the others. All of my pieces were covered well, but were forming condensation inside the plastic. I assumed this had something to do with a property of the clay; however, I discovered a baseboard heater hiding behind my shelves. Once I included a small amount of 30 mesh grog (3%) in my recipe and moved all of my pieces to the other side of the room to dry, I did not have any more pieces crack while drying.

With commercial clay, stress cracks while throwing are normally due to an excess of water being left in the bottom of a pot. I was not leaving any excess water in the bottom of my pots, but #3 absorbed a large amount of water quickly while throwing. The splitting was being caused by low plasticity and by the clay absorbing too much water (Image 5). To prevent splitting, I added a small amount of OM4 ball clay to increase plasticity (too much ball clay increased water absorption), and I used as little water as possible when throwing. This combination allowed me to throw taller and wider pieces. Unfortunately, even with additives to increase plasticity, normal pulled handles did not survive either the pulling "wet" stage and/or the firing process.

Image 5: Stress cracks developed during throwing a large bowl

While strength did not seem to be an issue with this clay body, I added a small amount of soda feldspar and silica to help increase strength and durability to the body. As a fluxing agent, the two should fuse together and create a much stronger body. However, even adding a small amount (10% soda feldspar with 5% silica) seemed to contribute to warping (Image 6) during firing.

Image 6: Non-warped bowl vs. warped bowl

A good deal of experimenting went into finding a workable combination; the best recipe I found for clay #3 was 6% OM4 ball clay and 3% 60 mesh grog added on top of screened clay powder and 5% vinegar added on top of the water used to rehydrate the clay.

When firing, the kiln was heated and allowed to cool slowly to reduce cracking and glaze defects during firing. I had several handles crack during the firing process, but only one piece exploded during the firing. This was a large bowl that I had made thicker than usual to reduce the chance of cracking while drying; it’s most likely that there was too much moisture still left in the pot when firing.

I successfully produced 15 pieces that ranged from small cups and bowls to dinner plates and serving bowls. These different pieces tested the different characteristics of the clay, and proved that I had developed a fairly successful clay body for throwing. Unfortunately, my pieces made from clay #3 exhibited a large amount of pinholing (Image 7), especially with a commercial white glaze (Oatmeal, Mayco) over a black glaze (Obsidian, Amaco) that created a blue glaze. I suspect this was due to the grittiness of the fired texture and expulsion of elements coming out of the clay during the glaze firing. On bare clay, these spots were either gold in color and were raised lumps or were black spots that created holes (Image 8). Further testing is needed to try to remedy this glaze defect because with this much pinholing, these pieces cannot be considered food safe.

Image 7: Significant pinholing was observed in glaze for clay #3

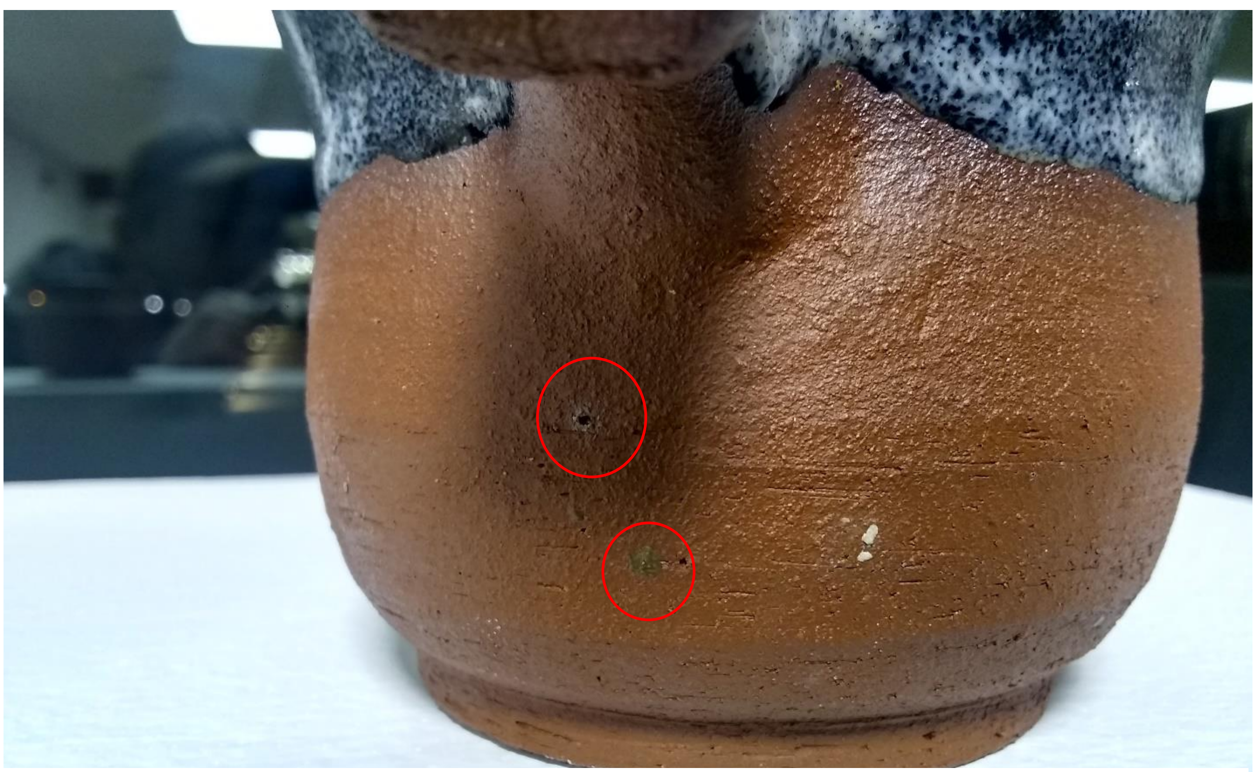

Image 8: Expelled materials caused irregularities on #3 fired clay surface

Table 2: Location of Clays

#	Location	
1	Still House Ln, Deerfield 24432	38.186261, -79.422475
2	Augusta Farms Rd, Waynesboro 22980	38.072359, -78.999112
3	Troxel Gap Rd, Craigsville 24430	38.047948, -79.350139
4	Sherando Lake Rd, Lyndhurst 22952	37.917548, -79.016307
5	Lotts Rd, Steeles Tavern 24476	37.982737, -79.238893

Table 3: Qualitative Properties of Found Clay Bodies

#	Plasticity	Water abs (throwing)	Strength to hold shape	Texture when throwing	Glaze Cone to maturation	Glaze defects
1	low	low	low-med	extremely gritty	9	pinholing, crazing
2	low	medium	Low-med	gritty	6	pinholing
3	medium	med-high	medium	smooth	6	pinholing
4	extremely low	medium	none	sticky	7-8	dunting, crazing, bubbling
5	low	low	medium	smooth	7-8	pinholing

Table 4: Absorption, Shrinkage, and Warping of Clays without Additives

	Cone 04			Cone 6			Cone 10		
#	Abs (%)	Shrink (%)	Warp (cm)	Abs (%)	Shrink (%)	Warp (cm)	Abs (%)	Shrink (%)	Warp (cm)
1	16.045 ± 0.078	6.0 ± 0.0	0.1	9.590 ± 0.071	8.04 ± 0.002	0.1	1.36 ± 0.080	12.12 ± 0.002	0.2
2	4.420 ± 0.071	15.67 ± 0.010	0.1	1.435 ± 0.092	16.14 ± 0.018	0.2	-	-	melt
3	5.05 ± 0.25	16.33 ± 0.010	0.2	1.38 ± 0.22	16.98 ± 0.010	0.2	-	-	melt
4	26.38 ± 0.31	13.30 ± 0.012	0	5.15 ± 0.35	17.14 ± 0.011	0	1.01 ± 0.36	Too warped	0.35
5	12.40 ± 0.15	8.33 ± 0.006	0.2	3.51 ± 0.13	10.01 ± 0.010	0.2	0.77 ± 0.22	Too warped	0.5

*Warping was observed as the "rising" of the middle of the test tile

Table 5: Pyrometric Cone Chart (Orton® Standards)

Cone #	Degrees Celsius
019	683
04	1060
02	1120
4	1186
6	1222
10	1305

Conclusion:

This project presented the development and basic testing and analyses of raw clay samples in Augusta County, Virginia. Various materials were added to the raw clay to change the clay's characteristics to make it more suitable for throwing on the wheel. The most important characteristics taken into consideration were plasticity, strength, absorption, and glaze effects. The materials added to sample #3 to create the ideal clay body were 6% OM4 ball clay, 3% 60 mesh grog, and 5% vinegar. With this combination, 15 glazed pieces were produced that successfully tested different aspects of the clay. The one weakness of the body of work was pinholing in the glaze.

References

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A selection of the finished ware in images: