Addition of selected materials to clay for ceramic sculpture
by Jean Kay Ferris Feist

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF APPLIED ART
Montana State University

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Clay bodies containing substances such as vermiculite, sawdust, shredded paper, and straw were found to be light in weight when fired, but they were difficult to work with. Fiber glass cloth and burlap imbedded inside slabs of clay decreased the weight of the clay and also made the clay very easy to work with by increasing its tensile strength. Most of the substances added to the clay reduced shrinkage and produced an interesting surface.

ADDITION OF SELECTED MATERIALS TO CLAY FOR CERAMIC SCULPTURE

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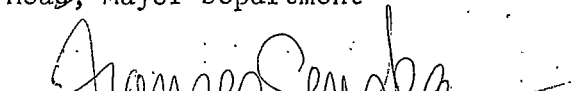
Approved:

Head, Major Department



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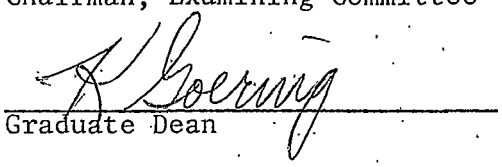

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ABSTRACT

A variety of materials were added to earthenware and stoneware clay to produce clay bodies for sculpture that would be light in weight when fired, have reduced shrinkage, have increased strength when plastic, and have a variety of surface effects. Tests were conducted on samples of the clay bodies to determine shrinkage, weight loss, and porosity. The samples were glazed to find what effect the additives would have upon glaze. Sculptures of various sizes were made from some of the clay bodies to determine if the clay bodies were practical for use as sculpture.

Clay bodies containing substances such as vermiculite, sawdust, shredded paper, and straw were found to be light in weight when fired, but they were difficult to work with. Fiber glass cloth and burlap imbedded inside slabs of clay decreased the weight of the clay and also made the clay very easy to work with by increasing its tensile strength. Most of the substances added to the clay reduced shrinkage and produced an interesting surface.

INTRODUCTION

This study undertakes to determine if selected additives can extend the properties of clay for use in creating ceramic sculpture. Because of the heaviness of clay when fired and its lack of tensile strength when moist, ceramic sculpture is somewhat limited in regard to size, shape, and weight. Weight is often a limiting factor in creating ceramic sculpture because the sculpture must be relatively small in order to be transported, especially when it is in either the leather hard or dry stage. The general shape is also relatively limited by weight because the sculpture must be constructed in such a way that it can support itself. This frequently results in a rather compact, solid-looking sculpture. The large amount of shrinkage of the clay body as it is taken from the plastic state through the final firing is another problem, as this shrinkage often results in a much smaller sculpture than was anticipated. The question arose as to whether these limitations could be lessened by adding various substances to the clay. To carry out this experiment organic and inorganic materials were added to the basic stoneware and earthenware clays used in the ceramics department at Montana State University in order to make the clay body lighter in weight, to give the clay greater tensile strength when plastic, to reduce its shrinkage, and to create varied textured and colored surfaces.

EXPERIMENTAL PROCEDURES

The first test was conducted to determine the comparative amount of shrinkage involved as the clay went from the plastic state through the final firing at cone 9. A sample ten centimeters in length was made from the clay that contained no additives. Then samples ten centimeters in length were made from the clays to which materials had been added. After the samples had dried to the greenware or dry stage, they were again measured. They were also measured after the bisque firing at cone 04 and after the glaze firing at cone 9. Because of their varying properties the materials were added using three different methods. The first eight samples contained primarily materials that were light in weight and which were added volumetrically. The next six samples contained heavy materials which were added by weight. The fiber glass cloth and the burlap were imbedded inside the clay, and the last four samples contained substances imbedded in the surface of the clay. The results from this experiment are shown in Table I for stoneware and Table IV for earthenware.

The second test made was to determine the comparative weights of the clays before and after firing. For this test a small plaster mold was made into which clays of all the various types were pressed. In this manner pieces of plastic clay identical in size were obtained. Each piece of plastic clay was weighed, and its weight was compared to that of the other clays. The clays were again weighed after the final firing to learn the amount of weight loss, and the percentage of weight loss was then calculated for each body. These samples were soaked in water for one hour and weighed again. The percentage of weight gained from the water was calculated to show the relative amount of porosity for each sample. A comparison of the

findings from these tests can be seen in Table II for stoneware and Table V for earthenware.

From these samples it was also possible to learn what the appearance of the clay would be in its final state. The texture and color could be seen as well as which materials burned out of the clay, which fused to form glaze, and which did not change. Tables III A and III B for stoneware and Tables VI A and VI B for earthenware show comparisons of these qualities. Glazes were applied to the samples for the final firing, and after the firing it was possible to determine what effect, if any, the substances added to the clay had upon glaze. The strength of the fired clay could also be inferred from the appearance of large holes, cracks, and the amount of burned out material. Information relative to the effect of additives on glaze and on fired strength can be found on page three for stoneware and eight for earthenware.

Another method used was to make small sculptures two to five inches in size from certain clay bodies to see how well they would stand up under firing and to determine if the clay could be easily worked. This method was not highly satisfactory, for almost any piece of clay so small is readily workable and will withstand firing. It soon became apparent that the experiment would be more practical and more would be learned if the sculptures were made on a larger scale. This method did prove to be the most successful in determining the value of the different clay bodies. A comparison of the workability of various clay bodies begins on page thirteen.

TEST RESULTS FOR STONEWARE

In the average pottery and sculpture studio the technical control of firing varies, making absolute accuracy in test results unlikely. Consequently, the following test results are indicative rather than conclusive.

Only four of the substances added to the clay had any effect on glazes applied to the samples. The copper filings melted together with the glaze and gave the glaze a gray metallic luster. The brass pieces caused crystalline gray metallic spots in the glaze. Large spots of grayish glaze formed when the glass pieces melted under the glaze. The microcline caused small, grayish bumps of glaze to form in the glaze applied to the sample.

Two clay bodies of doubtful strength were those with 50% wheat straw and 30% rice straw added. Very large holes and a number of cracks developed which made these clay bodies seem quite fragile. The clay body with 50% compressed shredded paper seemed to lack durability because of the large quantity of paper that burned out and because it absorbed more than twice as much water as any other sample, which indicated it was quite porous. Other samples which had materials burn-out seemed satisfactory in strength, although they did not appear to be as strong and durable as those in which the materials either fused with the clay or remained unchanged.

Table I, Comparison of Shrinkage Rates of Stoneware Bodies

	Plastic Length	Dry Length	Cone 04 Length	Cone 9 Length
Stoneware	10	9.5	9.2	8.8
50% Vermiculite (v)	10	9.6	9.5	9.0
50% Sawdust (v)	10	9.7	9.4	9.0
50% Loose Shredded Paper (v)	10	9.5	9.2	8.9
50% Compressed Shredded Paper (v)	10	9.5	9.4	8.9
25% Cotton String (v)	10	9.5	9.1	8.8
50% Wheat Straw (v)	10	9.7	9.6	9.2
30% Rice Straw (v)	10	9.6	9.4	8.9
25% Coarse Grog (v)	10	9.6	9.4	9.2
10% Seasand (w)	10	9.5	9.2	8.9
10% Montana Kaolin (w)	10	9.6	9.4	9.1
10% #½ Quartz (w)	10	9.5	9.4	9.1
10% Skyrme (Copper Ore) (w)	10	9.5	9.3	8.9
10% Microcline (w)	10	9.6	9.4	9.0
10% 30 Mesh Alfalfa Ash (w)	10	9.6	9.3	9.1
Imbedded Fiber Glass Cloth	10	9.6	9.4	8.8
Imbedded Burlap	10	9.5	9.3	9.0
Imbedded Copper Filings	10	9.5	9.1	8.9
Imbedded Brass Pieces	10	9.5	9.3	9.0
Imbedded Cotton String	10	9.5	9.2	8.9
Imbedded Glass Pieces	10	9.6	9.2	8.9

All measurements are shown in centimeters. (v) means added volumetrically. (w) means added by weight.

Table II, Comparison of Weight and Porosity of Stoneware Bodies

	Plastic Weight	Cone 9 Weight	Weight Loss %	Weight Gained After Soaking	Weight Gain %
Stoneware	52	38	27%	1	3%
50% Vermiculite (v)	48	34	29%	2	6%
50% Sawdust (v)	46	32	30%	3	9%
50% Loose Shredded Paper (v)	50	36	28%	2	6%
50% Compressed Shredded Paper (v)	43	26	40%	5	19%
25% Cotton String (v)	48	35	27%	1	3%
50% Wheat Straw (v)	47	33	30%	2	6%
30% Rice Straw (v)	45	33	27%	2	6%
25% Coarse Grog (v)	53	42	21%	3	7%
10% Seasand (w)	52	40	23%	2	5%
10% Montana Kaolin (w)	51	38	25%	1	3%
10% #½ Quartz (w)	51	39	23%	3	8%
10% Skyrme (Copper Ore) (w)	50	37	26%	1	3%
10% Microcline (w)	53	41	23%	1	2%
10% 30 Mesh Alfalfa Ash (w)	50	37	26%	1	3%
Imbedded Fiber Glass Cloth	47	34	28%	2	6%
Imbedded Burlap	48	34	29%	3	9%

All weights are shown in grams. The various types of clays were pressed into a mold forming pieces of plastic clay of identical size. (v) means added volumetrically. (w) means added by weight.

Table III A, Comparison of Appearance of Stoneware Bodies

	Texture
Stoneware	Smooth
50% Vermiculite (v)	Slightly rough, full of holes and cracks
50% Sawdust (v)	Very rough, especially on cut edges
50% Loose Shredded Paper (v)	Uneven surface with some holes
50% Compressed Shredded Paper (v)	Rough, uneven surface with many holes
25% Cotton String (v)	Uneven surface with string-shaped holes
50% Wheat Straw (v)	Very rough with grooves and cracks
30% Rice Straw (v)	Very rough with grooves and cracks
25% Coarse Grog (v)	Slightly rough
10% Seasand (w)	Smooth except for bumps of melted sand
10% Montana Kaolin (w)	Smooth
10% #½ Quartz (w)	Smooth
10% Skyrme (Copper Ore) (w)	Smooth and slightly shiny
10% Microcline (w)	Rough because of lumps of glaze
10% 30 Mesh Alfalfa Ash (w)	Smooth and shiny
Imbedded Fiber Glass Cloth	Smooth
Imbedded Burlap	Smooth
Imbedded Copper Filings	Smooth and metallic
Imbedded Brass Pieces	Smooth except for lumps of brass
Imbedded Cotton String	Rough with string-shaped grooves
Imbedded Glass Pieces	Rough because of melted glass

(v) means added volumetrically. (w) means added by weight.

Table III B, Comparison of Appearance of Stoneware Bodies

	Fusion or Burn-Out of Additives	Color Compared to Stoneware
Stoneware	None	Brownish Gray
50% Vermiculite (v)	Fused	Darker
50% Sawdust (v)	Burned Out	Lighter
50% Loose Shredded Paper (v)	Burned Out	Lighter in Spots
50% Compressed Shredded Paper (v)	Burned Out	Lighter
25% Cotton String (v)	Burned Out	Lighter in Spots
50% Wheat Straw (v)	Burned Out	Same
30% Rice Straw (v)	Burned Out	Same
25% Coarse Grog (v)	Neither	Lighter
10% Seasand (w)	Fused	Same
10% Montana Kaolin (w)	Neither	Lighter
10% #½ Quartz (w)	Neither	Lighter
10% Skyrme (Copper Ore)	Fused	Darker
10% Microcline (w)	Fused	Same
10% 30 Mesh Alfalfa Ash (w)	Fused	Darker
Imbedded Fiber Glass Cloth	Fused	Same
Imbedded Burlap	Burned Out	Lighter in Spots
Imbedded Copper Filings	Fused	Darker in Spots
Imbedded Brass Pieces	Fused	Darker in Spots
Imbedded Cotton String	Burned Out	Lighter in Spots
Imbedded Glass Pieces	Fused	Same

(v) means added Volumetrically. (w) means added by weight.

TEST RESULTS FOR EARTHENWARE

Because of variations in kiln firings in the average pottery and ceramic sculpture studio, absolute accuracy in tests is not probable. Consequently, the following test results are indicative rather than conclusive.

Two additives which affected cone 04 glazes were the imbedded copper filings and the imbedded glass pieces. The copper filings caused gray metallic spots to appear in the glaze, and the glass pieces created gray glassy spots in the glaze.

Two additives which substantially reduced the strength of the clay were the wheat straw and the rice straw. Because of the large size of the straw, many holes and cracks developed which weakened the clay body and made it extremely fragile.

The only additive to change the body color of the earthenware clay was the skyrme or copper ore. The clay body was darkened by this additive. Two other additives also had interesting results in relationship to color. These were the vermiculite which remained unchanged in the cone 04 firing causing gold colored flecks to appear in the clay and the copper filings which melted and covered the clay with a metallic gray luster.

Table IV, Comparison of Shrinkage Rates of Earthenware Bodies

	Plastic Length	Dry Length	Cone 04 Length
Earthenware	10	9.5	9.2
50% Vermiculite (v)	10	9.6	9.4
50% Sawdust (v)	10	9.7	9.4
50% Loose Shredded Paper (v)	10	9.5	9.2
50% Compressed Shredded Paper (v)	10	9.6	9.4
25% Cotton String (v)	10	9.6	9.3
50% Wheat Straw (v)	10	9.6	9.4
30% Rice Straw (v)	10	9.6	9.3
25% Coarse Grog (v)	10	9.5	9.3
10% Seasand (w)	10	9.5	9.3
10% Montana Kaolin (w)	10	9.5	9.2
10% #½ Quartz (w)	10	9.5	9.3
10% Skyrme (Copper Ore) (w)	10	9.5	9.2
10% Microcline (w)	10	9.6	9.4
10% 30 Mesh Alfalfa Ash (w)	10	9.6	9.3
Imbedded Fiber Glass Cloth	10	9.6	9.4
Imbedded Burlap	10	9.5	9.2
Imbedded Copper Filings	10	9.5	9.2
Imbedded Brass Pieces	10	9.5	9.1
Imbedded Cotton String	10	9.5	9.2
Imbedded Glass Pieces	10	9.6	9.2

All measurements are shown in centimeters. (v) means added volumetrically. (w) means added by weight.

Table V, Comparison of Weight and Porosity of Earthenware Bodies

	Plastic Weight	Cone 04 Weight	Weight Loss %	Weight Gained After Soaking	Weight Gain %
Earthenware	54	40	28%	6	15%
50% Vermiculite (v)	49	35	29%	8	23%
50% Sawdust (v)	45	31	31%	9	29%
50% Loose Shredded Paper (v)	49	36	27%	8	22%
50% Compressed Shredded Paper (v)	44	29	34%	9	38%
25% Cotton String (v)	51	38	26%	7	18%
50% Wheat Straw (v)	45	32	29%	8	25%
30% Rice Straw (v)	45	33	25%	8	24%
25% Coarse Grog (v)	54	41	24%	8	20%
10% Seasand (w)	54	41	24%	6	15%
10% Montana Kaolin (w)	50	38	24%	6	16%
10% #½ Quartz (w)	55	43	22%	6	14%
10% Skyrme (Copper Ore) (w)	49	36	27%	5	19%
10% Microcline (w)	55	42	24%	7	17%
10% 30 Mesh Alfalfa Ash (w)	52	39	25%	6	15%
Imbedded Fiber Glass Cloth	52	39	25%	6	15%
Imbedded Burlap	47	34	28%	7	18%

All weights are shown in grams. The various types of clays were pressed into a mold forming pieces of plastic clay of identical size. (v) means added volumetrically. (w) means added by weight.

Table VI A, Comparison of Appearance of Earthenware Bodies

	Texture
Earthenware	Smooth
50% Vermiculite (v)	Slightly rough
50% Sawdust (v)	Very rough, especially on cut edges
50% Loose Shredded Paper (v)	Slightly uneven surface with some holes
50% Compressed Shredded Paper (v)	Very rough with many holes
25% Cotton String (v)	Uneven surface with string-shaped holes
50% Wheat Straw (v)	Rough with grooves and small cracks
30% Rice Straw (v)	Rough with grooves and small cracks
25% Coarse Grog (v)	Slightly rough, especially on cut edges
10% Seasand (w)	Smooth
10% Montana Kaolin (w)	Smooth
10% #½ Quartz (w)	Smooth
10% Skyrme (Copper Ore) (w)	Smooth
10% Microcline (w)	Smooth except for cut edges
10% 30 Mesh Alfalfa Ash (w)	Smooth
Imbedded Fiber Glass Cloth (w)	Smooth
Imbedded Burlap	Smooth
Imbedded Copper Filings	Slightly rough
Imbedded Brass Pieces	Smooth except for lumps of brass
Imbedded Cotton String	Rough with string-shaped grooves
Imbedded Glass Pieces	Rough

(v) means added volumetrically. (w) means added by weight.

Table VI B, Comparison of Appearance of Earthenware Bodies

Earthenware	Fusion or Burn-Out of Additives
Earthenware	None
50% Vermiculite (v)	Neither
50% Sawdust (v)	Burned Out
50% Loose Shredded Paper (v)	Burned Out
50% Compressed Shredded Paper (v)	Burned Out
25% Cotton String (v)	Burned Out
50% Wheat Straw (v)	Burned Out
30% Rice Straw (v)	Burned Out
25% Coarse Grog (v)	Neither
10% Seasand (w)	Neither
10% Montana Kaolin (w)	Neither
10% #½ Quartz (w)	Neither
10% Skyrme (Copper Ore) (w)	Fused
10% Microcline (w)	Neither
10% 30 Mesh Alfalfa Ash (w)	Neither
Imbedded Fiber Glass Cloth	Neither
Imbedded Burlap	Burned Out
Imbedded Copper Filings	Fused
Imbedded Brass Pieces	Neither
Imbedded Cotton String	Burned Out
Imbedded Glass Pieces	Fused

(v) means added volumetrically. (w) means added by weight.

COMPARISON OF WORKABILITY OF SELECTED CLAY BODIES

Stoneware and Earthenware. Clay without any additives is very plastic and workable, but it has a tendency to collapse in the plastic state. Also it is difficult to handle in large slabs.

50% Vermiculite. This clay body is very unplastic. It cracks easily in the plastic state and must be used primarily in rather flat slabs. Coils can be made, but with difficulty, because the clay and vermiculite tend to separate when rolled out. Fairly large slabs can be made from this clay. See figures 1B, 2, and 3D.

50% Sawdust. This body is a little more plastic and workable than the clay containing vermiculite, but it, too, must be used primarily in flat slabs because cracks develop when it is bent. Fairly thin slabs can be made, however. Another difficulty encountered in working with this body is that it is somewhat crumbly when slightly dry. See figures 1D, 1E, 4A, and 4B.

50% Loose Shredded Paper. This clay body is more plastic than the vermiculite and the sawdust bodies. Pinched forms can be made, but quite a few small cracks develop. Coils are difficult to make because of the lumpiness of the paper. See figures 1G, 3B, and 4C.

50% Compressed Shredded Paper. This body is much less plastic and workable than the body containing loose shredded paper, but it is much lighter in weight. Many large cracks develop that must be smoothed together to keep the sculpture from becoming too fragile. One way to eliminate the cracks is to create a textured surface. The slabs created from this clay can be bent if the resulting cracks are filled in. Coils are virtually impossible to make because of the lumps of paper. See figures 1A, 1H, and 3C.

50% Wheat Straw. This body is fairly plastic. It is somewhat difficult to make into slabs because of the chunks of straw. It is also difficult to cut the slabs because pieces of straw pull out, pulling with them some of the clay. However, this body seems much less likely to collapse in the plastic state than the clay containing no additives because of the increased tensile strength gained from the straw. See figure 3A.

25% Coarse Grog. This clay is fairly plastic, although not nearly as much so as the clay without additives. Some cracks develop when slabs are bent, but the plastic clay seems to have more tensile strength than the clay with no additives. See figures 1C, 1F, and 5.

Imbedded Fiber Glass Cloth. This body is very plastic and easy to work with. Very large slabs can be formed which are strong, can be bent easily, and will not collapse. This body has the greatest tensile strength of any of the bodies tested. See figure 6.

Imbedded Burlap. This clay body is similar to the fiber glass body, but it is not quite as strong when in the plastic state. It is stronger in this state than the clay without additives, and large slabs can be easily bent and shaped. See figure 7.

Figure 1. (left to right) A. Stoneware and 50% Compressed Shredded Paper, B. Stoneware and 50% Vermiculite, C. Stoneware and 25% Coarse Grog, D. Stoneware and 50% Sawdust, E. Earthenware and 50% Sawdust, F. Earthenware and 25% Coarse Grog, G. Earthenware and 50% Loose Shredded Paper, H. Earthenware and 50% Compressed Shredded Paper

Figure 2. Stoneware and 50% Vermiculite

Figure 3. (left to right) A. Stoneware and 50% Wheat Straw, B. Stoneware and 50% Loose Shredded Paper, C. Stoneware and 50% Compressed Shredded Paper, D. Earthenware and 50% Vermiculite

Figure 4. (left to right) A. Stoneware and 50% Sawdust, B. Stoneware and 50% Sawdust, C. Earthenware and 50% Loose Shredded Paper

Figure 5. Stoneware and 25% Coarse Grog

Figure 6. Stoneware and Imbedded Fiber Glass Cloth

Figure 7. Stoneware and Imbedded Burlap

SUMMARY OF BEST CLAY BODIES

No single clay body was produced by the use of selected additives which included all of the desirable qualities of being light in weight, having reduced shrinkage, having increased tensile strength when plastic, and having an interesting surface. However, several clay bodies were created which included most of these qualities.

The stoneware and earthenware bodies with 50% vermiculite added to them produced satisfactory results. The vermiculite bodies were fairly light in weight and had reduced shrinkage. Although this clay was a little difficult to work with and lacked tensile strength when plastic, the vermiculite produced some of the most interesting surface effects of any of the additives. In the stoneware body the vermiculite fused, leaving small holes and creating a dark glaze in these areas. In the earthenware body the material remained unchanged, producing a body with gold colored flecks.

Another satisfactory clay body was the one which contained 50% sawdust. It was the second lightest in weight and had two percent less shrinkage than the regular clay. It also had an interesting rough texture which was produced when the sawdust burned out. Its greatest limitation was its tendency to crack when worked with because of the great amount of sawdust added to it.

The clay body with 50% compressed paper added to it was also very satisfactory. It was the lightest clay body produced, as the shrinkage was slightly less than that of the clay with no additives. A pleasing rough texture was created when the paper burned out. Because the paper was softened by moisture absorbed from the clay, it bent with the clay making possible the creation of more varied shapes than with the sawdust

or vermiculite bodies. It also had more tensile strength when moist than the sawdust or vermiculite bodies. One drawback of the compressed paper and clay body was its high porosity. It was the most porous of all the clay bodies and perhaps would not weather as well outside as some of the other bodies.

The clay body with the imbedded fiber glass cloth proved to have the greatest tensile strength when plastic of any of the clay bodies. Because of this fact it is conceivable that very large ceramic sculptures could be made from this clay body. This clay is very easy to work with, and a great variety of shapes can be made from it. The stoneware and fiber glass body is also fairly light in weight when fired. Burlap is similar to fiber glass cloth in that it creates more tensile strength in the plastic clay and results in a more light weight fired clay.

An interesting surface effect was produced in the stoneware clay body with 10% 30 mesh alfalfa ash added. The ash melted to darken the color of the clay and to give it a somewhat shiny surface. Other interesting surface effects were found in the samples which had copper filings and glass pieces imbedded. These two substances also had a striking effect on glazes.

CONCLUSION

This study has uncovered a few ways in which certain properties of clay used for ceramic sculpture can be improved. There are areas which the project has left open for further study. Because the project was primarily concerned with sculpture, no work was done to find whether or not any of the clay bodies might be suitable for throwing. Studies could be carried out to determine if certain additives which were not satisfactory could prove to work successfully in reduced quantities. More work could be done in the area of imbedding substances, especially metals, in the surface of the clay for their effect on the surface and on glazes. There is much more to be discovered in the area of adding materials to clay, as this project has dealt with only a few of the possibilities.

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