A STUDY IN SOFT PORCELAINS

A Thesis Presented for the Degree of Master of Arts

by

Margaret Steenrod, B.F.A.

OHIO STATE UNIVERSITY

THE OHIO STATE UNIVERSITY

1934

Approved by:

[Signature]
TABLE OF CONTENTS

I. Introduction
   II. Historical Survey........ pages 1-12
III. Technical Study......... pages 13-25
IV. Conclusion............... pages 25-26
V. Illustrations............. pages 27-33
VI. Bibliography............. page - 34
"Once more within the Potter's house alone
I stood, surrounded by Shapes of Clay.

Shapes of all sorts and sizes, great and small,
That stood along the floor and by the wall:
And some loquacious vessels were; and some
Listened perhaps, but never talked at all.

Said one among them - "Surely not in vain
My substance of the Earth was ta'en
And to this Figure molded, to be broke,
Or trampled back to shapeless Earth again."

"Rubaiyat"  Omar Khayyam
With the development of porcelain in China and its exportation through the trade routes linking China with the Near East and Europe, a fresh incentive was given to ceramic art. The choice and hitherto unknown wares coming out of the Orient aroused the greatest admiration and set a new goal for all potters who saw them. Without specific knowledge of the Chinese raw materials or procedure they began to seek some way to imitate the whiteness and translucence of these beautiful new ceramic products.

Not for many years was the mystery of high fire porcelain solved by the potters of Europe. But their efforts produced another distinct contribution to the art, a type of ware now known as soft porcelain. Lacking the hardness and refractoriness of its oriental inspiration, this softer body was nevertheless translucent and possessed a notable quality and beauty of its own. In origin they were imitations but, as developed through the years, soft porcelains form a worthy class of ceramic wares which can stand among their fellows without apology.

In high fire porcelain that much desired quality of translucency is due to the union of kaolin, a non-fusible silicate of alumina, with the fusible alkaline silicate, feldspar. This occurs in the 'grand feu', i.e. 1350-1450°C. On the other hand, soft paste porcelain, as produced in Italy in the 16th C. and in France in the 17th, was compounded of white clay and artificial fusible silicates such as glass or frit. These pastes were fired only to about 1100°C.
In his differentiation of these two types of porcelain, Hanover writes - "Natural, hard porcelain is of a dazzling white, and so hard that steel will not scratch it; it is impermeable to liquids, unaffected by acids. When broken, it presents conchoidal lines of fracture, similar to those seen in flint.

"Artificial, soft porcelain, in which glass or frit has been used as a flux, is never so white as the hard porcelain. It can be scratched with steel, will absorb liquids, is susceptible to the action of acid, and when broken reveals a sugary grain at the fracture, due to its not having been completely "porcellanised."

Probably the earliest ware which may be classified as soft porcelain was the highly silicious artificially compounded body produced in Egypt and usually called Egyptian faience. While this body was frequently very porous, coarse and sandy, some unusually hard fired specimens exist which are translucent in thin section due to the fluxing action of soda which was one of the minor constituents of the paste.

Furnival describes a fragment of porcelain, unquestionably of Egyptian origin, discovered at Sakkara, and attributed to about the 3rd Dynasty (2980 - 2680 B.C.). The


(Chas. Scribner's Sons, New York 1925)
hard translucent body is of a pale blue color and has the following composition:

\[
\begin{align*}
\text{silica} & \quad 36.6 \\
\text{Ferric Oxide} & \quad 0.4 \\
\text{Alumina} & \quad 1.4 \\
\text{ Lime} & \quad 2.1 \\
\text{ Soda} & \quad 5.8 \\
\text{Cupric Oxide} & \quad 1.7
\end{align*}
\]

He continues - "It is thus a true soft porcelain, colored blue by a little copper, and may be imitated by compounding a body from blue glass being prepared of such ingredients as to correspond to the formula:

\[
\begin{align*}
0.23 \text{ CaO} & \\
0.64 \text{ Na}_2\text{O} & \\
0.13 \text{ CuO} & \\
\end{align*}
\]

Firing at 1050\(^\circ\)C. gives a pale blue mass, which turns green if the kiln temperature be raised to about 1200\(^\circ\)C. By reason of the low portion of clay, the body, when damp, is of low plasticity, and is only suitable for moulding into solid shapes like the Egyptian statuette in question. In spite of the non-plastic quality of the body, this type of ware was produced in Egypt for some thousands of years.

This Egyptian development was not an imitation of the Chinese porcelain. In fact it preceded the Chinese

---

invention. Its quality of occasional translucence in thin,
harder fired pieces gives it what may be called an accident-
al claim to be regarded as the first soft porcelain. It is
quite probable that the Egyptian potters themselves did not
seek or especially value this quality. Certainly it does
not seem to have been a main objective with them for most of
the articles produced in this paste were too thick and too
low fired to bring out the body's translucent possibilities.

Chinese porcelain importations into Persia, es-
specially during the time of the Ming Emperors (1368 - 1643)
probably inspired the production of a very delicate, waxy,
translucent white ware which has been much admired by col-
lectors. Much of this "Gombroon" ware (it takes its name
from the English trading station of that name on the Persian
Gulf) was exported to Europe and may be regarded as the
starting point of all the soft-paste porcelains of Italy,
France, Spain and England.

The body of this Persian porcelain is believed to
have been compounded of a washed white pipe-clay and glass.
It is somewhat gritty and crumbles readily when scratched
with a file. The faint creamy or greenish glaze which is
usually used presents a soft waxy surface.

The high expression attained by the Persian potter
can best be described in the words of William Burton. "It
surely cannot be fanciful to suggest that this Persian por-
celain with its softness and tenderness of texture and dec-
oration, typifies the dreamy, poetic and imaginative nature
of the Persian intellect, which is in such marked contrast with the noble grandeur of the Greek or the Chinese mind which always displays a reserved, stern and eminently practical character. All the arts as practiced in Persia serve to reflect the same essential spirit, and the work of the Persian potter, whether in his rich, painted faience or in his delicate porcelain, has contributed more appropriate decorative ideas to his fellow-craftsmen of other races than were ever derived from the study of Greek vases, which, from the rebirth of classicism in Europe about the middle of the 18th C., have weighted like veritable "old men of the sea" on the shoulders of English, French and German potters alike. One is almost tempted to say that one Graeco-Roman Vase of glass, the famous Portland or Barberini Vase in the Gem Room of the British Museum, has wrought more evil, in misleading the footsteps of modern European potters, than will be undone in another hundred years, while all along the truly appropriate decorative pottery of the Middle East has been awaiting due recognition and honor."

Considering the close trade relations existing during the Middle Ages between the great mercantile cities of northern Italy and the Levant, and the travels of such

---


Funk and Wagnalls Co. New York 1921

-5-
men as Marco Polo who made his way overland through Persia and China to the Pacific coast - it is not strange that the first attempts to reproduce the much sought for Chinese porcelain occurred in Venice, that city whose artisans were long skilled in industries of Oriental origin - above all, that of glass making. The first documentary evidence of such a manufacture (there are no known examples of it) is in a letter written by Ulielmo da Bologna in 1470 to a friend at Padua. With this letter were forwarded two pieces of transparent and very light porcelain, the work of an alchemist at Venice - Maestro Antonio. Considerably later (1519) at Ferrara "porcellana fecta" was manufactured under the patronage of Alfonso II. These old alchemists seem to have started with the idea of combining the properties of glass and of faience by mixing a frit or glass with various kinds of pure white clay.

The Medici soft porcelain, of which a number of examples have been preserved, was invented in Florence during the reign of Francesco Maria, second Grand-Duke of Tuscany (1574 - 1587). An account of its manufacture states that it was composed of impure china clay (terra di Vicenza), a fine white sand and powdered glass. The materials used, as well as the style of some of the decoration, definitely connects the Medici porcelain with the work of the Nearer rather than that of the Farther East, and is the connecting link between the glassy Persian porcelain and the related
wares of France, England and the other countries of Western Europe.

About a hundred years later (1673), independent of the discovery of the Medici soft porcelain but quite similar to it, there appeared at Rouen, France, the first French porcelain. Edme Poterat and his son Louis are accredited with its discovery. A more extensive manufacture of pâte tendre occurred at St. Cloud. This white or more frequently yellowish porcelain, invented in 1677 by Pierre Chicaneau, is highly translucent and greenish by transmitted light and forms the proper introduction to the soft-paste wares of France. Artistically speaking, the most important French soft porcelain of this earlier period was produced at the factory in Chantilly, founded in 1725 by Louis-Henri de Bourbon, Duc de Conde.

The soft paste developed at Vincennes from 1740 to 1755 at which time the factory was transferred to Sèvres, was a technical improvement over that of the earlier manufacture of St. Cloud, Chantilly and the other small factories. It is this perfection of the beautiful but impractical material at Vincennes that accounts for the favored position which soft porcelain held in France, despite the invention of true hard porcelain by Böttger (about 1708) at Meissen, Germany. Hanover writes that it was under the influence of the factory at Meissen that the Vincennes-Sèvres factory came into existence, and that it was the consciousness of the victorious march of Saxon porcelain through Europe which
caused disquiet among the French potters and awakened them to a recognition of the fact that serious efforts were necessary to meet the German competition. Early securing the protection and patronage of the French crown (1763) this factory at Sevres became most important, supplying the dinner services and decorative pieces for almost every court in Europe.

A strictly private document, written for the king in 1753 by Jean Hellot, director of the Vincennes pottery, gives the composition of the frit used at that factory as follows:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fused nitre</td>
<td>22.0</td>
</tr>
<tr>
<td>Sea salt</td>
<td>7.0</td>
</tr>
<tr>
<td>Alicante soda</td>
<td>3.7</td>
</tr>
<tr>
<td>Rock alum</td>
<td>3.7</td>
</tr>
<tr>
<td>Montmartre gypsum</td>
<td>3.7</td>
</tr>
<tr>
<td>Fontainebleau sand</td>
<td>30.0</td>
</tr>
</tbody>
</table>

This frit varied little in composition up to the close of the soft-paste production in France. After being melted, pulverized and washed, it was combined with the other ingredients which made up the body. Six parts of this frit were mixed with one part of washed marl found at Argenteuil and one part of chalk (called blanc d'Espagne, which later was dispensed with). These were ground together for nine days and the resulting paste made into balls and allowed
to age for seven or eight months.\textsuperscript{1}

Because of the small amount of clay present (Salvétat finds only 2.23% alumina in a fragment of old Sévres) this paste was extremely "short" or non-plastic, and in order to be thrown on the wheel or even moulded, had to be worked up with a mixture of black soap or glue. Later gum tragacanth was used. These difficulties later were partly overcome by the introduction of the English process of casting.

Hellot writes that after the long biscuit fire (a hundred hours or more) in which poplar wood was burned, more than two-thirds of the pieces had generally to be rejected. After being polished the remaining biscuit was thickly covered with a glaze consisting of litharge (nearly 40%), Fontainebleau sand, soda, flint and potash, and fired again at a lower temperature.\textsuperscript{2} The ware was then decorated with pigments suspended in a flux similar to the base glaze. The temperature of the decorating kiln caused these colors to become completely incorporated with the underlying glaze. This last firing was a long and complicated process, often lasting for fifteen days.\textsuperscript{3} In view of the above, it is not to be wondered that French soft-porcelain manufacture was

\begin{itemize}
\item \textsuperscript{1} Edward Dillon "Porcelain" (Methuen) 1904 pp. 279 - 280
\item \textsuperscript{2} Emil Hanover "Pottery and Porcelain"(Scribner's)Vol.III p.277
\item \textsuperscript{3} Edward Dillon "Porcelain" (Methuen) 1904 p. 282
\end{itemize}
never a financial success and, in order to exist, had to receive support from the Crown.

The manufacture of hard porcelain was introduced at Sèvres in 1708 but soft porcelain continued to be made until 1804, at which time it was finally abandoned by Brongniart, the new director.¹

Considerable soft porcelain was produced in England about the middle of the 18th C. Instead of adopting the hard porcelain as the Continent was doing by this time, England was still endeavoring to improve the French soft porcelain. In order to give it a longer firing range, the sand and glass were in part replaced by bone ash. By the beginning of the 19th C. Spode replaced the remainder of the glassy frit by kaolin and china-clay, retaining the bone ash. Here we have produced a new kind of porcelain — the so-called "bone china", china being the English term for porcelain. It comes about midway between the hard and soft pastes in regards to whiteness, hardness and impermeability.

The composition of this porcelain, produced in Staffordshire in 1840 is:

- Cornish kaolin 31.0
- Cornish china-stone 26.0
- Flint 2.5
- Prepared bones 40.5

At present this Staffordshire porcelain is composed of

¹ Edward Dillon "Porcelain" (Methuen) 1904 p. 303
bone-ash 8 parts, china-stone 4 parts and kaolin 3 1/2 parts. The glaze for these earlier wares was compounded from white lead, nitre, and salt. Later a harder glaze was used, considerable amounts of china-stone, china-clay and a little borax being added to the above.¹

"Belleek China", a further development of this Staffordshire porcelain, was first manufactured under the direction of Robert Williams Armstrong in 1857 at Belleek Ireland. This early Belleek may be classed as a soft porcelain or glazed "Parian". The original body composition is approximately:

- Pulverized Frit 50
- Ball Clay 10
- Cornwall China Clay 30
- Flint 10

the frit being made up of Soda Spar 60%, Whiting 20% and Flint 20%.² Belleek is noted for its great thinness, toughness, light weight and its beautiful iridescent glaze prepared with a salt of bismuth.

The manufacture of Belleek China was introduced into America about 1892 by William Bromley Jr., of the

1. Edward Dillon "Porcelain" (Methuen) 1904 p. 330
2. Watts' Notes - "Bodies, Glazes and Colors" Cer. Eng. 605

Ohio State University.

-11-
Ott & Brewer Co. of Trenton New Jersey. This china has been greatly improved in recent years. It contains a calcine, made from feldspar and a small addition of $K_2CO_3$ and $K_2BO_3$, and a small amount of frit which are ground wet for 200 hours. This seems to be more satisfactory than the old method of fusing a greater amount of glass and grinding a shorter time. The composition, as given by Watts, is:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frit</td>
<td>20</td>
</tr>
<tr>
<td>Calcined Feldspar</td>
<td>40</td>
</tr>
<tr>
<td>Ball Clay</td>
<td>10</td>
</tr>
<tr>
<td>China Clay</td>
<td>30</td>
</tr>
</tbody>
</table>

the frit being Feldspar 25%, Cornwall Stone 10%, Pearl Ash ($K_2CO_3$) 5%, Flint Glass 5%, and Sand 55%. This body resists warping much better than the original Belleek and is also much tougher. It is biscuited at about Cone 6 and glazed at Cone 1 with a soft boro-silicate glass.

1. Watts' Notes - "Bodies, Glazes and Colors" Cer. Eng. 605
Ohio State University.
This study in soft pastes grew out of an attempt to reproduce a body similar to the Egyptian and Persian soft porcelains. These were very high silica bodies, low in alumina and contained soda as a flux. They were glazed with an alkaline glaze which in some cases has fitted the body. The analysis of the Egyptian paste as given by Furnival is silica 38.0%, soda 5.8%, lime 2.1%, alumina 1.4%, cupric oxide 1.7%, and ferric oxide 0.4%.

In the attempt to approach this type of low fire porcelain, the following batch was made up:

<table>
<thead>
<tr>
<th>Body</th>
<th>Jasper Flint</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powdered Glass</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>M and M English Ball Clay</td>
<td>10</td>
</tr>
</tbody>
</table>

Assuming the flint to be pure SiO₂, the glass \( \frac{0.5 \text{ Na}_2\text{O}}{0.5 \text{ CaO}} \cdot 3.0 \text{ SiO}_2 \cdot 2 \text{ Al}_2\text{O}_3 \cdot 2 \text{ H}_2\text{O} \), the above body was calculated in terms of the materials given by Furnival (see above) in the Egyptian analysis. The similarity between the two may be seen:

1. Furnival, "Leadless Decorative Tiles, Faience, and Mosaics"  
   (W. J. Furnival, Stone, Staffordshire) 1904, p. 39.
Egyptian Porcelain

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Body I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>88.6</td>
<td>84.68</td>
</tr>
<tr>
<td>Soda</td>
<td>5.8</td>
<td>6.44</td>
</tr>
<tr>
<td>Lime</td>
<td>2.1</td>
<td>2.89</td>
</tr>
<tr>
<td>Alumina</td>
<td>1.4</td>
<td>4.98</td>
</tr>
<tr>
<td>Cupric Oxide</td>
<td>1.7</td>
<td>-</td>
</tr>
<tr>
<td>Ferric Oxide</td>
<td>0.4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>99.99</td>
</tr>
</tbody>
</table>

To test the matter of glaze fit (one of the main problems in this study) the following was used:

Glaze (1) \[
0.8 \text{Na}_2\text{O} \quad \begin{aligned} \text{0.4 B}_2\text{O}_3 \\ \text{0.2 CaO} \end{aligned} \quad 1.95 \text{SiO}_2
\]

Equivalent Batch Weights:

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcined Borax</td>
<td>18.83</td>
</tr>
<tr>
<td>Sodium Silicate (Philadelphia Quartz Co., SS-20)</td>
<td>71.85</td>
</tr>
<tr>
<td>Whiting</td>
<td>9.32</td>
</tr>
</tbody>
</table>

While this differs from the analysis of the early Egyptian glaze in that it contains boracic acid, its color possibilities and general characteristics are very similar.

Although Body I is higher in clay content than the Egyptian porcelain, it is still quite short in plasticity. To improve this condition an addition of 3% Bentonite was made. This is a very fine grained plastic material and is quite similar in composition to clay. With this addition of bentonite, Body I throws nicely and in the form of slip can be cast. It has a long firing range, being translucent at Cone 02 and withstands Cone 10 with no
visible change in body structure. It is very white and hard, has a sugary fracture and a punky ring. All types of glazes were tried on it, the alkalines causing it to shiver, the others being absorbed.

In order to correct the shivering tendency, feldspar and additional clay were substituted for a part of the flint:

<table>
<thead>
<tr>
<th>Body II</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Powdered Glass</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Keystone Spar</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>M and M English Ball Clay</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Bentonite, 3%</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

In throwing and casting this is about the same as Body I. The firing range is not so long, being translucent at Cone 04 and quite white and hard at Cone 4. At Cone 4, it has a conchoidal fracture. The ring is slightly improved. Glaze (1) crazes which is just the opposite extreme of shivering.

<table>
<thead>
<tr>
<th>Body III</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Powdered Glass</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Bone Ash</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>M and M English Ball Clay</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Bentonite, 3%</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

The substitution of bone ash for spar in II produced a body so short that it was unworkable.
Body IV

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint</td>
<td>60</td>
</tr>
<tr>
<td>Keystone Spar</td>
<td>10</td>
</tr>
<tr>
<td>Bone Ash</td>
<td>10</td>
</tr>
<tr>
<td>Hommel's #8 Flux</td>
<td>10</td>
</tr>
<tr>
<td>M and M English Ball Clay</td>
<td>10</td>
</tr>
<tr>
<td>Bentonite, 3%</td>
<td>100</td>
</tr>
</tbody>
</table>

This body, in which spar, bone ash and a high lead flux are substituted for the glass in I, is very short but can be thrown. It is not castable. At Cone 02 it is quite vitreous and translucent, the transmitted light being a warm cream. It has the concoidal fracture and melodious ring of the true high fire porcelains. After six months, Glaze (1) began to craze. A variation of this glaze in which a substitution of bone ash was made for half the whiting fitted Body IV. A number of other alkaline glazes were here introduced and tried:

Glaze (2) Cone 010

\[
\begin{align*}
0.8 \text{ Na}_2\text{O} & \quad 2.0 \text{ SiO}_2 \\
0.2 \text{ ZnO} & \quad 0.1 \text{ SnO}_2
\end{align*}
\]

Equivalent Batch Weights:

<table>
<thead>
<tr>
<th>Component</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Silicate</td>
<td>73.53</td>
</tr>
<tr>
<td>Soda Ash</td>
<td>10.11</td>
</tr>
<tr>
<td>Zinc Oxide</td>
<td>7.73</td>
</tr>
<tr>
<td>Flint</td>
<td>1.43</td>
</tr>
<tr>
<td>Tin Oxide</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

Glaze (2) Cone 06  0.8 Na₂O
    0.1 K₂O
    0.2 ZnO
    0.1 CaO

    0.1 Al₂O₃we
    2.0 SiO₂
    0.1 SnO₂

Equivalent Batch Weights:

Sodium Silicate (SS-20)  60.62
Keystone Spar  22.23
Zinc Oxide  6.44
Whiting  3.38
Tin Oxide  6.01
Flint  72

100.00

Glaze (4) Cone 06  0.5 Na₂O
    0.1 K₂O
    0.2 ZnO
    0.2 CaO

    0.1 Al₂O₃we
    2.0 SiO₂
    0.1 SnO₂

Equivalent Batch Weights:

Sodium Silicate (SS-20)  54.36
Keystone Spar  23.65
Zinc Oxide  6.85
Bone Ash  8.71
Tin Oxide  6.43

100.00

Glaze (S) Cone 06

\[
\begin{align*}
0.5\ Na_2O \\
0.1\ K_2O \\
0.2\ ZnO \\
0.2\ CaO \\
\end{align*}
\]  \[\begin{align*}
0.2\ Al_2O_3 \\
\{2.0\ SiO_2 \\
\{0.1\ SnO_2 \\
\end{align*}\]

Equivalent Batch Weights:

- Sodium Silicate (38-20) \(52.11\)
- Keystone Spar \(22.67\)
- Zinc Oxide \(6.57\)
- Bone Ash \(8.35\)
- Tin Oxide \(6.16\)
- Alumina \(4.14\)

\[100.00\]

These glazes all fit Body IV.

Still seeking a body which would fit Glaze (1), the following was tried:

Body V

- Flint \(45\)
- Powdered Glass \(15\)
- Keystone Spar \(10\)
- Bone Ash \(5\)
- Hommel's #8 Flux \(5\)
- Bedminster Ball Clay \(15\)
- English China Clay \(5\)
- Bentonite, 3% \(100\)

This body is good for throwing but unsuitable for casting. It is translucent at Cone 03 and is self-glazed at Cone 5. The color is slightly yellow, this being intensified with the temperature increase. It has the conoidal
fracture and ring of true porcelain. Glaze (1) fits this body when it has been biscuited at a low temperature — about Cone 05. It crazes upon the vitrified body.

Substituting china clay for all the bone ash and a part of the feldspar, the following batch was derived:

Body VI

<table>
<thead>
<tr>
<th>Material</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint</td>
<td>45</td>
</tr>
<tr>
<td>Powdered Glass</td>
<td>15</td>
</tr>
<tr>
<td>Keystone Spar</td>
<td>5</td>
</tr>
<tr>
<td>Hommel's #8 Flux</td>
<td>5</td>
</tr>
<tr>
<td>Redminster Ball Clay</td>
<td>15</td>
</tr>
<tr>
<td>English China Clay</td>
<td>15</td>
</tr>
<tr>
<td>Bentonite, 3%</td>
<td>100</td>
</tr>
</tbody>
</table>

Here the working properties are about the same as for Body V. It is hard and translucent at Cone 4, the transmitted color being a pleasing warm-yellow. It has a punky ring and does not fit Glaze (1).

Another series of body experiments was run parallel to Bodies IV, V, and VI. These are blends between Bodies I and II. Replacing 10% of the flint in Body I with equal parts of ball clay and spar, one arrives at:

Body VII

<table>
<thead>
<tr>
<th>Material</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flint</td>
<td>50</td>
</tr>
<tr>
<td>Powdered Glass</td>
<td>30</td>
</tr>
<tr>
<td>Keystone Spar</td>
<td>5</td>
</tr>
<tr>
<td>M and M English Ball Clay</td>
<td>15</td>
</tr>
<tr>
<td>Bentonite, 3%</td>
<td>100</td>
</tr>
</tbody>
</table>

This can be thrown and cast. The firing range is about the same as for Body II, the body being translucent.
at Cone 04 and vitreous at Cone 4. It has a sugary fracture, punky ring, and in color is a pure white. Glaze (1) crazes upon it but variations of this containing from 10 to 30% additional silica, fit.

<table>
<thead>
<tr>
<th>Body VII</th>
<th>Flint</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powdered Glass</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Aluminum Hydrate</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>M and M English Ball Clay</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Bentonite, 3%</td>
<td>100</td>
</tr>
</tbody>
</table>

This replacement of 10% flint in Body I by aluminum hydrate does not show any marked improvement over the other experiments.

A 50 - 50 blend of Bodies I and VII was next tried. It is:

<table>
<thead>
<tr>
<th>Body IX</th>
<th>Flint</th>
<th>55.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powdered Glass</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>Keystone Spar</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>M and M English Ball Clay</td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>Bentonite, 3%</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Glaze (1) fitted this body, but as Glaze (2) caused it to dunt, still another body was tried. This time the ball clay was increased at the expense of flint in I as follows:

<table>
<thead>
<tr>
<th>Body X</th>
<th>Flint</th>
<th>55</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Powdered Glass</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>M and M English Ball Clay</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Bentonite, 3%</td>
<td>100</td>
</tr>
</tbody>
</table>
This body has proven to be quite satisfactory. It throws well and can be cast. The firing range is quite long, the body being translucent at Cone 04 and withstanding Cone 8. Blisters develop when the temperature is carried higher than this. The body is quite white and hard but has the characteristic sugary fracture and puny ring of the early soft porcelains. All the alkaline glazes fit it.

A number of different clays have been used to improve the plasticity of this body, the most successful being Texas Kaolin. In a further development of Body X, Federal Frit #1 was substituted for glass:

<table>
<thead>
<tr>
<th>Body XI</th>
<th>Flint</th>
<th>55</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Federal Frit #1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Texas Kaolin</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Bentonite, 3%</td>
<td>100</td>
</tr>
</tbody>
</table>

This body is much more plastic and castable if .06% Crystalline Soda is added to the batch before grinding. The firing range is very short, the body self-glazing at Cone 05 - 04 and deforming when the temperature rises above this. It is quite vitreous and has a concoidal fracture. The color is a waxy white and resembles quite closely the "Parian" body developed in England at the Spode factory. The velvety texture of the unglazed biscuit suggests the possible use of this material for statuettes and cameo-like decorations.

1. \[
0.316 \text{ Na}_2\text{O} + 0.684 \text{ CaO} + 0.8 \text{ B}_2\text{O}_3 + 1.47 \text{ SiO}_2
\]
The desire to produce a body characteristic of the Egyptian colored faience led to another series of experiments in which an attempt was made to introduce color into the above translucent pastes and still retain their translucency. As a means of introducing this color, a series of stains was made up, calcined at Cone 9, and pulverized to 100 mesh. These were introduced into Bodies I. and X, percentage additions being made directly to the paste or replacing the flint in part.

(a) Cobalt-blue Stain

\[
\begin{align*}
&0.2 \text{ Na}_2\text{O} \\
&0.8 \text{ MgO} \\
&1.4 \text{ B}_2\text{O}_3 \\
&1.714 \text{ SiO}_3
\end{align*}
\]

Equivalent Batch Weights:

- Sodium Silicate (88-20) 20.57
- Talc 40.23
- Boric Acid 39.20
- \( \text{Co}_3\text{O}_4 \) 7% 100.00

As this was too fluid at Cone 9, talc and flint were added to stiffen the batch, 40% being found to be about the right amount. 15% of the stain with additional talc was substituted for that amount of flint in Bodies I. and X.

Biscuited at Cone 03, the bodies were not translucent until after being glazed with Glaze (1). The color under Glaze (1) is a deep purple-blue.

The same tests were repeated, this time substituting the stain in which 40% flint has been added. These bodies were translucent in thin section at Cone 03 but the color was not so deep.
(b) Brown Stain

\[
\begin{array}{c}
0.8 \text{ Na}_2\text{O} \\
0.2 \text{ CaO}
\end{array}
\]

\[
6 \text{ SiO}_2
\]

Equivalent Batch Weights:

- Flint: 61.5
- Sodium Silicate (8S-20): 35.1
- Whiting: 3.4

Total: 100.0

A manganese brown stain was made by adding 5 to 10\% \text{ MnCO}_3 to the above base and calcining at Cone 9. Substituted for flint in Body I, a test containing 15\% of the 5\% manganese stain was translucent at Cone 2. Under Glaze (1) the color was a pinkish-tan.

(c) Copper Blue Stain

Using the same base as stain (b), stains containing up to 20\% \text{ CuCO}_3 were tried. A body in which 10\% of the 20\% copper stain was substituted for that amount of flint in Body I, was translucent in thin section from Cone 3 to Cone 10. It dulled under Glaze (1). In a 15\% replacement by this same stain, the body was translucent at Cone 6 and again withstood Cone 10. It likewise dulled when glazed with Glaze (1). Biscuited at a lower temperature, this glaze fits. A beautiful intense copper blue color was obtained.

20\% of this 20\% copper stain replacing flint in Body \text{ X} produced a deep green body which was translucent at Cone 1. 20\% of the 15\% copper stain produced a beautiful robin-egg blue. Fired at Cone 010 - 07, this second body takes a fine polish and closely resembles in color and
texture a number of small Egyptian human and animal reliefs in the Carnarvon Collection of the Metropolitan Museum.

A series of experiments was made in which soda was added to the above colored body in an effort to obtain a "self glazed" effect upon the fired body. The alkali was added in three different ways:

(1) 7% Crystalline Soda replaced that amount of Powdered Glass in the batch:

Flint 35
15% Copper Stain 20
Texas Kaolin 15
Powdered Glass 23
Crystalline Soda 7
Bentonite, 3% 100

Upon drying, this soda crystallized in a very thin layer upon the surface of test vases thrown from this body, and when fired to Cone 012 - 011, caused the pieces to be covered with a thin alkaline glaze.

(2) The unfired colored body was dipped in a soda solution and allowed to dry, the results being the same as (1) above.

(3) In a third method, this soda, suspended in Bentonite (83.33% Soda, 16.67% Bentonite) was painted over the unfired body and fired to Cone 012 - 011.

In all of these, the very thin soda glaze fitted the body. The second and third methods of supplying the soda are best suited for the glazing of pieces cast or pressed.
in plaster molds as soda destroys the plaster.

The success of these tests tends to confirm the belief that at least some of the Egyptian ware was glazed in a similar manner by soluble fluxing agents introduced into the body.

Because of the sandy, non-plastic nature of his material, the Egyptian potter's use of his soft paste body was limited to small simple shapes and a wide variety of statuettes and small ornaments which could be pressed in molds. The bodies which have been developed in the study here reported are greatly superior to their Egyptian ancestors in workability. They not only may be pressed and cast in moulds, but some of them may be formed successfully on the potter's wheel. They have the favorable characteristics of the Egyptian paste; its ability to hold alkaline glazes without crazing and its potential quality of translucence when fired to the required temperature, which in the case of several of the new bodies is remarkably low. While these bodies require perhaps a bit too careful treatment to be practical for routine commercial use, in the hands of the individual potter who is willing to
spend time and care upon his product, they have excellent possibilities some of which have been demonstrated in the finished pieces which accompany this report.

All potters have been interested in the beautiful color possibilities of alkaline glazes; the brilliant, luminous blue of copper, the egg-plant purple of manganese, and others. These glazes, however, are almost impossible to use without crazing on any ordinary ceramic body. Some of the bodies in the present study offer a promising advance step toward solving this problem.

Among other uses to which these bodies are especially suited may be mentioned the production of costume jewelry, small ceramic sculpture and other ornamental objects. To the ceramic artist possessing imagination and patience, this field offers possibilities for the production of fine and beautiful things with a very modest investment in space, materials and equipment.
Fig. I

A Persian (Rhages) bowl, dating from the 13th C. The dense body is light buff and of the soft porcelain type. Its turquoise blue glaze has iridescent areas due to the decomposition of the alkaline glaze. An incised inscription decorates the piece. The background has been pierced and then filled with glaze.

Courtesy - the Freer Gallery of Art
Washington, D.C.
Fig. II

A shallow 4 inch bowl with deep spreading foot. This is an example of Body X (see p. 20). The turquoise blue alkaline glaze fits the body. The bird and leaf decoration is carved and the background pierced. These openings are filled with glaze.
Fig. III

View of Fig. II with illumination from beneath to show the pierced pattern.
Fig. IV

A small light bulb 4 inches in height and glazed with a turquoise blue glaze. The floral decoration is carved and the background pierced. Glaze fills the openings.
Fig. V

View of light bulb Fig. IV, illuminated to show piercing.
Fig. VI

Facsimile of a hieroglyphic sign meaning "Millions of Years" - in the Carnarvon Collection of the Metropolitan Museum, New York City.

It is an example of Body X in which a copper blue stain was used (see pp. 23-24). The unglazed blue body is polished. The inlaid decoration is in a purple blue. This is on file in the office of the Fine Arts Department.
Figs. VII, VIII, and IX

The pendant and carved scarab ring sets are of the same polished body as used in Fig. VI. The mounting was designed by Wilbur Varne West and executed in silver by T.K. Compton.
BIBLIOGRAPHY

Barber, Edwin Atlee.
The Pottery and Porcelain of the United States.

Burton, William.
A History of Porcelain, Vol. I.
Funk and Wagnalls Co. New York, 1921.

Dillon, Edward.

Furnival, William James.
Leadless Decorative Tiles, Faience, and Mosaics.
W.J. Furnival, Stone, Staffordshire - 1904.

Hanover, Emil.
Pottery and Porcelain, Vols. II and III.
Chas. Scribner's Sons, New York - 1925.

Holl, Arnulf.
Turquoise Glazes. (Abstract from Keramos, in

Watts, Arthur S.
Notes - Bodies, Glazes and Colors - Ceramic
Engineering, 305 - Ohio State University.