A DESCRIPTIVE ANALYSIS OF THE KILNING TECHNIQUES AND TYPES OF CLAY USED BY THE TRADITIONAL POTTERS OF LYAMAGALE VILLAGE IN WESTERN PROVINCE OF KENYA, WITH A VIEW TO SUGGESTING IMPROVEMENTS

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN KENYATTA UNIVERSITY

By

MARGARET M.N. OTENYO

JUNE, 1984
"THIS THESIS IS MY ORIGINAL WORK AND HAS NOT BEEN PRESENTED FOR A DEGREE IN ANY OTHER UNIVERSITY".

Margaret M.N. Otenyo

"THIS THESIS HAS BEEN SUBMITTED FOR EXAMINATION WITH OUR APPROVAL AS UNIVERSITY SUPERVISORS".

Prof. G.S. Eshiwani

Mrs. M.A. Mambo

Mr. C. Agbemenu
DEDICATION

To my loving parents, Jane K. Otenyo and Julius H. Otenyo
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Tables</td>
<td>vii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
<tr>
<td>List of Plates</td>
<td>ix</td>
</tr>
<tr>
<td>List of Maps</td>
<td>xii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>xiii</td>
</tr>
<tr>
<td>Abstract</td>
<td>xv</td>
</tr>
</tbody>
</table>

### CHAPTER ONE

1.0 Introduction 1
1.1 Problem and Background of the Study. 9
1.2 Purposes of the Study 11
1.3 Statement of the Problem 12
1.4 Definition of Terms 13
1.5 Hypotheses 19b

### CHAPTER TWO

... Review of Related Literature 20
2.1 Clay Description and Properties 27
2.2 Preparation of Clay 38
2.3 Reaction of the Clay in Fire 40
2.4 Influence of Major Constituents of Clay 46
CHAPTER THREE: Design and Procedure of the Study

3.0 Chemical Analysis and Petrological Examination of Clay Samples

3.1 Physical Analysis of the Clay Samples

3.2 The Research Design

3.3 The Experiments

3.4 Test for Porosity and Vitrification

3.5 Limitations of the Study

CHAPTER FOUR: Data Analysis, Results and Observations

4.0 The Pottery-Making Procedure by the Traditional Potters in Lyamagale

4.1 Interview with the Potters

4.2 Results of Clay Analysis

4.3 Observation of the Firings

4.4 Wastage

4.5 Data Analysis

4.6 Observation

4.7 Hypotheses Testing
**CHAPTER FIVE: Summary, Recommendations, Comments and Implications 151**

| 5.0 | Summary | 151 |
| 5.1 | Answers to the Research Questions on the Lyamagale Pottery-Making Processes. | 156 |
| 5.3 | Comments on the Experimental Pots | 162 |
| 5.4 | Conclusion | 167 |
| 5.5 | Implications for Further Research | 174 |

Appendices 177

Bibliography 196
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLES</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Comparison of Mineral Composition of an Igneous Rock and Sedimentary Red-Burning Clay.</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>Average Chemical Composition of Clay, Shale and Schist.</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>Drying Shrinkage of Clays</td>
<td>37</td>
</tr>
<tr>
<td>4</td>
<td>The Research Design</td>
<td>57</td>
</tr>
<tr>
<td>5</td>
<td>Chemical Composition of Clay Samples in Percentage</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Shrinkage of the Clay Samples</td>
<td>103</td>
</tr>
<tr>
<td>7</td>
<td>Wastage from the Sawdust Firing</td>
<td>108</td>
</tr>
<tr>
<td>7b</td>
<td>Wastage From the Potters Firing</td>
<td>114</td>
</tr>
<tr>
<td>8</td>
<td>Record of Wastage</td>
<td>116</td>
</tr>
<tr>
<td>9</td>
<td>Kiln Wastage</td>
<td>117</td>
</tr>
<tr>
<td>10</td>
<td>Wastage of the Building Techniques in each Clay.</td>
<td>118</td>
</tr>
<tr>
<td>11</td>
<td>Wastage Percentage of each clay</td>
<td>118</td>
</tr>
<tr>
<td>12</td>
<td>Record of Wastage of clays per Kilning Technique.</td>
<td>119</td>
</tr>
<tr>
<td>13</td>
<td>Wastage of Building Technique 1</td>
<td>120</td>
</tr>
<tr>
<td>14</td>
<td>Wastage of Building Technique 2</td>
<td>121</td>
</tr>
</tbody>
</table>
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set-up for the Bonfire Firing</td>
<td>61</td>
</tr>
<tr>
<td>2</td>
<td>The Raku Kiln</td>
<td>67</td>
</tr>
<tr>
<td>3</td>
<td>Arrangement of Clay Rings in the kiln</td>
<td>69</td>
</tr>
<tr>
<td>4</td>
<td>The Gas Kiln for Bisque Firing</td>
<td>74b</td>
</tr>
<tr>
<td>5</td>
<td>Gas Kiln for Raku Technique</td>
<td>75</td>
</tr>
<tr>
<td>6</td>
<td>Positions of the Cracked Pots from the Bottom Layer</td>
<td>106</td>
</tr>
<tr>
<td>7</td>
<td>Positions of the Cracked Pots from the Top Layer</td>
<td>107</td>
</tr>
<tr>
<td>8</td>
<td>Positions of the Cracked Pots in the Sawdust Firing</td>
<td>109</td>
</tr>
<tr>
<td>9</td>
<td>Positions of the Cracked Pots in the Gas Firing</td>
<td>110</td>
</tr>
<tr>
<td>10</td>
<td>Positions of the Cracked Pots in the Bisque Firing for the Raku Technique.</td>
<td>111</td>
</tr>
</tbody>
</table>
## LIST OF PLATES

<table>
<thead>
<tr>
<th>PLATE</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digging clay on the banks of Hangai stream</td>
<td>128</td>
</tr>
<tr>
<td>2</td>
<td>The potters carrying the clay to the village</td>
<td>128</td>
</tr>
<tr>
<td>3</td>
<td>The three different colour samples (Black, Cream and Red)</td>
<td>129</td>
</tr>
<tr>
<td>4</td>
<td>Each of the clay samples being crushed separately</td>
<td>129</td>
</tr>
<tr>
<td>5</td>
<td>Water being sprinkled on the clay as it is crushed</td>
<td>130</td>
</tr>
<tr>
<td>6</td>
<td>The samples are heaped together to form a complete mixture</td>
<td>130</td>
</tr>
<tr>
<td>7</td>
<td>The clay is pounded to make a uniform mixture</td>
<td>131</td>
</tr>
<tr>
<td>8</td>
<td>Handwedging the clay</td>
<td>132</td>
</tr>
<tr>
<td>9</td>
<td>Removing pebbles and air from the clay in preparation for moulding</td>
<td>133</td>
</tr>
<tr>
<td>10</td>
<td>A crack on a raw pot</td>
<td>133</td>
</tr>
<tr>
<td>11</td>
<td>Moulded pots set in the sun to get leather hard before fixing their necks and mouths</td>
<td>134</td>
</tr>
<tr>
<td>12</td>
<td>Fixing the first coil in the process of building the neck and mouth of a pot</td>
<td>134</td>
</tr>
<tr>
<td>13</td>
<td>Smoothening the lip of the pot using the palm of the hand</td>
<td>135</td>
</tr>
<tr>
<td>14</td>
<td>Giving the final touch to the rim using the forefinger and the middle finger</td>
<td>135</td>
</tr>
<tr>
<td>15</td>
<td>Scrapping the bottom of the pot after removing it from the cradle</td>
<td>136</td>
</tr>
<tr>
<td>PLATE</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>16</td>
<td>Padding the base of the pot with a cows' spatula</td>
<td>136</td>
</tr>
<tr>
<td>17</td>
<td>Decorating the pot with a plaited cord roulette</td>
<td>137</td>
</tr>
<tr>
<td>18</td>
<td>Drying the pots indoors</td>
<td>138</td>
</tr>
<tr>
<td>19</td>
<td>Pots being dried in the sun just before the firing</td>
<td>139</td>
</tr>
<tr>
<td>20</td>
<td>The set-up of the firing: the biggest pot is put in the centre</td>
<td>139</td>
</tr>
<tr>
<td>21</td>
<td>The smaller pots made to surround the biggest pot</td>
<td>140</td>
</tr>
<tr>
<td>22</td>
<td>Twigs placed in between the pots and their mouths made to face in different directions</td>
<td>140</td>
</tr>
<tr>
<td>23</td>
<td>More twigs piled over the pots</td>
<td>141</td>
</tr>
<tr>
<td>24</td>
<td>The pots covered with dry grass</td>
<td>142</td>
</tr>
<tr>
<td>25</td>
<td>Green grass piled over the heap and the mass tied up with a rope</td>
<td>143</td>
</tr>
<tr>
<td>26</td>
<td>Lighting the pyre from the base</td>
<td>143</td>
</tr>
<tr>
<td>27</td>
<td>The pyre poked with a stick as it burns</td>
<td>144</td>
</tr>
<tr>
<td>28</td>
<td>Unloading the pots from the mouldering pyre</td>
<td>144</td>
</tr>
<tr>
<td>29</td>
<td>The stick used for unloading the pots ablaze</td>
<td>145</td>
</tr>
<tr>
<td>30</td>
<td>A cracked pot</td>
<td>145</td>
</tr>
<tr>
<td>31</td>
<td>A thrown Western clay pot after the bisque firing for the Raku technique. It shows little cracks in a patch of creamish clay indicating an uneven mixture</td>
<td>146</td>
</tr>
</tbody>
</table>
A Western clay pot built by the coil method and fired by the Sawdust technique. It shows the points from which the cracks spread

A thrown Western clay pot fired in the Gas kiln. It shows bigger and deeper cracks. Note the manner in which the cracks spread!

A thrown Western clay pot fired by the Sawdust technique. It shows a pebble that was about to force its way out of the wall of the pot leaving a hole and probably damaging the neighbouring pots

A thrown Western clay pot after the bisque firing for the Raku technique. This pot was in the process of fusing

A Nyeri clay pot built by the coil method and fired by the Sawdust technique. It shows a chipped bottom.

A thrown Nyeri clay pot fired by the Sawdust technique. It shows a small slit on the neck and a peeling wall

A pot composed of Kenyatta University clay, built by the coil method and fired by the Raku technique. It shows a chipped side.

A thrown pot composed of Kenyatta University clay and fired by the Bonfire technique. It shows a slit running from the rim to the neck

A pot composed of Kenyatta University clay, built by the coil method and fired in the Gas kiln. It probably exploded due to the unevenness in the wall
LIST OF MAPS

<table>
<thead>
<tr>
<th>MAPS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lyamagale Village; the area of the Study.</td>
<td>79</td>
</tr>
<tr>
<td>2 Areas from where clay samples were collected for chemical analysis in Kakamega District.</td>
<td>80</td>
</tr>
<tr>
<td>3 Area from where a clay sample was collected for chemical analysis in Bungoma District.</td>
<td>81</td>
</tr>
<tr>
<td>4 Area from where a clay sample was collected for chemical analysis in Busia District.</td>
<td>82</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENT

To undertake a study of this magnitude a lot of self-sacrifice, encouragement and cooperation are required. In view of the foregoing, I wish to acknowledge with gratitude Kenyatta University under whose auspices this study was undertaken and the traditional potters, without whose cooperation this study would not have been possible.

The following individuals also deserve special mention for their contribution to this study:

Dr. S.J. Gaciri of Geology Department, University of Nairobi who willingly assisted with the chemical analysis of the clay samples; Dr. S. Wandibba of the National Museums of Kenya for carrying out a petrological examination of the clay samples; Mrs. L. Tendo for reading through the drafts and making very valuable comments and suggestions; Mr. C. Maina for his assistance during the practicals and particularly with the firing.

I also owe special gratitude to my academic supervisors, Mrs. M.A. Mambo and Professor G.S. Eshiwani who always availed themselves for discussions, and to Mr. C. Agbemenu for supervising the final corrections. Their encouragement, counsel and patience were of immense value to me.
My gratitude also goes to Mr. J. Kariru, Chairman of Fine Art Department, for all the encouragement and promptness in administrative services that concerned this work.

Many thanks are also due to Miss. D. Munene and Mrs. Rosemary Okelo for their skilful typing and Mr. A.D. Bojana for technical editing. Above all, my thanks are extended to my family for their support, understanding and encouragement. I am most grateful to my brothers Eric and Kennedy who often accompanied me on those tedious trips to the potters.

Finally, I wish to express my gratitude to Mr. Matanda Wabuyele, without whose help and encouragement, the printing of the plates would not have been completed in time.
This study was concerned with finding out what causes pottery wastage in Lyamagale Village, Western Province of Kenya, when traditional techniques are employed. In an attempt to determine the specific cause(s) several tests were done. Ten clay samples were collected from different places within the province and analysed. This was done in order to find out the chemical composition, physical properties and whether they were appropriate for pottery-making. The pottery-making processes from the collection of the clay to the firing and even selling of the ware, were observed and analysed. This clay plus two other clays namely, a Nyeri and a Modified Nyeri clay used in the ceramics studio at Kenyatta University, were experimented with to find out whether the type of clay used, the building or kilning techniques or a combination of any of the techniques contributed to wastage.

With this in mind, a total number of 240 experimental pots was moulded from the three clays. Two building techniques, the coil (handbuilt) method and throwing on the wheel (machine made) methods were employed. The pots were then fired by using
four different kilning techniques namely the Bonfire, Sawdust, Gas and Raku methods.

From each of the clays, 80 pots were moulded, 20 being fired in each of the four kilning techniques. Of these 20 pots, 10 were built by the coil method and the other 10 thrown on the wheel. The total number of pots therefore fired in each of the kilns was 60 (30 handbuilt and 30 machine made).

The results of the chemical and physical analyses showed that the clays were basically similar in terms of elemental composition and that they were appropriate for pottery making, both in composition and in physical properties.

The results of the firings which were analysed by simple percentage showed that:

(i) there is a difference in wastage between pots made from Lyamagale clay, the Nyeri and the Modified Nyeri clay.

(ii) there is a difference in wastage between pots built by the coil method and those thrown on the wheel.
(iii) there is a difference in wastage between pots fired by the Bonfire, Sawdust, Gas and Raku kilning techniques.

In the case of the Lyamagale clay it was observed that the best combination was the coil method and the Bonfire firing which produced 0% wastage. The second best combination was the Gas and Raku methods which both had 10% wastage with equal wastage from both building techniques. The worst kilning technique was the Sawdust firing which produced 100% wastage. It was further observed with the Lyamagale clay that both the building techniques produced 30% wastage, suggesting that the kind of building technique employed does not contribute to wastage.

The best combination in the Lyamagale clay is apparently the combination the traditional potters used: yet, unlike the results of the experiments, it produced 23.5% wastage. The wastage, it was assumed, occurred because of factors such as:

(i) the time allowed for drying the raw ware was not sufficient.

(ii) the method of drying the raw ware was not appropriate.
(iii) The kiln construction and firing procedure were not appropriate.

The researcher gave suggestions on ways of preventing wastage and possible kiln constructions that would not only retain heat but also attain a temperature high enough to vitrify the ware.
CHAPTER ONE

1.0 Introduction

Pottery is one of the most ancient crafts that has been practised by almost every people of all races in the world. Fagg\(^1\) noted that in the Middle East at Jericho in Palestine, Pottery was first discovered around the sixth Millennium B.C. and spread into North Africa soon after. Grimshaw\(^2\) wrote that simultaneous discoveries of fired clay had been unearthed in England, Belgium, Germany, North and South America, Egypt, Mesopotamia and elsewhere, dating back to about 5000 B.C. Horn\(^3\) on the other hand described the Greeks' slip decorations to have been of 'high levels' in the sixth and fifth centuries B.C. The history of pottery therefore stretches back, literally, into the unknown. In fact Olson suggested that 'the exact origin of pottery will likely never be known'.\(^4\)


\(^3\) J. Horn, Ceramics Techniques and Projects (London: Lane Magazine and Book Company, 1973), p.4.

\(^4\) Delmar Olson, Pottery: Getting Started in Ceramics (Toronto: Van Nostrand Co., 1953), p.3.
The cause of pottery taking root and flourishing in many countries like Kenya, Uganda and Nigeria is the easy availability of clay which can be found almost everywhere. In the Kenyan situation, particularly in the Western Province, women from the Vigulu clan in South Maragoli produce the largest number of pots because they live in the vicinity of large clay deposits.\(^5\)

The uses of pottery and processes of manufacturing in the early times were not as varied as today. Advances in technology have introduced changes in the clay preparation where pugmills are used and in moulding methods such as the use of wheels on which pots are thrown. In most areas, Kilns have now almost replaced the traditional open firing which cannot attain a temperature above \(750°C\)\(^6\).

---

Women are generally the potters in most parts of the world. Fagg reported that:

women are the potters in Africa; their hands dig clay from the earth, pound it ready for use, model it and smooth it, decorate and fire it, and finally take the finished objects to the market.\(^7\)

This view was supported by Jefferson\(^8\) who attributed it to the 'delicacy of the pieces'. Junod\(^9\) wondered whether this was not because earthenware utensils were principally used in the kitchen, where 'women belonged'. There are however a few exceptions in some countries such as Pakistan where men were the potters\(^10\). In an observation of pottery making at Santa Clara Pueblo, LeFree\(^11\) noted that a number of men and children helped in pottery making.

---

In South Maragoli, Western Province of Kenya, women are the potters (the Kitosh* and Kabras pots are moulded by both men and women and according to Wagner their ware are 'most durable')\(^{12}\). These women potters have undergone informal training in pottery making processes by elder women. Their knowledge is further enhanced when they all set off to collect clay and through experience, are able to identify suitable clays for pottery. Clay is often found in swamps and occasionally on the banks of streams. They search for clay which is plastic in feel as this is more malleable and therefore easier to shape.

This quality in clay has led to its being used for an astonishing variety of purposes. To be precise, these have ranged from storage pots, cooling utensils to ritual and religious ceremonies. Although these pots are built by the same method, they vary in size. The size and shape of the mouth often determine the kind of foodstuff for which a pot is built. Amongst the largest pots produced in South Maragoli is the 'isika' which has a small curved neck and is used for storing

---

* Presently known as the Bukusu

grain. One similar pot is 'esiongo' specifically used for storing millet. It is medium-sized with a curved neck unlike 'esiongo yamazi' (water pot) whose neck is narrower and sometimes longer. Sorghum is stored in 'eyanguluga' which is a neckless pot that could also be used for cooking 'ovukima' (thick porridge) if it is smaller. Pots for cooking include 'eyamegele' which has a curved neck of medium width. It is used for cooking such foods as maize and beans, bananas, cassava, yams, sweet potatoes and so on. Meat is cooked in 'oluvindi' which is not very small and has a curved short neck. Fish is cooked in 'eyambeva' which like 'eyanguluga' is neckless but has ears. Pots for brewing beer look like 'eyamegele' but are bigger. Shallow bowls 'oludju' or 'olubagu' are also moulded and used for serving food.

Sebandeke, writing on the Ugandan pottery, noted that more than half of the pots used in Uganda are for carrying water. This, he said was because every family needed a pot for their carrying or holding water more than a beer pot or a milk bowl.

13 F.X. Sebandeke, Design and Decoration of Ugandan Pottery (Nairobi: University College, Nairobi), p.11.
After studying quite a number of the water pots, Sebandeke grouped them into the following four groups:

(i) Rounded body with long small mouth.
(ii) Rounded body, short neck with small mouth.
(iii) Tall body, long neck with small mouth.
(iv) Tall body with wide mouth.

Like the Ugandan potters, the Kenyan potters display a variety of shapes in their ware. Even from within the pots used for cooking, there are different shapes. The base and stomach are basically the same shape. These take on a round form and are beautifully decorated with various techniques and designs. The Kamba pottery, though undecorated, has 'personal marks' incised in two or four places on the necks of the pots by the potters for 'good luck' and identity. Herskovits wrote that:

... the remarkable facts about the pottery that is the product of non-literate cultures ... is the sureness with which the potters shape their vessels. Not only do they achieve a perfect form without the use of any measuring device, but their vessels are so shaped as to be objects quite as much of aesthetic as of utilitarian value. This quality of aesthetic form

---

arises only training that betokens careful observation and effective use of resources, and which yields motor skills that permit the play of such creation ability as the potters may.\textsuperscript{15} Although beautiful pots are thus produced, they cannot be of any serviceability unless fired to the required temperature. Being hardened in a fire is what would qualify a raw pot to be called pottery for fire makes it strong and permanent. In fact Olson said that without it, clay would be useless for pottery\textsuperscript{16}. A given clay, depending on its ingredients, will need a specific heat before it matures. Beyond this point, it will fuse and finally turn into slag\textsuperscript{17}.

The earliest pottery was sun-hardened (this would not hold liquids or remain intact for any length of time) and probably after many trials,\textsuperscript{18} it was simply burnt in a bonfire. As a method this has remained without improvement in some parts of Africa, Indonesia and India\textsuperscript{19}. This kind of firing,

\textsuperscript{15} Herskovits, \textit{Man and His Works}, 1960, p. 263
\textsuperscript{16} Olson, \textit{Pottery: Getting Started in Ceramics}, p.53.
which is apparently used by the Lyamagale traditional potters in Western Kenya, could bring about a lot of wastages as described by Trowell. According to this author, the Acoli of Uganda have tremendously improved on their firing set-up. This was done by placing the pots in a dug pit and covering them with sand before piling on the grass and reeds in order to prevent the pots from direct contact with the flame. Firing can be a disaster and according to Fraser, many craft potters who are highly skilled in the art of shaping and decorating are disappointed at the outcome of their firing. This could result from many factors such as overlooking the 'cooling of the firing' which Cottier-Angeli stressed was part and parcel of the firing procedure. The results of the firing would also to some extent be influenced by the type of clay used, as is pointed out in the


21 Fraser, Kilns and Kiln Firing for The Craft Potter, p.v.

review of literature (section 2.4). Kenny advises that one should work with several different kinds of clay in order to become familiar with them and even try composing a clay body according to one's own formulae. To determine the type of firing that would give satisfactory results with a given clay experimentation would perhaps be the best tool.

1.1 Problem and Background of the Study

The researcher developed a keen interest in the study as an undergraduate in 1980, when carrying out a project assigned to second year students on 'ceramic processes'. The researcher visited Kima Market in Western Province of Kenya. It was alarming to note that at least 20 out of 100 pots made were discarded, either because they had cracked before or after firing. The researcher strongly sympathised with these traditional potters who tirelessly coil and mould their pots only to be left with cracked pots or a heap of potsherds. Asked what they thought caused this, the potters gave answers that were based on

---

superstitions. But with the current literature available as to why pots break, it was not logical to believe in or rely on such superstitions. It was from this point that the researcher decided to carry out a study that would help determine the cause of the wastage. One writer and potter remarked that:

most pottery faults are caused by incorrect making procedures, incorrect materials or ignorance on the part of the potter ... and some faults are indeed caused by incorrect firing procedures\(^\text{24}\).

This remark is significant in relation to this study because almost half of the traditional potters in Kenya are mainly grandmothers who have not undergone any formal education and cannot, therefore, make use of the published documents on ways of making the best use of the available local materials. With the presidential decree concerning adult literacy classes, it is hoped that this problem will eventually be solved.

On the materials used, the researcher collected ten clay samples (section 3.0) from Western Province to

\(^{24}\) Fraser, op.cit., 1969, p.111.
test for their chemical composition and physical properties in order to determine whether they were suitable for pottery making. The making and firing procedures or the building and kilning techniques were also analysed. Several experiments were carried out using clay from the selected areas of study (section 3.3) and the findings compared with a Nyeri clay and a modified Nyeri clay used in the Ceramics Studio at Kenyatta University.

This study, will presumably open up new avenues for further research on traditional pottery. It will also provide information on the differences that occur in wastage, due to the type of clay, building and kilning techniques which hitherto have not been studied,

Finally, the findings of this study may help the potters to be more self-reliant and thus help to alleviate the country's ever increasing problem of unemployment.

Purpose of study

The purpose of this study is to find out whether pottery wastage in Lyamagale village of
Western Province of Kenya is caused by:

(i) the type of clay used
(ii) the building technique
(iii) the kilning technique

1.3 **Statement of the problem**

Every potter aims at turning out a product which will satisfactorily serve the purpose for which it is intended. Some potters make pots for their aesthetic values while others are concerned about the utilitarian aspects alone. Whichever the case, it is very important that the ware is solid and durable. This, as is pointed out in the introduction, can only be achieved if the correct material and pottery making processes and procedures are used. The present study aims at finding out specifically, how best this can be achieved using clay from South Maragoli. In carrying out these experiments, the researcher set out to find solutions to the following questions:

1. Is the chemical composition of the clay suitable for pottery making without any modification?

2. Do the physical properties of the clay affect the manipulation of the ware?
3. Is the method used for preparing the clay correct?

4. Is the building technique used by the traditional potters suitable for this kind of clay?

5. Is the method used for drying the green ware appropriate?

6. Is the time allowed for drying the green ware sufficient?

7. Is the kiln set up well enough to attain a temperature that will vitrify the ware?

8. Is the kiln loading well done?

9. Is the firing procedure appropriate?

10. Is the length of time allowed for cooling the bisque ware sufficient?

11. Is the unloading of the kiln correct?

12. Does the type of fuel used for firing affect the results?

1.4 Definition of Terms

The following are the definitions of terms as they are used in this study:
Ball Clay

A type of potter's clay found in England in Devon and Dorset, so called because the clay was cut into balls weighing about 30 lb. Unfired they are usually grey, blue, or a colour closely approaching black, but after firing the colour of the clay is white or almost so.

Bisque Firing

A preliminary firing of pottery which transforms the ware into the bisqued state. This is followed by glazing and decoration, unless the ware is intended to be left unglazed.

Bisque Ware

Unglazed ware which has been fired only once.

Black Cores

These are small primple-like projections that appear on the surface of bisqued ware due to the presence of impurities in the clay.
Building Technique

A specific method of constructing the desired shape of a pot. Examples being coiling, slab and throwing on the potter's wheel.

Clay

Decomposed felspathic rock. There are mainly two types: primary clay which has coarse particles and is not very plastic, and secondary clay which is fine in texture and very plastic.

Clay Body

The material from which a pot is made. It may be a natural clay or a balanced mixture of clays and other ingredients such as flint, felspar, grog, cornish stone.

Clay Minerals

The chief chemical constituents of clay such as silica, alumina, iron.

Coiling Method

A hand method of forming pots by building up the walls with ropelike rolls of clay and then smoothening over the joints.
Firing - verb: The process of baking the pots in a kiln.

noun: The content of a kiln.

Flux

Any substance which lowers the melting point of another.

The term used to describe the state of the clay during the drying process when any quantity of moisture is taken up by the clay.

Fuse

To melt under the action of heat.

Gloss Firing

A second firing of ware for the purpose of fusing the glaze which is applied after the bisque firing.

Green ware

Dry unfired ware

Groq

Previously fired clay that is crushed and added to bodies in order to reduce shrinkage and warping.

Kaolin

Chinese name for China clay derived from the place it was first discovered. It has since been discovered in many places throughout the world. Kaolin is an extremely pure aluminium silicate.
Kiln

Furnace or oven in which pottery is fired.

Leather Hard

The term used to describe the state of a clay body during the drying process when any necessary turning on a lathe, ornamental incision or attaching of handles, spouts, is done.

Maturing Point

The temperature or time at which a clay or clay body develops the desirable characteristics of maximum non-porosity and hardness, or the point at which the glaze ingredients enter into complete fusion, developing a strong bond with the body, a stable structure, maximum resistance to abrasion, and a pleasant surface texture.

Modern Potter

A potter who confines himself to the modern processes and techniques of pottery making.

Pottery

Earthenware vessel shaped first, dried and then fired to the maturing temperature.
Raku

A process of gloss firing which utilizes low firing temperature, and involves a very rapid firing of pieces usually coated with low-fire glazes. The pot is placed in a red-hot kiln and taken out in a few minutes as soon as the glaze has melted. The hot pot is either oxidised or reduced by covering it with combustible material. (The clay must be able to withstand rapid changes in temperature).

Sawdust Firing

Open firing using sawdust for fuel.

Slab

A lump of clay rolled out flat into an even thickness.

Slip

A fluid suspension of clay or other materials and water.

Throwing

The process of forming a hollow circular shape from clay by hand with the use of a fast-turning potter's wheel.
Traditional Firing

Open firing using wood and grass for fuel.

Traditional Potter

A potter who confines himself to the traditional processes and techniques of pottery making.

Vitrify

To fire to the point of glassification.

Wastage

The pots that are discarded as a result of having cracks or those that explode during the firing.

Wheel

A machine used for throwing pottery forms. It consists of a disc on a vertical spindle which revolves like a gramophone turntable when set in motion (manual or power). A ball of clay is banged on the disc and shaped as it revolves.
1.5 Hypothesis

The following null hypotheses will be tested in this study:

Hypothesis 1

There is no difference in wastage between pots made from:

(i) Lyamagale clay
(ii) A Nyeri clay
(iii) A modified Nyeri clay

Hypothesis 2

There is no difference in wastage between pots built by using:

(i) the coil method
(ii) the wheel method.

Hypothesis 3

There is no difference in wastage between pots fired by the following methods:

(i) the Bonfire
(ii) the Sawdust
(iii) the Gas
(iv) the Raku
CHAPTER TWO

REVIEW OF RELATED LITERATURE


The following is a summary of researches conducted by Rye, Junod, LeFree, Roscoe, and Brown in the above mentioned countries, respectively, on pottery making processes.

The different potters observed in these countries dug their clay from swamps or from open pits on uncultivated land. Rye observed that the Pakistani potters used any clay regardless of its mineralogical advantage. In his analysis of the chemical composition of fourteen


clay samples and two clay slips, Rye came up with the conclusion that the clays used by the Pakistani were suitable for pottery making and observed no wastage of ware. Junod, in his study on pottery making amongst the Thongas of South Africa, reported that clays differing in quality were found in abundance in several places. All these researchers noted that the clays were tempered with different substances, with the exception of the Akamba of Kenya whose clay was composed of three different coloured clays alone (red, black, cream). Ground potsherds were added to the clays and, in the case of Pakistan, even salt.

Clay Preparation

The Santa Clara potters, Rio Grande Valley of New Mexico, like the Baganda of Uganda and the Pakistani, spread their clay outside in the sun to dry. When the clay had evenly dried, it was crushed down into finer pieces. The Pakistani and the Baganda sprinkled water on the crushed clay and wedged it. The Santa Clara potters soaked their crushed clay for two to four days in water, poured the water off, added more clean water and repeated the process until the water was clear. Impurities were discarded during this time and the clay sieved. The clay was finally mixed with fine
sand and then used. The Thongas, like the Akamba, added a little water to the damp clay and then wedged it to the right consistency, ready for use.

The proportion of clays to the additives was determined by the potter’s own judgement and experience rather than measurement in all these cases. The clays, after the preparation, were kept moist by covering them with damp rags or in lidded containers.

Building Techniques

The coil method was reported as being the most popularly used technique amongst the Pakistani, the Santa Clara, Baganda and Akamba potters. The Thongas, however, moulded their pots by taking a lump of clay, making a hole in it and gradually widening it into a cone shape after which it was rounded. The Pakistani, besides using the coil method, used pit-wheels and molds, and like the Thongas also moulded from a lump of clay. The Akamba also used the latter method. Using the coil method, the Akamba built the top half of the pot, turned it upside down when leather hard, and then completed the bottom part.
The potters used various kinds of techniques for decorating their pots. The Baganda decorated their pots with plaited cord roulettes while the pots were leather hard. The Pakistani incised patterns on their pots whereas the Akamba incised their personal marks on the neck of the pots. The Santa Clara allowed their pots to dry for about two days depending on the weather and size, and then burnished them first with coarse sand paper and then very fine sandpaper. The pot was then smoothened with a damp cloth until the entire surface was very smooth and uniform in texture. The Baganda also burnished their ware using a smooth stone.

All these potters were said to dry their pots slowly under shades or indoors for several days until they were completely dry before firing them. In the case of the Baganda, Roscoe noted that the pots were kept for as long as three weeks in order to ensure that they were completely dry.

Firing Techniques

The Pakistani, unlike the rest of the people studied, carried out both bisque and glost firings.

---

Their most common firing technique for bisque firing was the 'mixed firing' where the pots and dung were set together in a pit and fired. The Punjab and Sind potters used the 'open pit' firing for bisque ware and the updraft kiln for glost firings. The Thongas, Santa Clara, Baganda and Akamba potters carried out open firings using different kinds of fuel. The Thongas made a hole in sand, wide enough to accommodate the number of pots that were to be fired. They then arranged the pots in the hole and covered them with small pieces of wood or palm pith and set the heap ablaze. The firing went on until such a time when the potter was convinced that they were well fired. The pots were left to cool. The good pieces were painted brilliant brown derived from a combination of herbs boiled together.

The Santa Clara potters fired their pots in the same area on the fairly level ground and used bark slabs, cotton wood, cow dung and pulverised horse manure for fuel. The Baganda used large quantities of dry grass, wood, reeds and sometimes papyrus stems. After the firing the pots were left to cool for several hours. Some pots such as the milk-pots were made black by smoking them over a fire that did not blaze. The Juicy
smoke blocked the pores of the pots thus making them water-tight. The Akamba used dry stalks of thick swamp grass and a finer meadow grass. Brown reported that the firing she observed took about 35 minutes - the fire having burnt properly for about 15 minutes. The hot pots were then removed from the fire to cool. Broken pots were discarded.

Wastage during firing was not uncommon in some of these countries. LeFree and Rye reported no wastages. Junod, like Brown, observed wastage amongst the Thongas. Wastage amongst the Thongas, Akamba and to some extent the Baganda was associated with witchcraft. Some of the taboos that influenced pottery making amongst the Thongas were quite close to those observed by Brown in the Akamba pottery-making processes. The potters, for example, believed that successful pottery production depended on the hand that had dug the clay or lit the pyre. It was also believed that if a person of the same age, (i.e. of circumcision or dance group) as the potter expressed admiration for the pots, they would explode during the firing. In the latter case, the Akamba potters forced the person to spit on the pots and swear that they did not have a bad tongue.
Conclusion

From what these researchers reported on the pottery-making processes in the named countries, it is clear that the potters had a knowledge of the essential factors that lead to good production of pottery. Clays which could not be used as dug from the deposits were modified by the addition of tempering materials. Some of the purposes for which this was done were, to:

(i) improve the working characteristics of the clay.

(ii) reduce the rate of shrinkage.

(iii) prevent the clay from cracking both in the green state and during firing.

(iv) improve the firing characteristics of the clay.

The prepared clay was kept moist and weathered in order to improve its plasticity. The unfired pots were allowed to airdry slowly, ensuring that the free water previously mixed with the clay evaporated. After firing the pots, the potters tested them to confirm whether they were well fired. The Thongas, Baganda and Akamba further hardened their fired pots by smoking them over pungent smoke in order to have the pores of the clay filled with juicy soot.
Finally, it was reported that four of these countries made use of the cracked pots by pounding and mixing them with clay rather than discarding them. Contrary to this, the Akamba, as Brown put it, discarded the broken pots as they believed that a jealous potter bewitched another's pots by using broken pots. Although the Akamba, Thonga and Baganda potters were said to be superstitious as far as their pottery making procedures were concerned, it was noted that some of the factors Fraser (quoted in section 1.1 p.10) mentioned as contributing to wastage in pottery-making, were avoided.

2.1 Clay Description and Properties

Cardew in his Pioneer Pottery pointed out that researches that had been carried out in the last forty years had made it known to practical potters the nature and properties of clay. It was said that previously although potters had known how to utilise clay, it was all by instinct.

Clay has been described by scholars such as Ruscoe, Glenn, Barton, and Lunn, as a decomposition of granitic and feldspathic rocks caused by weathering. This process 'took millions of years to complete and is still going on.' Due to the varying conditions under which this breakdown took place, clays were classified into several categories (Billington, Gillot, Norton, Ryan, and Winter). This was mainly based on their location, chemical and physical properties. The two broadest categories are residual (primary) clays and sedimentary (secondary) clays.

Residual (Primary) Clays

These are found at or near their parent granitic or feldspathic rock. They are free from impurities, are coarse grained and not very plastic. Although these clays have often been called 'pure', Norton argued that the purity of the clay could only be determined by the purity of the parent rock. He went on to say that in fact only about 10% pure clay could be got from such a deposit\(^\text{19}\). The physical properties of residual clays make them very difficult to work with unless blended with more plastic clays such as ball clay. Grimshaw said that lack of some important 'impurities' in the clay made its products very weak when fired\(^\text{20}\). Winter, however, acknowledged the fact that these clays found place in the manufacture of white ware in industries, white sculpture bodies and in slip decorations\(^\text{21}\).

\(^{19}\) Norton, 1952, p.21


Sedimentary (Secondary) Clays

These have been transported from their original sources by water, wind, glaciers, etc. During the transportation they collect both vegetable matter and minerals of various kinds. Their particles are broken up into a fine texture by the grinding action of water thus giving them a fine-grained texture and plasticity.

Sedimentary clays are divided into three distinct groups. The Refractory, Vitrifiable and Fusible clays. These are based on practical firing tests rather than chemical analysis. Shephard confirmed this and added that they were further classified by their uses such as China clay, fire clay, stoneware clay, pot-clay and so on. Backing up Shephard, Grimshaw explained that factors such as the

22 Billington, 1974, p.15.
mineral species predominant in the clay, characteristics of the clay, for example flint clay, contributed to the naming of clays. Others were indeed trade-names. The presence of impurities in sedimentary clays have effects on their firing temperatures as will soon be discussed.

Chemical Composition

The chief chemical constituents in clays are grouped as follows: (a) silica; (b) alumina; (c) alkali-bearing minerals; (d) iron compounds; (e) calcium compounds; (f) barium compounds; (g) magnesium compounds; (h) titanium compounds; (i) manganese and other compounds which occur in small proportions in some clays; (j) complex alumino-silicates often containing other elements; (k) carbonaceous matter; (l) moisture and colloidal water; (m) exchangeable bases.

---

There are however, some other kinds of impurities present in some clays which occur in extremely small proportions but are of little importance.

Winter carried out a chemical analysis of an igneous rock which is the source of quite a number of clays, and she compared the results to a clay that had in fact been formed from that source. The results presented in Table 1 show that the two had the same kind of minerals in common and the proportions of such minerals as silica, aluminium and iron were quite close.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Average Igneous</th>
<th>Winter Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium Oxide</td>
<td>7.4%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Water (Ignition loss)</td>
<td>6.4%</td>
<td>6.4%</td>
</tr>
</tbody>
</table>

Table 1: Comparison of Mineral Composition of an Igneous Rock and a Secondary Red-Burning Clay


### Table 1: Comparison of Mineral Composition of an Igneous Rock and a Secondary Red-Burning Clay

<table>
<thead>
<tr>
<th>Mineral Composition</th>
<th>Average Igneous Rock</th>
<th>Secondary Red-burning Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica SiO₂</td>
<td>63.18</td>
<td>63.2</td>
</tr>
<tr>
<td>Aluminium Oxide Al₂O₃</td>
<td>15.35</td>
<td>18.13</td>
</tr>
<tr>
<td>Ferric Oxide Fe₂O₃</td>
<td>2.97</td>
<td>6.4</td>
</tr>
<tr>
<td>FeO</td>
<td>3.35</td>
<td></td>
</tr>
<tr>
<td>Magnesium Oxide MgO</td>
<td>2.79</td>
<td>0.5</td>
</tr>
<tr>
<td>Calcium Oxide CaO</td>
<td>4.58</td>
<td>0.3</td>
</tr>
<tr>
<td>Sodium Oxide Na₂O</td>
<td>3.28</td>
<td>2.18</td>
</tr>
<tr>
<td>Potassium Oxide K₂O</td>
<td>3.24</td>
<td>3.2</td>
</tr>
<tr>
<td>Titanium Oxide TiO₂</td>
<td>1.41</td>
<td>1.3</td>
</tr>
<tr>
<td>Water (Ignition loss) H₂O</td>
<td>6.4</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Another study whose results were almost the same as these was that by Gillot. He analysed the chemical composition of a variety of sedimentary rocks and worked out the average percentages of individual elements of each clay\textsuperscript{29}. The results, which are presented in Table 2 are close to those by Winter on a different analysis of a secondary Kaolin\textsuperscript{30}. The latter however, showed a high level of plasticity by its water content which read 12.8%.

\begin{table}[h]
\centering
\begin{tabular}{cccc}
3.13 & 1.26 & 1.91 \\
1.05 & 0.65 & 0.25 \\
0.124 & 0.00 & 0.00 \\
\end{tabular}
\caption{Average Chemical Composition of Clay, Clay, Clay slate and Schist.}
\end{table}

\textsuperscript{29} Gillot, 1968, p.33.

\textsuperscript{30} Winter, 1973, p. 25.
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Physical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>igneous</td>
<td>shale</td>
</tr>
<tr>
<td>sandstone</td>
<td>limestone</td>
</tr>
<tr>
<td>$\text{SiO}_2$</td>
<td>59.14</td>
</tr>
<tr>
<td>$\text{Al}_2\text{O}_3$</td>
<td>15.34</td>
</tr>
<tr>
<td>$\text{Fe}_2\text{O}_3$</td>
<td>3.08</td>
</tr>
<tr>
<td>$\text{MgO}$</td>
<td>3.49</td>
</tr>
<tr>
<td>$\text{CaO}$</td>
<td>5.08</td>
</tr>
<tr>
<td>$\text{K}_2\text{O}$</td>
<td>3.13</td>
</tr>
<tr>
<td>$\text{TiO}_2$</td>
<td>1.05</td>
</tr>
<tr>
<td>$\text{MnO}$</td>
<td>0.124</td>
</tr>
</tbody>
</table>

Table 2: Average Chemical Composition of Clay, shale, Slate and Schist.


Note: The total percentage does not add up to 100% because other elements included in the original version have been omitted for the purposes of this study.
Physical Properties

The most important qualities of clay for pottery are plasticity, porosity and vitrification (densification)\(^{31}\). Clay should be plastic so that it can be shaped without cracking or collapsing; be porous enough to allow air and chemically combined water to escape during firing and, be able to vitrify without undue shrinkage or fusion. (Ruscoe\(^{32}\), Ryan\(^{33}\), and Cardew\(^{34}\).

While in the green state, clay shrinks and when it is fired it shrinks even further. According to Cardew it can shrink up to about 16\(^{35}\) and Cottier-Angeli between 10-20\(^{36}\). Norton in his


\(^{33}\) Ryan, 1968, p. 19.

\(^{34}\) Cardew, 1969, p. 61


tests on the shrinkage of certain clays observed that the fine-grained clays shrunk more than the coarse-grained. The results in Table 3 show the percentages of the clays before and after firing.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Linear Shrinkage in percentage from plastic state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaolin, crude</td>
<td>5 - 8</td>
</tr>
<tr>
<td>Kaolin, washed</td>
<td>3 - 10</td>
</tr>
<tr>
<td>Ball clays</td>
<td>5 - 12</td>
</tr>
<tr>
<td>Flint clays (ground)</td>
<td>0.5 - 6</td>
</tr>
<tr>
<td>Sagger clays</td>
<td>3 - 11</td>
</tr>
<tr>
<td>Paving brick clays</td>
<td>1 - 6</td>
</tr>
<tr>
<td>Sewer pipe shales</td>
<td>2 - 7</td>
</tr>
<tr>
<td>Glacial brick clays</td>
<td>3 - 7</td>
</tr>
</tbody>
</table>

Table 3: Drying Shrinkage of Clays.

37 Norton, 1952, p.35.
2.2 Preparation of Clay

A potter who digs up his own clay removes all the pebbles and organic matter before wedging it. During firing, the pebbles left in a clay suddenly break away from the body, causing damage to the neighbouring pots. Clay is wedged so as to evenly distribute the moisture. Lack of this causes internal tensions in the ware which could result in explosions or cracks. During this process the lumps are removed or crushed and any trapped air (which expands on firing and blows out) forced out. Clay can be wedged by using different types of techniques such as pug-mills, hands or even feet. Although pugged clay is more convenient for working with, Rhodes argued that 'hand-wedging seemed to give the clay an orientation and a life lacking in the mechanically prepared clay'. He therefore advised that 'the rule was long enough and then a little more', as too much of it rendered the clay short and was time consuming. Lunn in her book on Pottery in The Making pointed out that it was customary to

39 Ibid., p.8
tread on the clay in the East and in Spain. She concluded that the technique had been used for centuries when she read in Isaiah (41:25) that the potter treaded clay\(^{40}\). Describing the processes of clay preparation Billington, like Dickerson\(^{41}\), felt that although most clays could easily be shaped, some were only suitable for certain building techniques. She gave an account of how difficult it would be to use clay that is excellent for press moulding on a wheel. In her conclusion she wrote that the two basic qualities that building techniques depended on, were the ability for clay to be manipulated into a required shape and its ability to stand additives such as in the use of slabs and coil techniques\(^{42}\).

Before the ware is fired, it is allowed to either dry in the air or is dried by automatic dryers as in the case of industries. The

\(^{40}\) Lunn, 1961, p.22.


Chemically combined water is still retained and this is given off as steam at a specific temperature in the kiln. According to Billington the proportion of this water can be 5% or even more\textsuperscript{43} and that if by temperature 100°C it is still in the clay, wastage may result. She stressed the fact that if fire and clay were put together they reacted in the same way regardless of the type of kiln in use.

2.3 Reaction of the Clay in Fire

Firing of ware has been divided into three phases. The dehydration period (both mechanical and chemical), oxidation period and the vitrification period (Shephard\textsuperscript{44} and Hartung\textsuperscript{45}). The mechanical dehydration occurs at temperatures 20-150°C or 68-302°F\textsuperscript{46} in order to expell the atmospheric moisture in the clay.

\begin{flushright}
\textsuperscript{43} Op.cit, p. 138.  \\
\textsuperscript{44} Shephard, 1956, p. 81.  \\
\textsuperscript{45} Rolf Hartung, Clay (London: B.T. Batsford Ltd., 1971), p.10.  \\
\textsuperscript{46} Winter, 1973, p.103.
\end{flushright}
According to Winter, the chemical dehydration takes place at temperatures 150 - 600°C or 302-1112°F; Green, at about temperatures 300-500°C. Fraser reported that this occurred between temperatures 200°C and 460-600°C and sometimes even up to 900°C depending on the clay. Earthenware, for example, will fuse at temperatures above 1090°C or 2000°F compared to stoneware and porcelain which will stand a higher temperature. During this period, the chemically held water plus gases from organic material are removed and if the temperature is suddenly risen, too much steam is produced and may cause disaster. According to Fraser the steam produced is fifty times the volume of the kiln's interior.

48 Green, 1967, p.80.
49 Fraser, 1969, p.75.
51 Fraser, 1969, p.75.
Oxidation period occurs at temperatures 400-900°C\textsuperscript{52} according to Fraser or between 350-900°C or 662-1742°F\textsuperscript{53} according to Winter. At these temperatures the carbonaceous matter is burnt away. If this does not successfully happen, small black holes or 'pimples' may appear on the body of the ware. Winter further said that by temperatures 500°\textsuperscript{54} and 800°C\textsuperscript{55} according to Fraser all the chemically held water is lost and the ware is as porous as a sponge and lighter than it originally was before firing. If the firing is discontinued at this point, the ware will be porous such that if put against the tip of the tongue, it would stick due to the absorption of the moisture. This 'test' is carried out by experienced industrial potters\textsuperscript{56} in order to determine whether the bisque ware has fired enough. The ware is said to be underfired if any suction is experienced and overfired, if it is too vitreous.

\textsuperscript{52} Op.cit., p. 76.
\textsuperscript{53} Winter, 1973, p.103.
\textsuperscript{54} Winter, 1973, p. 104.
\textsuperscript{55} Fraser, 1969, p. 76.
\textsuperscript{56} Ibid., p. 76.
Vitrification period takes place at about temperatures 900°C or 1652°F\(^\circ\) during which time the volume of the clay slightly increases due to what Winter described as the 'quartz inversion'. As the temperature rises, a reaction between the clay and the fluxes in it occurs causing the ware to soften. Should the temperature suddenly drop at this point, the ware may crack. If the firing is taken beyond that, the fluxes literally boil and the ware melts or fuses. Vitrification takes place at different temperatures with different clays. Clays rich in iron and other mineral impurities such as the common red clay, vitrifies at about temperatures 1000°C or 1832°F but will fuse at about 1250°C. Porcelain on the other hand will only be porous at the latter temperature but will fuse at about 1800°C or 3272°F\(^\circ\).


\(^{58}\) Ibid., 1973, p. 105.
Methods of Firing

Early potters simply sun-dried their pots. These could not hold water and were thus used for grain storage. After the discovery of fire, the pots were fired in an open firing using a variety of methods. The principles underlying these methods were basically the same. Natural inexpensive fuel such as dung, twigs, wood and grass were used. The pots were simply stacked in a pit or shallow depression in the ground or on a flat ground and covered with the fuel before lighting it. Lunn wrote that this lasted for an hour\(^{59}\), Glenn for two hours\(^{60}\) whereas Rhodes reported that this lasted between an hour and two\(^{61}\). The general temperatures arrived at in this firing is about \(750^\circ C\)\(^{62}\) according to Fraser and between \(700-900^\circ C\)\(^{63}\) according to Rhodes. The firing pits were later improved in such a way that heat was evenly circulated and did not escape. A low wall was constructed over the pit and holes made at the base for letting in air to aid in oxidation. This was perhaps the beginning of kiln construction.

\(^{59}\) Lunn, 1961, p. 47,

\(^{60}\) Glenn, cited in The Encyclopaedia Americana, p. 472.

\(^{61}\) Rhodes, Kilns: Design, Construction and Operation, p.4

\(^{62}\) Fraser, 1969, p.2

\(^{63}\) Rhodes, op.cit., p.8.
There are several types of kilns that vary in construction, source of heat and operation. Rhodes in his book on kilns, defined the kiln as 'a box of refractory material which accumulates and retains the heat directed into it'. He identified over twenty types of kilns that had been used by different potters at different times and places. Norton reported that the earliest type of kiln to be used was the periodic kiln. He noted that the firing in such kilns lasted from between a day to a whole month, depending on the production. The hot gases passed upward from the firebox to the ware by a natural draft and this was thus called 'the updraft kiln'. The chimney action of this kiln, and too much heat at the bottom of the kiln affected the general temperature uniformity of the kiln. This was rectified by having the gases pass down through the charge and out through the chimney. Another similar kiln is the downdraft kiln. This kiln, according to Rhodes, is the best of all fuel burning kilns. This is because the distribution of the heat can be easily controlled. In downdraft kilns, the heat from the firebox goes upwards and is then drawn.

downwards to the floor of the kiln which has holes joined to the flue. The heat goes out through the chimney or the brickwork of the kiln through a hole at the top.

Heat is generally transferred by either conduction, convection or radiation, depending on the source of heat, kiln design, load of the kiln (in terms of ware), the texture of the ware and its colour.

2.4 Influence of Major Constituents of Clay

Clays constitute several types of minerals that vary considerably in composition. The mineralogy and chemical composition of some of them have however, not been scientifically analysed due to the complications and difficulties involved.

Grimshaw stressed that the clay minerals were the most effective elements of a clay. He, however, noted that some clays such as brick and tile clays had only about 30-35% minerals in them.

This is still appreciated as each individual mineral has its part to play in the use of clay.

---

65 Rhodes, 1968, p. 92.
67 Ibid., p. 290
Their influence on clays was discussed by Grimshaw at length. He said that silica, for instance, reduces the plasticity of clay. This factor lessens the general shrinkage of the clay when it is drying and on firing. The force under which the clay is stretched and compressed is reduced unless the size of its particles is small. In some clays the refractoriness is even reduced.

Alumina

Since it is non-plastic in nature, it reduces the plasticity of the clay. If the production is over 5% refractoriness of the clay is increased. It, however, decreases the refractoriness of a silica brick by 10°C for each 0.1 per cent. Alumina has been associated with alkalis and other fluxes. In clays, alkalis occur in such forms as felspars, micas and soluble salts, examples of which are potassium sulphate, sodium sulphate and sodium chloride. Their effect on clay is that they lower the refractoriness or vitrification temperature. At 700°C they combine with alumina and silica and form a liquid which gives strength and impermeability to the fired ware.
Iron Compounds

These contribute to colour variations that occur in clays. On firing, they sometimes form scums or iron spots on the body of the ware and may also lower the refractoriness of the clay. If fired in a reducing atmosphere, they turn black.

Calcium Minerals

The presence of calcium in a clay reduces its shrinkage and promotes even drying. When it combines with alumina and silica, a low melting liquid is formed which reduces the vitrification temperature and refractoriness of the clay. The liquid fills the pores of the ware and cements the particles together such that the ware becomes water-tight and resistant to chemicals such as acids. The body may crack or deform when the liquid is cooling. At about temperature 900°C, it changes into lime which swells on absorbing moisture from the air and may make it explode. A small proportion of calcium in brick-clays increases the vitrification temperature. In a glost firing it replaces alkalis and raises its maturing point. Barium compounds are not present in most clays but their effects are like those of calcium when fired.
Magnesium Compounds

They reduce the refractoriness of the clay in which they occur as they act as fluxes. This compound is generally harmless and does not cause any distortion to the ware.

Titanium Minerals

Although these occur in many clays, they rarely go beyond 3%. Some clays from the United Kingdom contain as much as 10%. These minerals act as weak fluxes at temperatures above 1500°C but at lower temperatures remain unchanged.

Manganese Minerals

These occur in small proportions in some clays. They behave like fluxes and stain ware too. The stains vary in colour from off white to black.

Organic (carbonaceous) Matter

The presence of organic material in a clay gives it a dark colour which becomes lighter on firing. During this period, it imparts such conditions in the kiln that interfere with the bahaviour of
vitrification. Sometimes the organic humus may be consumed too rapidly and therefore cause the ware to overvitrify and finally collapse. It also lowers the amount of fuel needed for firing the clay and as it burns porosity of the ware increases. Black cores on the ware may be caused by the presence of impurities in the clay.

Nyari clay, were also analysed. These analyses are used in the ceramics studio at Kenyatta College. The modified Nyari clay is composed of a mixture of grog and kaolin in the following proportions:

- A Nyari clay = 75
grog = 2
kaolin = 4

In the collection of the clay from Western Province, the researcher went to the various locations and inquired from the inhabitants about pottery being made. The researcher interviewed the potters from the different locations to find out what kind of the clay they used. Sometimes the researcher accompanied the potters to the site and collected clay. In some cases where efforts to trace the potters' home failed, the researcher went to
3.0 Chemical Analysis and Petrological Examination of Clay Samples

Ten of the clay samples for these analyses were collected from the Western Province of Kenya. Two other clays, namely a Nyeri clay and a modified Nyeri clay, were also analysed. These are clays that are used in the ceramics studio at Kenyatta University. The modified Nyeri clay is composed of a Nyeri clay, grog and kaolin in the following proportions:

- A Nyeri clay: 75 kilograms
- Grog: 2 kilograms
- Kaolin: 4 kilograms

In the collection of the clay from Western Province, the researcher went to the various locations and inquired from the inhabitants where any pottery was being made. The researcher requested the potters from the different locations to spare a lump of the clay they used. Sometimes the researcher accompanied the potters to the site and collected clay. In some cases where efforts to trace a potters' home failed, the researcher went to
market places and talked to the potters about the possibilities of having access to some of their clay and further arrangements were made.

**Chemical Analysis**

**Aim:** (i) To determine the elemental combination that gives clay its characteristic properties.

(ii) To give a brief comparative survey of the composition of clays from the Western Province and Nyeri District.

**Theory**

Clay, a widely employed material in pottery-making has two unique characteristics; the ability to bind strongly, especially after firing and a characteristic colouring in the final product.

The binding characteristics of clay are mainly attributed to the presence of silica ($\text{SiO}_2$) in large amounts and to a lesser but significant extent by the presence of alumina ($\text{Al}_2\text{O}_3$). These two
compounds also make up the bulk of the constituent of cement, a material employed widely in the construction industry for purposes of binding. The strength of any clayey product, therefore, will largely depend on the percentage composition of silica and alumina.

Iron oxide (Fe₂O₃) another constituent of clay plays an important role in imparting colour to the fired product. When the percentage composition of iron oxide in clay is high, that is, more than 6%, the product is normally brown, going to brick red with compositions of 10% and above.

Clay that contains a larger amount of titanium oxide than iron, when fired gives white products. These require very high firing temperatures and lead to products such as chinaware and marble.

**Apparatus:**
- Assorted pyrex beakers
- Measuring cylinders, 50 cm³ and 10 cm³
- A centrifuge
- Atomic absorption spectrophotometer (AAS - Varian Techtron AA6).
Method (Acid Digestion)

The clay samples were pulverised to between 250 - 300 mesh. Each sample was weighed to 100 mg and put in a 250 ml beaker. It was then mixed with 4 cm$^3$ of conc. nitric acid (HNO$_3$), 1 cm$^3$ of perchloric acid (HClO$_4$60%) and 6 cm$^3$ of hydrofluoric acid (HF 40%). The contents were then boiled for about 30 minutes, with stirring, in a fume cupboard.

The resulting solution was cooled in 4.8 g boric acid (H$_3$BO) and 30 cm$^3$ of distilled water, with constant stirring. The resulting solution was then centrifuged for 10 minutes and the supernatant solution put into a volumetric flask and topped with distilled water to 100 ml.

The solutions were put in plastic bottles, labelled and then analysed with the atomic absorption spectrophotometer and observed. This method of analysis was selected as it is more accurate than calorimetric methods.

Observation

Solutions of clay samples No.2, 5, 6 and 9 were brown in colour whereas No. 3, 8 and 10 were yellowish. Samples No. 1, 4, 7, 11 and 12 were almost clear.
3.1 **Physical Analysis of the Clay Samples**

The two properties looked for in this analysis were plasticity and shrinkage. To measure plasticity, each of the clay samples was pulled out into a thin cylindrical shape about the size of a pencil and coiled around the finger. If it went round without breaking or crumbling, it was plastic and if it did not, then it was less plastic. To measure shrinkage, each of the samples was rolled out at its working consistency into three rectangular slabs of 0.6 cm thick. The length was 15.2 cm and width 2.5 cm. A line measuring 12.7 cm was drawn at the centre of the slab leaving 1.3 cm from the edges (points A and E) as shown below.

![Diagram of a rectangular slab with measurements and points A and E marked]
Each of the slabs was allowed to air dry for several days and the distance between points A and B measured before bisque firing (1050°C). The slabs were measured again and the dry shrinkage, firing shrinkage and total shrinkage expressed in percentage as follows:

\[
\text{Dry Shrinkage} = \frac{\text{Original Length} - \text{Dry Length}}{\text{Original Length}} \times 100
\]

\[
\text{Fired Shrinkage} = \frac{\text{Dry Length} - \text{Fired Length}}{\text{Dry Length}} \times 100
\]

\[
\text{Total Shrinkage} = \frac{\text{Original Length} - \text{Fired Length}}{\text{Original Length}} \times 100
\]

### 3.2 The Research Design

The total number of experimental pots used in this study was 240. Half of these were handbuilt (coil method) and the other half thrown on the wheel. These pots were moulded from three different types of clay and fired by four different types of kilning techniques. Out of each of the clays, 80 pots (40 handbuilt and 40 thrown on the wheel) were made. The pots were then distributed in each kiln as shown in Table 4.
### Table 4: The Research Design

<table>
<thead>
<tr>
<th>Clay</th>
<th>Building Technique</th>
<th>Kilning Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>C₁</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₁₁</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₂</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₂₁</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₂₂</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₃</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₃₁</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>C₃₂</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

**Key:**  
- C₁ - Lyamagale Clay  
- C₂ - A Nyeri Clay  
- C₃ - A Modified Nyeri Clay  
- 1 - Handbuilt technique  
- 2 - Throwing technique  
- Kilning technique 1 - Bonfire (traditional)  
- Kilning technique 2 - Sawdust  
- Kilning technique 3 - Gas (modern)  
- Kilning technique 4 - Raku  

The clay was dug and collected from the river but dug when it finally got to Kenya. 

Preparation of the Lyamagale clay:  
The clay was dug and collected from the river but dug when it finally got to Kenya. 

**References:**  
- Clay Building Techniques  
- Kilning Techniques  
- Key:  
- Table 4: The Research Design  
- Table 4: The Research Design
3.3 The Experiments

In the experiments, Lyamagale clay was used as it was from the source - the traditional potters did the same. The preparation of this clay in the studio was however different from that by the traditional potters in terms of time taken and the facilities used. The Nyeri clay was prepared as it was from the source and the modified Nyeri clay prepared by using the set formula on page 51.

Preparation of the Lyamagale clay

The clay was damp when collected from Hobunaka river but dry when it finally got to Kenyatta University. This clay, as was mentioned before, was composed of three different coloured clays which were mixed in specific proportions. This clay was crushed down into rather fine particles and pebbles and vegetable matter discarded. It was then put in a metal drum and covered with little water for two days. The clay was made soggy in order to enhance thorough mixing. It was then spread on brick troughs to get leather hard. The clay was removed from the troughs and wedged on a plaster bench. It was then stored in plastic bags.
Preparation of the Nyeri Clay

The clay was dry and like the Western clay, crushed and cleaned. It was then soaked in water for a day and later spread on the troughs. When the clay was leather hard, it was removed and wedged on the plaster bench. This clay was stored in plastic bags.

Preparation of the Modified Nyeri Clay

The Nyeri clay was soaked in water overnight and stirred with a heavy duty drill the next day into a slip. The clay was sieved through a 30 mesh sieve. Grog and Kaolin were added and the mixture sieved again. The clay was then spread on the troughs and removed when it was leather hard. The clay was then wedged in lumps or rolls on a plaster bench and stored in plastic bags.

Building Techniques

There were two types of building techniques used in the experiment:
(i) the coil method for handbuilt pots.
(ii) throwing on the potters' wheel for machine-made pots.

Firing Techniques

The firing techniques consisted of the following methods:
(i) the Bonfire
(ii) the Sawdust
(iii) the Gas
(iv) the Raku

The Experimental Bonfire (traditional) Firing

Two big stones of approximately 111.8 cm and 94.0 cm high were placed in juxtaposition approximately 310.6 cm away from each other. High temperature bricks were joined to these stones forming a circle of approximately 975.4 cm in circumference. The bricks were built up to about 30.5 cm high leaving small spaces of approximately 10.1 cm from every 61.0 cm for letting in oxygen to help in the burning of the fuel. This is illustrated in Figure 1.
Arrangement of Fuel and Pots

The pots were fired in two layers. The distribution and loading of the kiln was determined by the sizes of the pots. To avoid premature wastages in this kilning technique, like the sawdust method, the researcher placed more pots on the bottom layers and decreased the number on the subsequent layers.

1. Green grass was laid on the flat ground to form a bed for the first layer of pots to be fired. The level of the grass was about 30.5 cm high.

2. Dry grass, twice the level of the green grass was spread all over the first layer of grass.

Fig 1: Set-Up for the Bonfire Firing
3. The following 32 pots were then arranged all over the spread grass, leaving a space of about 30.5 cm away from the interior of the wall.

<table>
<thead>
<tr>
<th>Handbuilt Clay</th>
<th>Thrown Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale</td>
<td>4</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>5</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>3</td>
</tr>
</tbody>
</table>

4. Thin wood and dry grass were put beside and over every pot such that all the pots were fully covered.

5. More dry grass was piled onto this mass.

6. Green grass was then put over this dry grass and more dry grass piled on the green grass.

7. The second layer of pots consisting of the following, were arranged over the dry grass.

<table>
<thead>
<tr>
<th>Handbuilt Clay</th>
<th>Thrown Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>6</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>5</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>7</td>
</tr>
</tbody>
</table>

There were four layers of randomly distributed pots stacked in this compact kiln. The total amount of sawdust used was seven and a quarter bags of very fine sawdust and three-quarters bag of shavings.
8. Then wood and dry grass were put beside and over every pot such that all the pots were fully covered.

9. Bigger chunks of wood were then arranged from the bottom (filling the 30.5 cm space from the wall) forming a pyramid-like structure.

10. More dry grass was used for covering this structure.

11. A lot of green grass (twice the total amount of dry grass used) was covered over the pyramid-like structure, forming a roundish form.

12. A wire was used for tying the form to hold it together in place of a rope made out of Hyparrhenia diplandra that the potters in Lyamagale used.

13. The mass was lit all round at a distance of every 61.0 cm.

This firing lasted for approximately seven hours.

Kiln Packing of the Sawdust Firing

The kiln was built up of high temperature bricks

The size of the kiln was:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>106.7 cm</td>
</tr>
<tr>
<td>Height</td>
<td>122.0 cm</td>
</tr>
</tbody>
</table>

There were four layers of randomly distributed pots stacked in this compact kiln. The total amount of sawdust used was seven and a quarter bags of very fine sawdust and three-quarters bag of shavings.
One and a half bags full of fine sawdust was evenly spread on the flat ground. Seventeen pots were spread on the sawdust leaving a space of 30.5 cm from the bricks. These pots consisted of:

<table>
<thead>
<tr>
<th></th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

One and a half bags of fine sawdust was then piled all round and inside these pots until it was level and no pot exposed. The following 16 pots were then arranged on this layer of sawdust.

<table>
<thead>
<tr>
<th></th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
One and a half more bags of fine sawdust was spread all over and inside these 16 pots and 15 more pots arranged on as follows:

<table>
<thead>
<tr>
<th></th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

One and half more bags of fine sawdust was spread all over and inside the 15 pots and the last layer consisting of 12 pots arranged as follows:

<table>
<thead>
<tr>
<th></th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

One and a quarter bags of fine sawdust was piled all over and inside these 12 pots and the three-quarter bag of shavings spread over. A lit match stick was placed at the centre of this heap and fire started spreading from that point. The sawdust smouldered for about 93½ hours.
Kiln Packing of the Gas Firing

The gas kiln given on page 74 was selected as the most suitable for the modern firing. The following 60 pots were all stacked in the kiln and fired at 1050°C.

<table>
<thead>
<tr>
<th>Clay Type</th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Kiln Packing for the Bisque Firing of the Raku Technique

The following 60 pots were bisque fired in the gas kiln for the Raku technique.

<table>
<thead>
<tr>
<th>Clay Type</th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Raku Firing Technique

A small gas kiln (Figure 2) was specifically constructed for the actual Raku technique.

Judging from Rhodes\(^1\) colour scale for temperatures, this kiln attained a temperature close to between 600 - 900°C. The formulae of the glazes used were:

---

### (i) Soda Ash
- 8,000 gms

**Silica**
- 120 gms

**Alumina**
- 1,880 gms

**Manganese**
- 300 gms

### (ii) Soda Ash
- 8,000 gms

**Silica**
- 120 gms

**Alumina**
- 940 gms

**Cobalt**
- 75 gms

The pots were fired in singles or doubles depending on the size. The reason for using the Raku method as one of the firing techniques was to test the ability of clay to withstand thermal shock.

### 4 Test for Porosity and Vitrification

A test was carried out to determine the vitrification temperatures of the three clays used in the experiments. This was done by first making four clay rings of about 17.0 cm in circumference from each of the clays. Twelve clay stands were made and then high temperature cones connected to them at an angle of 45° while they were leather hard. These cones were merely used
as objects onto which individual rings would be suspended. Both the clay rings and the clay stands were allowed to dry and then arranged in the kiln in four rows as illustrated in Figure 3. Twelve spy holes were made in the kiln to enable each clay ring to be seen and also to be removed through the same.

Fig 3: Arrangement of Clay Rings in the Kiln.
Orton cones 1 (1160°C), 7 (1250°C), 9 (1285°C) and 10 (1305°C) were put in the kiln to guide in the temperature reading. The gas kiln was lit and the progress of the cones constantly checked through a spy hole.

When cone 1 fell, clay rings on row 1 were removed from the kiln using a wire and put in a container to cool. Each of the rings was carefully weighed and then immersed in water for about three hours. The rings were then removed from the water and reweighed. In order to find out the percentage of absorption, the gain in weight due to absorbed water was divided by the original weight and the product multiplied by 100. When cone 7 fell, the rings on row 2 were removed and the same procedure followed. This process went on until when temperature 1305°C was attained.

3.5 Limitations of the Study

(a) Pottery-making Processes

Much as the researcher would have liked to observe the pottery-making processes of all the eleven areas from which the clay samples were
collected for the chemical and physical analyses, there were limitations due to the time and funds allocated for the research. Lyamagale village (clay sample no.6) was thus selected for an intensive study. This was mainly because it is within the area where the problem of wastage is most evident as is pointed out in section 1.1.

In view of the fact that the largest number of pots from the Western Province appear to be manufactured in this area\(^2\) the researcher felt that there was a need to help the potters produce more durable ware and cut down on the rate of wastage encountered. The other reason for selecting this area for the study was that the traditional potters worked in larger groups compared to the other traditional potters who used the other clay samples. This was thought advantageous because of the structured oral interview that was to be administered later. Interviewing only one or two potters would not have been very meaningful.

(b) Collection of clay

Hobunaka, the river from whose banks the clay for pottery was collected in Lyamagale is communal and

potters travel from neighbouring places to get clay. Sometimes when a favourite spot is invaded, a potter opts for another spot along the same river occasionally a few kilometres away. From the results of the ten clay samples collected from Western Province, it was found that there was a difference in chemical composition of clays even in two samples that were collected along the same river. This variation could therefore interfere with the findings of the study, particularly if the clay used by the traditional potters was not collected from the same spot every time.

(c) Clay Proportions

The clay used by the traditional potters was composed of three different coloured clays. These clays are mixed together in different proportions. Since the potters do not use the same size of baskets all the time for collecting clay, it was difficult to control the mixture to ensure that all traditionally manufactured pots were made up of a uniformly mixed materials in terms of proportions.
Building Techniques

Whereas it was easy to standardize the thickness of the walls of the experimental pots that were machine made (thrown on the wheel), it was almost impossible to have the 120 handbuilt pots in the study have walls of perfectly even thickness. This was due to the coil method used. In this regard one handbuilt pot made from the modified Nyeri clay broke during the bisque firing for the Raku technique because its wall was uneven.

During the observation of pottery-making process in Lyamagale, the researcher noted that some potters specialized only in specific parts of the pot form. A pot could, for example, be moulded up to the shoulder, passed over to the neck specialist and finally to the mouth specialist. This exercise is a factor that could lead to wastage if for example:

(i) the coils of the second potter are not of the same thickness as the coils of the first potter and

(ii) if the clays do not have the same moisture content.
(e) Firing Techniques

Due to the bonfire kind of firing (traditional) it was not possible to fire the pots at some fixed temperature because of the variations in the amount of fuel used and the arrangement of the pots. It was also not possible to measure and regulate the temperature accurately as it was with the kilns.

(f) Sizes of the Pots

The general size of the experimental pots was approximately 70.4 cm in circumference and 34.0 cm in height which is slightly smaller than the pots made by the traditional potters which were respectively 77.2 cm and 40.9 cm in size. This was dictated by the sizes of the kilns available at the Kenyatta University ceramics studio where the experiments were being carried out. The measurements of the kilns used for the 'modern firing' and the Raku firing are given below.
Opening of the kiln floor through which the heat escapes via the flue to the chimney.

Fig 4: The Gas Kiln for Bisque Firing.
For grass they used *Hypsiphyllum*, *Hyparrhenia* and *'ligugu'*. The researcher interviewed by the researcher quoted the grass whose vernacular name is *Hyparrhenia* is common around the University.

Dye was from boiling the bark of *treffi* (Hottentot Spurge) or 'Tiganda' sprinkling on the hot pots for decoration purposes. This was because

(i) it would not have been possible to scrape the dye after the pots were still hot.

(ii) Raku pots would not have taken colour after the glaze cooling.

The experimental hand-built pots, therefore, not have the same design but in the same routine.

Fig 5: Gas Kiln for Raku Technique.

(g) Firing Fuel

They The traditional potters used twigs from trees whose vernacular names are 'Lidogo', 'Vimenenwa' and 'Amafwa'.

Chimney

Damper

Kiln

Fire Box

Gas Burners

Flue
For grass they used Amasinde (*Hyparrhenia diplandra*) and 'Ligugu'. The researcher improvised by using big chunks of scrape wood from the University and some kind of grass whose botanical name is *Hyparrhenia dissoluta*, common around the University.

Dye got from boiling the bark of 'Omusenjeli' (Wattle bark tree) or 'Kigangania' was not used for sprinkling on the hot pots for decoration purposes. This was because:

(i) it would not have been possible to unload the gas kilns while they were still hot and

(ii) the Raku pots would not have taken in the dye after the glast firing.

The experimental handbuilt pots, therefore, do not have the traditional mottled design but have the patterns produced by the effect of the plaited cord roulette.

(h) **Interview with the Potters (Appendix B)**

Although the interview on pottery-making processes was successfully carried out, it was observed that what the potters said was not always what they did. They had their own little shortcuts for faster
completion, both in the presence and absence of the interviewer. It was also quite difficult to get detailed information on the traditional beliefs and superstitions governing the pottery-making processes because as one potter put it "This is a very sensitive issue to be discussed now when so much pottery making is in progress ... we might live to regret"*. Efforts to get the information when less pottery-making was in progress failed.

* Communication with a potter
MAPS

From pp. 79 - 82
KEY:

- Area from where clay samples were collected for chemical analysis.

1. Eshimichini; Eshibeye sub-location, Butsotso Location.
2. Ilesi; Mukhonje sub-location, West Isukha Location.
3. Ebunandi; Mmbihi sub-location, South Maragoli Location.
4. Hobunaka + Hangai; Ebusundi sub-location, East Bunyore location.
5. Eshitare; Lunza sub-location, Marama location.
6. Malinda; Ibola sub-location, Nyang'ori location.
BUNGOMA DISTRICT
SCALE 1:100,000

BOUNDARIES
PROVINCIAL
DISTRICT
DIVISION
LOCATION

KEY:
1. Area from where a clay sample was collected for chemical analysis.
2. Namaloko; North Kanduyi sub-location, East-Bukusu location.

KEY:

1. UNYALA

2. Area from where a clay sample was collected for chemical analysis.

3. BuMilla

CHAPTER 4

DATA ANALYSIS, RESULTS AND OBSERVATIONS

4.0 The Pottery-Making Procedure by the Traditional Potters in Lyamagale

Geographical Background

Lyamagale is a village in Vigulu sub-location, South Maragoli Location, Kakamega District, Western Province of Kenya. It is situated between Kima (Western end) and Vihiga (to the East), a few kilometres off the main Kakamega-Kisumu road. The area has a hilly landscape lying within the altitudes of 1500 to 2,000 metres above sea level. It forms the Western end of the Nandi escarpment. To the south are the Maragoli hills which approximate a height of 1900 metres above sea level. The area is drained by a river called Hobunaka (or Hangai) which is a secondary tributary of River Yala. The soils of the area are according to the National Atlas, (1970); dark, red friable clays which have been derived from both volcanic and basement complex rocks.
CHAPTER 4

DATA ANALYSIS, RESULTS AND OBSERVATIONS

4.0 The Pottery-Making Procedure by the Traditional Potters in Lyamagale

Geographical Background

Lyamagale is a village in Vigulu sub-location, South Maragoli Location, Kakamega District, Western Province of Kenya. It is situated between Kima (Western end) and Vihiga (to the East), a few kilometres off the main Kakamega-Kisumu road. The area has a hilly landscape lying within the altitudes of 1500 to 2,000 metres above sea level. It forms the Western end of the Nandi escarpment. To the south are the Maragoli hills which approximate a height of 1900 metres above sea level. The area is drained by a river called Hobunaka (or Hangai) which is a secondary tributary of River Yala. The soils of the area are according to the National Atlas, (1970); dark, red friable clays which have been derived from both volcanic and basement complex rocks.
The Fieldwork

The potters involved in this study were eight women aged between 29 and 64 years old. The least experienced potter had been making pottery for five years, whereas the eldest and most experienced had been at this craft for 49 years. This group was occasionally assisted by two young girls, daughters of one of the potters, in the collection of fuel and going to the well to fetch water.

One of these potters learnt this craft from her grandmother, two from their mothers, four from other women potters in the village and one from her co-wife. They, however, all had one thing in common which prompted them into taking up this craft: Trade.

These potters gathered at the group leaders' home, which was the central place for meeting, every morning and made pots up to evening. On market days they would take the finished products for sale. Extensive pottery goes on between January and March, August and from October to December. These are dry seasons. April according to two members of this group, is associated with wastage, not so much because of the weather, but because 'the pots will "announce" famine, in the kiln'.
Hobunaka, the river on whose banks the clay (ovodohi) was dug is approximately three kilometres away from Lyamagale. There were three different samples of clay which were collected in shallow baskets. The clays were dug between 91.4 - 122 cm deep. The potters generally believed that the deeper one went, the purer the clay. Two of these potters reported that pots made out of clay that the public had walked on, particularly witches, was contaminated and would thus give problems during the building process and explode during firing. This was demonstrated to the researcher. The pots started exploding about 25 minutes after the 'kiln' was lit. Five photographs were taken of the flying potsherds and on developing the film, the prints were blank, except one which is in fact blurred. The traditional potters would have attributed this to the influence of witchcraft.

On completion of collecting the required material and in correct proportions, the potters set off for the 'workshop' passing through domeshaped rocks that are part of the weathered granitic boulders related to the numerous bare-rock inselbergs and tors that form much of the scenery in parts of Maragoli and Bunyore locations of Kakamega District and Karateng' and Seme locations of Kisumu District.
The samples collected consisted of a black clay normally referred to by the potters as 'were', a reddish-brown clay 'kelonze' and a creamish clay referred to as 'lidohi lilavu'. The proportions were two baskets of the black clay to each of the other clays. These clays were spread on flat ground for cleaning. The black clay was put separately because it is finer in texture and has the least impurities to be discarded. The reddish-brown and creamish clays were kneaded together to ensure thorough mixing due to their differences in texture. The clay, which was generally damp, was split into small pieces before the black clay was added to make a complete mixture for potting. As the three materials were mixed together, water was sprinkled into them by hand to the desired consistency.

As soon as that was achieved, the potters transferred the clay from the ground to the tors for pounding so that the hard lumps would be crushed and also to have a uniform mixture. This was done by beating the clay with the back of a hoe. The clay was further transferred from the tors back on to the ground for handwedging. This was done by rolling the clay back and forth, and pressing any lumps that came their way between their fingers. The clay was then removed
from the bare ground to a bed of banana leaves for storage, under the shade formed by the thatched roof, against the wall of the hut. This was covered by banana leaves and sometimes polythene paper for restoring the dampness so that it would not dry up too fast.

The whole process of clay preparation took approximately 2 hours and 15 minutes. This left the potters too exhausted to pot on the same day. The clay was left overnight and preparations for moulding made for the following day.

The tools used for pottery making consisted of 'oludju lwokulonga' (cradle) for supporting the base of the pot, 'embasa' (pods from the fruit of Tylosema fassoglensis) for scraping and smoothening, scapula of a cow or goat for padding the base of the pots in order to get a non-bumpy finish and 'olusitilu' (plaited cord roulette) made from papyrus reed, for decorating.

The Building Technique

The potters carried out the craft outside in the shade of trees. Each of them took a portion of clay from the bulk, water and the tools for scraping
(pods) to their working places. They sat on flat ground and placed the cradles either before them or on their right hand side over shallow depressions on the ground to enable easy rotation. Fine sand collected from the river was sprinkled on the cradle or banana leaves spread in order to prevent the wet clay from sticking. The potters then rolled out a coil by holding a mass of clay in both hands and rolling it to and fro between the palms. The coils were approximately 5.1 - 8.9 cm in circumference depending on the size of the pot. The larger the pot, the bigger the coil. From experience, the potters were able to estimate the length of a coil that would complete a round.

Holding the rolled coil in their left hands, one end of the coil would be planted at the centre of the cradle with their right hand and pressed with the thumb. The coil would be coiled directly on top in a spiral movement, joining it from the inside using the forefinger and rotating the cradle until it all went round. The inside was then scraped with the pods which were always placed in water so that they would remain open and leather like. The pods curve and remain hard when this is not done. Another successive coil was directly pinched on this form until it was just above the cradle.
This was now scraped from the interior to thin the wall in diagonal strokes, from right to left, while the left hand supported it from the outside. Left-handed potters did the reverse. The bowl-shaped base was turned upside down on the knuckles of the left hand and scraped from the exterior. It was then put back on the cradle and successive coils pinched back to form a cylindrical shape. As this was done, the pot was scraped both from the exterior and interior.

The height of the cylinder determined the size of the pot. When the required height was attained, the potter blew up the stomach of the pot by gently pushing out the wall from the centre of the interior in a diagonal movement towards the rim. The exterior often showed little cracks (plate 10 page 133) and this was erased by scraping or filling in with more clay. More successive coils were pinched back, and this time more on the interior than directly on top of the rim. This was done in order to reduce the roundness of the pot thus making way for the shoulder. This was scraped from the interior and exterior until the opening of the pot was reduced to the required circumference. The pot was left to stand for about 15 to 20 minutes in the sun in order to get leather hard before the neck and the mouth were
fixed. While this was setting, the potter started on one pot after another until the first one was ready, the second and so on.

The neck was fixed by rolling out shorter and thinner coils and pinching them directly onto the neckless pot. The neck was moulded to the required height depending on what it was for. Water storage pots (zisiongo zamazi) had the longest necks while cooking and grain storage pots (zisika) had shorter and wider necks. When the neck was long enough, the mouth was shaped by pinching more coils from the exterior. This gave an outward extension which was then shaped into a curve using pods.

The last coil on the rim was finely rolled out in order to avoid having a bumpy finish. After scraping this last coil, the last touch was got by pressing the rim between the thumb and the forefinger or forefinger and the middle finger of the right hand while the left hand rotated the cradle. This was repeated several times and the fingers were made wet by dipping them in water as was necessary.
The pots were then carried to the hut to dry on the cradles. After two to three days, depending on the weather, the pots were removed from the cradle and put upside down on a bed of banana leaves or on the lap, scraped, and padded with a scapula. Water was then smeared on the exterior and a plaited cord roulette gently rolled over in any preferred movement. Other forms of decoration such as incising or dotting were put on at this stage and the pots placed back on the cradles and left in the sun to dry further. When the neck was strong enough to support the rest of the body, a pot was removed from the cradle and stored in the house for three more days. If the weather was hot, the pots would be dried in the sun for one or two days and then fired. The total number of pots that these potters moulded was between six and ten, depending on the sizes.

The Firing Technique

Firing was done on sunny days and more so, it was preferred on Sunday afternoon after Church service or Friday in the late hours of the morning. This was because market days fell on Mondays and Saturdays. Fuel for firing was not left for the
last minute. Every time a potter was free, particularly during the months that pottery was not being produced, she would fetch twigs and grass (p.76) and store them in preparation for the firing. Certain types of twigs such as 'lisatse' and 'olusololia' (Marhamia platycalyx) were never used as the potters believed that they 'exploded' on heating and in the process shattered the ware.

Firing, more often than not, was done at the same site except during the light rains when one had to look for a more dry spot. No pre-heating of the site was observed. The first step the potters took prior to firing was to transfer the fuel from the place of storage to the site which had formed a shallow depression due to frequent use.

Stones of approximately the same size (the average size of an adult's head) were laid down to form a circle. The circumference of the circle was usually determined by the number and sizes of the pots to be fired. Dry grass was spread on the hard ground and twigs piled on top. After this, the biggest of all the pots was placed at the centre of the circle (plate 20 p.139). If the potters suspected somebody of having bewitched their pots (looking at them
maliciously or parading the firing site without commenting on the pots), they would smear juice from the leaves of blackjack plant in order to render the 'curse' void. The other bigger pots were made to surround the biggest.

As they got closer to the edges, smaller pots would be arranged. The openings of the pots were made to face different directions because the potters would never be sure of where the wind would suddenly be blowing from. They resorted to taking precautions rather than chances so that if anything happened some pots would survive during the firing. If some pots remained, they would be piled over the others on the first layer. During the arrangement, twigs were placed in and beside the pots. No pots were allowed to lean against each other, even the ones that were piled over others.

More twigs were piled onto the pots and then dry grass. A lot of green grass was piled on the dry grass and the mass tied up with a long rope plaited from 'Amasinde' (Hyparrhenia diplandra) in order to hold it together for stability. They chose to use a rope made out of this material because of its 'slow rate of burning out'
Before lighting the kiln, the potters looked uneasy and restless. Each one told the other to say something in form of blessing. Nobody looked like they wanted to take the responsibility until one bold potter said:

"Ah! God ... we have struggled to this stage do not forsake us. If the devil's disciple has wished us evil, may it backfire......*

And no sooner had she finished than the rest harmoniously answered - AMEN. Soon after this, a bunch of long grass was lit and an elected potter went round lighting the pyre from the base at a distance of about 76.2 - 91.4 cm away between the stones. This was done as fast as lightning in order to have all the lit sides burn out at the same rate. More green grass was twice added in the middle of the firing and the pyre poked with a stick to let in air. This fire was lit at 1.40 p.m. and by 3.30 p.m. the whole mass had burnt out having burnt properly for about 1½ hours.

* A potter's prayer.
Unloading of the 'Kiln'

This was a very quick process and the most active part of the firing schedule. The first thing that was done was to clear the area where the pots were going to be splashed with hot juice from boiled bark of 'omusenjeli' (wattle bark tree) to give them the mottled design that is characteristic of pots from Western and Nyanza Provinces of Kenya.

One potter removed one pot at a time using a long stick from 'omusala gwa basungu or gwezi mbao' (Eucalyptus tree) which they claimed did not easily catch fire. This stick would occasionally catch fire (plate 29 p. 143) and this would be rubbed against the ground to extinguish the fire. As soon as it was put on the ground, another potter straight away sprinkled the hot dye onto the pot using a broom of uprooted young plants 'mukuviza nyingu'. A lot of steam was produced and this was very exciting to watch. As soon as this was done, another potter carried it out of the way for storage at a selected site where the pots were left to cool.
When the pots had cooled there would be a lot of rejoicing if the wastage was low. If high, the potters would curse not the suspect for the cause, but why they even bothered to pray. The potters 'tested' whether a pot had fired well by tapping against its wall with a coin and listening to the tone produced. A sharp tone was attributed to successful firing whereas a dull one was attributed to underfiring.

Eager villagers could be seen flocking to the firing site to purchase pots. Sometimes all the pots could sell so that the potters did not have to go to the market the next day. Pots with chipped rims sold at a cheaper price than they would at the market. The prices ranged from Ksh.2/50 to Ksh.22/=.

The underfired pots were kept aside for the next firing.

The potters had a special way of packing their pots for the market. The pots were tied up together with ropes in a straight line. The mouths were all made to face in one direction and between them were stacked rings (head pads) made out of banana fibres.

On their way to the market, the potters would be stopped by wholesale dealers. Thus, the chances that the potters would get to the market with their pots were 50 - 50.
4.1 Interview with the Potters

An oral structured interview was administered to the potters individually and the responses were tape recorded. The aim of carrying out this interview was to enhance the researcher's understanding of the traditional pottery-making processes which were to be observed later. These were recorded in the form of writing and photographs. In the interview, the potters were expected to answer all the questions in the questionnaire (see Appendix B).

4.2 Results of Clay Analysis

The results given in Table 5 (p.100) were obtained from the spectrophotometric analysis of the following clay samples:

Sample 1

ESHIMICHINI clay, collected from Eshibeye sub-location, Butsotso Location, Kakamega District.

Sample 2

NAMALOKO clay, collected from North Kanduyi sub-location, East Bukusu Location, Bungoma District.
Sample 3
ILESEI clay, collected from Mukhonje sub-location, West Isukha Location, Kakamega District.

Sample 4
MALANGA clay, collected from Nambale sub-location Bukhayo Location, Busia District.

Sample 5
EBUNANDI clay, collected from Mmbihi sub-location, South Maragoli Location, Kakamega District.

Sample 6
HOBUNAKA clay, collected from Ebusundhi sub-location East Bunyore Location, Kakamega District.

Sample 7
NYERI clay, collected from Kiria-ini, Central Province.

Sample 8
HANGAI Clay, collected about three kilometres away from where sample 6 was collected.

Sample 9
ESHITARE clay, collected from Lunza sub-location, Marama Location, Kakamaga District.

Sample 10
MALINDA clay, collected from Ibola sub-location, Nyang'ori Location, Kakamega District.
Sample 11

MUSHINAKA clay, collected from Muluanda sub-location, Kakamega District.

Sample 12

MODIFIED NYERI clay, (See formulae on pg. 51)
<table>
<thead>
<tr>
<th>Sample</th>
<th>Silicon dioxide SiO$_2$</th>
<th>Iron Oxide Fe$_2$O$_3$</th>
<th>Magnesium Oxide MgO</th>
<th>Manganese Oxide MnO</th>
<th>Potassium Oxide K$_2$O</th>
<th>Calcium Oxide CaO</th>
<th>Titanium Oxide TiO</th>
<th>Aluminium Oxide Al$_2$O$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>52.07</td>
<td>2.00</td>
<td>0.34</td>
<td>1.1</td>
<td>2.36</td>
<td>3.33</td>
<td>1.26</td>
<td>2.65</td>
</tr>
<tr>
<td>2</td>
<td>53.74</td>
<td>11.15</td>
<td>2.23</td>
<td>Trace</td>
<td>3.71</td>
<td>5.00</td>
<td>2.67</td>
<td>11.71</td>
</tr>
<tr>
<td>3</td>
<td>58.70</td>
<td>6.58</td>
<td>0.51</td>
<td>0.7</td>
<td>3.78</td>
<td>1.67</td>
<td>1.08</td>
<td>11.53</td>
</tr>
<tr>
<td>4</td>
<td>54.57</td>
<td>4.43</td>
<td>0.25</td>
<td>Trace</td>
<td>0.94</td>
<td>3.33</td>
<td>1.99</td>
<td>13.22</td>
</tr>
<tr>
<td>5</td>
<td>53.18</td>
<td>9.86</td>
<td>1.33</td>
<td>Trace</td>
<td>3.49</td>
<td>3.33</td>
<td>1.25</td>
<td>9.45</td>
</tr>
<tr>
<td>6</td>
<td>59.12</td>
<td>10.29</td>
<td>0.53</td>
<td>Trace</td>
<td>3.52</td>
<td>5.12</td>
<td>1.05</td>
<td>4.16</td>
</tr>
<tr>
<td>7</td>
<td>55.25</td>
<td>2.72</td>
<td>0.07</td>
<td>0.2</td>
<td>1.16</td>
<td>5.00</td>
<td>0.39</td>
<td>6.80</td>
</tr>
<tr>
<td>8</td>
<td>59.07</td>
<td>7.72</td>
<td>0.16</td>
<td>0.4</td>
<td>4.09</td>
<td>5.25</td>
<td>0.76</td>
<td>4.35</td>
</tr>
<tr>
<td>9</td>
<td>51.01</td>
<td>12.87</td>
<td>0.28</td>
<td>1.0</td>
<td>2.14</td>
<td>3.35</td>
<td>0.67</td>
<td>12.09</td>
</tr>
<tr>
<td>10</td>
<td>55.78</td>
<td>8.29</td>
<td>0.49</td>
<td>0.1</td>
<td>2.87</td>
<td>1.67</td>
<td>1.85</td>
<td>28.15</td>
</tr>
<tr>
<td>11</td>
<td>64.10</td>
<td>1.72</td>
<td>0.03</td>
<td>0.2</td>
<td>1.16</td>
<td>Nil</td>
<td>0.43</td>
<td>10.96</td>
</tr>
<tr>
<td>12</td>
<td>56.23</td>
<td>2.85</td>
<td>0.08</td>
<td>Trace</td>
<td>1.36</td>
<td>4.98</td>
<td>0.47</td>
<td>7.04</td>
</tr>
</tbody>
</table>

Table 5: Chemical Composition of Clay Samples in Percentages.
Observation

From the results of the chemical analysis of the clay samples shown in Table 5, it is noted that the percentages do not add up to 100%. This could be partly as a result of not analysing all the compounds that make up any clay sample. This analysis focused mainly on the significant elements.

The difference in total percentage between sample 1 and 10 could be due to the presence of organic matter, soluble and insoluble salts being present in the latter sample in bigger quantities than the former.

The A.A. Spectrophotometer method of analysis measures concentration of liquids only. It is possible that the total percentage weight of these samples do not measure up to 100 because of the following:

(i) Undetermined proportions of the insoluble material after centrifuging.

(ii) The presence of the non-determined soluble salts in the supernatant liquid e.g. sodium salts.
(iii) The loss of organic matter (digested) in form of a gas, due to the oxidization by hydrofluoric acid.

Conclusion

From the foregoing results, it was observed that clay is mainly made up of silica ($\text{SiO}_2$) with an average composition of 56.06. Two other major components are aluminium oxide ($\text{Al}_2\text{O}_3$) 10.17% and iron oxide ($\text{Fe}_2\text{O}_3$) 6.70%, other trace elements in clay include magnesium oxide, potassium oxide, calcium oxide and titanium oxide.

The clay from Nyeri is basically similar to that from Lyamagale in terms of elemental composition.

### Physical analysis of clay samples

The results of the shrinkage test of the clay samples are expressed in Table 6 in percentage.
Table 6: Shrinkage of the Clay Samples.

*Leaving allowances of 0.05% to 0.5% for experimental error.

Workability

Samples Nos. 6, 7 and 12 were the three clays used in the study. No.6 being the clay from Lyamagale, 7 Nyeri and 12 Modified Nyeri clay.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Dry Shrinkage %</th>
<th>Firing Shrinkage %</th>
<th>Total Shrinkage* %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.4</td>
<td>5.2</td>
<td>14.2</td>
</tr>
<tr>
<td>2</td>
<td>7.9</td>
<td>0.9</td>
<td>8.7</td>
</tr>
<tr>
<td>3</td>
<td>3.9</td>
<td>0.8</td>
<td>4.7</td>
</tr>
<tr>
<td>4</td>
<td>7.9</td>
<td>1.7</td>
<td>9.4</td>
</tr>
<tr>
<td>5</td>
<td>6.3</td>
<td>2.5</td>
<td>8.6</td>
</tr>
<tr>
<td>6</td>
<td>7.1</td>
<td>2.5</td>
<td>9.4</td>
</tr>
<tr>
<td>7</td>
<td>3.9</td>
<td>1.6</td>
<td>5.5</td>
</tr>
<tr>
<td>8</td>
<td>8.2</td>
<td>1.0</td>
<td>9.0</td>
</tr>
<tr>
<td>9</td>
<td>10.2</td>
<td>0.9</td>
<td>11.0</td>
</tr>
<tr>
<td>10</td>
<td>4.7</td>
<td>0.8</td>
<td>5.5</td>
</tr>
<tr>
<td>11</td>
<td>5.5</td>
<td>0.8</td>
<td>6.1</td>
</tr>
<tr>
<td>12</td>
<td>3.9</td>
<td>0.8</td>
<td>4.7</td>
</tr>
</tbody>
</table>
No. 6

For the handbuilt pots, this was a perfect clay. This was due to its physical properties and the ability to retain its form after the shaping. It was however very difficult to work with on the wheel due to lack of fineness in its texture. The clay had stubborn lumps that did not dissolve when it was soaked during the preparation and this caused problems in the latter building technique particularly when it came to trimming.

No. 7

For the handbuilt technique, this clay was good. It was fairly difficult to work with on the wheel. This was because of its coarse-grain structure and the fragments of quartz.

No. 12

For the handbuilt technique, this clay was good. It was a perfect clay for throwing on the wheel, due to its fine-grained structure.
4.3 Observation of the Firings

The Experimental Bonfire (traditional) Firing

Out of the 60 pots fired, 53 survived. The seven casualties consisted of:

<table>
<thead>
<tr>
<th></th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

from the bottom layer. The top layer had the following casualties:

<table>
<thead>
<tr>
<th></th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 6 shows the position of the cracked pots from the bottom layer while Figure 5 shows those that cracked from the top layer.
Figure 6: Positions of the cracked pots from the Bottom Layer

*Key

Lyamagale clay Handbuilt
Lyamagale clay Thrown
A Nyeri clay Handbuilt
A Nyeri clay Thrown
A Modified Nyeri clay Handbuilt
A Modified Nyeri clay Thrown

The overall number of pots (circles) in the 'Kilns' is not representational of the content.
Figure 7: Positions of the cracked pots from the Top Layer

*See Key on p. 106.
Sawdust Firing

The highest wastage came from the second layer from the bottom, followed by the first layer, third layer and the least was from the topmost layer. Table 7 gives a description of the pots that cracked while Figure 8 shows the positions of the cracked pots in the kiln.

<table>
<thead>
<tr>
<th>From Bottom</th>
<th>Clay</th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Layer</td>
<td>Lyamagale</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A Nyeri</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A modified Nyeri</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2nd Layer</td>
<td>Lyamagale</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>A Nyeri</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>A modified Nyeri</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3rd Layer</td>
<td>Lyamagale</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>A Nyeri</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A modified Nyeri</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4th Layer</td>
<td>Lyamagale</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>A Nyeri</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A modified Nyeri</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Out of the 60 pots fired by this kilning technique only 31 survived.

Table 7: Wastage from the Sawdust Firing
Figure 8: Positions of the cracked pots in the Sawdust Firing.

* see Key on p.106.
Gas Firing

Out of the 60 pots fired 57 survived. The three which broke consisted of:

<table>
<thead>
<tr>
<th>Clay Type</th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A Nyeri</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The positions in the kiln, of the three pots that broke are shown in Figure 9.

* see Key on p. 106.
Bisque Firing for the Raku Technique

Out of the 60 pots fired only 55 qualified for the Raku technique. The five that broke consisted of:

<table>
<thead>
<tr>
<th>Clay Type</th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

The positions of these pots in the gas kiln are shown in Figure 10.

Figure 10. Positions of the cracked pots in the Bisque Firing for the Raku Technique.

* see Key on p. 106.
Raku Firing Technique

During the Raku firing technique a number of pots exploded simultaneously and it was discovered that pre-heating helped a great deal. For this reason, the pots were dried over the chimney, the top of the kiln, and finally put into the red-hot kiln. The pots that exploded or cracked during this firing were 12. These consisted of:

<table>
<thead>
<tr>
<th>Clay Type</th>
<th>Handbuilt</th>
<th>Thrown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyamagale clay</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A Nyeri clay</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>A modified Nyeri clay</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

The total number of pots thus moulded for the Raku technique was reduced from 60 to 55 and to 43.

Observation of the Test for Porosity and Vitrification

It was observed that:

(i) At temperature 1160°C, the Lyamagale clay had an absorption of 10.0%, the Nyeri clay 16.3% and the Modified Nyeri clay 11.7%. 
(ii) At temperature 1250°C, the Lyamagale clay had an absorption of 0%, the Nyeri clay 13.6% and the Modified Nyeri clay 0%.

(iii) At temperature 1285°C, the Lyamagale clay had an absorption of 0% but, the colour turned to a dark green, became rough in texture and acquired a shape close to a concave. The Nyeri clay had an absorption of 11.5% and the modified Nyeri clay 0%.

(iv) At temperature 1305°C, the Lyamagale clay was no more on the clay stand, but when the kiln had completely cooled, it was removed and was found to be terribly distorted. The Nyeri clay had an absorption of 7.7% and the modified Nyeri clay had fused.

Conclusion

From this test it was concluded that the Lyamagale clay vitrifies at temperature 1250°C. The Nyeri clay vitrifies at a temperature above 1305°C. It was not possible to determine the specific vitrification temperature of this clay because the kiln used was constructed of K23 firebricks which cannot stand a temperature beyond 1305°C. The modified Nyeri clay vitrifies at temperature 1285°C.
Record of Wastage in the Traditional Firing

Three firing schedules were observed. The first firing consisted of 49 pots which were all fired in one layer. Out of these 6 broke. The second firing had 64 pots of which 11 broke. These pots were fired in two layers. The bottom layer had 35 pots and the top had 29. The bottom layer lost 7 pots whereas the top layer lost 4 pots. The third firing consisted of 23 pots which were all fired in one layer. Out of these 15 broke.

The Ratio of wastage to the total number of pots fired is as follows:

<table>
<thead>
<tr>
<th>Firing</th>
<th>Wastage</th>
<th>Pots</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>49</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>64</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 7b: Wastage From the Potters Firing

Wastage

Kiln packing and the arrangement of the pots were outlined in Chapter Three. It was reported that each kilning technique had all its 60 pots
fired at a go. It was however, different for the Raku technique as wastage started right at the bisque stage. Five pots broke, leaving 55 for the actual Raku 'test'. Two of these five (1 Lyamagale handbuilt pot and 1 thrown) over vitrified because they were close to the fire box and would not have therefore taken in the Raku glaze. Plate 35 p.146 is a picture of the warped thrown pot. One handbuilt pot from the Modified Nyeri clay (plate 40 p.150 ) broke due to the unevenness in the wall. The fourth and fifth pots were both of the modified Nyeri clay that had been thrown on the wheel. One had a vertical slit (about 8.3 cm) running down from the lip to the neck. This looked like it had been in direct contact with the flame in the kiln as the side of the slit even appeared to be shiny and darker than the rest of the body. The other pot had a horizontal crack across the base of the neck. This looked like it had been there before, but invisible, and opened up on firing. This perhaps developed while it was still drying (in an upside down position) due to the weight of the body on the neck.
When all the pots were fired, not all survived. Some clays had more casualties than others with different building and kilning techniques. Table 8 gives a record of the computed results.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Building</th>
<th>Kilning Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁</td>
<td>C₁₁</td>
<td>0 10 1 1</td>
</tr>
<tr>
<td>C₁₂</td>
<td></td>
<td>0 10 1 1</td>
</tr>
<tr>
<td>C₂</td>
<td>C₂₁</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>C₂₂</td>
<td></td>
<td>2 3 0 1</td>
</tr>
<tr>
<td>C₃</td>
<td>C₃₁</td>
<td>2 2 0 5</td>
</tr>
<tr>
<td>C₃₂</td>
<td></td>
<td>3 2 1 4</td>
</tr>
</tbody>
</table>

Table 8: Record of Wastage.

4.5 Data Analysis

To determine which of the kilning techniques, type of clay, building technique (or which combinations) had the least to the highest wastages, the computed results of the wastages were worked out in percentages and the results compared.
The percentages of wastages produced in each of the kilning techniques were achieved by adding up the total wastage from all the three clays (including the building techniques used), divided by 60 and converted into percentages. The results are presented in Table 9.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Building</th>
<th>Kilning Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>C₁</td>
<td>C₁₁</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C₁₂</td>
<td>0</td>
</tr>
<tr>
<td>C₂</td>
<td>C₂₁</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C₂₂</td>
<td>2</td>
</tr>
<tr>
<td>C₃</td>
<td>C₃₁</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>C₃₂</td>
<td>3</td>
</tr>
<tr>
<td>Total wastage</td>
<td>7</td>
<td>29</td>
</tr>
<tr>
<td>Percentage</td>
<td>11.6</td>
<td>48.3</td>
</tr>
</tbody>
</table>

Table 9: Kiln Wastage

To determine the total wastage of each of the building techniques in each clay, wastages from each building technique in each clay were added together, divided by 40 and converted into percentages. The results are presented in Table 10.
Table 10: Wastage of the Building Technique in each Clay.

To determine the total wastage of each of the three clays, the total wastages from both building techniques in each clay were added together, divided by 80 and converted into percentages. Table 11 represents the results in percentages.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Building Techniques</th>
<th>Kilning 1</th>
<th>Kilning 2</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁</td>
<td>C₁₁</td>
<td>0</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>C₁₂</td>
<td>0</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>C₂</td>
<td>C₂₁</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C₂₂</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>C₃</td>
<td>C₃₁</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C₃₂</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 11: Wastage Percentage of each Clay.
To determine the total wastage from each clay with different kilning techniques, the wastages from both building techniques in each clay and for each kilning technique were added together, divided by 20 and converted into percentages. The results are presented in Table 12.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Building</th>
<th>Kilning Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>C₁</td>
<td>C₁₁</td>
<td>0 10 1 1</td>
</tr>
<tr>
<td></td>
<td>C₁₂</td>
<td>0 10 1 1</td>
</tr>
<tr>
<td>Total wastages</td>
<td></td>
<td>0 20 2 2</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>0 100 10 10</td>
</tr>
<tr>
<td>C₂</td>
<td>C₂₁</td>
<td>0 2 0 0</td>
</tr>
<tr>
<td></td>
<td>C₂₂</td>
<td>2 3 0 1</td>
</tr>
<tr>
<td>Total wastage</td>
<td></td>
<td>2 5 0 1</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>10 25 0 5</td>
</tr>
<tr>
<td>C₃</td>
<td>C₃₁</td>
<td>2 2 0 5</td>
</tr>
<tr>
<td></td>
<td>C₃₂</td>
<td>3 2 1 4</td>
</tr>
<tr>
<td>Total wastage</td>
<td></td>
<td>5 4 1 9</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>25 20 5 45</td>
</tr>
</tbody>
</table>

Table 12: Record of Wastage of Clays per kilning Technique.
To determine the total wastage of each of the building techniques, the wastages from building technique 1 from all the three clays and building technique 2 were separately added together, divided by 120 and converted into percentages. The results are presented in Tables 13 and 14.

<table>
<thead>
<tr>
<th>Clay</th>
<th>Building</th>
<th>Kilning Techniques Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁</td>
<td>C₁₁</td>
<td>0 10 1 1 12</td>
</tr>
<tr>
<td>C₂</td>
<td>C₂₁</td>
<td>0 2 0 0 2</td>
</tr>
<tr>
<td>C₃</td>
<td>C₃₁</td>
<td>2 2 0 5 9</td>
</tr>
</tbody>
</table>

Table 13: Wastage of Building Technique 1.

- Total wastage: 23
- Percentage: 19.1

Table 14: Wastage of Building Technique 2.
Table 14: Wastage of Building Technique 2.

4.6 Observation

From the information contained in Tables 9 to 14, the following were observed:

Clays

The clay from Lyamagale (clay 1), Nyeri (clay 2) and a Modified Nyeri clay (clay 3) had a total wastage of 30%, 10% and 23.7% respectively.
Building techniques in each clay

In clay 1, the total wastage from building technique 1 (coil) was 30% and building technique 2 (throwing) 30%. In clay 2, the total wastage from building technique 1 was 5% and in building technique 2 it was 15%. In clay 3, the total wastage from building technique 1 was 22.5% whereas the wastage from building technique 2 was 25%.

Coil Method (traditional)

The total wastage from all the three clays using this building technique was 19.1%.

Throwing on the Wheel (Modern)

The total wastage from all the three clays using this building technique was 23.3%.

Kilning techniques

The total wastage produced in kilning technique 1 (Bonfire) was 11.6% while kilning technique 2 (Sawdust) had 48.3%. In kilning technique 3 (Gas) the total wastage was 5% and in kilning technique 4 (Raku) there was 20% wastage.

Wastage of Clays Per Kilning Technique

Clay 1 (Lyamagale)

This clay had 0% wastage from the Bonfire firing with 0% wastage from both building techniques 1 and 2.
In the Sawdust firing the wastage was 100% with 100% wastage from both building techniques 1 and 2. The wastage from the Gas firing was 10% with 10% wastage from building technique 1 and 10% from building technique 2. The Raku firing also had a total wastage of 10% with 10% wastage from both building techniques 1 and 2.

Clay 2 (A Nyeri clay)

This clay had 10% wastage from the Bonfire firing with 0% wastage from building technique 1 and 20% from building technique 2. In the Sawdust firing the wastage was 25% with 20% wastage from building technique 1 and 30% from building technique 2. The wastage from the Gas firing was 0% with 0% wastage from both building techniques 1 and 2. In the Raku firing, there was 5% wastage with 0% wastage from building technique 1 and 10% from building technique 2.

Clay 3 (A Modified Nyeri clay)

This clay had 25% wastage from the Bonfire firing with 20% wastage from building technique 1 and 30% from building technique 2. In the Sawdust firing the wastage was 20% with 20% wastage from both building techniques 1 and 2. The wastage from
the Gas firing was 5% with 0% wastage from building technique 1 and 10% from building technique 2. In the Raku firing, there was 45% wastage with 50% wastage from building technique 1 and 40% from building technique 2.

From these observations, the null hypotheses tested in this study were all rejected.

4.7 Hypotheses Testing

Hypothesis 1

There is no difference in wastage between pots made from:

(i) Lyamagale clay
(ii) A Nyeri clay
(iii) A modified Nyeri clay

The findings showed that there was a difference and that the Lyamagale clay had the highest wastage with 30%. It had 6.3% more wastage than the Modified Nyeri clay which came second with a total wastage of 23.7%. The Modified Nyeri clay had 13.7% more wastage than the Nyeri clay which had the lowest wastage with only 10%.
The difference in wastage between the clay with the highest wastage (Lyamaga) and that with the lowest wastage (Nyeri) was 20%.

Hypothesis II

There is no difference in wastage between pots built by:

(i) the coil method
(ii) throwing on the wheel

The findings showed that there was a difference. The second building technique (throwing on the wheel) had a total wastage of 23.3% whereas the first one (coil method) had 19.1% wastage. The difference in wastage between the two building techniques was 4.2%.

Hypothesis III

There is no difference in wastage between pots fired by the following methods:

(i) the Bonfire
(ii) the Sawdust
(iii) the Gas
(iv) the Raku
The findings showed that there was a difference and that the Sawdust firing had the highest wastage of 48.3%. It had 28.3% more wastage than the Raku technique which came second with a total wastage of 20%. The latter technique had 8.4% more wastage than the Bonfire technique which came third with a total wastage of 11.6%. The Bonfire technique had 6.6% more wastage than the Gas firing which had the least wastage with a total of only 5%.

The difference in wastage between the Kilning technique with the highest wastage (Sawdust) and that with the lowest wastage (Gas) was 43.3%.
PLATES

From pp. 128 - 150

Plate 1: Digging clay on the banks of River

Plate 2: The potters carrying the clay to the kiln
Plate 1: Digging clay on the banks of Hangai Stream.

Plate 2: The potters carrying the clay to the village.
Plate 3: The three different colour samples (Black, Cream and Red).

Plate 4: Each of the clay samples being crushed separately.

Plate 5: Water being sprinkled on the clay sample as it is crushed.
Plate 5: Water being sprinkled on the clay as it is crushed.

Plate 6: The samples are heaped together to form a complete mixture.
The clay is pounded to make a uniform mixture.
Plate 8: Handwedging the clay.
Plate 9: Removing pebbles and air from the clay in preparation for moulding.

Plate 10: A crack on a raw pot.
Plate 11: Moulded pots set in the sun to get leather hard before fixing their necks and mouths.

Plate 12: Fixing the first coil in the process of building the neck and mouth of a pot.

Plate 13: Smoothening the lip of the pot using the palm of the hand.

Plate 14: Giving the final touch to the rim using the forefinger and the middle finger.
Plate 13: Smoothening the lip of the pot using the palm of the hand.

Plate 14: Giving the final touch to the rim using the forefinger and the middle finger.
Plate 15: Scraping the bottom of the pot after removing it from the cradle.

Plate 16: Padding the base of the pot with a caws' spatula.
Plate 17: Decorating the pot with a plaited cord roulette.
Plate 18: Drying the pots indoors.
Plate 19: Pots being dried in the sun just before the firing.

Plate 20: The set-up of the firing: the biggest pot is put in the centre.
Plate 21: The smaller pots made to surround the biggest pot.

Plate 22: Twigs placed in between the pots and their mouths made to face in different directions.
Plate 23: More twigs piled over the pots.
Plate 24: The pots covered with dry grass.
Plate 25: Green grass piled over the heap and the mass tied up with a rope.

Plate 26: Lighting the pyre from the base.
Plate 27: The pyre poked with a stick as it burns.

Plate 28: Unloading the pots from the smouldering pyre.

Plate 29: The stick used for unloading the pots from the pyre.

Plate 30: A cracked pot.
Plate 29: The stick used for unloading the pots ablaze.

Plate 30: A cracked pot.
Plate 31: A thrown Lyamagale clay pot after the bisque firing for the Raku technique. It shows little cracks in a patch of creamish clay indicating an uneven mixture.

Plate 32: A Lyamagale clay pot built by the coil method and fired by the Sawdust technique. It shows the points from which the cracks spread.
Plate 33: A thrown Lyamagale clay pot fired in the Gas kiln. It shows bigger and deeper cracks. Note the manner in which the cracks spread!

Plate 34: A thrown Lyamagale clay pot fired by the Sawdust technique. It shows a pebble that was about to force its way out of the wall of the pot leaving a hole and probably damaging neighbouring pots.
Plate 35: A thrown Lyamagale clay pot after the bisque firing for the Raku technique. This pot was in the process of fusing.

Plate 36: A Nyeri clay pot built by the coil method and fired by the Sawdust technique. It shows a chipped bottom.
Plate 37: A thrown Nyeri clay pot fired by the Sawdust technique. It shows a small slit on the neck and a peeling wall.

Plate 38: A pot composed of a modified Nyeri clay, built by the coil method and fired by the Raku technique. It shows a chipped side.
Plate 39: A thrown pot composed of a modified Nyeri clay and fired by the Bonfire technique. It shows a slit running from the rim to the neck.

Plate 40: A pot composed of a modified Nyeri clay, built by the coil method and fired in the Gas kiln. It probably exploded due to the unevenness in the wall.
SUMMARY, RECOMMENDATIONS, COMMENTS AND IMPLICATIONS

5.0 Summary

The purpose of this study was to find out what causes pottery wastage in Lyamagale village in South Maragoli, Western Province. Field research was done in which all the pottery-making processes, from the collection of clay to the final stage of firing and selling of the ware were observed. A structured oral interview was administered to the traditional potters to enhance the researcher's understanding of the traditional techniques used in the manufacture of pottery.

Some of the clay used by the traditional potters was transported to the ceramics studio, Kenyatta University where experiments to determine the cause of the wastage were done. It was hypothesised that:

(i) There is no difference in wastage between pots made from:
(i) Lyamagale clay
(ii) A Nyeri clay
(iii) A Modified Nyeri clay

(ii) There is no difference in wastage between pots built by using:

(i) the coil method
(ii) the wheel method

(iii) There is no difference in wastage between pots fired by:

(i) the Bonfire
(ii) the Sawdust
(iii) the Gas
(iv) the Raku

In this view, the researcher included two other clays used at the University in the experiments. These were a Nyeri clay and a Modified Nyeri clay prepared at the ceramics studio. They were used in order to find out whether there would be any difference in wastage between the three clays.

The first task done before embarking on the actual experiment was to carry out a mineralogical analysis of these clays. Nine other clay samples collected from the Western Province were also
analysed in order to find out whether clays from
different places differed in composition. Tests were
also done to determine the physical properties of the
12 clay samples and the results compared.

The actual experiment involved the use of
only three clays. The clay used by the traditional
potters in Lyamagale Village, the Nyeri clay and the
modified Nyeri clay. Two building techniques were
used in the construction of the pots. The first one
being the coil method, which the traditional potters
observed use, and throwing on the wheel, a method
unknown to the potters. Four kilning techniques
were used: among them, the Bonfire (traditional)
firing which the traditional potters employed. The
rest of the kilning techniques (unknown to the
potters) consisted of the Sawdust, Gas and Raku
firing methods.

Ten pots were made from each clay for every
building and kilning technique. The total number
of pots thus moulded was 240 and each kilning
technique had a total of 60 pots, 20 (ten from
each building technique) out of each of the clays.
The results of the firings were analysed by using simple percentages to determine what combinations of building and kilning techniques produced the least wastage with which clay.

5.1 Answers to the Research Questions Presented on Pages 12 and 13.

The answers to some of the questions the researcher set out to find regarding Lyamagale pottery processes on pages 12 and 13 are as follows:

1. The chemical composition of this clay sample, like the other clays collected from Western Province of Kenya, is suitable for pottery making without any modification. Reference: Section 4.2 Table 5 and under Subtitle 'Workability' of the clay samples.

2. The physical properties of the clay are appropriate for handbuilding but a little difficult to work with on the wheel. This is mainly due to its coarse particles. It would probably do better in the latter technique if screened through a very fine mesh. Reference Section 4.2 under subtitle 'Workability' of the clay samples.

The physical properties do not affect the production as all the 80 pots required of this clay, for the experiments, were realised.
3. The method used for preparing the clay is correct. Aging is recommended for purposes of improving its physical characteristics.

4. The building technique used by these potters, namely the Coil method, is suitable for this clay. The results of the experiments in Table 10 show that the building technique does not contribute to wastage.

5. The method used for drying the raw ware is not correct. The ware should be allowed to dry gradually indoors and when leather hard, should not be piled over each other. The green ware should be stored individually and the position altered to ensure thorough and even drying. Tables 7b and 10 give a comparison of wastages encountered by the traditional potters and in the experiments.

6. The time allowed for drying the green ware is not sufficient. It is suggested that the ware, particularly the bigger ones, be allowed to dry for a minimum of two weeks. Reference: as above.

7. The kind of kiln set-up cannot allow the ware to vitrify because of heat loss encountered. Possible kiln designs are given on pages 160 and 161.

8. The kiln loading practised by these potters is capable of causing wastage due to the manner of arrangement of the ware, as shown in plate 23. Twigs, chunks of wood and grass are placed in between pots and when these burn out the pots on the top layer could suddenly fall onto the ones underneath, resulting in wastage.

9. The firing procedure is good in the early stages of firing until the potters start poking the burning pyre with sticks. This allows cold air to get in at the pots causing a sudden change in temperature which could result in wastage. Reference: Plate 27, p.144.
10. The length of time allowed for cooling the ware is not sufficient. It is recommended that the pyre cools down completely before the 'kiln' is unloaded. Cooling, as is pointed out in the literature review, is part and parcel of firing process.

11. The unloading of the kiln is not correct. The ware, as mentioned above, should be allowed to cool before it is removed. The stick used for unloading could also burn out causing the pot to drop down. Reference: Plate 28.

12. There is no evidence to show that the kind of fuel used in the bonfire (traditional) type of firing has any effect on the results.

5.2 Comments and Recommendations on the Lyamagale Pottery-Making Processes

The results of the data analysis in Chapter Four indicated that both the building and kilning techniques used by the traditional potters and which produced 23.5% wastage, produced 0% wastage in the experiments. This means that the coil method and the Bonfire firing are the best combination for the clay used by the traditional potters.

In the chapter on the methodology of the study it was pointed out that the researcher prepared the Lyamagale clay in a slightly different way from the traditional potters. The drying procedure was gradual and long. The kilning technique (Bonfire) was modified, the pyre burnt undisturbed for about 7 hours, and the ware was allowed to cool totally before
unloading. The following factors, in this case, were thought to contribute to wastage of pots made in Lyamagale Village.

Clay preparation

The time taken between the preparation of the clay and the moulding was too short. It was felt that if the clay was aged its working characteristics would be improved.

Building technique

The potters exercised a lot of skill in the craft and worked with rapidity ensuring that the pot did not stick on the cradle. Cracks developing on the raw pot were well taken care of. Plate 10 p.133 shows a crack on a pot that possibly occurred due to direct exposure to the sun, during the hardening period, before the neck and mouth were fixed. It was felt that this could have been prevented by having the pot set in the shade no matter how long it took. Sundrying raw pots, as was reported in the literature review, promotes unequal drying and uneven shrinkage which can cause wastage.
Repairing cracks is difficult and rarely successful. Sometimes on firing the filler breaks off from the joint due to the differences in moisture.

Another factor observed was that of the passing over of a pot built up to the shoulder to a neck and mouth specialist. If the second potter failed to pinch the coils in the same way as the first potter, the sudden change in technique could cause uneveness in the wall resulting in a disconnection of the two pieces or cracks all round the neck.

The moulded pots were kept indoors for two to three days before they were removed from the cradles in order to scrape and pad the base and decorate with a cord roulette. The pot would be quite dry then and the potter had to literally pour water on the base in order to soften the coils to enable her to scrape and decorate it. Watering a drying pot is dangerous in that cracks may form on the surface and expand on firing or the watered area may absorb water while the unwatered areas continue drying. When such a pot is fired, all the areas are not equally dry and it may therefore explode. The decorated pot was further dried in the sun and burnished using a smooth stone and water! They were then stored in the house in a pile as is seen in
plate 18 (p.138) for three more days before firing. The bases of the pots are covered and remain in that position until the day for firing. Considering that each one of all the pots had its base treated as has just been mentioned, the rate of drying was lowered and this is a fact that could lead to the kind of wastage in plate 30 (page 145) which was a common sight in Lyamagale pottery wastage.

It was noted that the time allowed for pots to dry did not exceed a week. This is quite a short time given that some pots were bigger and thicker than others. The potters used thicker coils for bigger pots and smaller for small pots. It would therefore be suggested that the pots be dried for a minimum of two weeks during which time their drying positions are altered. This would ensure thorough and even drying.

The firing lasted for not more than 2 hours and twice during this period more grass was added and the burning pyre poked with a stick (plate 27 p.144). Asked why they did it, the potters said their intention was to have the centre of the pyre burn fiercely like the outside. This, it was felt, was quite dangerous in that it only made way for cold air
to get in at the pots which could cause a sudden change in the atmosphere. When this happens the temperature in the pots is also altered and the result could be explosions. Secondly, the stick could easily push a pot off position thus disturbing the entire set-up, resulting in wastage. The best thing would perhaps be to let the pyre burn out undisturbed.

The time allowed for firing was insufficient and the procedure not appropriate. The flames were just blown about by the wind causing a lot of heat loss. The researcher felt that if more heat was retained in the firing, the pots would be fired evenly and perhaps vitrify (in this case it's 1250°C). Since vitrification is to a great extent influenced by the kiln construction, it would be suggested that the following kilns be tried out.

**Suggested kilns**

![Diagram of a kiln](image)

- Flue
- Door
- Flat ground

Pots to be placed on raised ground
If the kilns managed to attain the temperature just mentioned then there would be perhaps no use of sprinkling dye from boiled bark of the wattle bark tree to render the pots impervious. The danger noted in the latter process was that, the pots were removed from the pyre while they were hot and carried through the cold atmosphere, tended to crack. The pots would also cool outside the damper, which Cottier-Angeli attributed to cracks.
carried through the cold atmosphere (sudden change!) to the reserved area for sprinkling the dye. This could cause a pot to crack. The pots cooled outside the kiln, which Cottier-Angeli advocated against.

If the suggested kiln constructions cannot achieve a temperature of 1250°C, then other means of making the pots non-porous, such as smoking them over a fire or boiling unpeeled sweet potatoes or bananas as the potters did, could be practised. It is true the sprinkling of dye is also for decoration, but if the process can cause wastage then it might as well be abandoned or the pots should be allowed to cool first instead of removing them from the fire as soon as the flames start dying out.

5.3 Comments on the Experimental Pots

Lyamagale clay

The clay used was made up of the three clays previously mentioned. It was however stated in section 3.5 that the mixture could not have been identical to the traditional mixture in terms of mineralogical proportions, due to having no standard measuring device during the clay collection. The
researcher however tried as much as possible during the digging of the clay to make up a similar mixture with the help of the potters.

One thing observed about this clay was that, despite soaking it in water for two days, there were stubborn lumps that did not soften. These were from the reddish-brown clay. There were also creamish patches showing in the clay. After wedging, it was stored in plastic bags for almost two months before it was used.

Building Techniques

Lyamagale clay was a beautiful clay for the coil method. The lumps just mentioned were only problematic as far as throwing on the wheel was concerned. This was particularly so during the trimming. The clay on aging was nice and plastic and firm. There is no single time a pot collapsed - even on fixing the sections above the shoulder. The built pots had scattered patches of reddish-brown and cream over the grey body.
Firing Techniques

On firing, the little patches of the creamish clay had little cracks. It was noted that no matter how small the creamish patch was, there was a little crack over it. This was particularly evident of the thrown pots (see plate 31 p.146). There was almost no visible crack on the handbuilt pots (coiled) most likely because of their rough texture produced by the effect of the plaited cord roulette. In severe cases the creamish patches served as the central point from which cracks continually grew (plates 32 p. 146) and 33 (p. 147). This was more pronounced in the pots fired by the sawdust firing technique.

The Finish

The pots fired a cherry-brown except in the sawdust firing where they turned black due to the reduced atmosphere. When tapped with a coin the reduced pots produced a denser tone compared to the pots fired by the Bonfire, Gas and Raku kilning techniques which gave a bell-like ring. One aspect observed of the sawdust fired pots was that they had beautiful rainbow colours like those seen when a drop of diesel is dropped in water. A
possible cause for this is that on heating, the sawdust gave off tar and oil which could not disappear in the flame and therefore stuck on the pots. These marks appeared permanent.

**Wastage**

This clay had the highest wastage of the three clays used in the study. Wastage was not influenced by either of the building techniques. The best kilning techniques for this clay appeared to be the Bonfire with 0% wastage closely followed by the Gas and Raku techniques each of which had 10% wastage. The worst kilning technique for this clay was Sawdust with 100% wastage. The Sawdust technique, therefore, should never be attempted under any circumstances by these potters for it cannot work.

**Nyeri Clay**

The procedure used in the preparation of this clay was outlined in section 3.3 and the physical properties in terms of their workability in section 3.0.
The Finish

The bisqued pots fired a creamish colour whereas the ones fired in Sawdust were black and had the same colouring effects like those from the Lyamagale clay. It was noted that there was no difference in the sound produced in all the pots when tapped with a coin.

Wastage

This clay was the best of the three clays used in the study. It was particularly found to be excellent when fired by the gas kiln regardless of the building technique. The second best kilning technique was Raku and particularly with the coil method followed by the Bonfire technique using the same method. The worst kilning technique for this clay, like the Lyamagale clay, was the sawdust firing.

A Modified Nyeri clay

The modified clay as was previously stated in section 3.0 had Nyeri clay for the base. The additives and the formulae for its preparation were also given.
The Finish

This clay fired a whitish-brown colour except for the pots fired in the sawdust firing which like the rest, were black and had patches of rainbow colours on the surface.

Wastage

This clay was number two out of the three clays used in the study. Out of all the kilning techniques by which it was fired, the gas firing seemed to give the best results, particularly with the coil method. The second best technique was apparently the Sawdust technique regardless of the building technique. This was followed by the Bonfire technique and particularly with the coil method. The worst kilning technique for this clay was Raku and more so, when thrown on the wheel.

5.4 Conclusion

This was an experimental study carried out with a view to determining the specific cause(s) of pottery wastage in Lyamagale Village of Western Province of Kenya. The idea of comparing the clay
from Nyeri and the modified Nyeri clay body, prepared and used in the ceramics studio at Kenyatta University was very rewarding. It helped bring out clues that led to the assumed causes of the wastage.

The analysis to determine the chemical composition and physical properties of these clays, plus nine other clay samples which were collected from the Western Province, revealed that clays are mainly made up of: Silica (SiO₂) with an average composition of 55.32%, Aluminium oxide (Al₂O₃) 10.46% and Iron oxide (Fe₂O₃) 7.07%, and several trace elements such as magnesium oxide, potassium oxide, calcium oxide and titanium oxide.

From the same analysis, it was concluded that as far as the chemical composition of clays used for pottery is concerned, they are basically made up of the same components though they may vary in proportion, even when collected from the same stream (Table 5 p. 100 samples 6 and 8). This slight difference in proportion may however, be a factor in affecting the rate of wastage.
The petrological examination and the analysis of the physical properties of these clays revealed that seven of the clay samples collected from the Western Province were of granitic source. These clays which ranged from yellow, green, brown and grey when raw, were found to be basically fine grained in texture with an average total shrinkage of 8.9%. Two clay samples which in the raw state ranged from yellow-brown to light grey from this province, and which were moderately-coarse grained, were found to be of igneous source with an average total shrinkage of 9%. One more clay from the Western Province which was grey in the raw state and fine grained was of sedimentary source with an average total shrinkage of 6.1%.

The two clays (a Nyeri and a Modified Nyeri clay) which were used in the experiments together with the selected sample from the Western Province, ranged from grey to light grey in the raw state with contrasting grain structures (coarse and very fine) respectively. They were of volcanic source with an average total shrinkage of 5.1%.
From the results of these tests, it could be concluded that clays from volcanic sources have the least total shrinkage, followed by clay from a sedimentary source. The total shrinkage of clays from igneous and granitic sources was relatively higher than those two. This is, however, only an assumption which further research could investigate.

From the results of the outcome of the experiments using the three clays, it was concluded that the clay from Lyamagale, the Nyeri and the modified Nyeri clay all differed in wastages produced. The clay from Lyamagale had the highest wastage, followed by the Modified Nyeri clay and the Nyeri clay which had the least.

Looking closely at these clays, it was noted that the tempered Nyeri clay otherwise referred to as Modified Nyeri clay had more wastage than the Nyeri clay which was used as collected from the original source. The Lyamagale clay, having been used without an addition of any tempering materials, had the reverse results. This brings in a feeling that tempered clay bodies may not necessarily be the best.
It can further be concluded from the experiments that the two building techniques (coil method and throwing on the wheel) differ in the rate of wastages produced. This was however, not the case with the clay from Lyamagale as both building techniques produced the same wastage percentage, suggesting that both techniques are equally suitable for this clay.

Lastly, it was observed that the four kilning techniques used in the study: Bonfire, Sawdust, Gas and Raku methods, all differed in the wastage percentage produced. Some kilning techniques were found to be better with certain combinations; for example the Bonfire technique produced 0% wastage with the Lyamagale clay while Sawdust produced 100% with the same clay. The Gas technique produced 0% wastage with the Nyeri clay but 10% with the Lyamagale clay. As for the Modified Nyeri clay no kilning technique produced 0%, each had a small wastage, the Gas producing the least with a wastage of 5%.

The highest wastage seemed to come from the Sawdust kilning technique. This was most evident with the clay from Lyamagale. The researcher was left to wonder why the wastage was 100% and not
even 20% as was the case with the Modified Nyeri clay. Was it due to the mineral proportions in the clay or was it something to do with an ingredient in the Sawdust, which was composed of assorted grains of cypress, camphor, podo and cedar woods?

The kilning technique with the second highest wastage was the Raku method which produced a wastage of 45% with the Modified Nyeri clay, 5% with the Nyeri clay and 10% with the Lyamagale clay. From the results of this particular technique, it can be concluded that although Lyamagale clay cannot stand a temperature of above 1250°C, it is able (when bisqued) to withstand thermal shock as is demanded by this technique.

Finally, the Bonfire had the third highest wastage while the Gas method produced the least. Therefore, on the basis of the data gathered and analysed, the causes of pottery wastage in Lyamagale Village of Western Province of Kenya were neither of the techniques (Coil method and Bonfire firing) employed in their traditional processes. What could have perhaps caused the wastages was a faulty procedure in the pottery-making processes. A few
examples are: setting the raw pots in the sun to dry promoted uneven drying and shrinkage which could cause wastage. The potters sprinkled water on the bases of the pots while they were in the process of drying causing unequal drying which could also result in wastage during the firing. The pots were dried indoors in a pile and the positions were not altered to ensure thorough drying. The result was that the covered areas remained damp and this could also bring about wastage. The time given for these pots to dry was not sufficient too. While the pots were in the process of firing, the potters disturbed the pyre by poking it with sticks, not knowing that they were only making way for cold air to get in at the pots, which would cause wastage. The pots were then removed from the 'kiln' before they had completely cooled.

The cause of the wastage could also be due to a weakness in the clay composition or in the mixing of the three components. However, from the experiments, it was noted that if the proper procedures are adhered to, the Lyamagale clay, like the Nyeri clay can produce minimal (0%) wastage using the Coil building technique and the Bonfire kilning technique. Apart from the bonfire kilning technique, the Nyeri
clay can produce minimal (0%) wastage using both the building techniques (Coil and throwing on the wheel) and the Gas kilning technique. On the other hand, the Modified Nyeri clay would produce minimal (10%) wastage using the wheel and the Gas kilning technique.

In view of the fact that the Modified Nyeri clay is not available and cannot be used in the rural areas by the traditional potters, potters using the Lyamagale and Nyeri clays are at an advantage because the best combination for these clays; the Coil building technique (handbuilt) and the Bonfire technique which operates on inexpensive material for fuel (grass and wood), are at their disposal.

5.5 Implications for Further Research

Further research could be carried out with the following questions:

1. The study experimented with only one clay sample out of the ten collected from the Western Province of Kenya. Would a similar study covering all the ten areas help determine:
(i) the nature and degree of wastages encountered with each sample and their vitrification temperatures?

(ii) the most suitable combination of clay, building and kilning technique for each area?

2. The chemical composition of the Lyamagale clay used in the study was analysed as a complete mixture. Would an analysis of each of the three components of the mixture help determine the cause of the cracks that only appeared over the creamish patches on the surface of the fired pots?

3. Clays derived from a volcanic source appeared to have a lower total shrinkage than those from sedimentary, granitic and igneous sources. Would a more detailed investigation help determine whether the degree of shrinkage of clays is influenced by their source of origin?

4. The worst (100% wastage) combination of clay, building and kilning technique in the whole study was: Lyamagale clay, using both building techniques (coil and throwing) and fired by the Sawdust technique. Was this due to the composition of the clay or an ingredient in the Sawdust or a combination of both?
5. The Modified Nyeri clay was basically composed of the Nyeri clay plus tempering materials. The result was that the untempered clay produced better results. Would the same happen if the Lyamagale clay was treated as the Modified Nyeri clay?

6. The Lyamagale clay was used as collected from the source. Would the results be better if it was mixed with other pottery clays from neighbouring Karateng' and Seme locations of Kisumu District?

7. The study was restricted to only three types of clay, two building techniques and four kilning techniques. Would the findings of the experiments remain the same if more clays, building and kilning techniques were included?
Twelve clay samples were submitted for petrological analysis. The results of this analysis are given below. The terms abundant, common, sparse, well sorted and ill-assorted are used in the sense of Peacock (1977).

Sample 1

Thin-sectioning reveals a groundmass of baked clay containing common to abundant inclusions of ill-assorted quartz which are also sub-rounded and rounded. The matrix also contains sparse feldspars, common iron ores plus a few clay pellets. The feldspars consist of microclines plus plagioclases with albite twins. Some of the feldspars are decomposed. These petrological results seem to suggest that this clay sample was derived from an igneous, probably granitic, source.

Sample 2

Under the microscope this sample reveals a groundmass of baked clay containing common inclusions of well sorted, sub-angular and sub-rounded quartz.
The matrix also contains common inclusions of feldspars, some of which are decomposed. Those that are not decomposed were observed to include microclines and plagioclases. Some of the plagioclases have albite twins whilst others have combined albite and carlsbad twins. In addition to quartz and feldspars, the matrix contains very sparse inclusions of biotites and iron ores. These results suggest that this clay originated from a granitic source. This sample, however, differs from sample 1 in having more inclusions of feldspars and in having biotites.

Sample 3

Thin-sectioning reveals a groundmass of baked clay containing common to abundant inclusions of ill-assorted quartz which is also sub-angular and sub-rounded. The matrix also contains common inclusions of feldspars, plus very sparse inclusions of iron ores and shreds of muscovites. Some of the feldspars are decomposed. Those that were undecomposed consist of microclines. These results suggest that this sample was derived from a granitic source. This matrix, however, differs from those of samples 1 and 2.
Sample 4

Under the microscope this sample appears as a groundmass of baked clay containing abundant inclusions of ill-assorted, sub-angular and sub-rounded quartz. The matrix also contains sparse inclusions of feldspars and iron ores plus a few leucoxenes. The feldspars consist of microclines and plagioclases with carlsbad twins. Some of the iron ores occur as cementing material. These results suggest that the sample derives from an igneous source.

Sample 5

This appears as a groundmass of baked clay containing common inclusions of ill-assorted, sub-angular and sub-rounded quartz grains, together with common inclusions of feldspars. Some of the feldspars are decomposed. Both microclines and plagioclases with albite twins were observed to be present. In addition, the matrix contains sparse inclusions of iron ores, some of which occur as cementing material, a few of leucoxenes and two apatites. These results suggest that the clay was derived from an igneous source.
Sample 6

Thin-sectioning reveals a groundmass of baked clay containing abundant inclusion of ill-assorted, sub-angular and sub-rounded quartz grains. The matrix also contains sparse inclusions of feldspars, including some microclines, together with common inclusions of iron ores, some leucoxenes and one clay pellet. This matrix resembles that of sample 4. The petrological results indicate that this clay was derived from a granitic source.

Sample 7

Under the microscope this sample appears as a groundmass of baked clay containing common inclusions of ill-assorted, sub-rounded and rounded quartz, together with sparse inclusions of orthoclase feldspars. The matrix also contains sparse inclusions of iron ores, a few leucoxenes, a pyroxene and a biotite. These results suggest a volcanic source, probably rhyolitic.
Sample 8

This appears as a groundmass of baked clay containing fairly common inclusions of ill-assorted, sub-angular and sub-rounded quartz, together with sparse inclusions of feldspars. The feldspars include plagioclases and microclines. The plagioclase feldspars are characterized by albite as well as carlsbad twinning. In addition to quartz grains and feldspars, the matrix contains fairly common inclusions of iron ores plus some leucoxenes. These results suggest a granitic source for this clay.

Sample 9

Thin-sectioning reveals a groundmass of baked clay containing common inclusions of generally well-sorted quartz grains together with common inclusions of microcline feldspars. The matrix also contains fairly common inclusions of iron ores, some muscovites, some leucoxenes plus some inclusions of what appear to be limonites. These results suggest that this clay derives from a granitic source.
Sample 10

Under the microscope this sample appears as a groundmass of baked clay containing common, well-sorted, angular and sub-angular inclusions of quartz, together with common to abundant inclusions of feldspars. Some of the feldspars are decomposed but microclines were identified in the matrix. In addition, the matrix contains very sparse inclusions of biotites and iron ores. These results suggest that this clay has its origins in a granitic source.

Sample 11

Thin-sectioning reveals a groundmass of baked clay containing abundant inclusions of well-sorted angular and sub-angular quartz. The matrix also contains sparse inclusions of iron ores together with very sparse inclusions of iron and leucoxenes. The results suggest that this clay derives from a sedimentary formation.

Sample 12

This appears as a groundmass of baked clay containing common inclusions of ill-assorted, sub-angular and sub-rounded quartz, together with
fairly common inclusions of orthoclase feldspars. This matrix also contains inclusions of a few iron ores. The petrology of this sample is basically similar to that of sample 7.

Conclusion

Petrological examination reveals that nearly all the clay samples were derived from a granitic source. There were only two exceptions to this rule, namely, samples 7 and 11. Sample 7 was obtained from a volcanic source whilst sample 11 was derived from a sedimentary source. Each of the granitic samples has, however, its own subtleties which appear to confirm the fact that each of them was obtained from a different site.
APPENDIX B

QUESTIONNAIRE TO POTTERS AND THEIR RESPONSES

NAME OF POTTER ----------------------------------------

VILLAGE---------------------SUB-LOCATION---------------

DISTRICT--------------------DATE-----------------------

Q.1 For how long have you been making pottery?

Res. Each of the potters in the group of potters interviewed in this study had been making pottery for the following years respectively: 14, 10, 49, 17, 5, 24, 11 and 8.

Q.2 Whom did you learn this skill from?

Res. 50% of the respondents said they learnt pottery from other women potters in their village. 25% learnt from their mothers, 12.5% from their grandmothers and 12.5% from their co-wives.

Q.3 Do you make pots all year round or in one season?

62.5% of the respondents said they made pots from January to March, August and from October to December. They said during the other months the village was pre-occupied with other duties. 37.5% said they made pots all year round depending on how much time they had. 50% said pots were never moulded in April due
to the heavy rains. 25% said that due to famine experienced in April, the pots would not survive a firing (superstition).

Q.4 Where do you collect your clay from?

Res. 100% of the respondents said they collected their clay from the banks of Hobunaka river.

Q.5 How many different kinds of clay are available?

Res. 62.5% of the respondents said there were 3 (Red, Black and Cream) different kinds of pottery clay available on the banks of Hobunaka river. 12.5% said that there were 4 (Red, Black, Cream and off White) kinds of clay available and 25% said there were 2 (Red and Black) kinds of clay although the Red one could be found in varying tones.

Q.6 Do you use one sort of clay or several mixed together?

Res. 100% of the respondents said that all the different kinds of clay collected from the banks of Hobunaka river were wedged together and that no other clay or material was added.
Q.7 How do you prepare your clay?

Res. 100% of the respondents said that each of the clay samples collected from the banks of river Hobunaka was broken down into finer particles and then all wedged together.

Q.8 Do you add anything or do you use the clay in the state you dig it up?

Res. 62.5% of the respondents said that during the clay preparation, a little water was added to the right consistency and pebbles and organic matter removed as the water was sprinkled on the pound clay. 37.5% said that water was added to the pound clay when necessary.

Q.9 When do you use the prepared clay?

Res. 12.5% of the respondents said that the prepared clay was used after 4 days of storage. 37.5% said the clay was used after 3 days, 25% said it was used after 2 days and 25% said that it could be used after 1 day.

Q.10 What techniques do you use for building your pots

Res. 100% of the respondents said that they used the coil method for making their pots. From this percentage 12.5% said that they had never heard of the existence of any other building technique.
Q.11 How many pots can you make in a day?

Res. The group of potters made a total number of 55 pots per day with an average of about 7 pots per potter.

Q.12 Do you decorate your pots before or after firing?

Res. 100% of the respondents said they decorated pots either before or after firing.

Q.13 What techniques do you use for decorating?

Res. 100% of the respondents said they used the following techniques for decorating their ware:

(a) Before firing: plaited cord roulette, blunt objects such as feather-ends for incised and dotted decorations, river stones for burnishing leather dry pots.

(b) After firing: sprinkled dye obtained from bark of wattle bark tree on pots.

Q.14 What tools do you use for decorating?

Res. 100% of the respondents said that they used plaited cord roulettes, blunt objects such as feather-ends, river stones for decorating their pots. They also used a broom of uprooted young plants to splash dye from the bark of wattle bark tree onto the pots.
Q.15 How do you dry your pots?

Res. 100% of the respondents said they dried their ware both indoor and out-door.

Q.16 How long does the drying process take?

Res. 50% of the respondents said the drying process of the pots took 1 week; 25% said it took between 5 days and 1 week for ware to dry up. 12.5% said it took between 6 days and 8 days and another 12.5% said it took between 5 days and 8 days for ware to dry up.

Q.17 How do you tell whether a pot is dry enough for firing?

Res. 25% of the respondents said that after drying the pots for 5 days to 7 days from the time of moulding, the pots would definitely be ready for firing. 12.5% said that after sun-drying pots for 3 days, it was alright to fire them. 25% said that they sundried their pots for 2 days and then fired them after tapping the walls with a river stone and carefully listening to the tone produced. 25% said that once a pot had been sundried it was ready for firing. 12.5% said they could tell whether a pot was ready for firing just by looking at it.
Q.18 Give a detailed description of the firing procedure.

Res. 100% of the respondents described the firing procedure as follows:

(a) Stones are arranged around the firing site in a circle.

(b) A bed of dry grass is spread on the ground for the pots.

(c) Pots are spread all over the grass with the biggest being placed in the centre and smaller ones on the sides. These are then covered with twigs, dry and green grass.

(d) The pyre is tied up with a rope made from a special kind of grass so that the wind does not blow the grass away.

(e) The pyre is lit all round from the base.

Out of the above percentage, 12.5% noted that all pots, regardless of the purposes for which they were built, were fired at the same time. Another 12.5% from the 100% mentioned above said they believed that during the loading of the 'kiln' the mouths of the pots should not touch each other. They argued that heat got into the inside of the pots through their mouths and therefore if they touched, the pots would explode in protest.
Q.19  Do you fire your pots in a group or individually?

Res.  100% of the respondents said they fired their pots in a group.

Q.20  Do you fire your pots in the same spot or do you select a new site every time?

Res.  75% of the respondents said they fired their pots at the same site all the time unless it was wet after the rains. 25% said the firing site remained the same but could be changed if they suspected that it had been bewitched.

Q.21  Are any arrangements made prior to the firing? Describe.

Res.  100% of the respondents said that there were responsibilities assigned to potters prior to the firing. Some potters were asked to take care of the fuel, to load and unload the kiln, to clear the site for storage, to splash dye onto the pots. The group would also appoint the person to pray for the pots prior to the firing.

Q.22  How many pots do you fire at one firing?

Res.  25% of the potters said they fired about 50 pots at one firing. 12.5% said that the number of pots was determined by the number of pots each potter had produced and whether all potters in the group had effectively participated. 12.5% said that there was no specific number of pots that was fired at one firing but whatever was not used was wasted. They estimated that the average number of pots per firing was between 23 and 65.
the group had effectively participated. 12.5% said that there was no specific number of pots that was fired at one firing but whatever the number it never exceeded 120. 50% of the respondents said that the average number of pots per firing was between 23 and 68.

Q.23 How many pots crack during one firing?

Res. Non of the respondents pinpointed the exact number of pots that cracked in any given firing. 75% of the respondents however gave scientific explanation as to why the level of wastage was indefinite. 25% of the respondents gave superstition based arguments as to why wastage level was unpredictable. The researcher observed three firings conducted by the traditional potters and noted that the total wastage amounted to 23.5%. From experiences, however, it appears that wastage up to 10% is acceptable. Figures beyond this percentage would require an investigation.

Q.24 What do you do with the cracked pots?

Res. 75% of the respondents said that they sold cracked pots at throw away prices at the market. 12.5% of these respondents said that if the pots were not badly cracked, they would give them to poorer relatives or neighbours. Another 12.5% of the latter said they gave poultry farmers cracked pots so that they could use them for holding water for their chicken. 25% of these respondents said that if the bases of pots were not cracked, they would make cradles for moulding out of them. 25% of the respondents said that cracked pots were used for bewitching other potter's pots in revenge of the same.
Q.25 What do you think causes these pots to crack?

Res. 87.5% of the respondents attributed wastage occurrence to superstitions and witchcraft. 37.5% of the respondents said that pots would crack if they were moulded and fired in the month of April. 12.5% of the respondents said that the kind of fuel (e.g. 'Lisatse' and 'Olusololia' - *Marhamia platycalyx*) would cause pots to explode in the firing. 12.5% of the respondents said that if clay for pottery was collected from the same spot over a long period, wastage would occur.

Q.26 What fuels do you use for the firing?

Res. 100% of the respondents used the following fuel for firing:

(a) Wood: 'Lidogo', 'Vimenenwa' and 'Amaua'

(b) Grass: 'Amasinde' and 'Ligugu' both in their green and dry state.

Q.27 Where do you get the fuel from?

Res. 100% of the respondents collected the fuel for firing from the forest, or the surrounding hills.
Q.28 How do you regulate your firing temperature?

Res. 62.5% of the respondents said that they added more grass to the pyre to increase the heat. The temperature was never lowered according to them. 25% of the respondents said that the firing was never regulated. The pyre was lit and left to burn out without any further addition of fuel. 12.5% of the respondents said that they added green grass to the pyre if the flame was too wild.

Q.29 How do you tell when the pots are ready and well fired?

Res. 100% of the respondents said that they would tell that the pots were ready when the flames in the pyre burnt out. They confirmed by tapping the walls of the pots with a coin and listening to the tone produced. 12.5% of these respondents said that they could tell if the pots were ready by the smell in the atmosphere.

Q.30 When do you remove your pots from the firing site?

Res. 100% of the respondents said that, as the 'kiln' was unloaded, the hot pots were removed from the firing site and sprinkled with hot juice obtained from the bark of the wattle bark tree. The pots were then left to cool and transferred to the house to await packing and transportation to the market.
OBSERVATION

Although this oral structured interview was administered to the potters individually, most of the responses are quite similar. This is mainly because the potters worked together as a group and therefore had their own laid down rules regarding the processes of pottery production.

CONCLUSION

From the above responses it is noted that the potters interviewed in this study have different explanations and interpretation of the causes of pottery wastage. Whereas they were a little specific about the number of pots they could mould in a day, they were unable to pinpoint the number of pots that cracked in each firing. 75% of the interviewees gave answers that had some scientific bearing. One potter can be quoted as having said "... the number of pots that crack is indefinite. They can even all break. It is however very rare that they all survive". 25% gave answers that had elements of superstition. One potter for example said that "... if the clay does not like you, only 3 out of 40 pots will survive". Another
potter asserted that "... God decides as to how many pots to spare for the potter".

From the experiments carried out with this clay using different building and firing techniques, it can be concluded that the wastage encountered by the traditional potters in Lyamagale was brought about by irregularities in the actual making processes and in the firing procedure. Reference: Section 5.1 "Comments and Recommendations on the Lyamagale Pottery - Making Processes".
BIBLIOGRAPHY


Ndung'u, Fred. "Women Who Sustain a Dying Heritage" 
The Daily Nation, Wednesday, November 24

Newcomb, Rexford. Ceramic Whitewares: History,
Technology and Applications. New York:

Norton, H.F. Elements of Ceramics. Massachusetts:


Olson, Delmar. Pottery: Getting Started in Ceramics.

Powell, Harold. The Beginner's Book of Pottery Part One.

Price, Christine. Made in West Africa: Illustrated
With Photographs and Drawings. New York:
Dutton, E.P. 1975.

Rhodes, D. Clay and Glazes for The Potter. London:

Rhodes, D. Kilns: Design, Construction and Operation.

1976.

Rhodes, D. Stoneware and Porcelain: The Art of High

Roscoe, John. The Baganda: An Account of their
Native Customs and Beliefs. London: Frank

Rosenthal, Ernst. Pottery and Ceramics, From Common
Brick to Fine China. Harmondsworth: Penguin

Tiranti Ltd., 1963.


