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Prospecting And Testing Of Clay For Schools Offering Ceramics In The Sekondi- Takoradi Metropolis, Ghana

Kofi Asante-Kyei[1*] Kwaku Nkrumah Acquah[2]

1. Lecturer/ Former Head Of Ceramics Department, Takoradi Polytechnic, P.O Box 256. Takoradi
2. Lecturer Takoradi Polytechnic, P .O Box 256. Takoradi

*asantekyei@yahoo.co.uk kanacquah@gmail.com

Abstract

Clay, which is a natural mineral in the earth remains the major ceramic raw material since time immemorial. With the introduction of the new Educational Reform in 1987, many second and some third cycle institutions have taken ceramics as one of the vocational subjects in Ghana. Clay, which is the main raw material, is difficult to come by within the Sekondi-Takoradi Metropolis. This has somehow affected the performance of institutions offering ceramics including St. John's Senior High School, Ahantaman Senior High School and Takoradi Polytechnic, all in the Metropolis. To find a solution to this problem, the researchers had made effort to prospect and test for varieties of clay from areas closer to the metropolis. Literature related to the topic had been reviewed. The experimental research method was employed. The purposive sampling technique was used to select the proposed clay deposits in the selected districts. All the general procedures and processes used in prospecting and testing for clay were followed. For example, water of plasticity test, presence of lime test, dry shrinkage test, fired shrinkage test and porosity test. From the findings, it was realized that these clay deposits could be very useful to schools offering ceramics in the Metropolis. It was recommended among other things that institutions offering ceramics should patronize clay from these areas, and the district assemblies should try to construct roads to the various clay sites, so as to make them motorable to people who might need the clay.

Keywords: Clay, Prospecting, Plasticity, Testing, Shrinkage

1.0 Introduction

Clay is a natural mineral and a major raw material for the ceramic industry. It is an earthly mineral substance composed largely of a hydrous silicate of alumina which becomes plastic when wet and hard and rocklike when fired (Rhodes 1973). In Ghana, clay can be found in almost all the ten regions. What matters most is whether the clay is useful for pottery and ceramics. Hence, the need to prospect and test for clay.

1.1 Statement of the Problem

Most second cycle schools in the Western region especially Sekondi-Takoradi Metropolis, which offer ceramics as a subject rely solely on Abonko clay from Central Region for their works. Again, there is a problem of acquiring clay for Takoradi Polytechnic students offering ceramics. Also, some local pottery industries in the Metropolis are on the verge of collapsing due to lack of clay. From the above mentioned problems, the researchers deem it necessary to prospect and test for clay so as to alleviate the problem of getting clay for students offering ceramics at Takoradi Polytechnic and second cycle schools within the Sekondi-Takoradi Metropolis.

1.2 Objective of the Study

To prospect and test for clay in Wasa-Amenfi area for possible future mining of clay.

1.3 Scope of the Study

The scope of the study is limited to clay prospecting and testing in Wasa-Amenfi area.

1.4 Importance of the Study

- The study would make clay more accessible to the second cycle schools in the Metropolis
- It would encourage more schools to offer ceramics as a subject.
- The study would also encourage the youth in those areas to undertake pottery as a profession.

1.5 Working Definitions

- *Clay*: Is a variety of earthly materials formed by the decomposition of granite

- *Dry Shrinkage*: The ability of the clay to contract during drying
- *Fired Shrinkage*: The ability of the clay to contract during firing
- *Maturity*: Refers to the temperature and time in firing at which clay reaches the desired condition of hardness and density
- *Plasticity*: The ability of damp clay to yield under pressure without cracking and to retain the formed shape after the pressure is released
- *Porosity*: Refers to the water absorption capacity of the clay

1.6 Abbreviations

D.L.: Dry Length

TT.DL: Total Dry Length

AV.DL: Average Dry Length

F.L.: Fired Length

TT.FL: Total Fired Length

AV.FL: Average Fired Length

P.L: Plastic Length

AV.DW: Average Dry Weight

AV.SW: Average Saturated Weight

2.0 **Review Of Related Literature**

2.1 Clay Classifications

Basically, there are two types of clay. These are primary and secondary clays. According to Grainshaw (1971), primary clay or residual clay is the type which is white in colour, of a little plasticity and can stand high temperatures without deforming. Gardew (1969), explains secondary clays as more plastic than the primary clays. They are plastic due to their finer particle sizes produced by constant grinding while being transported from one site to another.

Generally, clay has shrinkage capacity which could occur in any of these stages, thus drying, firing and at glost stage. The rate of shrinkage varies from clay to clay and similarly is the water absorption ability of the clay. The impurities present in clays are the most influential factors that affect the maturing temperature and the fired colour of clays.

Clays vary in physical properties such as colour, hardness, plasticity, abrasion, coarseness, and mineralogical content. However, most clays do have certain properties in common. For example, they have the ability to be crushed and mixed with water to form a plastic material which can be moulded into various shapes. This can be fired to a higher temperature for it to attain a hard weather resistant characteristic.

3.0 **Methodology**

The experimental research method was employed since the study was to prospect and test for clay. The purposive sampling technique was used for the selection of proposed clay deposits in the districts. Four (4) samples of clay were taken from Akropong, Ankonsia, Abreshia and Saamang; all in Wasa Amenfi East District. Three(3) samples of clay were also taken from Arku Nkwanta, Ayisi and Ntaboune, all in Wasa Amenfi West District.

At the sites, a simple test of plasticity was conducted on each clay samples by pounding some amount of the clay and mixed with water. The researchers rolled the sticky clay in a ropelike form and then coiled it around their fingers. At the sites, some of the clay proved more plastic than others.

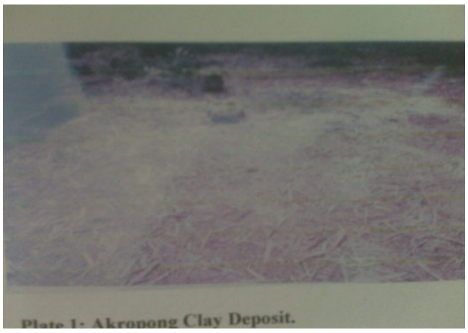

Plate1: *Akropong Clay Deposit*

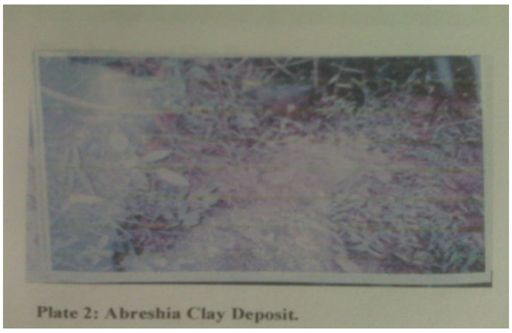

Plate 2: Abreshia Clay Deposit

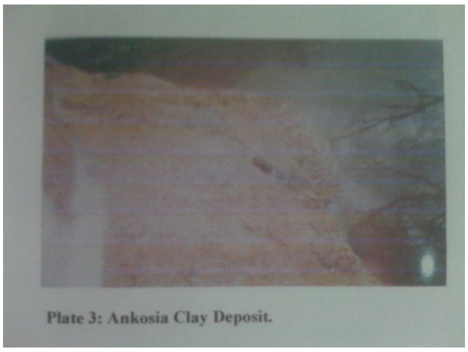

Plate 3: Ankonsia Clay Deposit

Plate 4: Saamang Clay Deposit

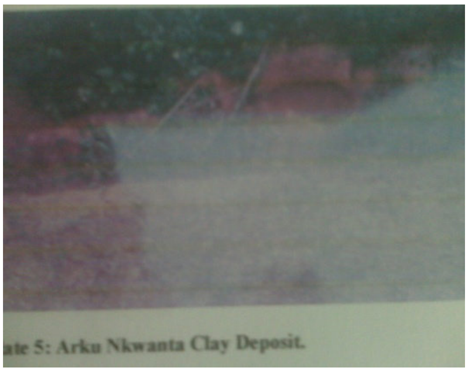

Plate 5: Arku Nkwanta Clay Deposit

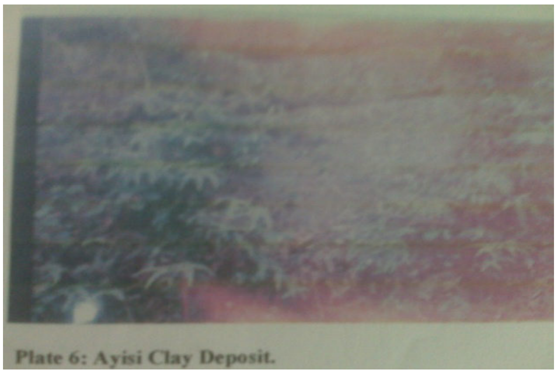

Plate 6: Ayisi Clay Deposit

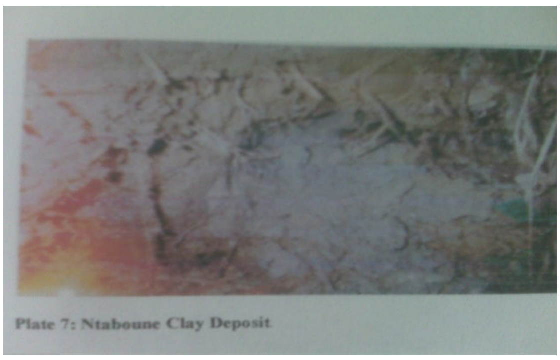

Plate 7: Ntaboune Clay Deposit

The samples of clay gathered were sent to the studio where they were seived through 60 mesh, dried, kneaded and stored in a separate polythene bags for six (6) weeks in a damp state for the clay to season. Newly prepared clays should be given at least weeks rest in a damp atmosphere (wrapped in polythene) before plasticity tests are made (Fournier 1973). In comparing bodies, it must be ensured that all samples have been aged for equal length of time (Nelson 1975).

3.1 Materials and Tools

(i) Dry Powder of Clay (ii) 60 mesh sieve

(iii) Measuring Cup (iv) Weighing Scale

(v) Mortar and Pestle

3.2 Method

The samples of the clay were dried thoroughly for the same length of time, pounded and sieved through 60 mesh. Eight hundred (800) grams of each samples was weighed into plastic bowls separately. For each sample, 500 grams of water was weighed into a measuring cylinder. The water was added to the clay samples in a bit until the clay reached its workable state. The amount of the water left in the measuring cylinder was weighed, making deduction possible. The water of plasticity (amount of water needed to make some amount of powered clay samples workable or plastic) of the clays was determined by subtracting the amount of water left in the measuring cylinder from the initial volume of water, over the clay sample multiplied by hundred.

The formula therefore is;

$$\frac{\textit{The weight of water}}{\textit{The weight of clay}} \times 100$$

Table 1: Water of Plasticity Test

Clay Samples	Weight of Clay in Grams	Initial Water Level in Grams	Final Water Level in Grams	Water of Plasticity Calculation	Results
Akropong	800	500	230	500 – 230	270
Abreshia	800	500	250	500 – 250	250
Ankonsia	800	500	300	500 – 300	200
Saamang	800	500	250	500 – 250	250
Arku Nkwanta	800	500	300	500 – 300	200
Ayisi	800	500	360	500 – 360	140
Ntabourne	800	500	325	500 – 325	175

Source: Field Survey, March 2012.

To calculate for the percentage of water of plasticity, the amount of water poured onto the clay was expressed over the quantity of the clay, multiplied by hundred. For example,

$$\frac{270}{800} \times 100 = 34\%$$

Table 2: Percentage of Water of Plasticity Test

Clay Samples	**Weight of Clay in Grams**	**Weight of Material in Grams**	**Water of Plasticity Calculation**	**Results**
Akropong	800	270	$\frac{270}{800} \times 100$	34%
Abreshia	800	250	$\frac{250}{800} \times 100$	31%
Ankonsia	800	200	$\frac{200}{800} \times 100$	25%
Saamang	800	250	$\frac{250}{800} \times 100$	31%
Arku Nkwanta	800	200	$\frac{200}{800} \times 100$	25%
Ayisi	800	140	$\frac{140}{800} \times 100$	18%
Ntabourne	800	175	$\frac{175}{800} \times 100$	22%

Source: Field Survey, March 2012

Plate 8: The researcher conducting water of plasticity test

3.3 Presence of Lime Test

Another impurity which disqualifies the usefulness of clay is lime. This is because when lime is fired, it alters calcium carbonate to calcium oxide which is unstable oxide in the atmosphere. Because lime takes water or hydrates, the hydration goes on slowly in even a small lump of limestone causing swellings in the clay and eventually breaking the wares (pieces). The test for presence of lime was to find out from the clay samples if it contains lime.

3.4 Procedure for Testing Presence of Lime

Samples from all the seven (7) sources were dried and put in seven separate test tubes containing 50% dilute hydrochloric acid. The apparatus were carefully observed, because the presence of lime in hydrochloric acid creates effervescence or bubbling effect.

Table 3: Results of Lime Test

Clay Samples	Reaction of Hydrochloric Acid	Presence of Lime
Akropong	No Bubbles	Nil
Abreshia	No Bubbles	Nil
Ankonsia	No Bubbles	Nil
Saamang	No Bubbles	Nil
Arku Nkwanta	No Bubbles	Nil
Ayisi	No Bubbles	Nil
Ntabourne	No Bubbles	Nil

Source: Filed Survey, March 2012.

3.5 Dry Shrinkage Test

This experiment was to find out the rate at which each of the clay samples shrinks. Thus, from plastic to bone dry state and from the bone dry to the fired temperature of about 600°C.

3.5.1 Materials and Tools for the Test

(i) Kneaded clay sample from each source
(ii) Rolling Pin
(iii) Guide Stick
(iv) Sack Board
(v) Flat Wooden Board
(vi) A Pair of Divider
(vii) Straight Edge
(viii) Cutting Knife

3.6 Procedures for Dry Shrinkage Test

Each of the seven (7) samples of clay were kneaded and wedged thoroughly. The samples were rolled into slabs and cut into five (5) smaller pieces of slabs measuring 10cm length, 5cm wide and 1cm thickness and each bearing the name of the sample for identification. A sharp straight line was drawn on each test pieces measuring 8cm diagonally. The slabs were allowed to dry by room temperature and turning them frequently so as to eliminate warpage. After drying, the length of the slabs were measured and recorded. The dry shrinkage of each slab was determined by deducting the dry length from the plastic length.

Thus, the Plastic Length – the Dry Length = the Dry Shrinkage.

In terms of dry shrinkage percentage, the formula is:

$$\frac{\text{Plastic Length} - \text{Dry Length}}{\text{Plastic Length}} \times 100$$

Table 4: Dry Shrinkage Test

	Akropong	Abreshia	Ankonsia	Saamang	Arku Nkwanta	Ayisi	Ntabourne
Slab Number	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
P. L.	8cm each	8cm each	8cm each	8cm each	8cm each	8cm each	8cm each
D. L.	7.8, 7.5, 7.7 7.6, 7.6	7.7, 7.6, 7.7 7.4, 7.5	7.6, 7.6, 7.6 7.7, 7.6	7.6, 7.8, 7.6 7.6, 7.8	7.5, 7.6, 7.5 7.4, 7.5	7.6, 7.5, 7.5 7.5, 7.4	7.4, 7.5, 7.5 7.5, 7.6
TT.DL	38.2	37.9	38.1	38.4	37.5	37.5	37.5
AV.DL	7.6	7.6	7.6	7.7	75	7.5	7.5
%	5	5	5	4	6	6	6

Source: Field Survey, March 2012.

From table 4, the dry shrinkage percentage calculations based on formula were as follows:-

The Plastic Length = 8cm,

The Average Dry Shrinkage = 7.6 for Akropong Clay

Therefore:

$$\text{The Percentage Shrinkage} = \frac{8cm - 7.6cm}{8cm} \times 100 = \frac{0.4}{8} \times 100 = \mathbf{5\%}$$

Again, from table 4, the dry shrinkage percentage was expressed in terms of :

$$\frac{\text{The Total Plastic Length - The Total Dry Length}}{\text{Total Plastic Length}} \times 100$$

Therefore, the percentage shrinkage of Ayisi clay using the formula was:

$$\frac{40cm - 37.5cm}{40} \times 100 = \mathbf{6.25\%}$$

Furthermore, the shrinkage percentage could also be calculated by summing up the individual shrinkage value of each slab, find the average and express it over the average plastic length times hundred. Thus:

$$\frac{\text{Average Dry Shrinkage Value}}{\text{Average Plastic Length}} \times 100$$

Using an Ayisi clay sample to prove the formula:

$$0.4 + 0.5 + 0.5 + 0.5 + 0.6 = \frac{2.5}{5} = \text{Average}$$

Therefore: $\frac{0.5}{8} \times 100 = \mathbf{6.25}$

3.7 Fired Shrinkage Test

3.7.1 Materials, Tools and Equipment

- Gas Test Kiln
- A Pair of Divider
- A Straight Edge
- Gas
- Bone Dry Slabs

3.8 Procedures for Fired Shrinkage Test

All the 35 pieces of slabs from the seven sources were packed into test gas kiln. They were pre-heated for three (3) hours and finally fired to 600^{o}C. The line on each slab was then measured again and recorded. The fired shrinkage was determined as follows:

Dry Length – Fired Length = Fired Shrinkage

Therefore, Fired Shrinkage Percentage =

$$\frac{\text{Average Dry Length - Average Fired Length}}{\text{Average Dry Length}} \times 100$$

Plate 8: Drying Clay Slabs Pieces

Table 5: Fired Shrinkage Test Results

	Akropong	**Abreshia**	**Ankonsia**	**Saamang**	**Arku Nkwanta**	**Ayisi**	**Ntabourne**
Slab Number	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
AV.DL	7.6	7.6	7.6	7.7	7.5	7.5	7.5
F.L	7.4, 7.5, 7.6 7.5, 7.5	7.6, 7.6, 7.6 7.4, 7.5	7.4, 7.5, 7.5 7.6, 7.5	7.5, 7.8, 7.6 7.6, 7.6	7.4, 7.5, 7.5 7.5, 7.5	7.5, 7.4, 7.4 7.4, 7.4	7.5, 7.5, 7.4 7.5, 7.5
TT.FL	37.5	37.7	37.5	38.1	37.4	37.1	37.4
AV.FSL	7.5	7.5	7.5	7.6	7.5	7.4	7.5
% Calcu-lation	$\frac{7.6-7.5}{7.6}$ x 100	$\frac{7.6-7.5}{7.6}$ x 100	$\frac{7.6-7.5}{7.6}$ x 100	$\frac{7.7-7.6}{7.7}$ x 100	$\frac{7.5-7.5}{7.5}$ x 100	$\frac{7.5-7.4}{7.5}$ x 100	$\frac{7.5-7.5}{7.5}$ x 100
%	1	1	1	1	0	1	0
Fired Colour	Brown	Yellow	Brown	White	Red	Green White	Red

Source: Field Survey, March 2012

3.9 Porosity Test

- Materials, Tools and Equipment
  - (i) Fired Clay Slabs
  - (ii) Rubber Bucket
  - (iii) Weighing Scale
  - (iv) Rag

3.10 Procedure for Porosity Test

Each of the fired clay slabs from the various sources was weighed after firing to 600^{o}C and the weight recorded. The bisque slabs were soaked overnight. After twelve hours, each slab was removed from the water and wiped clean. The slabs were weighed again and the weight recorded as shown below:

Table 6: Porosity Test Values Recorded

Slab Number	Akropong	Abreshia	Ankonsia	Saamang	Arku Nkwanta	Ayisi	Ntabourne
DW							
1	100	75	85	80	60	75	80
2	100	80	80	90	60	75	90
3	100	80	80	75	55	80	90
4	100	80	80	80	60	70	80
5	100	100	70	80	60	75	90
AV.DW	**100**	**83**	**79**	**81**	**59**	**75**	**86**
SW							
1	134	115	95	100.5	84	93	90
2	134	115	100	128	80	93	90
3	134	120	100	90.5	80	93	90
4	134	120	95	118	92	93	90
5	134	130	110	128	84	93	90
AV.SW	**134**	**120**	**100**	**113**	**84**	**93**	**90**
% Calcu-Lation	$\frac{134-100}{100}$ x100	$\frac{120-83}{83}$ x 100	$\frac{100-79}{79}$ x 100	$\frac{113-81}{113}$ x 100	$\frac{84-59}{59}$ x 100	$\frac{93-75}{75}$ x 100	$\frac{90-86}{86}$ x 100
%	**34**	**44**	**26**	**39**	**42**	**24**	**4.6**

Source: Field Survey, March 2012

The percentage of water absorption was calculated by using the formula:

$$\frac{\textit{Saturated Weight} - \textit{Dry Weight}}{\textit{Dry Weight}} \times 100$$

It must be stated that when specifically more than one test piece is used in experiment like this, the average saturated weight and the average dry weight is used for porosity calculation.

Therefore the formula is:

$$\frac{AV.SW - AV.DW}{AV.DW} \; X \; 100$$

4.0 Results Or Findings

It was observed that all the seven (7) clays tested at the sites, Arku Nkwanta clay showed much cracks in the ropelike or coiled form. Akropong clay although very plastic, was very rough textured at the raw state and seemed physically to contain much sand.

From table 2, Akropong clay sample recorded the highest water of plasticity being 34%, followed by Abreshia and Saamang recording 31% each. Ankosia and Arku Nkwanta also recorded plastic value of 25% while Ntabourne recorded 22%. The least value was recorded by Ayisi clay, thus 17%, showing the chronologically arranged level of the plasticity of each clay sample. It must be acknowledged that the more plastic the clay, the more water it needs to change from powered state to plastic state.

For the presence of lime test, all the clay samples tested were negative. This means that all the clay samples could be used without eventual breaking of wares (pieces).

For dry shrinkage test, according to table 3, Saamang clay recorded the least dry shrinkage value of 4%, followed by Akropong, Abreshia, and Ankosia with 5% each. The other three samples such as Arku Nkwanta, Ayisi and Ntabourne recorded 6% each.

For fired shrinkage, as shown in table 5, the clay samples recorded one percent (1%) fired shrinkage being the normal value at which good clay should shrink, but two clay samples from Wasa Amenfi West District, Arku Nkwanta and Ntabourne were little bit controversial recording zero percent (0%).

For porosity test, Ntabourne clay sample according to table 6, recorded the least porosity value of 4.6%, followed by Ayisi 24%, Ankonsia 26%, Akropong 34%, Saamang 39%, Arku Nkwanta 42% and Abreshia 44% being the highest porosity value and very porous.

Table 7: Findings From the Testing of the Clay

Test	**Akropong**	**Abreshia**	**Ankonsia**	**Saamang**	**Arku Nkwanta**	**Ayisi**	**Ntabourne**
Water of Plasticity	34%	31%	25%	31%	25%	17%	22%
Lime Test	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Dry Shrinkage Test	5%	5%	5%	4%	6%	6%	6%
Fired Shrinkage Test	1%	1%	1%	1%	0%	1%	0%
Fired Colour	Brown	Yellow	Brown	White	Red	Green White	Red
Porosity Test	34%	44%	26%	39%	42%	24%	4.6%

Source: Field Survey, March 2012.

5.0 Conclusion

It can be conclusively established that this study was designed to find a lasting solution of getting suitable and workable clays for schools which have already introduced ceramic subjects into their curriculum but have problem of getting clay, especially institutions in the Sekondi-Takoradi Metropolis.

It can also be concluded that all tests conducted on the clay samples from the scoped areas (Wasa Amenfi West and East District) yielded good results to support ceramics when used either as a body or individually.

6.0 Recommendations

It is recommended that institutions offering ceramics should patronize these clays to be used as raw materials. This will also serve as a source of income for landowners of the clay deposits.

There should be establishments of pottery and ceramic industries in these areas either individually or by the government. This will go a long way to create employment opportunities and reduce the level of unemployment in the country.

Finally, the District Assemblies should construct roads to the clay sites, so as to make them motorable.

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