UTILIZATION OF DZUMAH RED CLAY AS COLOURANT IN STONEWARE GLAZES

MATHIAS H.
University of Maiduguri
Department of Industrial Design
Maiduguri
mathias.helga@gmial.com

Abstract
The desire for a steady growth of industries by all nations has called every country to look inward for raw material substitutes. This paper is an attempt to source local ceramic raw materials for glazes as a substitute to the imported ones. The paper reports a study of "Dzumah" red clay from Adamawa State, Nigeria, as a colouring oxide in stoneware base glazes. The paper recommends further researches into the abundant locally available ceramics raw materials in Nigeria for a steady growth of ceramic industries.

Introduction
Nigerians, have spent a lot of money for the purchase of imported glaze materials. Research has shown that there are abundant ceramic materials in Nigeria. The sufficient minerals can b e properly and maximally harnessed and economically utilized by the ceramic artists to promote personal and national greatness. Something needs to be done in the area of ceramic production towards the foreign wares that have occupied the market instead of the nation products: Kashim (2005) rightly said that the "flooding of Nigerian market with the English and Chinese white ware and porcelain is an embarrassment to a nation like Nigeria that has abundant ceramic materials and the human resources.

The non-metallic component of ceramic minerals comprises 85%-99% clay and smaller amounts of limestone, quartz and feldspar (RMR&DC 2003). The most available and abundant mineral in the earth crust is clay especially the common red clay which is found on top of the soil profile which is also rich in red iron oxide (Worrall, 1978). Dzumah community in Hong Local Government Area of Adamawa State, Nigeria, has abundant deposit of red clay which has potentials as colouring oxide in stoneware base glazes. The potters in the community use the red clay for covering the back of their traditional pots as a kind of body decoration. Opoku (2007) opined that man used Cinnabar Ochre and red hematite as pigments long before smelting was devised.

The formulation of a glaze recipe is a science which should not be undertaken without thorough understanding. To make effective use of a particular material the ceramists do not need only the artistic dexterity, but a clear understanding of the materials to work with. To undertake a study of glaze is more complex than that of clay bodies. The materials involved in glazes need to be exact in order to arrive at a standard recipe. Therefore, in order to arrive at a good glaze composition there must be some good knowledge of chemistry to describe what happened actually during its formation. With the current search towards the attainment of self reliance in local sourcing of industrial raw materials, Dzumah red clay can be exploited and use for glazes, rather than relying heavily on an imported ready-made glazes that lead to high cost of ceramic products in the market.

Classification of Clay

Clay has been classified according to its use or the geology and location. There are however, two main types of clay; Primary clay and secondary clay. Primary clay refers to those clays found in site and have not been transported by natural agencies to another location, rather than their original sites. Worall (1975) said they are extracted from the parent rock and obtained in the comparatively pure state. The clay tends to be large in particle size and low in plasticity. China clay or kaolin is an example of the primary clay. It maintains its whiteness even after firing due to less or free impurities that are capable of giving the clay its colour. It is one of the refractory clays that can withstand high temperature without deformation. While secondary clays are those which have been removed from their original place of formation by natural agencies like water, ice and wind, and have gradually settled in places like estuaries lakes or river sides. Hamer (1975), assert that these clays were subjected to abrasion, frost action, leaching and other weathering agencies. As they move they collide and break into finer particles. Most of them contained impurities which are responsible for plasticity and colour of the clay.

Common Red Clay

Common red clays are usually buff-burning clays, with only enough other materials added to achieved good working and firing properties. The presence of iron-oxide, titanium and other colouring agents in nearly all secondary clays found near the surface of the earth accounts for the red colour of the clay, and also accounts for the relatively low temperature. Rhodes, (1973) opined that common red clay that is high in iron and other impurities may fire to hardness and density at about 1000°C and may melt to a liquid at about 1250°C. The tendency in common red clays to melt at temperature of cone 8 to 11 has been utilized in making slip glazes, or glazes which are made up largely of fusible clay. According to Cardew (1969), iron-oxide, whether in a glaze or fired clay will only produce a red colour if it is in the state of red-iron oxide. He added that small quantities up to three percent or more will produce a possible colour of celadon. Large quantities produce some range of colours, such as reddish, brown, dark-brown, tenmoku.

Glaze

Glaze can be defined as a glassy coating melted in place on a ceramic body, which may render the body smooth, non-porous and of a desired colour and texture. The degree to which the potter delves into the mysteries of glaze making will depend on his interest and the type of pottery he wishes to make. Therefore, a potter is being encouraged to formulate his/her own glaze in order to achieve harmony between the body and the glaze applied. For example, a high-fire glaze cannot go with earthenware body or vice versa. The effects of colour present in the body sometimes enhance the outcome of glaze appearance.

Brief History of Early Glaze Development

Glazing is fascinating, though mysterious aspect in ceramic production. A glaze is a composition of some minerals that melts to glassy state at a given temperature in a fire. The use of glaze developed chronologically. Starting from the unglazed wares to high-fire glaze ware. Nelson (1966) states that, the Neolithic wares from northwest China, were found glazed tiles with a green copper colourant found in Egypt and dating as far back as 500 B.C are our first examples of ceramic glazes. This indicates the development of pottery as the civilization continued in some areas like the fertile crescent of the Nile and Tigris Euphrates Rivers. As the result of urbanized settlement, man became more industrious, and ceramics evolved at a very early age.

According to Rhodes (1973), the discovery of the first glaze happened as a chance of bonfire in a desert area; some of the soda ash which is so prevalent in the desert could have gotten mixed accidentally and melted. With keen observation of the phenomenon we would understand the advanced techniques of man which paved the way for subsequent discoveries of glaze recipe.

Ceramics developed so rapidly, especially in China glazed wares had been made in the Near East China and the control of colour and texture was achieved by the Chinese. It is hard for us now to realize what a difficult thing it must have been to achieve a range of

temperature from bisque to glazed wares with a careful control of colours. Rhodes (1973) noted that, green is obtained from copper, yellow and brown from iron, blue from cobalt and purple from manganese. All these colours at one time or the other were refined from natural minerals, mixed and blended with the glaze ingredients without the benefit of any exact knowledge of mineralogy or chemistry. The potters worked out their techniques through a long period of trial and error. With the advancement in technology, contemporary potters have great advantage whereby the ceramic materials are now being analyzed easily in the metallurgical laboratories for easy composition.

Rhodes (1973) noted that, prior to the Han Dynasty 206 B.C – A.D 220, Chinese pottery were rough and mostly unglazed. The knowledge of the use of lead glazes was brought from the Near East China. One of the important characteristics of the Chinese potters which was quite apparent during the Han Dynasty, and even before was their ability and willingness to make use of the natural character of ceramic materials. By the end of the Tang Dynasty and the beginning of the Sung Dynast, came the discovery of porcelain by the Chinese in 9th century A.D and later Europe on quest for whiteness, translucency and fineness (Nelson 1966).

Contemporary potters have the whole history of the development of ceramic production and it inspiration. The way clay was used for pottery and how glaze was made in the past, and how their forms and decorations had some special meaning in their own time. Professional potters are now left with a challenge to see how to improve on the works of the past ceramics to express the desire of our own age. People like Benard Leach, William Murray and others, in their difference ways affected the course of ceramics. These potters emphasized the use of natural clay for pots and glazes. Casson (1977) stresses the use of natural, unrefined materials and hand processes with the acceptance of somewhat fortuitous effects that come from direct first-hand experience with clay and fire.

Essential Base Glaze Components

The composition of a stoneware base glaze recipe most involved all the three essential elements; silica the glass former, alumina the binder and fluxes the melter. These are the most important oxides in the formulation of any type of base glaze at all type of temperatures. Each of these oxides has its own part to play in complimenting the other to make a successful base glaze that can be added to or altered to produce number of new glazes. Casson (1977) states that silica is the most important oxide in this composition, but its melting point is high at about 1700°C, while most of the earthenware clay can only withstand temperature of about 1300°C or lower. Silica alone cannot be used as a pottery glaze, therefore, it has to be compounded with lower melting oxides the flux in order to equalize their strength. The other main element is alumina which acts as a sticker or binder. The glaze produce solely of silica and either lead or any powerful flux tends to run. The introduction of alumina the amphoteric oxides help in adjusting the composition.

The study is trying to highlight the suitability of using Dzumah red clay as a colourant in stoneware base glazes to bring about some colour variations in glazes for industrial use. When one is aiming at some specific quality in a glaze, such as particular degree of texture or certain response to colour, a small change in the base formular may have an important effect. In the words of Ali (2006) that transparent glazes respond very well to small additions of colouring oxides. Rhodes (1973) added that mathematically there are a great number of possible variation in materials and the proportioning of materials for glaze of any given firing temperature. This possible variation in base glazes are the large number of variations brought about by the addition of colouring oxides and opacifying agents. Okunna (2006) says, that iron oxide could only be effective when there is a right kind of balance of materials-flux, alumina, and silica. He further said the working of iron oxide as a variable that is in response to a situation. As the result of the colouring oxides loaded in Dzumah red clay, it can be used to produce a wide range of effects which are the responses of the different base glaze compositions.

Constituent Elements of Dzumah Red Clay

The role of clay in glaze batch cannot be over emphasized it is useful as raw material in glaze composition. The geological history of these clays is washed down to river or seas. During this process they were contaminated with useful glaze fluxes with large amount of colouring oxides. Albany slip is an example of the contaminated alluvial clay containing fluxes such as calcium, potassium and magnesium together with iron and clay minerals alumina and silica. It is an ideal raw glaze material without any addition will make a dark shiny glaze at 1280°C.

The sampled clay was determined through the use of X-Ray Fluorescence Spectrometer Technique at National Metallurgical Development Centre, Jos. Based on the analysis of the clay, it has all the essential elements needed for a stoneware glaze. Colouring oxides available such as Ferric oxide 13.18%, Copper 0.04%, Vanadium 0.04%, Titanium 1.18%, Chromium 0.04%, Nickel oxide 0.02%, etc these oxides are enough to give any base glaze its needed colour. The opacifiers are Tin oxide 0.02%, Ziconia 0.15% and Zinc oxide 0.04%. below is the chemical analysis of the sampled clay.

Methodology

The study is to alter the appearance of a stoneware base glaze which is usually when fired under a stoneware temperature appears neutral or transparent. Dzumah red clay was introduced into a recommended composition of a stoneware base glaze of; silica 30%, feldspar 50% and kaolin 20% as a source of colour in the glaze batch Casson (1977).

The sampled clay was sourced from a pit of the traditional potters, soaked in water, sieved, dried and pounded into fine power clay. The above stated stoneware base composition was used as one ingredient compounded with the Dzumah red clay measured at different percentages. Tests were conducted by the use of line blend or biaxial method on an eleven member slab, fired under the temperature of about 1250°C in an electric kiln of the Department of Industrial Design University of Maiduguri. Below is the composition of the Dzumah red clay and statement base.

Results/Observation

To test the effectiveness of the red clay in base glaze, a base glaze comprising of feldspar – 50% silica 30% Alumina 20% was prepared and biaxial blend of the glaze and the red clay was conducted and fired to 1250°C temperature. The following results were obtained.

Test 1

This is 100% Dzumah red clay on tile number 1 to ascertain whether the clay alone can produce a glaze of 1250°C. It was found that the test is under fired due to the temperature needed could not attained. As the only fluxing agents in the red clay were not enough to melt at this temperature. No doubt little amount of active flux can make the clay to melt.

Test 2

Tile number 2 is the mixture of Dzumah red clay 90% and 10% stoneware base glaze. This shows an improvement obtained from the addition of the base glaze. The test hardened to dark red, not properly fused to glaze.

Test 3

Tile number 3 is the mixture of 80% Dzumah red clay and 20% base glaze. This indicates the increased amount of the base glaze affects the melting of the batch.

Test 4

A combination of 70% Dzumah red clay and 30% base glaze. This trial resulted to a beautiful tenmoku shiny glaze. The presence of the colouring oxides in the red clay affects the batch by given this appreciable colour surface.

Test 5

A mixture of 60% Dzumah red clay and 40% base glaze. The batch melted to shiny glossy tenmoku glaze. It is as the result of high content of the red clay in the batch attributed to the result obtained.

Test 6

A mixture of equal amount of the materials 50% Dzumah red clay and 50% base glaze. This composition reacted interestingly upon another and cause an appreciable colour of dark brown glaze.

Test 7
This trial gave similar result to 6 above. 40% Dzumah red clay and 60% base glaze. The batch produced a fantastic dark brown shiny glaze.

Test 8
A composition of 30% Dzumah red clay and 70% base glaze. The resulting colour of this batch is semi-transparent brown glaze. This change may be as the decrease of the red clay affects the appearance moving from darker to transparent surfaces.

Test 9
A mixture of 20% Dzumah red clay and 80% base glaze. This result nearly depicted the true nature of the base glaze recipes. It is always transparent unless altered. The colour is light brown transparent glaze.

Test 10
A composition of 10% Dzumah red clay and 90% base glaze. This resulted to semi-pure transparent glaze, as the result of high content of the base glaze recipe.

Test 11
This is 100% base glaze recipe. This yielded the natural colour of pure transparent glaze. It is done as a control experiment to compare and contrast to changes occurred with the previous experiments as the result of the blend.

Conclusion
Pottery made without the finishing touch with a good glaze remained of less value to the customers. Modern ceramics are made to suit the taste and desires of the people in order to face market competence. Therefore, the need to advance so rapidly in the area of glaze making has called for every developing nation to develop high technology both in material search and production. Datiri (2007) added that even the studio potters have to redesign their products to meet current market demand, especially in terms of colour.

Based on the information available the research has revealed the potentials in Dzumah red clay as a colouring agent in stoneware base glaze. The tendency in the red clay to influence the base glaze by given it some hues of colour, from the transparent natural colour of the base glaze to light brown, dark brown, dark red and tenmoku glazes. With this encouraging result, the experiment shows that the potters can rely solely on these locally available glaze materials as a colouring agent for steady growth of ceramic industries in Nigeria. The country is highly endowed with abundant deposits of ceramic raw materials that have not been beneficiated. Current search particularly with the Dzumah red clay has reveal that Nigerian common red clays could be used as colouring agent instead of imported pigments in ceramic industries. The exploitation and exploration of more locally sourced ceramic materials should be encouraged among the professional potters in Nigeria. The government should encourage investors to provide equipments such as Jaw Crusher, Ball Mill machineries to mention a few for proper utilization of the ceramic materials in Dzumah and beyond.

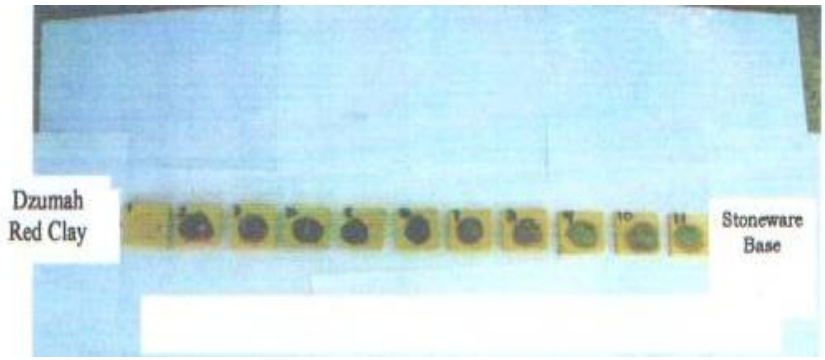

Plate 1: The Biaxial Glaze Blend Result of Dzumah Red Clay and Stoneware Base

Table 1: Chemical Analysis of Dzumah Red Clay

Compound	**Oxides%**
Alumina (AL_2O_3)	31.40
Silica (SiO_2)	45.90
Potash Feldspar (K_2O)	3.09
Calcia (CaO)	0.08
Titanium (TiO_2)	1.18
Vanadium (V_2O_5)	0.04
Chromium (Cr_2O)	0.04
Manganese (MnO)	0.03
Ferric oxide (Fe_2O_3)	13.07
Nickel oxide (NiO)	0.02
Copper oxide (CuO)	0.04
Magnesium oxide (MgO)	0.26
Tin oxide (SrO)	0.02
Barium oxide (BaO)	0.20
Ziconia (ZrO_2)	0.15

Source: NMDC, Jos (2010)

Table 2: A Biaxial Blend of Dzumah Red Clay and Stoneware Base

S/N	1	2	3	4	5	6	7	8	9	10	11
Dzumah Red Clay	100	90	80	70	60	50	40	30	20	10	0
Stoneware Base	0	10	20	30	40	50	60	70	80	90	100

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