EXPLORING NUMAN RED AND BLACK STONES FOR TENMOKU GLAZES

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Abstract
The earth crust contains all the raw materials needed for ceramic development. Many potters all over the world under use some of these materials around them, because of ignorance. To embark on a daily exploration of ceramic materials in this modern time will not be over – stressed. The paper seeks to develop the abundant red and black silt stones used by the local potters in Numan as raw materials for painting their traditional pottery wares, as raw materials for tenmoku glaze. These materials were scientifically analyzed in a laboratory to determine the compound elements embedded in the stones. Each of the stones were crushed into powder and mixed into twenty one triaxial glaze batches and subjected to stoneware temperature ranging from 1200^{0}C to 1250^{0}C as the right temperature for tenmoku glazes. The sample tests were analyzed and conclusion was made as to their suitability in making tenmoku glazes for contemporary ceramics.

Introduction
The strength and beauty of any moulded piece of clay depends largely on the work of fire and glaze upon the object. To achieve this lies solely on the ability of a potter to carefully identify good ceramic raw materials among the uncountable found on the surface of the earth crust. A survey was carried out in along the Numan Benue River bank and Bolong Village of Numan District. The materials were carefully selected for exploitation. The red and black stones were taken to the department of Geology, University of Maiduguri for physical identification. It was found that the stones are silt stones which have been converted into iron-stone with little differences in colour. The International Standard Dictionary (1970) defines silt as earthy sediment consisting of extremely fine particles of rock and soil suspended in and carries by water and deposited at the mouth of a river.

Numan is one of the twenty one local government areas in Adamawa State. It happens to be one of the locations situated at the meeting point of river Gongola and River Benue. At the bank of the river was found a large deposit of the red stone laid in strata in between parcels of white ball clay pits. While the black stone was excavated in a nearby community called Bolona Located at the mouth of a tributary to River Benue.

The study attempts to find out the glaze potentials of the red and black silt stones for the formulation of tenmoku stoneware glazes. Many local potters still employ a variety of iron invested clay and powdered rocks to decorate their pots. Numan traditional potters use the red and black silt stones as pigment to burnish their pots as means of decoration. As the potters displayed their skillful dexterity in interchanging of the coloured materials on their pots the pigments add both colour and beauty to the pots. They bisque fire the pots in an open air method, after which the pots are then polished with varnish to make it shine as if the pots are glazed wares, but honestly is not, it is just a shadow of modern glaze development which is so prevalent in the society. They are more valuable and durable in terms of quality and use. this era of industrialization does not encourage the crude method of decorating pot with local formulated pigments, but rather from the standpoint of view standardization of the use

of glaze is inevitable. Alkali (2012) rightly noted that since the beginning of the twentieth century pottery production in Nigeria has continued to evolve from its traditional origin. Advancement in technology has made it easier for the contemporary potters to advance in all aspects of techniques and material acquisition. As long as there is still opportunity, it is hoped that this study will throw more light into the importance of utilizing the red and black silt stones in composing good tenmoku glazes for use in small and medium scale ceramic industries.

Methods and Materials

After collecting the red and Black samples of the stones, they were grounded into fine powder separately and taken for analysis to know the kinds of elements content in each of the stones. This analysis was conducted in the Nigerian Mining Corporation, Jos.

The analysis performed has provided an easy perusal of the above materials which show that they are iron saturated stones; originated from iron saturated sedimentary soil that was later converted to iron-capping. Both the red and black silt stones provided some significant percentages of iron oxide, which are slightly above 50% but the remaining elements occurred in just some small measures, but as Mathias (2012) noted each of these oxides has its own part to play in complimenting a glaze composition.

Tenmoku Glaze

According to Hamer (1977) tenmoku is a stoneware glaze which is deeply stained by iron oxide and it is usually dark brown and black in colour. Tenmoku are glazes made with high content of iron oxide. The presence of iron in glaze may serve as (flux or colourant in the batch. The proportion varies depending on the colour variation and the temperature needed to achieve. Therefore, any stoneware glaze which is deeply stained by iron oxide is called tenmoku.

The origin of tenmoku glaze is said to have started in China during the Han Dynasty through the T'ang Dynasty (1st to 10th) centuries. Perhaps the people were longing for a brilliant dark shiny gloss ware, since the method of firing was traditionally, cooled quickly and were oxidized. As time went on during the Sung Dynasty (AD 960 to 1279) the quest for higher fired glaze started which resulted in the variation of the materials to the method of application and firing. Rhodes (1973) added that this type of iron base glazes have enormous range of colour and quality, though they may be affected by variations in the kiln atmosphere or can be profoundly changed by alterations in the percentages of the materials.

Developing Tenmoku Glazes

As clothes are to the human body so are glazes and their colours to pots. Leach, (1976) stated that both serve practical ends, and should enhance inherent beauty of form. This is because the other aspect of glaze is its aesthetic brilliant colours that appeal to the eyes.

Tenmoku glaze is iron base glaze as it is composed of relatively high amount of iron oxides. There are three main iron compounds used by the potters in all ages; red-iron-oxide or ferric-oxide (Fe_2O_3), black iron oxide ferrous-oxide (2 FeO) and magnetic – iron- oxide ferroso- ferric-oxide (Fe_3O_4). These oxides according to Hamer (1977) act similarly when fired in a glaze batch.

The paper is looking for ways to formulate good tenmoku glazes using other red or black silt stones on separate triaxial tests mixed to granite and calcium. The constituents of table 3, batch A, are those using the red silt stone, granite and calcium, while those in table 3, batch B are those with the black silt stone, granite and calcium. A triaxial glaze blend of the 21 different glaze compositions for each batch was adopted from Gukas (2012). The Granite dust used was collected from the quarry site near Numan along Yola road, while industrial calcium was used.

To compose a good glaze recipe Casson (1977) suggested a starting point of experimenting on a base glaze which is 85% feldspar plus 15% calcium. This particular recipe presents itself available for successful variations by adding one or two colouring oxides, that is enough to give a wide range of glazes. In this research, feldspar was substituted with granite dust which is more available in a ready – made powdered form

in all the Nigerian quarry sites. Though, Alkali (2012) observed that the use of granite in the formulation of glaze has attracted a very little interest among the ceramic practitioners. However in this research granite powder was collected and used. All the materials in the study were sieve through a fine 120 sieved. This was to improve their fusion points and to enhance adherence for a better result. They were mixed at various proportions and applied on each of the test tiles of the batch A and the batch B. The total recipes on each batch in the triaxial are 100 percent. They were applied on a stoneware clay body and subjected under the same stoneware temperature range from 1200^0C to 1250_0C in an electric kiln of the ceramic unit of the University of Maiduguri.

Discussion

The figures in each rectangle in the 21 member triaxial blend idnciate the amount of each material used in the glaze batch of that number. Each recipe was separately mixed into a glaze and applied on a text tile that bears the number of that batch in the triaxial blend. All the different blends in the batch in table 3 A and 3B were then arranged on kiln shelves and fired in an electric kiln to 1280^0C.

Casson (1977) opined that granite and calcium when heated alone will only produce a transparent or neutral glaze with pitted surfaces. However in this research there is no use of only granite or calcium. Conrad (1980) sited in Alkali (2012) that different treatment given to the same material and composition change the character and behaviour of a material or glaze completely.

The Results

The outcome of batch A and batch B glaze blends show that they are excellent tenmoku glazes. They all fused when fired to mid-temperature. The inclusion of the red and black silt stones have given an added quality to the appearance and the texture of the samples used.

As the result of the red or black stones used the pitted textures were sealed and the tenmoku colours were clearly seen. The batch A and batch B glazes all exhibited the same colour and texture with little or no significant difference at all. However, the results were divided into three categories based on the fusibility visibility, and application of the glazes. (See Appendix).

Category one; from tiles number 1 to 6 provided the same colour of black brown tenmoku, fused to fairly shiny. This happens due to the higher amount of the red and black silt in the batches. The glass forming material which is the granite occurred in smaller amounts.

Category two; tiles number 7 to 15 exhibited the most attractive good recipes of tenmoku glazes with dark brown colour but fused to brilliant dark shiny glazes. It is chiefly due to the equal proportions of the materials in the batches. It has been noted that 20% to 30% iron oxide will give some hues of brown, though it may be affected by the method of application and firing condition. When the glaze is thickly applied and fired in oxidized kiln to stoneware temperature, there is a tendency to produce a dark brown, while thin application will give a shiny brown to light brown on some parched areas.

Category three; thick and thin application from tile numbers 16 to 21 exhibited some attractive brown tenmoku glazes with some parched areas where the application was thin especially the edges. This colour was obtained based on the smaller amount of the oxides in the batches, and likely the correct firing condition attributed too.

Conclusion and Recommendations

The paper is of the conclusion that potters should always try to analyse their pottery raw materials, so as to enable then conduct a scientific research with the locally available raw materials around them. The research has revealed that the red and black silt stones which the local potters use only to decorate the back of their pots are found to be good materials for tenmoku glazes. All that the traditional potters need to do is to improve their clay body to achieve a higher firing temperature, and to also change their open air firing to that of kiln firing to be able to use the glaze. The study provides an open door for more interested professionals to continue the search into more of the pottery materials within their reach for the betterment of the society.

Recommendations

The paper is strongly recommending the use of these black and red silt stones as glaze materials for industrial ceramic. Mining industries in Nigeria should find a way of mining and processing the materials to make them readily available for people willing to use them; and for export purposes.

Traditional potters in Numan are advised to start using the arterials to glaze their beautiful traditional pots for a better patronage from the world at large; since all the raw materials are locally available.



Plate 1: Numan Red and Black Silt stones



Plate 2: Samples of fired work in Electric kiln



Plate 3: The test tiles of Numan red



Plate 4: The test tiles of Numan Black



Plate 5: Glaze sample from S/N 11



Plate 6: Glaze sample from S/N 18

A. The Red Stone

Table 1: The Analysis of the Red Silt Stone

Elements	Parameter %
SiO_2	26.80
Al_2O_3	1.85
Fe_2O_3	56.15
TiO_2	0.30
CaO	1.08
MgO	1.50
Na_2O	0.11
K_2O	0.13
LOI	11.35

Analysed at the Nigeria Mining Corporation, Jos (2014)

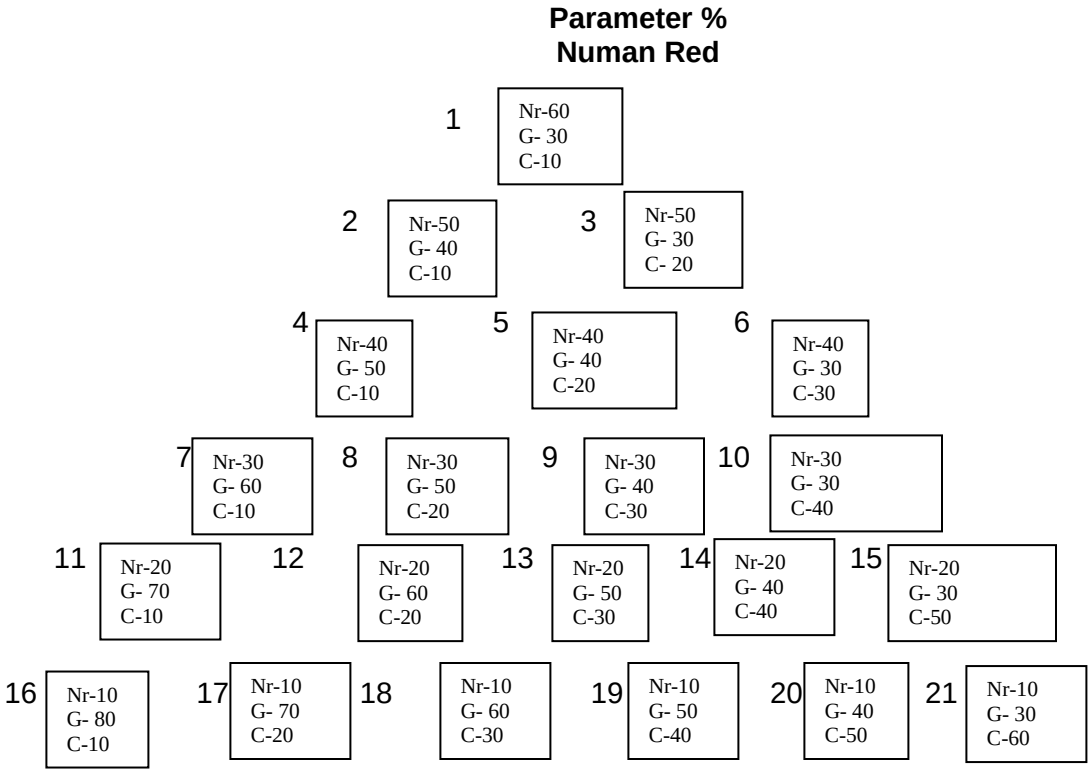
B. The Black Stone.

Table 2: The Analysis of the Black Silt Stone

Elements	Parameter %
SiO_2	15.80
Al_2O_3	16.80
Fe_2O_3	54.76
TiO_2	0.05
CaO	0.54
MgO	1.56
Na_2O	0.14
K_2O	0.12
LOI	9.76

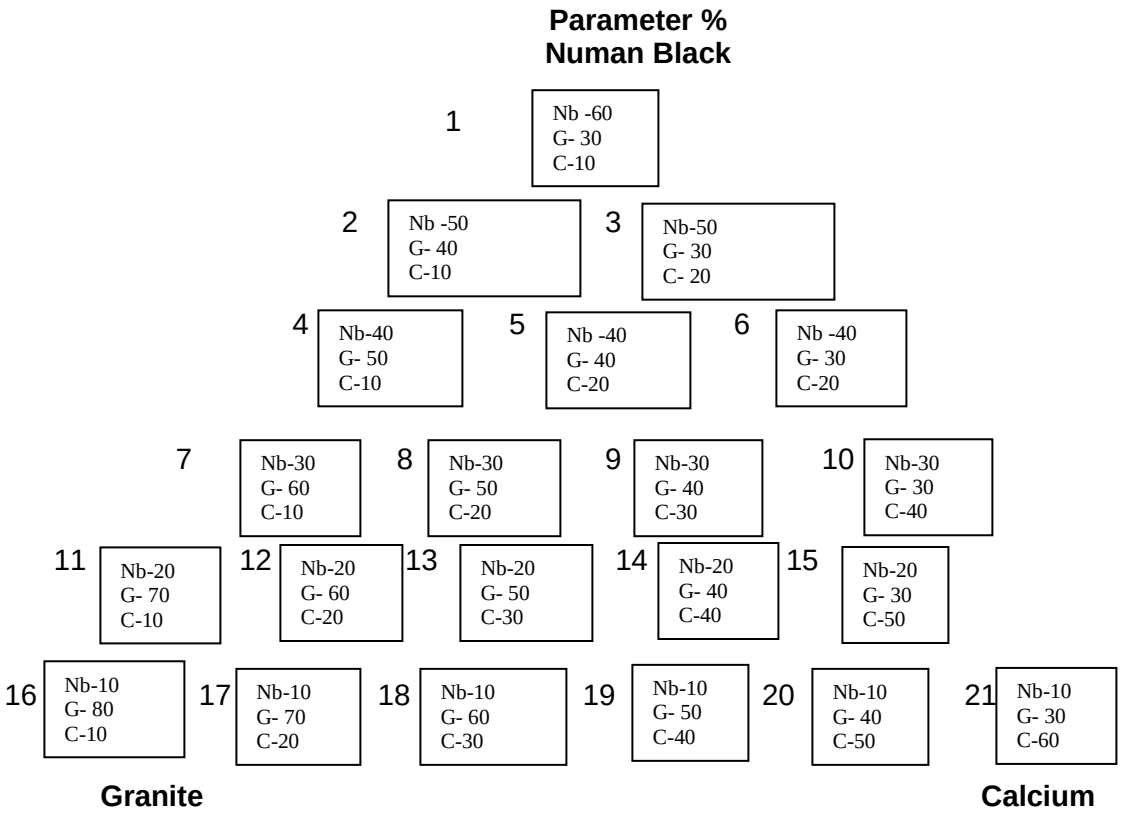
As Analysed by Nigeria Mining Corporation, Jos (2014)

Table 3: Batch A: The Compositions of the red silt stone, granite and calcium in the 21 triaxial glaze blend test.



Key
Nr- Numan red
G – Granite
C – Calcium

Table 3: Batch B: The Compositions of the black silt stone, granite and calcium on the 21 triaxial glazes blend test.



Key
Nb- Numan black
G – Granite
C – Calcium

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