BENEFICIATING VOLCANIC GLASS FOR CERAMIC GLAZES: CHALLENGES AND PROBLEMS

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Abstract
Beneficiation of ceramic raw materials in Nigeria is increasingly becoming a challenge. This study focused on identifying the challenges and problems facing the beneficiation of Volcanic Glass, a rich and available ceramic raw material found in two locations-Kerang and Miango of Plateau State in commercial quantities. The problems and challenges identified range between the hard characteristics of the material, the procedures involved before fine-dust particles are obtained before it is suitable for ceramic use and then the challenge it can pose to health if dust-free working environment is not maintained while beneficiation is ongoing. Recommendations that could remedy these challenges bothering around the beneficiation of volcanic glass are also proffered. A new scheme that could be used by potters/ceramists is also suggested.

Introduction
Over the years, research has revealed that Nigeria has deposits of over 98% ceramic raw materials available in various locations distributed in all the States and the Federal Capital Territory Abuja (Opoku 2004). Volcanic Glass and other volcanic materials that could be used as ceramic materials have already been identified in commercial quantities in Kerang of Mangu Local Government Area and Miango of Bassa Local Government Area, both in Plateau State. Plateau State is located in the middle belt zone of the country (North Central Geo-political Zone). It is within latitude 8^0:22' North and 10^0:24' North and longitude 8^0:32' East and 10^0:38' East. It is bordered to the North-west by Kaduna State, to the North-east by Bauchi State, to the South-west by Nassarawa State, and to the South-east by Taraba State (Ministry of Information, Plateau State, 2006) (See figure 1).

Proper beneficiation of these raw materials is most desirable for Nigerian ceramic wares to meet the needed qualities that will make them compete favorably with other ceramic products in international markets. Beneficiation in its simplest term according to Ryan and Radford (1987) connotes adding value by way of properly processing a raw material in order to give it the desired qualities needed to make it fit for the production of articles. In the case of ceramic raw materials, this could mean or include milling, sieving, extracting or removal of unwanted components, leaving only those needed components by the potter/ceramist. Clay, feldspars, silica and many other raw materials are examples of materials that cannot be used directly without one form of processing or the other.

Beneficiating of all ceramic raw materials provides the potter the advantage of having homogeneous blends when his materials are mixed or finally put to use. It usually results in fine homogeneous blends or mixtures both in ceramic bodies as well as in glazes. In glazes, it provides for fluidity and also for homogenous melting of glazes on ceramic wares (Martin 2000). As a result, Hansen (2003) recommended that, all volcanic materials should be thoroughly pulverized since they occur in sizes that are not sufficiently fine for glazes. Hansen stressed that as a very major characteristic, volcanic material are generally heavy and have the tendency to settle very quickly in glazes, hence the need for these materials to be thoroughly pulverized into dust-fine particle sizes.

Volcanic glass identified from these two locations (Kerang and Miango) require proper beneficiation as laboratory test result reveals that volcanic glass has very valuable elements desired by ceramist all over the world. Datiri (2011) revealed that, volcanic glass can serve as a perfect replacement for silica in both glazes and other ceramic bodies like porcelain especially if further beneficiation is conducted, since the laboratory test result shows very clearly that volcanic glass is a compound material with a broad spectrum of elements which can provide the advantage of blending it with just one other glaze material in order to formulate multi-coloured glazes.

This study reveals the step to step procedures undertaken to beneficiate volcanic glass from the two locations (Kerang and Miango), the challenges and problems encountered and tries to proffer suggestions that may yield better material suitable for the potters' studio.

Procedures

Before volcanic glass was analyzed in the Laboratory, it was beneficiated using scheme in Table 1. It should be noted here that the whole of these procedures were undertaken when the material was at its dry state. This was in attempt to attain dust-fine particle size which would be most suitable for any ceramic purpose. Importantly, the dust-fine material obtained from the scheme above was blended using a Triaxial Glaze Blend proffered by Riegger, (1978), in Datiri, (2011) to ascertain its suitability for ceramic glazes, and subsequently used on ceramic wares, revealed that volcanic glass is a very suitable replacement for silica in ceramic glazes(See Plate I).

Challenges

The major challenge encountered during the study is the hardness of the material (volcanic glass). Large dark coloured material that range between the sizes of pebbles and the fist were collected and washed in order to remove deposits of unwanted materials on them. The washed material was dried to eliminate physical water contents. In order to attain the desired dust-fine particle sizes for general ceramic use, five different mills were used. (The jaw crusher, cone crusher, raw crusher, dry ball mill and ring pulverizer). Undertaking tasks under these five stages of milling was not just cumbersome but also time consuming as the material is heavily characterized by hardness. This was also accompanied by the generation of heavy dust since the material was milled in its dry state. The hardness of the material coupled with the fact that the material was in a dry state, paused severe health risk and challenges as the operator(s) of the milling machines had to be inhaling part of the dust generated even when protective mask were used.

Other challenges include the non-availability of the mills in the open markets for the potters to access. Very few organizations have these set of mills and are purely restricted for their research work or use. Private individuals are either out rightly denied the usage of such facilities or charged heavily. These results in serious problems for any intending researcher or potter who desires to use either the same facility or raw material since they are not readily available for him to access.

The laboratory test result of volcanic glass revealed yet another major challenge to the researcher: of the fifteen (15) different elements available in volcanic glass, iron oxide alone took 15.2% .This is quite on the high side, in fact far above the desired level for most glazes as Rhodes (1973) and Reeve (1996) recommended quantities of iron oxide not exceeding 2% and 5% for glazes that should be white and off-white respectively. 15.2% is definitely on the high side even though Bullard (1984) had reported that volcanic materials generally have a higher percentage of occurrences of Iron Oxide than other elements. The researcher feels this high level of iron oxide might have been attained not from the material alone but also from the wear and tear of the mills due to the hardness of the raw or unprocessed volcanic glass.

Recommendations:

- Hard volcanic glass materials should be softened by way of calcining in a Kiln to at least 800^0 C to soften the hardness. It is the recommendation of the researcher that the material be softened or rather weakened through heating in a kiln to

bisque temperature as recommended by Cardew (2002).

- It is also the recommendation of this study that, rather than having the entire process of milling in its dry state, volcanic glass be ball milled (wet) after the first two stages of dry milling as this will help minimize the issue of excessive dust, since these first two stages merely deals with the aspect of crushing of the material. The challenge of handling dusty environments will this way be taken care of, saving the operators from the hazards of dust related infections like silicosis, bronchitis, emphysema, pneumothorax, and Cather to mention a few. Inhalation of silica dust, or free silica or crystalline quartz can cause a respiratory infection called silicosis, a severe disease of the lungs, developing gradually within 15 – 20 years of exposure before symptoms are visible (Sullayman, 2003). In essence, this study is recommending the following beneficiating scheme for volcanic glass (See Table 2):
- To further curtail the likelihood of depositing more iron oxide during the process of beneficiating volcanic glass, a device to track or magnet all metal/iron properties should be used continuously to stir the material either in its powdered or slurry stages. This, it is believed will remarkably reduce the iron content of the beneficiated material for better appearance and especially for possible application and usage on white-ware ceramic products.
- The Ceramic Research Association of Nigeria (CerAN) should look inwards, conceptualize ideas and pursue with determination the possibility of setting up its beneficiation plant in order to help its members who are willing to conduct research but are limited by the lack of equipment. As a matter of concern, this should be taken very seriously as Nigerian potters had in the past over relied on the open market and other Research Institutions which both have failed in meeting adequately the needs of the Nigerian potter.

Conclusion

Alkali (2004) has been joined by Fatuyi & Ologunwa (2011) in lamenting the poor sales of ceramic products due to substandard products resulting from substandard materials. Certainly poor beneficiation of raw materials generally results in substandard products. As rich in elements as volcanic glass could be, it is obvious that its beneficiation is necessary even though it demands a lot.

The challenges as well as the suggestions proffered in this study may not be the ultimate. It is hoped however that these suggestions shall serve potters reasonably well, especially to enable them access this very rich and available material since if blended with just a flux, it results in a glaze suitable for most pottery studios. It is hoped that one day, challenges and problems in beneficiating volcanic glass for the use of Nigerian and international potters will become an issue of the past.

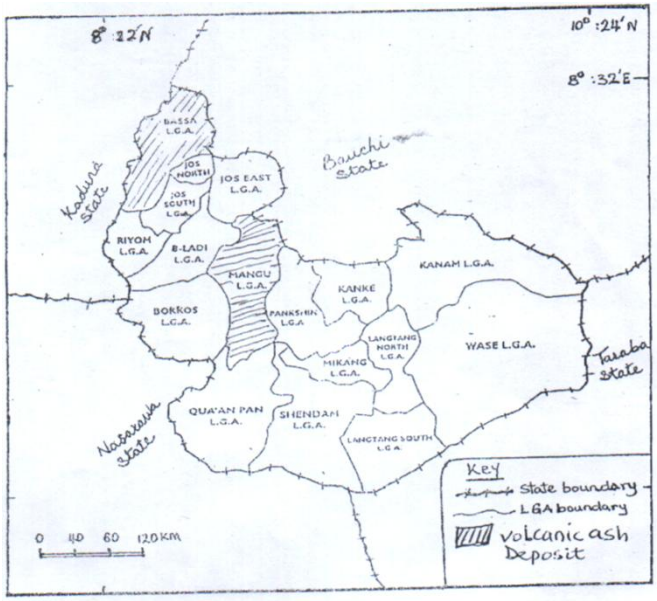

Figure 1: Plateau State of Nigeria
Source: Ministry of Information, Plateau state (2006)



Plate 1: Testing glaze containing volcanic glass
Source: Datiri (2011)

Table 1: Beneficiation Scheme

1. Washing	2. Size reduction	3. Jaw crushing 20mm	4. cone crushing 10mm
5. Raw crushing	6. dry ball milling very fine particles		7. rings pulverizing dust fine particles

Source: Datiri, (2011)

Table 2: Beneficiation scheme for volcanic glass

1. Washing & drying	2. Calcining	3. Jaw crushing to 20mm
4. cone crushing to 10mm	5. Wet ball milling	6. De-watering and drying

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