SOURCES OF GLAZE MATERIALS IN GHANA

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ABSTRACT

This paper identifies the type and sources of raw materials for the preparation of ceramic glazes in Ghana. It deals with the formulation of glazes; the major chemicals and their materials sources of supply and finally lists the common raw materials obtainable in different parts of the country. The minerals are listed under major rock types and their chemical constituents in percentages are quoted. The chemicals that occur in insignificant quantities have been lumped under the heading 'others'. This has been done for easy identification and comparison. It is believed an adequate information on raw materials for glaze preparation would go a long way to stimulate interest in research institutions and in the universities in the country in that direction.

Keyword: *Traditional pottery, ceramics, glazes, studio pottery, craft, potters, lead glazes, leadless glazes.*

INTRODUCTION

Pottery ranks high among traditional crafts practised in Ghana and it can be found across the length and breath of the country. In major clay deposit areas such as the Nkawkaw and Okwanya areas in the Eastern Region, Tanoso area in the Brong Ahafo Region and many other places in the country, the practise of pottery has become a major source of economic activity and livelihood, particularly for women. The term pottery or ceramics, covers all objects made of clay, with or without the addition of other earthy materials, shaped first, dried and then made hard and permanent by the action of considerable heat. Colbeck, J (1974 13) (1)

The art of traditional pottery has been practised for many, many years the world over. Rhodes, D (1979) (2) has noted that countless generations of potters have bequeathed to us a craft of great complexity and beauty. In many cultures pottery making was one of the household arts necessitated by the need for storage containers and cooking pots. From time immemorial, the traditional pottery has employed very simple technology in its operations and the products are of simple design and fired black by traditional bonfire method or open-air firing. The traditional pottery has survived modernisation although this position is weakening as a result of technological and sociological changes. In recent times, studio pottery, which combines traditional and modern pottery practices has emerged. The products of studio pottery are mainly glazed and more refined as compared with traditional pottery. This demand coupled with the desire of the trained and modern potter to express his artistic potentials via the media of clay and glaze have resulted in the setting up of studio pottery in some parts of the country.

However, the emerging studio pottery faces a number of problems. For instance, in contrast with the abundant deposits of clay, which is the most basic raw material for the pottery industry, is the scarcity and high cost of other equally important materials such as glaze materials and ceramic equipment. Undoubtedly, the survival of studio pottery depends on adequate and regular supply of glaze materials. This could only be possible if local substitutes are found for the importation of major glaze components. This calls for adequate information on the available glaze materials such as the size and quality of deposits and their accessibility. Such information is very crucial if the ceramic industry is to develop appreciably and contribute to the socio-economic development of the country. A con-

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certed effort is therefore needed to ensure the availability of such materials and equipment for the development of the pottery industry in the country. Although raw materials for glaze composition could be found in commercial quantities in some parts of the country no firm is currently producing glazes for sale to potters. Furthermore, most potters have very little knowledge of where raw materials for glaze formulation occur. Glaze formulation is highly technical but to the potter it adds to artistic creativity.

Glaze Formulation

Glazes are simple super cooled liquids of high viscosity at ordinary temperatures or are thin glasslike coatings that are fused to the clay surface of a pot by the heat of the kiln (Shaw K. 1971:1) [3]. In studio pottery, glaze composition is normally quite elaborate and time consuming for the busy potter. This is because a variety of chemical compounds are made use of and expert skill is needed for good result. However, scientific and technological advancements have made it possible for industrial formulation and composition of glazes that are packed and supplied to the potter in any quantity and quality. Given the foreign exchange constraint and for the fact that the trained potter wants to be 'part of the pot' from the beginning to the end, glaze preparation should be made simpler for generally it contains only three essential elements; silica, flux and refractory elements (Nelson, G. C. 1971:205) [4].

Silica

Silica is commonly called flint and also known as quartz in its pure crystalline state. It is the glass former and it is an essential glaze ingredient. However, this essential glaze ingredient cannot be used on its own because of its very high melting point of about 1700° C. This is a serious draw back else this single material would suffice to form a glaze. It is necessary to note that the stoneware porcelain bodies mature between 1238° C and 1315° C. Thus silica in its pure state cannot be used on its own on ceramic bodies. This calls for the introduction of other elements such as fluxes.

Flux

Fluxes are the lowest-melting compounds in a glaze. Interestingly there are many chemicals with low melting points which readily combine with silica to form a glassy crystal. Two types of fluxing materials are commonly used in low-firing glazes. These are (1) lead oxides (lead carbonate, red-lead, galena and ligharge) and (2) alkaline compounds (borax, colemante, soda ash, boric acid and bicarbonate of soda). During firing the flux melts first and surrounds refractory materials like silica and takes them into solution and thereby helps higher-melting alumina-silica compounds to eventually form a glass. A flux softens glaze and makes it runny, as a result a hardening element such as refractory is needed to make the glaze less runny and to stay on the ware over which it has been applied.

A Refractory Element

A refractory element gives strength to glazes and helps glaze to better withstand the wear of normal use. Silica and alumina unite to form tough, needle-like mullite crystals, creating a bond more resistant to abrasion and shock.

In its final composition, therefore, a glaze includes the three necessary elements; (1) silica and boricoxide which are the glass formers, (2) a flux, which lowers the fusion point of the silica, and (3) alumina, a refractory element that gives added toughness and hardness to the glaze. It also allows a higher maturing temperature, increases viscosity and prevents devitrification.

Types of Glazes

Glazes can be classified in various ways according to temperature range, minerals used or ware on which they are applied (Shaw, K. 1971:64) [3]

1) According to temperature range there are; (1) low-fire glaze and (2) high-fire glaze.
2) The classification based on the ware on which the glaze is applied are; (1) Mayolica glazes, (2) Earthenware glazes, (3)

Stoneware glazes, (4) Sanitary glazes, (5) Porcelain glazes.

For this purpose the discussion will be limited to the low-firing and high-firing glazes, the two most commonly used glazes in Ghana.

Low-Firing Glazes

Lead glazes can be grouped into two distinct categories distinguished by the major flux included in the glaze as lead glazes and leadless or alkaline glazes.

1) **Lead Glazes**

Low-firing glazes comprise the largest group of glazes firing at a temperature range of between 790° C and 1120°C. These glazes derived their name from the fluxes used, which are basically oxides of the lead compounds. The principal fluxes are white lead (2 · $PbCo_3$ Pb $(OH)_2$ and red lead (Pb_3O_4).

2) **Alkaline Glazes**

These groups of glazes are similar to the lead glazes because of their firing range of between 790° C and 1120° C. Alkaline glazes however, use an alkaline flux such as borax, colemanite, or soda ash without the use of any lead compound.

High-firing Glazes (Feldspathic Glazes)

Feldspathic glazes need extreme temperatures

Table 1: Sources of Base (RO) Oxides

	Chemical	Formula	Raw Materials	
1	Barium	CO	▪ Barium Carbonate	- $BaCO_3$
2	Calcium Oxide	CaO	▪ Calcium Carbonate ▪ Calcium Colemanite/ borate ▪ Dolomite ▪ Fluorspar ▪ Bone ash	- C_aCO_3 - $CaO3B_2O.5H_2O$ - CaMg $(CO_3)_2$ - CaF_2 - Ca_3 $(PO4)_2$
3	Lead Oxide	Pbo	▪ Galena ▪ Litharge ▪ Red Lead ▪ White lead	- Pbs - Pbo - Pb_3O_4 - 2 Pb CO_3.$Pb(OH_2)$
4	Magnesium Oxide	(MgO)	▪ Magnesium Carbonate ▪ Dolomite ▪ Talc ▪ Diopside	- $(MgCo_3)$ - CaMg $(Co_3)_2$ - $4MgO.5Sio_2$-H_2O - CaO.MgO.$2Sio_2$
5	Potassium Oxide	K_2O	▪ Potassium Carbonate ▪ Potash Feldspar	- K_2CO_3 - $K_2O.A1_2O_3.6Sio_2$
6	Sodium Oxide	Na_2O	▪ Sodium Chloride ▪ Sodium Carbonate ▪ Borax ▪ Soda Feldspar ▪ Nepheline Syenite	- NaCl - Na_2CO_3 - $Na_2O.2B_2O_3.10H_2O$ - $Na_2O.A1_2O_3.6Sio_2$ - $K_2O.3Na_2O.4A1_2O_3.9Sio_2$
7	Zinc Oxide	ZnO	▪ Zinc Oxide	- ZnO

Source: Copper. E. (1970)[5]

of between 1150° C and above to mature. This high temperature calls for the replacement of common low-fire fluxes such as lead borax and calcium carbonate which malt at about 816° C. Feldspar is the principal ingredient of high-fire glazes.

Common Ceramic Chemicals

There is a wide range of ceramic chemicals that cannot be covered here but for the purpose of this paper, the major ones and their sources will be listed in Table 1 and an attempt made later to look at their local sources. For convenience the chemicals will be grouped under R0. R_2O_3 and RO_2 (Flux and acid based). (Cooper, E. 1970) (5)

Source of Glaze Materials in Ghana

There is a wide range of natural occurring glaze materials in different parts of the country, which may be collected, in large quantities and process into glaze component either for commercial

Table 2: **Sources of Natural/Amphotric (P203) Oxides**

	Chemical	Formula	Raw Material	
1	Alumina	A1203	▪ Alumina hydrate ▪ Feldspar ▪ Kaolin (China Clay) ▪ Nepheline Synite	- $Al(OH)_3$ - $K_2O.Al_2O_3.6SiO_2$ - $Al_2O_3.2SiO_2.2H_2O$ - $K_2O.3Na_2O.4Al_2O_3.9SiO_2$
2	Antimony Oxide	Sb203	▪ Antimonious Oxide	- Sb_2O_3
3	Baric Oxide	B203	▪ Boric Acid ▪ Borax ▪ Calcium Carbonate (Colemanite)	- $B_2O3.2H_2O$ - $Na_2O.2B_2O_3.1OH_2O$ - $2CaO.3B_2O_3.5H_2O$

Source: Cooper. E. (1970) [5]

Table 3: **Source of Acid (RO_2) Oxides**

	Chemical	Formula	Raw Materials
1	Silica	Si02	Sandstone Quartz Sand Flint Pebbles Note Silica can also be obtained from other ceramic materials listed earlier on. The following is a list of commonly used silica compounds. ▪ Ball Clay - $Al_2O_3.2SiO_2.2H_2O$ ▪ Kaolin - $Al_2O_3.2SiO_2.2H_2O$ ▪ Soda Feldspar - $Na_2O.Al_2O_3.6SiO_2$ ▪ Potash Feldspar - $K_2O.\ Al_2O_3.6SiO_2$

Source: Cooper. E. (1970) [5]

purposes or for use by the artist potter. It is not difficult to locate some of the raw materials but the assistance of the local inhabitants is usually helpful to locate the sites without wasting too much time. Table 4 presents the list of glaze materials available in different parts of the country. The materials that are found in their raw states occur in different form – massive, flaky and coarse-according to material type. Most of the raw materials listed in the table are located close to settlements and are fairly accessible. With the exception of few materials, very simple tools and equipment such as pickaxe, cutlass and shovel are the only tools needed for mining the materials.

Table 4: Sources of Raw Materials for Glaze Preparation in Ghana

GRANITE										
Mineral Source	**Chemical %**								**Location**	
Medium-grained granite Hornblende granite Boltoo granite Kukurantumi granite	**SiO_2**	**Al_2O_3**	**FeO**	**Mgo**	**CaO**	**Na_2O**	**K_2O**	**Others**	**Town**	**Region**
	76.26 76.20 76.10 75.00	11.86 13.10 12.40 13.10	1.02 0.43 1.57 0.92	- - - -	0.87 0.76 1.56 1.12	3.41 4.78 3.66 3.68	4.77 3.32 2.92 3.20	1.81 1.41 1.79 2.98	Bisugu Sanyon Kobo Kintampo	Northern Western Brong Ahafo
Granodiorite										
Granodior Discove granodiorite Pegmatite	75.50 67.62 77.20	12.80 14.73 16.30	1.10 3.36 0.28	0.46 1.93 0.40	1.54 3.98 0.10	3.76 3.98 0.90	3.50 1.80 1.90	1.5 2.60 2.92	Mamkuma Dixcove Atia	Northern Western Ashanti
Prophyry										
Quartz feldspar prophyry Carbonated quartz Quartz prophyry	74.11 72.90 70.66	13.18 15.43	1.99 1.22 1.61	0.35 0.89 0.64	2.04 0.31 2.36	4.54 1.97 5.44	2.34 2.40 1.49	1.46 6.11 2.80	Penakrom Amamoso Busua River	Western Ashanti Western
Gabbros/Basalt										
Gabbro Altered Gabbroic rock Coarse Gabbro	50.50 48.50 48.30	13.40 13.60 16.30	7.65 5.27 9.12	12.60 13.50 6.90	11.80 14.40 11.13	1.24 0.66 2.62	0.10 0.03 0.48	2.71 4.04 5.15	Amechekrom Cape Fredrick Ankam	Western Western Ashanti

ALTERED IGNEOUS ROCKS										
Altered biotite granite	72.10	14.90	1.24	0.80	2.33	3.94	2.67	4.02	Mpohor (Afram River)	Western
Sheared granodiorite	71.10	15.30	2.23	0.67	2.89	4.32	2.00	1.49	Mpasaso	Western
PHYLITES										
Phylites	70.38	15.14	1.87	0.93	2.51	5.28	1.82	2.07	Womasi	Ashanti
Flack Phylites	66.09	15.33	3.63	2.18	4.73	3.97	1.21	3.13	Sese	Western
Phylites	59.50	19.00	0.92	0.19	0.23	1.10	0.77	18.33	Tihinti	Western
GREYWACKS										
Sal-greywackes	78.20	10.10	1.40	1.51	0.54	4.19	0.86	8.20	Aposika	Western
Nbung greywackes	63.30	15.70	4.74	2.80	3.23	5.98	0.49	3.76	Mese Mesa	Western
Asuoja greywackes	64.10	13.50	5.67	5.37	4.03	3.31	1.35	3.67	Asuoja	Western
SCHISTS										
Micaceous schists	67.90	16.90	3.74	1.40	1.70	3.32	1.58	3.46	Wenchi	Brong Ahafo
Green schists	61.00	14.10	6.13	5.33	2.62	4.20	0.50	5.92	Jedua	Western
GNEISSES										
Biotite Granite Gneiss	70.27	15.79	1.51	1.01	3.33	4.62	1.70	1.77	Nkwanta	Western
Biotite Granite Gneiss	70.24	16.56	1.36	0.77	3.02	5.17	1.22	1.66	Asanwinso	Western
LIMESTONE										
Limestone	0.84	0.96	0.84	1.06	52.32	43.98	-	-	Nauli	Western
Asuboin Limestone	6.43	1.84	1.08	1.22	50.65	38.78	-	-	Asuboni	Eastern
Dede river limestone	16.98	-	0.80	1.53	43.02	37.67	-	-	Asuboni	Eastern
Anvaboni limestone	10.89	-	1.02	3.23	45.15	39.73	-	-	Anyaboni	Eastern
Afram River limestone	11.50	-	1.27	10.10	35.87	41.26	-	-	Anyaboni	Eastern

MAGANESE ORES										
Nsuta Maganese Carbonate	2.38	1.30	0.64	2.49	4.08	50.41	38.70		Nsuta	Western
IRON ORES										
Shiene Iron Ore Open Mansi Iron Ores Navrongo Iron Ores Dzake-jakai Iron Ores	7.76 4.30 - -	5.17 - - -	83.35 55.90 83.83 75.52	3.72 39.80 16.17 24.48	- - - -	- - - -	- - - -	- - - -	Shiene (Zabzugu) Opon Mansi Navrongo Dzake-jakai (peki)	Upper Western Upper Volta
SPODU-MENE										
Mankwadzi Spodumene Saltpond Spodumene Atra Spodumene Winneba Spodumene	7.25 4.00 5.65 0.60	0.36 - 1.11 0.69	0.30 - 1.06 0.76	92.36 96.00 92.18 91.89	- - - -	- - - -	- - - -	- - - -	Mankwadzi Saltpond Atta Winneba	Central Central Ashanti Central
FELDSPARS										
Moree Feldspar Abandzi Microline Feldspar Birriwa Microline Feldspar Egyaa Microline Feldspar Amoanda Microline Feldspar	2.30 2.37 2.31 [illegible] [illegible]	13.7 13.0 9.25 13.20 13.75	0.70 0.90 1.26 0.54 0.51		- - - - -	- - - - -	- - - - -	- - - - -	Moree Abandzi Birriwa Egyaa Amoanda	Central Central Central Central Central
SHELL										
Battor Shells Achwa Shells	0.27 0.93	0.23	0.14 0.18	0.66	54.30 51.60	44.40 46.39	- -	- -	Battor (Akuse) Achwa (Nakwa Lagoon)	Eastern Central
SHALES										
Siliceous Scale	80.70	6.38	3.00	1.42	1.15	1.01	1.08	6.26	Buipe	Northern

SANDSTONE/QUARTZITE										
Nuali Sandstone Qautz Cobble Essamang Quartzite Bojisango Quartzite	80.40 99.20 99.78 99.86	19.60 0.80 0.22 0.14	- - - -	- - - -	- - - -	- - - -	- - - -	- - - -	Nuali Dunkwa Essamang (Bekwai) Bojisango	Western Central Ashanti Ashanti
SAND										
Aboso Sand Petepong Sand	94.95 97.26	5.05 2.74	- -	- -	- -	- -	- -	- -	Aboso Petepong	Western Western
LATERITES										
Laterite Ironstone Dunkwa Laterite	3.85 15.00	14.70 24.00	63.00 49.00	0.81 -	0.21 -	0.11 -	0.02 -	6.28 12.00	Wouwou Dunkwa	Western Central
KAOLINS										
Saltpond Kaolin Kibi Kaolin Anyinasi Kaolinite Clay	46.66 45.30 82.20	38.70 38.20 10.00	0.74 1.16 1.27	0.10 0.16 0.15	0.14 0.15 0.13	0.12 0.02 0.10	0.58 0.60 2.28	13.29 4.41 3.51	Saltpond Kibi Anyinasi (Hohoe)	Central Eastern Volta

Glassy-glaze

In the 1980s the Ceramic Section of the Department of Industrial Art of College of Art, Kwame Nkrumah University of Science and Technology, Kumasi in an attempt to get over the acute shortage of glaze materials for academic work, experimented with the use of glasses as major glaze ingredients with great success. Glazes and glasses are both solid solutions and have similar random arrangement of atoms and molecules at room temperature. This arrangement is the same when the glaze or glass was in molten state (Boateng, K., 1983) [7]. It is therefore concluded that glazes and glasses have common physical properties. Furthermore, the chemical composition of glass is similar to that of glaze. Table 4 presents a typical glass composition:

Table 4: Glass Composition

	Chemical	Percentage
1	SiO_2	81
2	B_2O_3	12
3	Al_2O_3	2
4	Na_2O	4
5	MgO/CaO	1

Source: Boateng, K., 1983 [7]

Wood Ash

Wood ash is perhaps the most variable and most useful glaze material that can be obtained cheaply and readily throughout the country. Wood ashes can be prepared by burning various spices of wood, fibres and shrubs. Ashes may be sieved and washed to various degree of purity. The chemical agents present in wood include silica, alumina. Calcium and magnesium oxides, potassium and sodium oxides, phosphates and certain colouring elements such as manganese and iron. The chemical composition and physio-chemical properties, and hence the final effects of ashes in glazes, will depend on the type of wood used in the burning, (Shaw, K (1971149) [3]. Wood ashes often give unique and unexpected effects to glazes which add to the creativity of the artist potter.

Conclusion

The paper has revealed the immense raw material potential for the glaze industry in Ghana. A comprehensive list of glaze raw materials and their locations have been presented to serve as a guide to prospective investors and also potters who may want to collect their raw materials for their glaze composition.

A survey of raw material base for glaze composition shows that high firing raw materials like silica, alumina and fluxes such as calcium and felspars are mostly obtainable in the country. This means that only high firing glazes can be composed locally. This calls for very high firing kilns that can achieve high temperatures of at least 1300° C. A large amount of energy input would be required and that would consequently step up production cost. A way out of this handicap would be to import low fluxing materials such as lead bisilicate and borax frint to enable economic composition of low-firing glazes in the country with the available materials as bases.

The glaze industry is undeveloped although it has the potential of generating substantial employment and income to many people in both rural and urban areas. For that reason the Government may offer attractive incentive packages to encourage the private sector to invest in the sector.

Suggestions

It is clear from the paper that there abounds in the country a great variety of raw materials for glaze composition that when exploited, would go a long way to stimulate interest in the ceramic industry and save substantial foreign exchange for the country and create jobs. To do this, the following suggestions are made. First, the Geological Survey Department takes a closer look at the known deposit of glaze raw materials and assesses the economic variability of such materials for the benefit of prospective investor. Second, a detailed information such as the quality and quantity of the deposits and accessibility to them should be made available by researchers to entrepreneurs who may want to go into commercial production of glazes in the country. Third, research institutions must be strengthened, equipped and encouraged to undertake more research into raw materials for glaze composition in the country and make their findings available to investors. Fourth, all institutions and individuals involved in the ceramic industry should come together to make use of opportunities that exits in the ceramic industry for the benefit of the nation through coordination and networking.

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