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Geochemical and Economic Application of Marble from Igarra and Ikpeshi Areas, S.W. Nigeria

[1]Obasi, R A, [2]Anike, O. L
[1]Department of Mineral Resources Engineering, Federal Polytechnic, Ado-Ekiti.Ekiti State, Nigeria.
[2]Department of Geological Sciences, Nnamdi Azikiwe University Awka, Anambra State, Nigeria

ABSTRACT

Marble deposits occur prominently in Igarra and Ikpeshi areas of Southwestern Nigeria. Forty marble samples were subjected to geochemical and physical analysis in order to determine their applications. Geochemical data show that the Igarra marble is characterized by low SiO_2 (1.84 – 4.83%), Al_2O_3 (0.16 – 0.67%) and MgO (1.10 – 5.33%) and high CaO (46.51 – 53.06%) and LOI (40.59 – 44.26%). This results in markedly low dolomite, $MgCO_3$ (2.30 – 11.14%) and high calcite, $CaCO_3$ (85.45 – 94.68%). The Ikpeshi marble is majorly calcitic having contained high values of $CaCO_3$ (61.003 – 95.61%) and low values of $MgCO_3$ (1.35 – 7.44%). However, the marble at the Golden Girl quarry is dolomitic having a $MgCO_3$ content of 41.38 – 41.42%. The marble is suitable as sources of industrial raw materials for a variety of consumer products such as drugs, toothpaste, animal feeds and paper production. Other areas of application include agriculture, monuments, electrical, interior decoratives, flooring tiles, terrazzo chips, and fittings. However, the marble cannot be used for cement production due to low values of CaO (53.06%) and high values of LOI (>43%) unless the CaO and the SiO_2 are blended.

Keywords: *Geochemistry, application, marble, low lime and silica, blended*

1. INTRODUCTION

The Igarra and Ikpeshi areas lie within the Pre-cambrian Basement Complex of Southwestern Nigeria . Most geological studies have been carried out on these areas by Elueze, 1980, 1991; Turner, 1983; Rahaman, 1992; Odeyemi et al, 1991 and Ekwueme, 1990, 2000. The basement rocks notably include migmatite gneiss complex, biotite-hornblende gneiss, metasediments and Older granite nitrusives (Rahaman, 1978, Elueze, 1982). The metasediments occur as a supracrustal cover on the basement and consists of quartz-biotite, calc-gneiss and marble, metaconglomerate and mica schist (Okeke and Meju, 1985; Ajibade et al, 1987; Odeyemi, 1988; Ekwere and Ekwueze, 1991; Imeokparia and Emofurieta, 1991 and Ocan et al, 2003).

Marble deposits around Ubo and Ukpilla (the surrounding areas of the study areas) are exploited for use in Portland cement production (Ofulume, 1993). However, very little data are available on the marble chemistry of Igarra and Ikpeshi areas. This work therefore presents data on the marble chemistry with a view to evaluating its economic potentials and industrial application. Samples were collected and subjected to chemical and physical analyses. The results were then used to determine the areas of economic application.

2. MATERIALS AND METHODS

2.1 Sample Collection

Forty representative marble samples of 500g each were collected from the studied areas (Figs.1) by means of a sledge hammer. Care was taken to avoid contaminated portions. Global positioning system instrument (GPS) was used to locate and determine the elevations and co-ordinates – the Northings and Eastings of each location.

2.2 Sample Preparation

Thirty of the samples were pulverized into powder (180mm mesh) using Denver pulverizer equipment. Twenty of them were put into sterilized bottles and sent to the ACTIVIATION LABORATORY (ACTLAB) in Ontario, Canada for major oxides geochemical analyses using the Inductively Coupled Plasma Mass-spectrometry (ICP-MS) method. Five samples each were analysed with the X ray fluorescence (XRF) and X ray diffractometer (XRD) in the Geological Sciences Laboratory of the University of Cape Town, South Africa. In XRF analysis, major oxides and minor elements were also determined.

The whole-rock CO_2 abundances were calculated following duplicate determination of $CaCO_3$ using the karbonat – bombe method of Birch, (1981).

In the XRD method, diffratograms were obtained with a Philip 1140 equipment using Cuk alpha radiation operated at 40KV, 30MA and 1^0 2 q per minute. The results of the XRD show the diffractogram profiles (Figs 2-3). The remaining ten samples were tested for their physical properties.

3. RESULTS AND DISCUSSION

Table 1 presents the chemical data for the Igarra marble which is marked by low SiO_2, Al_2O_3 and MgO and high values of CaO and LOI. Low MgO in marble translates to low dolomite content $MgCO_3$ (2.30 – 11.14%) while high CaO results in high calcite mineral content (85.45 – 94.68%). Bathurst (1975) suggests that marble with less than 6 percent $MgCO_3$ content is a low magnesium marble and is therefore referred to as calcitic.

Brown (2007) states that marble with less than 0.50% of $MgCO_3$ is calcitic, those with greater than 40% of $MgCO_3$ are dolomitic and those that fall between 5 and 40% of $MgCO_3$ are referred to as magnesian marble. Based on this, the Igarra marble is calcitic (Fig4) and therefore can be applied in a variety of industries.

Table 2 reveals a characteristic variation in the geochemical composition of the Ikpeshi marble. The SiO_2, CaO and MgO contents are variable. The Golden Girl marble contains over 41% of $MgCO_3$. Elsewhere, $MgCO_3$ content is less than 11% showing that within the Ikpeshi geological environment, calcitic marble with $CaCO_3$ of 83.99 – 95.60% and dolomitic marble of $MgCO_3$ 41.3 – 41.42% occur. (Fig 5). An interpretation of the XRD profiles reveals the presence of calcite, dolomite, illite, montmorillonite, quartz and kaolinite.(Table3)

4. ECONOMIC EVALUATION OF MARBLE

Igarra and Ikpeshi are important marble producing areas of Southwestern Nigeria. The marble and their associated minerals in Table 3 form sources of raw materials to a variety of consumer products such as paints, toothpaste, drugs, paper and animal feeds. The supply of marble to industrial markets is based on its physical or chemical properties as well as purity. The purity is a measure of the amount of CaO, SiO_2, and Al_2O_3 and the presence or absence of impurities.

Physically, the colour of marble makes it unique for high pricing in the market. The white and the pink colours of the calcitic and dolomitic marble respectively give aesthetic appeals in the manufacturing of chips, terrazzo and white wares. The colours are utilized by paint industries for emulsion paints as colouring pigments or stainers and as good fillers and extenders. They also stabilize the paint and act as a weather resistant (Robert, 1979).

Finely ground white calcitic marble serves as a coating pigment. As a paper filler, it imparts high brightness to the sheets, opacity, surface smoothness and ink receptivity to printing. In plastics, marble filler provides necessary reinforcements for greater impact strength, rigidity, stiffness and high brightness.

5. CEMENT PRODUCTION

Ordinary Portland Cement (OPC) is produced by using a mixture of the following raw materials specificatios; lime, CaO (63%), silica,SiO_2(22%) alumina,Al_2O_3 (6%) haematite,Fe_2O_3 (3%) magnesia MgO (2.5%) and LOI. (1.50%) (Rajput, 2008). The standard data of the chemical constituents are shown in Table 4 . The data show that the values of lime, (53.08 and 51.35%) silica, (4.83 and 9.73%) alumina (0.54 and 1.86%) and iron oxide (0.58 and 1.23%) respectively in the marble of the studied areas are below the required standard, while the magnesium oxide, (5.33 and 19.81%) , LOI, (41.61 and 45.75%) silica ratio and lime saturation factor are significantly higher than the standard. (Labahn and Kaminsky, 1971). Based on these chemical differences, the marble in Igarra and Ikpeshi areas is unsuitable for cement production. However the marble can be made suitable if the CaO and the SiO_2 are blended while excess LOI is reduced by heat in the kiln.

6. AGRICULTURAL APPLICATION

Processed marble is diversely applied in agriculture as lime, CaO, slaked lime, $Ca(OH)_2$ as conditioner for mixed fertilizer, as source of Ca and Mg for plant nutrients, as animal feed supplement and as poultry grit. The $CaCO_3$ used for animal feed must be within the range of 98% - 98.5% (Boynton, 1979).

However, the maximum $CaCO_3$ contents in the marble of the studied areas are 95.65% and 95.61% respectively. These values are tolerable since the little chemical difference can be supplemented by an addition of phosphorus and salt in the making of a good organic feed and mashes . Marble helps in neutralising acidity that stems from acidic nitrogen chemicals and superphosphate components of fertilizer.

7. PAINT MANUFACTURING

Paint manufacturing requires both the physical and chemical properties of marble. Essential physical requirements include good white or pink colour, small particle sizes (98% passing through 325 mesh) and absence of hard particles while chemical specification provides that Al_2O_3 must be greater or equal to 2%, MgO + SiO_2 must be equal to 75% and LOI must be within the range of 4% - 8%. Table 5 (Robert, 1979).

The studied marble satisfied all the physical specifications but differed significantly in the chemical compositions. The Al_2O_3 is less than 2% (1.86%), MgO+SiO_2 is less than 24% (23.35%) while the LOI is greater than 32%, (32.59 and 34.78%).These chemical differences make the marble unsuitable for use for paint manufacturing. However, paint manufacturers have their individualized specifications so much so that they establish their peculiar standards as long as their brands of paint satisfy their quality, their customers and in conformity with their production formulations. The pink-coloured marble from the Golden Girl quarry at Ikpeshi is highly priced by paint manufacturers due to its aesthetic colour pigment and decorative characteristics.

8. OTHER APPLICATIONS

Marble is used in a variety of applications as flooring tiles in bedrooms, bathrooms, kitchens, restaurants and public places like hotels, public toilets churches and town halls. These tiles give a feel of luxury and a soothing cooling touch due to low heat conduction properties. Tiles provide glistering appearance and aesthetic luster. Other areas of the uses of marble are in sculpture, monumentals, shop fittings, electrical and decoratives as well as dietary calcium supplement (Herbert et al; 1990).

9. CONCLUSION

Geochemical data of marble from Igarra shows that it is calcitic (85.45 – 94.08%) with low dolomite content (2.30 – 11.14%). The Ikpeshi marble is majorly calcitic except the Golden Girl marble which is dolomitic (with over 41% dolomite). An economic evaluation of these rocks and their associated minerals indicate that they serve as sources of raw materials for a variety of industries in Nigeria. As industrial fillers, they find application in glass, paper, and in china wares. Other areas of industrial application include agriculture, pharmaceutical, electrical, decorative construction, monumental, surface coatings (paint making) and cement manufacturing.

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Table 1 Chemical analysis of marble (Carbonate) from Igarra (vol.%)

Oxide	1	2	3	4	5	6	7	8	9	10
SiO_2	1.84	2.11	1.89	2.79	4.33	4.83	1.90	3.69	3.53	4.26
Al_2O_3	0.67	0.65	0.16	0.54	0.52	0.31	0.38	0.61	0.45	0.36
Fe_2O_3	0.38	0.35	0.12	0.14	0.32	0.58	0.08	0.26	0.33	0.52
MnO	0.05	0.32	0.18	0.07	0.03	0.22	0.04	0.011	0.24	0.26
MgO	1.45	1.27	1.28	1.89	2.8	1.1	5.33	3.22	3.02	3.52
CaO	51.35	53.06	52.76	52.24	48.68	47.89	47.82	50.66	50.12	46.51
Na_2O	0.90	0.60	0.13	0.23	0.18	2.06	0.05	0.13	0.62	0.31
K_2O	0.50	0.16	0.03	0.07	0.23	0.28	0.01	0.15	0.18	0.29
TiO_2	0.11	0.25	0.03	0.015	0.22	0.27	0.03	0.22	0.04	0.24
P_2O_5	0.04	0.28	0.02	0.04	0.04	0.01	0.05	0.04	0.04	0.04
LOI (H_2O and CO_2)	43.0	40.59	43.38	42.0	42.61	42.25	44.26	41.08	41.36	43.65
Total	99.23	99.64	99.98	100.0	99.8	99.8	99.95	100.17	99.93	99.95
$MgCO_3$	3.03	2.65	2.67	3.95	5.85	2.30	11.14	6.73	6.31	7.36
$CaCO_3$	91.63	94.68	94.15	93.22	86.86	85.45	85.33	90.40	89.43	82.99

Table 2: Chemical characteristics of Ikpeshi marble (Vol. %)

Oxide	1	2	3	4	5	6	7	8	9	10
SiO_2	1.94	1.94	1.43	0.44	1.94	1.18	1.90	1.88	1.40	1.96
Al_2O_3	1.76	0.31	0.02	0.11	1.04	0.48	1.80	0.33	1.08	0.39
Fe_2O_3	1.23	0.18	0.03	0.08	0.05	0.26	0.77	0.16	0.47	0.36

MnO	0.04	0.05	0.01	0.02	0.01	0.01	0.01	0.08	0.01	0.09
MgO	3.67	2.45	19.81	19.79	2.14	3.54	3.56	2.04	2.65	2.59
CaO	48.05	51.35	33.95	33.64	50.08	50.3	45.83	48.36	53.02	49.59
Na_2O	0.40	0.09	0.01	0.03	0.06	0.01	0.28	0.58	0.2	0.01
K_2O	0.62	0.05	0.05	0.07	0.05	0.63	0.60	0.08	0.29	0.01
TiO_2	0.15	0.02	0.02	0.03	0.01	0.01	0.10	0.01	0.05	0.03
P_2O_5	0.06	0.06	0.02	0.05	0.04	0.17	0.04	0.08	0.13	0.03
TiO_2	41.98	43.5	44.66	45.75	44.53	43.32	45.30	45.61	40.7	44.23
Total	99.90	100.00	100.00	99.96	99.95	99.91	100.1	99.21	100.00	99.29
CaCO3	86.74	92.63	**61.58**	**61.03**	90.36	90.76	82.78	87.29	95.61	89.49
MgCO3	7.67	5.12	**41.42**	**41.38**	4.48	7.40	7.44	4.26	5.54	5.42