VOL. 2, NO. 10, Nov 2012 ISSN 2225-7217

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Geochemistry and Appraisal of the Economic Potential of Calc – Gneiss and Marble from Igarra, Edo State, Southwest, Nigeria

Obasi R.A

Department of mineral resources engineering, federal polytechnic, ado – ekiti, Ekiti state, Nigeria.

ABSTRACT

Igarra has notable large deposit of calc-gneiss and marble that has generated a polyglot of mining activities in the Akoko area of Edo State, Southwest Nigeria. Geochemical and physical analysis has been used to appraise the economic potentials and areas of application of these carbonate rocks. Forty five (45) samples were subjected to geochemical and physical analyses. Geochemical data indicate characteristically low values of SiO_2 (1.8 – 4.83wt %), Al_2O_3 (0.16 – 0.67wt %) and MgO (1.10 -5.33wt %) and relatively medium to high CaO (46.51 – 53.06wt %) and loss on ignition (LOI) (40.59 -44.26wt %) in the Igarra marble. This results in markedly low dolomite $MgCO_3$ (2.30-11.14wt %) and corresponding relatively high calcite (85 – 45 – 94.68wt %). Physical tests show that the marble has high compressive and tensile strength which are expressions of their hardness and durability potentials when used in monuments, sculpturing or fittings. The marble and calc- gneiss are raw materials for a number of products such as paper and animal feed production, toothpaste, drugs, flooring tiles, and ceramic wares. However, the marble from Igarra is has low values of CaO (53.06wt %) and SiO_2 and high contents of LOI (>43wt %) .These characteristics do not permit the use of the marble for paint making or cement production unless blended to meet up with the world best standards.

Keywords: *Geochemical appraisal, potential application, raw materials*

1. INTRODUCTION

Igarra area lies between latitudes $7^0 00'$N and 7º 30′N and longitudes $6^0 00'$E and $6^0 30'$E. It is situated at the northern fringe of Akoko Edo local Government authority of Edo State, Southwest Nigeria (Fig.1). The landforms comprise undulating low land separated by hillrocks representing granites. The Older granites occur in ridges and rise between 20m and 40m above the general ground level. Most of the hills occur in the northeast and southeast of Igarra.

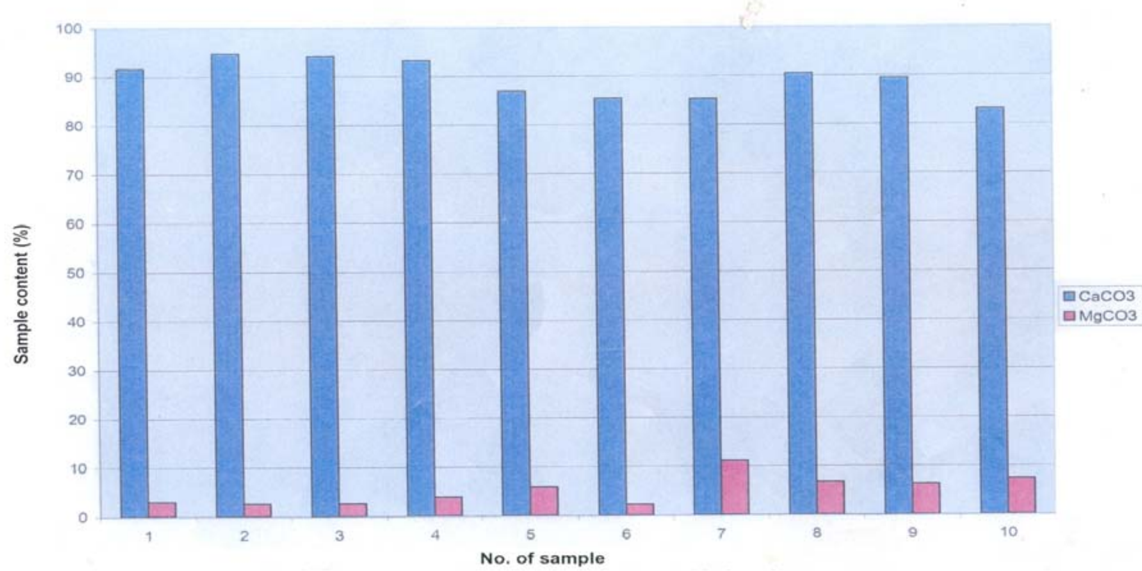

Fig 1: Histogram of Calcitic and Dolomitic Marble from Igarra

The geology of Igarra area has been studied at various degrees by many authors including Rahaman (1992), Odeyemi (1988), Okeke, Akinnagba and Anike (1988), and Ekwueme (1990, 2000). These authors indicate the major rock groups, their distribution and structural relationship. The major rock groups that occur in the Basement Complex of the area are notably migmatite gneiss, schists (including marble and calc gneiss), older granites and late intrusions.

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

The schist (metasediments) occurs 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 at Ubo and Ukpilla were processed for use in Portland cement production in the 1970s (Ofulume 1993). Little data are available on the chemistry of the marble from Igarra. This work therefore presents data on the marble chemistry with a view to appraising its economic potentials and areas of applications.

2. MATERIALS AND METHODS

Forty five (45) representative marble and calc – gneiss rock samples were collected from quarry sites around Igarra area. (Fig2). Global position system (GPS) instrument was used to locate the elevation and to determine the northings and eastings on the location

3. SAMPLE PREPARATION

Thirty (30) samples were pulverised into powder (180μm mesh) using Denver pulverizer equipment in the Department of Mineral Resources Engineering of Federal Polytechnic, Ado-Ekiti. Twenty five of the samples were sent to the Activation laboratory (ACTLAB) in Ontario, Canada for major oxide and trace element geochemical analysis using the Inductively Coupled Plasma – Mass Spectrometry (ICP – MS). The analysed oxides include SIO_2, AL_2O_3, Fe_2O_3 (T), MnO, MgO, CaO, Na_2O, k_2O, TiO_2, P_2O_5 and LOI. Five (5) samples were sent to the Department of Geological Sciences Laboratory of the University of Cape Town, South Africa for major oxide geochemical analysis using the x – ray fluorescence (XRF) .Ten (10) of the samples were prepared for various strength tests using the triaxial testing machine.

4. RESULT AND DISCUSSION

The carbonate rocks of Igarra are composed of metamorphosed calcareous rock mainly marble and calc – gneiss. Marble is a major component of the carbonate. It is a recrystalised limestone and consists of chemically precipitated calcite ($CaCO_3$) and little dolomite CaMg $(CO_3)_2$. Calc-gneiss occurs in association with marble in places especially around the Geoworks quarry sites. Touret (1977) suggests that it is the product of a reaction between calcite derived from marly sediments or original limestone and quartz from detrital grains during metamorphism the geochemical composition of the carbonate as obtained from ICP – MS analytical method is presented in Table 1. Geochemical data show that the Igarra marble is characterised by low SiO_2, AL_2O_3 and MgO and relatively high values of CaO and LOI. Low MgO in marble translates to low dolomite content (CaMg $(CO_3)_2$ (2.30-11.14%) and results in high calcite mineral content (85.45 – 94.68%). Sam, B. (1995) states that marble with less than 4% of $MgCO_3$ is a low magnesium calcite while those with greater than 40% of $MgCO_3$ are dolomitic (Brown, 2007). Based on this, the calcitic marble from Igarra which is less than 40% of $MgCO_3$ can be used in many industries. Fig 3 shows that dolomite contents in Igarra marble is less than that of Ikpeshi marble (Obasi and Isife, 2012) . Ikpeshi town produces enough pink dolomite for paint industries and for the production of the antacid (Philip milk of magnesia) used for the cure of stomach ache. The silica, SiO_2 contents in the calc-gneiss (6.34% - 39.12%) is higher than that in the marble but it cannot be used for cement making. However, the silica in the calc gneiss makes it siliceous but this reduces towards the marble deposit. The high proportion of silica affects its purity and renders it less attractive to cement or paint manufacturers. The calc-gneiss is economically useful in the production of animal feeds and asbestos in the long run. The CaO content varies from 23.65% to 48% increasing towards the marble deposit. The LOI of the calc-gneiss ranges between 16.87% and 42.03%.

5. ECONOMIC POTENTIAL AND APPLICATIONS

The industrial, domestic or private applications of marble are based either on its physical or chemical properties or both as well as its purity. The purity of marble is measured by the amount of lime (CaO), silica (SiO_2), iron (Fe_2O_3), alumina (Al_2O_3) and the presence or absence of impurities like manganese oxide (MnO).

The colour of marble and calc-gneiss varies from grey and dark to white when ground. The data in Table 1 indicate that the grey and dark types contain > 4 wt% silica and < 48 wt% lime representing the calc-gneiss and the high purity and white- coloured type contain < 3 wt% of silica and > 50 wt% lime representing marble.

Finely ground white calcitic marble serves as a coating pigment. As paper filler, it imparts high brightness to the sheets, opacity, surface smoothness and ink receptivity to printing. In plastic making, marble filler provides necessary reinforcement for greater impact strength, rigidity, stiffness, high brightness, dimensional stability and thermal conductivity. The grey and dark coloured ground calc – gneiss is mostly employed in asbestos and in animal feed productions. In the case of poultry grits, the calc-gneiss becomes a major source of raw material. It possesses the required chemical characteristics of SiO_2 (6.34%-39.12%), CaO (23.65-48.76%) and LOI (16.87.42.03%) as shown in Table 1

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

5.1 Marble for Tiles and Chips

Marble from Igarra is extensively used for making tiles of assorted types in Lagos – Nigeria. Marble tiles for flooring are commonly used in offices, homes, industries and corporate institutions especially where aesthetic, luxurious and exquisitely unique value is appreciated. Tiles made from marble are either glazed (polished) or unglazed. The polished types provide glistering appearance and are highly priced while unpolised types lack exquisite finishing and are relatively low cost. Their tensile and compressive strengths are high, an indication of their absolute resilience and durability properties (Table 2)

5.2 Use of Marble for Paint

In paint making, certain physical and chemical specifications must be met. Essential physical requirements include good white colours, small sized particles (98% passing through 325 mesh) and absence of hard particles. Standard chemical specifications provide that AL_2O_3 > 2 wt%, MgO + SiO_2 > 75 w% and LOI must be within the range of 4 -8wt% (Robert 1979). The marble from Igarra satisfies the physical specifications but show contrast in their chemical requirements. The data in Table 3 indicate that AL_2O_3 < 1 wt% (0.67), MgO+SiO_2 < 15 wt% and LOI > 32 wt%. The chemical difference in MgO + SiO_2 and LOI over the required specification implies that when used for paint manufacturing , the product will not only be susceptible to quick fading on the wall but also lead to low quantity due to increased water content. The marble is therefore not adequately suitable for paint making. However, paint manufacturers always beat their market by individually setting their standards so long as their brands of paint satisfy their quality, their customers and inconformity with their production formulations and so long as their advertorial jingles impress the prospective buyers of their products.

5.3 Marble for Cement Manufacturing

The basic raw materials for Portland cement (PC) making are lime (CaO), silica (SiO_2), alumina (AL_2O_3, magnesia (MgO) and trisulphide (SO_3) derivable chemically from either marble or limestone. The chemical components and standard proportions required for cement production have been highlighted by Obasi and Isife, 2012. The data show that the values of lime (53 wt%), silica (4.83 wt%) alumina (0.67 wt%), are below the required standard of 63 wt% for lime, 22 wt% for silica, 6.0wt% for alumina and a range of 66-102 of LSF respectively for cement production (Rajput,2008).

Deficiency in the lime decreases the strength of the cement and gives a quick setting of the cement. Excess of it makes the cement unsound and causes it to expand and disintegrate. A right proportion of lime makes the cement sound and strong. SiO_2 in excess of 22 wt% provides greater strength to the cement but prolongs its setting time. SiO_2 imparts strength to the cement due to formation of dicalcium (2caO.SiO_2 and tricalcium (3.caO.SiO_2) silicate.

Cement production requires lateritic iron oxide in amounts generally acceptable. The marble at Igarra lacks these essential ingredients needed for cement making. The lime saturation factor (LSF) must not be greater than 102% or less than 66 wt% (66-102 wt %) range in the production of cement. The LSF for the Igarra marble 361.36%. This vlue is higher than the maximum value of 102% and can cause the over burning of CaO (Labahn and Kaminsky 1971 and Rajput, 2008). Based on these analyses, the marble from Igarra becomes unsuitable for cement production.

5.4 More Uses of Igarra Marble

The Igarra marble is also used for outdoor sculpture and for sculpture bases. In the areas of architecture it is used in exterior walls and veneers, staircases and walkways. Marble is susceptible to weathering and may require some treatment to avoid deterioration when eternally exposed. It can be applied in the making of electrical insulators, china wares, and in decorative construction. Marble is equally used in such areas like kitchens, butchers tables and tombs where the strength of the materials is properly assured. In the recent time, marble chips are used in lawns and gardens.

6. CONCLUSION

Geochemical data of marble from Igarra indicate that the calcite content ranges between 85.45wt% and 94.08wt% while the dolomite varies from 2.30 – 11.14wt%, an indication that the marble is calcitic with low dolomite content. An appraisal of the economic potential shows that the marble can serve as sources of industrial raw materials for a variety of consumer products such as tooth paste, plastics, paper, white wares terrazzo and marble chips. However, chemical data show that the marble is unsuitable for Portland cement production due to low values of CaO and SiO_2 and high values of LOI . The marble is also unsuitable for paint production due to deficiencies in its chemical properties.

The calc-gneiss serve as raw materials for the production of poultry grits, animal feeds as well as asbestos for civil work.

REFERENCES

[1] Ajibade, A C. Rahaman, M A and Woakes, M. 1987. Proterozoic Proterozoic Lithospheric evolution (Kroner Ed) American Geophysical Union, 17, p. 259-271

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

[2] Attewell, P,B. and Farmer, I, W. 1976. Principles of Engineering Geology, Chapman and Hall, London, 104 p

[3] Brown, T. 2007. Setting the standard in the natural stone industry. Marble Institute of America. 278 p.

[4] Ekwueme. B.N. 1990. Petrology of Southern Obodu Plateau Bamenda Massif, Southeastern Nigeria. In Rocci G and Deschamps, M (Eds). Recent data in African Earth Sciences CIFEG occasional Publication. 22. p.155-158

[5] Ekwueme B N. 2000. Zircon evaporation ages from Obudu Platea first evidence of Archean components in the schist of Southeastern, Nigeria. Book of Abstracts 37th Nigerian Mining and Geosciences Conferences, Jos.

[6] Ekwere S J and Ekwueme, B .N. 1991. Geochemistry of Precambrian Gneiss in the eastern part of the Oban massif, Southern Nigeria. Geo Mynbouw, 70, p. 105-114.

[7] Imeokparia, E G. and Emofurieta, W, O.1991.Protoliths and Petrogenesis of Precambrian gneisses fron the Igbeti area, S W Nigeria. Geochemical Journal. Erde 51 p .337-347.

[8] Labahn, O and Kaminsky, W .A. 1971. Cement Engineer Handbook. Bauverlag GMBH, Wiesbaden, Berlin. 620p.

[9] Ocan, C.O. Coker, S. L. and Egbuniwe, I. G. 2003. The Geology of Igarra-Auchi area, Excursion guide at the annual conference of the Nigerian Mining and Geosciences Society (NMGS), Itakpe, 2003 52p

[10] Odeyemi, I. B.1988. Lithostratigraphic and structural relationships of the upper Precambrian metasediments in Igarra area, Western Nigeria. In Ogezi in the Pre-cambrian Geology of Nigeria. Geological survey of Kaduna, p.111-123.

[11] Ofulume, A.B .1993. An assessment of the suitability of the Jakura marble for use as flux in steel making. Journal of Mining and geology, 29, (1) p.1-9.

[12] Okeke, P. O, Akinnagbe, T. and Anike, L. O. 1988. Major and minor element evaluation of the Igarra granite. Journal of mining and geology, 24 (1) p.101-106.

[13] Okeke, P. O. and Meju, M.A. 1985. Chemical evidence for the sedimentary origin supracrustal rocks, Southwest, Nigeria. Journal of mining and geology, 22 (1&2) p. 97-104

[14] Rahaman, M. A.1992. Precambrian geology of Nigeria. Proceedings of high grade terrains Benin-Nigeria traverse, programme and lecture series. P. 150-200.

[15] Rajput, R. K.2008. Engineering materials S.Chand 3rd edition, New Delhi. P. 89-94.

[16] Robert, S. B 1979. Chemistry and technology of lime and limestone. A W iley-Inters cience Publication. 2nd Edition, p. 95-158

[17] Sam, B 1995. Principles of Sedimentology and Stratigraphy. Prentic Hall, A Simon and Schuster Company, Upper Saddle River, New Jersey. P. 195-196.

[18] Touret, J. 1997. The significance of fluid inclusions in metamorphic rock In: D. G Fraser (ed) Thermodynamics in geology, Reided, Dordrecht, p.27-203.