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Assessment of Industrial Potentials of Marble Deposits in Ugya, North Central Nigeria Based on Mineralogical and Chemical Studies

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ABSTRACT

This study was conducted to ascertain potential industrial uses for Ugya marble deposits in Nasarawa state, North Central Nigeria. This requires mineralogical and geochemical characterisation of the deposits, which contain white and gray varieties. The characterisation was achieved by combining geological mapping with X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) spectrometry analyses of the marble samples. Field geological mapping reveals schist, white and gray marble varieties, quartzite and granite as the rock units in the area. The white variety contains 53.75 wt% CaO, 0.80wt% MgO, 1.03 wt% SiO_2, 0.17 wt% Na_2O, 0.35 wt% K_2O, 0.47 wt% Al_2O_3, 0.14 wt% Fe_2O_3, 0.31 wt% P_2O_5, 0.21 wt% SO_3 and 42.92 wt% Loss on Ignition (L.O.I). The gray marble contains 42.92 wt% CaO, 7.80 wt% MgO, 4.58 wt% SiO_2, 0.31 wt% Na_2O, 0.15 wt% K_2O, 0.80 wt% Al_2O_3, 0.86 wt% Fe_2O_3, 0.03wt% P_2O_5, 0.04wt% SO_3, and 42.44wt% Loss on Ignition (L.O.I). Mineralogical composition of the white and gray marble shows calcite content of 97.47 wt% and 73.27 wt% respectively, while the dolomite content is 1.73 wt% and 17.63 wt.% respectively. Subsidiary mineral content in both marble varieties are quartz and muscovite. The white marble is suitable for manufacture of Portland cement, sodium carbonate, calcium carbide, bleaching powder, ammonium nitrate fertilizer and sugar. It is also used as flux in smelting of metalliferous ores in metallurgical industry, neutralization of sewage, water softening and as filtering gravel in water treatment plant. Both white and gray marble have potential to be used to enhance soil nutrient status, as soil acid ameliorant and source of calcium in livestock and poultry feeds. Both the white and grey marble need to be beneficiated to be applicable in pharmaceutical, paper, paint, rubber and glass industries.

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1. INTRODUCTION

Marble deposits presently rank among strategic economic mineral deposits [1, 2]. This is because marble is a major raw material in cement, metallurgical, chemical, agricultural, construction and environmental industries [3, 4]. The specific, potential industrial uses of the deposits hinge partly on their mineralogical and chemical attributes [5]. Marble deposits with the right combination of mineralogical and geochemical attributes can be utilised to increase production of poultry feeds and carbonate-based fertilizers. This will impact positively on food production, and thereby restrain looming global food crisis. Additionally, suitable marble deposits can also be used to increase production of Portland cement clinker to curb mounting housing cost and global homelessness. The mineralogical and geochemical requirements for specific industrial marble usage have been given in different geosciences research works [5, 6, 7, 8, 9, 10, and 11].

Mineralogical and geochemical characterisation earlier conducted for some marble deposits combined surface geological mapping with X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) spectrometry to determine their mineralogical, major oxide and trace element content [12, 13, 14, and 15]. Nevertheless, there are still other marble deposits with un-established geochemical and mineralogical attributes scattered around the world. These include Obugu, Soka and Ugya marble deposits located within the Muro Schist Belt (also known as Toto-Gadabuke Schist Belt) in the North-Central Nigeria's Basement Complex. The surface area of the Muro Schist Belt is estimated to be 208.50 km^2 [16]. Chemical studies of major oxides on eight (8) marble samples from the Muro Schist Belt were carried out by [17]. This gives a sampling density of 1 sample per 26 km^2, which is inadequate to give a representative geochemical attribute for the marbles of the schist belt. Besides, mineralogical attributes were excluded in the investigation. The data outcome is inadequate for determining the specific potential uses of Ugya marble deposits. This study was conducted to ascertain the specific potential industrial uses of the Panda marble deposits by deploying geosciences procedure comprising surface geological mapping, determination of mineralogical content using XRD technique and determination of major oxides content using XRF spectrometry.

2. STUDY AREA

Ugya marble deposits are within latitudes N8°10' 00'' to N8°14' 00'' and longitudes E7°11' 00'' to E7°15' 00'', inside the Muro Schist Belt (Figure 1). It is part of the Nigerian Katakawa Topographic Sheet 228SW. This location is within the geological setting of the Northern Nigerian Basement Complex.

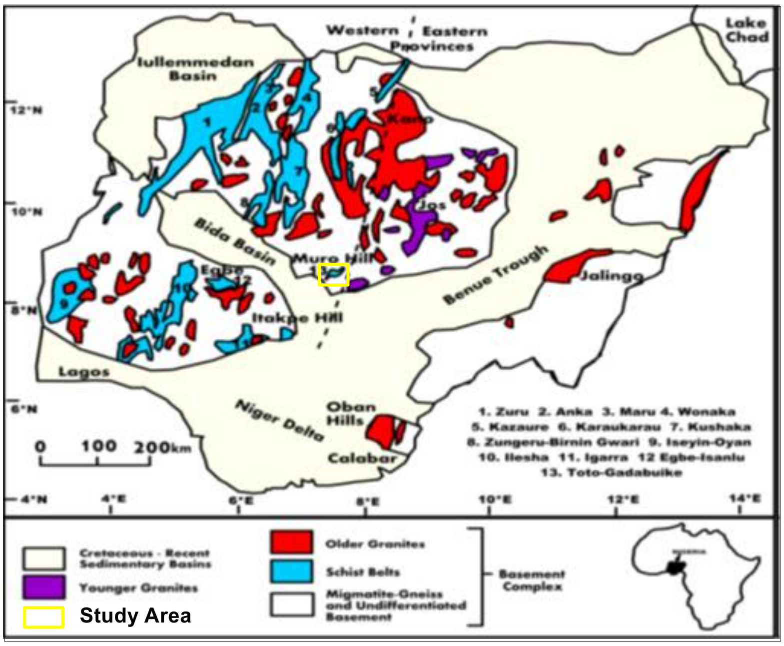

Figure 1: Simplified geological map of Nigeria, showing Muro Schist (Toto-Gadabuke) Belt [18].

3. MATERIALS AND METHODS

Surface geological mapping was conducted by locating rock outcrops. Each outcrop was observed and described base on its mode of occurrence and macroscopic characteristics such as colour, structures, textures, and mineralogy in hand specimen. Marbles were identified from the presence of calcite and effervescence with dilute mineral acids. Geographic coordinates of rock outcrop locations were taken using Geographic Positioning System (GPS). Strike, dip direction and dip values of rocks were measured using compass clinometer. Thirty-two (32) representative samples of white and grey marble were collected from marble quarry pits and outcrops using sledge hammer (Figure 2). A geological map was then produced using ArcGIS software. Fourteen (14) representative samples comprising of eight (8) white marble and six (6) grey marble were selected and analysed for mineral compositions and major oxides compositions using XRD and XRF techniques respectively. Both the XRD and XRF analyses were conducted at the geochemical laboratory of the Federal University of Technology in Akure, Nigeria. The appropriate, specific potential uses of the marble deposits were inferred by comparing the XRD and XRF results with marble industrial usage requirements prescribed in geoscience literatures.

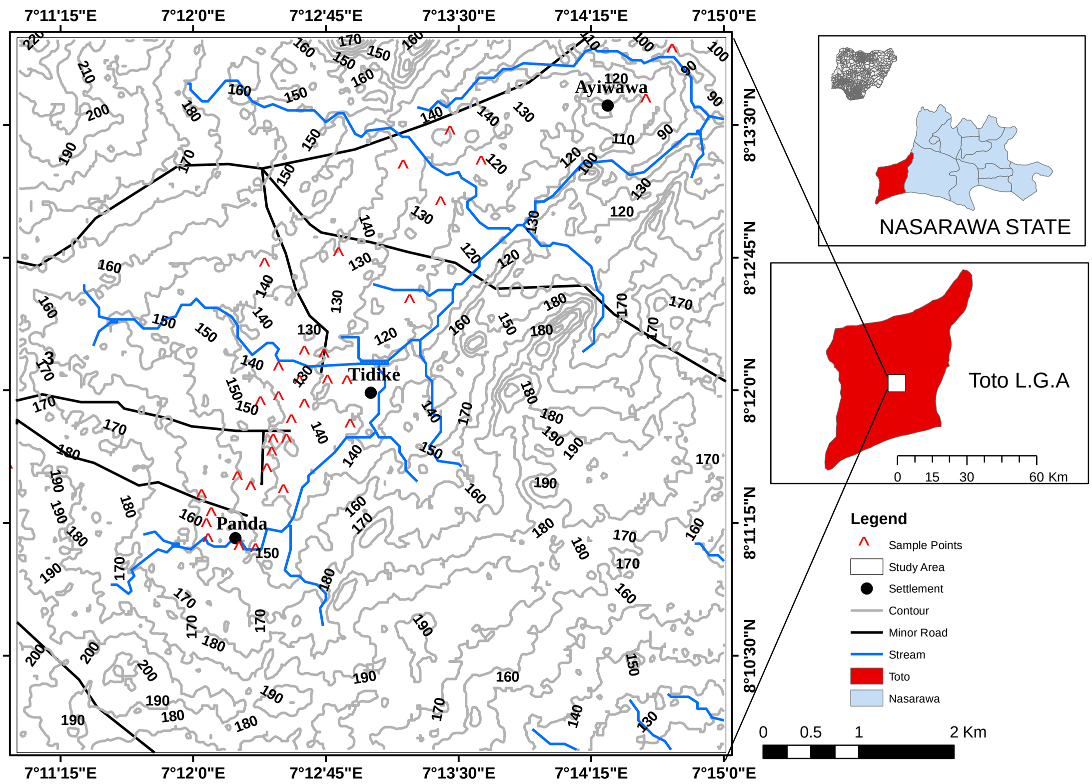

Figure 2: Marble sample location points

4. RESULTS AND DISCUSSION

4.1. Surface Geological Aspect

The rocky outcrops within Ugya and environs are schist, marble, quartzite and granite. The schist strikes NE-SW, and dip generally 48° NW. Quartz, muscovite, feldspar, and biotite have been observed in hand specimens of schist. Marbles are found in the area as low-lying rock units that trend NE-SW and cover the centre half of the area with an average dip of 50° in the NW direction. The marble in the area is both are white and grey varieties both of which also occur as bands (Figure 3) and have fine to medium grained textures. The colour of the grey marble ranges from light to dark grey and has sharp bands ranging from a few millimetres to 10 cm in thickness. The granite is pinkish and medium to coarse grained. Minerals seen in its hand specimen are quartz, biotite and alkali feldspar. The spatial relationship of the rock bodies is illustrated in the produced geological map (Figure 4).

Figure 3: Marble outcrops (A) white marble (B) light grey marble (C) band of white and grey marble (D) dark grey marble

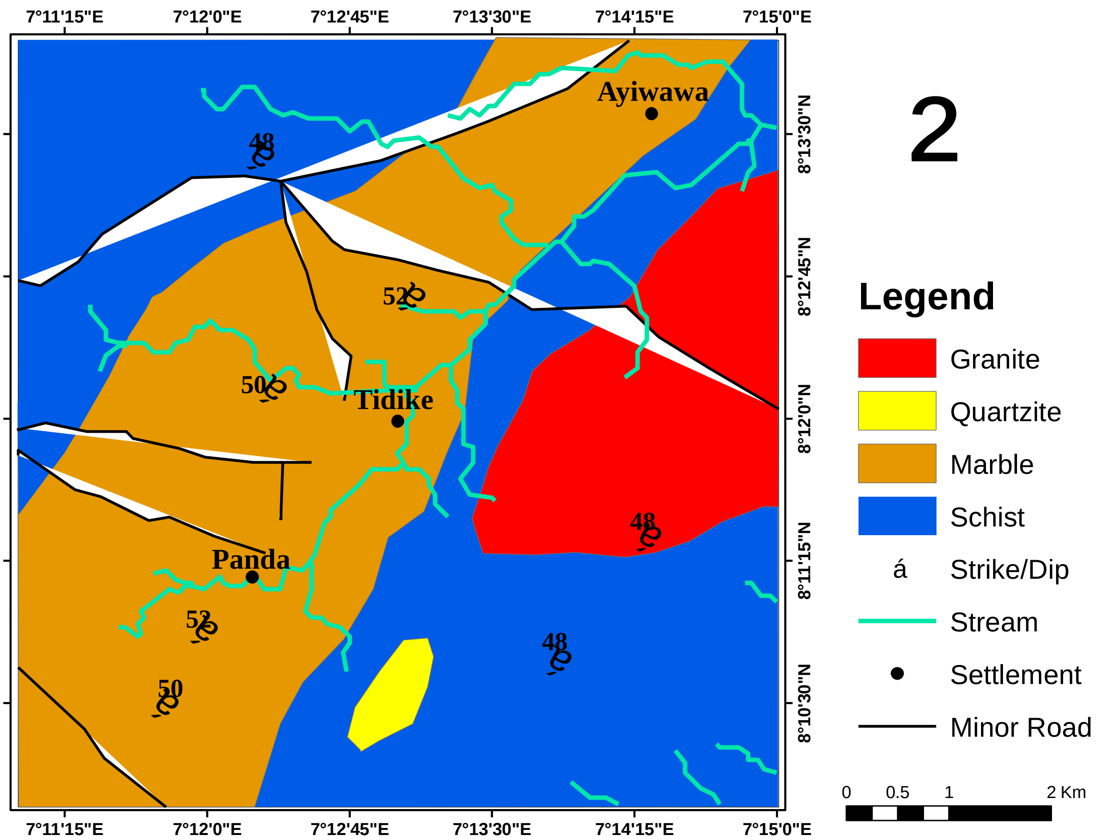

Figure 4: Geological map of the study area

4.2.
Mineralogical Aspect

The XRD diffractogram for samples W1 and G9 from the white and grey marble outcrops are Figures 5 and 6 respectively. The relative abundance of their mineral content from the diffractogram in weight per cent (wt%) is given in Table 1.

Calcite dominates the white marble, with value ranging from 96.40 – 98.90 wt%. Its dolomite content ranges from 0.90 – 2.20 wt%. Quartz content ranges from 0.3 – 1.1 wt%. The muscovite content ranges from 0.00 – 0.30 wt%.

Calcite also dominates the gray marble, with value ranging from 70.80 – 75.60 wt%, and a mean value of 73.27 wt%. Its dolomite content ranges from 15.10 – 20.20 wt%, and has a mean value of 17.63 wt%. Quartz content ranges from 5.20 – 7.40 wt% (with 6.30 wt% mean value). The muscovite content ranges from 0.10 – 4.20 wt%, and has a mean value of 2.80wt%.

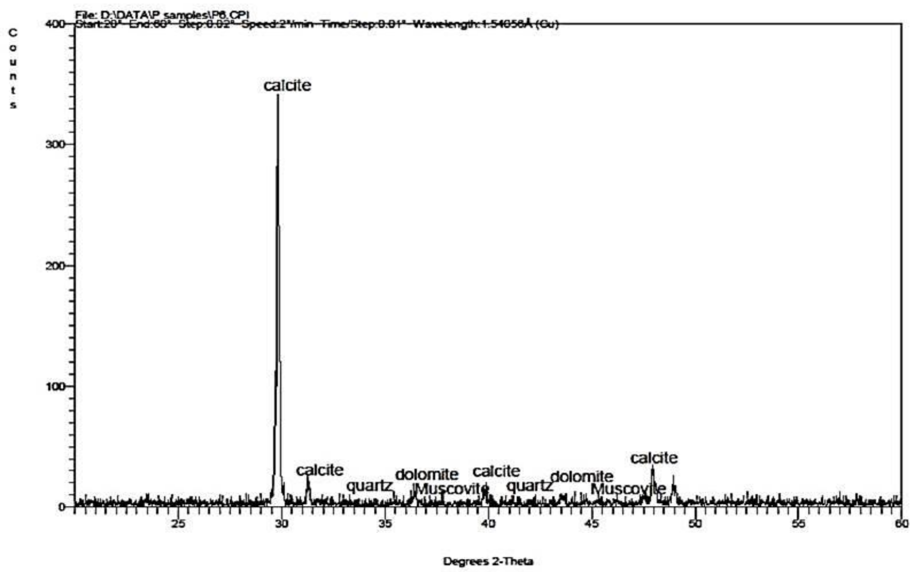

Figure 5. XRD pattern for sample W1 (white marble)

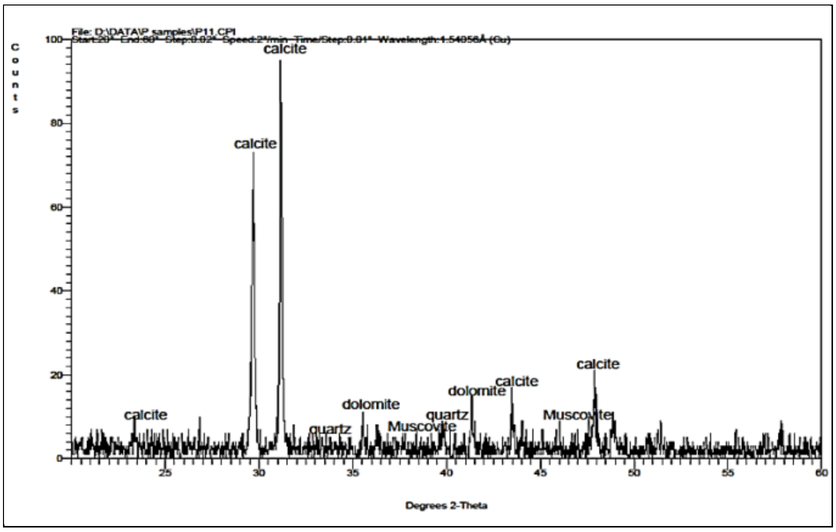

Figure 6. XRD pattern for sample G9 (grey marble)

Table 1. Mineral content in samples of white and grey marble (wt%)

Marble varieties	Minerals wt %	Calcite	Dolomite	Quartz	Muscovite
White Marble	W1	98.90	0.90	0.30	0.00
	W2	97.10	2.20	1.10	0.02
	W3	96.40	2.10	0.50	0.30
	W4	95.40	3.40	0.82	0.20
	W5	96.50	2.82	1.15	0.10
	W6	94.80	1.91	0.51	0.15
	W7	93.40	1.72	0.74	0.25
	W8	95.40	2.80	0.85	0.10
	Mean	95.85	3.26	0.75	0.14
Gray Marble	G9	75.60	15.10	5.20	4.10
	G10	70.80	17.60	7.40	4.20
	G11	73.40	20.20	6.30	0.10
	G12	82.10	12.10	5.10	0.80
	G13	83.00	10.30	4.30	2.50
	G14	78.90	12.50	3.80	3.50
	Mean	77.50	14.63	5.35	2.53

4.3.
Chemical Aspect

The major oxides data of the white and grey marble is given in Table 2. White marble samples have a higher CaO content than grey marble samples. The CaO content of the two marbles ranges from 50.97 wt% to 55.1 wt% in the white marble, with a mean of 53.17 wt%, and 39.5 wt% to 44.50 wt% in the grey marble, with a mean of 42.92 wt%.

The grey marble has a higher content of MgO with concentrations ranging from 5.87wt% to 11.09wt% and a mean value of 7.80wt%. MgO contents in the white marble ranges from 0.31wt% to 1.04wt% with mean value of 0.80wt%.

All other oxides except SiO_2 with average concentration of 1.02 wt% and 4.58 wt% in white and grey marble respectively have concentration less than 1.0 wt%. The white marble and the grey marble have $CaCO_3$ of 95.68 wt% and 75.81 wt% respectively, and $MgCO_3$ of 1.68 wt% and 18.40 wt% respectively.

The chemical composition of the marble is compared to that of other carbonate rock deposits (Table 3). White marbles have similar CaO, MgO, and SiO_2 compositions to Ekinirin-Adde marble [19], Obajana marble [20], Akure marble, Ososo marble [21] and Jakura marble [22]. All of these deposits were classified as pure calcitic marble, so the white marble is as well.

Grey marble contains more CaO and less MgO than Alaguntan marble [23], Burum-Takalafia-FCT [5], Igbeti marble [21] and Ikom marble [24]. These deposits are known as dolomitic marble. Compared to these dolomitic deposits, the grey marble has a slightly higher SiO_2 content.

Figure 7 displays a triangular diagram that classifies carbonate rocks based on the weight per cent of $CaCO_3$, $MgCO_3$, and SiO_2. The white marble is classified under the pure calcite marble field, while the grey marble is classified under the pure calcite dolomite and dolomite marble fields.

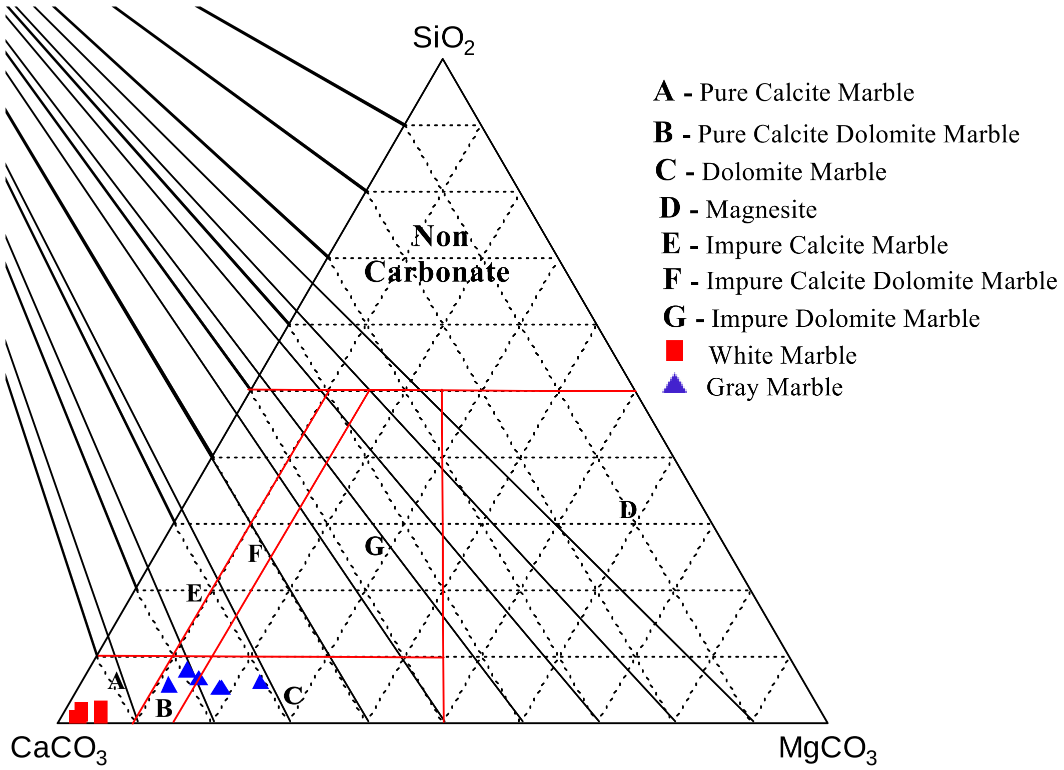

Figure 7: Classification of Ugya Marbles [After 25]

Table 2: Values in wt% of major oxides in white marble

Oxides	W1	W2	W3	W4	W5	W6	W7	W8	Mean
SiO_2	0.30	1.12	0.50	1.12	1.05	1.04	1.06	1.41	1.02
TiO_2	0.009	0.01	0.02	0.06	0.03	0.02	0.03	0.04	0.03
Al_2O_3	0.10	0.13	0.13	0.72	0.52	0.43	0.60	0.11	0.34
Fe_2O_3	0.08	0.04	0.09	0.19	0.16	0.14	0.18	0.21	0.14
MgO	0.41	0.50	0.68	1.04	0.95	0.85	1.01	1.04	0.81
MnO	0.03	0.03	0.04	0.06	0.05	0.04	0.05	0.07	0.05
CaO	55.58	55.30	54.40	52.21	53.66	54.20	53.45	51.30	53.75
Na_2O	0.05	0.07	0.11	0.31	0.16	0.13	0.22	0.31	0.17
K_2O	0.01	0.17	0.21	0.79	0.23	0.21	0.35	0.71	0.35
P_2O_5	0.06	0.07	0.09	0.61	0.03	0.62	0.50	0.74	0.31
SO_3	0.12	0.10	0.09	0.21	0.36	0.19	0.23	0.21	0.20
L.O.I	43.11	41.72	43.47	43.48	42.52	43.09	42.31	43.75	42.87
$CaCO_3$	98.93	98.43	96.83	92.74	95.51	96.48	95.14	91.31	95.68
$MgCO_3$	0.86	1.05	1.42	2.17	1.99	1.78	2.11	2.17	1.69

Table 3: Values in wt%of major oxides in grey marble

Oxıdes	G9	G10	G11	G12	G13	G14	Mean
SiO_2	5.20	7.40	6.30	5.95	5.18	5.15	4.8
TiO_2	0.04	0.05	0.05	0.08	0.06	0.07	0.06
Al_2O3	0.26	0.40	0.48	1.64	0.95	1.06	0.80
Fe_2O_3	0.04	0.06	0.63	1.23	0.40	1.15	0.74
MnO	0.08	0.08	0.08	0.11	0.09	0.01	0.08
MgO	5.20	5.87	6.89	11.09	8.87	8.90	7.80
CaO	43.50	42.27	42.27	39.50	43.26	42.72	42.92
Na_2O	0.15	0.04	0.34	0.13	0.36	0.76	0.46
K_2O	0.02	0.06	0.12	0.28	0.19	0.22	0.35
P_2O_5	0.03	0.01	0.02	0.06	0.02	0.04	0.03
SO_3	0.04	0.10	0.09	0.02	0.01	0.04	0.04
L.O.I	45.07	42.89	42.64	41.33	39.81	39.67	42.32
$CaCO_3$	77.43	75.24	75.24	70.31	77.00	76.04	76.40
$MgCO_3$	10.87	12.27	14.40	23.18	18.54	18.60	16.31

Table 4: The average composition of major element oxides (in wt%) in the Ugya marble deposit in comparison to other marble deposits in Nigeria

Oxides	A	B	C	D	E	F	G	H	I	J	K
SiO_2	1.02	4.58	2.81	3.80	0.49	2.31	3.60	1.90	0.44	0.50	1.18
TiO_2	0.03	0.06	-	-	-	0.01	-	0.03	-	0.00	-
Al_2O_3	0.34	0.80	0.07	0.61	0.03	0.22	1.02	0.24	0.07	0.07	0.10
Fe_2O_3	0.14	0.74	0.15	0.73	0.07	0.08	0.57	0.11	0.04	0.04	0.07
MnO	0.05	0.08	0.03	0.01	0.002	0.01	-	0.02	0.002	0.00	0.003
MgO	0.80	7.80	23.20	20.72	20.70	16.70	1.56	1.10	0.32	0.42	1.75
CaO	53.75	42.92	32.16	31.03	28.94	35.79	51.08	53.31	55.33	54.92	53.64
Na_2O	0.17	0.46	0.03	0.05	0.01	0.01	0.19	0.12	0.03	0.02	0.02
K_2O	0.35	0.15	0.02	0.12	0.03	0.07	0.15	0.07	0.001	0.03	0.01
P_2O_5	0.31	0.03	-	0.02	-	0.07	-	0.06	-	0.00	-
SO_3	0.20	0.04	-	-	-	-	-	-	-	-	-
LOI	42.87	42.32	41.15	42.40	-	44.41	41.66	42.18	-	43.37	-

A. Ugya white marble (Present work)
B. Ugya grey marble (Present work)
C. Alagunta marble [23]
D. Burum-Takalafia F.C.T. marble [5]
E. Igbeti marble [21]
F. Ikom marble [24]
G .Ekinirin-Adde marble [19]
H. Obajana marble [20]
H. Akure marble [21]
I. Jakura marble [22]
K. Ososo marble [21]

5. POTENTIAL INDUSTRIAL USES OF UGYA MARBLE DEPOSITS

5.1. Manufacture of Portland Cement

Lime (CaO) is one of the ingredients in manufactures of Portland cement. The main source of lime is calcareous materials, like limestone or marble. The main ingredients needed to make Portland cement are calcium carbonate contents higher than 82 wt%, magnesium content less than 3.0 wt%, and total alkalis (potassium oxide, K_2O, and sodium oxide, Na_2O) less than 0.6 wt% [9]. CaO > 43 wt% and a silica content of less than 5.0 wt% are limited by other specifications [26].

With average calcium carbonate of 95.68 wt%, MgO (0.80 wt%), CaO (53.75 wt%), silica (1.03 wt%), and total alkali (0.52 wt%), the Ugya white marble is a pure calcite marble and satisfies the requirements to produce high-quality cement clinker. Due to its high MgO content (7.8 wt%) above the specification standard and low CaO (42.92 wt%) and calcium carbonate (75.81 wt%) below the specification standard, grey marble is not suitable for use in the manufacture of cement.

5.2. Chemical Industry

Lime products from marble are extensively used in chemical industries to manufacture sodium carbonate, calcium carbide, bleaching powder and insecticide dust. A marble must meet the following basic chemical requirements in order to be used in the production of sodium carbonate: its total carbonate ($CaCO_3$ + $MgCO_3$) content must be greater than 94.6 wt%, CaO >53 wt%, SiO_2<3.0wt% and MgO <1.0 wt% [27, 26]. Ugya white marble meets specifications for manufacture of sodium carbonate while the grey variety does not because the mean contents of SiO_2 and MgO are 4.80 wt% and 7.80 wt% greater than the maximum standards.

Marble used in the production of calcium carbide has a variety of chemical requirements, but all of them state that the material must have a calcium carbonate content of at least 95 wt%, a maximum of 0.5 wt% for both alumina and ferric oxide combined, less than 1.2 wt% for silica, and less than 0.8 wt% for magnesia [10, 27, 26, 28 and 3]. Based on the specification above, Ugya white marble can be used as raw material for the manufacture of calcium carbide. The grey marbles are unsuitable because the calcium carbonate in grey marble is 76.40 wt% less than the minimum standard, average concentration of combined alumina and ferric oxides (0.61 wt%), silica (4.8 wt%) and magnesia (7.80 wt%) are above specification standard.

Marble with minimum of 96 wt% $CaCO_3$ and 54 wt% CaO, less than 0.75 wt% SiO_2, 0.5 wt% Fe_2O_3 and 2.0 wt% MgO is suitable for the manufacture of bleaching powder [27, 26]. The grey marble does not meet these requirements and hence unsuitable as a raw material for bleaching powder. All the chemical components of the white marble except SiO_2 match the specification standards. This has no much effect on the manufacturing if beneficiated.

Powdered marble has been found to be satisfactory for the formation of insecticide dust. It also found useful in pesticide production where arsenic acid is reacted with milk of lime to form calcium arsenate. Lime content of at least 60.0 wt% is required. Ugya white and grey marbles are not suitable for use in the manufacturing of pesticides and insecticides because they do not meet these requirements.

5.3. Metallurgical Industry

The metallurgical industry makes extensive use of raw marble and its lime products. In blast furnaces and for fluxing steel, however, the most widespread specific application is found [22]. The world's steel flux industry uses 85 per cent of the lime produced globally [29]. In addition, marbles are helpful as fluxes when smelting metalliferous ores. The combination of these substances with ores' impurities, including silica, phosphorous, sulfur, and alumina, results in a fluid slag that can be separated from the metal. This slag takes the form of calcium silicate, phosphate, and sulphate, respectively. The industrial specifications of alumina less than 2.0 wt%, magnesia less than 4.0 wt%, and silica less than 5.0 wt% (preferably 2.0 wt%) with a minimum of 91.0 wt% calcium carbonate are always required. [27, 30, 31 and 32]. Ugya white marble's chemical composition qualifies it for use as a steel flux ingredient in the metallurgical industry, but grey marble's 7.80 wt% magnesia content exceeds recommended limits, making it unsuitable.

5.4. Environmental Uses

There are many environmental uses for raw marble and its lime products, including water treatment and sewage neutralization [26]. Marble, or its calcined products, are used in water softening processes to eliminate temporary bicarbonate hardness and pH correction. Additionally, it is used to remove Si, Mn, Fe, and F from water as well as for coagulation, neutralization of acidic water, and purification. Most bacteria are killed by lime's high pH of greater than 11[33]. The specification standard of lime for water softening and purification include $CaCO_3$> 80 wt%, MgO < 2.0 wt%. White marble meets these specifications while grey marble does not. The grey marble has $CaCO_3$ less than the minimum standard and MgO greater than the maximum requirement.

In water treatment, marble is also utilized as filtering gravel when the following conditions are met: SiO2 < 1.0 wt%, CaO > 53.20 wt% and $CaCO_3$> 95 wt% [10]. The white Ugya marble can be used as filtering gravel in the water treatment process because it satisfies the aforementioned specifications. The lower $CaCO_3$ (75.81 wt%), lower CaO (42.92 wt%), and higher SiO_2 (4.58 wt%) of the grey marble make it unsuitable.

5.5. Agricultural Industry

Marble is used in agricultural industries to enhance soil nutrient status and also serve as soil acid ameliorant. Low grittiness, low acid insoluble content, and high CaO are required. Both white and grey marble of Ugya meet this specification.

Powdered marble is added to livestock feeds to serve as source of calcium. It is used for fish pond liming. Any kind of marble will serve; therefore, composition is largely irrelevant; however, the most crucial factor is that the marble must have a neutralizing value and be in a grounded form [11]. Both the marble varieties in Ugya meet these specifications.

The production of calcium ammonium nitrate fertilizer is a more recent application for marble. $CaCO_3$> 85 wt%, CaO > 47.6 wt% and SiO_2< 5.0 wt% are the specifications for this use [10]. Because the white panda marble contains 95.68 wt% $CaCO_3$, 53.75 wt% CaO, and 1.03 wt% SiO_2, it satisfies the requirements to be used in the production of fertilizer containing ammonium nitrate. Because the grey marble's 75.81 wt%$CaCO_3$ and 42.92 wt% CaO are below the acceptable range, it is not suitable.

5.6. Sugar Industry

Raw juice from sugar beets is agitated with milk of lime, and carbon dioxide is then passed through the juice. Impurities present are carried down by the precipitated calcium carbonate that forms which is then removed by thickening and filtration. The lime and carbon dioxide are made by burning marble at the sugar factory. [34 and 26] stipulated the following specification for marble to be used in sugar production: CaO > 50 wt%, silica < 2.0 wt%, MgO content should be less than 1.0 wt%, Al_2O_3 + Fe_2O_3< 1.5 wt%. The presence of iron must be negligible or absent as iron tends to colour the finished product. High silica and magnesia content is not recommended because the former separates acid gelatinous precipitate which covers the sugar crystals and their growth and filtration, while for the later, magnesium carbonate is soluble in sugar juice. According to the specifications above, the grey marble is not suitable for use in the production of sugar due to its low CaO (42.9 wt%), higher silica (4.58 wt%), and Al_2O_3 + Fe_2O_3 (1.54 wt%) concentrations. On the other hand, the white Ugya marble can be used.

5.7. Glass Industry

Marble in it raw form, or burned to lime is an important constituent used in the manufacture of glass. Marble primarily serves as a flux in the glass-making process, allowing glass raw materials to melt at a comparatively low temperature. The calcium carbonate content of the marble should exceed 96 wt% with silica maximum of 0.3 wt%, alumina and magnesia contents expected to be very low not more than 0.8 wt% and 0.4 wt% respectively, and ferric oxide (Fe_2O_3) not more than 0.05 wt% are generally demanded [21, 30, 31, 34 and 35]. Marble containing up to 0.1 wt% Fe_2O_3 is sometimes used for colour glass. Due to higher than recommended Fe_2O_3 levels and carbonate contents below 96 wt%, neither the white nor the grey Ugya marble deposits are suitable for use in the production of glass.

5.8. Paper, Plastic and Paint Industry

Marble is useful as fillers/extenders in the manufacture of paint, plastic and paper. Specific standard requirements include high CaO > 52 wt%, Al_2O_3< 0.2 wt%, Fe_2O_3< 0.2 wt%. MgO and SiO_2 must be low (< 3 wt%), SO_3< 0.2wt%, and P_2O_5< 0.15 wt% [26]. Based on the specifications provided, it can be concluded that the white and the grey marbles are unsuitable for use as raw materials in the production of plastic, paper, or paint. This is due to the fact that while the CaO (42.92 wt%) of the grey marble is below the standard, the Al_2O_3 (0.47 wt%) and P_2O_5 (0.31 wt%) of the white marble and the Al_2O_3 (0.80 wt%), Fe_2O_3 (0.86 wt%), MgO (7.80 wt%), and SiO_2 (4.58 wt%) of the grey marble are higher than the standard.

5.9. Pharmaceutical Industry

Marble is used in pharmaceutical industry as neutralization and filtration aid in antibiotic manufacture. It is also applicable in the manufacture of antacids and as bulking agent in manufacture of tablets. Specification standards includes $CaCO_3$> 96 wt%, CaO > 54 wt%, SiO_2 < 0.12 wt%, Fe_2O_3< 0.1 wt% and MgO < 0.42 wt% [32]. Both the white and grey marble do not meet these requirements and thus cannot be used in pharmaceutical industry.

6. CONCLUSION

The marble deposit in Ugya has a white variety and a grey variety. The white variety is a high purity calcite marble while the grey variety is a dolomite marble. Based on the mineralogical and chemical data, the white marble has industrial economic potentials in the manufacture of Portland cement, sodium carbonate, calcium carbide, bleaching powder, ammonium nitrate fertilizer and sugar. It is also meeting specifications to be used as flux in smelting of metalliferous ores in metallurgical industry, neutralization of sewage, water softening and as filtering gravel in water treatment. Both white and grey marble have potential to be used to enhance soil nutrient status, as soil acid ameliorant and source of calcium in livestock and poultry feeds. Both the white and gray marble need to be beneficiated to be applicable in pharmaceutical, paper, paint, rubber and glass industries.

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