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# Field geologic occurrence and petrographic characteristics of precambrian marble body in Itobe area, Central Nigeria

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**ABSTRACT**

*Field geologic mapping and petrographic studies involving X–Ray Diffraction (XRD )analysis of the Precambrian marble body in Itobe area, central Nigeria reveals the occurrence of two marble outcrops (described as mass I and mass II). Mass I, which occurs as a minor lensoid body, is light gray, fine grained and outcrops at a road cut about 150m from Alo Village. Mass II, which outcrops on the Ayanka hill about 800m from mass I along a NE–SW axis, is dark gray and medium grained. The Itobe marble body and the host rocks of mica/quartz schist and quartzite trend in the NNE – SSW direction; parallel to the dominant foliation trend of the associated basement rocks. (XRD) analysis of the marble reveals an average mineralogical composition of Dolomite (33.3%), Calcite (64.9%) and Quartz (1.8%) for mass I and Dolomite (1.7%), Calcite (92.5 %) and Quartz (6.3 %) for mass II.*

**Keywords**: Rock, Marble, Precambrian, Mass and Itobe

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## INTRODUCTION

Marble, a major raw material for industries, is a crystalline, non-foliated metamorphic rock formed from limestone or dolostone due to the action of heat and pressure. For practical purposes, pure marble (high calcium marble) is composed primarily of the minerals calcite or aragonite with total $CaCO_3$ content of between 97 – 99%, and pure dolomite is composed of 45.7% $MgCO_3$ and 54.3% $CaCO_3$ or 30.4% lime (CaO) and 21.8% Magnesia (MgO), Boynton, 1980. Marble results from the metamorphism of limestone, a carbonate sedimentary rock formed at the bottom of lakes and seas as silt and organic matter settle from the water body to the bottom.

Marble deposits all over the world are mainly confined to metasedimentary belts. Examples include the Saxon deposit in Germany (Ihenyen, 1992), Atakora units in Benin Republic (Affaton *et al*, 1978), Igbetti, Ososo, Jakura, Burum-Toto marble deposits of Nigeria (Okunlola, 1996).

The Itobe marble body is located about 1km from Itobe town along the Ajaokuta-Anyigba road, Kogi state, central Nigeria. The study area lies between longitudes $6^0 40'$ E and $6^0 48'$E and latitudes $7^0 22'$N and $7^0 30'$ N (Fig.1).

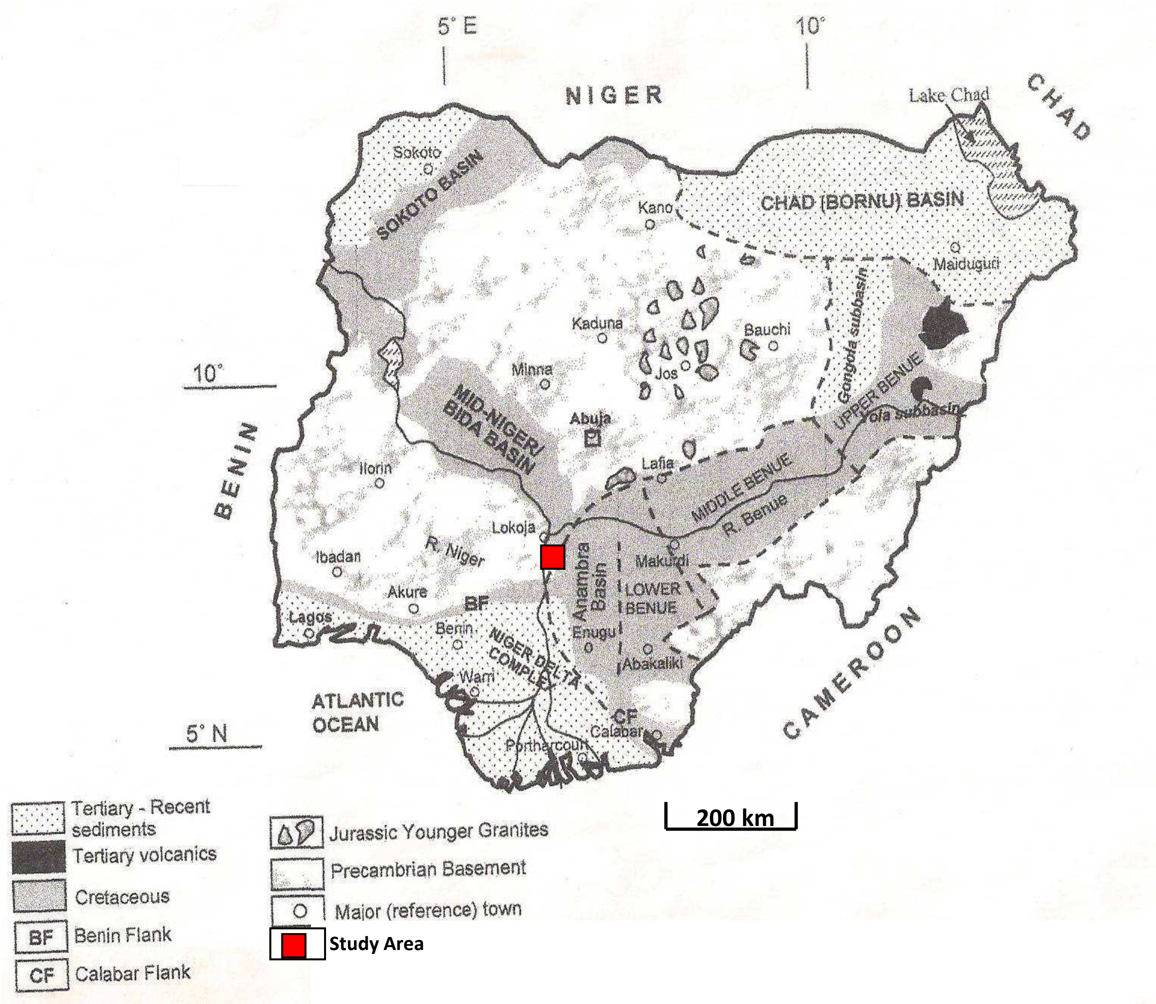



**Fig.1: Geological sketch Map of Nigeria Showing the Location of the Study Area (After Obaje, 2009)**

Very little is known about the geology of the Itobe marble body. Hockey *et al.*, (1986) in the regional study of the geology of the Lokoja – Auchi area described the Itobe marble as a dark grey, fine- medium grained narrow band of marble.

Akoh (2004) based on limited geochemical and mineralogical data described the Itobe marble body as a dolomitic marble.

This study therefore seeks to contribute to the knowledge of the Itobe marble by
i) carrying out a field geological mapping of the Itobe marble area and preparing a geologic map of the area on a much larger scale of 1:25,000 with a view to establishing from it the field occurrence and distribution of the marble body
ii) carrying out a petrographic study to determine the mineralogical composition of the marble body using the X – Ray Diffraction analysis.

## MATERIALS AND METHODS

Geological mapping of the marble body and the associated rocks was done along very closely spaced compass traverses, rivers and bush paths. Mapping was done using a topographic map on a scale of 1:25000 (prepared from the Idah topographic map sheet - sheet 267, on a scale of 1:100,000). Strike and dips of the rocks were measured at regular intervals using the Bruton compass clinometer. Measurements/observations made on rock outcrops were plotted on the topographic map, and the Geologic map was produced by drawing the contacts between the rock types. The ILWIS 3.1 Academic software obtained from the National Remote Sensing Centre, Jos, Nigeria was used to produce the geologic map (Fig. 2).

Fresh representative portions of outcrops of the rock types encountered in the area were obtained using a sledge hammer. A rectangular grid sampling pattern designed to reveal any significant mineralogical variation within the marble body was employed.

A total of seven samples of the marble body were collected for mineralogical analysis- four samples (L 27, L31, L26B and M16) from mass II and three samples (r1, r4 and s3) from mass I. Mineralogical analysis was done using the X-Ray Diffraction (XRD) technique using pressed (non-oriented) powdered mounts. Scanning of the samples was from 2° (2θ) to 65° (2θ). The relative proportions of the minerals present were determined using the American Crystal Structure Database [Down and Hall-Wallace] based on the characteristic d-spacing of the minerals.

Instrumental settings and operational conditions for the XRD analysis are as follows:
Instrument-Philips PW1011 Goniometer
X-Ray Generator – 40KV and 40MA
Radiation/filter – $FeK_{\alpha}$/Mn – filter
Scanning Rate – $2^{o}$ (2θ)/Min
Chart Speed - 1 cm/ min
Divergence slit – $1^{o}$
Receiving slit – 0.2mm/$1^{o}$
Time constant – 4
Attenuation – $2^{1}$
Range – 4 x $10^{2}$ per sec

## RESULTS AND DISCUSSION

### Field Geologic Occurrence

The Itobe marble body is associated with crystalline rocks of the Precambrian basement complex including biotite schist, mica (muscovite & biotite) schist, quartz- muscovite schist, quartzite, biotite- hornblende schist, quartz schist, gneissic granite and minor intrusive rocks including pegmatite, quartz and quartzo-feldspathic veins. The marble body occurs within a host rock of mica/ quartz schist and feldspathic quartzite (Fig. 2). Two outcrops (described as mass I and mass II) of the marble have been identified in the study area. Mass I with a dimension of 1.4m x 0.6m, trends NE - SW with a strike azimuth of $033^{0}$. It is poorly exposed at the road cut about 150m to Alo I village along the Anyigba – Itobe road (Plate1). It is light grey in colour and fine grained in texture. Mass II, which is about 800m from mass I on a NE- SW axis, is a much larger marble body and outcrops on the Ayanka hill as massive boulders. It is medium grained in texture, dark grey in color and rises from an elevation of 132m to 138m on the hill (Plate 2). It has a sharp contact with the quartz schist below and the feldspathic quartzite overlying it.

**Fig. 2 Geologic Map of the Itobe Marble Area**

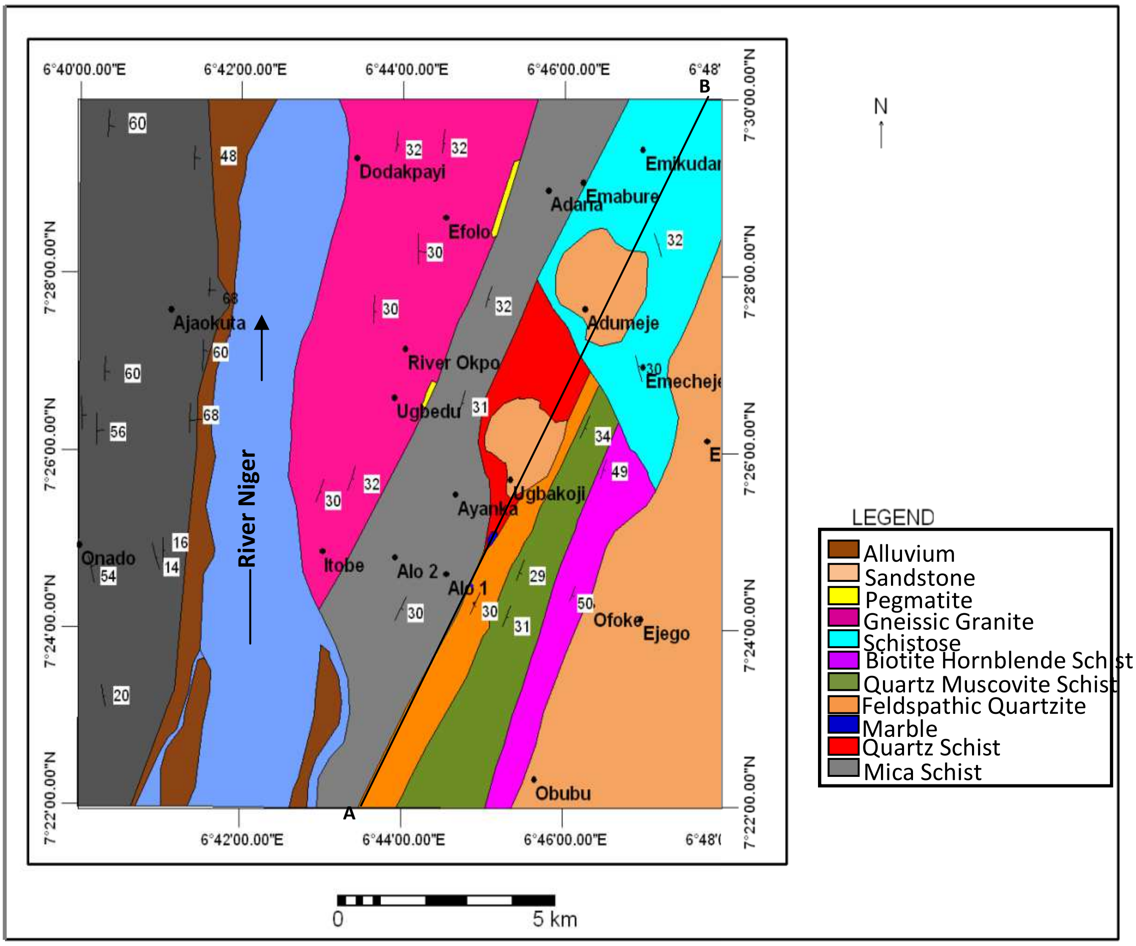



**Plate 1: Marble Outcrop (Mass I) at a Road Cut about 150m to Alo (GPSLocation: N 07°24.627′, E 006° 45.163′)**

**Plate 2: Marble Outcrop (Mass II) on Ayanka Hill (GPS Location N 07°24.714′, E 006°44.848′)**

**Plate 3: Marble Outcrop on Ayanka Hill (Mass II) showing Relict Bedding Structure and Joints (GPS location N07° 25.047′, E006°45.470′)**

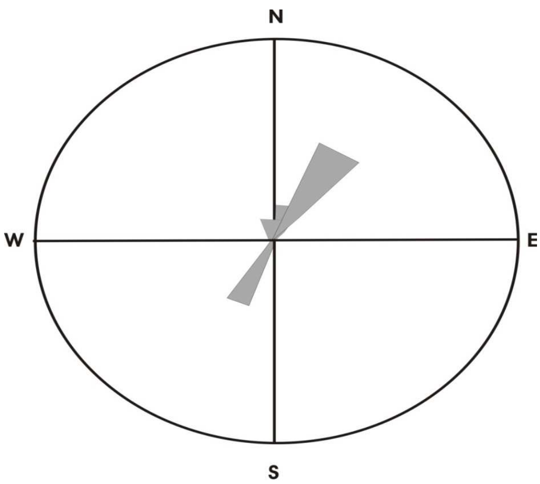



**Fig. 3: Rose Plot of Foliations in Rocks of the Study Area**

## Structures

Field studies of the rocks in the area show that the structural features of the basement rocks are mainly evidence of shearing of the rocks. The structures observed in the rocks are foliation, folds, joints and fractures. No foliation was observed in the marble body, however, Joints trending E - W and relict sedimentary structures (bedding) have been observed on the marble outcrop of mass II (Plate 3). No major fault was observed in the study area, however, faulting is inferred from the extensive shearing of the gneissic granite and feldspathic quartzite east of the River Niger over a distance of about 1km. Shear belts are usually associated with faulting and fault zones [Ajibade *et al.*]

Two foliation trends have been observed in the rocks of the area; a dominant foliation trend in the NNE - SSW/NE - SW direction and a minor foliation trend in the NW- SE direction. A Rose plot of measured strike azimuth of foliations in the rocks of the area showing the trends of foliation in the rocks of the area is shown in fig. 3

The foliation trends in the rocks are inferred to correspond to two major ductile tectonic events that have affected the area during metamorphism [Kogbe]. The minor NW - SE foliation trend has been attributed to an earlier tectonic event regarded as Pre- Pan African [Ekwueme] while the NNE/NE - SSW/SW foliation trend is associated with a later deformation during the Pan African orogeny [Uzuakpunwa and Ekwueme].

## Petrography of the Itobe Marble

Mineralogical composition of marble samples (Sample numbers: L 27, L 31, L 26B, and M16) of mass II estimated from the identified peak intensity of the XRD Scan (Figs. 3 – 7) shows that the dominant mineral in mass II is calcite ($CaCO_3$). It varies from 82.20% to 96.50% with an average value of 92.5%. Dolomite content varies from 0.72% to 2.1 % with an average of 1.70%. Quartz content varies from 2.1% to 17.80% with an average content of 6.30% (Table 1)

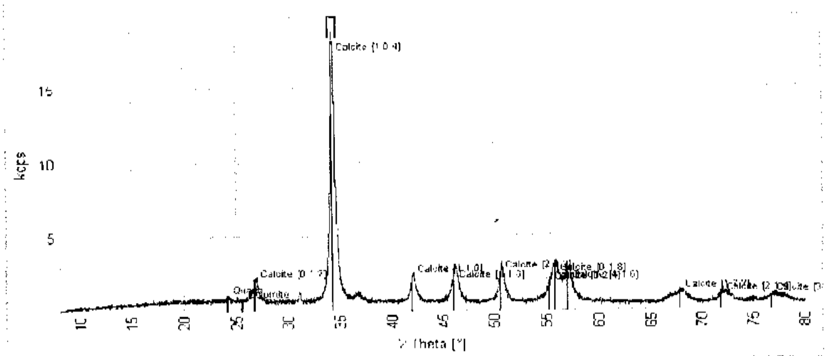
**Table 1: Mineralogical Composition of Marble Samples (Mass II) determined from Identified Peaks of the X-Ray Diffractogram**

| Sample Number | Mineralogical composition (%) | | |
|---|---|---|---|
| | Calcite | Dolomite | Quartz |
| M16 | 82.20% | - | 17.80% |
| L 26B | 57.50/59.1 × 100 = 96.5% | 0.75/59.1×100 = 1.3% | 1.27/59.1 ×100 = 2.2% |
| L 27 | 41.28/42.9 × 100 = 96.2% | 0.72/42.9×100 = 1.7% | 0.9/42.9 × 100 = 2.1% |
| L 31 | 40.29/42.45 ×100 = 95.6% | 0.91 /42.45×100 = 2.1% | 1.25/42.45×100 = 3.0% |
| **Average Composition** | **92.5%** | **1.7%** | **6.3%** |

XRD Scan Report

Thermo SCIENTIFIC

Instrument FLSMIDTH OBAJANA - NG




**File Information**

| File Name | File Date and Time | Scan Parameter Name |
|---|---|---|
| 127.xml | 05/04/2010 11:06:20 | XRD PURE LIMESTONE |

**Scan Parameters**

| Gonio | Detector | kV | mA | PBF/ PBD | Count Time | Inc. | Rotation | Thres. | Wind. | Type |
|---|---|---|---|---|---|---|---|---|---|---|
| XRD 1 | FOD | 40 | 40.00 | XRD Tube | 0.15 | 0.02 | Yes | 40 | 100 | Fast Digital |

**Scan Identification**

| Line | Angle [deg] | Intensity [Kcps] | DSpacing |
|---|---|---|---|
| Calcite | 26.83 | 2,12 | 3.855007 |
| Quartz | 24.27 | 0,90 | 4.255608 |
| Dolomite | 25.66 | 0,72 | 4.028507 |
| Calcite [0 1 2] | 26.83 | 2,12 | 3.855000 |
| Calcite [1 0 4] | 34.27 | 18,17 | 3.035700 |
| Calcite [1 1 0] | 42.02 | 2,39 | 2.495000 |
| Calcite [1 1 3] | 46.10 | 2,79 | 2.284800 |
| Calcite [2 0 2] | 50.56 | 2,53 | 2.094600 |
| Calcite [0 2 4] | 55.30 | 1.82 | 1.927500 |
| Calcite [0 1 8] | 55.77 | 3,15 | 1.912500 |
| Calcite [1 1 6] | 56.97 | 2,70 | 1.875400 |
| Calcite [1 2 2] | 67.78 | 1,19 | 1.604200 |
| Calcite [2 1 4] | 71.81 | 0,96 | 1.525300 |
| Calcite [3 0 0] | 76.77 | 0,91 | 1.440500 |

**Sample Information**

Scan N°1 Position:11

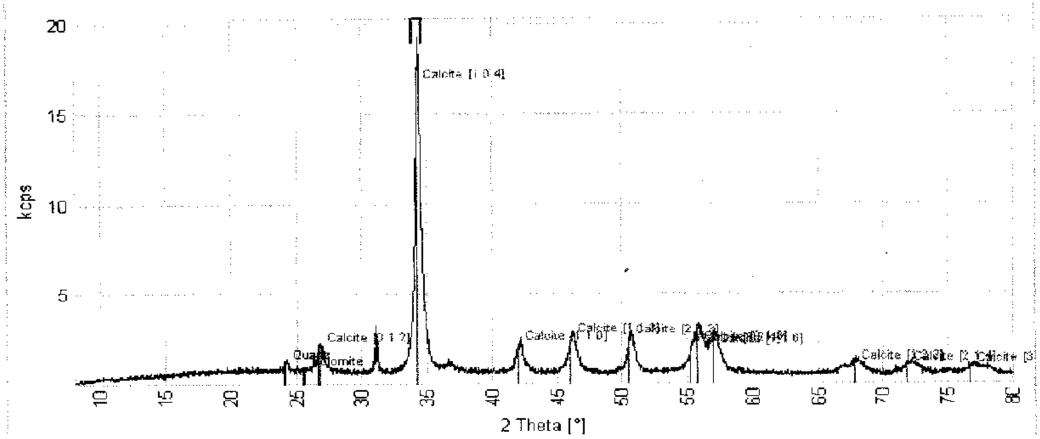
**Date&Time:**05/04/2010 10:57:57 **Software**: OXSAS **Version:**1.1.4.710 **Page** 1 **of** 2

**Fig. 3: XRD of Marble Sample from Mass II of the Itobe Marble (Sample No. L 27) showing the identified peaks**

## XRD Scan Report

Thermo SCIENTIFIC

Instrument: FLSMIDTH OBAJANA - NG




**File Information**

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| L31.xml | 06/04/2010 10:13:37 | XRD PURE LIMESTONE |

**Scan Parameters**

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|---|---|---|---|---|---|---|---|---|---|---|
| XRD 1 | FDD | 40 | 40.00 | XRD Tube | 0.13 | 0.02 | Yes | 40 | 100 | Fast Digital |

**Scan Identification**

| Line | Angle [deg] | Intensity [Kcps] | DSpacing |
|---|---|---|---|
| Calcite | 26.83 | 2,15 | 3.855002 |
| Quartz | 24.27 | 1,25 | 4.255608 |
| Dolomite | 25.66 | 0,91 | 4.028507 |
| Calcite [0 1 2] | 26.83 | 2,15 | 3.855000 |
| Calcite [1 0 4] | 34.27 | 17,63 | 3.035700 |
| Calcite [1 1 0] | 42.02 | 2,20 | 2.495000 |
| Calcite [1 1 3] | 46.10 | 2,64 | 2.284800 |
| Calcite [2 0 2] | 50.56 | 2,59 | 2.094600 |
| Calcite [0 2 4] | 55.30 | 2,08 | 1.927500 |
| Calcite [0 1 8] | 55.77 | 2,96 | 1.912500 |
| Calcite [1 1 6] | 56.97 | 2,88 | 1.875400 |
| Calcite [1 2 2] | 67.78 | 1,09 | 1.604200 |
| Calcite [2 1 4] | 71.81 | 0,99 | 1.525300 |
| Calcite [3 0 0] | 76.77 | 0,93 | 1.440500 |

**Sample Information**

Scan N°1 Position:10

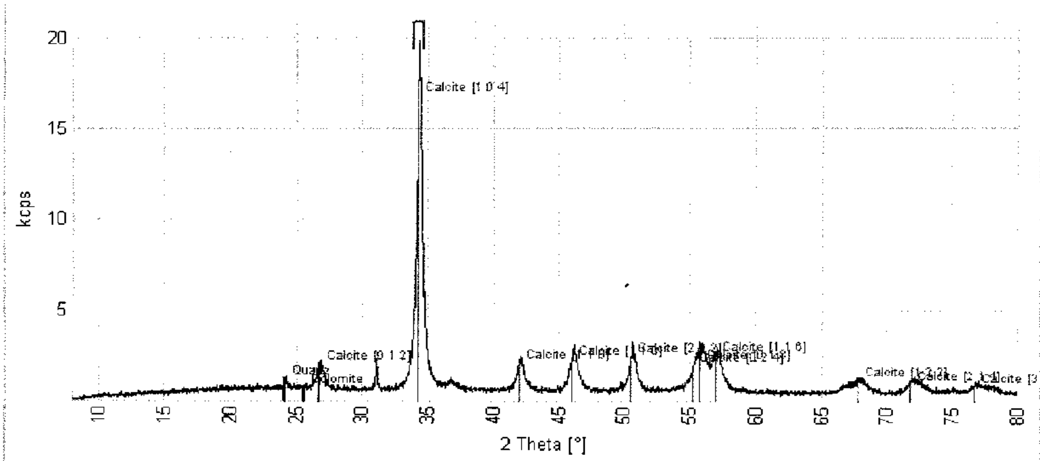
**Date&Time:**06/04/2010 10:05:01 **Software**: OXSAS **Version:**1.1.4.710 **Page 1 of 2**

**Fig. 4: XRD of Marble Sample from Mass II of the Itobe Marble (Sample No. L 31) showing the Identified Peaks**

XRD Scan Report

Thermo SCIENTIFIC

Instrument: FLSMIDTH OBAJANA - NG




**File Information**

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**Scan Parameters**

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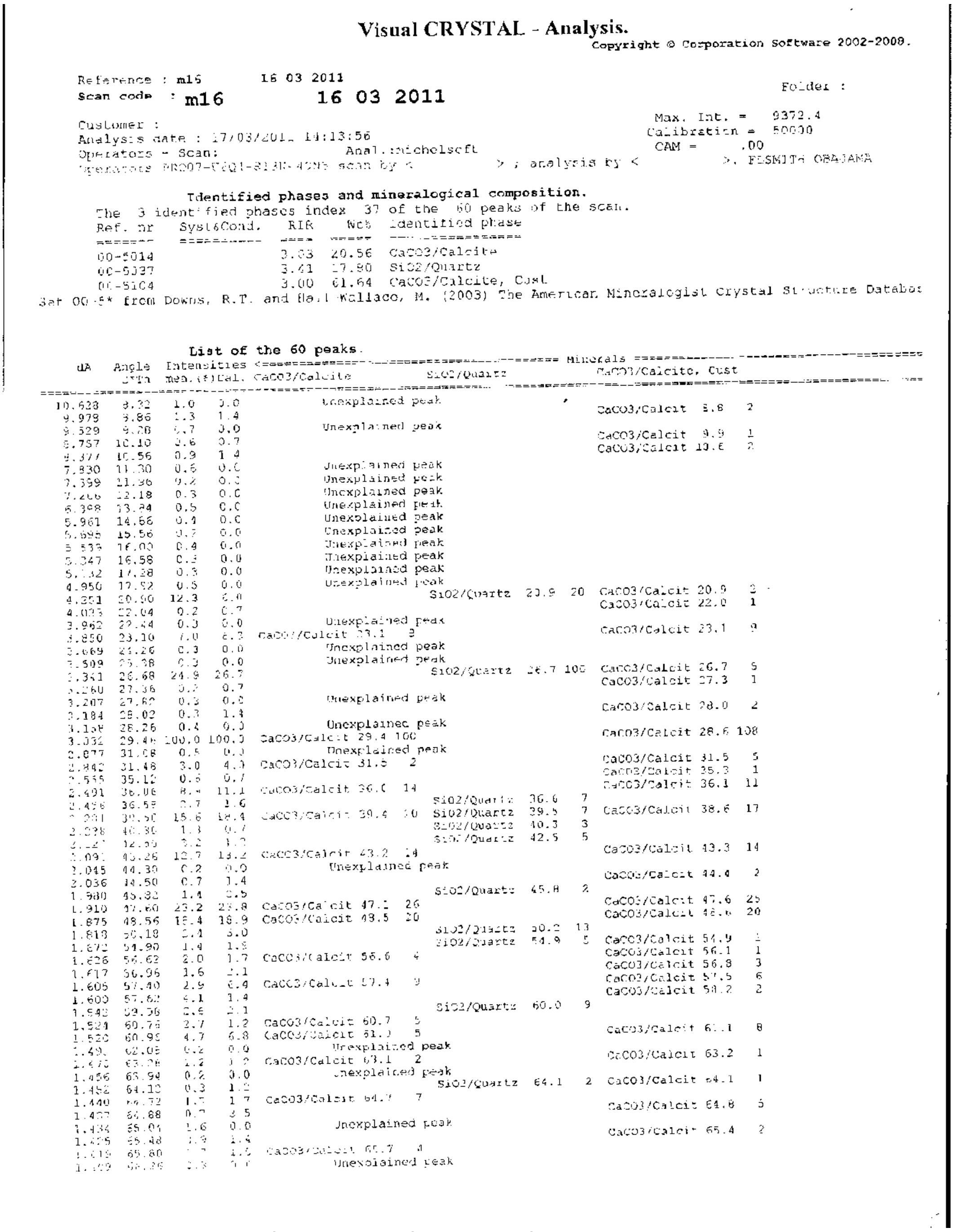
|---|---|---|---|---|---|---|---|---|---|---|
| XRD 1 | FDD | 40 | 40.00 | XRD Tube | 0.13 | 0.02 | Yes | 40 | 100 | Fast Digital |

**Scan Identification**

| Line | Angle [deg] | Intensity [Kcps] | DSpacing |
|---|---|---|---|
| Calcite | 26.83 | 2,08 | 3.855002 |
| Quartz | 24.27 | 1,27 | 4.255608 |
| Dolomite | 25.66 | 0,75 | 4.028507 |
| Calcite [1 0 4] | 34.27 | 17,71 | 3.035700 |
| Calcite [0 1 2] | 26.83 | 2,08 | 3.855000 |
| Calcite [1 0 4] | 34.27 | 17,71 | 3.035700 |
| Calcite [1 1 0] | 42.02 | 2,15 | 2.495000 |
| Calcite [1 1 3] | 46.10 | 2,36 | 2.284800 |
| Calcite [2 0 2] | 50.56 | 2,46 | 2.094600 |
| Calcite [0 2 4] | 55.30 | 2,00 | 1.927500 |
| Calcite [0 1 8] | 55.77 | 2,96 | 1.912500 |
| Calcite [1 1 6] | 56.97 | 2,58 | 1.875400 |
| Calcite [1 2 2] | 67.78 | 1,19 | 1.604200 |
| Calcite [2 1 4] | 71.81 | 0,95 | 1.525300 |
| Calcite [3 0 0] | 76.77 | 0,82 | 1.440500 |

**Date&Time:**05/04/2010 10:36:46 **Software**: OXSAS **Version:**1.1.4.710 **Page 1 of 2**

**Fig.5: XRD of Marble Sample from Mass II of the Itobe Marble (Sample No. L 26B) showing the Identified Peaks**



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Reference : m16 16 03 2011
Scan code : m16 16 03 2011
Folder :

Customer :
Analysis date : 17/03/2011 14:13:56
Operators - Scan: Anal.:nicholsoft
Max. Int. = 9372.4
Calibration = 50000
CAM = .00

Identified phases and mineralogical composition.
The 3 identified phases index 37 of the 60 peaks of the scan.

| Ref. nr | Syst&Cond. | RIR | Wct | Identified phase |
| --- | --- | --- | --- | --- |
| 00-5014 | | 3.03 | 20.56 | CaCO3/Calcite |
| 00-5037 | | 3.41 | 17.80 | SiO2/Quartz |
| 00-5104 | | 3.00 | 61.64 | CaCO3/Calcite, Cust |

Set 00-5* from Downs, R.T. and Hall-Wallace, M. (2003) The American Mineralogist Crystal Structure Databas

List of the 60 peaks.

| dA | Angle 2Th | Intensities meas. | Intensities Cal. | CaCO3/Calcite | SiO2/Quartz | CaCO3/Calcite, Cust |
| --- | --- | --- | --- | --- | --- | --- |
| 10.628 | 8.32 | 1.0 | 0.0 | Unexplained peak | | CaCO3/Calcit 8.8 2 |
| 9.978 | 8.86 | 1.3 | 1.4 | | | |
| 9.529 | 9.28 | 0.7 | 0.0 | Unexplained peak | | CaCO3/Calcit 9.9 1 |
| 8.757 | 10.10 | 0.6 | 0.7 | | | CaCO3/Calcit 10.6 2 |
| 8.377 | 10.56 | 0.9 | 1.4 | | | |
| 7.830 | 11.30 | 0.6 | 0.0 | Unexplained peak | | |
| 7.399 | 11.96 | 0.2 | 0.0 | Unexplained peak | | |
| 7.266 | 12.18 | 0.3 | 0.0 | Unexplained peak | | |
| 6.398 | 13.84 | 0.5 | 0.0 | Unexplained peak | | |
| 5.961 | 14.66 | 0.4 | 0.0 | Unexplained peak | | |
| 5.695 | 15.56 | 0.7 | 0.0 | Unexplained peak | | |
| 5.533 | 16.00 | 0.4 | 0.0 | Unexplained peak | | |
| 5.347 | 16.58 | 0.3 | 0.0 | Unexplained peak | | |
| 5.132 | 17.28 | 0.3 | 0.0 | Unexplained peak | | |
| 4.950 | 17.92 | 0.5 | 0.0 | Unexplained peak | | |
| 4.251 | 20.90 | 12.3 | 6.0 | | SiO2/Quartz 20.9 20 | CaCO3/Calcit 20.9 2 |
| 4.033 | 22.04 | 0.2 | 0.7 | | | CaCO3/Calcit 22.0 1 |
| 3.962 | 22.44 | 0.3 | 0.0 | Unexplained peak | | |
| 3.850 | 23.10 | 7.0 | 6.3 | CaCO3/Calcit 23.1 9 | | CaCO3/Calcit 23.1 9 |
| 3.669 | 24.26 | 0.3 | 0.0 | Unexplained peak | | |
| 3.509 | 25.38 | 0.3 | 0.0 | Unexplained peak | | |
| 3.341 | 26.68 | 24.9 | 26.7 | | SiO2/Quartz 26.7 100 | CaCO3/Calcit 26.7 5 |
| 3.260 | 27.36 | 0.2 | 0.7 | | | CaCO3/Calcit 27.3 1 |
| 3.207 | 27.82 | 0.3 | 0.0 | Unexplained peak | | |
| 3.184 | 28.02 | 0.3 | 1.4 | | | CaCO3/Calcit 28.0 2 |
| 3.158 | 28.26 | 0.4 | 0.0 | Unexplained peak | | |
| 3.032 | 29.46 | 100.0 | 100.0 | CaCO3/Calcit 29.4 100 | | CaCO3/Calcit 28.6 108 |
| 2.877 | 31.08 | 0.5 | 0.0 | Unexplained peak | | |
| 2.842 | 31.48 | 3.0 | 4.0 | CaCO3/Calcit 31.5 2 | | CaCO3/Calcit 31.5 5 |
| 2.555 | 35.12 | 0.6 | 0.7 | | | CaCO3/Calcit 35.3 1 |
| 2.491 | 36.06 | 8.4 | 11.1 | CaCO3/Calcit 36.0 14 | | CaCO3/Calcit 36.1 11 |
| 2.456 | 36.58 | 0.7 | 1.6 | | SiO2/Quartz 36.6 7 | |
| 2.281 | 39.50 | 15.6 | 18.4 | CaCO3/Calcit 39.4 10 | SiO2/Quartz 39.5 7 | CaCO3/Calcit 38.6 17 |
| 2.238 | 40.30 | 1.3 | 0.7 | | SiO2/Quartz 40.3 3 | |
| 2.127 | 42.50 | 3.2 | 3.2 | | SiO2/Quartz 42.5 5 | |
| 2.091 | 43.26 | 12.7 | 13.2 | CaCO3/Calcit 43.2 14 | | CaCO3/Calcit 43.3 14 |
| 2.045 | 44.30 | 0.2 | 0.0 | Unexplained peak | | |
| 2.036 | 44.50 | 0.7 | 1.4 | | | CaCO3/Calcit 44.4 2 |
| 1.980 | 45.82 | 1.4 | 2.5 | | SiO2/Quartz 45.8 2 | |
| 1.910 | 47.60 | 23.2 | 23.8 | CaCO3/Calcit 47.1 26 | | CaCO3/Calcit 47.6 25 |
| 1.875 | 48.56 | 15.4 | 18.9 | CaCO3/Calcit 48.5 20 | | CaCO3/Calcit 48.6 20 |
| 1.818 | 50.18 | 2.4 | 3.0 | | SiO2/Quartz 50.2 13 | |
| 1.672 | 54.90 | 1.4 | 1.5 | | SiO2/Quartz 54.9 5 | CaCO3/Calcit 54.9 1 |
| 1.626 | 56.62 | 2.0 | 1.7 | CaCO3/Calcit 56.6 4 | | CaCO3/Calcit 56.1 1 |
| 1.617 | 56.96 | 1.6 | 2.1 | | | CaCO3/Calcit 56.8 3 |
| 1.605 | 57.40 | 2.9 | 6.4 | CaCO3/Calcit 57.4 9 | | CaCO3/Calcit 57.5 6 |
| 1.600 | 57.62 | 4.1 | 1.4 | | | CaCO3/Calcit 58.2 2 |
| 1.543 | 59.56 | 2.6 | 2.1 | | SiO2/Quartz 60.0 9 | |
| 1.524 | 60.76 | 2.7 | 1.2 | CaCO3/Calcit 60.7 5 | | CaCO3/Calcit 61.1 8 |
| 1.520 | 60.95 | 4.7 | 6.8 | CaCO3/Calcit 61.0 5 | | |
| 1.491 | 62.05 | 0.2 | 0.0 | Unexplained peak | | |
| 1.470 | 63.28 | 1.2 | 1.2 | CaCO3/Calcit 63.1 2 | | CaCO3/Calcit 63.2 1 |
| 1.456 | 63.94 | 0.2 | 0.0 | Unexplained peak | | |
| 1.452 | 64.10 | 0.3 | 1.2 | | SiO2/Quartz 64.1 2 | CaCO3/Calcit 64.1 1 |
| 1.440 | 64.72 | 1.7 | 1.7 | CaCO3/Calcit 64.7 7 | | |
| 1.437 | 64.88 | 0.7 | 3.5 | | | CaCO3/Calcit 64.8 5 |
| 1.434 | 65.04 | 1.6 | 0.0 | Unexplained peak | | |
| 1.425 | 65.48 | 1.9 | 1.4 | | | CaCO3/Calcit 65.4 2 |
| 1.419 | 65.80 | [illegible] | 1.5 | CaCO3/Calcit 65.7 4 | | |
| 1.409 | 66.26 | 0.3 | [illegible] | Unexplained peak | | |

**Fig. 6: XRD of Marble Sample from Mass II of Itobe Marbles (Sample No. M16)**

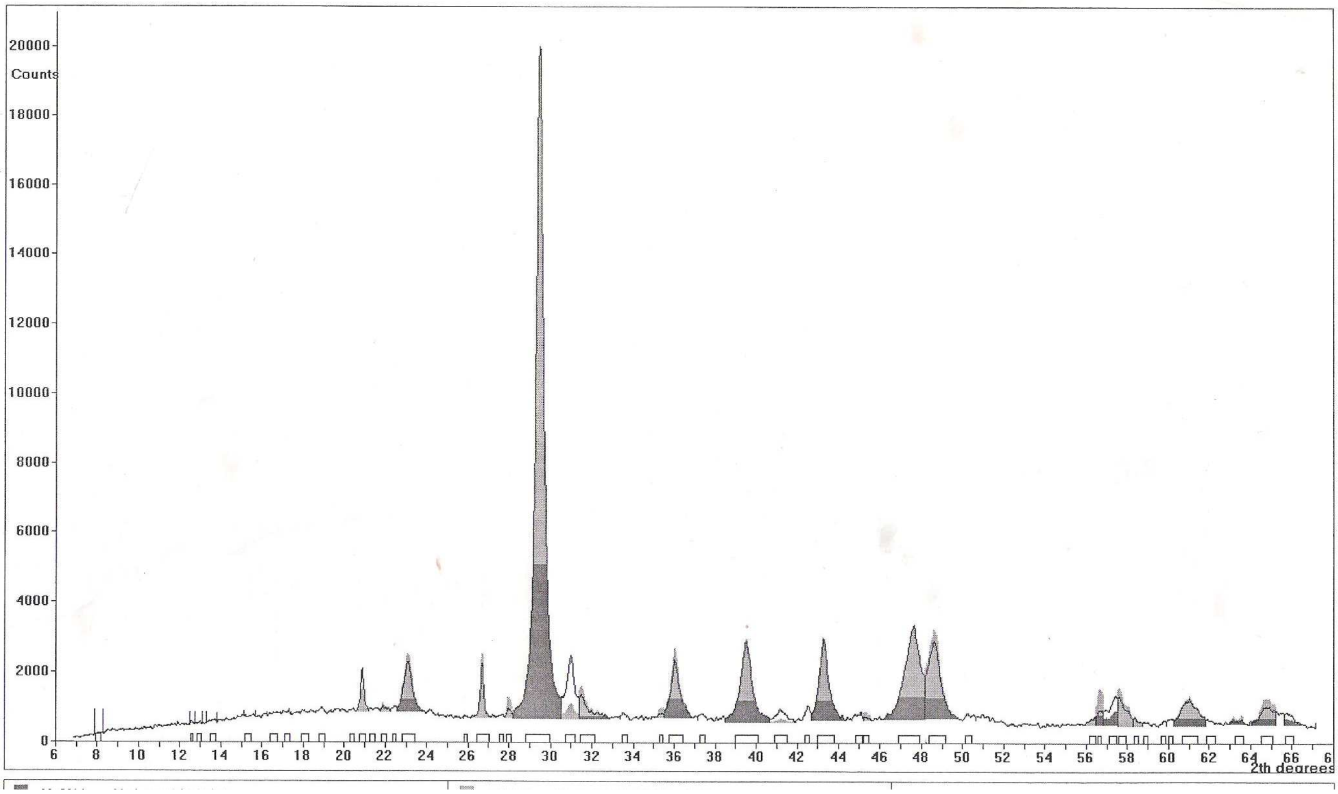


**Fig. 6: XRD of Marble Sample from Mass II of Itobe Marbles (Sample No.M16)**

Mineralogical composition of marble samples (Sample numbers: r1, r4 and s3) of mass I estimated from the identified peak of the XRD Scan (Figs. 7 - 9 ) shows that the dominant mineral in mass I is calcite ($CaCO_3$). It ranges in composition from 0% to 100% with an average value of 64.9%. Dolomite content varies from 0% to100% with an average content of 33.3%. Quartz content varies from 0% to 5.3% with an average value of 1.8 %. (Table 2)

**Table 2: Mineralogical Composition of Marble Samples (Mass I) determined from Identified Peaks of the X-Ray Diffractogram**

| Sample Number | Mineralogical composition (%) | | |
|---|---|---|---|
| | Calcite | Dolomite | Quartz |
| 1 | 100% | 0% | 0% |
| 2 | 0% | 100% | 0% |
| 3 | 94.71% | 0% | 5.3 % |
| **Mean** | **64.9%** | **33.3%** | **1.8%** |

Visual CRYSTAL - Analysis.

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```
Reference : r1      22 03 2011
Scan code  : r1     22 03 2011                                    Folder :

Customer :                                                    Max. Int. =   9784.3
Analysis date : 22/03/2011 15:27:16                           Calibration =  50000
Operators - Scan: .             Anal.:nichelsoft              CAM =       .00
Operators PRO07-U6Q4-813K-40N5 scan by <        > ; analysis by <        >. FLSMITH OBAJAMA

              Identified phases and mineralogical composition.
  The  2 identified phases index  25 of the  48 peaks of the scan.
  Ref. nr    Syst&Cond.    RIR    Wt%   Identified phase
  =======    ==========    ====   =====  ================
  00-5014                  3.03   23.57  CaCO3/Calcite
  00-5104                  3.00   76.43  CaCO3/Calcite, Cust
Set 00-5* from Downs, R.T. and Hall-Wallace. M. (2003) The American Mineralogist Crystal Structure Databas
```

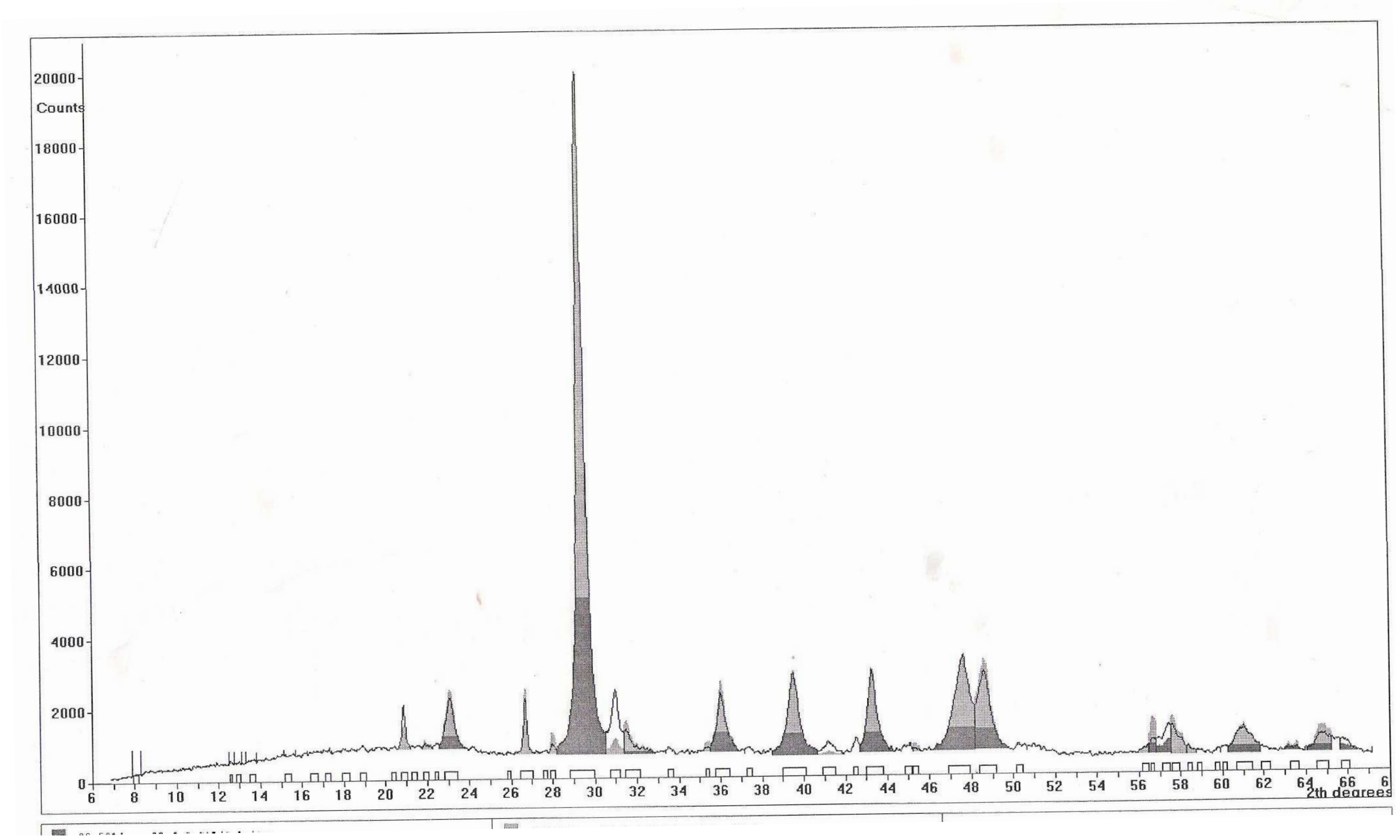
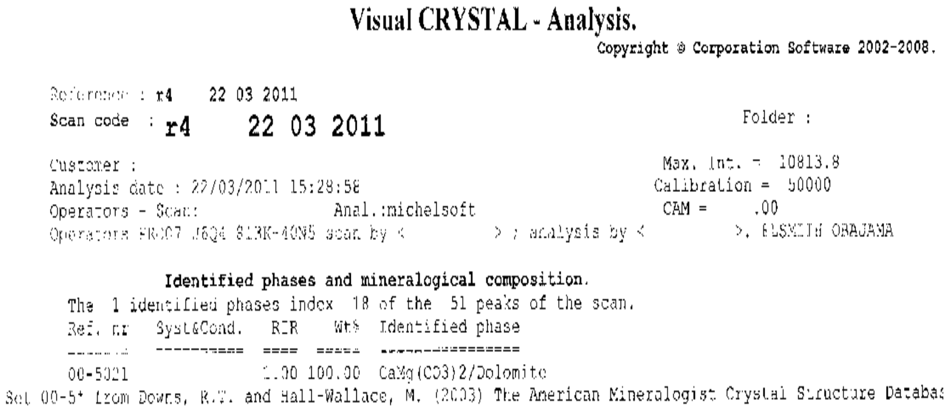



**Fig. 7: XRD of Marble Sample from Mass I of Itobe Marbles (Sample No. r1)**



Visual CRYSTAL - Analysis.

Copyright © Corporation Software 2002-2008.

Reference : r4 22 03 2011

Scan code : r4 22 03 2011

Folder :

Customer :

Analysis date : 22/03/2011 15:28:58

Operators - Scan: Anal.:michelsoft

Operators FR007 J6Q4 813K-40N5 scan by < > ; analysis by < >. ELSMITH OBAJANA

Max. Int. = 10813.8

Calibration = 50000

CAM = .00

Identified phases and mineralogical composition.

The 1 identified phases index 18 of the 51 peaks of the scan.

| Ref. nr | Syst&Cond. | RIR | Wt% | Identified phase |
|---|---|---|---|---|
| 00-5021 | | 1.00 | 100.00 | CaMg(CO3)2/Dolomite |

Set 00-5* from Downs, R.T. and Hall-Wallace, M. (2003) The American Mineralogist Crystal Structure Databas

**Fig. 8: XRD of Marble Sample from Mass I of Itobe Marbles (Sample No. r4)**

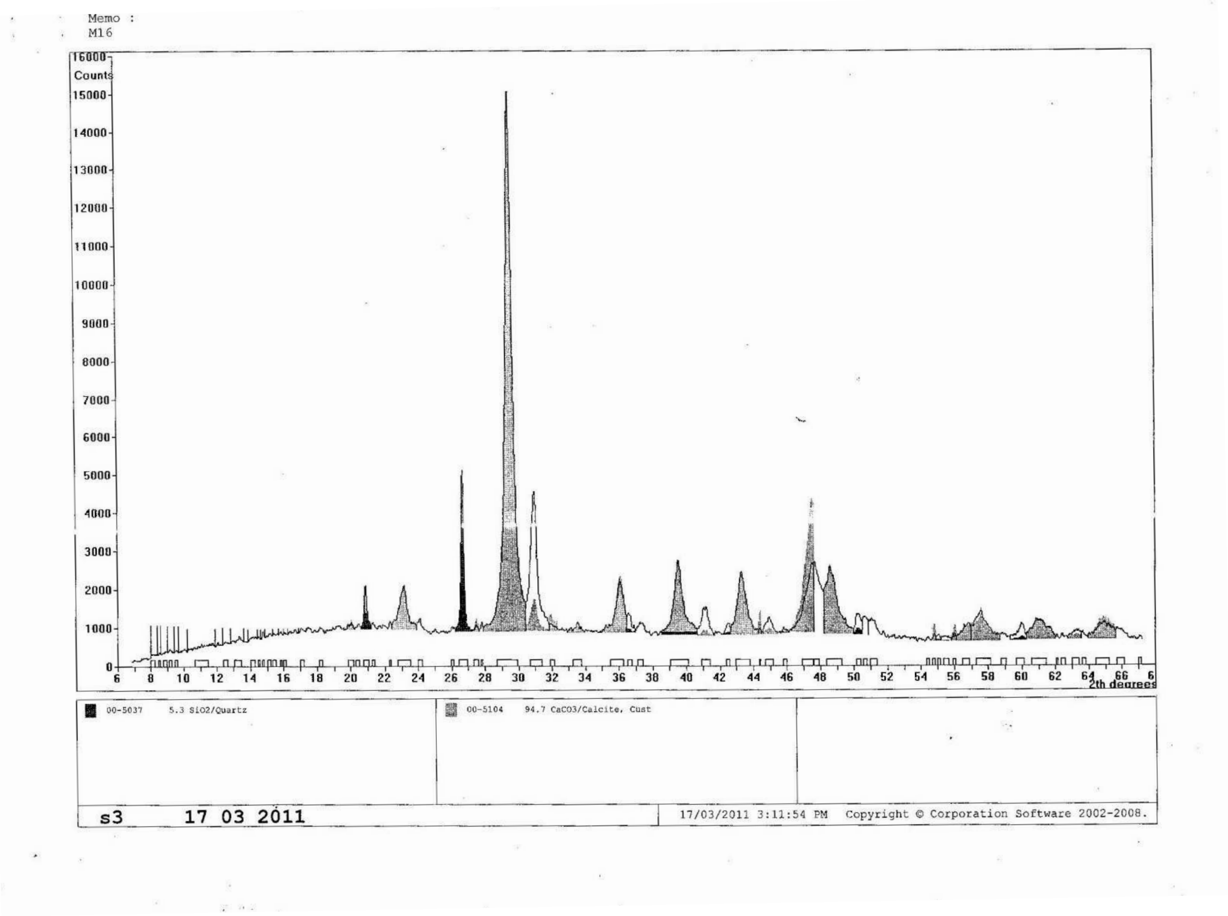



**Fig. 9 XRD of Marble Sample from Mass I of Itobe Marbles (Sample No. s 3)**

## CONCLUSION

Field geological mapping and petrographic studies of the Itobe marble body in Kogi state, central Nigeria, reveals the occurrence of two outcrops (described as mass I and mass II) of the marble body occurring about 800metres apart along a NNE- SSW axis. Mass I occurs as a poorly exposed minor lensoid body at the road cut (about 100m from Alo I village) along the Ajaokuta – Ayingba road. It is light to bluish gray in color, fine grained and highly competent. Mass II is a larger, hilly body, and outcrops on the NNE – SSW trending Ayanka ridge. It rises from an elevation of 132m to a peak elevation of 138m on the Ayanka ridge. It is dark gray in color, medium grained in texture, with joints running perpendicular to the trend of the rock. The Itobe marble body occurs in association with Precambrian basement rocks including biotite schist, mica schist, quartz-schist, biotite - hornblende schist, felsdpathic quartzite, quartzitic schist, gneissic granite and minor intrusive rocks including pegmatite and quartz veins.

Structures of the basement rocks surrounding the Itobe marbles show a dorminant NNE/NE –SSW/SW trend and a minor NW-SE trend corresponding to the Pan-African and Pre-Pan African orogeny respectively.

X – Ray Diffractogram (XRD) analysis of the marble reveals an average mineralogical composition of Dolomite (33.3%), Calcite (64.9%) and Quartz (1.8%) for mass I and Dolomite (1.7%), Calcite (92.5 %) and Quartz (6.3 %) for mass II.

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