Geochemical Aspects of Calcite and Dolomite Deposits Around Rajawaka off Balangoda, Sri Lanka, and Suitability for Industry

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Abstract

Major calcite and dolomite occurrences are found in Rajawaka off Balangoda in Sri Lanka. The area is undertaken by Precambrian marble rock which is one of the most common sources of calcite and dolomite in Sri Lanka. Field investigation, locating sample points, analytical work using AAS, ETDA titration, colorimetric methods and microscopic analysis were carried out in different phases to obtain chemical and mineralogical composition of calcite and dolomite. Results revealed that the marble samples contain major proportion of calcite mineral, calcitic marble with minor amount of dolomite. Quartz, graphite, pyrite, diopside, apatite, muscovite, phlogopite and biotite occur as accessory minerals. Also, analytical data showed an average acid insoluble of 5.73% and SiO_2 of 4.71%, moderately high CaO content` of 81.71%, with low MgO content of 4.91% and very low iron oxide content of 0.37% and aluminum oxide content of 1.62%. These characteristics make this deposit suitable for major industrial uses especially the production of high quality lime and fertilizer manufacturing industries, and it is not suitable for the high-quality glass industry due to high content of silica and other accessories.

Keywords: AAS, Chemical, Colorimetric, EDTA, Marble, Microscopic, Mineralogical, Precambrian

1. Introduction

Sri Lanka is rich of various kinds of mineral resources. Thus, Sri Lanka is well-endowed with industrial minerals including Graphite, Ilmenite, Rutile, Zircon, Quartz, Silica Sand, Garnet sand, Mica, Feldspar, Clay, Kaolin, Apatite, Calcite and Dolomite. Therefore, Sri Lankan's mineral resources are an important component of the nation's wealth. The effort to find new economic mineral deposits or ore bodies is essential for development of mineral based industries[1][2].

This study is carried out in Rajawaka off Balangoda to ascertain the geochemical aspects of calcite and dolomite deposits and evaluate the suitability of the materials for the local industry.

Calcite and dolomite deposits are widely distributed throughout the metamorphic terrain in Sri Lanka. The study is focused on the Rajawaka off Balangoda area, situated in

Rathnapura district of the Sabaragamuwa province.

Preliminary studies in the area around Balangoda show number of calcite and dolomite occurrences within marble bands in Rajawaka, Illukpellessa, Molamure and Kalthota.

Dolomite and calcite are widely used in many local industries depending mostly on their mineralogical purity and chemical content. Therefore, prior concise chemical characterizations are necessary before any industrial application.

2. Methodology

2.1 Field study

A reconnaissance geological survey of Rajawaka off Balangoda area was carried out. This was done in order to locate the calcite and dolomite deposits. Sampling locations were selected around the study area considering the extend of the deposit and accessibility.

2.2 Sample collection

Sixteen representative calcite and dolomite samples of approximately 2 Kg each were collected from the studied area (Figure-2.1). Global Positioning System (GPS) was used to locate and determine the elevations and co-ordinates of sample points.

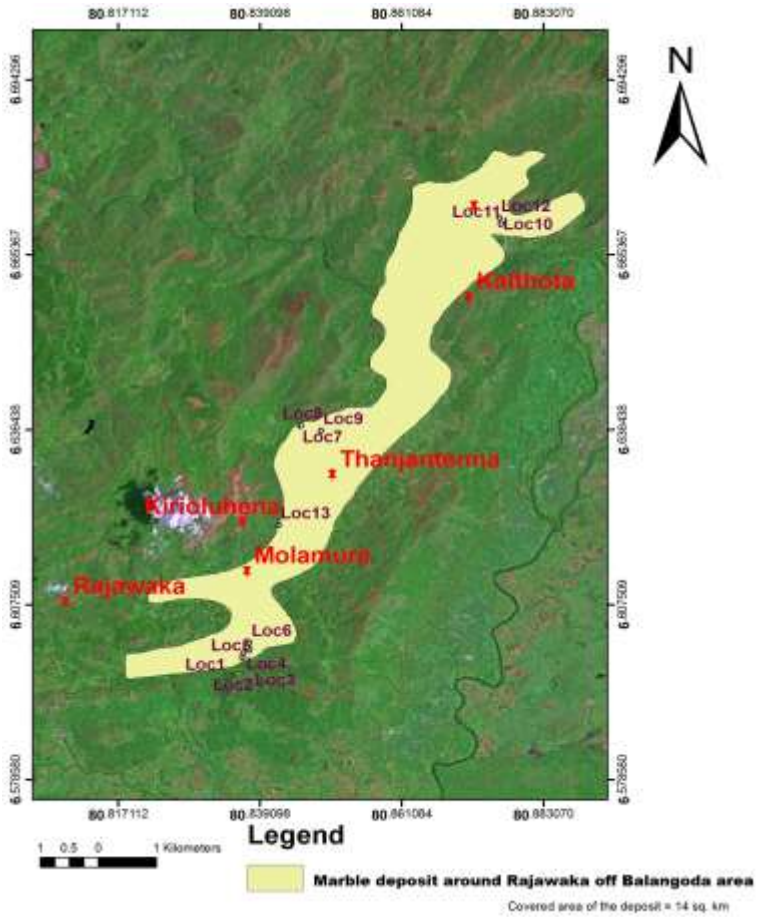

Figure 2.1 - Sampling Locations

2.3 Sample preparation

The crushed samples (< 4 mm) were ground by using a laboratory mill.

A representative assay portion from each sample was digested.

2.4 Sample analysis

The samples were analysed using atomic absorption spectroscopy, ETDA titration, colorimetric methods and a microscopic analysis, to determine chemical and mineralogical components [3][4].

2.5 Mineralogical Analysis

Residue of digested samples were dried and subjected to microscopic analysis to identify non-carbonate minerals. Then, approximate volume percentage of present accessory miners were calculated by counting grains.

3. Results and Discussion

Table 3.1 - Chemical Analysis Results

Sample ID	CaO (%)	MgO (%)	Acid in-Soluble (%)	Al_2O_3 (%)	Fe_2O_3 (%)
WL/1	46.35	1.33	3.39	1.69	0.03
WL/2	25.48	2.93	3.57	0.58	0.30
WL/3	32.50	1.06	2.53	1.81	0.24
WL/4	41.37	11.44	20.76	2.07	0.04
WL/5	40.26	3.72	9.06	2.20	0.09
WL/6	53.00	2.13	7.79	1.50	0.94
WL/7	48.01	4.66	7.64	1.80	0.11
WL/8	41.55	3.33	9.59	0.20	0.69
WL/9	18.10	13.17	8.69	0.88	0.34
WL/10	40.44	12.64	13.30	1.60	0.88
WL/11	53.18	1.86	1.50	2.55	0.03
WL/12	53.92	1.60	3.55	1.85	0.66
WL/13	54.11	1.06	28.83	1.45	0.76
WL/14	50.78	4.26	2.46	1.71	0.18
WL/15	50.97	2.00	3.29	1.81	0.03
WL/16	54.66	0.93	7.73	2.20	0.60

3.1 The Field Relations and Mode of Occurrences Characteristics of the Marble

The calcite and dolomite deposits are located in marble bands along the Rajawaka, Moramulla and Illukpelassa in Balangoda district. The major rock types in Rajawaka off Balangoda area are gneisses, quartzite and marble. Rocks in this area generally have a North-East to South-West trend and dip in a North-West.

The calcite and dolomite deposits (marble bodies) are not exposed abundantly throughout the study area. They are two textural varieties of the marble rock which are fine-grained and medium to coarse grained. In addition to the carbonate minerals abundant in the marble samples, quartz, graphite, muscovite, biotite, phlogopite, hessonite garnet, spinal, apatite, diopside and pyrite were also present as accessory mineral constituents. However, the distribution of these accessory minerals is not homogeneous for instance; pyrite is found in the marble samples located around Thanjantenna while the green diopside and apatite are enriched in samples from near to the Rajawaka and Kalthota areas which give light to dark green colors to marble.

3.2 Geochemical Characterization

The test results of the marble found in the study area (Table 4-1) shows that calcite ($CaCO_3$) is the most abundant mineral of the total composition, while dolomite ($CaMg(CO_3)_2$) is relatively low. Determination of the major and trace for geochemical analysis were carried out for some selected representative marble samples by Complex metric titration, colorimetric and AAS methods.

The chemical composition of these carbonate minerals is given in Table 4.4 that result reveals an averagely low SiO_2 content of 4.71%, with moderately high $CaCO_3$ ranging from 45.51% to 97.64%, in Rajawaka it ranging from 32.32% to 74.2%. But very high average $CaCO_3$ content of 93.85% can be seen in the deposits around Molamure, Kaltota and Illukpelessa.

However, the iron oxide and aluminum oxide content is very low in concentration (respectively from 0.025% to 0.94% and from 0.2% to 2.55%). Another important observation is an average $MgCO_3$ content in the deposits is low (ranging from 1.96% to 9.78%) in most places, except the deposit around Thanjantenna (an average $MgCO_3$ content of 20.39%).

Table 3.2 - Mineralogical Analysis Results

Sample ID	**Non-Carbonate Minerals in volume %**			
WL/1	50% Quartz	Nearly 50% Graphite flaky	Bellow 1% Hessonite garnet, Phlogopite, Apatite	
WL/2	30% Quartz	35% Muscovite	35% Phlogopite	Below 1% Graphite flaky
WL/3	100% Quartz	Below 1% Hessonite garnet		
WL/4	100% Quartz	Few grains of Biotite, Hessonite garnet, Graphite flaky are founded less than 1%		
WL/5	Nearly 100% Quartz			
WL/6	90% Quartz	Bellow 10% diopside and Apatite		
WL/7	Nearly 90% Quartz	Below 10 % Apatite, diopside	Below 2% Graphite flaky	
WL/8	76% Quartz	15% pyrite and graphite	10% Hessonite garnet, Muscovite, Spinal, Phlogopite	
WL/9	40% Quartz	5% Muscovite, Biotite	50% Pyrite, Graphite	
WL/10	Nearly 100% Quartz			
WL/11	30% Quartz	Nearly 70% Muscovite	Below 1% hessonite garnet, graphite flaky	
WL/12	80% Quartz	15% Phlogopite	5% Graphite flaky	
WL/13	60% Quartz	Nearly 40% Major part of undissolved mineral Diopside		Below 1% Spinal and Garnet,
WL/14	80% Quartz	20% Phlogopite		
WL/15	40% Quartz	Nearly 60% Mica(muscovite)	Bellow 1% graphite flaky	
WL/16	60% Mica (Muscovite & Phlogopite)			

3.4 Industrial Uses

Marble is one of the industrial rocks that are presently gaining prominence in the manufacturing sector of the Sri Lankan as well as the world economy. The marble deposits of Rajawaka off Balangoda were quarried by different companies for different economic applications.

The specifications of calcite and dolomite required for some main local industries are given in Table 3-3 and Table 3-4

Table 3.3 - Calcite specifications for industrial uses[5]

Industry	CaO Wt.%	MgO Wt.%	SiO_2 Wt.%	Al_2O_3 Wt.%	Fe_2O_3 Wt.%	Acid insoluble Wt.%
Glass	53	MgO + CaO > 54.5	2.5(max)	_	0.2(max color) & 0.02(colorless)	_
Cement	42(min)	4(max)	2-4(min)	12-6(max)	1-2	_
Fertilizer	CaO + MgO > 50		5	_	_	14

Table 3.4 - Dolomite Specifications for industrial uses[6]

Industry	CaO Wt.%	MgO Wt.%	SiO_2 Wt.%	Al_2O_3 Wt.%	Fe_2O_3 Wt.%	Acid insoluble Wt.%
Glass	MgO (+/-0.5 wt.%)	CaO (+/- 0.5 wt.%)	2.5(max)	_	0.5(max)	_
Lime	32-42	13-23	_	_	_	8(max)
Fertilizer	CaO + MgO > 50		5(max)	_	_	_
Ferro-Manganese	28-30	19-20	2-5	2.-2.5	_	_

4. Conclusions and Recommendations

- The geochemical analysis of the deposits show that $CaCO_3$ content varies from 32.32% to 97.61% and $MgCO_3$ content varies from 1.96% to 27.65%. Other impurities include: Fe_2O_3, Al_2O_3, and SiO_2. That reveals the most of the marble deposits consists of both calcitic and dolomitic mineral but locally high calcite marble present and pure crystalline limestone is existed in the area around Moramue, Kalthota and Ilukpelessa.

- The marble deposit chemically varies from calcite to dolomite verities and impure varieties. In some areas, the relative proportions of $CaCO_3$ and $MgCO_3$ vary from location to location even within a few meters and it is generally impossible to distinguish between the verities in the field.

- Calcite is found to be the major mineral in that marble deposits. Dolomite and quartz appears as the minor mineral in almost all varieties of Rajawaka off Balangoda marble deposits. Other minerals present are diopside, apatite, spinel, graphite, muscovite, biotite, phlogopite and hessonite garnet as accessory minerals. All these characteristics makes the marble deposits are highly suitable only for fertilizer and lime manufacturing industries and as dietary supplement for animals, and it is not suitable for the high-quality glass industry due to high content of silica and other accessories.

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References

[1] Herath, J. W., (1995) Economic Geology of Sri Lanka, Ministry of Industrial Development, P.99-P.121.

[2] Manawansa,P.(2014).Mineral Year Book.Colombo: Geological Survey and Mines Bureau.

[3] Jeffery,P. and Hutchison,D.(1981).Chemical Methods of Rock Analysis. 3rd ed. Oxford: Pergamon Press, pp.18-27.

[4] Vogel, A. and Jeffery,G.(1989).(Arthur Israel) Vogel's Textbook Of Quantitative Chemical Analysis. 5th Ed.Harlow: Longman,pp.654-663.

[5] King, H. (2016). Calcite Mineral Uses and Properties. [online]Geology.com.Available at: http://geology.com/minerals/calcite.shtml [Accessed 22 July. 2016]

[6] King. (2016). Dolomite Mineral Uses and Properties. [online]Geology.com.Available at: http://geology.com/minerals/dolomite.shtml [Accessed 22 July. [2016].