Research & Reviews: Journal of Chemistry

e-ISSN:2319-9849
p-ISSN:2322-00

Determination $^{13}C/^{12}C$ and $^{18}O/^{16}O$ Isotope Ratios with Mass Spectrometer in Turkish White Marbles

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Research Article

Received date: 04/05/2017
Accepted date: 07/08/2017
Published date: 18/08/2017

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Keywords: Stable isotope, Mass spectrometer, White marble, Turkey, Carbon, Oxygen

ABSTRACT

$^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope ratios of marble samples taken from different region of Turkey such as Afyon (27 samples), Marmara (24 samples) and Uşak (16 samples) have been studied. The marble reserve in the other cities of Turkey is high, so $^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope ratios of these samples were determined by mass spectrometer. In order to rationalize the result both marbles were not only compared to themselves but also compared with Afyon, Marmara and Uşak samples to reach the conclusion that marbles of their regions could be classified. Using a vacuum extraction line, carbon dioxide prepared by dissolving the marble samples in 105% orthophosphoric acid was purified and subsequently collected in a glass tube for later isotopic analysis. The relative abundance of the ^{13}C and ^{18}O isotopes was determined with a high precision mass spectrometer. The $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios were measured relative to the ratios in a secondary standard.

INTRODUCTION

The identification of sources of white marble used for the production of ancient artifacts is clearly of value to anyone studying economic and art history. Since often no texts can be found which reveal the provenance of the marble used, the identification based on the characteristics of the material itself is a major source of fundamental information for archaeological research. Generally speaking, the naked eye is rather poor tool for the study of marble especially of white marble, due to the subjectivity inherent in visual inspection, the presence of superficial weathering layers and the fact that the differences between marbles from different regions can be very subtle [1-6].

In order to construct a valuable database for archeologist to identify the white marbles, sampling in different sources such as Italy, Greece and Turkey was carried out. The origin of the ancient artifacts was determined usually by determining the ratio of $^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope ratio levels. To do this, 5 to 10 mg of samples were found to enough for analyzing the samples to construct of a database. Further, analyzed samples were used to estimate the origin of the samples.

It is the aim of this work to determine the isotope ratios of the white marbles taken from different regions of Turkey and to compare the results with the other works. In this work, preparing the samples for isotope analysis was also discussed.

EXPERIMENTAL

Instrumentation

Magnetic Mass Spectroscopy (MAT, Finnigan Delta E). The apparatus used for the production of CO_2 from marbles.

Methodology

$^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope ratios are determined relative to the secondary standard. Carrara and Pee Dee Bolemnite PDB marbles are used as standarts for working and for instruments respectively.

Materials

A summary of the procedure for preparing CO_2 is as follows: Fresh samples were taken and grounded and loaded in white

e-ISSN:2319-9849
p-ISSN:2322-00

polypropylene bottles. 5 to 10 mg samples were placed in a glass tube and the tube was assembled to the unit. High vacuum line technique was applied to remove all air and the acid (3 ml H_3PO_4 105%). At the same time a reference sample (A standard from Sarcophagus in the British Museum, Coleman and Walker 1979) was subjected to the same methodology. Obtained CO_2 gas was placed in the MAT instrument and the isotope ratşos were detrmined and the mean wa calculated.

RESULTS AND DISCUSSION

The experimental set up procedure for analyzing the samples. In the initial step, vacuum line technique was used to detrmined the air, since the air is the major problem for determining the isotope ratios. A final step in the analyzing is to remove the samples from the apparatus and to prepare for analysis [7].

According to the results, Malatya Yeşilyurt and Malatya Doganşehir samples lie beyond the optimum. Whereas Kırşehir, Nigde originated from the central part of Anaotolia are alike. Not only Bursa Kemalpaşa, Sümenköy and Örencik, but also Kavaklıdere, Mugla region, Milas pink, Başaran, Milas Kavaklıdere and Biga white marbles are formed a different category among themselves. Others, İda, Bayrami and Kazdagı. Samples resemble to the white marbles of Uşak. Yatagan, Mugla and Manyas are alike with Afyon white marbles. Denizli Kavaklıbeki and Elbistan are much alike with the marbles of Uşak and Denizli **(Table 1)**.

Table 1. Sample description and data.

Marble samples	Samples (mg)	Pressure mbar	$CaCO_3$ %	$\delta^{13}C$	$\delta^{18}O$
1) Malatya Yeşilyurt	9.865 9.38	117.4 119.7	87.76 94.07	+4.801 +5.124	-6.643 -7.216
2) Malatya Doganşehir	9.22 9.13	83.2 84.4	67.14 68.75	+0.742 +0.716 +0.735	-3.739 -3.581 -3.267
3) Kırşehir	9.268 9.925	120.6 129.7	95.91 96.18	+3.044 +3.024	-2.623 -2.456
4) Mugla Yöresi	9.001 9.415	114.2 119.4	93.62 93.49	+3.665 +3.704	-5.134 -4.818
5) Mugla Kavaklıdere	9.415 9.455	123.6 126.1	96.71 98.21	+4.295 +4.298	-5.025 -4.843
6) Afyon.3.	9.841 9.205	127.4 114.4	95.32 91.71	+3.780 +3.725	-3.333 -3.612
7) Marmara.2.	9.209 9.175	121.8 121.1	97.47 97.28	+3.528 +3.539	-1.458 -1.735
8) Nigde	8.876 9.175	119.8 122.5	99.5 98.38	+3.824 +3.866	-0.308 -0.539
9) Mugla Yatagan	8.604 9.005	117.0 120.2	100 98.39	+1.350 +1.363	-3.885 -4.133
10) Milas Sedefi	9.334 8.76	124.1 121.8	97.94 102	+3.809 +3.825 +3.809	-1.358 .2.105 -1.672
11) Mucur white	9.565 9.24	129.3 123.1	99.50 98.16	+2.923 +2.917 +2.899	-1.228 -1.695 -1.260
12) Maraş Elbistan	9.249 9.65	123.3 126.7	98.22 96.68	+2.337 +2.347	-1.525 -1.751
14) Mugla Başaran	9.815 9.5	131.8 125.7	98.80 97.44	+3.868 +3.906	-3.025 -2.914
16) Uşak Afyon arası	9.202 9.245	123.3 121.3	98.72 96.70	+2.091 +2.098	-4.662 -4.840
17) Manyas	9.527 9.44	128.5 124.4	99.29 97.07	+2.573 +2.592	-3.716 -3.697
18) Milas pembe	9.701 9.23	131.0 118.6	99.37 94.74	+3.932 +3.976	-3.134 -3.039
19) Mugla	9.81 9.305	132.5 122.7	99.37 97.16	+1.762 +1.759	-3.324 -3.494
20) Milas Kavaklıdere	9.193 9.465	118.5 121.0	95.05 94.22	+3.714 +3.762	-5.191 -5.161
21) Bursa Kemalpaşa	9.405 9.1	126.6 118.2	99.12 95.78	+4.647 +4.631 +4.639	-2.544 -3.085 -2.505
22) Bursa Kemalpaşa Sümenköy	9.805 9.55	131.2 126.6	98.46 97.61	+4.915 +4.920	-2.447 -2.363

e-ISSN:2319-9849
p-ISSN:2322-00

23) İda Kazdagı	9.525 9.185	127.0 120.7	98.17 96.86	+0.962 +0.968	-2.660 -2.730
24) Kazdagı Bayramiş	9.275.9.235	122.7 123.4	97.47 98.44	+1.895 +1.888	-1.765 -1.700
25) Denizli	9.6 9.36	124.3 123.2	95.38 96.97	+2.769 +2.766 +2.760	-2.857 -2.224 -2.290
26) Bursa Örencik	9.46 9.165	124.8 122.4	97.17 98.41	+5.098 +5.140	-1.187 -0.943
27) Sivaslı Kavallıbeki köyü	9.115 9.595	120.8 129.1	97.68 99.04	+2.374 +2.383	-2.405 -2.246
28) Kazdagı	9.305 9.54	125.1 129.0	99.02 99.53	+2.747 +2.779	-3.701 -3.594
29) Uşak	9.645 9.25	128.4 123.8	98.00 98.60	+2.576 +2.620	-5.745 -5.476
30) Afyon İslihisar	9.8 9.5	130.7 127.2	98.14 98.58	+1.657 +1.655	-8.891 -9.050
31) Bursa Karlık	9.24 9.36	121.4 125.5	96.82 98.74	+0.786 +0.836	-3.799 -3.653
32) Biga	9.83 9.39	131.2 125.3	98.21 98.28	+3.695 +3.706	-5.514 -5.418

As a result it is found possible to identify and categorize the Bursa, Malatya, Central Anotolia and south Aegan white marbles by means of isope ratio levels [8,9].

CONCLUSION

$^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope ratios of marble samples taken from different region of Turkey such as Afyon (27 samples), Marmara (24 samples) and Uşak (16 samples) have been studied. it is found possible to identify and categorize the Bursa, Malatya, Central Anotolia and south Aegan white marbles by means of isope ratio levels.

ACKNOWLEDEMENTS

We gratefully thank the Instituut Voor Nucleaire Wetenschappen, Proeftuinstraat 86, B.9000 GENT, Belgium.

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