Geophysical Research Abstracts,
Vol. 11, EGU2009-1081-1, 2009
EGU General Assembly 2009

Carbon, oxygen and strontium isotopic systematics of Mediterranean white marbles used in the Antiquity

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Many geological and petrographic systems have been utilized to determine the provenance of classical marble artefacts. Normally the first steps in sourcing a lithic artefact should be the macroscopic and thin section study with the petrographic microscope. Unfortunately, often to take sample, which is large enough to make thin section is not allowed from precious artefacts. A common procedure to analyse powder sample in various ways: The most widely used system today is that of stable δ^{13}C and δ^{18}O isotopic signatures. Previous studies showed that, unfortunately, many quarry fields overlap in values. Because of great advantage of isotopic ratio analysis, principally the need of only small samples and homogeneity over large areas, we decided to include the ^{87}Sr/^{86}Sr isotopic ratios. Therefore we tested the δ^{13}C, δ^{18}O and ^{87}Sr/^{86}Sr isotopic system, based on the data set entry in MissMarble measurement and information system of marble (Zöldföldi et al. 2008), how fare the system characterises the provenance.

The reason to include Sr is that the Sr contained in carbonate should reflect the composition of seawater at the time of deposition. Thus the ^{87}Sr/^{86}Sr values found in carbonate rocks will depend largely on the seawater composition at the original time of deposition. Isotope geochemical studies show that Sr isotopes do not fractionate during metamorphism.

Thus after initial formation, the principal determinant for oxygen ratios is varying temperatures during metamorphism and atmospheric weathering; δ^{13}C values are depending on the initial organic vs. inorganic material composition; and strontium by the time of origin and a marine vs. terrestrial source of material. Since each isotopic variable is determined by different physical factors and each has a different response to later geological history of the marble, therefore this tree variable make an ideal system for provenancing marble.

δ^{13}C, δ^{18}O and^{87}Sr/^{86}Sr ratios are presented for white marbles collected from some of the most famous classical quarry areas of the Mediterranean: Hymettos, Paros, Paros-Lychnites, Naxos, Thasos, Pentelikon (Greece), Carrara (Italy), Afyon, Aphrodisias, Marmara (Turkey), Viana do Alentejo, Vilavicosa (Portugal) and Las Cabreras, Los Covachos and Macael (Spain).

1017 data pair of δ^{13}C and δ^{18}O isotopic system and 322 data of ^{87}Sr/^{86}Sr ratios of the above mentioned marble quarries (Brilli et al. 2005, Attanasio et al. 2006, Morbidelli et al. 2007), including our own measurements, have been considered in this study. Concerning the Western Mediterranean localities our study is the first to compare them to Greek, Anatolian and Carrara marbles.

The ranges of the different quarry areas are notably overlapped; this prevents a common adoption of this parameter in distinguishing the quarry locations for the classification of marbles used for classical architectural and sculptural artefacts. However some quarry areas show peculiar distributions of their isotopic values, which could help to assign the provenance to an unknown marble artefact.

Because of the limited number of published Sr isotopic compositions measured on white marbles, it restricts standalone application, but permits the creation of a widespread database of 15 classical quarries. Unlike the samples of the Eastern Mediterranean (Anatolia and Greece) the Iberian marbles show different isotopic patterns.

Furthermore the number of samples in this database allows studying the distribution as well. Some sample distri-

butions show asymmetry that may turn to be important in later studies.

The study confirms that the strontium isotope ratio could be used in marble provenance determination, together with other methods, as an ancillary technique.

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