

Isotope characterisation of historical alabaster quarries in Western Europe

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The origin of the raw material of gypsum alabaster artwork is still largely underinvestigated as conventional chemical and mineralogical analyses have not yielded convincing results due to the rather homogeneous composition, especially of the most wanted pure white varieties. Yet, identifying the origin of raw materials used for sculpture is crucial for art historians and museums aiming at identifying artists, rarely nominally documented before the 16th century, workshops and historic trade roads. A pilot study (Kloppmann *et al.*, 2014) revealed the potential of multi-isotope fingerprinting of alabaster provenance, using a combination of sulphur, oxygen and strontium isotopes. Here we present an enlarged data base of isotope analyses of samples from known or suspected historical alabaster exploitations in France (Jura, Alps, Provence, Burgundy, Lorraine, Aquitaine, Paris region), Spain (Aragon and Catalonia), England (East Midlands/Nottingham region, Cumberland, N Yorkshire), Germany (Harz Mountain foreland). Strontium and sulphur isotopes appear to be particularly discriminative with a strong inter-site variability and intra-site homogeneity. Isotope ratios of both elements in seawater and associated evaporites have strongly varied over geological timescales (Claypool *et al.* 1980; Burke *et al.* 1982; Denison *et al.* 1998) so that W-European alabaster samples, ranging from Permian (Zechstein) to Miocene ages, show age-specific differentiation. Additionally, for both elements, non-marine sources such as sulphides, organic sulphur and strontium derived from mineral weathering provide basin- or sub-basin-specific signatures that further discriminate alabaster provenances. Oxygen isotopes provide supplementary evidence even if there is a stronger overlap of signatures. In conclusion, we consider that we have now an operational tool to distinguish the main alabaster sources for historical workshops in Western Europe. This methodology is currently applied to sculptures ranging from the 14th to 16th century from the Louvre Museum, Cleveland Museum of Fine Arts, the Petit Palais Museum in Avignon and several regional collections and monuments.

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