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Authors: Ferdinand Drünert, Eleni Palamara, Nikolaos Zacharias, Lothar Wondraczek, Doris Möncke

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Ancient Roman Nano-Technology: Insight into the Manufacture of Mosaic *Tesserae* Opacified by Calcium Antimonate

Ferdinand Drünert[a], Eleni Palamara[b], Nikolaos Zacharias[b], Lothar Wondraczek[a], Doris Möncke[c,d]

[a]*Otto Schott Institute of Materials Research, University of Jena, Fraunhoferstraße 6, D-07743 Jena, Germany* [b]*Laboratory of Archaeometry, Department of History, Archaeology and Cultural Resources Management, University of the Peloponnese, 24100 Kalamata, Greece*
[c]*Theoretical and Physical Institute, National Hellenic Research Foundation, 48 Vassileos Constantinou Avenue, 11635 Athens, Greece*
[d]*Department of Built Environment and Energy Technology, Linnæus University, Hus N 2086, 351 95 Växjö, Sweden*

Abstract

Opaque mosaic glass *tesserae* containing calcium antimonates from Ancient Messene, Greece (1st to 4th century CE) were investigated by scanning electron microscopy, Raman spectroscopy and X-ray diffraction. Both trigonal $CaSb_2O_6$ and cubic $Ca_2Sb_2O_7$, with crystallite diameters below 1µm, were identified as opacifying agents. To better understand ancient technologies, we prepared model glasses that were opacified by crystallisation via a secondary heat treatment, by direct crystallisation during the melting process, or by the addition of pre-reacted calcium antimonate to a base glass. We found that direct crystallisation replicated the antique glass artefacts most accurately.

We demonstrated that 0.2wt% of nucleating agents like TiO_2 and SnO_2 already exert significant influence on the crystallisation behaviour of calcium antimonates. Secondary scattering centres such as silicates and carbonates contribute to the optical appearance. Concurrently, we reproduced opaque white glass ceramics in a reconstructed, wood-fired, Roman-type glass furnace built by Wiesenberg et al. (2014).

Keywords: Roman Glass Mosaics
Opacification
Calcium Antimonate
Mosaic Tesserae
Nucleation

1. Introduction

One of the earliest applications of manmade glasses was decorative; they were used as brightly coloured materials, in some instances substituting equally precious gemstones [1]. Many inorganic dyes which are found in glasses had already been used earlier in ceramic glazes. However, calcium antimonates appear to have been