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Importance of optical microscopic investigation in provenance studies and quality characteristics of both historical and natural Lower *Globigerina* building limestone of Malta

Значение на оптичномикроскопското изследване при проучване на произхода и качествените характеристики на исторически и на естествени долноглобигеринови строителни варовици от Малта

Elena Koleva-Rekalova[1], Lino Bianco[2]
Елена Колева-Рекалова[1], Лино Бианко[2]

[1] Geological Institute, Bulgarian Academy of Sciences, Acad. G. Bonchev str., bl. 24, 1113 Sofia, Bulgaria;
E-mail: e_koleva@geology.bas.bg
[2] University of Malta, Department of Architecture and Urban Design, Faculty for the Built Environment, 2080 Msida, Malta;
E-mail: lino.bianco@um.edu.mt

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Introduction

Several megalithic architectural structures dating to the Neolithic Period as well as many early Baroque buildings were constructed from limestone extracted through open-pit mining from the Lower *Globigerina* Limestone of the Maltese Islands (Bianco, 2018). The Lower *Globigerina* Limestone Member is the oldest member of the *Globigerina* Limestone Formation, widely cropping out in the Maltese Archipelago. It is composed of massive, pale yellow in colour limestone that contains tests of globigerinid planktonic forminifera (Pedley, 1974). Limestone quarried from this member has been used as a building stone since time immemorial (Bianco, 2017). Being soft and porous and constantly exposed to atmospheric influences and weathering, the subsequent deterioration of this limestone significantly damages historical monuments. Different methods are used to study its properties, one of which is optical microscopic investigation (thin-section analysis) (Bianco, 2017, 2018). The objective of thin-section analysis is to investigate the texture, porosity and permeability, important properties of a given limestone, which have a bearing on its durability and weathering characteristics. Such investigation is particularly useful when rocks are fine-grained or strongly weathered (Dreesen et al., 2006).

The objectives of the present study are to petrographically investigate Lower *Globigerina* Limestone samples from sites in Malta (first and second quality-type limestone from a quarry, a church and samples from outcrop located in Msida that contain blue lenticular patches) and to characterize their peculiarities. All thin-sections were examined using light transmitting microscope "Zeiss Axioscope 40". Photomicrographs were taken with a ProgRes GT3 digital camera.

Results, discussion and conclusions

The studied limestones are mudstones, wackestones and packstones with matrix-supported texture. The first quality-type is represented by *Globigerina*-bioclastic packstone (Fig. 1a). Echinoid bioclasts prevail and their sizes are less than 0.5 mm, rarely up to 1.5 x 0.5 mm. Planktonic *Globigerina* and benthic foraminifera also exist. There is a relative enrichment of glauconite grains. Single clastic quartz grains are observed. The packstones possess a greater porosity – intraparticle and vuggy. The second quality-type represents *Globigerina* wackestone (Fig. 1b) in which the micrite matrix predominates over allochems. Planktonic *Globigerina* and benthic foraminifera occur. Bioclasts are observed, but their sizes are significantly smaller than those in the first limestone type. The porosity is also reduced. The church building stone is *Globigerina* wackestone. Planktonic *Globigerina* are the main allochems and they are very characteristic of this limestone formation (Fig. 1c). Commonly, their chambers are empty thus forming intraparticle porosity; the bioclasts are very rare with sizes smaller than 0.25 mm. Single echinoid fragments possess syntaxial overgrowths. The terrigenous constituents are sporadically presented and of insignificant sizes. The outcrop located in Msida is composed of *Globigerina* bioclastic wackestone, *Globigerina* wackestone and *Globigerina* mudstone.

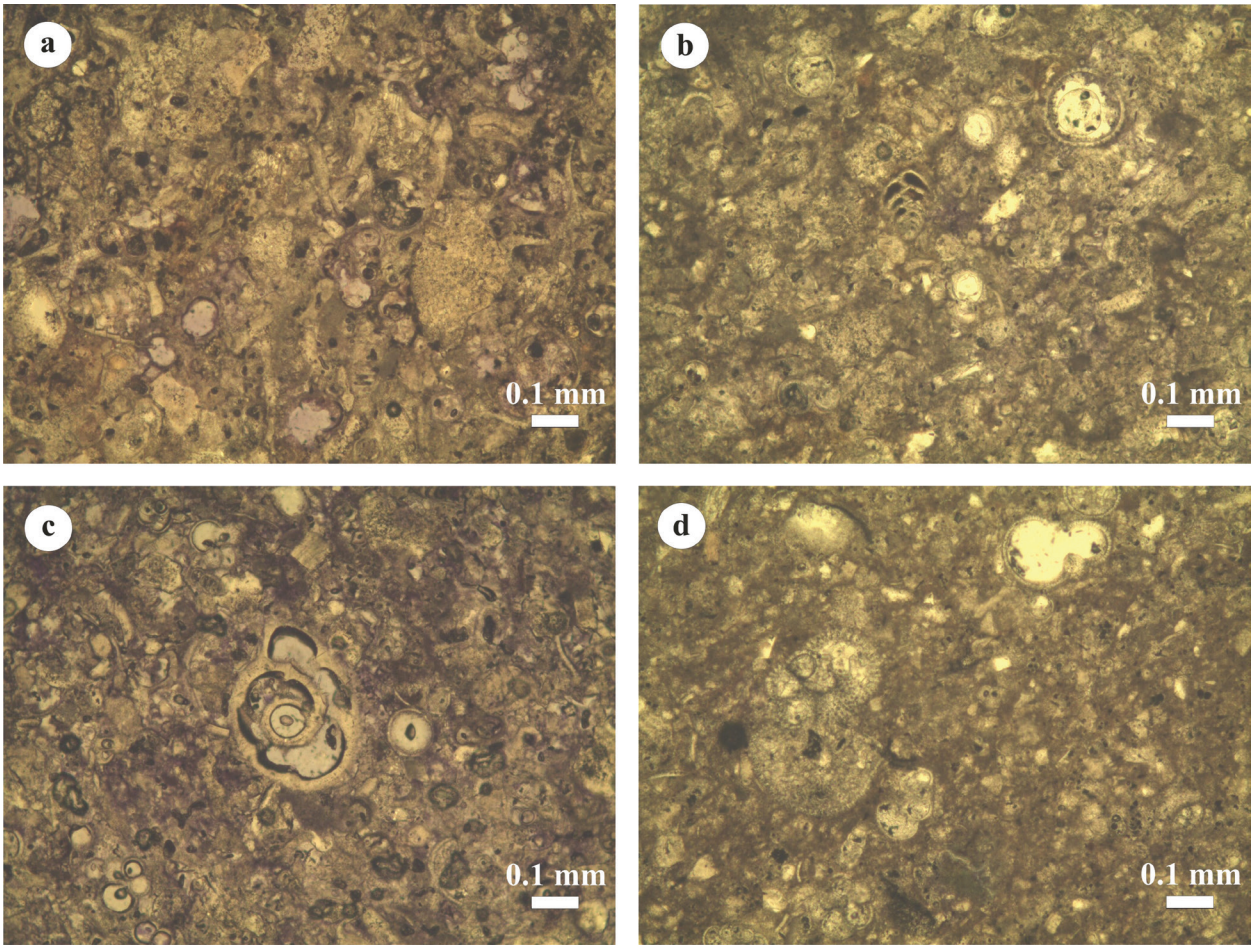

Fig. 1. Microphotographs (plane-polarized light) of the Lower *Globigerina* Limestone: *a*, first quality type; *b*, second quality type; *c*, church material; *d*, outcrop sample, Msida

The most widely occuring characteristic component is the presence of *Globigerina* tests (Fig. 1d).

The microscopic study shows that the first quality-type Lower *Globigerina* Limestone consists mainly of echinoid bioclasts (Fig. 1a) and possesses a greater porosity. This makes the limestone softer and easier to work. At the same time, the greater porosity leads to accelerated deterioration of limestone utilised in historical monuments. The church building limestone contains very characteristic *Globigerina* tests (Fig. 1c) which would help to determine its provenance by using comparative analysis. The appearance of blue lenticular patches in the outcrop in Msida is not related to the textural differences (mudstone, wackestone and packstone) of the studied limestones as suggested by Bianco (2018).

The present study proves that the optical microscopic investigation of the Lower *Globigerina* Limestone is important for determining its provenance, quality and some of its peculiarities.

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