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Research Article

Petrographic Investigations on Stone Materials of Modern Mosaic Tiles

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Abstract

Mosaics in Italy represent an important historic-artistic patrimony, and since the last century a renewal of interest for mosaic-manufacture induced a flourishing industrial activity appreciated world-wide. We studied fifty lithologies, ranging from sedimentary to metamorphic and magmatic rocks, used in mosaic manufacture in the Ravenna area. We recognized that only thirty-two of these lithologies were used in mosaic-making laboratories; in particular, we focused our attention on the sedimentary-carbonate lithotypes, characterizing their palaeontological features. This petrographical approach could also be useful for archaeometric purposes in order to find out suitable methods and procedures in restoring activities of ancient mosaics.

Introduction

The Ravenna mosaic has reached levels of excellence constituting one of the economically driving sectors of our country [1]. In the city of Ravenna, the craft activity has been kept alive and in the last century the industrial one has developed stimulated by an experimental phase of artistic evolution, with the introduction of tesserae obtained with new stone materials [2,3]. Through procedures of fragmentation and juxtaposition of small tiles, the peculiar system of expression of mosaics is created, a technique that falls within the vast category of multi-material decorations [4,5]. The chromatic range offered by natural stones is surprisingly vast such as blue, bright yellow, sea green, bright red. Over time, a selection of the most suitable materials has been verified to enhance the artistic motif and to reacquire the original chromatic characteristics, removing any layer of alteration and polishing the surfaces.

The prior characterization of the tesserae becomes essential to define: - the lithologies used in the various eras, the composition of the pigments, the processing methods, and the supply areas to describe the technologies used to obtain all the essential data to competently deal with restoration and / or refurbishment interventions [6,7]. The analysis of the proposed mosaic tiles was preceded by the collection of the materials used by the numerous craft shops and the stone industry of Ravenna. This activity made it possible to identify the lithologies used and therefore the representative samples to be submitted to the petrographic and paleontological study.

Materials and Methods

From the census of mosaic industries, fifty lithologies were found. Although Ravenna (Emilia Romagna region, north-east of Italy [8] is located near two of the most important marble districts in Europe Verona and Carrara, as shown in (Figure 1), where marbles from all over the world are processed, the artisans remain faithful to the materials used by their ancestors. The petrographic study was performed on 32 rocks (19 organogenic limestone, 1 travertine, 8 marbles, 2 oficalcites, a granite and a porphyry) and on 50 lithologies of recent industrial activity (26 limestone, 5 travertines, 9 marbles, 3 oficalcites, 5 granites, a porphyry, and a quartzite). The prevalence of sedimentary lithologies, mostly carbonate, is less marked due to industrial activity which has introduced mainly silicate rocks confined in historical times to particular artistic needs. The pigments were identified using a reflection optical microscope (Leica IM 1000) [9]. The classification of the lithologies was performed with the integration of compositional data obtained by X-ray fluorescence analysis (XRF) with a wavelength dispersion spectrometer ARL Advant-XP (Thermo Fisher Scientific, USA) [10].

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For carbonates, the determination of the carbon dioxide content was also performed. All sedimentary materials were also classified through a paleontological study on thin sections by an Optical Transmitted Light Polarized Microscopy (BX51 Olympus) [11].

Figure 1: Map of the sampling site: a) and b) examples of modern mosaic tiles investigated.

Results

Microscopic observation highlights color differences due to the presence of main minerals or minutely diffused coloring pigments. The rocks can have a single and uniform color or two or more distinct colors. The minerals that give the white color are calcite, dolomite, gypsum, anhydrite, feldspar, and light micas; quartz is colorless; orthoclase can take on pink, red or brown - purple hues due to the pigmentation of iron oxides, as in granite or syenites; light green chlorite, antigorite, and epidote; light gray labradorite; blue glaucophane, sodalite, blue quartz; black or dark green biotite, amphiboles, and pyroxenes [12]. The following pigments have been recognized:

a. Organic are black (carbonaceous or bituminous) or straw yellow (humic or cellulosic); the carbonaceous and bituminous pigments make the limestone black (Figure 2a).
b. Limonite-hematitics depending on the percentages of limonite and hematite there are yellow-reddish, orange, pink as the degree of hydration decreases (Figures 2b, 2c and 2d).
c. Green silicates represented by phyllosilicates. We find chlorite and biotite in metamorphic limestone lined with green, glauconite in normal ones mottled with green (Figure 2e).

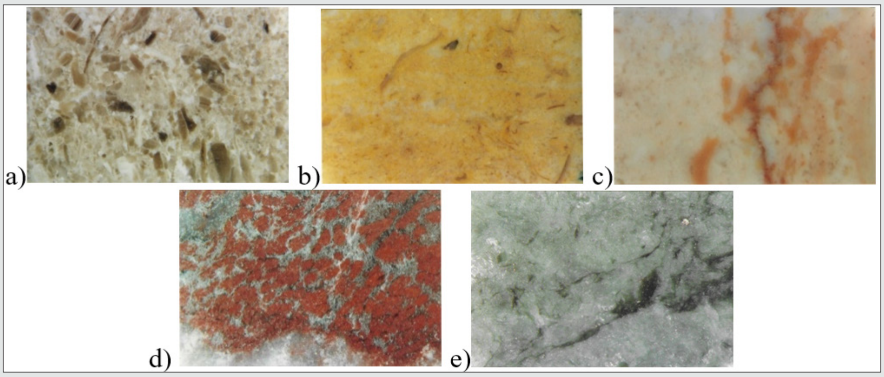

Figure 2: Photo imaging obtained by optical microscope at magnification 9x: a) organic sample; b) limonite-hematitics sample; c) limonite-hematitics sample; d) limonite-hematitics; e) green silicate.

The least stable pigments are black organics, which fade by oxidation of the organic substance that evaporates together with CO_2. Red or pink colors due to the presence of pigment of iron oxides (hematite, limonite) lighten due to their progressive hydration. Minerals with divalent iron can become stained with rusty patches due to iron oxidation. Sedimentary rocks are mainly carbonate with iron oxides and bituminous substances present as aggregates and single crystals, as glauconite, pyrite, quartz and feldspar, or, finally, be segregated in nodules and concretions, as for flint and pyrite. The main components of carbonate rocks are:

a) All chemical components (bioclasts, intraclasts, peloids, oolites, pisolites, algal nodules) often mixed creating granular and porous framework.
b) matrix: microcrystalline sediment or micrite may be absent or fill the voids located into the frame.

c) cement represented by spathic calcite with larger crystal size (5μm-1mm).

In accordance with the relative abundance of the microcrystalline sediment and spathic calcite, the studied samples were evaluated belonging to the following groups:

Sparitic-allochemical limestone (sparitic cement with >10% allochemicals): Accumulation of allochemical granules (50-60%) cemented by spathic calcite. The beige color represents limestone devoid of pigmentation (Figure 3a). Calcite appears both in fragments and of sparitic cement. The allochemical components are in contact with each other [13].

Micritic-allochemical limestone (micritic matrix with >10% allochemicals): Immersed in a microcrystalline carbonate sediment as a matrix; spathic calcite is strongly subordinate or absent (Figure 3b). Porosity is absent. The allochemical components include micrite and peloids; others are fragments of broken bioclasts difficult to identify.

Micritic limestone (micritic matrix with <10% of allochemicals): Microcrystalline carbonate sediment with allochemical granules without spathic calcite [13]. The samples are characterized by fine-grained, homogeneous, and compact rocks and quite uniform in color (Figure 3c). Some have hollow cavities or are lined with calcite crystals, while others appear free of vesicles and pores. Microscopic investigations show micritic matrix containing 1-10% of allochemical components and subspheroidal concentrations of ferrous pigments. Porosity is almost absent.

Microsparitic and biomicrosparitic limestone: Uniform and equigranular texture with particle size between 5-15μm instead of 2-5μm (Figure 3d). This relatively coarser material probably represents an appealing recrystallization of microcrystalline matrix. These rocks have been classified as Microsparites and Biomicrosparites [13].

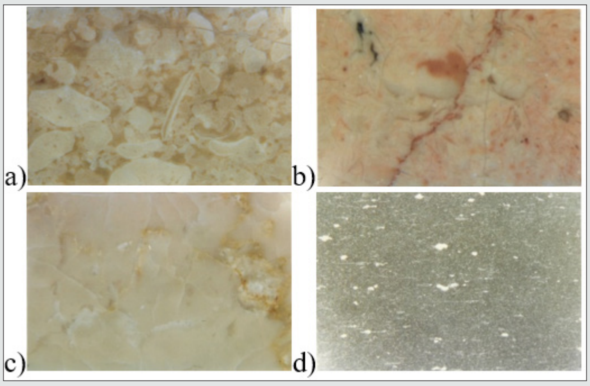

Figure 3: Photo imaging at magnification 9x: a) Sparitic - allochemical limestones; b) Micritic - allochemical limestones; c) Micritic limestones; d) Microsparitic and biomicrosparitic limestones.

Conclusion

From the study of modern mosaics and the stone materials used for their construction, some considerations emerged:

a) In the mosaic the color becomes important. The samples studied offer a varied chromatic scale.

The prevalence of the use, in modern mosaic, of sedimentary rocks, mostly carbonate, is evident due to their widespread diffusion in all continental areas and therefore in their easy availability, in their good technical characteristics (good workability and polish ability mainly due to the fine grain and the low hardness value of calcite) and in the wide range of colors they present.

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