Biological degradation of glazed ceramic tiles

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ABSTRACT: Tilling is one of the most sophisticated techniques used on architectural surfaces. It plays a role of great importance in the study of the Brazilian–Portuguese cultural heritage. Although ceramic tiles are highly resistant to temperature changes, due to manufacturing-related issues, they are susceptible to natural environmental causes. The objective of this paper is to identify degrading agents that cause stains and interfere negatively in the design of panels exposed to the open air – a frequent phenomenon in tropical and sub-tropical areas. The use of X-ray diffraction (XRD) allowed the mineralogical categorization of the samples. Optical microscopy was used to identify cracks and microflora. The presence of *Cyanophita* and *Bacillariophita* algae was identified in samples from Belém (Pará) and Salvador (Bahia). The glazing width, irregularity, and origin are discussed.

1 INTRODUCTION

Tilling is one of the strongest cultural ties uniting Portuguese and Brazilians. Its presence in Brazil is due to the Portuguese custom of coating certain walls with this material in a noble way. They are frequently treated iconographically with illustrations of great aesthetic value. Faithfully following the Portuguese trend, Brazilian architecture includes many tile panels of pleasant iconography. These tile panels have artistic value and are very important for historical research since they depict scenes of times past. The cultural value of tile panels is certainly one of the main reasons for their preservation. The city of Salvador (Bahia) has the honor of housing many buildings with large tiled surfaces. One of these buildings is the St. Francis Church and Convent that, according to prominent scholar Santos Simões, has approximately 2.500m^2 of ceramic tile walls. The city of Belém (Pará) has equally large tiled surfaces, especially on the façade of its buildings.

Tiles are ceramic artifacts of reasonable resistance and durability due to their nature and manufacture. However, they often suffer from salt crystallizing problems. This crystallization, which is the greatest agent of destruction, attacks porous materials, especially those from old buildings, through scaling that expel the vitrification and the drawing that characterize the aesthetic instance of the piece.

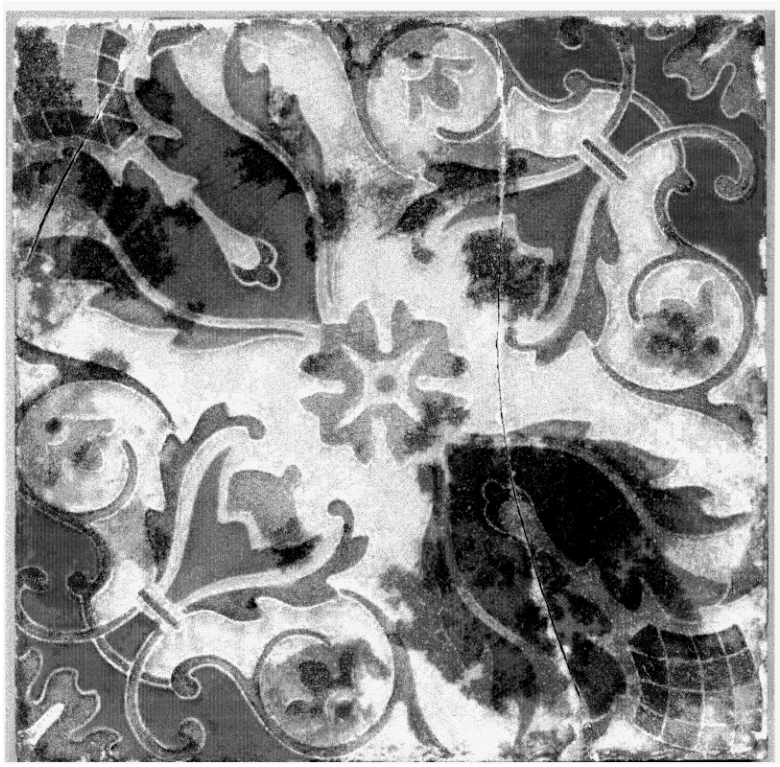
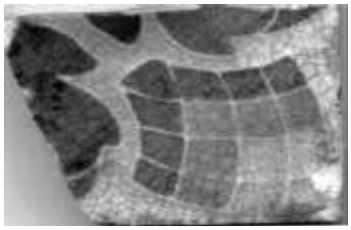


Figure 1 – The tile on which some dark stains were observed due to algae colony formation under the glazed surface.

Technical records of the tile			
1- Origin	Country: Germany	Manufacturer: Villeroy & Boch	Date: 19th Century
2-Localization	External coating of the façade of "Palacete Pinho", in Belém (Pará), Brazil		Fragment with craquelure
3-Dimensions	Length and width: 17.5X17.5cm Thickness including the glazing: 1.12 cm Vitrification (irregular): from 0.04 to 0.21 mm Micro-organisms affected area: from 0.04 to 0.8mm thick		
4-Technique	Half embossed work with painting applied directly on the ceramic part, covered with colorless glazing.		
5-Measurings	Color of the paste (Munsell table): HUE 2.5y N8/white Total water absorption: 11.50% Density: 1.90g/cm^3 Presence of soluble salts: NaCl (little)		

In Brazil's coastal cities – especially in Salvador (Bahia) – the salty spray from the ocean and the highly humid tropical climate cause the spreading of living organisms. These organisms range from plants (whose roots find their way between tile and substratum), to fungi, algae, and bacteria that contribute to the degradation of the tiles, particularly to those found on external walls and consequently more exposed to the weather conditions.

The main objective of this research is to identify the pathology that causes dark stains on the tile drawings and damages the glazed surface and the drawings in addition to creating problems for preservation. This specific physical damage, on the other hand, will be the objective of

future research. Scanning electronic microscopy (SEM) can be used in future research to analyze the interaction of the glazed surface with the ceramic surface.

First it was observed that the deterioration happened more often on some types of tile, especially when the technique decalcomania was used in the manufacture of nineteenth-century ceramic tiles. Deterioration was also prevalent on tiles with a thinner opaque glaze where craquelures allowed microorganisms to spread through the micro-fissures.

The B1-A sample contains a white "biscuit" with the following mineral constitution: quartz, mullite, cristobalite, calcite, and anorthite. The presence of calcite may be attributed to the lime migration from the mortar to the pores of the tile.

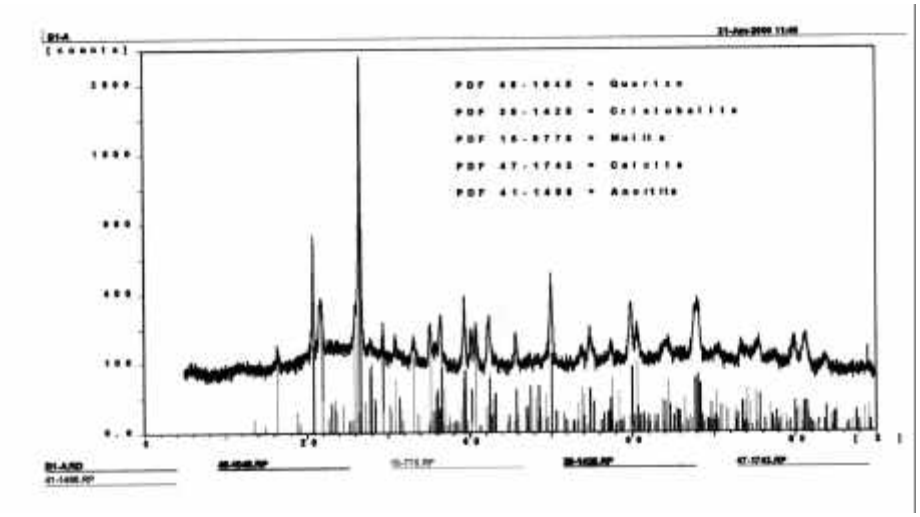


Fig.ure 2. XRD Graphics

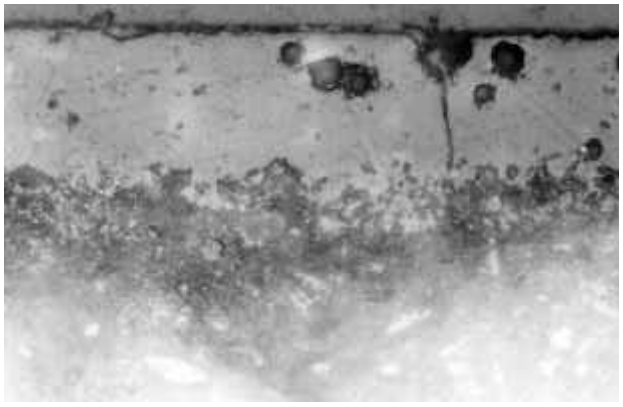


Figure 3. Microphotography at a petrographic microscope of the polished section of a tile sample.

Fissures can be observed on the glazing, and under it in the porous body of the "biscuit", it is possible to find an algae colony installed forming a dark stain (fig. 3) The round shapes are air bubbles from the original glazing.

2 IDENTIFYING MICRO-ORGANISMS

Cyanophyta (*Cianoficae*), and *Bacillariophyta* (*Diatomacae*) algae were found. It was only possible to identify them as a class. The following table shows the occurrence of "taxons" found per sample:

Table 1 : Occurrence of “taxons” found per sample

Samples	Taxonomical	
	Cianoficae	*Diatomacae*
B1-A	*Chroococcus sp1*	-
	Chroococcus sp2	-
	Cyanosarcina sp	-
	Scytonema sp	-
B1-B (sample 1)	*Chroococcus sp*	*Navicula sp*
B1-B (sample 2)	*Chroococcus sp* *Scytonema sp*	-
B2-A	*Chroococcus sp*	-
B3	*Chroococcus sp*	-
S1-L*	*Chroococcus sp*	-
S7-A*	*Chroococcus sp*	-
S7-B*	*Chroococcus sp* *Lyngbya sp*	*Navicula sp*
S7-C	*Chroococcus sp* *Lyngbya sp*	-

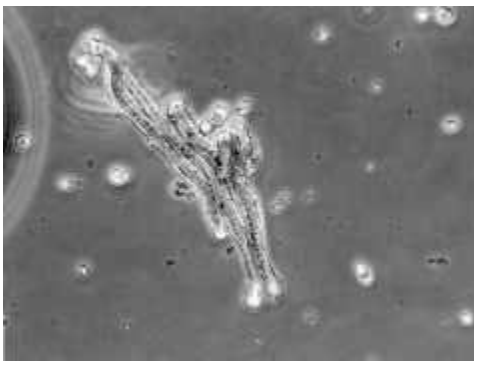


Fig. 4. *Scytonema* sp.

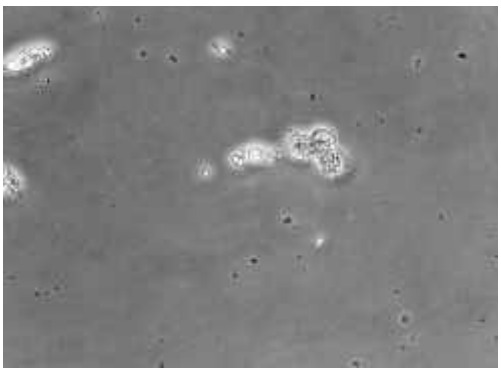


Fig. 5. *Chroococcus* sp.

3 CONCEPTUAL AND TECHNICAL ASPECTS OF CLEANING

All technical and scientific problems in restoration run parallel to theoretical and conceptual problems. A technical solution that initially seems good cannot always be applied, because it may interfere with basic principles of the modern conservation culture. Due to this proposal to solve the problem of stains that are found on the original substratum, it is necessary to reflect upon the appropriate action.

As one reflects on tile conservation, the expert opinion of Cesare Brandi is recalled. He admits that according to the condition of the piece, part of the “material consistence” can be sacrificed for the benefit of the “aesthetic instance” (Brandi, 1996). This means that Brandi recognizes that to preserve a piece of art it is necessary to decide on the value scale that will determine the sacrifice of one part in order to save another more important part. In the case of tilling, it seems obvious that the work of art is on the drawing and in the different shades of color on the tile surface; the “biscuit” (or “chacota” in Portuguese) is the support and will be considered secondary as a cultural value. The mortar that is under the tiles is the substratum of the substratum of the drawing. Within a value hierarchy the mortar should rank third. It is fair to think that this part can be sacrificed if the integrity of the work of art is threatened. If this cannot take place, restoration needs to be abolished from the techniques of replacement of canvas, “strappo”, “parchettaggio,” etc.

It should be mentioned that other less drastic methods for stain removal that impact upon the glaze present difficulties, because glaze tiles make traditional cleaning methods difficult. The only process that was really effective was the removal of pieces from the wall to be treated and later reapplied. The most common technique used so far has been re-burning, a technique that makes the organic vestige disappear, provided careful attention is given to the temperature of the kiln, that must stay below the temperature of the glaze and drawings, always lower than that of the "biscuit". Carelessness here can result in melting the glaze and altering the color of the painting. In this case successive burns were made, in a kiln, with increasing temperatures, being as prudent as Sanpaolesi always advised. The stain was removed when the temperature reached 550^{o}C. On craft tiles the experts used temperatures at around 900^{o}C and on the manufactured pieces even higher temperatures. This way the re-burn that was used for cleaning the tiles was done at lower temperature, preventing damages to the drawings and color of the painting.

4 CONCLUSIONS

The presence of stains on the tiles negatively interferes with the drawings on the piece. There is also evidence that invasion of algae on the irregularity of the glaze could irreversibly damage the piece. The technique applied to remove the stains, followed by a coat of "paraloid" (technically reversible material) to seal the cracks, to certain extent avoid the development of new colonies of organisms. This is a recommended procedure for tile panel preservation.

It was also observed that the phenomenon above described is more frequent in the nineteenth-century tiles. These tiles have a more uniform but thinner glaze with a larger number of craquelures. For this reason, these tiles provide the perfect environment for the proliferation of microorganisms since they combine the essential elements for their survival: light and humidity.

However, algae were also found on handcrafted seventeenth-century tiles (sample S7-B) and on manufactured tiles of the 19th century. The latter have no correlation to the colorless glaze technique but to the majolica technique, i.e., painting on a white tin lead oxide (sample S7-A and S1-L). In these cases the dark stain behind the glaze does not occur because the glaze is thicker and has a color that stops light from getting through. The algae can be found in the larger, deeper fissures that reach both the glaze and the "biscuit," excluding the fissures called craquelures that reach only the glaze. The technical literature on rocks by Caneva, Nugari and Salvadori (1991), and WEE and LEE (1980) refers to many microorganisms. Some of them were found on the tiles of Belém and Salvador.

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