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Microanalyse
Sciences des Matériaux Anciens et du Patrimoine - Etude des objets d'art

STUDY OF AN ABBASID BLUE GLASS PLATE

Assumed provenance and period: Iran, Syria, Abbasid, 10^{th}-11^{th} century

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NOTICE

The purpose of this study, performed following established norms of scientific integrity, is to carry out scientific investigations to provide analytical data concerning the manufacturing mode of the studied cultural property, the possible weathering of its constitutive material, either natural or artificial and to characterize the deposits or surface treatments on the object.

The investigations based on optical examination and physicochemical analyses of samplings of the object; follow the methods briefly described in the report, which are long-standing standards and protocols employed by the scientific community.

Comparison of the results obtained with the data actually available in the scientific community allows concluding if the physical evidences of the object are consistent or not with its supposed origin and period of time.

These scientific investigations are carried out not taking into consideration historical research, iconography and stylistics statements about the object. Information about provenance, period or attribution of the cultural property are under the responsibility of the owner or its authorized agent and written in the report only as indication. However, this given information is used in the discussion for final statement.

OBJECTIVES

Study of a blue glass plate with incised decoration (Ø : 22,8 cm)
Assumed provenance and period: Iran, Syria, Abbasid, 10^{th}-11^{th} centuries

Analysis of the manufacturing technique, the material from which the object is made, weathering, and any surface deposits, for determining whether it was subjected to natural, long-term weathering, compatible with its assumed age.

SYSTEMS USED

Stereomicroscope; Scanning electron microscope (SEM) with back-scattered electron (BSE, composition contrast) and secondary electron (SE, topographical contrast) imaging coupled with energy-dispersive X-ray element analysis (EDX).

SAMPLES

Microsamples of the base material of the object and its surface deposits were analysed.

- **P1** is a glass fragment from bubbles walls at the underneath of the plate;
- **R1** is a replica of the bottom side of the plate, on iridescent white and brown crusting;
- **R2** is a replica taken from the inner rim of the plate, on incised decorations.

All the samples were carbon coated for the SEM examination. This operation is partly responsible for the carbon (C) peak observed on the elementary X-ray spectra.

STUDY RESULTS

This study examined the technique used to produce the object, the type of glass from which it was made, any weathering and visible surface deposits. Inspection and analyses revealed that:

- The plate is made of soda-lime-silicate glass; the soda was obtained from plant-ash. It contains some lead. Its composition is comparable to scratch-decorated plant-ash soda Islamic glasses.

- The glass plate was blown and worked by filing and polishing before scratching. The scratching was performed with a very sharp tool.

- The whole surface of the plate shows evidence of weathering, essentially by pitting and formation of a thin multilayered iridescent crusting. There is a compositional variation between the superficial layers and the bottom layers resulting from surface leaching of sodium, calcium, potassium, magnesium and lead and exchange with a burying environment.

- Observation of areas where the crusting has flaked-off and the dark-blue colour is visible shows evidence of overall pitting weathering.

These characteristics are compatible with the object's assumed origin and age.

- Some calcium-rich material (soft abrasive from a cleaning process?) is observed on the plate surface.

1 - PRELIMINARY OBSERVATIONS

The plate has a slightly different appearance between its front and its back.

On the back, the glass shows numerous tiny bubbles (Fig. 1b, B) and fine parallel grooves (Fig. 1a and b, arrows). The bubbles are indicative of glassblowing and the grooves are the result of coldworking of the back of the plate by filing very probably to ground and flatten the vessel.

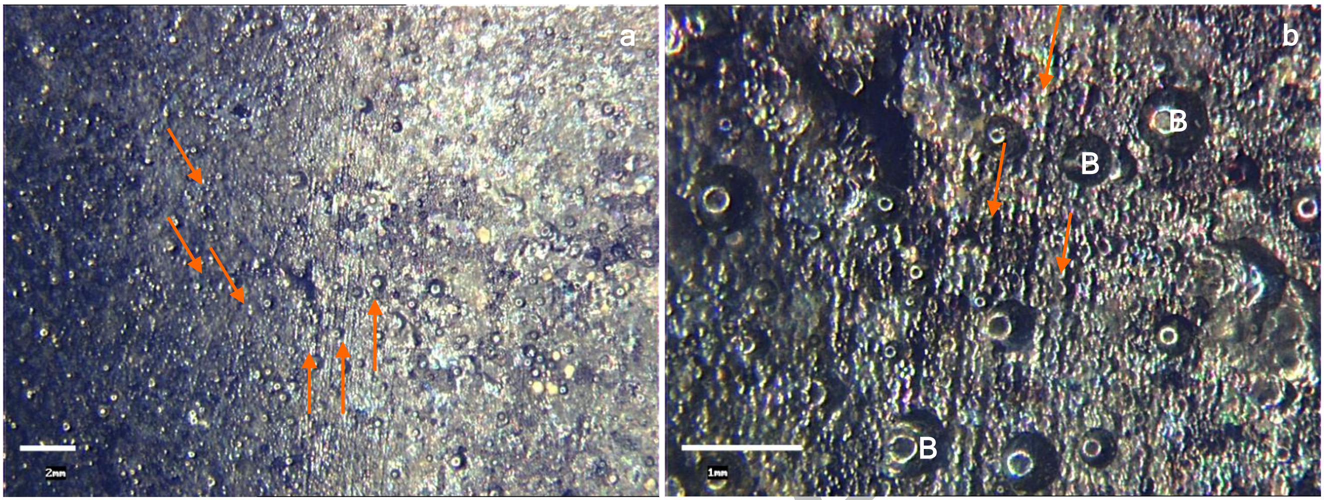
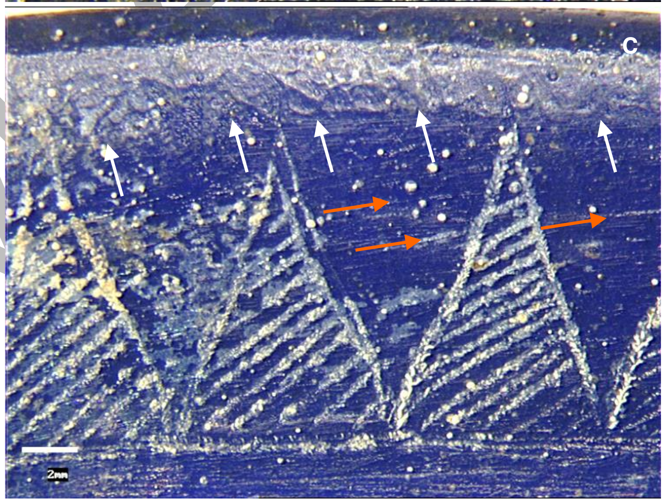


Figure 1: Detail views of the plate (stereoscopic microscope, **a**- x 5 , **b**- x 44 , back of the plate, **c**- x 5, edge, front of the plate).



On the front, the bubbles are less numerous, and the surface is smoother, more polished, with less filing grooves (Fig. 1c, orange arrows). This difference could be evidence of pressing process in an open mold.

The slight network of impression marks on the rim on the front of the plate (Fig. 1c, white arrows) could be remains of this pressing process.

After the pressing, the inside of the plate must have been finely polished, before decorating its surface by scratching (Fig. 2a).

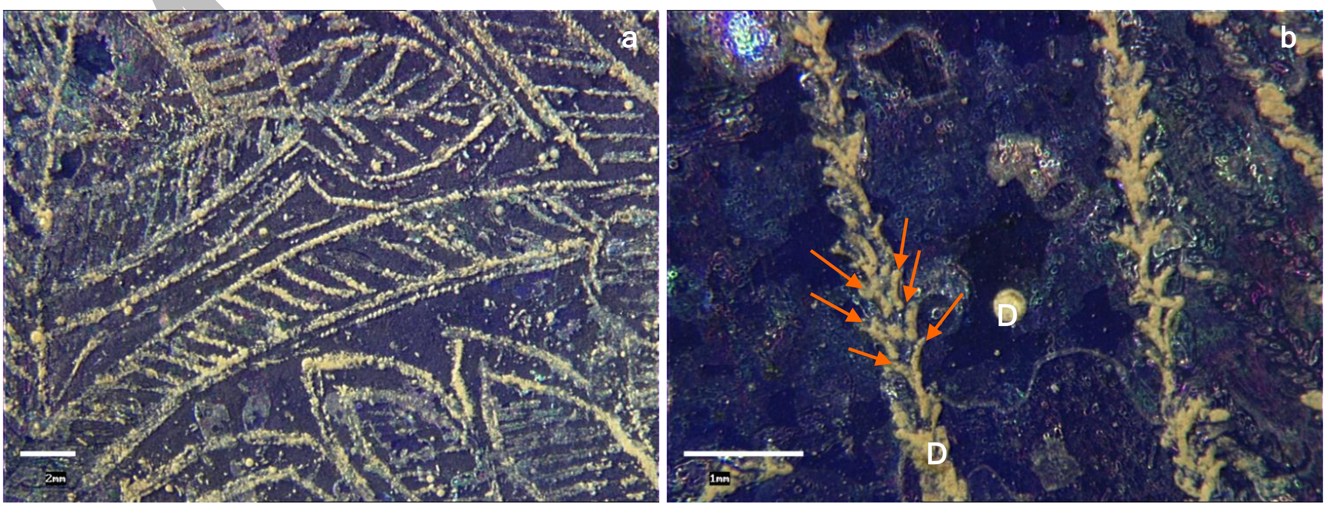


Figure 2: Detail views of the scratched decoration (stereoscopic microscope, **a**- x 5, **b**- x 21).

The thin lines, made by tiny repetitious incisions, sometimes in a herringbone motif (Fig. 2b, arrows), could have been achieved with a very sharp point.

Some fine-grained beige deposit is present in the recesses of the surface, as the scratching or the bubbles (Fig. 2b and Fig. 3b, D).

The glass surface shows thin superficial iridescent to blue pale layers, which flake off (Fig. 3a and b, arrows).

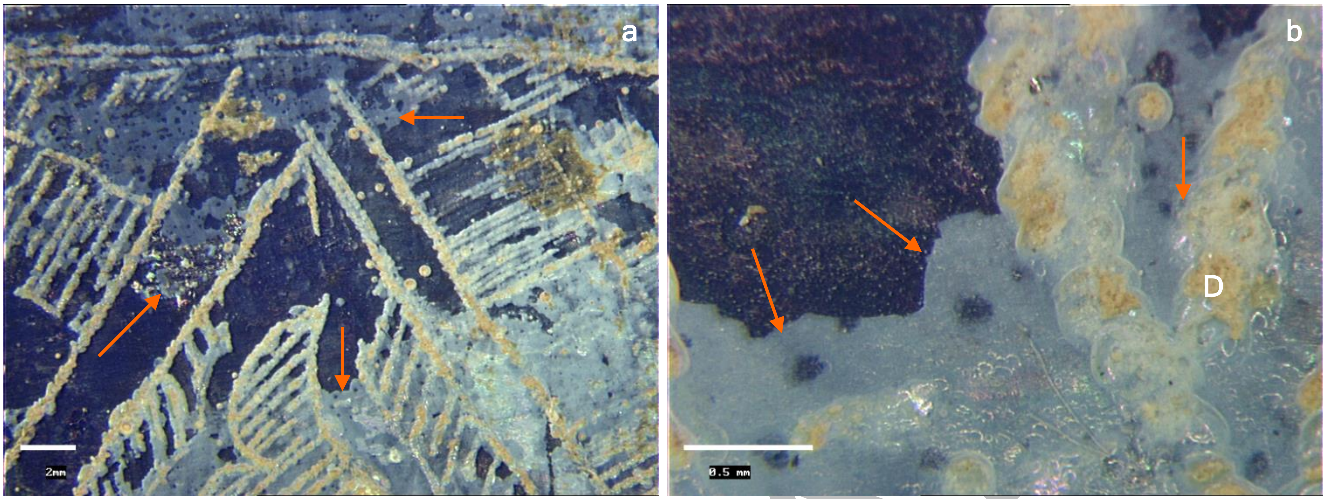
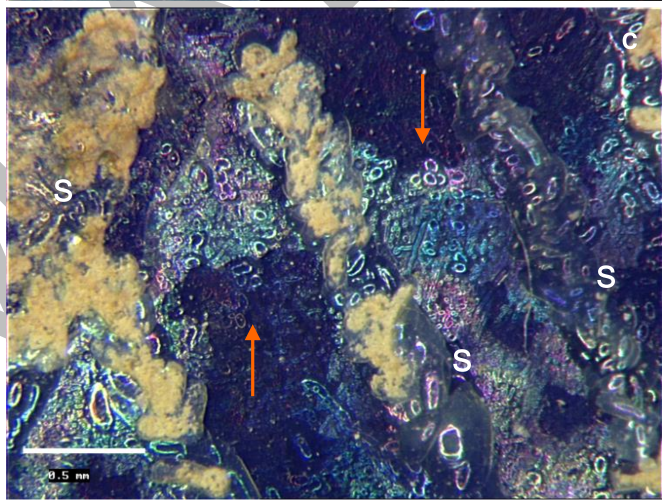


Figure 3: Detail views of the front of the plate (stereoscopic microscope, x 5).



In the dark-blue areas, where the layers have flaked off (Fig. 3c), the iridescent aspect is still visible and reveals the fineness of the scratching process (Fig. 3c, S).

Some very fine pitting of the glass surface is observed in the plain areas between the scratching (Fig. 3c, arrows).

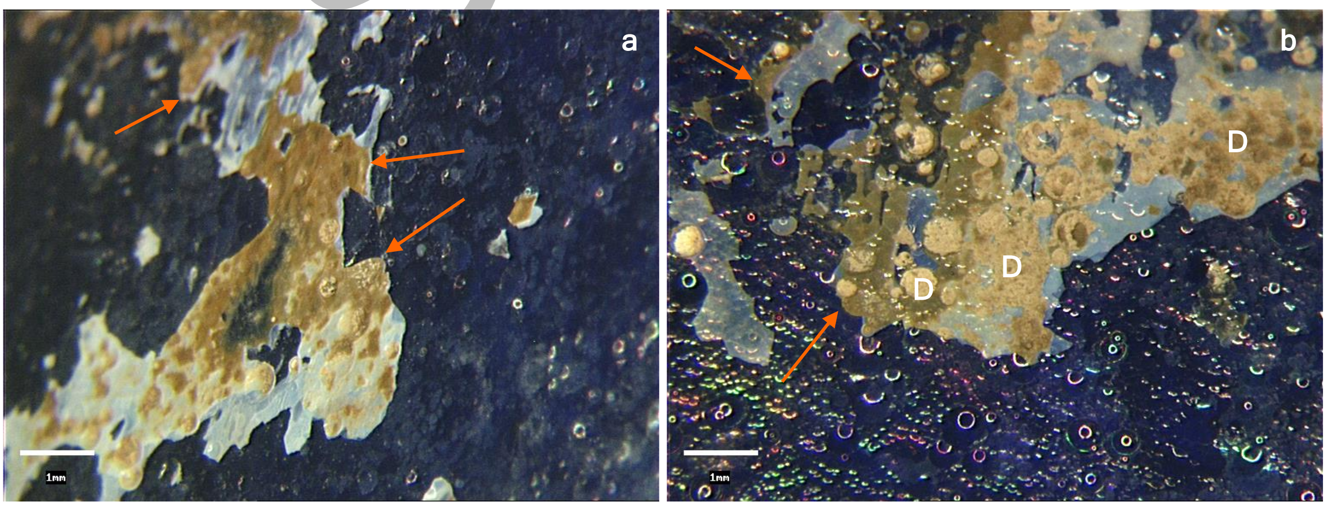


Figure 4: Detail views of the rear of the plate (stereoscopic microscope, **a**- x 5, **b**- x14).

The back of the plate has been probably less cleaned and shows thicker superficial layer, resulting in some parts in the formation of a brown crusting (Fig. 4, arrows). This crusting is covered by the beige mineral deposit (Fig. 4b, D).

2 - ANALYSIS OF THE SAMPLES

The glass

The micro sample was taken underneath the plate, from an area with three adjacent bubbles (Fig. 5a, square), allowing to take only fragments.

Semi quantitative EDX analysis (Fig. 5b) was performed directly on the glass fragments and not on a polished cross section so this result must be considered as only estimation of the composition.

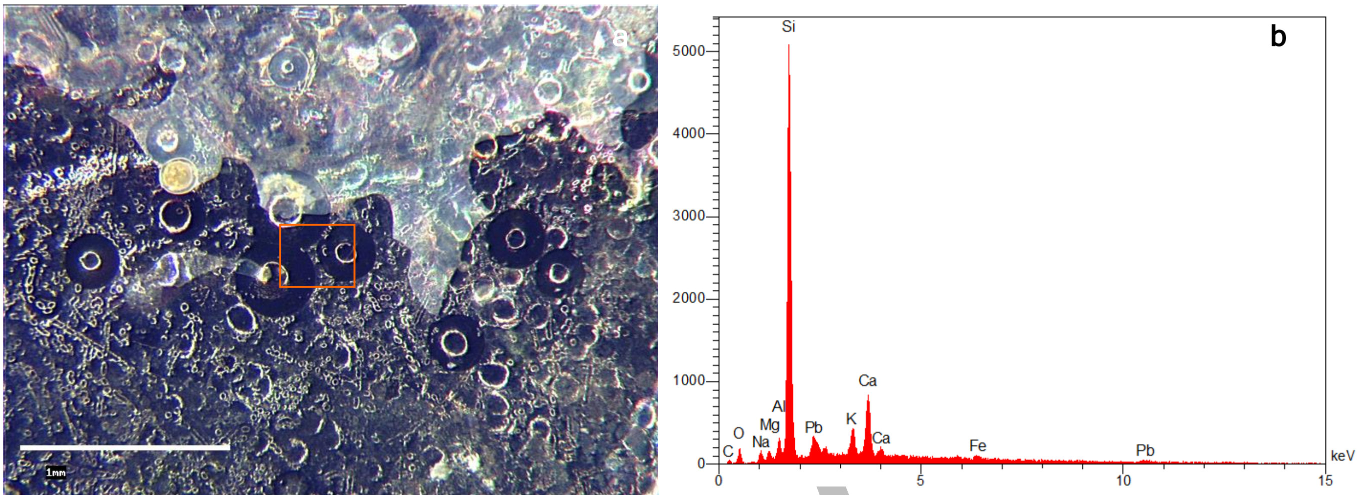


Figure 5: Location of sample P1 (**a**- stereoscopic microscope, x 34) and EDX analysis spectrum (**b**-) of one of the glass fragment.

The results are listed in the table 1 below (% oxide of each element):

The experimental conditions were as follows: accelerating voltage V=30KV, acquisition time T=50 seconds, working distance WD=15 mm, area examined x 500. The results obtained are expressed as an elemental atomic percentage [also known as percentage composition] normalised to 100%.
For EDX analysis, the detection threshold is deemed to be of the order of 1000ppm and measurement accuracy is of the order of 1% for the major elements under optimum conditions.
Elements that were not detected and those of which the levels detected were less than or equal to the uncertainty of measurement have been flagged using the abbreviation "nd" (for "not detected"). For such elements, when the levels measured are less than 1%, the fact that a value is listed is first and foremost an indication that the element is actually present in the sample in question.

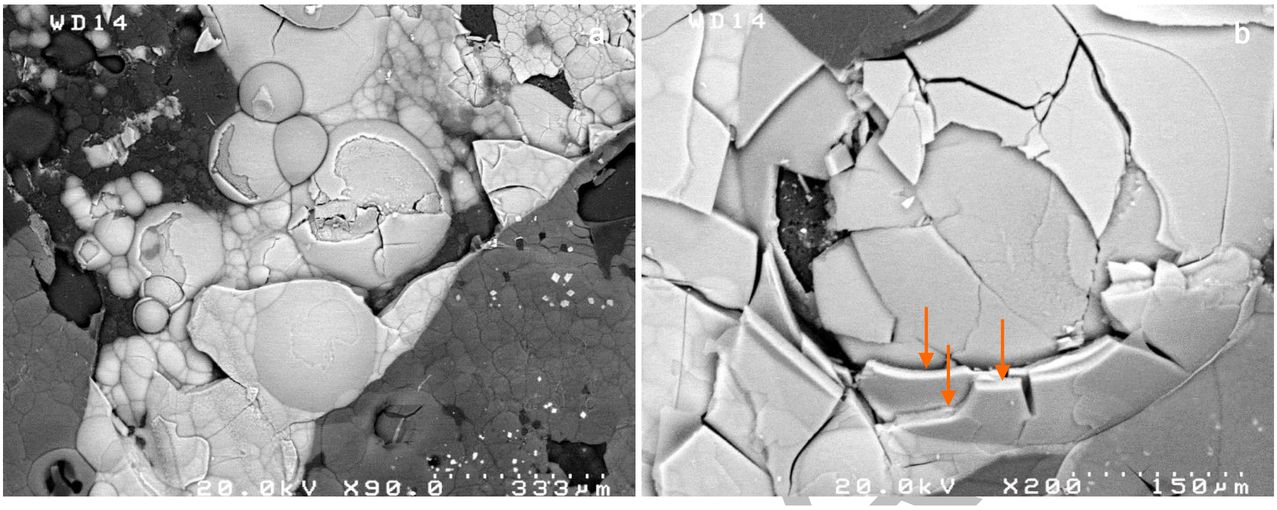
window	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	MnO_2	Fe_2O_3	CoO	CuO	PbO
1	7.10	9.11	0.30	71.38	0.48	8.97	0.54	0.93	0.38	0.20	0.61
2	6.54	1.37	0.11	82.20	0.90	7.59	0.11	0.42	0.34	0.19	0.23

The glass is made of soda-lime silicate glass. The high magnesium content suggests a soda derived from plant-as, but there is an important variation between the two analysis windows.
Some lead is detected. Copper and cobalt could be, with the iron to the origin of the blue colour.

The glass composition is comparable to scratch-decorated plant-ash soda Islamic glass (1).

The weathering process

SEM observation of replicas and analysis of fragments of the white iridescent and of the brown layer show characteristic pitting weathering morphology (Fig. 6a). The weathered material appears multilayered (Fig. 6b, arrows) and amorphous.



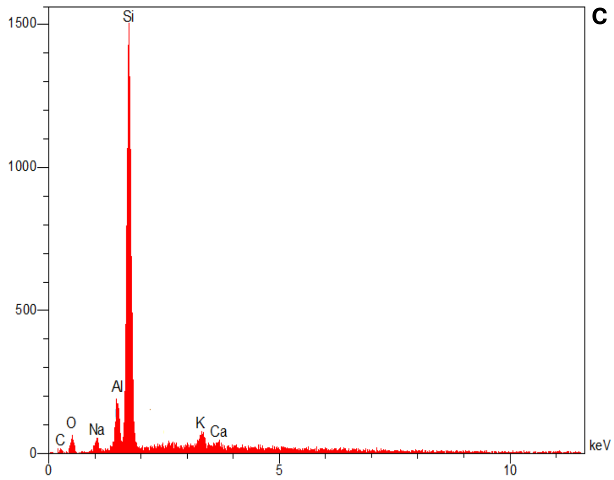


Figure 6: Detail views (SEM, BSE, **a**- x 90, **b**- x 200, Replica R1) and EDX analysis spectrum of the glass weathering products.

The analysis of the blue-pale iridescent layers, in direct contact with the glass and of the upper brown layer show chemical change compared with the bulk glass composition.

In the white iridescent layer, the potassium and calcium contents decrease, as well as magnesium and sodium (Fig. 6c). In the brown layer, magnesium is still present with a faint enrichment in iron.

This depletion of alkaline elements and the multilayered morphology is observed in archaeological glass weathering (2).

In some parts the weathering seems to be associated with the formation of calcium-rich (Fig. 7b) crystallites (Fig. 7a, arrows).

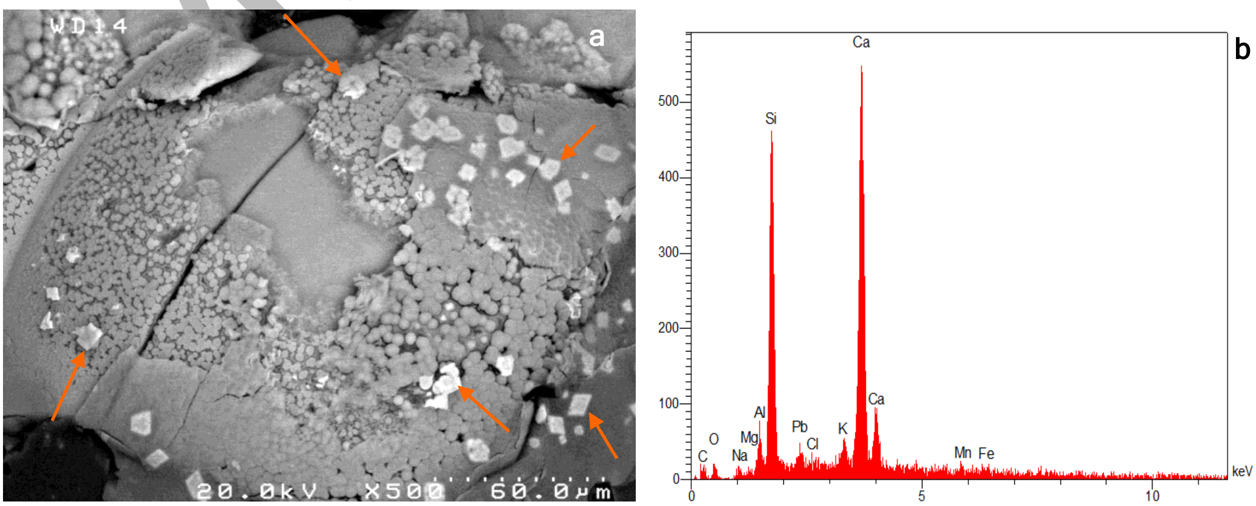


Figure 7: Detail view (**a**- SEM, BSE, x 500) of the glass weathering products and EDX analysis spectrum (**b**-) of the crystallites. Replica R1.

The same calcium-rich crystallites (Fig. 8a, arrows) are observed in weathering layers that show a very low compositional contrast in BSE observation (Fig. 8a).

These layers, sometimes fit in between the other weathered layers, and show potassium enrichment, with traces of chlorine and sulphur (Fig. 8b).

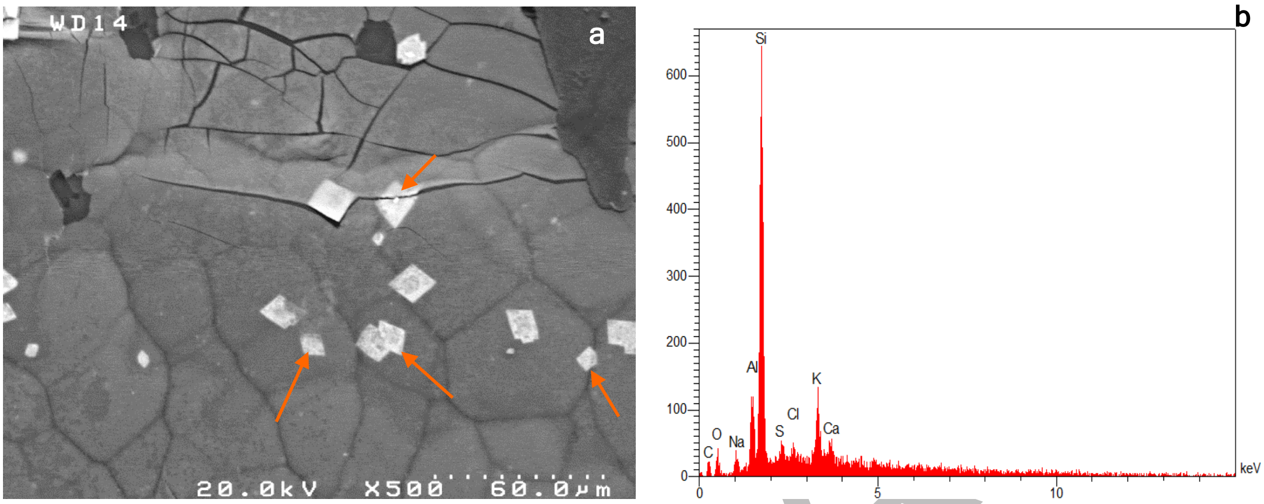
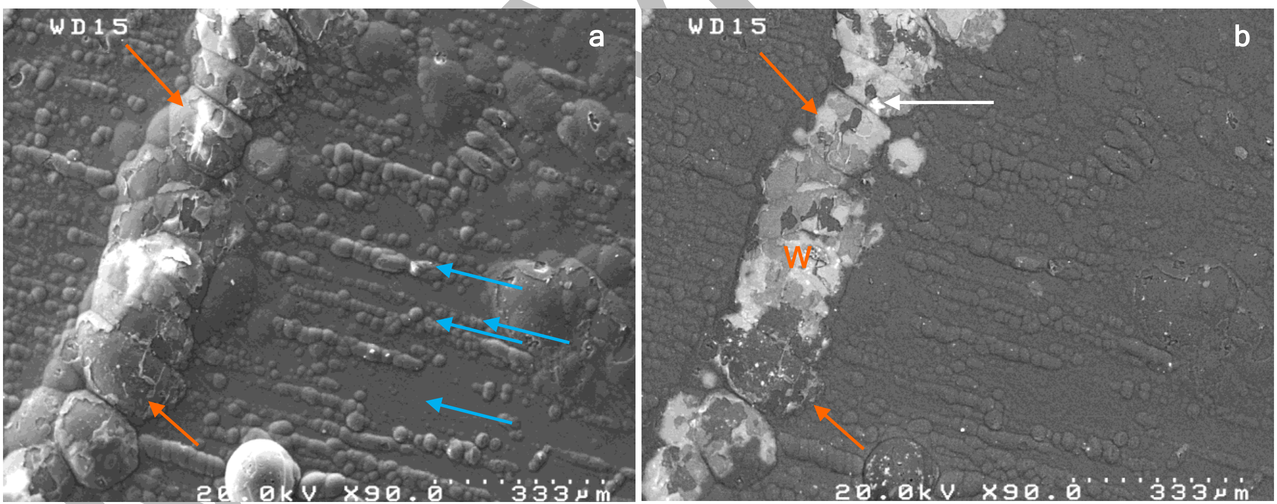


Figure 8: Detail view (**a**- SEM, BSE, x 500) and EDX analysis spectrum (**b**-) of a low compositional contrast weathering layer. Replica R1.

If potassium can originate from the leaching of the glass, chlorine and sulphur are very probably from the object environment. Some sodium chloride crystals are present among the glass weathering products (Fig. 9b, white arrow).



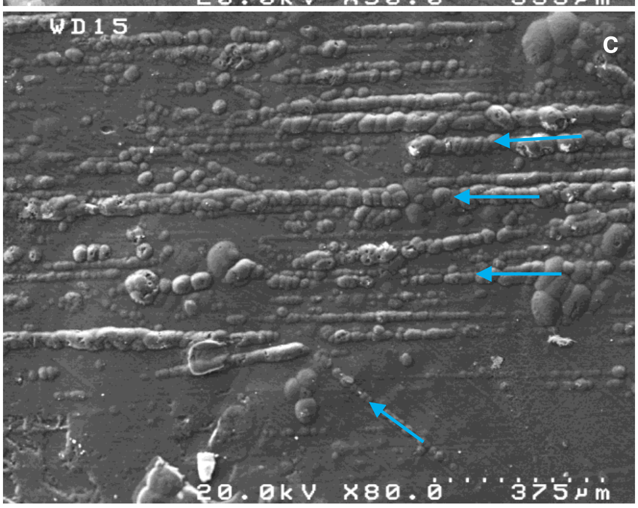


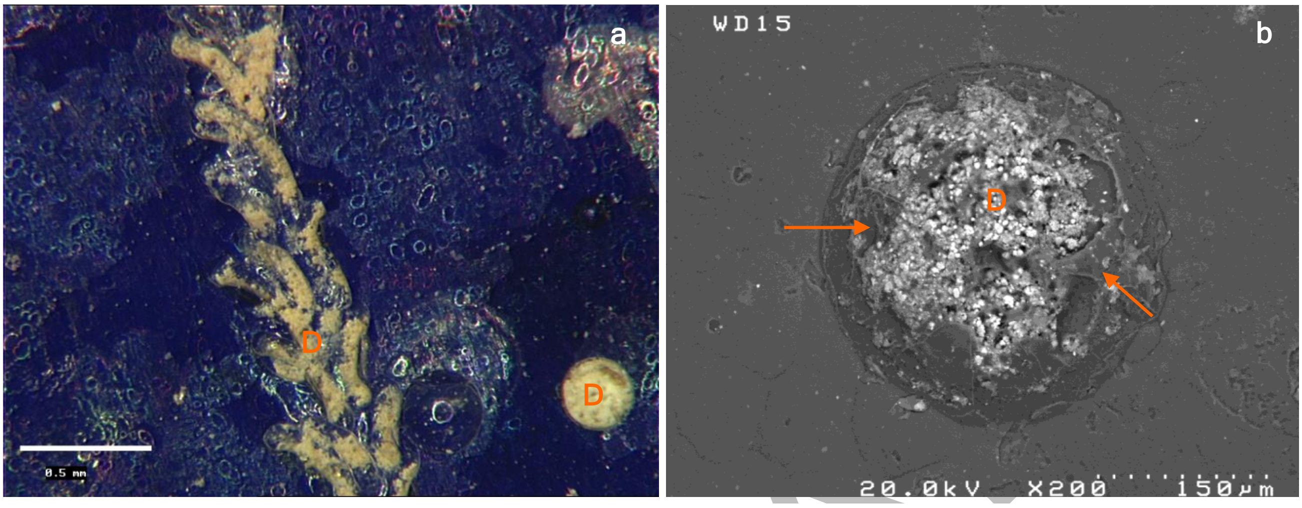
Figure 9: Detail views (SEM, **a**- SE, x 90, **b**- BSE, x 90, same fields as **a**- and **c**- SE, x 80) of the glass surface. Replica R2.

Weathering process develops from every cut on the glass surface: the scratches from the decoration (Fig. 9 orange arrows) and the fine grooves from the surface filing or polishing (Fig. 9, blue arrows).

The glass weathering products have been most preserved in the deepest hollows as the scratches (Fig. 9b, W) or in the bubbles. They have flaked off in parts where they have been submitted to accidental contact or rubbing.

The surface deposit

The fine-grained beige material observed in the depressed areas on the plate surface (Fig. 10a and b, D) is a calcium-rich material (Fig. 10c), associated with some organic matter (Fig. 10b, arrows).



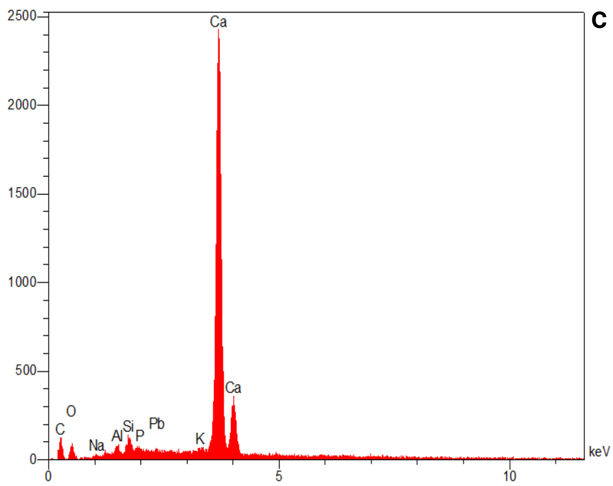


Figure 10: Detail views (**a**- stereoscopic microscope, x 45, **b**- SEM, BSE, x 200) and EDX analysis spectrum (**c**-) of the beige material. Replica R2.

This product which is present as well upon the weathered glass (cf. Fig. 2) as on the “clean” glass surface may be remains of a soft abrasive from a partial cleaning process.

Bibliography

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(2)- G. SALVIULO, A. SILVESTRI, G. MOLIN, R. BERTONCELLO, 2004. An archaeometric study of the bulk and surface weathering characteristics of early medieval (5^{th}-7^{th} century) glass from the Po Valley, Northern Italy. *Journal of Archaeological Science*, 31, p. 295-306.