PRESERVATION CONDITIONS OF ROMAN GLASS VESSELS OF 1ST CENTURY AD FROM RHODES ISLAND - GREECE

Lampropoulos V.*, Kontonikoli M., Papadimitriou M. & Karampotsos A.

**Department of Conservation of Antiquities and Works of Art, Faculty of Graphic Arts and Design, Technological Educational Institution of Athens.*
Ag. Spyridonos str., Egaleo 12210 Greece.
blabro@teiath.gr www.v-lampropoulos.com

INTRODUCTION

Five Roman glass vessels (1st century AD) from Rhodes Island were studied in order to understand the burial environmental influences combined with the material's structure and chemical composition on rates and forms of degradation. A systematic conservation project was established and a range of preventive measures has been proposed in order to ensure the appropriate conditions for storage and exhibition.

EXPERIMENTAL TECHNIQUES

Elemental analysis, using scanning electron microscopy (S.E.M.), has been carried out on 7 samples (Y931, Y932, Y933, Y934A, Y934B, Y941big, Y941 small) in order to evaluate the morphological and chemical changes. It was also essential to study the environmental conditions of the excavation area, as well as the topographical data To further investigate the effect of environmental conditions, pH, electric conductivity and concentration of sulfate (SO_4^{2-}) and chloride (Cl^-) ions measurements were performed on six soil samples. Finally, all types of deterioration were identified macroscopically and were confirmed by the S.E.M. analysis in order to give a broad outline of the restoration campaign.

RESULTS AND DISCUSSION

ANALYSES OF STRUCTURAL MATERIAL

Samples	Elements	Results
Y931	Si	<37% section, internal / <17% external
	Na	<1% in all cases
	K	≈0% in all cases
	Ca	<3% and little higher in the external
Y932	Si	<35% generally / <10% edge of section
	Na	<1% in all cases
	K	≈0% in all cases
	Ca	<5% and little higher in the external
Y933	Si	<40% in all cases
	Na	<1% in all cases
	K	≈0% in all cases
	Ca	<5% in all cases
	Al	<1% section 2
Y934A	Si	<42% section, internal / <17% external
	Na	<1% in all cases
	K	≈0% in all cases
	Ca	<5% and little higher in the external
Y934B	Si	<37% external
	Na	<1% in all cases
	Ca	<2% in all cases
	Al	≈2% in all cases
Y941big	Si	<18% in all cases / <10% external
	Na	<1% in all cases
	K	≈0% in all cases
	Ca	Normal level and little higher in the external
Y941small	Si	<10% in all cases
	Na	<1% in all cases
	K	≈0% in all cases
	Ca	Normal level and little higher in the external

1. *Results from SEM analysis. Elemental compositions given in wt%.*

The low and very low concentrations of Si, Na, Al, K and Ca (except samples Y941big and Y941small) are the consequences of materials' leaching out by the high humidity presence. The low concentration of K is also because of a possible lack in raw material. The concentration of Ca is a little higher in the exterior surface (samples Y931, Y932, Y934A, Y941big and Y941small) because of calcium salt crust formation.

ACIDITY - ALKALINITY - SALINITY OF GROUND OF EXCAVATION

Samples	pH	Conductivity (μS/cm²)	SO_4^{2-} (ppm)	Cl^- (ppm)
Sample 1 (Y931)	7,40	110	3,5	25,0
Sample 2 (Y932)	7,10	50	1,0	10,0
Sample 3 (Y933)	6,40	50	1,0	9,0
Sample 4 (Y934)	6,15	37	0,5	7,0
Sample 5 (Y941 small)	6,50	45	0,5	7,0
Sample 6 (Y941 big)	6,80	42	0,5	6,5

2. *Results from six soil samples taken from the excavation environment*

pH results: *alkaline ground that indicates a presence of $CaCO_3$ (sample Y931), light limestone ground (area of low alkalinity) (sample Y932), acidic ground that identifies a presence of aluminosilicates (quartz, clays etc.) (samples Y933, Y934), light acidic to neutral, which means ground of aluminosilicates composition (samples Y941 small, Y941 big)*

Conductivity*: low concentration of chlorides and salts. This shows that the presence of chloride (Cl^-) and sulfate ions (SO_4^{2-}) is due to the high bed level affected by the height of rainfall and the sea level.*

ENVIRONMENTAL STUDY

MONTHS	AVERAGE T °C	AVERAGE MAX T °C	AVERAGE MIN T °C	ABSOLUTE MAX T °C	ABSOLUTE MIN T °C	RH (%)	HEIGHT OF RAINFALL	WIND DIRECTION
JANUARY	11,9	15,1	8,8	22,0	-4,0	70,1	149,6	NW
FEBRUARY	12,1	15,2	8,8	22,0	-2,2	69,1	105,7	NW
MARCH	13,6	16,8	10,1	27,4	0,2	68,7	75,6	W
APRIL	16,6	20,0	12,5	30,6	5,2	66,5	27,8	W
MAY	20,5	24,2	15,8	34,8	5,0	64,4	18,6	W
JUNE	24,7	28,4	19,9	37,4	12,6	58,5	2,3	W
JULY	26,9	30,5	22,3	40,0	14,6	57,6	0,4	W
AUGUST	27,1	30,7	22,7	42,0	17,0	59,9	0,2	W
SEPTEMBER	24,6	28,2	20,5	36,6	10,6	61,4	5,8	W
OCTOBER	20,8	24,5	16,9	33,2	7,2	67,5	65,5	W
NOVEMBER	16,5	20,1	13,2	28,4	2,4	71,4	94,1	W
DECEMBER	13,4	16,6	10,4	22,8	1,2	72,4	157,4	NW

3. *Environmental data collected from 1955 to 2004 in order to assess the effects of the environmental context on the glass corrosion (Department of statistics of National Meteorological Service).*

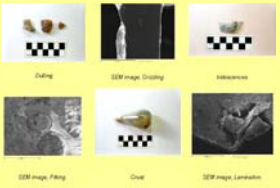
High average RH%, although the height of rainfall decreases drastically from June to September and is quite low from April to May. High RH% levels in the ground according to the data of moisture condensation, the rainfall and the ground-water level (capillary rising). Conditions of frost or particularly high temperatures have not been observed. Temperature changes affect only the superficial layers of the ground. Temperature differences between deep ground layers and superficial ground levels cause problems to the excavated objects because of their movement from a cooler to a warmer ground environment.

TOPOGRAPHICAL DATA (GROUND-WATER LEVEL)

The data collected from the National Institute of Geology and Mining Research led to the following conclusions:

- The sea influences the height of the ground-water level.
- The ground-water level is to close to the excavation level. Therefore, the moisture, rising by capillary action, affects the excavation level
- Petrographically, the ground is constituted by alluvium of certain dilouviac depositions (sand, gravel, mica) and few neogenic rocks (clay, metamorphic).

FORMS OF DETERIORATIONS



The forms of corrosion were caused by:

- the presence of humidity,
- the temperature variations,
- the crystallization of soluble salts,
- the low pH of the soil samples (pH<9),
- the biological action,
- the storage conditions.

PREVENTIVE MEASURES FOR DISPLAY AND STORAGE

RECOMMENDATIONS FOR STORAGE AND EXHIBITION

	RH – T	Light	Air quality
Museum Environment	-Constant range of 45-50% RH -Narrow band of controlled RH (40%) for crizzled glasses -Moderate temperature 18-21°C (no heating) -Good ventilation -Regularly monitoring and recording -Environmental control equipment -Avoid extremes or rapid fluctuations	-50 lux and annual exposure limit 10.000 lux hours per year for unstable glasses -Avoid heat build-up from lighting -No daylight -UV limit 10 μW/lumen	-Avoid VOCs -Protection from dirt - dust
Storage facilities Display	-Sturdy and well-balanced shelves or display cases, preferably closed -Horizontal and carefully fixed shelves -Avoid metal or adhesives for holding glass -Avoid deep shelves -Positioning objects on cushion surfaces with an additional stable support -Avoid any direct pressure -Each object must be well-spaced from others -Use soft materials in contact with the glass -Extra care should be taken to avoid rubbing iridescence surfaces -Minimize traffic		
Handling practices	-Avoid handling wherever possible, especially for iridescent glasses		

CONCLUSIONS

The extensive investigations have revealed:

- The environmental factors which may be affecting the deterioration/preservation of glass artifacts.
- The way to minimize or eliminate conditions that can cause damage.
- The appropriate conservation and restoration methods in order to deal with the archaeological vessels.
- The appropriate preventive measures in order to provide a stable exhibition and storage environment and consequently avoid those situations in which problems may arise.