INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE
ISSN: 2067-533X Volume 13, Issue 4, October-December 2022: 1187-1208 www.ijcs.ro

MODERN ASPECTS REGARDING THE CONSERVATION OF CULTURAL HERITAGE ARTIFACTS

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Abstract

Based on the over 30-year experience of the team that laid the foundations and developed the first academic specialization in the Science of Cultural Heritage Conservation in Romania, a series of modern aspects regarding the role of exact sciences and engineering were highlighted. These are represented by eight lucrative subdomains with their liberating professions, harmonizing the nomenclature in the field, substantiating the conservation levels with their priorities and the two groups of heritage elements and functions, the development of new archeometric and chemometric dating methods, new preservation-restoration materials and technologies and the development of criteria with quantification grids used in the evaluation of the stock market share or catalog. Related to these aspects, the reaserch briefly presents in a systemic form the results of the collective of the ARHEOINVEST Center of the Institute of Interdisciplinary Research of "Alexandru Ioan Cuza" University of Iași, obtained in the activity of scientific and technological research, with a degree of innovation.

Keyword*: Cultural and historical assets; conservation status; archaeometric and chemometric characteristics; authentication attributes; preservation; restoration; valorization*

Introduction

Currently there is more and more talk about Conservation Science, as a very attractive interdisciplinary field of Environmental Science and Engineering, which was developed from practical needs regarding the unaltered preservation of cultural heritage, natural assets and biodiversity [1-6].

The cultural heritage that we must know, appreciate and take care of is called Historical Heritage, which together with those of nature and biodiversity represents the identity card of a nation. It is known that the heritage represents the totality of the goods that the ancestors kept and left as a legacy to the descendants, sometimes to remember them and their life, other times by accident or chance. These goods represent accumulations of knowledge and experiences that have become launching platforms for new experiments that, in turn, lead to an increase in the quality of life [7-11].

Cultural, natural and biodiversity assets are a legacy passed down from one generation to another, and we all participate in this ongoing process because they provide both intrinsic and extrinsic value at the individual and community level. The three elements of heritage (cultural, natural and biodiversity) play an important role in shaping the future. They are areas/landscapes continuously transformed by human activity, either through preservation, restoration and

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valorization in the sense of preservation and ennobling, or through the deterioration of structural-functional elements and respectively the degradation of the component materials in the sense of their transformation to the state of collapse, of irreversible loss [12-23].

In the case of cultural artefacts, the main factors that determine the belonging of an object to the cultural heritage by establishing its value are the age of the artefact, its intrinsic qualities and its importance that allows the understanding of history [24-30].

From a patrimonial point of view, the artifact represents any object with artistic and/or historical value, starting from mobile or static works of art, up to monuments, including simple collectibles (coins, stamps, trinkets, minerals, old books etc.), to the old ethnographic or industrial ones [6, 31].

The science of historical artifacts conservation, improperly called *scientific conservation*, has become the generic term for the preservation of *cultural heritage*, measured by *the state or degree of conservation* or *the rate of conservability* (expressed as a percentage, %) [25-30, 32-34].

Based on the deepening of all aspects related to this field from the current specialized literature, regarding the evolution of some concepts, terms, definitions and lucrative approaches taken from related disciplines, which led to their harmonization and adaptation through new formulations, developed in the form of a modern nomenclature [32-34].

Personal experiences played an important role by developing a series of modern aspects regarding the role of exact sciences and engineering in the eight lucrative subdomains of Conservation Science, with their liberating professions, the foundation of conservation levels with their priorities and the two groups of heritage elements and functions, then the development of new archaeometric and chemometric dating methods, new materials and preservation-restoration technologies, culminating in the premiere with the development of the quantification grids criteria used in the evaluation of the stock market shares or catalog [18, 33, 34].

Related to these aspects, the research briefly presents in a systemic form the innovative results achieved within the collective of the Laboratory of Scientific Investigation and Cultural Heritage Conservation, ARHEOINVEST Center of the Institute of Interdisciplinary Research of ”Alexandru Ioan Cuza” University of Iași.

Lucrative Subdomain of Cultural Heritage Conservation Science

The Conservation Science of ancient heritage artifacts includes eight lucrative subdomains, in which certain disciplines are differentially involved, namely [32-34]:

- ✓ *Discovery* (Archaeology, Geomorphology, Geotechnics, Geophysics etc.), *acquisition/transfer/itinerary* (Museology, Marketing, Trade, Tourism etc.);
- ✓ *Heritage decommissioning, classification and evaluation, standards or evaluation criteria, cultural property* (History and Theory of Art, Aesthetics, Materials Science and Engineering, Marketing, Business, General Theory of Conservation etc.);
- ✓ *Scientific investigation regarding authentication, the establishment of the value through grids/credits, determining the state of conservation, compatibility studies of preservation and restoration interventions, monitoring for a given period the behavior of the interventions and permanent monitoring of the evolution of the conservation state* (Chemistry, Physics, Biology, Geology, Archaeometry or Artefactometry, Art History, Museography, Environmental Science and Engineering etc.);
- ✓ *Passive or preventive preservation through action on the environment, climate and the use of protection systems* (Environmental Science and Engineering, Thermophysics, Cryogenics, Climatology, Ecology etc.);
- ✓ *Active or prophylactic preservation applied directly to the artifact, involving treatments to stop the evolutionary effects of deterioration and degradation* (Materials Science and Engineering, Chemistry, Biology etc.);
- ✓ *Restoration through structural consolidation and reintegration, cleaning, chromatic, environmental and cultural reintegration* (Materials Science and Engineering,

Chemistry, Biology, Art Theory, Aesthetics, Colorimetry, Profilometry, Architecture, Landscaping, Climatology, Ecology etc.);

- ✓ *The valorization, which includes displaing or presentation in museums and collections, valorization through publications, web pages, films, workshops, open lessons and hoarding through new archival research or archaeological excavations* (Museography, Archaeology, Archival Studies, Bibliography, Artefactometry, Marketing, IT, Design etc.);
- ✓ *Protection, maintenance and presentation* (Museology, Tourism, Security and Protection Regulations, Ecology, Environmental Science and Engineering etc.).

Liberal Professions in the Field of Valorization of Old Artifacts of Cultural Heritage

At the European level, depending on the degree of training, as certified specialist or certified expert, and depending on the field of activity on certain types of artefacts (grouped by materials, collections or states of conservation) and operations or interventions for valorization at the level of the eight subdomains of Conservation Science, eight liberal professions with specific specializations are accepted, as follows [33, 34]:

The conservation scientist, who professionally has the title of Doctor of Sciences, can cover any of the activities of Scientific Conservation (classification, investigation, preservation, restoration, display, hoarding etc.), having the highest level of expert, can occupy positions of cultural manager, advisor or administrator of cultural institutions;

The scientific investigator, who takes into account the five groups of expertises (authentication, patrimonial assessment, determination of the conservation state, compatibility of interventions, monitoring their behavior for a determined period and monitoring the state of conservation for the entire period of display or storage in warehouse), with two levels of specialization, the basic one as a specialist promoted through the Master's degree and the superior one as an expert, obtained by attestation after the Doctorate;

The art historian is the job occupied by the graduates of the History and Theory of Art and History universities, who can occupy the positions of museographer or guide, and after a post-university specialization in the profile and that of curator or above, art expert;

The archaeologist is a graduate of History university, with the two professional levels of specialist or expert, who has responsible for the identification, investigation/research and discharge of the archaeological burden of the sites, as well as the valorization and hoarding of the discovered artifacts;

The preservative curator, who takes into account the protection and preservation activities (passive or preventive and active climate or prophylactic treatments to stop the effects of deterioration or evolutionary degradation), also with two levels of specialization, the basic one as a specialist promoted through the Master degree and the superior expert, obtained by attestation after the Doctorate;

The preservative restorer, who is responsible for the restoration activities through consolidation, stabilization and structural reintegration (completions/additions), chromatic or ambient, also with two levels of specialization, the basic one as a specialist, promoted through the Master degree and the superior one as an expert, obtained by attestation after the Doctorate;

The museographer is the complementary job of the preservative curator, who, in addition to his basic activity - display, can also cover the fields of activity of the curator and even the guide, being able to have the two levels of specialization, the basic one as a specialist, promoted through the Master degree and the superior expert, obtained by attestation after Doctorate;

The guide is the job occupied by the graduates of the faculties of History and Theory of Art, History or Tourism, having the role of leading and explaining to the public new data about the patrimonial goods exhibited in museums, usually. This profession only has the specialist level, with or without a Master's degree.

From these, the scientific investigator, together with the traditional expert - the art historian and archaeologist, can occupy the positions of art expert, who can serve evaluations in

galleries, antique shops and consignment shops that sell or organize auctions with works of art or can occupy positions of senior advisors in cultural institutions.

Harmonization of Nomenclatures by Taking over from Related Systems

Between 1993 - 2004, a series of ideas and terms that were used in current practice as synonyms, having different meanings and attributions, have been reformulated, moreover new definitions, typologies, criterias, classifications and characteristics were substantiated in the eight subdomains of activity. Since the beginning of 2004 new meanings and definitions have been given for the terms: conservation/preservation, restoration/rehabilitation, deterioration/ degradation etc. which have been accepted more easily or more difficult by the academic field world [32-34].

The experience accumulated during the first Transnational European School EPISCON (European PhD in Science Conservation) from the University of Bologna (2005-2010), then the one related to the participation in international events (1993-2022) and the development of the International Journal of Conservation Science (2010-2022), together with other highly appreciated scientific journals, such as: Studies in Conservation, Journal of Architectural Conservation, Journal of Conservation and Museum Studies, Journal of the American Institute for Conservation, International Biodeterioration & Biodegradation, Conservation Science in Cultural Heritage, ENCATC Journal of Cultural Management and Policy, European Journal of Cultural Management and Policy, European Journal of Cultural Studies, Journal of the Institute for Conservation, led to the acceptance of both the Norms and Principles of Ethics in Conservation Science, unanimously accepted at the international level, as well as the new Nomenclature in the domain.

Thus, *conservation* has the meaning of keeping in its original state, to protect, respectively to guard, becoming a generic term for the *Science of Conservation*. Instead of this, preservation is the lucrative approach with a *preventive role of conditioning and protection* or *the prophylactic one* of stopping the evolutionary effects of deterioration and degradation. Conservation, as a science, includes a set of measures, tools and actions, which aim to preserve unaltered the physical integrity, the appearance and the message that the artefact conveys, as close as possible to the original one, making an integrative-participatory valorization (displaying, capitalization and/or hoarding) continues with the preservation of the *historical stratification* (the traces left over time by certain significant events), having as a subsidiary the steps of investigation, preservation, restoration and display [31-34].

Restoration means the process of putting something back into its original condition by reintegration (structural, chromatic, environmental and cultural) of a work. In construction engineering, the concept of rehabilitation is often used instead of restoration, which actually defines *the restoration of a functional or technological system* – e.g. *rehabilitation of the heating or air conditioning system* [32].

The terms: *deterioration* and *degradation* were introduced because was a need to define differentially the change in the physical or functional state of the elements in the structure of artifacts through mechanical, dynamic actions/assisted or not by climatic factors and the nature of the materials under the action of chemical, electrochemical, biochemical factors, radiative/thermal etc. The damage will always relate to a structural or functional element and has a single or several actions, starting from inside the structural phases (active centers of minimum resistance) or from the external structures (under the influence of climatic and/or anthropic factors) [12, 21].

The term *monument*, differentiated as being *art, architectural*, or *natural* (landscape, faunistic, lacustrine, speleological/karst, geological/petrographic, dendrological), while the *artwork* is regarded as a creation of nature or anthropic when we attribute to it the activity of conception.

Two other associated terms, used only in scientific investigation, is that of method and technique of analysis, testing, study or proof, they must be rigorously differentiated from

procedure/methodology and application technology, for example: it will be called analysis method and mixing or extracting process and not extracting method [19, 20].

In the didactic activity, the names of *technique and artistic technologies* are often misused, in fact only the techniques are artistic (which define the typology of the artefact), instead the technologies or procedures are for implementation.

In the same way, when a working parameter is described, it will be differentiated from the unit of measure or the commensuration mode. The parameter should never ever be replaced by the measure unit, as in next example: instead of the *humidity of the gaseous medium* (as a monitored variation parameter) *the relative humidity, UR(%)* or *the absolute humidity, UA(mg/mc)* will not be used, although in chemistry the expression "depending on the molarity, normality etc.", the correct one is "depending on the concentration" [19].

There are also a number of terms that must be used differently: *native* (primordial)/*original* (the mark of time), *compounds* (chemical)/*components* (structural), *viability* (for living systems)/*reliability* (for material and technological systems or for processes in vitro), *adsorption* (surface physical process achieved through physical bonds) and *absorption* (dispersion (physical)/dissolution (physical and chemical)/solubilization (chemical) process at the molecular level, in the volume phase, of a system/material). For the last example, it is accepted: *spectral absorption, absorption of vibrations or sound* in a material/body, *biological absorption* (the passage of a substance through a biological barrier/membrane or cell) [19, 20].

As for the terms: *cohesion* and *adhesion*, used in the valorization of old paintings, they have different meanings. *Cohesion* refers to the binding of particles to each other by monolithization with the help of a binder, which plays the role of a dispersion medium. For example, for oil painting, fine pigment powders are dispersed in the oil-based drying binder, which, by hardening, fixes the respective color on the surface of the painting. In contrast, *adhesion* is the process of bonding surfaces in contact, for *structural reintegration* by strengthening, completing and fixing mobile/dynamic or missing components [20-24].

Regarding the presentation of the factors affecting an artifact, it is distinguishing the *calamity*/*cataclysm* which is caused by natural factors as *catastrophe*/*disaster*– caused by anthropogenic factors.

When the term *trace* is used, it is taken into account: *form trace – imprint* or *impression* (the touch of the brush, spatula, knife, finger used to develop the pictorial layer, or the chisel for sculptures, traces of burglary, textile or brush impressions etc.) and the *material trace – film/film/dust powder, textiles, hair, skin, pollen, color/paint, fat/exudate/secretion, dirt deposit* etc. The two terms are often used also in Forensic Sciences, as different term for **forgery** (replica or copy with illicit purpose) and **counterfeit** (partial forgery, by changing or inserting a graphic, applying a brand/stamp, copy by peddling etc.) [24, 25].

Another wrong use is that of the term ***expertise***, as an investigation/analysis/study/examination/test/completed by a finding report document instead of ***experience*** (commensuration of knowledge/capacity/ability) comprehension power. It is not correct to use the expression "a person has an expertise in the field", when in fact the correct terminology is "a person is certified or he has deep professional knowledge in the field" [13, 25, 30, 32].

Likewise, the expression ***scientific investigation*** (expertise, analysis, test, exam etc.) will be differentiated from that of ***study*** (case analysis or documentary analysis and synthesis, historiographical analysis), respectively that of ***research*** (differentiated by fields, e.g. forensic research, scientific research, technological research, on-site research etc.). The wording "studies and research on..." is allowed to cover a wider range of theoretical or experimental activities. There are many more aspects related to nomenclature, respectively terminology/definitions, norms, rules, activities and others, which as in any science must be representative and provide a clear/coherent understanding and commensuration of all aspects related to Conservation Science [24, 25].

Heritage Elements and Functions

In the valorization of artifacts and in the discussion of authentication attributes, a series of characteristics are used in an artifact related to the *heritage elements*, which can come from the commissioning, but can also be acquired and, respectively, the *heritage functions*, which are usually acquired over time [32 -34].

The first group includes:

- the conception (material, artistic technique, installation technology, size/gauge/complexity, finesse/degree of elaboration/detailing);
- the age/patina of time (archaeometric and chemometric characteristics/structures of the three patinas: noble or primary, poor or secondary, contamination or tertiary);
- dating (year/period);
- the author (school, workshop, disciple);
- the geographical area (of commissioning and use);
- the unique attribute (uniqueness), copy/replica, series/position;
- the originator/original attribute and the authentic attribute.

Related to the *patrimonial functions*, they are grouped into:

- aesthetico-artistic (the function that allows inclusion in a collection or display in a museum);
- historical documentary (provides information about the era and its society);
- technical-scientific (information about the cultural and technological level);
- socio-economic, administrative/building (other uses and implications throughout history until now);
- spiritual (the highest function, related to the primacy of the work, the degree of novelty of artistic techniques, style etc.)

Artifact Trails

Cultural and historical goods follow different routes from the commissioning to the museum, with well-defined historical contexts, such as phenomenon, form - aspect etc. Among the routes traveled by an artifact, it can be mentioned [32-34]:

- the normal one, common to many works of art or monuments;
- by abandon, when the functions of use are lost;
- by theft and discovery;
- by hiding and forgetting (treasures, jewelry, money etc.);
- by loss (jewellery or small artifacts);
- through bad weather or natural calamities (floods, landslides, earthquakes with debris, volcanic eruptions, explosions etc.);
- through catastrophes or anthropogenic disasters (explosions, wars, revolutions, collapses, diving etc.);
- through plagues – cities and long-abandoned monuments (the pyramids and temples of the Mesoamerican civilization, for which there is no universally accepted theory to explain this collapse (overpopulation, foreign invasions, popular uprisings, as well as the collapse of key trade routes, the ecological hypotheses that include environmental disasters/drought, epidemics and climate change etc.);
- causal series;

Typology of Historical Contexts

An artefact crosses a series of historical contexts, which remain on display imprinted in its form and appearance, respectively in the conservability and the message conveyed by it. Thus, the following causal series can be gradually realized: the context of the creation (the conception/primary form of creation), the manufacture or commissioning, the use/exhibition,

and for some the abandonment and the discovery, as finally for the majority we have the preservation, restoration and reintroduction into the circuit of values [32-35].

The context of the discovery includes:

• *Discovery mode* (through systematic archaeological excavations, by chance after agricultural operations, construction excavations, landslides, in alluvium or after floods, in old galleries or in those carried out by wild animals etc. and following *poaching traces* without exhausting the site);

• *Photofixing* and *making the stratigraphic relief* on treading levels (stratigraphic positioning and relief);

• *Determination of the physico-chemical and microbiological level* of the soil, along with the determination of the *chemical compositions and archeometric characteristics* of the internal structures (crevasses, patches, crackles, interfacial defects, diffusion and penetration zones etc.) and of the surface (products of the three age patinas, well highlighted in superficially corroded metal artifacts, with or without a metal core, for example: noble or primary, poor or secondary, contamination or tertiary patina, which can be in the form of zonally, continuous layer, thin layers sound crust form, dirt deposits etc.;

• *Evaluation of structural or compositional transformations/processes/effects*, with the determination of the evolution between abandonment and discovery (pedological effects), the identification and evaluation of archaeometric characteristics for *the establishment of heritage elements and functions prior to abandonment*.

Conservation Levels and Priorities

Due to the very intensive handling, which leads to various degrees of deterioration and degradation (such as wear and tear due to use or deterioration due to storage and supervision conditions), in most national archives and large libraries the book holdings, documents, manuscripts etc., are grouped together on conservation states, in correlation with intervention priorities through preservation and restoration operations. Starting from this aspect, five conservation levels were introduced for old cultural heritage artifacts, with their valorization priorities [32-34].

Level I, which includes goods of special patrimonial value that present a precarious state of conservation, which include unique items, treasured goods or very valuable goods that do not allow display due to certain historical, political, ideological, religious etc. considerations. or value-related, as strict safeguards. This level includes two subgroups: **IA** or *the closed level*, to which only scientific conservators have access, because they require urgent active conservation and restoration interventions, and **IB** or *the open level*, to which experts in art, historians or documentarians have access, along with scientific conservators and curators, with special approval.

Level II, which includes heritage assets of great value, but with a relatively better state of conservation, to which they have access, together with curators and various specialists for documentation. The goods can be included in the museum circuit through scientific replicas or under special protection and after a prior preventive or prophylactic consolidation and an appropriate active preservation intervention.

Level III, which includes well-preserved heritage goods that can be displayed in museums and that can participate in traveling exhibitions. The goods can be handled, packed and transported, moreover, visitors can have direct access to them.

Level IV refers to heritage goods existing in several versions or replicas, in the form of a surplus stock, which can participate in the exchange of values between collections.

Level V represents the *gray fund*, which includes heritage assets with damage and irreversible degradation, in collapse, with a state of conservation between 0.5 and 10% (depending on the type of asset), due to which no longer they can be exposed/displayed. These goods are kept for use as teaching material and in experiments. It is recommended that they be kept in special warehouses, in air-conditioned conditions, so as not to be damaged or degraded further. Under no circumstances will they be destroyed or removed.

Factors that Influence the State of Conservation of Heritage Assets

Factors that leave their mark over time on the state of conservation and the value of an artifact are grouped in [12, 13, 26-31]:

- **endogenous** related to the nature of the material, installation technology and defects and
- **exogenous** which can be climatic (*temperature, humidity, precipitation, pressure, air currents, light and cosmic radiation*), biological, anthropogenic and pollution (natural or from anthropogenic activities).

Exogenous factors can be *normal* or monitorable and *risk* factors:

• **natural calamities** or **cataclysms** (earthquakes, landslides, floods, fires, lightning, volcanic eruptions, explosions, storms, typhoons, tornadoes, tsunamis, hail, drought, frost etc.);

• **human disasters** or **catastrophes** caused by wars, revolutions, accidents of all kinds *(explosions, fires, vibrations, collisions, collapses, diving, subsidence, floods, accidental irradiation or nuclear accidents, induced earthquakes etc*.), *vandalism, uncontrolled deforestation and others which lead to damages, collapses, demolitions* etc., up to total destruction.

For archaeological pieces, factors from ***the deposition environment*** are taken into account, related to the chemical loading/aggressiveness of the soil, water dynamics, soil porosity, pedological and biological processes, soil movements etc.

These factors lead to a series of *deterioration and degradation phenomena* of artifacts produced by natural or anthropic processes of micro- or macrostructural destruction of the constructive and functional elements, respectively of alteration of the component materials.

Anthropogenic factors can have as a cause: the functions of the object, the successive interventions of putting into operation and those of inadequate preservation-restoration, poor maintenance/inadequate display and storage, vandalism and other anthropogenic destructions (political reasons; religious manifestations; economic purposes; changes in taste; negligence or lack of means of maintenance, degradation of notoriety).

Regarding vandalism, during the time the notion has evolved a lot. The meaning of the word has been extended far beyond a simple attack on patrimony to denote the indiscriminate, harmful and gratuitous destruction of movable or immovable property, public or private. With the development of information and communication technologies, there is now so-called electronic vandalism, which involves intentionally damaging programs and data on a computer, through viruses or other programs that can interfere with access to data or the proper functioning of the system informatics. There is also a kind of vandalism caused by time, but also one caused by poverty and ignorance; for example, when a state cannot maintain its monuments and historical sites as they are or when it has to sacrifice them to development imperatives.

If cultural heritage is considered "identity heritage", then acts of vandalism can be considered "crimes against humanity". In the last two centuries, vandalism has manifested itself mainly in connection with totalitarian ideologies eager to make a "total cleansing" of the past.

The Role of Scientific Investigation in the Valorization of Cultural Heritage Assets

The scientific investigation of *newly discovered or acquired/transferred artifacts* takes into account three aspects with different practical implications [24, 25]:

a. *obtaining new historiographical*, *archaeometric* data and respectively for the *technological* and *scientific* field related to the artifact (*gemology, ceramology, archaeometallurgy, archaeodendrology etc.*);
b. *museum display/protection*, introduction to the tourist circuit, *presentation*, *valorization* and *hoarding* of the artefact;
c. *the trade in antiquities*, with its two forms, *the licit trade* and *the illicit trade* respectively.

Elucidation of some Processes and their Formation Mechanisms

Based on the mechanism of electrochemical corrosion processes with electrodes of the same nature, with a single electrode (based on adjacent structures or in contact with different electrochemical potentials) or with two electrodes (encountered in anodic and cathodic protection) and those of selective corrosion, elucidated the processes of changing the basic structure by reformulating the composition of alumino-silicates from ancient ceramics, following alkaline dissolution through the diffusion of hydrocarbonate ions during the period of rest, with the formation of substitution meshes with aragonite [24, 25], the formation of mineralization structures of structural elements of an organic nature (wood, leather, cellulosic or collagenous textile fibers etc.) through the monolithicization with corrosion products of ancient bronze or iron parts and of substitution ones with differentiated morphologies and distributions in the volume phase of metal parts without a core metallic, the formation mechanism of *Liesegang rings* from the corrosion structure of ancient bronzes, by the presence of fluoro or hydroxoapatite pelliculogenic hydrogels and Sn(II), Zn(II) and Pb(II) oxohydroxides [36-48]. Regarding the *Liesegang effect*, the stratification differentiated by types of compounds (congruent) of the corrosion bulk resulting from deposition period in the archaeological site, is due to the oxyhydroxo compounds of Sn(IV), Pb(II) and Zn(II), which in certain hydrothermal conditions give pelliculogenic nano-structures formed by continuous and uniform hydrogels on the surface on adhesive supports, with osmotic membrane properties. These, following some acid-base, aqueous dissolution and complexation processes under the membrane, lead in drying conditions to the outside of the membrane, to the differentiated stratification of a certain compound, previously formed from the primary or secondary structure. Thus, the tertiary layer of contamination is formed, through processes of osmosis or in certain cases of electroosmosis during homo-precipitations or recrystallization of new congruent structures. A main role in these processes is played by the chloride anion, which together with the hydroxide anion and the hydronium cation creates conditions for the precipitation or crystallization of certain salts of Cu(I and II) ions in the form of successive layers. The chloride anion, together with the hydroxide anion and the hydronium cation, generate compounds from the secondary structures, which emerge from under the primary patina in the form of bumps, concretions, vesications etc. with evolution over time, until the total destruction of the primary patina [36-48].

Studying a series of ancient bronzes, three types of structures were highlighted in their corrosion crust [41-51]:

- *primary* - formed during the period of commissioning and use of the object, through redox processes of a chemical nature (oxides, sulphides etc.), some in the form of continuous and uniform films, forming the *noble patina*;
- *secondary* - results, starting from the final phase of the period of use and continuing with the initial phase after abandonment, following electrochemical redox processes, assisted by acid-base, ion exchange, hydrolysis (oxyhydroxides, oxy- or hydroxysalts, halogens, carbonates, sulfates, phosphates etc.) and sometimes thermal ones (calcinations, recrystallizations etc.) following incineration and anthropogenic or natural fires, which form *poor patina*;
- *tertiary* or *contamination patina*, formed in the archaeological site, under the influence of pedological, chemical and microbiological processes (segregation, diffusion, osmosis, monolithization, fossilization, hydration/dehydration mineralization, structural reformation etc.).

The three types of structures are identified, both in the pieces from disturbed sites and in the undisturbed ones.

Dating Methods and New Archaeometric and Chemometric Features

A series of methods are used in the dating of an old, recently discovered or less studied artefact, with instrumental techniques in a coexistence or interdisciplinary corroboration system. They take into account the nature and the preservation state of the component materials, form,

style, complexity and other structural features. Archaeometry, as a science is related to the study of evolution in time and space, uses a series of characteristics in dating, for which there are reference standards [24, 25].

Among the new methods carried out within our collective we mention [52-75]:

- The use of the two chemometric characteristics of the normal range of variation of the water balance: the maximum or minimum limits (of the absorption curve through hydration and of the desorption curve through dehydration or desiccation) and the point of intersection of the two curves. The latter being a characteristic specific to the essence of wood, the age of the tree, the age of the wood, the place of cutting from the trunk and the period or area of harvesting, has multiple practical implications: in dating and in evaluating the impact of preventive preservation interventions. The normal range of variation of the water balance varies with the reversible hygroscopicity of a material in relation to the humidity of the environment and which does not affect the chemical, physical-structural, mechanical and dimensional characteristics of the object of which it is a part. The critical correlation point of the water balance (the intersection of the adsorption and desorption curves of hygroscopic water is determined from the graphical representation RMC = f(t), with the limits of the domain between the maximum value RMC = ΔEMC and the hypothetical minimum RMC = 0 [52-60].

- For old wooden supports (panels, chassis, frames and frames or casings), a series of archaeometric characteristics related to the degree of penetration of dirt deposits and patina, porosity, crystalline cellulose concentration and residual weight were used in dating of ash, along with the dendrochronological method, with the corrections of the scales for the thickness of the annual rings, and among the chemometric ones were: the wood shrinkage ratios in the three directions: L (longitudinal), R (radial) and T (tangential), respectively ΔT/ΔL , ΔR/ΔT and ΔR/ΔT; concentration remaining in crystalline cellulose; the remaining concentration in volatile components; ash concentration and others [61-75].

- For cellulosic textile supports white matter, glycolysis rate, ratio of carbon/oxygen content (C/O), carbon/hydrogen (C/H), organic carbon/nitrogen ($C/N_{organic}$), pH/Humidity, $N_{mineral}$ /Ash, ratio between extractive components and hygroscopic moisture etc. [61, 62];

- For the pictorial material supports: protein, lipid and carbohydrate markers, the type of cracks, the stratigraphic distribution of the pictorial materials, the penetration degree of dirt deposits and patina, the degree of diffusion between layers, the porosity gradient regarding the penetration from the surface into the volume phase of colors, touch, age patina, chromatic displacement (ΔEab*), archeometric ratios between the chemical elements of the pigments (Pb/C, Zn/C, C/S etc.) [63-69];

- For varnishes: rate of encrustation or cornification of deposits and organic markers of degradation, type of cracks, stratigraphic distribution, degree of blackening or chromatic deviation (ΔEab*) [63-76];

- For primers or preparations: rate of embrittlement and sponginess, binder degradation markers, stratigraphic distribution etc. [69-76];

- For ancient ceramics: nature of chemical components, granulometry and stratigraphic arrangement, porosity, specific gravity, ratio between Si/Al, Ca/Mg and Na/K.

Among these methods, two applied to old cellulosic supports, have been patented and homologated: the determination of the degree of whiteness, which involves the leukometric or spectrophotometric technique by reflection CIE L*a*b* for the determination of the degree of whiteness by extrapolation using specific graphs of various cellulosic supports papers obtained by artificial aging and, respectively, the rate of glycolysis, with the help of intrinsic viscometry, when the degree of polymerization of the cellulosic or protein fiber is determined, and based on this, the rate of glycolysis is evaluated, which varies proportionally with the age. The standard curves were obtained by artificial aging [77-79].

Heritage Evaluation Criteria of Old Paintings and Other Artefacts

Starting with the year 1993 and until 1998, an important research direction of our group was related to the establishment of evaluation criteria through the share of the stock exchange or catalog [24, 25].

For paintings, sculptures and other works of art, taking into account the unanimously accepted criteria in numismatics, philately and cartophily, three groups of systems have been proposed (Tables 1, 2 and 3).

Table 1. The patrimonial grouping system a historical artifacts and art objects (Method of aesthetic-artistic and technical-scientific assessment)

Class	Level	Quota	Value group
A	Worldwide	10^6	Thesaurus
		10^5	Inestimable
		10^4	Very valuable
B	National	10^3	Valuable
		10^2	Common
-	0	10	Kitsch

Table 2. The patrimonial classification system by evaluation of the unique qualification a historical artifacts and art objects (Uniqueness Method)

Class	Level	Quota	Qualification	Value group
A	Worldwide	10^6	Unique	(U)
		10^5	Extremely rare	(I)
		10^4	Very rare	(FR)
B	National	10^3	Great rarities	(RR)
		10^2	Rare	(R)
-	0	10	Frequent or high series/ussual	(C)

Table 3. The patrimonial classification system by assessment of the conservation status a historical artifacts and art objects (Conservation state method)

Class	Level	Quota (procent, %)	Qualification	Value group
A	Worldwide	100	Uncirculated/immaculate (proof)	(N)
		90	Very beautiful (Exelent)	(X)
		80	Beautiful (Extremely fine)	(FR)
B	National	70	Very well preserved (Fine)	(F)
		60	Well preserved	(U)
		50	Medium preserved	(M)
-	0	40	Poor state of conservation	(P)
		≤30		

Moreover, in the patrimonial classification, for banknotes, cartophile and philately: unobliterated/obliterated, unveiled/veiled, fragment, on support (envelope, document etc.), the so-called Michel Quotas are used.

The aesthetic-artistic evaluation criteria and the method of calculation through the qualification grid

In the heritage assessment for paintings, sculptures and other works of art, the criteria are quantified by points (credits or impact index), specific to each one, which according to the complexity, importance in the fundamental analysis, content, hermeneutic, intrinsic value and the exhaustive (the evolution of the indicators), they are grouped into six scales:

a) from 1 to 10 points;
b) from 10 to 100 points,
c) from 100 to 1.000 points,
d) from 1.000 to 10.000 points,
e) from 10.000 to 100.000 and
f) from 100.000 to 1.000.000.

Seven criteria are used in the analysis, as follows:

- *The aesthetic-artistic value*, which includes 30 grids, quantified by specific credits (Table 4);

Table 4. The aesthetic-artistic assessment criteria

1. Chromatic complexity in primary, secondary and tertiary colors (C scale)	16. Internal resonance of lines, dots and color spots, as a Kandinski effect (Scale C)
2. The equation of color surface volume (scale B)	17. Involvement of plastic language elements (Scale C)
3. Resistance of the color and vivacity of the varnish, polishes or ornaments (scale A)	18. The concordance/discordance ratio (Scale B)
4. Refinement of chromatic chords and discords (Scale B)	19. The relationship between linear and chromatic in the iconographic pictorial context (Scale C)
5. The choice of chromatic dominants	20. Closed/open form of compassion (Scale A)
6. Equation of complementary and intermediate shades (Scale C)	21. Simplicity/complexity of compositional schemes (Scale B)
7. Expressiveness of colors and their symbolic values (Scale C)	22. Placement of singular elements within the compositional scheme (Scale B)
8. How to use background colors close to neutral and decorative virtues (Scale B)	23. How to achieve the reverse perspective, rendering the space and content elements (Scale C)
9. The sobriety/vivaciousness of colors, how to develop gradients (Scale A)	24. The involvement of declarative motifs and clothing, with the degree of their reproduction/reproduction (Scale C)
10. The juxtaposition of the tonal steps for the same shade, in the sense of their increase-decrease (Scale C)	25. The absence/presence of drawing elements and the highlighting or not of the sketch sequences (their aesthetic-artistic value) (Scale B)
11. Elaboration by equal, homogeneous stretching and step amplification (Scale B)	26. Presentation of miniatures, watermarks and elements of graphic and chromatic symbolism (Scale C)
12. Light-dark alternation (Scale A)	27. How to achieve the elements of compositional rhythm, plastic rhyme and overall harmony of the work (Scale C)
13. Correlation between lights and shadows (Scale A)	28. Number of iconographic registers and characters/architectural and landscape elements (Scale C)
14. The purity or conciseness of the lines of force or of those of the contour (Scale B)	29. Number of iconographic registers and characters/architectural and landscape elements (Scale C)
15. Disposition of the force or active center (Scale C)	30. The depth and delicacy of the details, with the framing of the plastic/drawing combination elements and the rendering of light, volumes and space (Scale C)

- *The primacy or original spiritual value* (this also includes the theological-dogmatic value of ecclesiastical artifacts), given by the value as a treasure asset, primacy as a fundamental work for a style or effect, then for liturgical ones: liturgical role and importance, meaning spiritual and scriptural foundation and its implications. For example, when evaluating the spiritual function for ecclesiastical artifacts, the miracle-working goods and the credibility of the masses are taken into account. Multiple assessment using *scales from d to f* is used.

- *The value of the artistic and technological technique of putting the artwork into practice*, takes into consideration the style, the invoice and the originality of the creation, the author's demands and the artistic level acquired, the spiritual function - the degree of artistic

novelty (opener of new concepts), then the technical-scientific function and the historical one - documentary, in order to finally evaluate the primacy in the achievement and development of style - multiple evaluation by *scale c.*

- *The value of the materials* and *the cost of the operations* involved in the commissioning - multiple evaluation through the *scales a and b.*

- *Authenticity, uniqueness and the degree of rarity/multiplication* (copies, variants etc.) and that of novelty, the way and frequency of approaching the iconographic motif, the arrangement of colors and systems used in climatic and mechanical protection, the value of ornaments and frames - *multiple evaluation by scales c and f.*

- *The age of the artwork* always provides an impact figure that amplifies the value of the work with a ranking/qualification coefficient, called the age or seniority coefficient (cv), given by the relationship:

$$c_v = v/10(1,2^{v/100}),$$

where: v represents the age or age of the icon - it applies to the final value summed up to this criterion;

- *The integrity and state of conservation* achieves a decrease in the value share (CV), given by the relationship:

$$CV = Summated\ Final\ Value\ x\ (100- conservability).$$

- This criterion also includes cleaning, varnishing/devarnishing, preventive consolidation, preservation and restoration etc. The conservability of *the patina of time*, dirt deposits, inappropriate repainting/falsification interventions, polishing and subsequent framing with ornamental elements are also taken into account.

New Materials and Preservation-restoration Technologies

Another important direction of research within our collective was related to the synthesis and characterization of new materials, as well as the development of modern technologies compatible with operating systems in the preservation and restoration of ancient heritage artifacts.

Among these we mention:

- New ecological physico-chemical systems, based on plant and vegetable supernatants, used in the cleaning of old paintings, which do not affect the old patina, washes and varnishes [80-87];

- New procedures for repatination of restored metal artifacts [88-92];

- New manufacturing processes of ceramic pigments, polychrome mosaics, frescoes etc. [93-108];

- New procedures for chromatic integration of old paintings with lacunar areas, using CIE L*a*b* reflection colorimetry and the virtual stitching system by photofixation, followed by reintegration by printing with water colors, using specialized software [109-112];

- New systems and processes of prophylactic preservation, for example for artefacts on wooden support: mechanical consolidation (with ennobling the fiber), insecto-fungicide, water stabilization (hydrophobization) and fireproofing [113-141].

Conclusions

During the 30 years of activity, the collective's scientific and technological results have allowed, on the one hand, a good development of academic specialization regarding the training of new specialists through the Master's degree (24 series) and certified experts after the completion of the Doctorate thesis (24 young people from Romania and 10 from abroad), and on the other hand to the interdisciplinary foundation of Conservation Science as a field of Environmental Science and Engineering. Particular attention was paid to the development of

course materials (32 mographies and 2 treatises), the development of research infrastructure (eight modern analysis techniques), participation in scientific events and international inventions salons (where 665 medals and 230 order), the publication of articles (over 400) in journals with a high impact factor and the patenting of over 60 inventions in Romania and the Republic of Moldova. These include the organization of 10 editions of the International Symposium on the Art and Science of the Conservation of Artifacts and 14 editions of the European Exhibition of Creativity and Innovation - EUROINVENT (which has become a world brand for Romania in recent years, attended by specialists from over 40 countries). Not without importance are the participation in excavations in archaeological sites in the country and in the restoration of very old ecclesiastical sites, one of which is included in the UNESCO list of Cultural Heritage. We also mention the development as a guest editor of special issues within the journal Applied Science-Basel and the periodical International Journal of Conservation Science.

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Received: March 22, 2022
Accepted: September 29, 2022