Transdisciplinary Studies for Valorisation of National Cultural Heritage Using Nuclear Techniques and Other Associated Methods

Radu Claudiu Fierascu[1][0000-0003-4224-9157], Irina Fierascu[1][0000-0002-1834-9812], Valentin Raditoiu[1][0000-0002-7708-4420], Cristian-Andi Nicolae[1][0000-0002-1278-9518], Mihnea Dulea[2], Dragos Alexandru Mirea[2][0000-0002-5812-6867]

[1] The National Institute for Research & Development in Chemistry and Petrochemistry - ICECHIM, 202 Spl. Independentei, 060021, Bucharest, Romania
[2] "Horia Hulubei" National Institute for Physics and Nuclear Engineering, 30 Reactorului Str., 077126, Magurele, Ilfov, Romania
radu_claudiu_fierascu@yahoo.com, dumitriu.irina@yahoo.com, vraditoiu@yahoo.com, ca_nicolae@yahoo.com, mihnea.dulea@nipne.ro, dragos.mirea@nipne.ro

Abstract. The presented project aims to offer integrated methodologies for the valorisation of national cultural heritage using nuclear and other analytical techniques. The results of the project will offer the potential stakeholders the opportunity to identify the most appropriate methods for the scientific investigation of a large variety of artifacts.

Keywords: Cultural Heritage Artifacts, Nuclear Techniques, Analytical Techniques.

1 Introduction

The application of scientific methods for the investigation of cultural heritage artifacts represents for the last two decades an attractive area of research for scientists with very different backgrounds: physicists, chemists, biologists, engineers, as well as for restoration/ conservation specialists.

Considering the general requirements regarding the application of analytical techniques in archaeometry studies (Hall, 1970), the nuclear techniques usually appear as the best candidates, due to their usual non-destructive character. Several works present the application of nuclear techniques for the evaluation of different types of artifacts (Ortega-Feliu, et al., 2017), (Lehmann, 2018). The International Atomic Energy Agency (IAEA) released a very well-documented and extensive study on the application of nuclear techniques for the analysis and dating of artifacts, with practical examples on different types of materials (paintings, pottery, metals, obsidian, etc.) (IAEA, 2011).

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At national level, Romanian archaeometry groups developed, in general, around very specific know-how (physics, chemistry, etc.) and the collaboration between groups was very often hard to accomplish.

2 Project Description

The project "Techniques for storing and capitalization the results of advanced scientific research" (SoVaReX) aims to develop an integrated information system for storing and capitalizing the results of advanced scientific research, involving several partners from different areas: "Horia Hulubei" National Institute for Physics and Nuclear Engineering (coordinator), National Institute for Laser Plasma & Radiation Physics (INFLPR), National Institute for Research and Development in Microtechnologies - IMT Bucharest, The National Institute for Research & Development in Chemistry and Petrochemistry – ICECHIM and Politehnica University of Bucharest. The project's objectives can be summarised as follows:

- Implementation of an integrated IT system for the acquisition, processing, storage, modelling and analysis of advanced scientific experiments, as well as ensuring its management by specialized personnel;
- *Validating the functionality of the computer system by carrying out three demonstrative scientific experiments in advanced research fields of nuclear physics, high intensity laser and radiation, the results of which will be exploited within the project;*
- Development, hosting and maintenance of electronic dissemination and communication tools for project beneficiaries, including at least 15 websites for representatives of target groups;
- Organization and support of professional training programs for researchers in the field of competence – achievement of numerical simulations, data capture - analysis / interpretation as part of the scientific research process, through a specialized accredited training centre in the nuclear field;
- Developing a set of courses for end-users in the fields of information technology, intellectual property and technology transfer, public communication, as well as a training program for both these courses and fields for the education system;
- Developing of technologies based on Internet of Things and sensor systems;
- Organizing information and initiation campaigns for entities eligible to use the integrated IT system by developing audio and video promotional materials, supporting national and international events, increasing the value of advanced research results in the field of nuclear physics, high intensity laser and radiation.

As described above, three demonstrative scientific experiments will be implemented in order to validate the functionality of the computer system. One of those demonstrative experiments (which can be considered mini-projects) is the research conducted by ICECHIM in collaboration with the coordinator - *Transdisciplinary studies for the valorisation of the national cultural heritage*.

3 Demonstrative Experiment - Transdisciplinary Studies for the Valorisation of the National Cultural Heritage

Considering the previous collaboration with the project coordinator in the field of archaeometry (Fierascu, R.C., et al. 2017; Fierascu, I., et al., 2018), the demonstrative experiment (D.E.) assumed by ICECHIM focused on development and implementation of methodologies for the study of cultural heritage artifacts (focusing on metallic artifacts, historical textiles and wood artifacts).

3.1 The degree of novelty and complexity

The use of analytical techniques proposed for the investigation of cultural heritage artifacts usually leads to a very large volume of data, difficult to interpret and present. The proposed advanced methodology will lead to more efficient use, including scale-up possibilities for large nuclear units or high-intensity laser installations, as well as a more compact form of research results, accessible to researchers working in this area, as well as those interested in other fields (NGOs, public authorities, etc.).

3.2 Methodology and techniques used

In the demonstrative experiment, evaluation methodologies will be developed, integrating nuclear techniques, high intensity lasers and other (classic) methods of characterising the various types of artifacts belonging to the cultural heritage.

The investigation techniques to be used are:

- Nuclear and associated techniques – X-ray fluorescence, X-ray diffraction, Electron Microscopy (transmission and scanning), particle-induced X-ray emission, micro-SR-XRF;
- Classical Investigation Methods - complementary non-destructive or micro-destructive techniques in the study of cultural heritage artifacts - Fourier-transform infrared spectroscopy (FTIR), thermal analysis, inductively coupled plasma atomic emission spectroscopy (ICP-AES), etc.);
- Evaluation of microbiological infestation of cultural heritage artifacts;
- Methods of decontamination of artifacts using ionizing radiation;
- In the demonstration experiment, the possibilities of using high intensity lasers in the study of cultural heritage artifacts will be evaluated.

3.3 Demonstrative experiment activities

The entire SoVaReX project is divided into three phases, the D.E. following the same distribution of the activities.

- Studies on the valorisation of the national cultural heritage – this activity is divided in three parts (corresponding to the three phases of the project), involving literature survey regarding the project's topic and archaeometry studies;

- Developing websites with information relevant to the project goal, containing information of interest for stakeholders;
- Information and dissemination activities: developing partnerships with stakeholders to disseminate developed methodologies and databases; creating and publishing guides for investigation techniques in archaeometry and good practice cases; editing and distribution of promotional materials.

3.4 Expected results

At the D.E. level, the expected results are:

- Methodologies for evaluating the cultural heritage artifacts, considering the nature of the support material (metallic objects, historical artifacts, wood artifacts);
- A database containing the results obtained, as well as presentation of the studied artifacts (historical and aesthetical data, images of the artifacts);
- Publication of at least one paper in a scientific journal, presenting specific archaeometry studies;
- Publication of two electronic books (on CD format) that will be disseminated to stakeholders and also be published on the D.E. web-page, one being currently in the last production steps (*Valorization of cultural heritage through archaeometry studies using nuclear techniques and other scientific methods. General considerations and short literature survey* - ISBN 978-973-0-27114-0) – Figure 1;
- Participation in at least three international scientific meetings, for the dissemination of the project and of the obtained results: International Symposium - Current Trends in Natural Sciences (April 19 – 21, 2018 University of Pitesti, Romania), 1st International Conference on VR Technologies in Cultural Heritage (VRTCH'18, May 29-30, Brasov, Romania), 18th International Balkan Workshop on Applied Physics and Materials Science (July 10-13, 2018, Constanta, Romania), 9th International Conference "Advanced Topics in Optoelectronics, Microelectronics and Nanotechnologies" (ATOM-N 2018, August 23 – 26, 2018, Constanta, Romania), 25th Congress of the Society Chemists and Technologists of Macedonia (SCTM, September 19-22, 2018, Ohrid, Macedonia).

The expected results will be completed with the contribution to the results obtained at the level of the entire project - web-page development, researchers trained to carry out numerical simulations (data analysis / interpretation) for the superior valorisation of the obtained results.

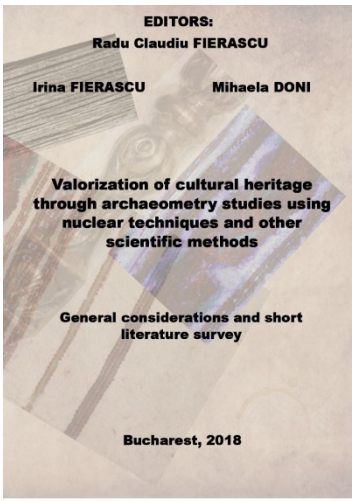

Fig. 1. The cover of the first e-book published as a result of the project.

3.5 Technical, economic and social impact

Archaeometry studies contribute to the safeguarding and understanding of the cultural property, for the benefit of present and future generations. Conservation of heritage has multiple values: cultural, aesthetic, educational, social, historical. An added value is the economic contribution of heritage preservation: jobs, city centre revitalization, tourist heritage, property value, small business development (Embaby, 2014).

The expected impact of the project will be scientific, technological, industrial, economic, educational, formative and social. Referring to scientific expertise during and after the end of the project, it is highlighted by:

- creating a unique team of researchers with inter- and trans-disciplinary competencies, which enhances the visibility of the institutions involved;
- creating a consortium able to attract funds by applying to international and national projects;
- creating new opportunities for international scientific collaboration;
- contributing to promoting sustainable development and equal opportunities: cascading the knowledge gained during the project;
- training opportunities.

Increasing institutional performance of partner organizations will be achieved through: capitalizing and disseminating knowledge and research results; providing high-tech technical and scientific assistance and technology to relevant stakeholders (at national, regional or local level); the possibility to initiate and develop viable collaborations with partners from the public and private economic environment; increasing engagement and visibility at international level.

At the level of the general public, the impact of this project will be significant - on the one hand, through its awareness / education actions on the sensitive aspects of cultural heritage; and on the other hand - by preserving this heritage for future generations.

4 Conclusions

Integrated into a very complex project, the presented demonstrative experiment will develop and implement methodologies for the evaluation cultural heritage artifacts (metallic objects, historical textiles and wood artifacts), incorporating nuclear techniques and other analytical techniques, for obtaining superior results. Supplementary information can be found at http://sovarex.nipne.ro/ - SoVaReX project and http://sovarex-patrimoniu.nipne.ro/ - demonstrative experiment site.

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