Participation of Croatia in the IAEA Project RER/8/015

Using Nuclear Techniques for the Characterisation and Preservation of Cultural Heritage Artefacts in the Europe Region

> Branka Katušin-Ražem, country coordinator, Ruđer Bošković Institute, Zagreb and Mario Braun, Croatian Conservation Institute, Zagreb



Seminar: Irradiation Methods in the Protection of Cultural Heritage, RBI/CCI, Zagreb and Zadar, 4 and 5 October 2011.



TC IAEA RER 8015 (2009 - 2011):

International Atomic Energy Agency (IAEA)



Regional Project of Tehnical Cooperation: RER 8015

"Using Nuclear Techniques for the Characterization and Preservation of Cultural Heritage Artefacts in the Europe Region"

(extension of the project RER/1/006 "Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region")

Objective:

To improve the characterization and preservation of cultural heritage artefacts through the application of nuclear techniques with special emphasis on gamma irradiation treatment, making use of techniques including insect eradication and disinfection in various cultural heritage materials and consolidation of degraded materials with radiation-curing resins

Presentation of regional TC Project RER8015:

Nevenka Novosel, National Liaison Officer (NLO), Croatian State Office for Nuclear Safety, Zagreb

Institutions from Croatia involved in RER 8015

1. RUÐER BOŠKOVIĆ INSTITUTE (RBI)

- Laboratory for Measurements of Low-level Radioactivity
- Laboratory for Ion Beam Interactions
- Laboratory for Radiation Chemistry and Dosimetry

2. CROATIAN CONSERVATION INSTITUTE (CCI)

3. ACADEMY OF FINE ARTS (AFA)

Laboratory for Science and Technology in Art

Institutions from Croatia involved in RER 8015:

Ruđer Bošković Institute, Zagreb

Laboratory for Measurements of Low-level Radioactivity (LMLR)

Radiocarbon dating

- Liquid scintillation counting technique (LSC)
- Preparation of samples for Accelerator Mass Spectrometry (AMS)



Laboratory for Measurements of Low-level Radioactivity Application in archaeology

Results of ¹⁴C dating of archaeological samples

From: Slovenia, Croatia, Hungary, Bosnia & Herzegovina, Serbia, Montenegro & Macedonia

About 170 archaeological samples are dated per year



Application in archaeology

Some important sites:

St. Donat, Zadar; Clarissae convent, Zagreb Upper Town

Stobi; Andautonia; ships at Nin

Kaptol, Požega; Zagreb City Museum; Privlaka, Vinkovci

Cave Bezdanjača; Pupićina peć-Istria; Igrišće, Kalnik

Vučedol, Vukovar; Grabrovac, Đakovo; Vinkovci; Rudine, Koprivnica

Sopot, Vinkovci; cave Vela špilja, Korčula

Lepenski vir; Vela špilja, Korčula

Reference:



B.Obelić, N.Horvatinčić, A.Durman: Radiocarbon chronology of archaeology sites in south-eastern Europe. In: "¹⁴C and Archaeology", (1999), p.233-238



Institutions from Croatia involved in RER 8015:

Ruđer Bošković Institute, Zagreb

Laboratory for Ion Beam Interactions (LIBI)



Laboratory for Ion Beam Interactions (LIBI)



IBI –about 200 samples analysed per year

Ion beam analysis in the caracteristion of cultural heritage objects

Cooperation with CCI: PIXE analysis



Dissolution of copper in sea water causes the increased concentration of lead close to the surface

Radiation Chemistry and Dosimetry Laboratory (RCDL)

Panoramic batch-type dry storage ⁶⁰Co irradiator (constructed 1967)

- ⁶⁰Co total activity: 130 kCi (1 July 2000)
- source assembly: 92 source pencils in 24 source rods; rods arranged as a cylinder 32 cm dia 32 cm high

Irradiation chamber:

- rectangular room:4.9 m 3.9 m, 3.5 m high
- capacity: 4 6 m³ of material

Radiation field mapping:

-ethanol-chlorobenzene (ECB) dosimetry system (ISO/ASTM 51538)



Radiation Chemistry and Dosimetry Laboratory

Panoramic batch-type dry storage ⁶⁰Co irradiator

- the only one of the kind in Croatia

Suitable for a broad scope of scientific investigations, from medium dose range used in radiobiology to high doses pertaining to investigations in radiation chemistry, radiation dosimetry and radiation processing

Suitable for providing multipurpose irradiation services in radiation processing of materials for desinsection, disinfection, pasteurisation and sterilisation



D. Ražem: **Twenty years of radiation sterilization in Croatia**, *Radiation Physics and Chemistry*, 71 (2004) 595-600.

Radiation Chemistry and Dosimetry Laboratory

Radiation treatment of cultural heritage objects

- desinsection:
- insect control 0.5 2 kGy

for: wooden objects, textiles, paper, parchment

- desinfestation:
- control of fungi 4 10 kGy
- decontamination 5 20 kGy

for: wooden objects, paper, leather





About 20 m³, mainly wooden heritage objects, are treated annually.

Radiation Chemistry and Dosimetry Laboratory

Radiation treatment of cultural heritage objects

Treated over more than 20 years:

More than 8000 wooden sculptures, parts of altars, furniture, tools, musical instruments, other wooden, paper, straw, textile, leather items, etc.











Institutions from Croatia involved in RER 8015: Croatian Conservation Institute

Research and Documentation Department

Science laboratory

- chemical and physical analyses (diagnostics) of cultural heritage objects;
- control of conservation processes;
- research on the use of advanced material in conservation and restoration
- climatic and environmental monitoring
- non-destructive analyses





Lab: about 5000 samples analysed by various techniques per year; XRF: 700-1000 analyses per year

Institutions from Croatia involved in RER 8015:

Croatian Conservation Institute

Research and Documentation Dept.

Photographic laboratory



Between 20 and 50 art objects analysed per year with various non-desctructive techniques

Institutions from Croatia involved in RER 8015: The Academy of Fine Arts, University of Zagreb

Department of Conservation and Restoration

Laboratory for science and technology in art - recently established at the Academy of Fine Arts in Zagreb

- it has obtained a national project to develop a portable XRF instrument for cultural heritage applications
- it is performing characterisation of materials: analyses of pigments, quantitative analyses of metal art objects

About 100 cultural heritage object analysed per year

RER 8015: Activities of Croatian Experts

Regional Planning and Coordination Meeting Vienna, Austria, February 2009 (The first Coordination Meeting of RER 8015 and, at the same time, the final meeting of TC Project RER 1006: *Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region*) Participants: Branka Katušin-Ražem (RCDL-RBI) Stjepko Fazinić (LIBI-RBI) Mario Braun (CCI)

Regional Planning and Coordination Meeting St Julian's, Malta, September 2010 (Midterm meeting) Participants: Branka Katušin-Ražem (RCDL-RBI) Mario Braun (CCI)

Final Regional Coordination Meeting Warsaw, Poland, September 2011, Participant: Stjepko Fazinić (LIBI-RBI)

RER 8015: Activities of Croatian Experts (cont.)

Task Force Meeting to Define the Strategy of the ExperimentalExercises in the Use of Radiation Processing Technology -Commissariat à l'Energie Atomique (CEA), ARC-NucleArt, Grenoble,France, 5 - 7 October 2009Participant:Branka Katušin-Ražem (RCDL-RBI)Presentation:Gamma irradiation treatment for the protection ofcultural heritage in Croatia

School for Conservators and Restorers on the Use of Nuclear Methods - Sofia, Bulgaria, 19 - 20 November 2010 Participant: Mario Braun (CCI) (in the capacity of IAEA expert)

National Conservation Centre for Cultural Heritage, NationalInstitute for the Protection of Cultural Heritage, Skopje, The FormerYugoslav Republic of Macedonia, 29 - 31 March 2011Visitor:Mario Braun (CCI) visit to the Project counterparts



RER 8015: Activities of Croatian Participants

Croatian participants at the Regional training courses

Regional Workshop on the Assessment and the Necessity of Prioritizing in the Protection of Cultural Heritage Banja Luka, Bosnia and Hercegovina, 19 - 21 October 2009 Participants: Irina Pucić (RCDL-RBI) Mario Braun (CCI) Training Course on the Characterisation of Cultural Heritage Objects by Using Nuclear Application Techniques Turkish Atomic Energy Authority (TAEK) Saraykoy Nuclear Research and Training Center, Ankara, Turkey, 5 - 13 July 2011 Veljko Grilj (LIBI-RBI) Participants: Domagoj Mudronja (CCI) Training Course on Demonstration of Techniques for Cultural Heritage Protection National Institute of Physics and Nuclear Engineering "Horia Holubei", Magurele, Romania, 5 - 13 September 2011

Participant: Tanja Jurkin (RCDL-RBI)

RER 8015: Activities of Croatian Participants (Cont.)

Scientific visits of Croatian Participants

Training on the Characterization of Ancient and Artificial Stone Samples by Using Micro XRD/XRF Based on Synchrotron Radiation Source

Swiss Light Source (SLS), Paul Scherrer Institute, Villigen, Switzerland, April 2011 (1 week)

Participants: Stjepko Fazinić (LIBI-RBI) Domagoj Mudronja (CCI)

Fellowships to Croatian participants

Training on the Optimization and Improvements in Sample Preparation Techniques for AMS of Cultural Heritage Objects Including Preparation of Targets for Dissolved Organic Carbon in Natural Water Samples Radiocarbon Laboratory, Natural Environment Research Council (NERC), East Kilbride, UK, March 2011) (1 month) Participant: Andreja Sironić (LMLR-RBI)

RER 8015: Activities of Croatian Participants (Cont.)

Joint RCDL - RBI and CCI Croatian National Seminar:

"Irradiation Methods in the Protection of Cultural Heritage"

Mimara Museum, Zagreb, 4 - 5 October 2011

(http://www.h-r-z.hr/en/index.php/djelatnosti/struni-skupovi/318-irradiation-methods-in-the-protection-of-cultural-heritage)

The aim of the seminar was to introduce irradiation procedures to conservators and all other specialists involved in the care, protection and presentation of cultural heritage artefacts

The seminar was covering two topics: "Desinsection and Disinfection of Cultural Heritage Artefacts by Irradiation" "Consolidation of Degraded Heritage Artefacts by Impregnation with Radiation-Curable Resin and Subsequent Irradiation"

Mr. Quoc Khoi Tran from the NucleArt Laboratory of the French Atomic Energy Commission (Commissariat a l'Energie Atomique), Grenoble, France, has been lecturing as an International Atomic Energy Agency expert



RER 8015: Visit of the IAEA Expert to Croatia

Mr. Quoc-Khoi Tran, ARC-NucléArt, CEA-Grenoble, France, was visiting Radiation Chemistry and Dosimetry laboratory (RBI) from 3 to 7 October 2011 as the counterpart in the Project.

He presented two lectures at the National Seminar in Zagreb:

- Irradiation treatments for the protection of cultural heritage objects -French experience

- Irradiation consolidation of degraded heritage objects by impregnation with radiation-curable resin monomers

The visit included the UNESCO Center for Underwater Archaeology in Zadar on 6 October 2011, where consultations on the consolidation of heavily damaged and water-logged arheological objects were held, as well as the presentation of the lecture:

Consolidation of water-logged heritage objects by impregnation (http://www.h-r-z.hr/en/index.php/djelatnosti/struni-skupovi/352-irradiationmethods-in-the-protection-of-cultural-heritage)

A brief visit to the Institute of Art History and the restoration workshop of the CCI in Split was paid on 7 October 2011

Scientific visits of international participants to Croatia

Macedonian experts: Mr. Behixhudin Shehabija Ms. Svetlana Mamučevska-Milković Ms. Ljuljzime Prusi Agai from the National Conservation Centre for Cultural Heritage, National Institute for the Protection of Cultural Heritage, Skopje, The Former Yugoslav Republic of Macedonia, visited CCI and RBI, 20 - 24 July 2009.

In continuation of active cooperation during RER/10/06, discussions on the topics of mutual interest took place in the CCI, as well as in the three RBI Laboratories, LIBI, LMLR and RCDL.

RER 8015: Fellowships Hosted in Croatia

- Ms. Nihal Kaya from the Turkish Atomic Energy Authority (TAEK) Saraykoy Nuclear Research and Training Center, Ankara, Turkey, spent two months training programme (October - November 2009) within the IAEA- RER/8/015 (TUR/09005) at the Laboratory for Measurements of Low-level Radioactivity, RBI. The training covered chemical techniques of sample preparation, mainly the production of benzene as an end product for ¹⁴C measurements by liquid scintillation counting (LSC).

- Ms. Dinara Abbassova from Azerbaijan Nuclear Energy Commission spent one month training (November 2011) (AZB11006) at the Laboratory for Measurements of Low-level Radioactivity, RBI. The training included radiocarbon dating and LSC applied to cultural heritage objects.

RER 8015: Education and Popularization of Nuclear Methods in the Preservation of Cultural Heritage

- lectures for pupils and students on the application of nuclear techniques;
- demonstration of facilities and instruments at RBI (LMLR, LIBI, RCDL), CCI and AFA for pupils and students;
- radiation treatment of woden artefacts for practical use for pupils and students in workshop exercises

Secondary school for professional education:

Carpenters School, Zagreb; multiannual cooperation

Graduate study:

Academy of Fine Arts, University of Zagreb

Department of Restoration - Conservation of Art Objects;

Cooperation since the establishment of the Department (more than 10 years ago)

Academy of Arts, University of Split

Department of Visual Arts, Section for Restoration -Conservation On-line journal *In Situ* (http://www.e-insitu.com)

Department of Art and Restoration, University of Dubrovnik

Postgraduate study:

Participation in doctoral studies in restoration, University of Dubrovnik Seminar: Irradiation Methods in the Protection of Cultural Heritage, RBI/CCI, Zagreb, 4 and 5 Oct 2011

RER 8015: National Cooperation between Institutes

Document:

Formal Cooperation Agreement RBI – CCI Ministry of Culture and Ministry of Science Signed 27 April 2006 at RBI



Seminar: Irradiation Methods in the Protection of Cultural Heritage, RBI/CCI, Zagreb, 4 and 5 Oct 2011

RER 8015: National Cooperation (cont.)

Partners of LIBI-RBI in the cooperation on the use of nuclear analytical methods for the characterisation of cultural heritage objects

Croatian Conservation Institute Most important partner, continuous cooperation since 1985

Academy of Fine Arts, University of Zagreb Department for Conservation/Restoration of Art Objects Continuous cooperation for over more than 10 years since the foundation of the Department

National and University Library, Zagreb

Croatian State Archives, Zagreb, Cooperation in progress

Archaeological Museum in Zagreb, other museums in and out of Zagreb

RER 8015: National Cooperation (cont.)

Partners of RCDL-RBI in the cooperation on the use of irradiation for the protection of cultural heritage

Croatian Conservation Institute

Most important partner, continuous cooperation since 1991

Academy of Fine Arts, University of Zagreb Department for Conservation/Restoration of Art Objects Continuous cooperation for over more than 10 years since its foundation

Croatian State Archives, Zagreb, Cooperation in progress National and University Library in Zagreb and others

Museums

Musem of Contemporary Art, Ethnographic Museum, Croatian History Museum, Museum Mimara, Museum for Arts and Crafts and many others

Zagreb archidiocese Serbian Orthodox Church Parish, Zagreb Jewish Church Community, Zagreb

RER 8015: National Cooperation (cont.)

Partners of LMLR-RBI in the cooperation on dating of cultural heritage objects:

Institute of Archeology, Zagreb Institute for Antrhropology, Zagreb Faculty of Art, Department for Archeology, University of Zagreb Croatian Conservation Institute National and University Library, Zagreb Croatian State Archives, Zagreb, Cooperation in progress

Archaeological Museum, Zagreb, Natural History Museum and other museums in and out of Zagreb

Academy of Fine Arts, University of Zagreb Department for Conservation/Restoration of Art Objects

Zagreb archidiocese Serbian Orthodox Church Parish, Zagreb Jewish Church Community, Zagreb

(About 18 institutions in total)

RER 8015: National Cooperations (cont.)

Partners of CCI in the cooperation on the protection of cultural heritage

Ruđer Bošković Institute Institute of Archeology, Zagreb Institute of Art History, Zagreb Croatian State Archives

Museums and Galleries

Museum for Arts and Crafts, Modern Gallery, Klovićevi dvori Gallery Croatian History Museum, Mimara Museum, Archaeological Museum and other museums in and out of Zagreb

Faculties

Faculty of Art, Zagreb Academy of Fine Arts, University of Zagreb Academy of Arts, University of Split Department of Art and Restoration, University of Dubrovnik Faculty of Architecture, University of Zagreb Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split

Zagreb archidiocese Serbian Orthodox Church Parish, Zagreb Jewish Church Community, Zagreb and Dubrovnik

RER 8015: National Cooperation between Institutions



National Project:

Identification, characterization and conservation of the Book of Statutes of the town of Dubrovnik from 1272 Ruđer Bošković Institute - Croatian State Archive

The book is a 15th c. transcript on parchment with wood/leather covers

The three RBI laboratories using nuclear methods are joining efforts in the same project for the first time:

- Laboratory for Ion Beam Interactions
- Laboratory for Measurements of Low Level Radioactivity
- Laboratory for Radiation Chemistry and Dosimetry

In the proccess of the conservation of the book, the characterisation of pigments and metals by PIXE and dating by ¹⁴C will be performed. For the protection against biodegradation the book covers will be treated by irradiation.



Croatia - Malta

The cooperation between CCI and Heritage Malta, initiated in 2007, has unfortunately not been completeld in time because of the problems with XRF equipment (which was solved only at the end of February 2010).

Croatia - The Former Yugoslav Republic of Macedonia

The cooperation between CCI and the National Conservation Centre for Cultural Heritage, National Institute for the Protection of Cultural Heritage, Skopje, was agreed under the IAEA Technical Co-operation Project MAK 2005/9001:

Establishing of Nuclear Techniques for the Analysis and Preservation of National Cultural Heritage Objects

Bilateral Agreement between CCI and National Institute for the Protection of Cultural Heritage was concluded in Zagreb in April 2010.

RER 8015: International bilateral cooperations (cont.)

Croatia - Hungary

The cooperation between RCDL- RBI and the Institute of Isotopes, Budapest, Hungary, was agreed under the Agreement of Scientific and Technical Cooperation between Croatian Academy of Sciences and Arts and Hungarian Academy of Science, (2010-2011) on the subject:

Nuclear Techniques for the Characterization and Preservation of Cultural Heritage Artefacts

Croatia - Slovenia

The cooperation between RCDL-RBI and Restoration Centre, Institute for the Protection of Cultural Heritage of Slovenia, (RC-ZVKDS), Ljubljana Slovenia, was concluded on the subject: *Irradiation Method in the Preservation of Historic Museum Textiles*

The results of experiments performed at the gamma irradiation facility of the RBI were included in the PhD Thesis:

Katja Kavkler: *Fungi on Museum Textiles and Their Impact on Natural Fibers,* presented to the Department of Textiles, Faculty of Natural Sciences and Engineering, University of Ljubljana, Slovenia

RER 8015: Future plans

Development of new methods and acquisition of instrumentation:

- accelerator mass spectrometry (LMLR and LIBI, RBI) for ¹⁴C dating of milligram-sized samples;

- thermoluminescence dating (RCDL-RBI);

- the reconstruction of the linear electron accelerator (LINAC) for the extension of irradiation capabilities (RCDL-RBI);

- the upgrade of panoramic cobalt-60 irradiation facility (RCDL-RBI);

- development and application of automatic devices for remote on line monitoring of physical conditions to control biological degradation of CH objects applicable upon conservation including radiation treatment (CCI);

- upgrade of the existing XRF to µXRF (CCI);

Some specific topics of our present interest within RER/8/015:

ageing, corrosion and alteration processes of alloys (bronze), glass and building stones; research of production of oxalate layers on stone materials as a basis for the development of a method of stone protection (CCI and LIBI-RBI);
analysis of paintings (pigments, binding media, imaging techniques) (CCI and LIBI-RBI);

- preparation of samples for AMS dating of organic material by the¹⁴C method (LMLR-RBI);



- introducing methods for radiation consolidation of heavily damaged cultural heritage objects of porous materials (wood, stones) (RCDL-RBI and CCI)

References:

Radiation technology in the protection of cultural heritage objects

Katušin–Ražem, B., Ražem, D. and Braun M. <u>Irradiation treatment for the</u> protection and conservation of cultural heritage artefacts in Croatia. Radiation Physics and Chemistry, 78 (2009) 729-731.

Dating of cultural heritage objects

Krajcar Bronić, I., Obelić, B., Horvatinčić, N., Barešić, J., Sironić, A., Minichreiter, K., <u>Radiocarbon application in environmental science and archaeology in Croatia</u>. Nuclear Instruments and Methods in Physics Research A, 619 (2010) 491-496.

Krajcar Bronić, I., Horvatinčić, N., Sironić, A., Obelić, B., Barešić, J., Felja, I. <u>A new graphite preparation line for AMS ¹⁴C dating in the Zagreb Radiocarbon</u> <u>Laboratory</u>. Nuclear Instruments and Methods in Physics Research B - Beam Interactions with Materials and Atoms, 268 (2010) 943-946.

Nuclear analytical methods:



Mudronja, D., Jakšić, M., Fazinić, S., Božičević, I., Desnica, V., Woodhead, J., Stos-Gale, Z.

Croatian Apoxiomenos alloy composition and lead provenance study. Journal of archaeological Science, 37 (2010) 1396-1402.





