

## THE IAEA TECHNICAL COOPERATION PROJECTS ON THE APPLICATIONS OF NUCLEAR TECHNIQUES FOR CULTURAL HERITAGE RESEARCH

### A NEMZETKÖZI ATOMENERGIA ÜGYNÖKSÉG EGYTTMŰKÖDÉSI PROGRAMJAI A NUKLEÁRIS MÓDSZEREK ALKALMAZÁSÁIRÓL A KULTURÁLIS ÖRÖKSÉG KUTATÁSÁBAN

ZSOLT KASZTOVSZKY

Centre for Energy Research, Hungarian Academy of Sciences

H-1121 Budapest, Konkoly Thege str. 29-33.

E-mail: [kasztovszky.zsolt@energia.mta.hu](mailto:kasztovszky.zsolt@energia.mta.hu)

#### **Abstract**

*The International Atomic Energy Agency was founded in 1957. Its mission was declared as to foster the safe and peaceful applications of the atomic energy and nuclear technologies. The four major fields of its activity are: 1, Nuclear and Radiation Safety, 2, Nuclear Energy, 3, Human Health and 4, Isotope and Radiation Technology Applications. Among the various applications of nuclear techniques, forensic and cultural heritage studies have become of more and more importance. In this paper, I give an overview of the Technical Cooperations on cultural heritage research, launched by the IAEA in the last decade.*

#### **Kivonat**

*A Nemzetközi Atomenergia Ügynökség (International Atomic Energy Agency – IAEA) 1957-ben alapított független nemzetközi szervezet, amelynek deklarált küldetése az atomenergia és a nukleáris technológiák biztonságos és békés felhasználásának elősegítése – amint azt mottója, „Atoms for Peace” is kifejezi. Tevékenységét a tagországok kutatóinak, szakembereinek munkáján keresztül négy fő területen végzi: 1, nukleáris biztonság és sugárvédelem, 2, nukleáris energia, 3, egészségügy valamint 4, az izotóptechnika, ill. sugártechnológia különböző alkalmazásai. Az alkalmazott kutatások közül egyre növekvő szerepet kapnak az ún. „nukleáris törvényszéki” vizsgálatok, valamint a kulturális örökség tárgyainak kutatása. Az alábbi összefoglaló írásban áttekinjtük az elmúlt évtizedben az IAEA által a kulturális örökség vizsgálata tárgyában indított regionális együttműködés programok (ún. „Technical Cooperation”-ok) főbb jellegzetességeit.*

KEYWORDS: INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA), NON-DESTRUCTIVE, NUCLEAR TECHNOLOGY, CULTURAL HERITAGE, TECHNICAL COOPERATION, COORDINATED RESEARCH PROJECT

KULCSSZAVAK: NEMZETKÖZI ATOMENERGIA ÜGYNÖKSÉG, RONCSOLÁSMENTES, NUKLEÁRIS TECHNIKÁK, KULTURÁLIS ÖRÖKSÉG, TECHNICAL COOPERATION, COORDINATED RESEARCH PROJECT

#### **Introduction**

The International Atomic Energy Agency (IAEA) was founded in 1957. The slogan of the worldwide independent organisation is known as “Atoms for peace” within the United Nations. Its mission is to promote the safe, secure and peaceful use of nuclear technologies together with Member States and multiple partners worldwide. The homepage of the Agency can be found at <https://www.iaea.org/>. The Agency carries out its European Regional activity through four thematic areas: 1, Nuclear and Radiation Safety, 2, Nuclear Energy, 3, Human Health and 4, Isotope and Radiation Technology Applications – including nuclear forensics, medical, environmental, food & agricultural, industrial and cultural heritage applications. The applications of nuclear technology or more precisely, the applications of ionizing radiation used to be on top in the 1960s and 1970s. Various nuclear-based

methods have been widely applied in industry, agriculture and medicine. Nowadays, the nuclear methods are gradually replaced by non-nuclear ones in the above fields, but in nuclear forensics and in the cultural heritage applications, nuclear methods are still preferred – mainly thanks to their non-destructive feature. In this paper and in the other few in this volume, we present the talks given on 12 January 2016 at the Budapest Neutron Centre, on the occasion of scientific visit of Maria Isabel Garrido Prudencio and Maria Isabel Marques Dias from the Universidade Técnica de Lisboa, Instituto Superior Técnico, Instituto Tecnológico e Nuclear, Portugal and Ziga Smit from Faculty of Mathematics and Physics, University of Ljubljana.

We would like to acknowledge the importance of the IAEA in fostering the co-operation of the participating countries in the field of Heritage Science.

## **Discussion**

### **The overview of the Technical Cooperations of the IAEA**

Let's overview, how nuclear techniques can contribute to the family of social sciences, including archaeology, art history, restoration and conservation.

During the investigation of a historical object, the first things to describe are their characteristics, such as its appearance, material(s) made of, technology of production and, last but not least, its age. For characterisation (determination of raw material composition, structure, degree of corrosion) and also for dating, various analytical methods can be applied. Obviously, the non-destructive and non-invasive methods are almost exclusively preferred. Among the archaeological dating methods, usually the C-14 method is considered as a nuclear one.

The results of the characterisation and dating studies can provide data for pure social sciences, such as archaeology, or may serve as background information for conservators or restorers.

On the other hand, high dose gamma radiation can be an effective tool to perform conservation treatment on cultural heritage objects, i.e. to destroy harmful insects or fungi. In this view, the IAEA divides the field of Applications of Nuclear Techniques for Cultural Heritage Research into three main tasks: characterisation, dating and preservation. Later on, authentication was also included, i.e. to distinguish original from counterfeit art objects, using non-invasive nuclear techniques.

As the importance of non-invasive nuclear techniques has been recognized, the IAEA has launched a series of European regional Technical Cooperations (TC) since 2005, with an increasing number of participants and with widening scientific activity within the Cultural Heritage applications.

The first TC (with a serial number of RER1006) was running from 2005 to 2007. Its title was "Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region". Its main objective was to contribute to the study and preservation of cultural heritage through the establishment of a sub-regional network of the project counterparts and end-users. In the beginning, there were only ten participating from the Central and South-Eastern European / Mediterranean countries in the project: Albania, Bosnia and Herzegovina, Croatia, Greece, The Former Yugoslav Republic of Macedonia, Malta, Romania, Slovenia, Serbia and Turkey. Invited experts from Western European leading institutions (for instance Prof. Cornelius Ponta from Grenoble, France) took part, too.

The second TC (RER8015, entitled "Using Nuclear Techniques for the Characterization and Preservation of Cultural Heritage Artefacts in the European Region") was running between 2009 and 2012. Its objective was to improve the characterization and preservation of cultural heritage artefacts using nuclear techniques with special emphasis on gamma irradiation treatment to consolidate degraded materials. Not only the scope, but also the number of participating countries indicates the growing interest in the topic. Already 23 countries – Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Greece, Hungary, Kazakhstan, Latvia, Lithuania, Malta, Montenegro, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Tajikistan, The Former. Yug. Rep. of Macedonia and Turkey – and even more invited experts from Grenoble, C2RMF Louvre Laboratory, France and from ENEA-UTTMAT, Rome took part. It was the first time when Hungary and Portugal joined the team.

The third TC (RER0034, entitled "Enhancing the Characterization, Preservation and Protection of Cultural Heritage Artefacts") lasted from 2012 to 2013 and its objective was to improve the characterisation, preservation, protection and authentication of cultural heritage artefacts by effective utilisation of nuclear analytical techniques and radiation technology. This project was a natural extension of the previous one, with the same participants and more or less the same work plan.

The objective of the last one between 2014 and 2015 (RER0039, entitled "Extending and Diversifying the Application of Nuclear Technology in Cultural Heritage") was defined as enhancing cultural heritage knowledge and its contribution to socioeconomic welfare. As it was indicated in the title, this project intended to achieve a synthesis of the efforts and achievements of the previous TCs.

During the course of the consecutive projects, the participating countries offered their research infrastructure and expertise into various bi- and multilateral co-operations among them. Many participating countries operate research reactors, accelerator-based ion beam laboratories, C-14 laboratories, other lab based or portable spectroscopic devices (XRF, XRD, IR-, and Raman-spectroscopy) and they possess the knowledge to utilise them in cultural heritage research.

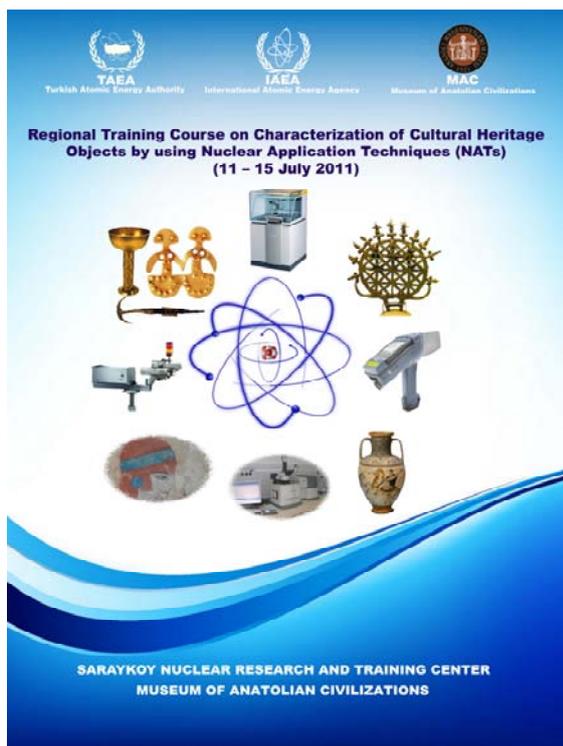
### **Participation of Hungary**

Hungary takes part in the series of the Technical Co-operations since 2009. The country is represented by three Academic research institutes, which geographically belong to two major centres: The Centre for Energy Research and the Wigner Research Centre for Physics constitute the Budapest

Neutron Centre (BNC). Here, many experimental stations are operated, connected to the Research Reactor. At the BNC, a set of methods, like PGAA, TOF-ND, SANS, NAA, RAD, PIXE are available for mostly non-destructive studies. Scientists here have extensive experience in the field of cultural heritage research since back to the end of 1990s. The other important centre is the Institute for Nuclear Research (Atomki) in Debrecen, where the scientists perform high quality research in the cultural heritage field since the 1990s. At the Atomki, the Laboratory of Ion Beam Applications and the Hertelendi Laboratory of Environmental Studies (HEKAL, which operates the C-14 laboratory) have significant results in the field.

### Main achievements and perspectives of the IAEA TCs

During the years, several important achievements have been realised within the TCs, which could not have been done without the support of the IAEA. In the following, we just give a list of the most significant ones.



**Fig. 1.:** Poster of the “Regional Training Course on Characterisation of Cultural Heritage Objects by using Nuclear Application Techniques” in Ankara, 2011.

**1. ábra:** A 2011-ben Ankarában tartott “A kulturális örökség tárgyainak vizsgálata nukleáris módszerekkel” c. regionális tanfolyam plakátja



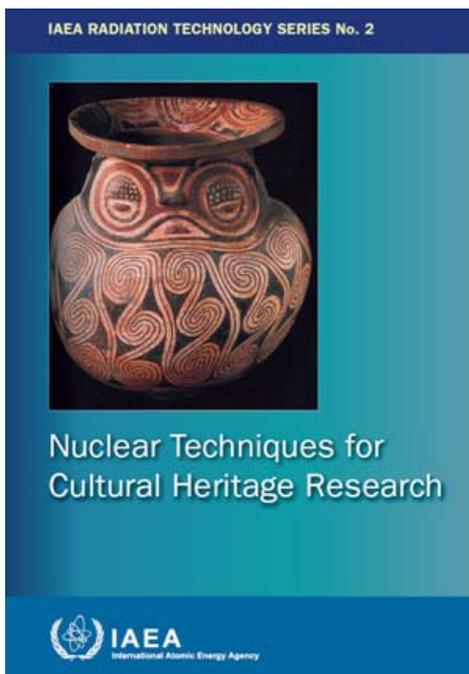
**Fig. 2.:** In situ application of a hand-held X-Ray Fluorescence analyser for the non-destructive examination of the traces of polychromy remained on the surface of ancient marble sculptures (Kunst Historisches Museum, Vienna, source: IAEA homepage)

**2. ábra:** Hordozható röntgenfluoreszcens spektrométer múzeumi alkalmazása. Festékmaradványok vizsgálata egy antik márvány szobor felületén. (Kunst Historisches Museum, Bécs, forrás: IAEA honlap)

First of all, a sub-regional network has started to form between the participating countries including bi- and multi-lateral collaborations between nuclear- and humanistic science. Furthermore, the IAEA facilitated the establishment of formal co-operations within two European regional initiatives of CHARISMA and SPIRIT.

As a result of the IAEA activities, the integration of different nuclear techniques for radiation treatment and characterization has significantly increased and an attempt towards standardisation has been done. Efforts towards the harmonisation of analytical and CH inventory data at the regional level have also been made, especially by distribution and measurements of reference materials (e.g. alloys) through proficiency tests.

In order to disseminate the knowledge and expertise, high quality regional training events focusing on nuclear techniques applications in cultural heritage have been organised by the participating institutions. Particularly successful courses were held for instance about the application of handheld XRF equipment in Ankara 2011 (**Fig. 1.**), at the Seibersdorf IAEA Laboratory in 2013 (**Fig. 2.**), and about the C-14 dating in Debrecen, Hungary, 2015.



**Fig. 3.:** The cover of the IAEA Radiation Technology Series No. 2, Vienna, 2011.

**3. ábra:** A Nemzetközi Atomenergia Ügynökség “Radiation Technology Series No. 2” c. kiadványának (Bécs, 2011) borítója.

As an outcome of these forums, several guidelines, technical documents, scientific and promotional publications have been published either by the IAEA (IAEA Radiation Technology Series No. 2, 2011, **Fig. 3.**) or by the individual researchers of the community. These publications become available to the member states. Furthermore, an online platform was established to give an opportunity to find up-to-date information, partners, etc. on the field of Heritage Science (**Fig. 4.**). Also, reports on each participating country’s activities can be found at <http://nuclculther.eu/>.

Last, but not least the IAEA gave a hand to many of the participating countries to improve their technical capabilities. For instance, developments have been done in new C-14 laboratories in Azerbaijan, Ukraine and Turkey, in a LA-ICP-MS laboratory in Bulgaria. For some countries, such as Serbia or Turkey, procurement of handheld XRF instruments has become available.

In spite of the many achievements, however, many things remained to improve. Below, the most important future tasks are listed:

- 1, If possible, standard procedures and guidelines in application of nuclear techniques in Heritage Science need to be developed and followed.
- 2, Experts have to develop the mechanism of cross-border sharing of information and the databases of analytical studies.
- 3, More sufficient collaboration between member states is still needed with promotion and sharing of technical expertise.
- 4, An improved outreach towards stakeholders is needed in promotion of nuclear techniques applied to Heritage Science. For this purposes, a viable website platform imperative for networking between member states in this area.

Being aware of the tasks remained, a new project already started and further more are planned to apply for. A Coordinated Research Project (CRP F23032) entitled “Developing radiation treatment methodologies and new resin formulations for consolidation and preservation of archived materials and cultural heritage artefacts” is already running with participation of Poland, Romania, Croatia, Turkey and Portugal. Other ideas to launch a CRP or TC on characterisation, dating or preservation of cultural heritage objects are considered.

### References

Nuclear Techniques for Cultural Heritage Research, IAEA Radiation Technology Series No. 2, International Atomic Energy Agency, Vienna 2011.



**Fig. 4.:** The starting page of the IAEA RER 0034 TC project web site, 2012, <http://nuclculther.eu/>

**4. ábra:** A Nemzetközi Atomenergia Ügynökség RER 0034 TC sz. együttműködési programjának honlapja, 2012, <http://nuclculther.eu/>

