

NEUTRONS REVEAL THE HISTORY OF TWO RELIEFS BY LORENZO Ghiberti, FROM THE BRONZE GATES OF THE "BATTISTERO DI FIRENZE"

"Ancient Charm Project - with neutron ancient art has no more secrets"

Neutrons help archaeologists to analyse their finds. Two reliefs of **Lorenzo Ghiberti**, two heads of prophets, from the Bronze Gates of the **Battistero of Florence**, have been analysed at the **FRM II Reactor** (Forschungsneutronenquelle Heinz Maier-Leibnitz), a neutron source placed in North Munich in the zone of Garching, and at the *Spallation Neutron Source* ISIS (*Rutherford Appleton Laboratory, Oxfordshire* UK).

Both studies have been performed within the *Ancient Charm* project which has the objective to develop a new non-invasive and non-destructive technique, namely Neutron Resonant Capture Imaging combined with Neutron Resonance Transmission (NRCI/NRT), where both gamma-emission and neutron-transmission measurements will be used in combination to determine the elemental composition of an object in 3D, to map of elements in objects from the fields of archeology and cultural heritage.

At Munich Reactor, in September 2008, the two Heads have been investigated via **Prompt Gamma Activation Imaging** (PGAI) a new technique which combines in one single instrument the use of two well established radiographic techniques employed in other fields, the **Prompt Gamma Activation Analysis** and the **neutron radiography**, that allow at recognizing the inner structure and morphology of the objects. These analysis provided unique and new information on sub-superficial areas, elemental composition of the objects from the surface down to a depth of 1 mm below gilding, and bulk structure of the re-melting. It has been established which one of the two possible restoration techniques applied by the Laboratory of "Bronzi and Armi antiche" in Florence (laser polishing and immersion in the Rochelle salts) to the **Head of the East Gate** would be the best and thus to be used on the **Head of the North Gate**. Differently from East Gate (or Paradise Gate), realized between 1425 and 1452, under restoration from the mid 80's after the inundation of Florence in 1966 and that will be placed in the Museo dell'Opera di Santa Maria del Fiore upon restoration completion, the **Head of North Gate** has been always located in the same place. The biggest surprise has been the discovery that the head of the East Gate was completely re-fused in some parts from the Ghiberti himself. The most likely hypothesis by the scientists is that the first fusion should present defects that induced Ghiberti to carry out a second fusion, inserting the new metal within the original cavity, in correspondence of the bottom side of the face.

On March the 2nd the two reliefs have been transported to ISIS spallation neutron source, where they will remain for a period of about four months, with the aim of performing further analysis, on the ENGIN-X and INES diffractometers, to derive **the phase and elemental composition and the residual strain of the artefacts**.

Prof. Carla Andreani, from the University of Roma Tor Vergata, states: "The preliminary results from PGAI and ENGIN-X confirm that, despite X-rays provide fundamental information in the composition of the artefacts, the use of neutrons give unique information in the bulk of the reliefs in a non-destructive and non-invasive way. Thanks to their deep penetration power - of the order of several centimetres - neutron studies will allow to understand how the artefacts have been realized, if the underwent restoration, and help also in determining the best way to preserve them. The analysis will also provide phase composition, chemical inhomogeneities and strain fields of the two reliefs, and are expected to guide the curators to the selection of the most suitable microclimatic conditions for the exposition of the East Door and for the future conservation work on the North Door.

Italy is at forefront for these analyses with neutrons applied to cultural heritages, after an experience developed over twenty years of fundamental research, made possible thanks to the international agreement signed by the CNR for the use of the neutron sources.

Dr. Antonia Recchia, who manages the "Settore Innovazione, Organizzazione e Formazione del Ministero", states: «this is the first result due to the collaboration promoted by the MIBAC, through a proper agreement with some Italian universities active in the field of neutron spectroscopy. The collaboration allowed the temporary exportation of the object to be analyzed to the neutron source. Restoration experts - from the Ministero per i Beni e le Attività Culturali (MIBAC) and the Opificio delle Pietre Dure- and University researchers closely worked, providing a positive example of multidisciplinary collaboration».

«The results obtained in Munich and on ENGIN-X- say Dr. Annamaria Giusti, Director of the Restoration Works on the Gate of Paradise and Dr. Simone Porcinai from Opificio delle Pietre Dure and collaborator of the Institute IFAC- CNR in Florence - revealed for the first time the dimensions and the depth of the re-fused part of one of the Head. The composition analysis of the interface strates between the metal and the alteration patina will furthermore allow the selection of the optimized exposition conditions for the preservation of the Gate of Paradise and development of more effective polishing methods. These results repay the organizational effort: temporary expatriation in foreign states for masterpieces of this value was possible for the approval of the President of Opera di Santa Maria del Fiore, Dott. Anna Mitrano, and of the Soprintendente at the Polo Museale Fiorentino, Dott.ssa Cristina Acidini».

«The following step", says Prof. Giuseppe Gorini who coordinates Ancient Charm on behalf of University Milano-Bicocca, "will be the start of the new beam line at the ISIS spallation neutron source near Oxford. In a few months we will be able to complete the elemental analysis of the objects using neutron resonances at higher energies. Then, images produced by different techniques with the contribution of all of the ten Partners of the project can be combined to provide more complete informations».

Analysed Objects

Togheter with Heads from the Battistero of Florence, within the same project, other two object from the **Museo delle Civiche Raccolte Archeologiche e Numismatiche** of Milano have been analysed throw neutron tomography.

The first one is a **belt bronze point** (VII sec a.C.) used to protect the leather of the belt and to envelope relics that would help the soldier during the battle; «The neutron tomography - says Dr. Donatella Caporusso, Curator in Chief of Civiche Raccolte Archeologiche e Numismatiche of Milano - gave beautiful results and allowed at confirming the hypothesis that within the point there was a double cavity to host relics. This analysis has renewed the interest of the Museum for investigations on these two findings, which we hope will continue to provide the exact composition of the two objects».

The Project

Ancient Charm is a project founded by European Community with about **two millions of Euro** with the participation of six European Universities and four Research and Preservation Centres. The European research project, started three years ago (started in January 2006 will finish in December 2009), used for the first time a radiographic technique which allows to recognize the structure and the compositions of archaeological objects. The Final aim of the project is the development of new non invasive investigation techniques on Cultural Heritages, combining competences of scientists

belonging to different fields and art experts. Ancient Charm is inserted in a more wide program, NEST (New and Emerging Science and Technology), within the Sixth Framework Programme (FP6).

Ancient Charm Partners

In Ancient Charm cooperate workers of Cultural Heritages and Physics; Ancient Charm Partners are ten: University of Milano-Bicocca, University of Roma Tor Vergata, Hungarian National Museum, Institute for Isotopes- Hungarian Academy of Sciences, Rheinische Friedrich-Wilhelms Universität zu Bonn (Germany), Universität zu Köln (Germany), European Commission - Joint Research Centre - Institute for Reference Materials and Measurements (Belgium), Leiden University (The Netherlands), Technical University of Delft (The Netherlands) and Science and Technology Facilities Council (United Kingdom).