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Nuclear physics unveils secrets of Bronze Age sword

Physicists at the European Commission's Joint Research Centre (JRC) have helped unveil the secrets of a Bronze Age sword with neutron beams normally used to study materials for nuclear reactors. The work was carried out by a team of European researchers investigating the application of modern scientific methods to cultural heritage objects.

European Research, Innovation and Science Commissioner Máire Geoghegan-Quinn, visiting the JRC-IRMM today, said: "This is a reminder of the enormous breadth of innovative research carried out by the JRC for the European Commission. The findings of research performed by the JRC and by EU-funded projects are crucial for the economy, for consumer safety and for tackling climate change. But this analysis of an ancient sword using 21st century technology is an example of how European research work also enhances cultural and historical knowledge. I want to use my mandate to tell more people about this kind of fascinating work and to show them that there is much more to Europe than Directives and Regulations."

By precisely measuring the ratio of copper to tin along the length of the sword (see Figure 1), scientists gained an insight into the craftsmanship of the sword, and determined that the blade and the hilt were cast separately with different bronze compositions. The presence of cobalt in the composition supports the assumption that the sword originates from the North Alps-Danuba region.

A radiograph of the sword's hilt revealed in unprecedented detail how the blade and the hilt are connected. The hilt is clearly hollow and fairly thin-walled. The blade has a tongue which extends far inside the hilt, and is attached to the hilt with the aid of two rivets (see Figure 2).

"This work reminds us that fundamental research often leads to exciting and novel applications which benefit society as a whole", said Krzysztof Maruszewski, Director of the JRC's Institute for Reference Materials and Measurements in Geel, Belgium.

A ceremonial sword

The sword was found near the village of Buggenum (the Netherlands), during the dredging of a lateral canal of the River Meuse. It is a richly-decorated all-metal sword originating from the region of the Upper-Danube and its alpine tributaries, and dates from 1300 – 1100 BC.

The owner of the sword, the National Museum of Antiquities in Leiden (the Netherlands), was interested in studying the sword by non-invasive, non-destructive methods, and a consortium of European researchers, including the Joint Research Centre, took up the challenge.

Getting up close with neutrons

Conventional x-rays give some basic information about the construction of such artefacts, but new techniques such as 'neutron resonance capture analysis' can penetrate deeper in objects and provide remarkable information on their composition and structure.

The secret lies in the use of neutrons – which are electrically neutral particles. Neutrons can approach atomic nuclei without being hindered by the Coulomb force – the force which governs the 'like charges repel' behaviour in electrostatics. It is this fundamental property of neutrons that distinguishes them from charged particles.

The JRC's Institute for Reference Materials and Measurements (IRMM) operates an electron accelerator which produces beams of neutrons. This sophisticated facility is normally used to study the interaction of neutrons and materials used inside nuclear reactors, contributing to safe nuclear energy production and potentially reducing the lifetime of harmful nuclear waste. The use of neutrons to investigate the composition of materials is a useful spin off of these activities.

Scientists at JRC-IRMM studied the composition of the Buggenum sword using pulsed neutron beams as part of the European-funded project called ANCIENT CHARM. In close collaboration with scientists from the Delft University of Technology, ten scientific institutes and museums collaborated to improve and develop certain neutron-based analytical and imaging methods for cultural heritage objects.

The sword also underwent 'time-of-flight neutron diffraction' at the Rutherford Appleton Laboratory in the UK. These measurements indicated successive annealing and working cycles, for the purpose of hardening the blade. This indicates that although the sword is considered a ceremonial object, it was manufactured as a potentially functional weapon.

Further information

The results of the sword measurements are published in the Journal of Radioanalytical and Nuclear Chemistry (vol.383(3), 2010, p.641):
http://www.springerlink.com/content/7242u32726211687/

A paper describing the technique of neutron resonance capture and transmission analysis has been published in the Encyclopaedia of Analytical Chemistry:
http://www.mrw.interscience.wiley.com/emrw/9780470027318/eac/article/a9070/current/abstract

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About the ANCIENT CHARM project

ANCIENT CHARM stands for 'analysis by neutron resonant capture imaging and other emerging neutron techniques: new cultural heritage and archaeological research methods': http://ancient-charm.neutron-eu.net.

About JRC-IRMM

The Joint Research Centre (JRC) is a Directorate-General of the European Commission providing independent scientific and technical support to European policy-making. The JRC's Institute for Reference Materials and Measurements (IRMM) promotes a common and reliable European measurement system in support of EU policies. The prime objective of the JRC-IRMM is to build confidence in the comparability of measurements by the production and dissemination of internationally accepted quality assurance tools, including reference materials, validated methods, reference measurements, inter-laboratory comparisons and training.

Figures

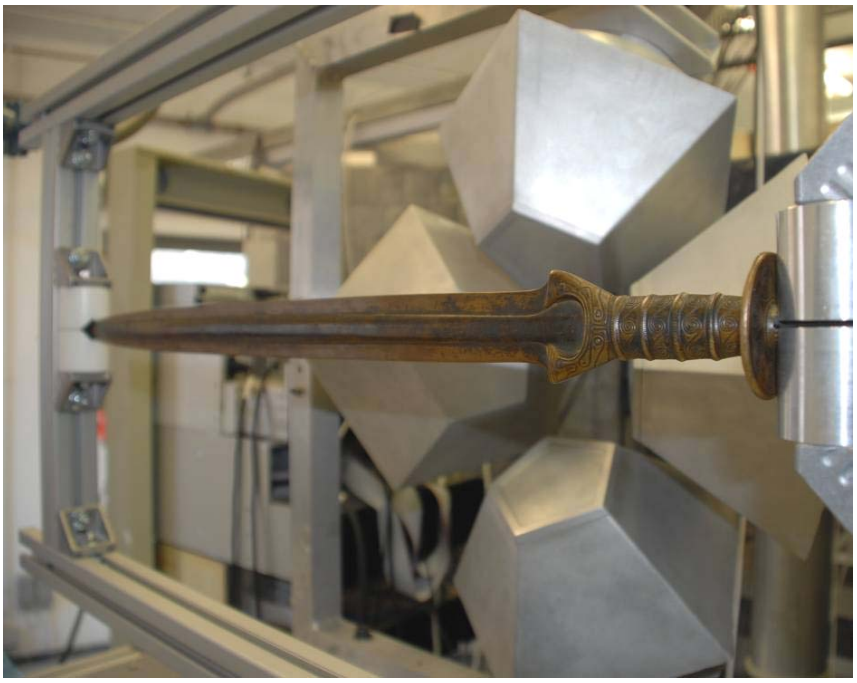

Figure 1. The Buggenum sword, dating from 1300-1100 BC, undergoing measurements at the Joint Research Centre (JRC) in Geel, Belgium. A beam of neutrons was directed onto the sword, and a technique called 'neutron-resonance capture analysis' was used to determine the composition and structure of the Bronze Age artefact.

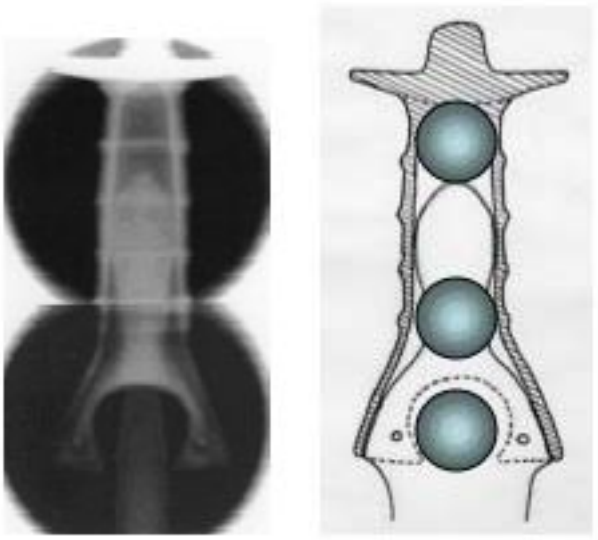

Figure 2. A radiograph and drawing of the hilt of the Buggenum sword, which reveals how the blade and the hilt are connected. The hilt is clearly hollow and fairly thin-walled. The blade has a tongue which extends far inside the hilt, and is attached to the hilt with the aid of two rivets.