Archaeometry Center

Introduction

Archaeometry is the science that combines historical-artistic research with qualitative and quantitative measurements obtained using analytical methods of physics, chemistry and biology. The Archaeometry Center of the University of Ioannina was recently established as member of the network of the horizontal laboratories of the University of Ioannina. Its aims include the search for specialised information from archaeological artefacts, monuments, works of art and materials, which are the major components in the building of civilisation and culture.

The region of Epirus (North –Western Greece) is endowed with its own natural beauty and cultural identity. The first traces of human presence in the area, dating back to 40.000 BC, were discovered in the Asprohaliko cave of Haradra on the Louros River. Important findings were also unearthed from caves in the Vikos Gorge, proving that life continued without a break up to the Mesolithic era. This is confirmed by the discovery of the prehistoric settlement of Kastritsa, (5000 B.C.) With the start of the Middle Helladic period (1.900 - 1.550 B.C.), the first Greek tribes settled in Epirus, marking the beginning of a rich history. It is no coincidence that in the Department of History and Archaeology of the University of Ioannina is well known for its research in archaeology.

Facilities & Infrastructure

Currently, the routinely applied methodologies are:

- Carbon-14 measurements through LSC counting only.
- Tritium dating through LSC counting, with or without enrichment of water samples with electrolysis.
- Thermoluminescence dating.
- Optically stimulated luminescence dating.
- Uranium series dating.

Major equipment available includes:

- A sample preparation laboratory.
- A Tricarb 3170 TR/SL, PACKARD INSTRUMENTS liquid scintillation counter (Fig. 1)
- A TL/OSL DA-15C/D Reader from Riso equipped with PC installed software to control the reader and for data acquisition (Fig. 2)
- Electrolysis equipment for tritium enrichment (Fig.3)
- Optical microscopes with on line computer connection (Radon Unit, Nuclear Physics laboratory)

Archaeometry studies are supported by other techniques, such as:

- Scanning Electron Microscopy (Advanced Electron Microscopy Unit)
- X-ray fluorescence (XRF Unit)
- X-ray diffraction (XRD Unit)

Figure 1: General view of the temporary installations of Tricarb 3170 TR/SL liquid scintillation counter.

Figure 3. Electrolysis equipment for tritium enrichment.

Services

Activities of the Archaeometry Center are not limited to the archaeology field only. The applications for the dating methodologies cover a broad spectrum, from archaeology and geology to materials and environmental sciences. When it will be fully operative, the activities of the Center will include the following:

Carbon-14 dating

Radiocarbon (^{14}C) is the radioactive isotope of the common element carbon. It is formed in the upper levels of the atmosphere following the interaction of cosmic rays with nitrogen (N_2). Then radiocarbon is oxidised to carbon dioxide (CO_2) and is diffused in the atmosphere. As carbon dioxide is used for photosynthesis, radiocarbon is integrated into all organisms. When a plant or an animal dies, radiocarbon decays with a half-life of 5730 years. At the radiocarbon dating laboratory the amount of remaining radiocarbon relative to the stable element is measured. Since radiocarbon's half-life is known, the age of the sample can be estimated.

Tritium dating

Tritium, the heaviest isotope of hydrogen, is radioactive and has a half-life of 12.4 years. Water in contact with the atmosphere will have some tritium in it, and this tritium will be decaying to a stable, inert isotope called helium-3. Tritium can be effectively used to investigate hydrologic mixing and transport processes. Due to its short half-life and steady state concentration, tritium is the ideal tracer for studies requiring a time resolution to the nearest month over the past 150 to 200 years. In using tritium as a hydrological tracer, the analysis should be conducted at the lowest practical detection levels because of the inherently low tritium levels found in natural waters (2 to 20 Tritium Units, or TUs (3.2pCi/L)). Through electrolytic enrichment of tritium in water samples prior to measurement, these low detection levels may be reached, affording greater accuracy and precision.

Uranium series dating

Uranium series dating is based on the radioactive decay of uranium in calcium carbonate and other minerals that precipitate from solution. Natural ^{238}U decays into ^{234}Th, while the other isotope of U, ^{234}U, decays into ^{230}Th. Because uranium is soluble in water and thorium is not, minerals that precipitate from solution often contain U but very little Th. Through time Th is formed in the mineral as the U decays. The Th is itself a radioactive element and it decays into daughter products (i.e. ^{234}Th decays into ^{234}U and ^{230}Th decays into ^{226}Ra). Ra is also radioactive, and it decays into Rn in a very short time.

If the mineral is of sufficient age, it contains the entire chain of U decay products, from ^{238}U through to ^{206}Pb. The critical elements in this series are ^{238}U, ^{234}U and ^{230}Th because of their half-lives. For any mineral that initially contained only U, the time since its formation can be calculated from the $^{238}U/^{234}U$ and $^{234}U/^{230}Th$ ratios.

Luminescence dating

Luminescence is the emission of light from non-conducting solids in addition to thermal radiation. It is caused by the stimulation of trapped electrons in crystal defects and/or impurities, and their subsequent recombination with emission of light. Ionizing radiation from natural radioactivity and cosmic rays produces free charge carriers, which are partly stored in the crystal lattice. Since the concentration of the charge carriers increases with time, their numbers and thus the intensity of the luminescence signal can be employed for dating.

The phenomenon of luminescence can be categorised according to the form of energy supply during the stimulation process as:

- Thermoluminescence (TL, stimulated by heat)
- Optical stimulated luminescence (OSL, stimulated by visible light)
- Infrared stimulated luminescence (IRSL, stimulated by infrared light)
- Radioluminescence (RL, stimulated by ionizing radiation)

Fission tracks dating

Minerals containing trace amounts of uranium register the decay of the uranium-238 isotope by spontaneous nuclear fission in the form of fission tracks. These tracks are formed along the trajectories of the nuclear fragments ejected by the fissioned uranium nucleus. The lattice damage along a track is gradually restored at elevated temperatures, resulting in a decrease of the length of the fission track. Fission-track research is concerned with the study the fission-track record in natural crystals with the aim of determining the geological age and temperature history of the rock that contains them. Fission-track dating is based on measurements of the number of tracks that have accumulated since the crystal last cooled below the temperature at which the tracks are retained.

Staff & Contact Information

The Archeometry Center is supervised by a Scientific Committee composed of academic staff members from the University of Ioannina.

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Representative Publications

1. *Determination of ^{226}Ra in aqueous solutions via sorption on thin films and α-spectrometry.* Karamanis, D., Ioannides, K.G., Stamoulis, K.C. 2006, Analytica Chimica Acta 573-574, pp. 319-327.
2. *A study of ancient pottery by means of X-ray fluorescence, multivariate statistics and mineralogical analysis*. C. Papachristodoulou, A. Oikonomou, K. Ioannides, K. Gravani Analytica Chimica Acta 573-574 (2006) 347-353.
3. *Spatial and seasonal trends of natural radioactivity and heavy metals in river waters of Epirus, Macedonia and Thessalia*. Karamanis, D., Stamoulis, K., Ioannides, K., Patiris, D. 2008 Desalination 224 (1-3), pp. 250-260.
4. *Rapid screening of ^{90}Sr activity in water and milk samples using Cherenkov radiation.* Stamoulis, K.C., Ioannides, K.G., Karamanis, D.T., Patiris, D.C., 2007, Journal of Environmental Radioactivity 93 (3), pp. 144-156.
5. *Elemental analysis of ancient pottery: a tool for tracing provenance and probing manufacture practices*. C. Papachristodoulou Seminar on "Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region", Athens, 20-22 October 2008.
6. Assessment of natural radionuclides and heavy metals in waters discharged from a lignite-fired power plant. Karamanis, D., Ioannides, K., Stamoulis, K. 2009. Fuel 88 (10), pp. 2046-2052.