Neutrons in the service of archaeological research

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Archaeology

'Classical' archaeology
New archaeology
Archaeometry, regular

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Neutrons

AM 2007/2

Table 1.

Neutron Activation Analysis for isotope and element analysis is based on the capture of neutrons. Characteristic gamma radiation is emitted during (prompt γ's) or after (delayed γ's) the neutron capture.

INAA, Instrumental Neutron Activation Analysis **(**Glascock & Neff 2003): high sensitivity to many trace elements; usually requires sampling; delayed γ's;

NAR, Neutron Autoradiography (Schroeder-Smeibidl et al. 2006): cold neutrons; delayed γ's; non-destructive method for investigation of (mainly) paintings;

PGAA, Prompt Gamma Activation Analysis (Revay & Belgya 2004) is based on thermal and cold neutron capture; prompt γ's; applied non-destructively on intact objects; high sensitivity for some light elements (H, K , Cl);

NRCA, Neutron Resonant Capture Analysis (Postma et al. 2004): is based on epithermal neutron capture; prompt γ's; applied non-destructively on intact objects; good sensitivity for some heavy elements (Au, As, Ag, Sb, Sn).

Neutron Radiography/Tomography (Deschler-Erb et al. 2004; Materna et al. 2004): real space imaging based on the capture and scattering of thermal and cold neutrons to provide an inside view of objects with a spatial resolution down to 100 micrometers; exploits the attenuation of a neutron beam passing through an object; attenuation contrast for different elements, high sensitivities for some light elements (e.g. hydrogen); contrast variation by variation of neutrons energies (Kardjilov et al. 2003). Further imaging prospects are provided by phase contrast radiography which is based on neutron refraction (Treimer et al. 2003).

Neutron Diffraction (Kockelmann et al. 2001; Siano et al. 2006) is based on the elastic scattering of thermal neutrons by periodic, long-range ordered (crystalline) or non-periodic, short-range ordered (glass) arrangements of atoms. Many structural aspects can be studied: phase and structure analysis, texture analysis, microstructure analysis; residual stress analysis (Santisteban et al. 2002). Bragg-Edge transmission for mapping of strains and phases is based on Bragg scattering (Santisteban et al. 2001).

Small Angle Neutron Scattering (SANS) (Botti et al. 2006), based on the elastic neutron scattering of thermal neutrons. Porosity of a material, and size and surface characteristics of mineral aggregates can be studied.

NAA, INAA

Most established in archaeometrical applications

Classical examples:

- Pottery (*Terra sigillata*, etc.)
- Lithics
- Glass
- … many more

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NAA, INAA

Case study - the early mediaeval pottery workshops around Szekszárd (VI-VII AD)

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NAA, INAA

Case study - the early mediaeval pottery workshops around Szekszárd (VI-VII AD)

Archaeometrical research on the subject:

SALAMON, Á., - DUMA, GY., *Archäologische und naturwisenschaftliche Untersuchungen der frühmittelalterlichen Tongefäße aus Környe, Komitat Komárom, Ungarn*. Veröffentlichungen der Komission für Frühmittelalterforschung 6. Anzeiger der Phil.-Hist. Klasse der ÖAW 119(1982/9) 180-203.

SALAMON, Á., - DUMA, GY., *Archäologische und naturwisenschaftliche Untersuchungen der frühmittelalterlichen Tongefäße aus Szekszárd, Palánkpuszta, Komitat Tolna, Ungarn*. Veröffentlichungen der Komission für Frühmittelalterforschung 7. Anzeiger der Phil.-Hist. Klasse der ÖAW 121(1984/7) 55-75.

ROSNER, GY., *Keramikherstellung und Handel im Karpatenbecken in der frühen Mittelalter*. WMMÉ 15(1989) 125-130.

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ROSNER, GY., *Keramikherstellung und Handel im Karpatenbecken in der frühen Mittelalter*. WMMÉ 15(1989) 125-130.

By NAA:

BALLA, M., BÉRCZI, J., KEÖMLEY, G., ROSNER, GY., GABLER, D. (1989): Provenance studies of ceramics by NAA. *ARH* **I.**, pp.103-118.

The implementation of the NAA method is summarized in this paper. The analytical protocol, the standardization method, uncertainty budget calculation, homogeneity studies and data procession techniques are treated. By applying the developed methods, specific archaeological problems of terra sigillata and Avar potteries are tackled.

BALLA, M., KEÖMLEY , G., ROSNER, GY. (1990): Neutron activation analysis for provenance studies of archaeological ceramics. *J. Radioanal. Nucl. Chem.* **141**. pp. 7-12.

A provenance study of ninth-century Avar pottery from the Transdunabian part of Hungary resulted in the identification of multiple contemporaneous production centres, which manufactured ceramic of the same style. These ceramics also have been documented in nearby cemeteries.

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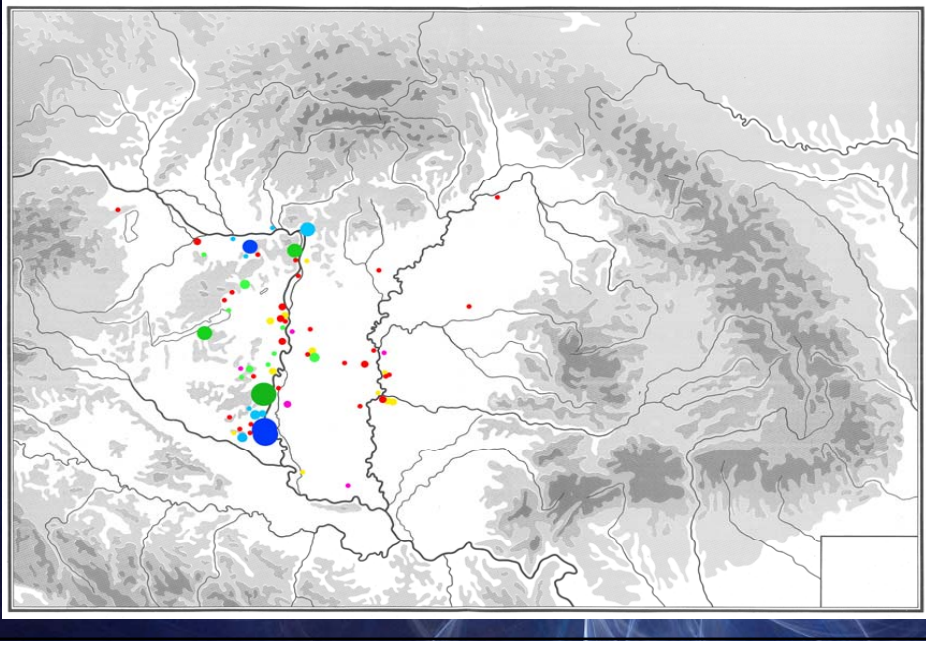
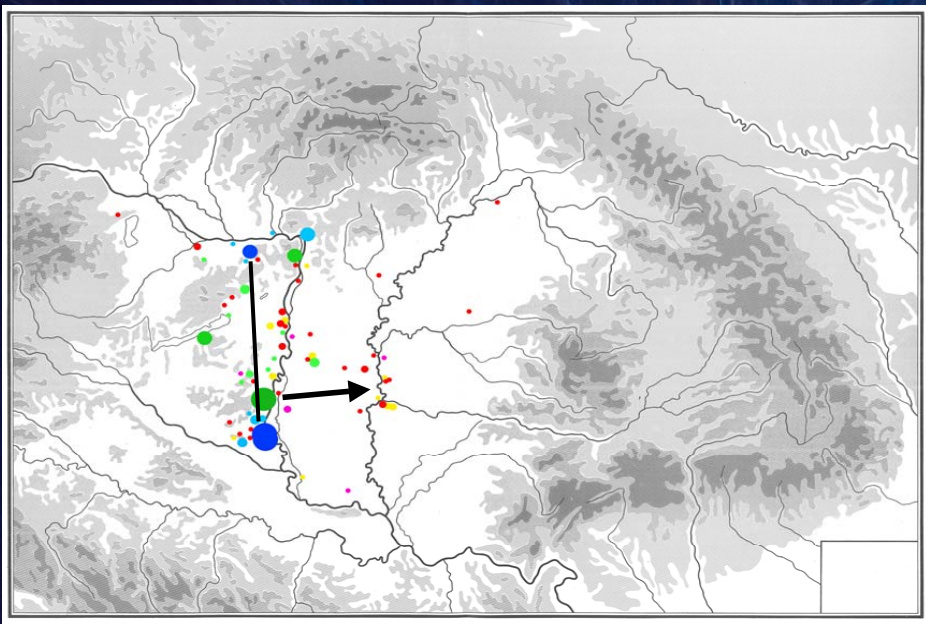
NAA, INAA



NAA, INAA



PGAA

Long-term collaboration of HNM with BNC (=IKI)

results on various materials:

- stone tools
- pottery
- glass
- metals

Case study: chipped stone tools

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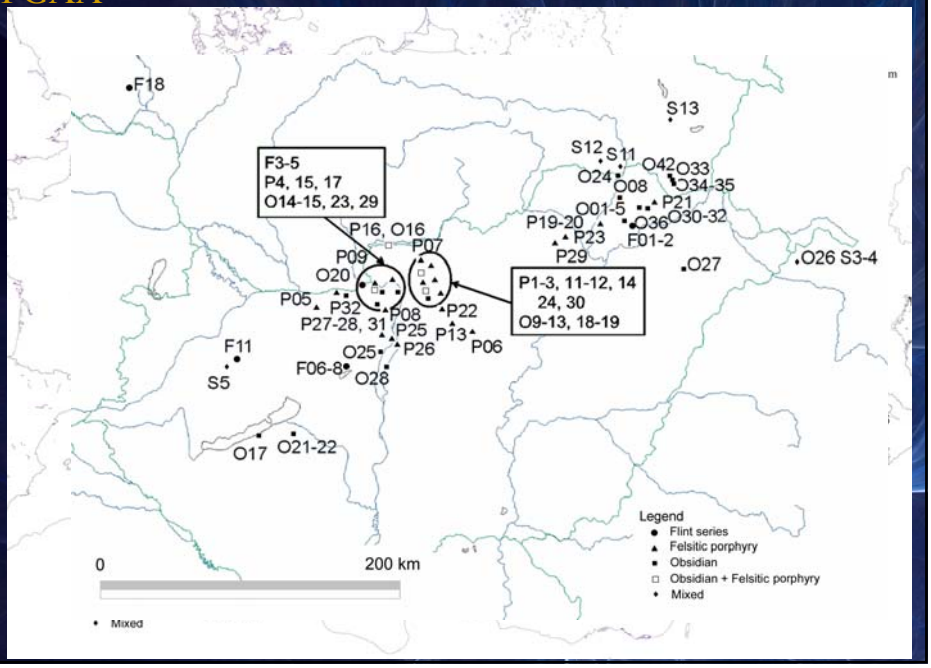
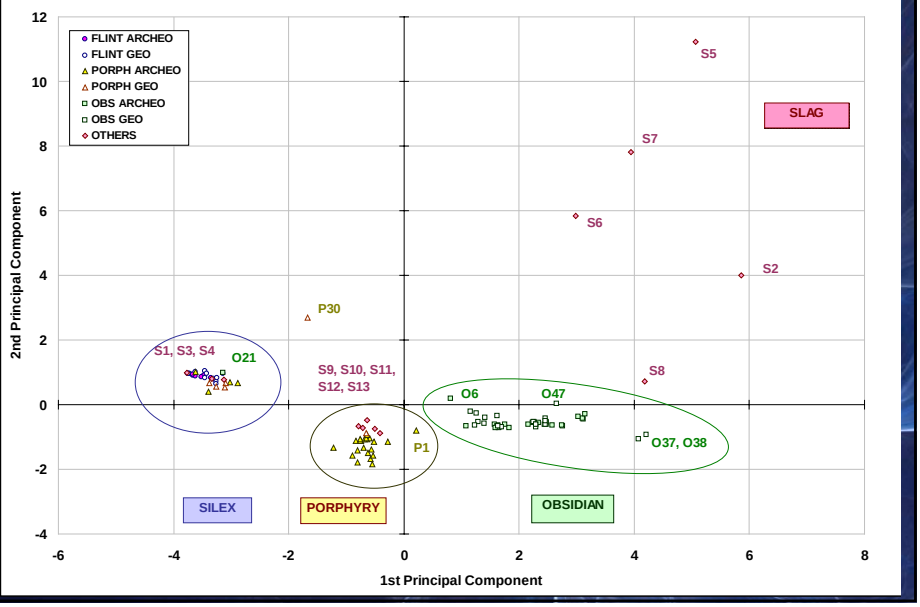
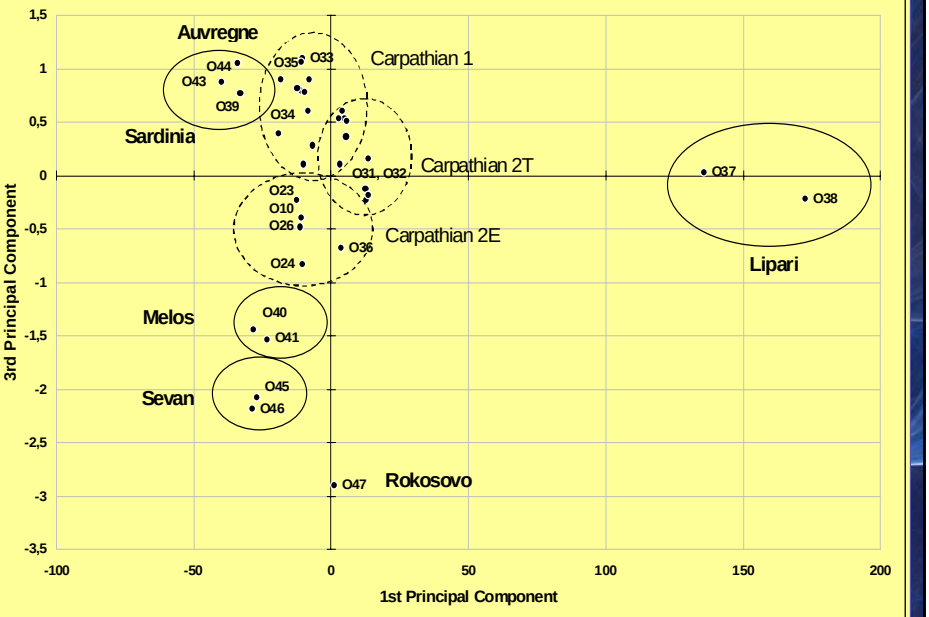
PGAA



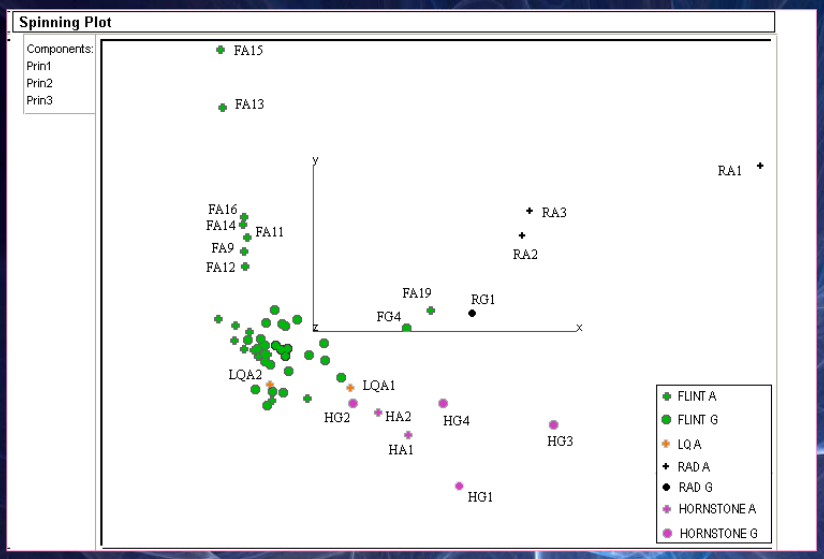
PGAA


FLINT ARCHEO
FLINT GEO
PORPH ARCHEO
PORPH GEO
OBS ARCHEO
OBS GEO
OTHERS
S5
SLAG
S7
S6
S2
P30
S1, S3, S4
O21
S9, S10, S11,
S12, S13
S8
O6
O47
O37, O38
P1
SILEX
PORPHYRY
OBSIDIAN
2nd Principal Component
1st Principal Component

PGAA


Auvregne
Carpathian 1
Sardinia
Carpathian 2T
Carpathian 2E
Lipari
Melos
Sevan
Rokosovo
3rd Principal Component
1st Principal Component

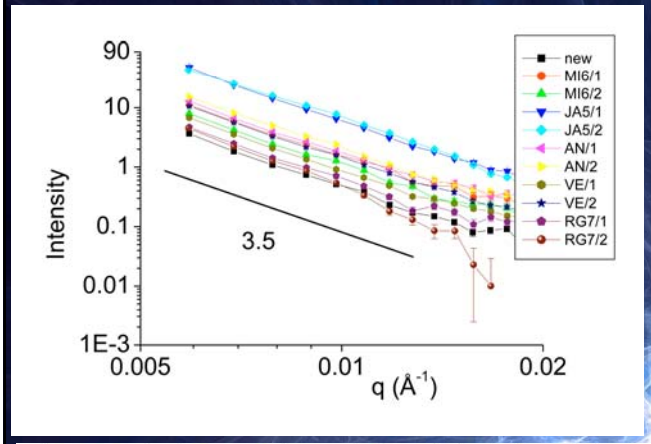
PGAA



SANS

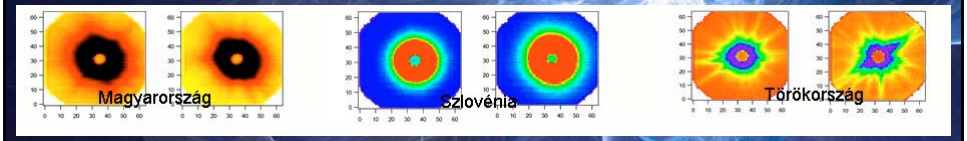
Len Adél, A kisszögű neutronszórás archeometriai alkalmazási lehetőségei / Possible Applications of Neutron Small Angle Scattering in Archaeology. Archeometriai Műhely / Archaeometry Workshop, 2006 3/2 27-31.

SANS



Organ pipes I=f(Q) curves

Scattering images on marble samples from various regions



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ND-TOF

Sánta Zsombor Nagyfelbontású repülési idő diffraktométer a Budapesti Neutron Kutatóközpontban / TOF powder diffractometer at the Budapest Neutron Center.
Archeometriai Műhely / Archaeometry Workshop Budapest 2006 3/2 22-26.

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NR/NT

Vörs-Máriaasszonysziget
modern b
2000/1 30

Vörs-Máriaasszonysziget
modern gl
2000/1 30-

Vörs-Máriaasszonysziget
Feature 16.
Kisapostag

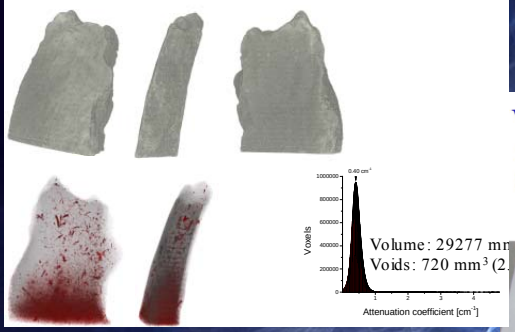
Vörs-Máriaasszonysziget
feature 43
Lengyel c

Vörs-Máriaasszonysziget
feature 2.
Starčevo Culture (EN)

L

NR/NT

Visser and Kardjilov, work in progress



Volume: 29277 mm
Voids: 720 mm³ (2

Vörs-Máriaasszonysziget
feature 2.
Starčevo Culture (EN)

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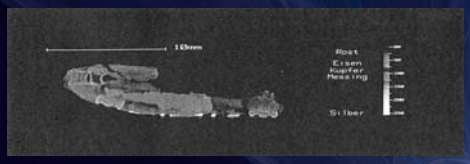
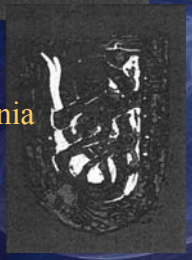
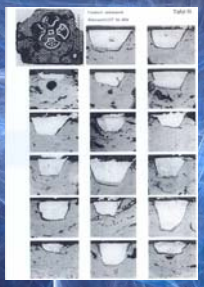
NR/NT



?= Avaria



Alemannia



Experiences

- Transport, safety and cooling conditions
- Costs involved
- Communication gaps
- Missing or deficient publications

Conclusions

Neutron-based analytical techniques: very important
Information on provenance, technology,
workmanship, authenticity,
Guidelines on conservation
Visualization/presentation of objects.

Problem: neutron-based techniques are expensive and some of them time-consuming
Routine means for CH studies ?
Meaningful projects with professional background both on the analythical and the archaeological side are needed