Centre for Energy Research

Cultural heritage studies at the BNC: Archaeological pottery

Dr. John Gait
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Pottery analysis at the BNC: an archaeological perspective

- **Why pottery?**

Classic period Kerma beaker, c.1750-1500 BC, Sudan

Early Bronze Age collared urn, c.2150-1600 BC, UK

Late Minoan “Marine style” octopus jar c.1500-1450 BC, Crete

Pottery analysis at the BNC: an archaeological perspective

- **Why pottery?**
  - One of the most common anthropogenic materials
    - Lots made and doesn't decay
    - An everyday commodity, used across social spectrum

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Pottery analysis at the BNC: an archaeological perspective

- **Why pottery?**
  - One of the most common anthropogenic materials
    - Lots made and doesn't decay
    - An everyday commodity, used across social spectrum
  - Human agency
    - Versatile material
    - Economic & environmental, but also social & cultural influences

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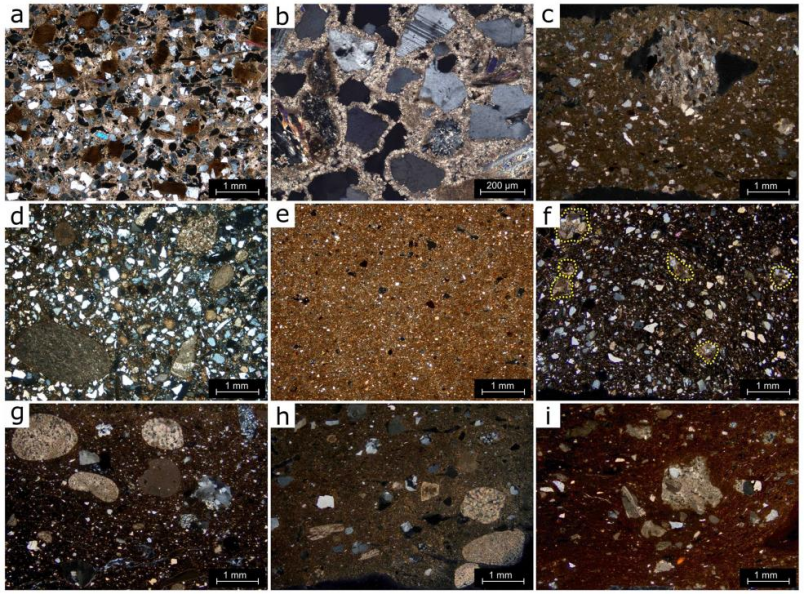
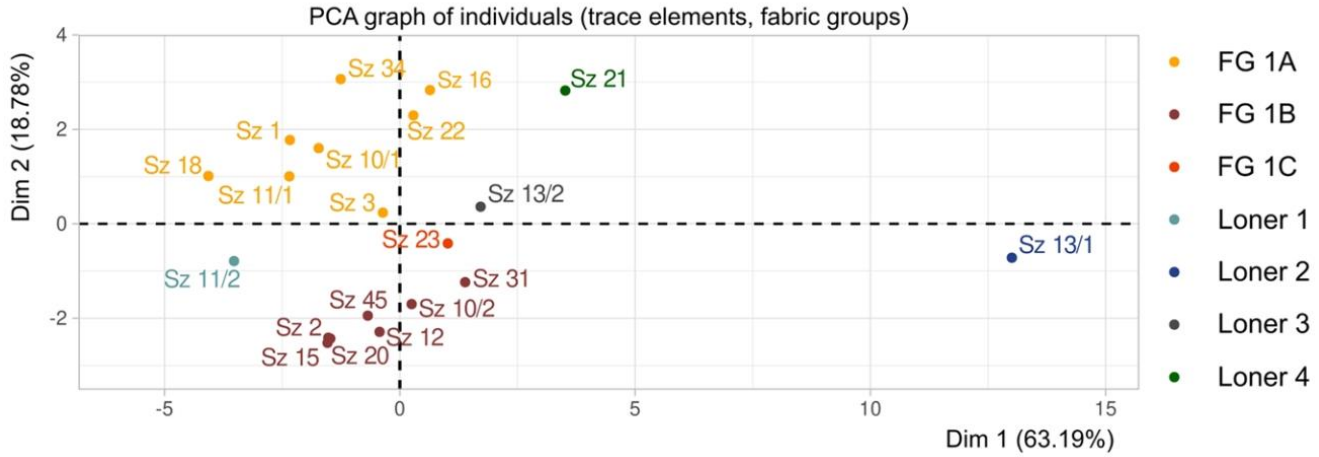
Pottery analysis at the BNC: an archaeological perspective

- **What can we learn?**

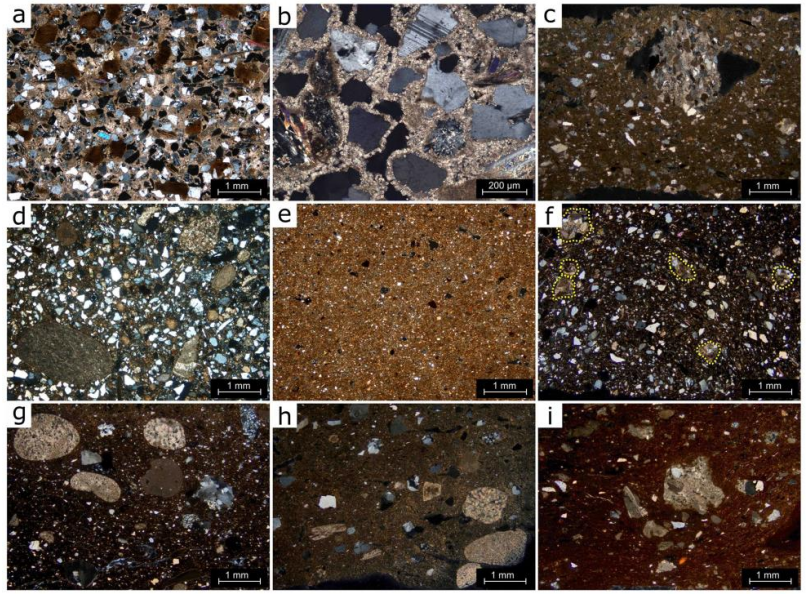


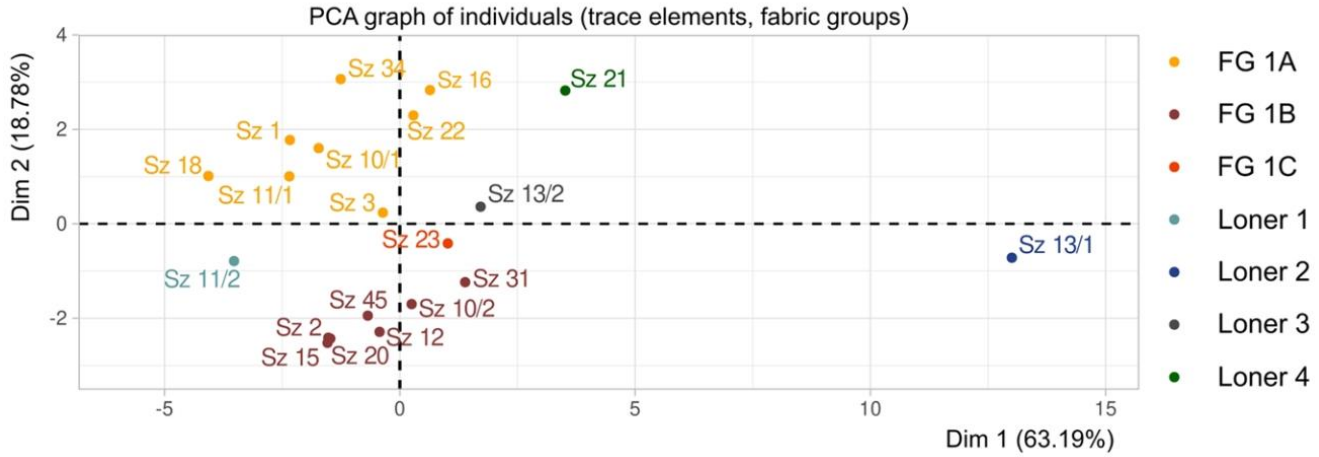


Pottery analysis at the BNC: an archaeological perspective

- **What can we learn?**
  - How was it used?

    Design, use ⟶ material sciences, physical properties, use-ware





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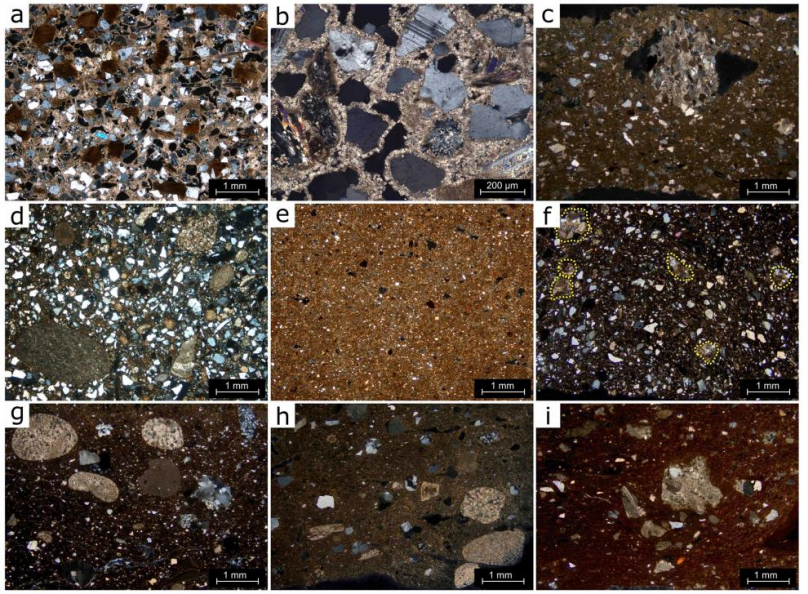
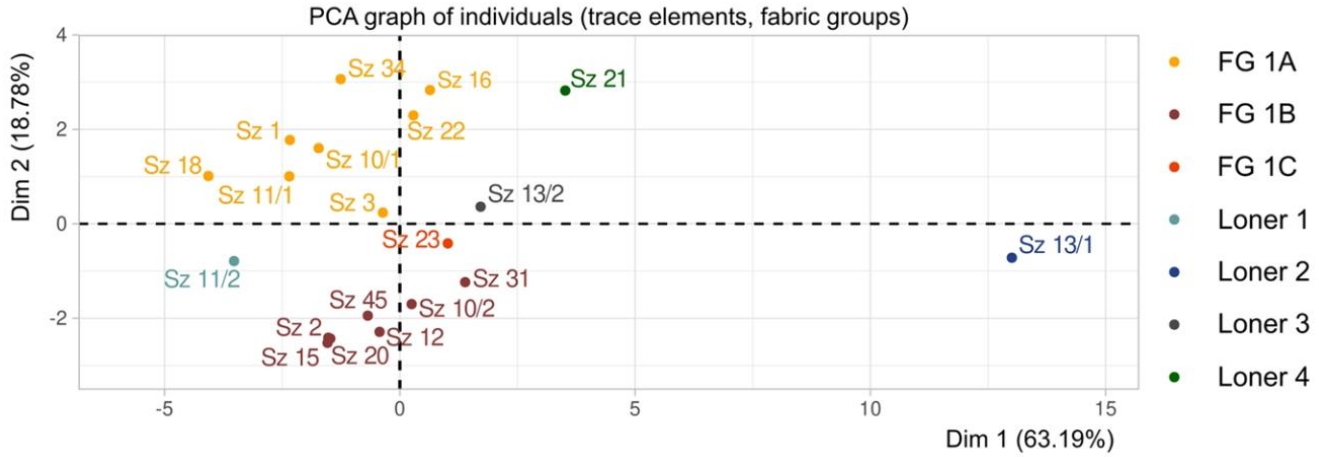
    Provenance, distribution ⟶ NAA, PGAA, SEM, optical microscopy





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  - Where was it made?

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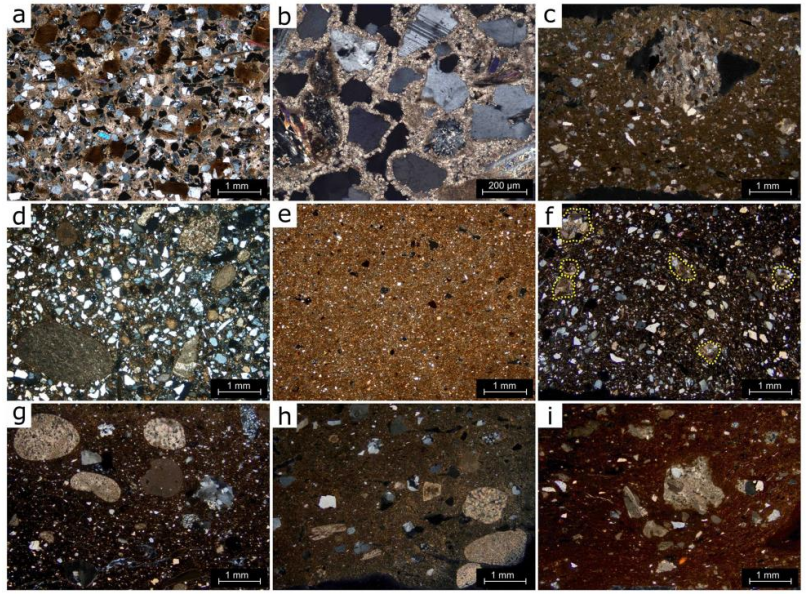
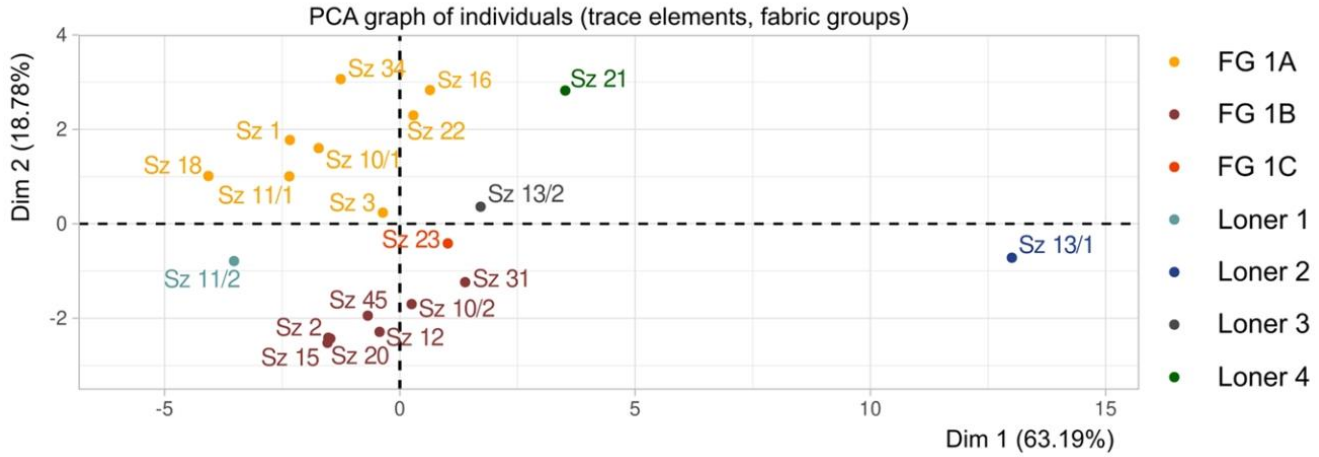
  - How was it made?

    Raw materials ⟶ NAA, PGAA, SEM, optical microscopy

    Forming techniques ⟶ imaging, SANS

    Firing technology ⟶ SEM, SANS

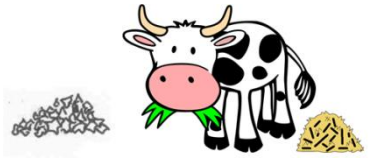




Pottery analysis at the BNC: an archaeological perspective

Pottery production sequence

CLAY



TEMPER

MIXING

PASTE

FORMING

UNFIRED POT

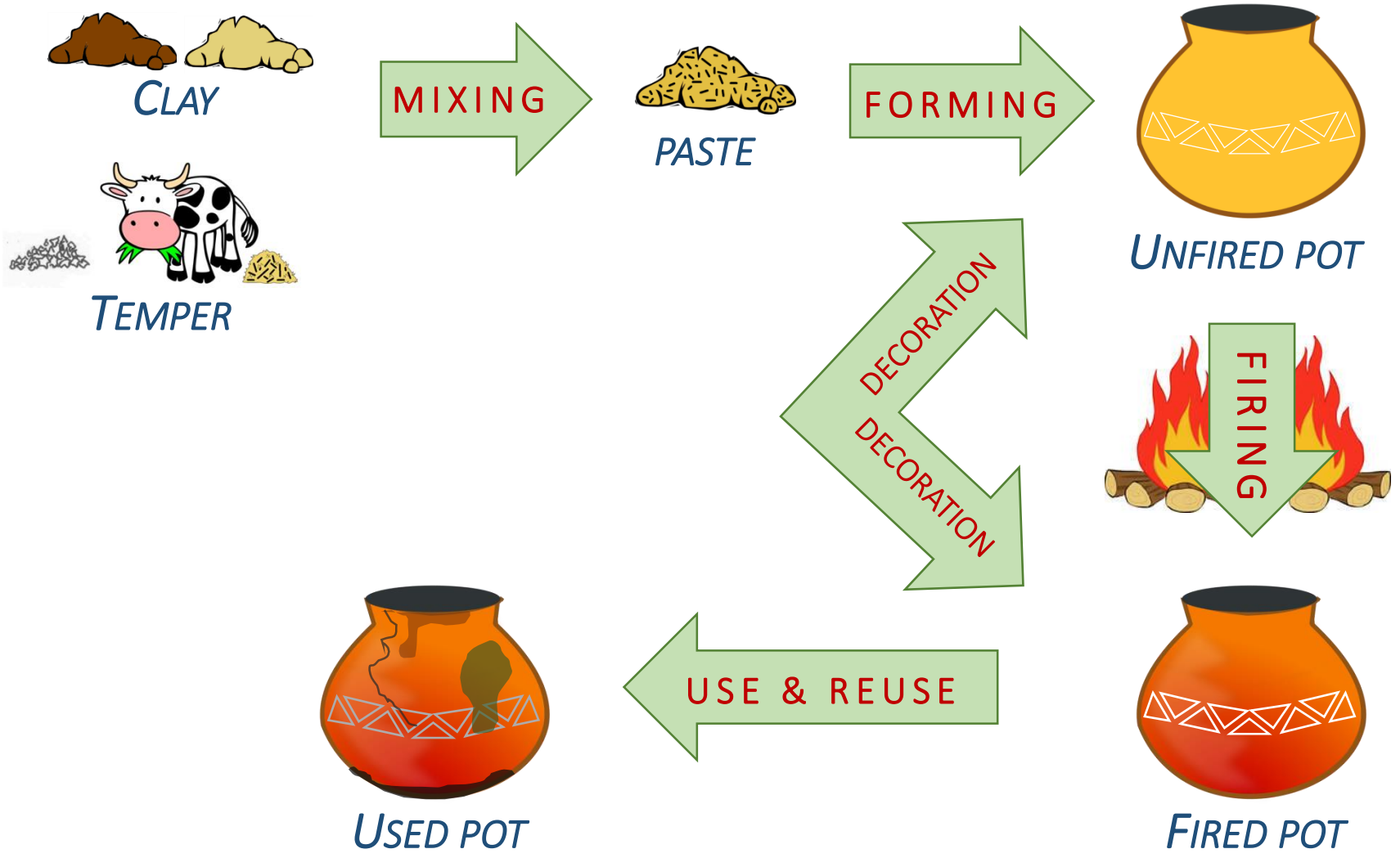
FIRED POT

USE & REUSE

USED POT

Pottery analysis at the BNC: an archaeological perspective

Pottery production sequence



Pottery analysis at the BNC: an archaeological perspective

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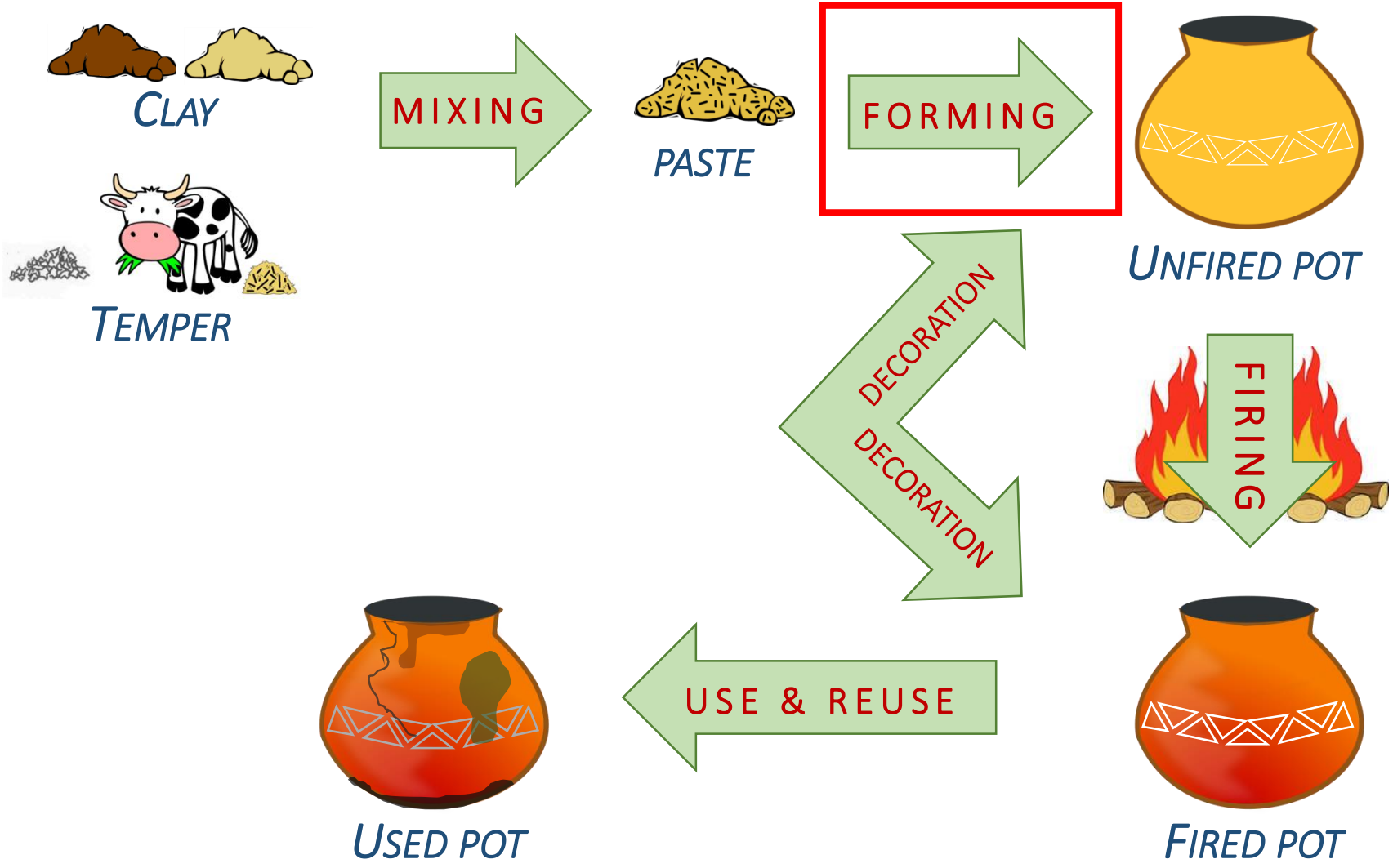


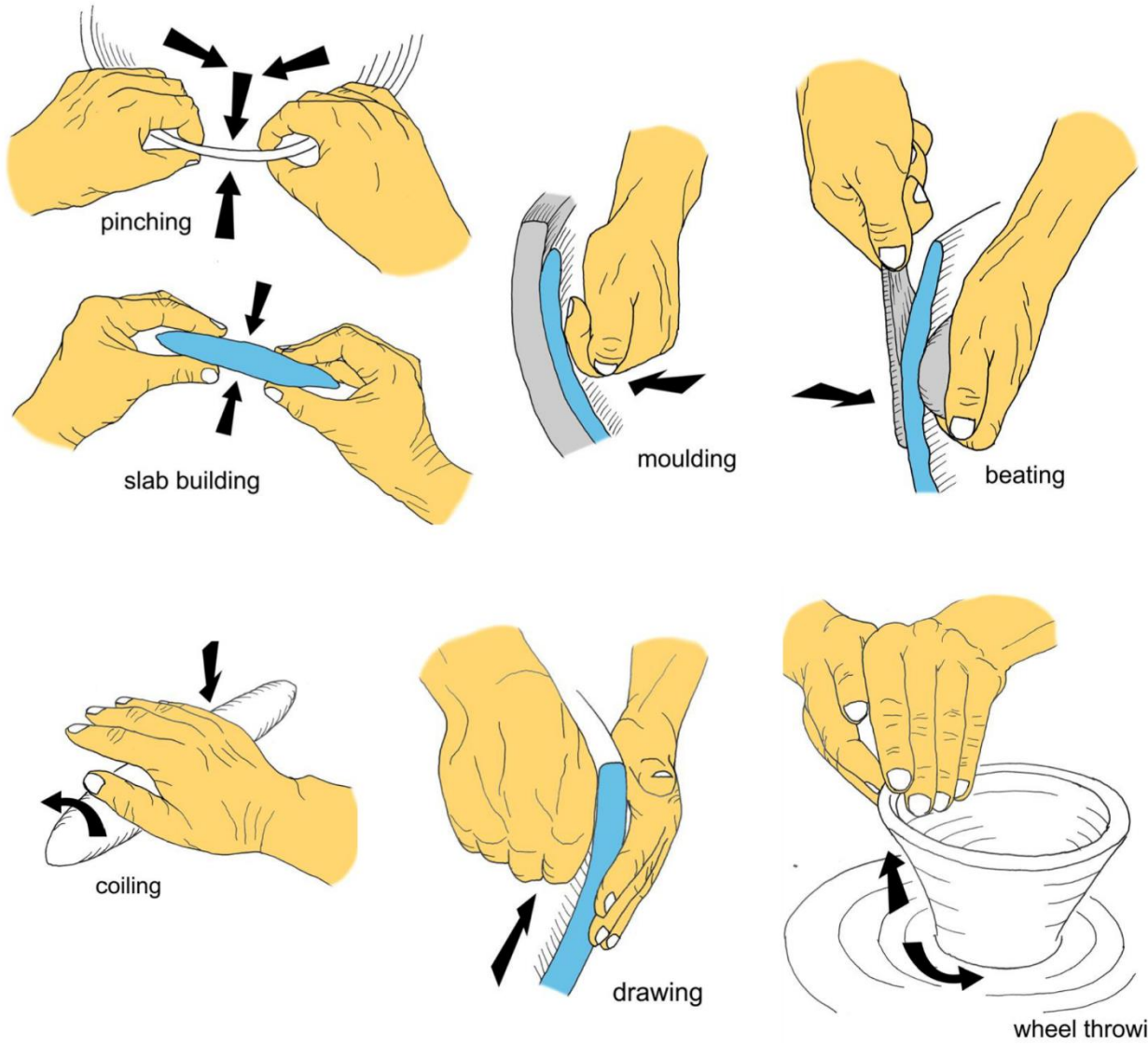
Pottery analysis at the BNC: an archaeological perspective

Forming techniques

Coiling
Percussion (beating)
Moulding
Slab-building
Pinching
Drawing
Wheel-throwing
…or combinations

→ Surface traces often destroyed or hidden

→ Distinctive orientations of particles and voids within pottery fabrics



Archaeometry 58, 2 (2016) 222–238

Pottery analysis at the BNC: an archaeological perspective

- **Current research at the BNC- Pottery forming techniques**
  - Challenges

    Non-destructive analysis → Rare cultural heritage, preservation for future
    → Regulatory approval

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    Verification of methodology → Controlled replication studies

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Large numbers of measurements→ Representativeness
→ Costs: instrument time, processing time
→ Development of instruments (e.g. sample changers)
→ Automation of data processing

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  - Development of new analytical applications

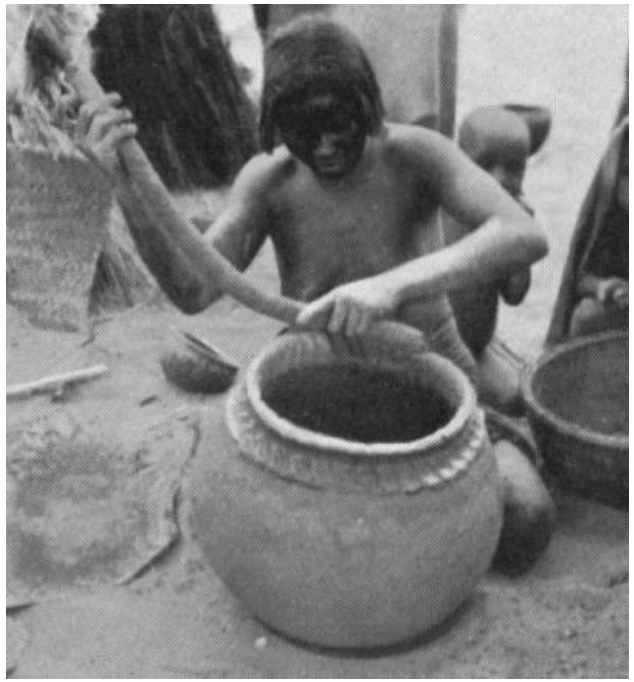
    Mesoscale → Imaging: µ-X-ray tomography (µ-CT) / neutron tomography (NT)
    Nanoscale → Small-angle neutron scattering (SANS)

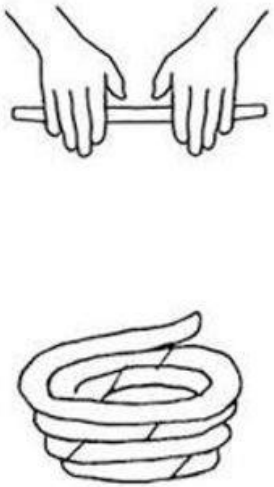
Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**
  - Tomographic imaging µ-CT and NT
  - Alignment of mesoscale particles and voids

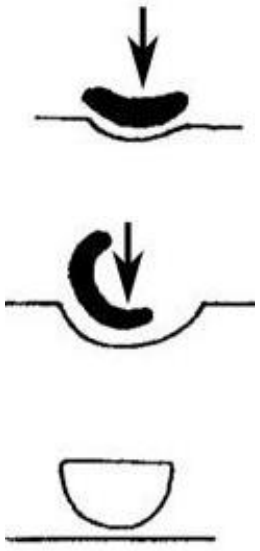
Historical ethnographic parallels: *were similar techniques used in the past?*

Coil-building





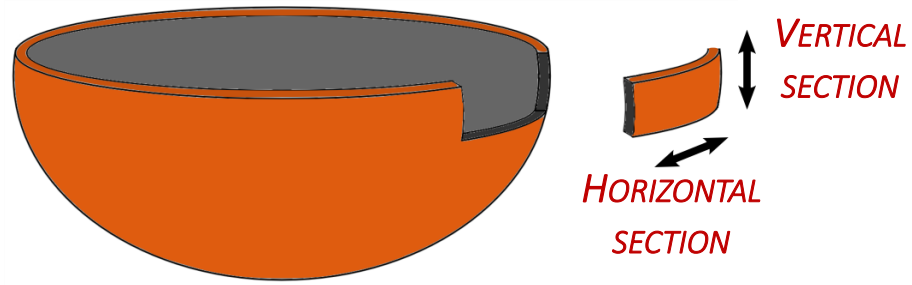
Percussion building

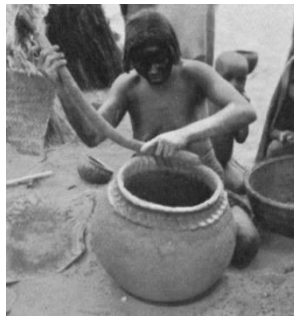
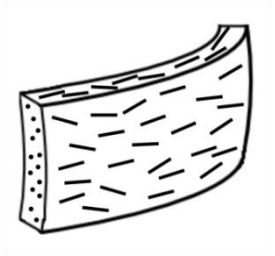
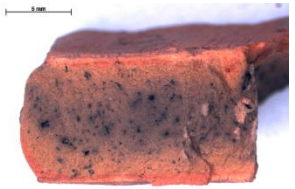
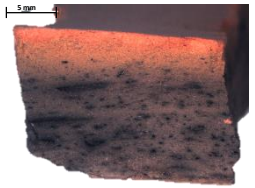


Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

  Expected alignment of organic particles and voids

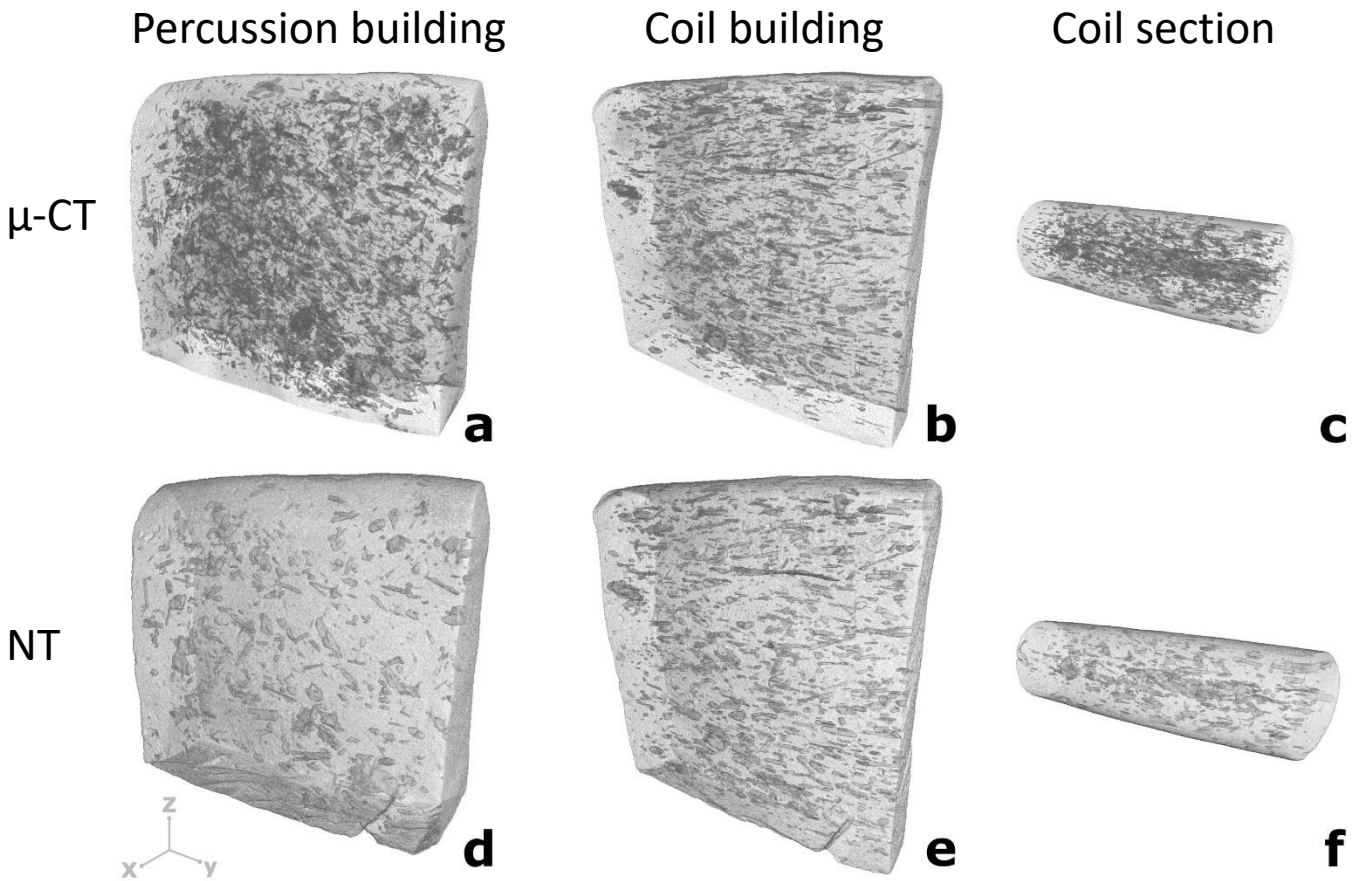


		HORIZONTAL SECTION	VERTICAL SECTION	ALIGNMENT
COILING	 			Parallel to walls and rim plane
PERCUSSION	 			Parallel to walls, and unaligned to rim plane

Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

  Alignment of organic particles and voids in experimental pottery



→ large number of objects detected in µ-CT

→ Coil built & coil section: objects tend to align towards sample walls & horizontally

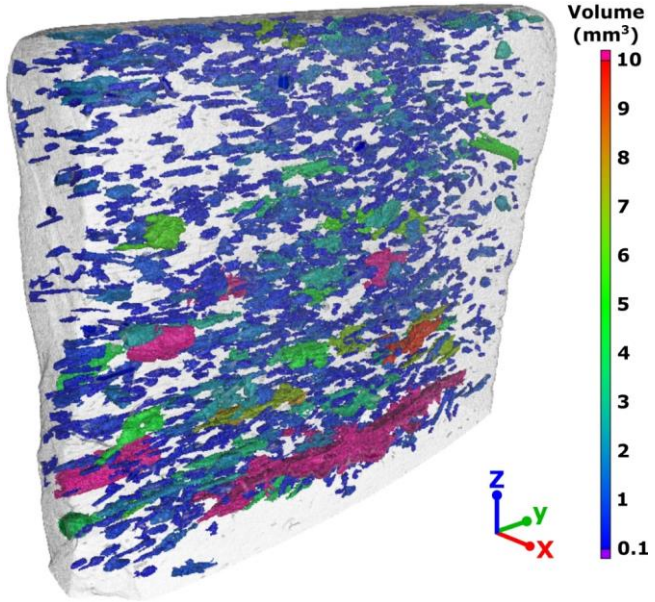
→ Percussion building: objects tend align to sample walls only

Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

  Segmentation of particles and voids

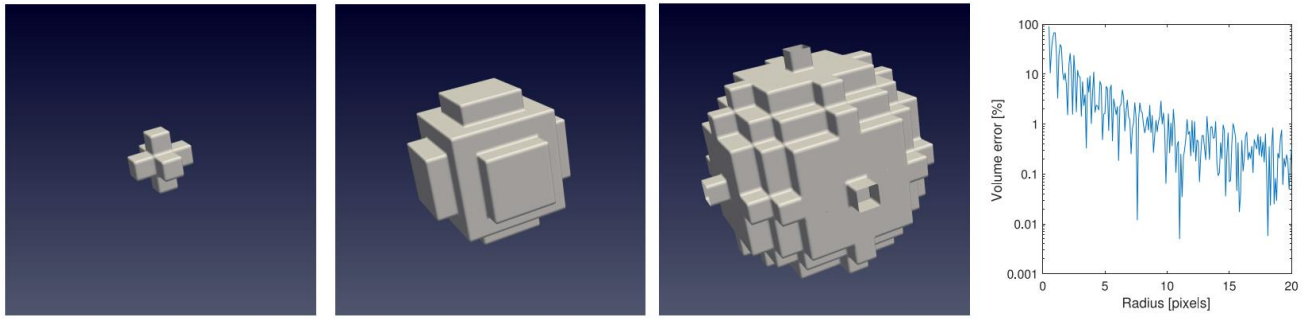
  Filtering by volume and aspect ratio



Spatial resolution:
µ-CT = c. 50 µm
NT = c. 300 µm

…but actual particles analysed are considerably larger

'voxalisation'⟶ poor estimate of volume for small objects



(a) (b) (c) (d)

Kaestner et al. 2017, Physics Procedia 88

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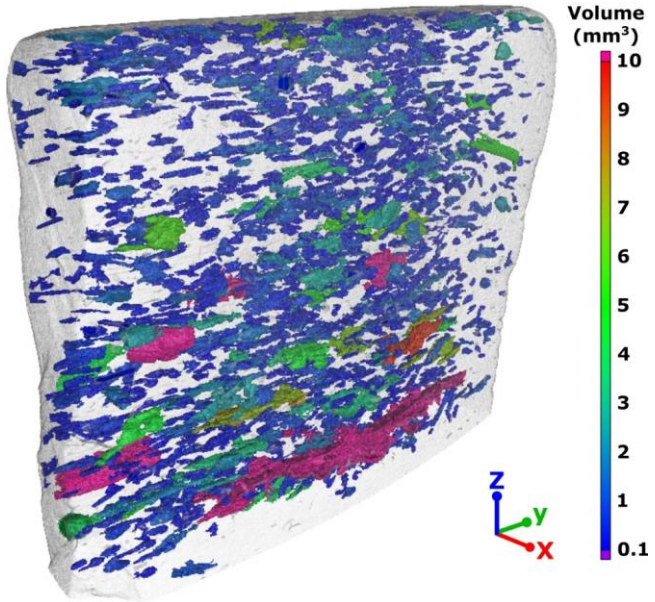

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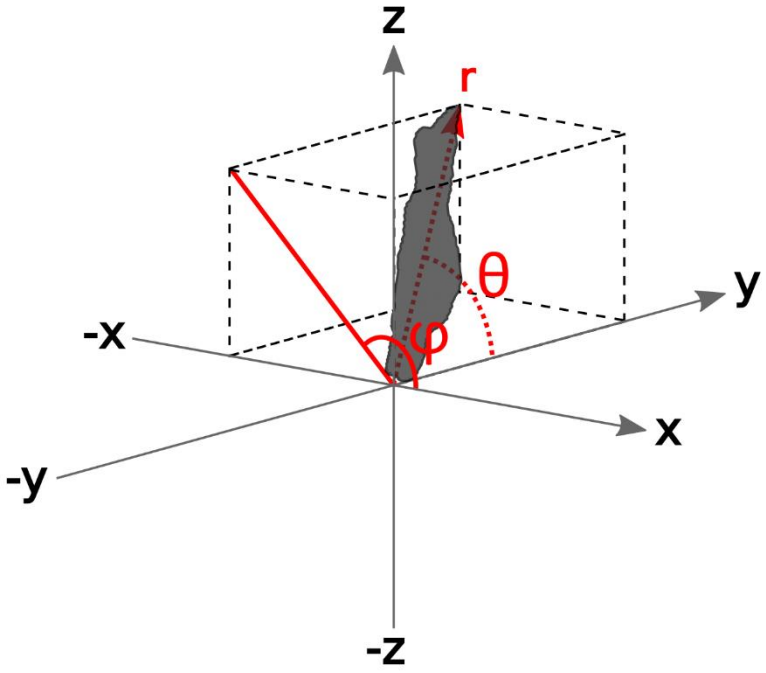
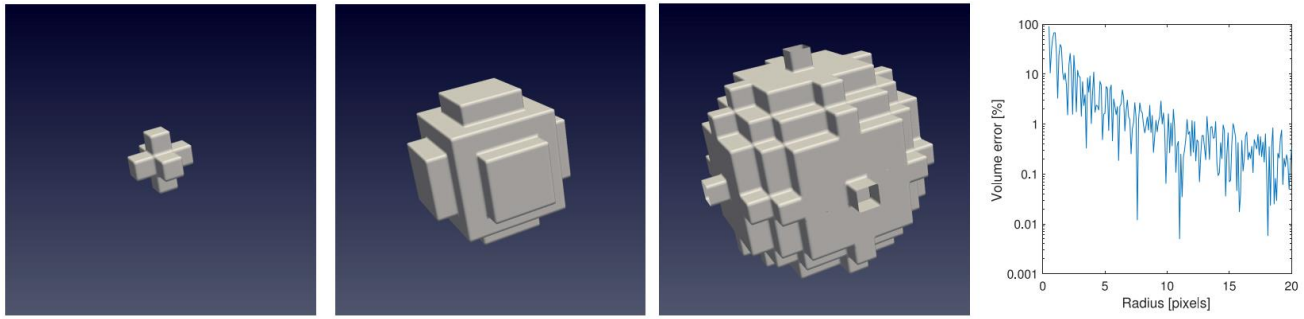
Orientation of objects:
3D spherical coordinates





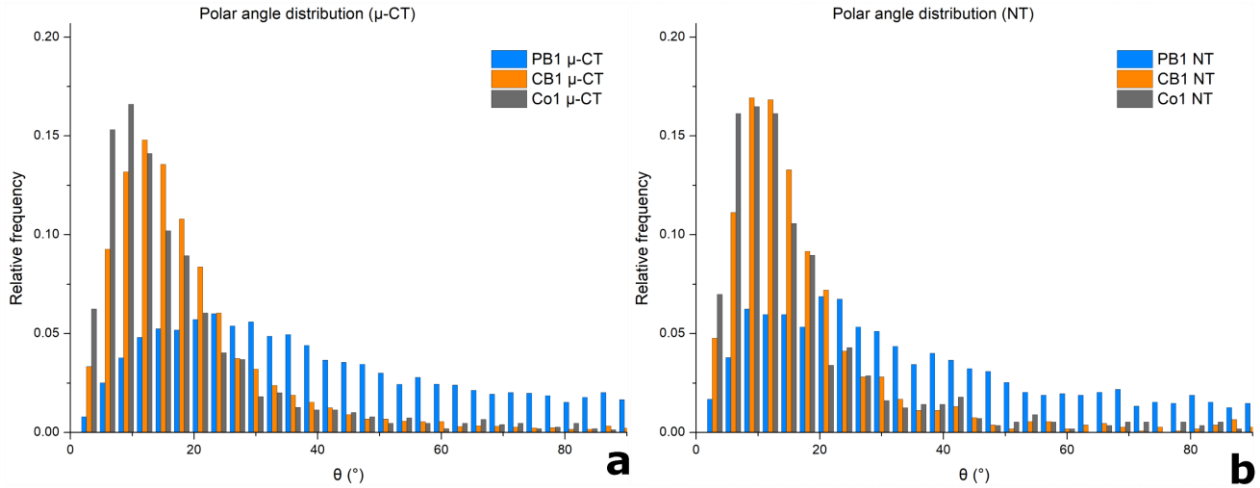
Kaestner et al. 2017, Physics Procedia 88

Orientation of ellipsoid fitted to objects
θ = Polar angle (0-90°)
ϕ = Azimuth angle (0-360°, axial)

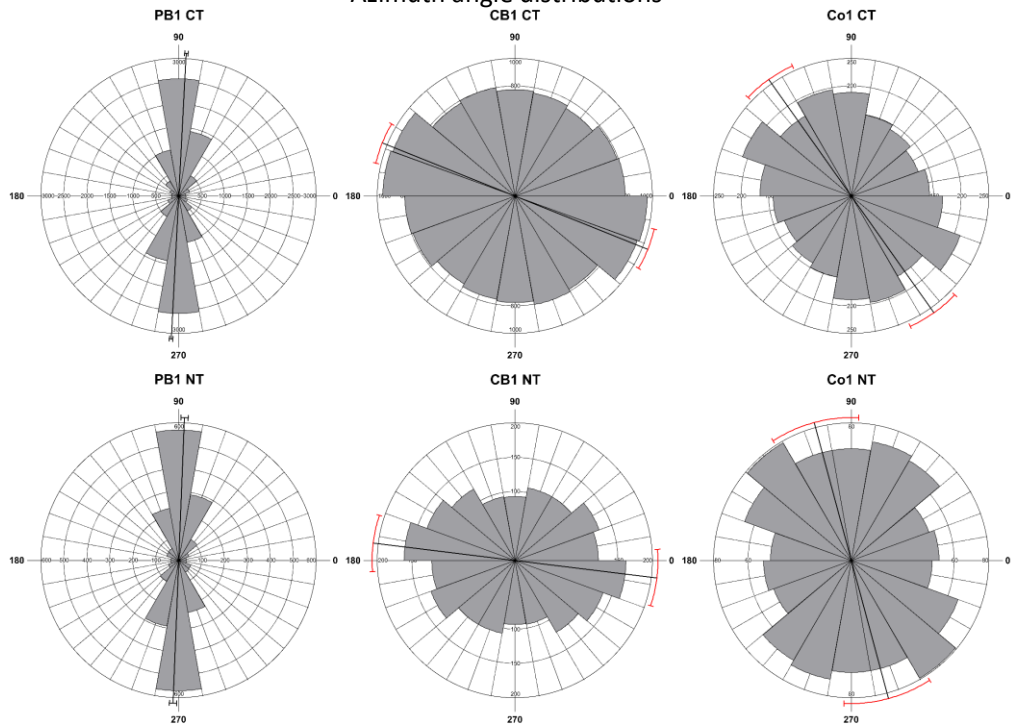
Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**
  Quantifying alignments

Polar angle distributions



Azimuth angle distributions



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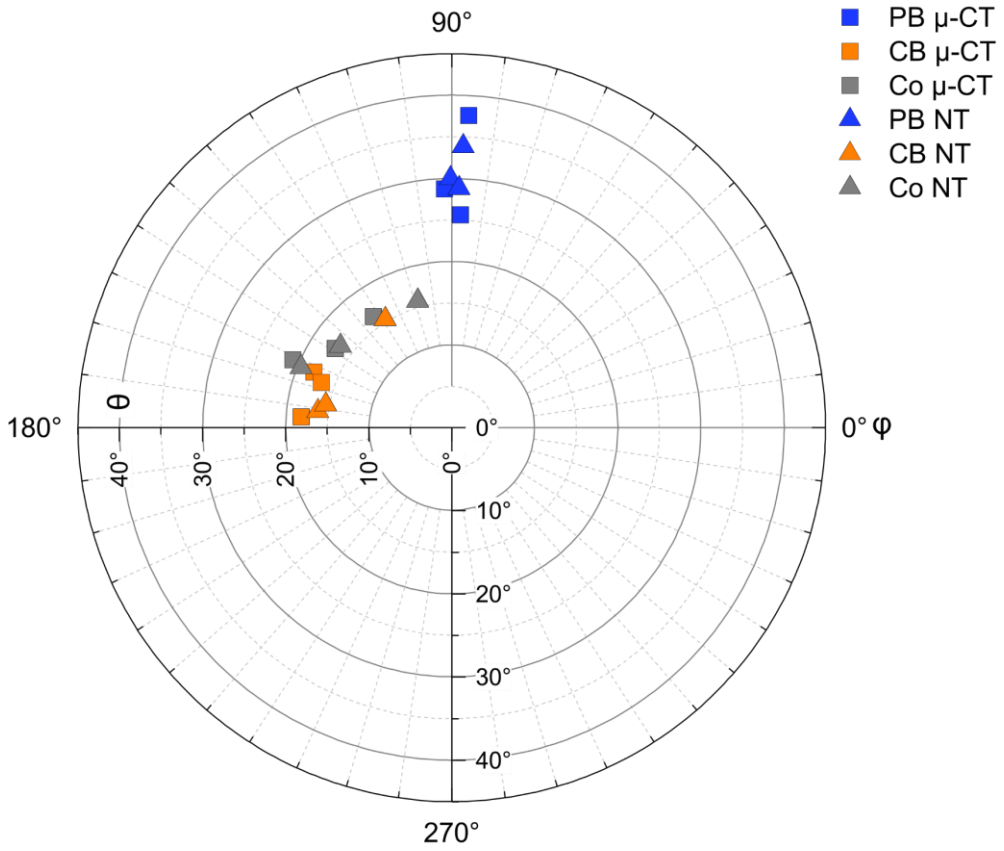

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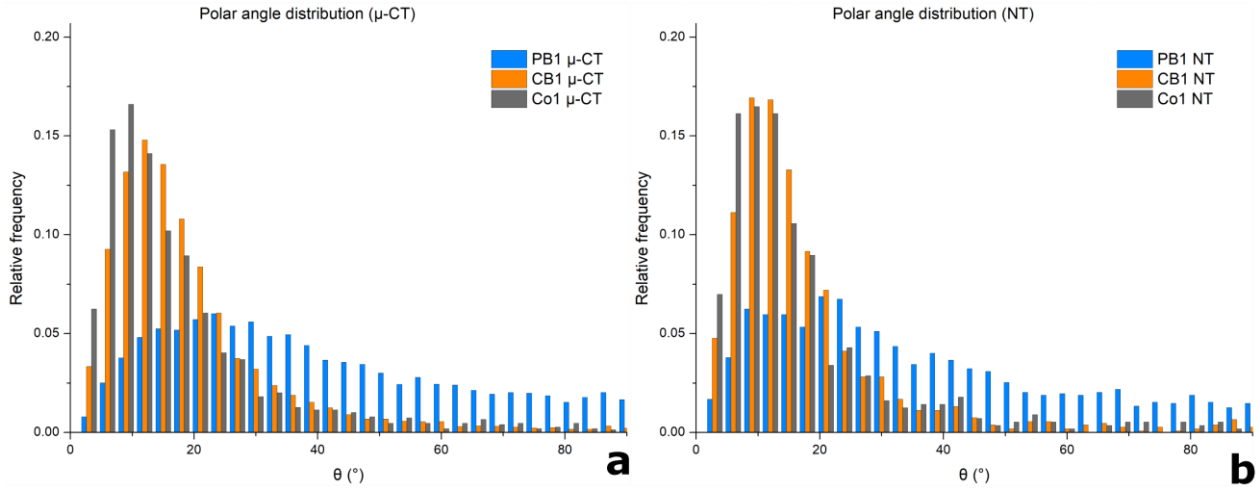

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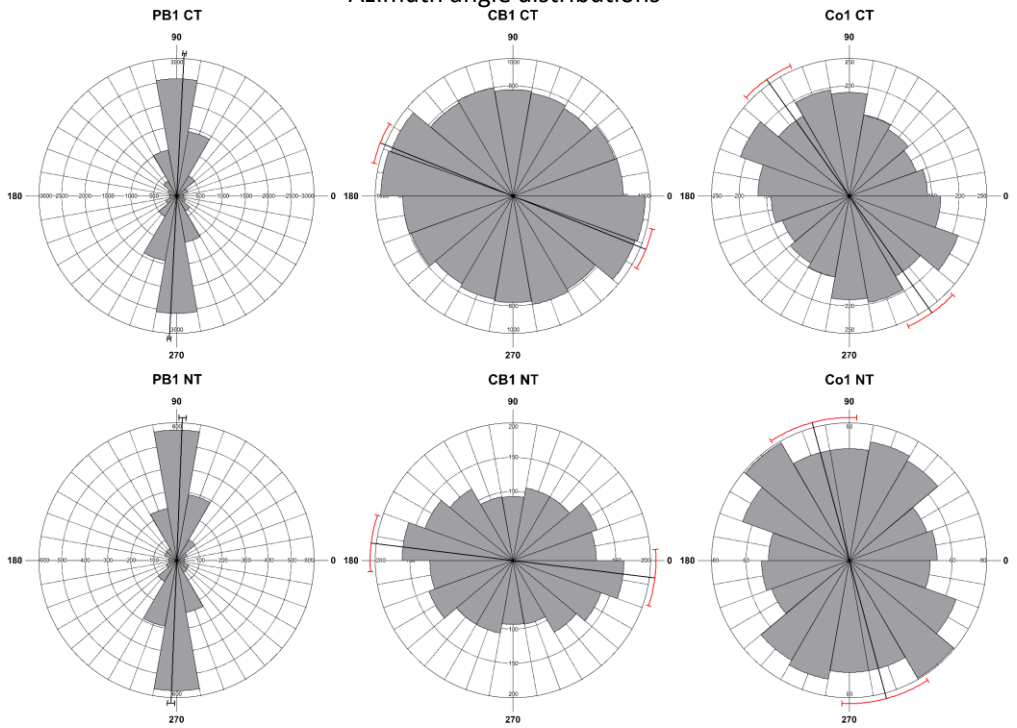

Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

What about other forming techniques?

What about fine-textured fabrics?

Small-angle neutron scattering

Alignment of nanoscale particles and voids

Pottery analysis at the BNC: an archaeological perspective

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Transitional, complex forming techniques:
Wheel-shaping combines both coil-building and wheel-throwing
A transitional stage in the spread of wheel-throwing technology (?)

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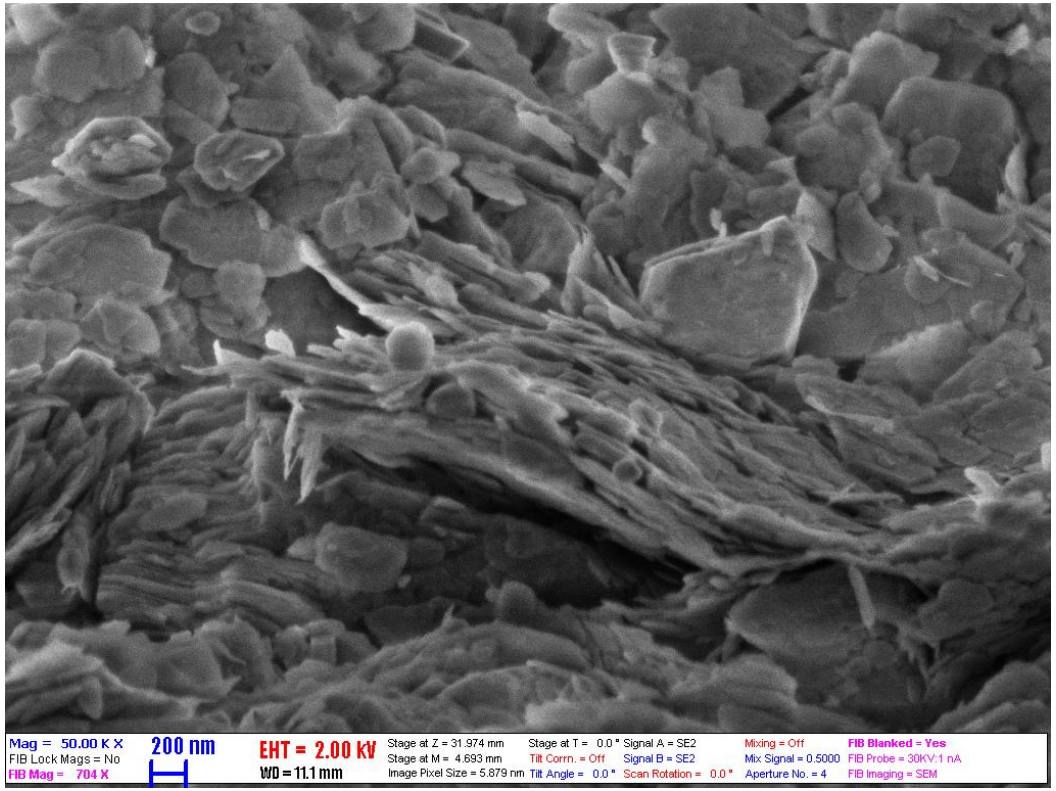

SEM image of clay minerals: minerals are elongated & thin

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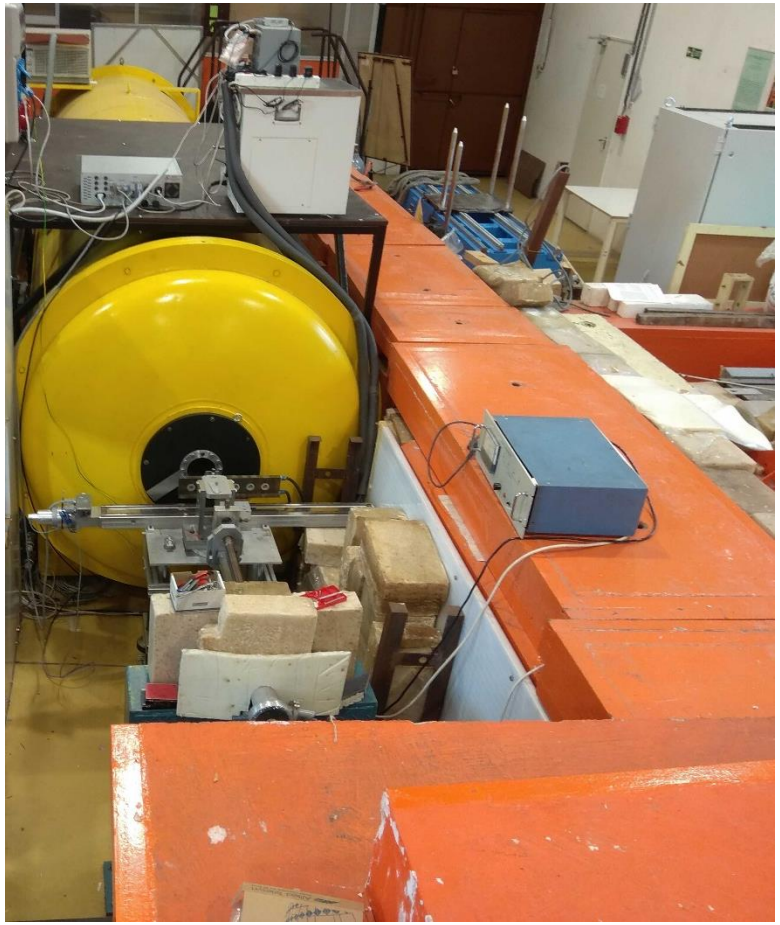
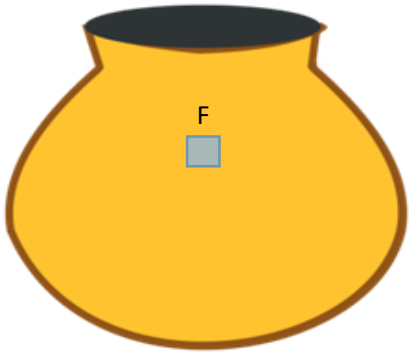
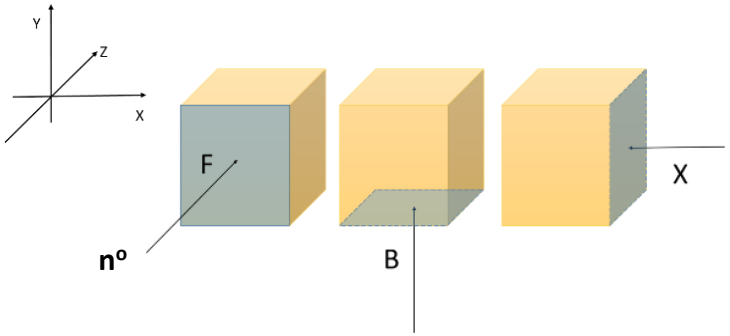
Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

  Multiple measurements of 2D anisotropic scattering







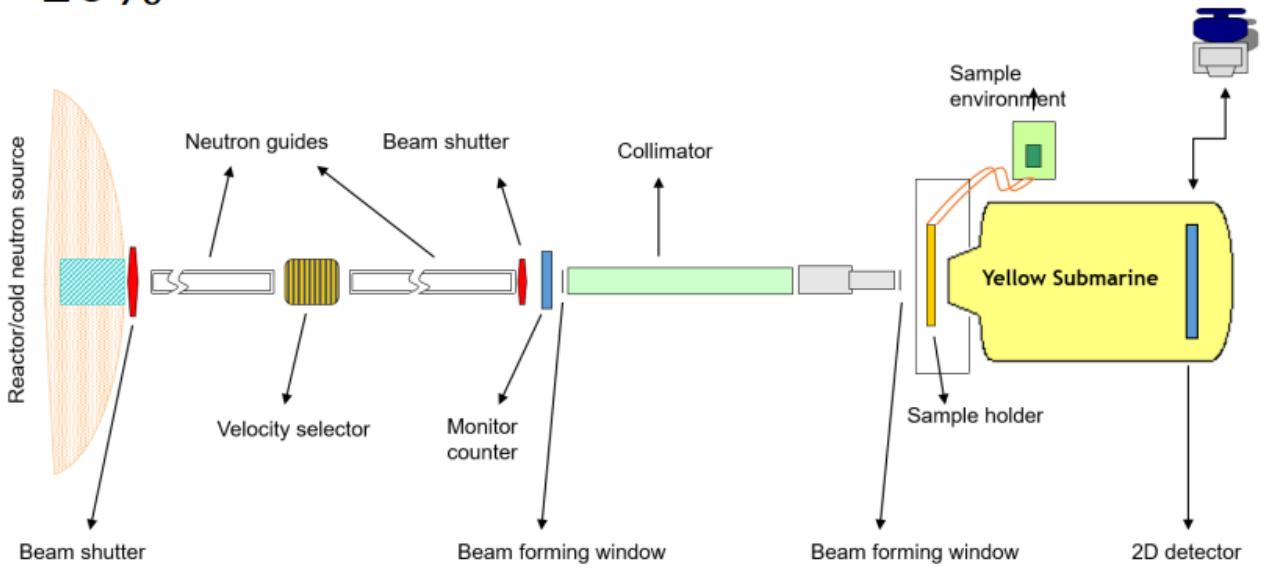
8 mm cubic samples analysed in three positions relative to axis of neutron beam

Cubic sample mounted in sample holder in F-view.
Orientation sample and relative direction of beam recorded

Sample changer

Pottery analysis at the BNC: an archaeological perspective

- Yellow Submarine SANS instrument @ Budapest Neutron Centre
  - 64x64 position sensitive detector
  - Sample to detector distance: $5.2\ m$
  - Wavelength: 4.5 Å, with $^{\Delta\lambda}/_{\lambda} = 20\%$
  - Q range: $0.015 - 0.080\ \text{Å}^{-1}$
  - Various beam sizes: $2mm, 4mm, 8mm, 10mm, 16\ mm$

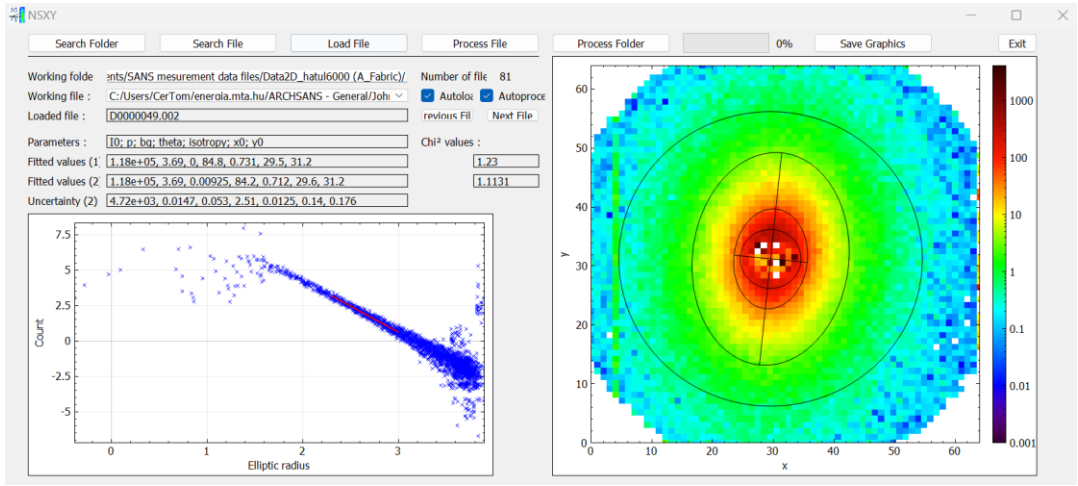


Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

  Large number of measurements

  Semi-automated evaluation software



Anisotropy → Aggregated alignment of scattering objects
and shape of objects

Direction of elongation in anisotropic scattering

=

Aggregated **tilting angle** of scattering particles and voids

Pottery analysis at the BNC: an archaeological perspective

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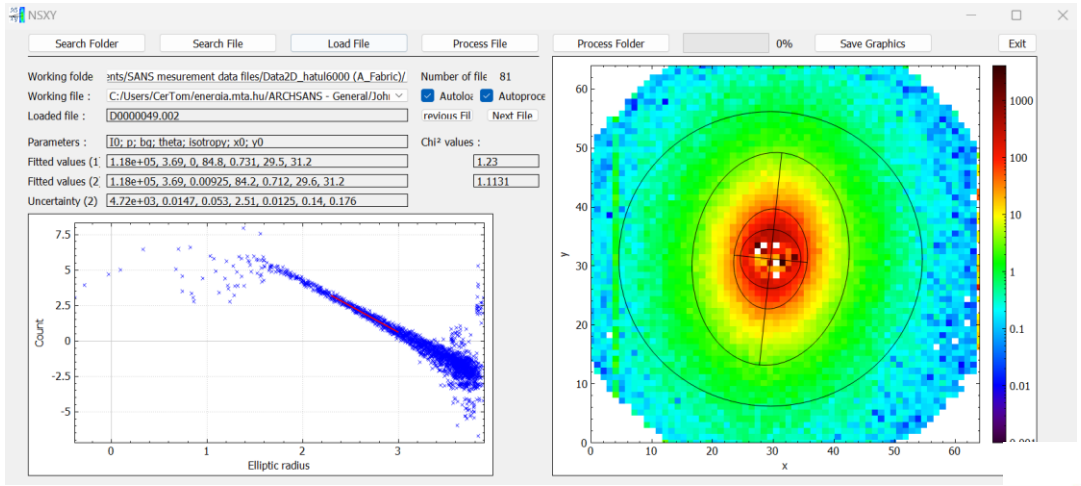

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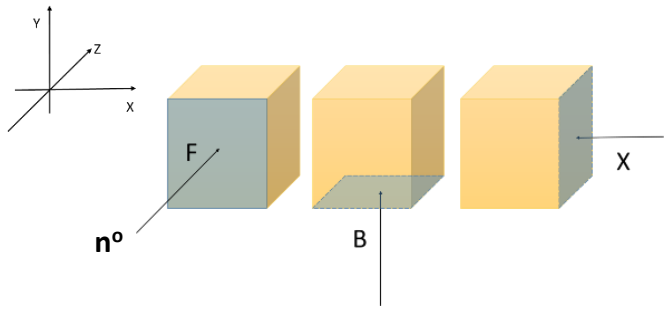
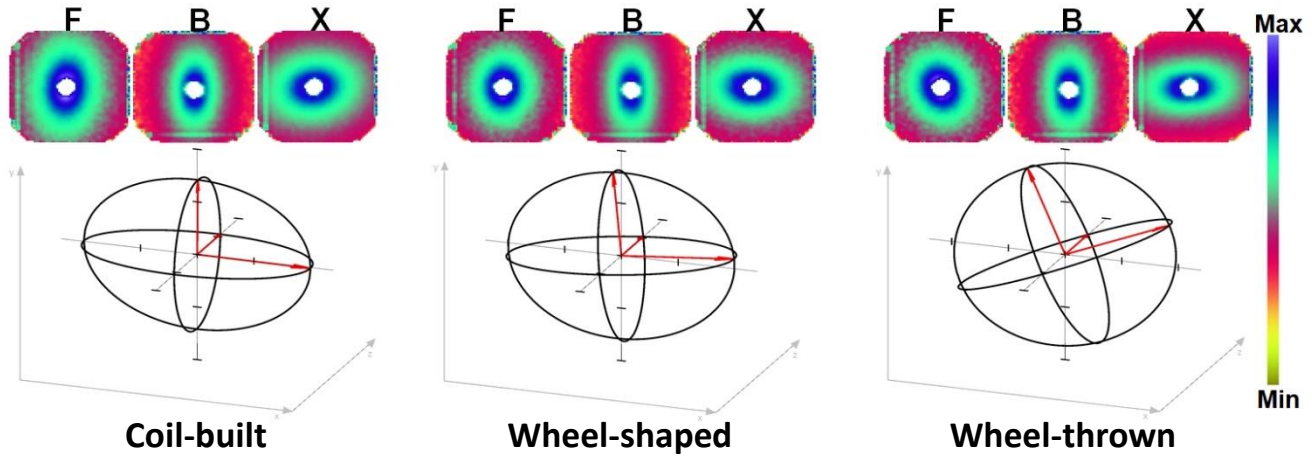
Aggregated tilting angle of scattering particles and voids

Scattering in 3D





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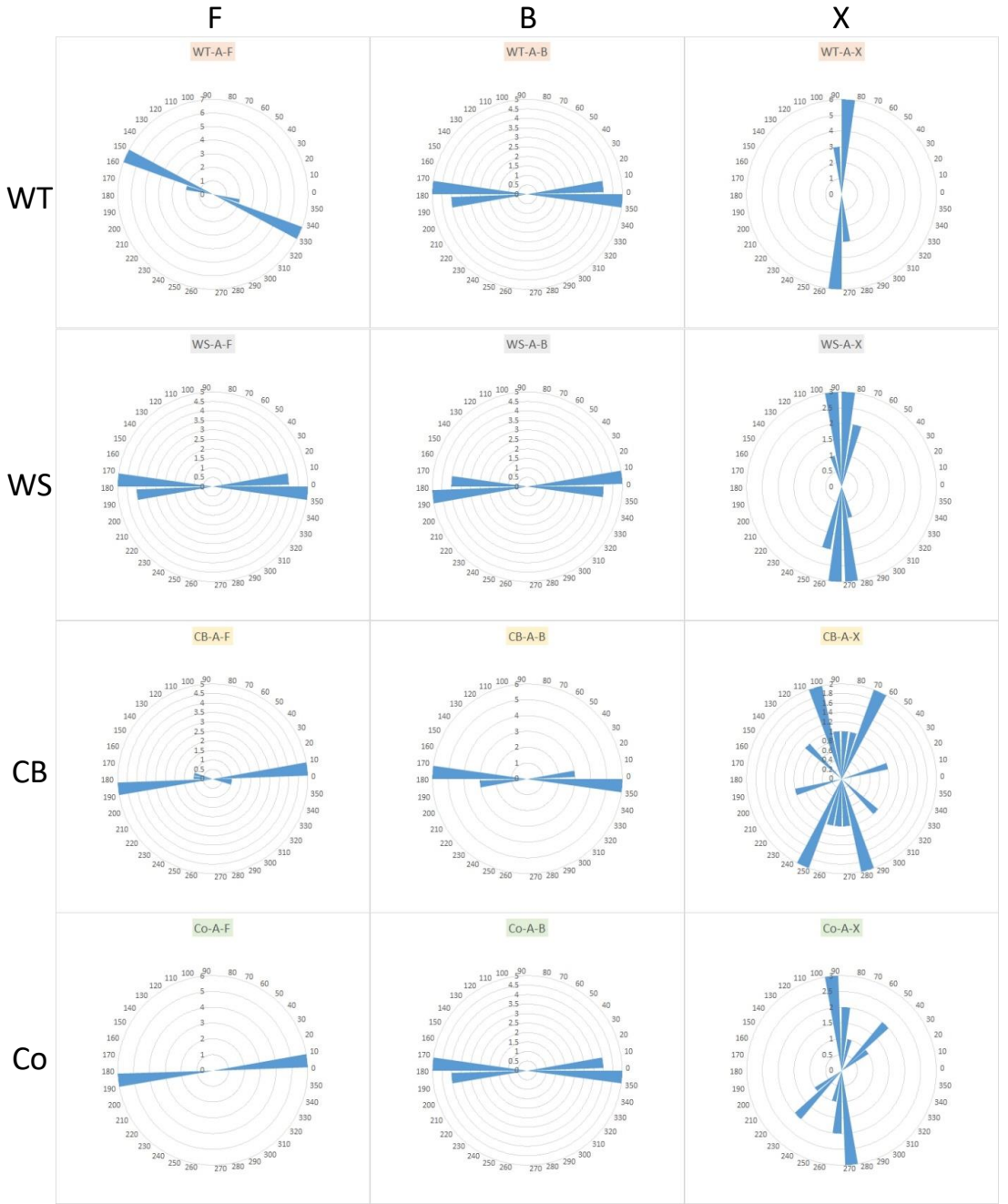
  Aggregated tilting angle of scattering particles and voids



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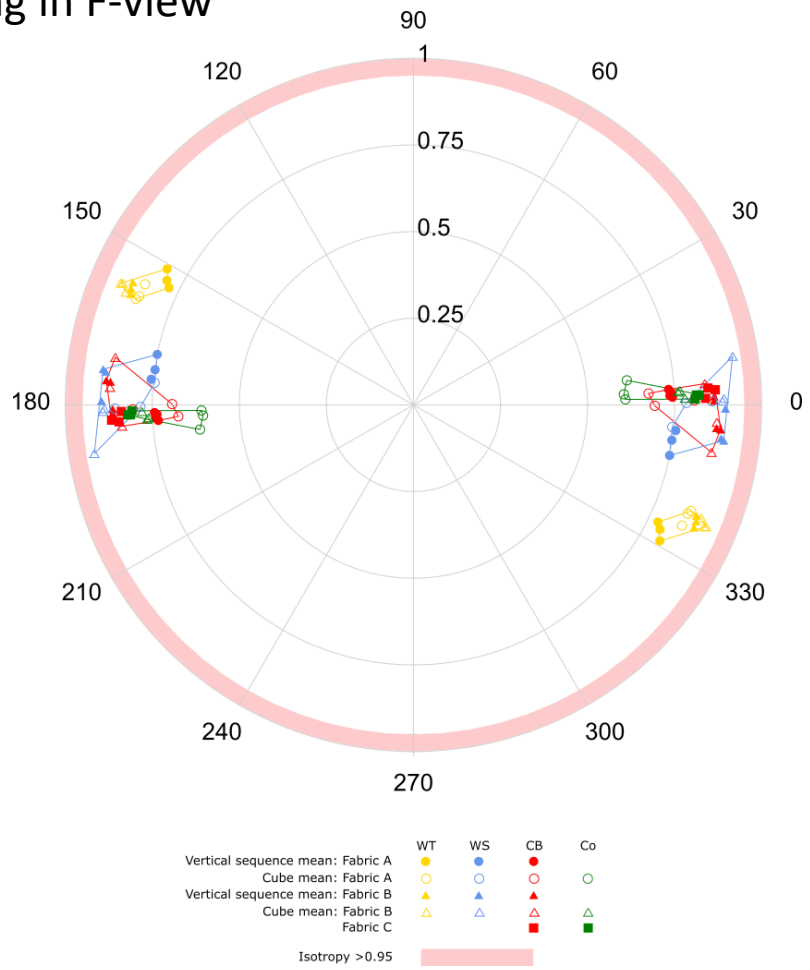
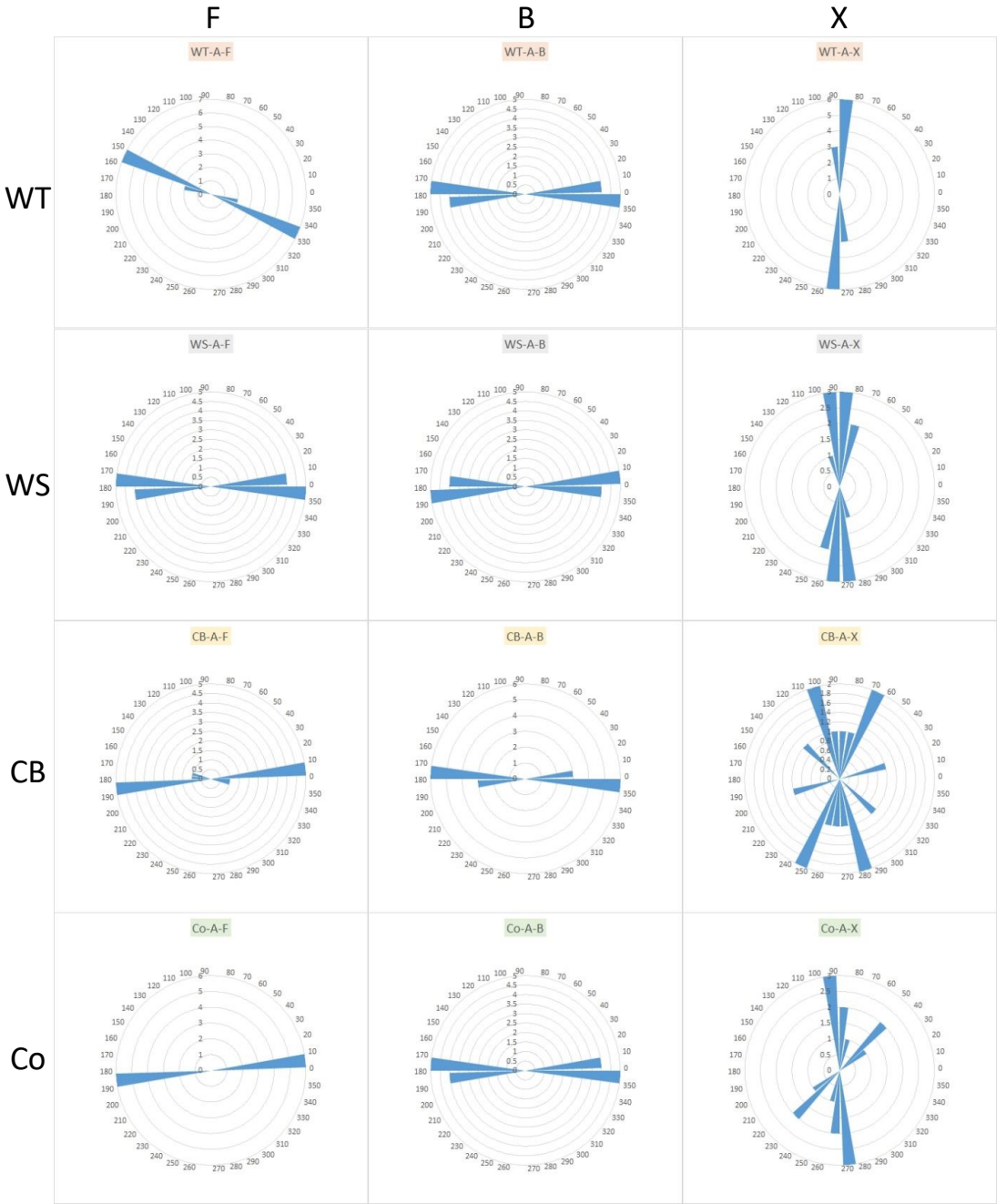
  Aggregated tilting angle of scattering particles and voids

Tilting in F-view

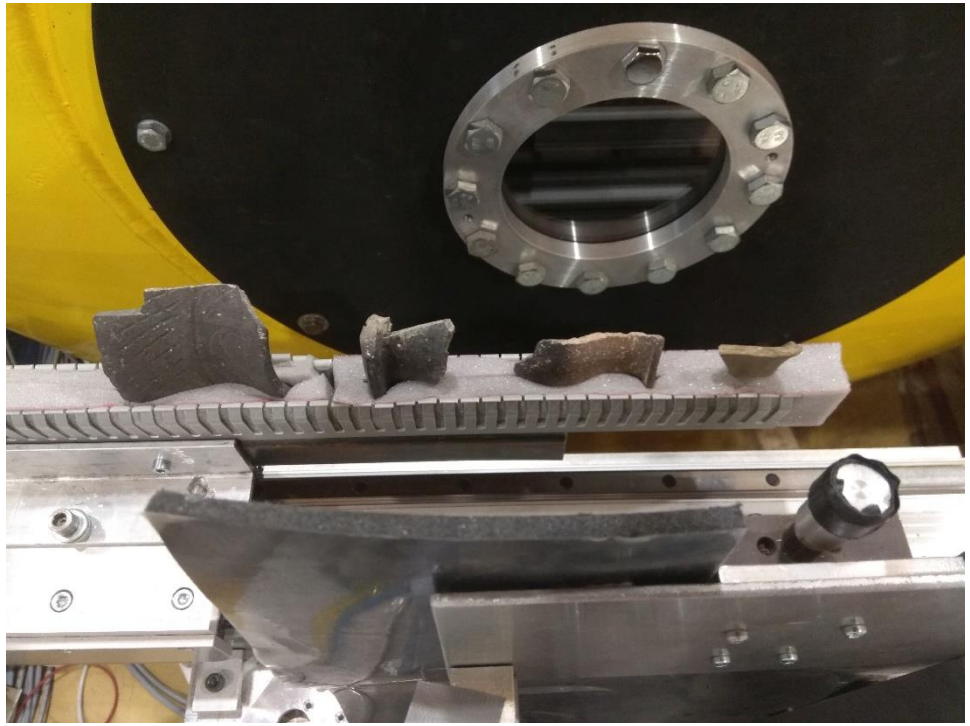




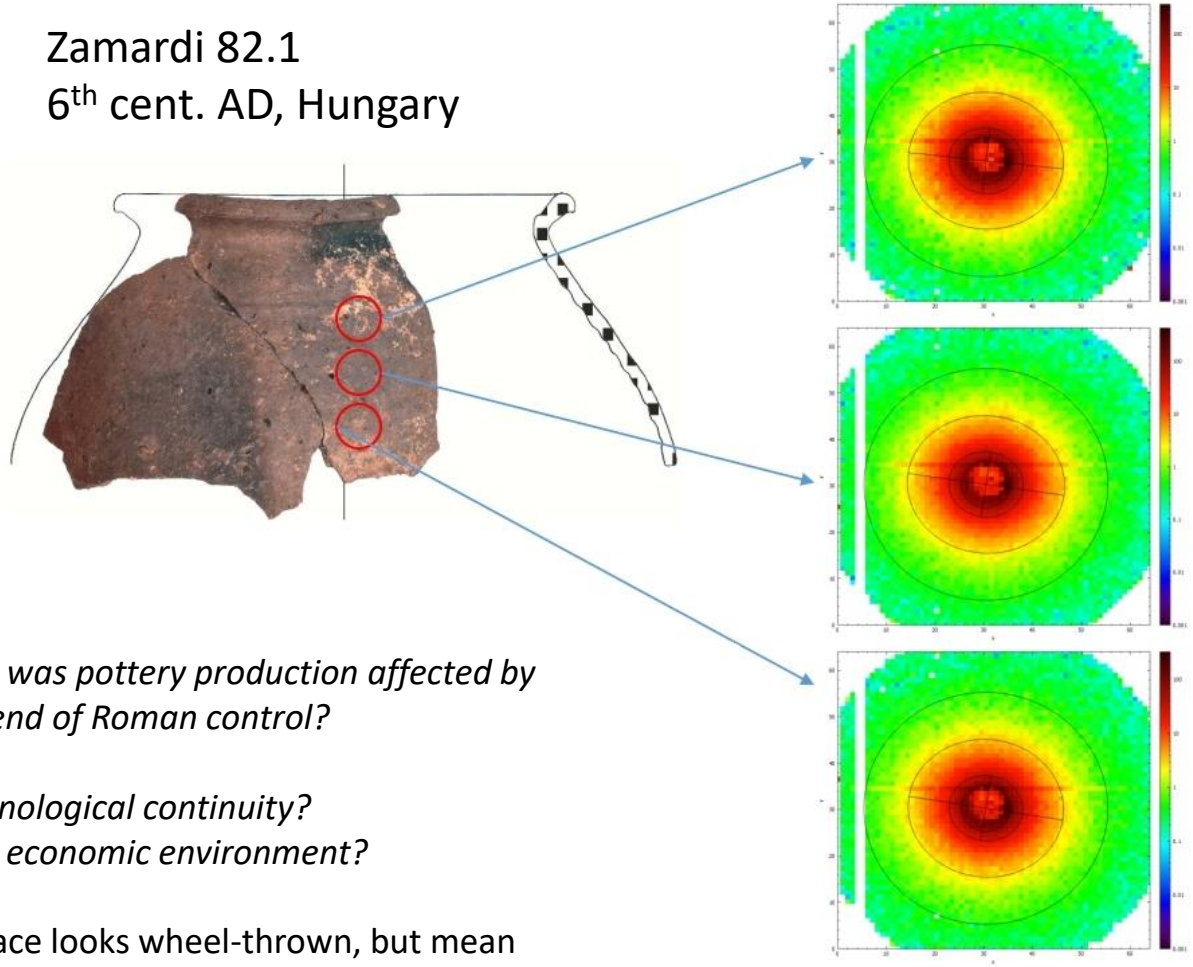
Pottery analysis at the BNC: an archaeological perspective

- **Pottery forming techniques**

  Archaeological samples



Zamardi 82.1
6th cent. AD, Hungary



How was pottery production affected by the end of Roman control?

Technological continuity?
New economic environment?

Surface looks wheel-thrown, but mean tilting angle = 8.3°
→Wheel-shaping

Smaller scale production
Smaller, more regional markets

Pottery analysis at the BNC: an archaeological perspective

Summary

- Orientation of particles and voids can be used to differentiate forming techniques including combined wheel-shaping technique
- Non-destructive analysis of archaeological pottery
- Suitable for fine- or coarse-textured fabrics
- Not affected by surface features (e.g. paint / polish)

Nubian C-Group bowl, Adindan, Egypt
c.1900-1650 BC

Nubian potters, Deir el-Medina, Egypt
Early 19th Dynasty (c.1290 BC)

Centre for Energy Research

Thank you for your attention!