ARCHAIDE

ARCHAELOGICAL
AUTOMATIC INTERPRETATION
AND DOCUMENTATION
OF CERAMICS

Holly Wright
Archaeology Data Service
University of York

Arch-I-Scan Workshop

21 April, 2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 693548

Università di Pisa · Consiglio Nazionale delle Ricerche · ISTI · Tel Aviv University · University of York · Universitat de Barcelona · Universität zu Köln · Baraka Arqueólogos · Elements · inera

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Funded by EU H2020

Research and Innovation Action

Duration: **36 months**

June 2016 to May 2019

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ARCHAIDE Partners

Archaeologists and Computer Scientists

University of York
Archaeology Data Service

University of Cologne
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University of Barcelona
Fac. de Prehistòria, Història Antiga i Arquelogia
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ArchAIDE
Archaeological Automatic Interpretation and Documentation of cEramics

cooking

eating
and drinking

illumination

transportion

storage

Pottery helps us to:

- Date archaeological contexts
- Understand dynamics of production and trade flows
- understand the social interactions

Pottery often represents a significant percentage of finds in many parts of the world, and therefore significant investment of time and expertise.

In some parts of Europe it is estimated that **80 or 90%** of the time and energy of an archaeologist it is spent in the analysis and quantification of excavation finds.

Quantification and analysis requires:

- Complex skills and since it is heavily dependent on human inspection and interpretation; it is a very time consuming activity
- Access to comparative information, which is often fragmented and time consuming to consult

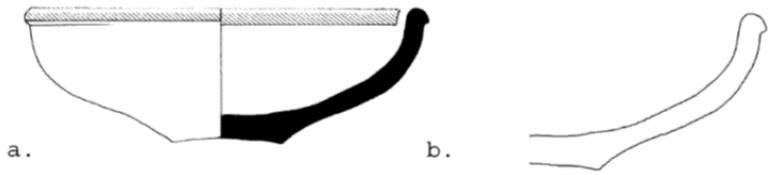
Analysis of sherds:

(a) the identification of the ceramic class, the specialist looks at:

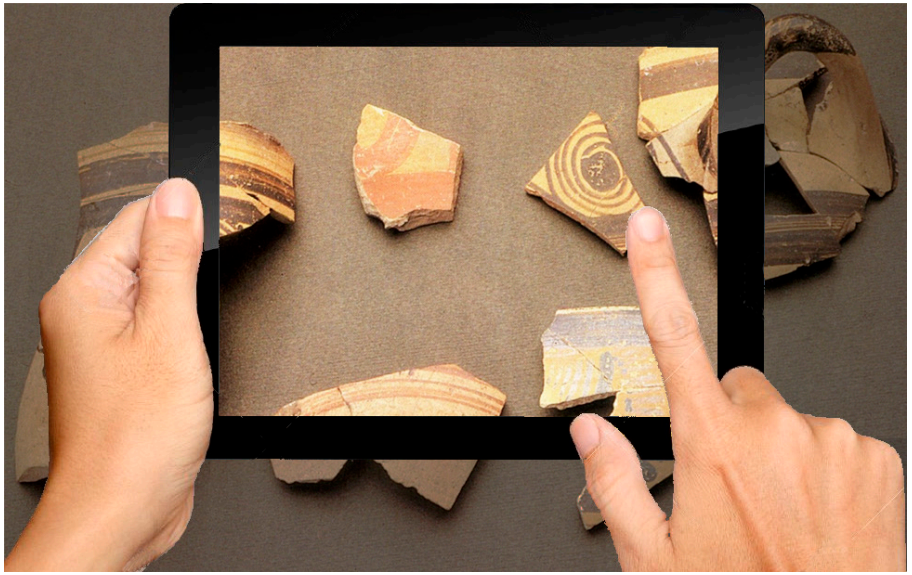
- surface treatment,
- the decoration
- the fabric

(b) identification of the **form type**:

- looks into the ceramic class paper catalogues for the specific form;
- analyses **the section of the potsherd and its profile**;
- makes a comparison with published types (**hundreds of pages and drawings**)



ArchAIDE developed a prototype app for tablets and smartphones to speed and support the ceramic classification and interpretation work of archaeologists, during both fieldwork and post-excavation analysis.



We wanted to speed tasks for experienced archaeologists and pottery specialists and help new researchers learn more about pottery identification, using a modern **computer-aided approach, but** keep the *overall methodologies* used by archaeologists to ensure the app complements existing workflows.

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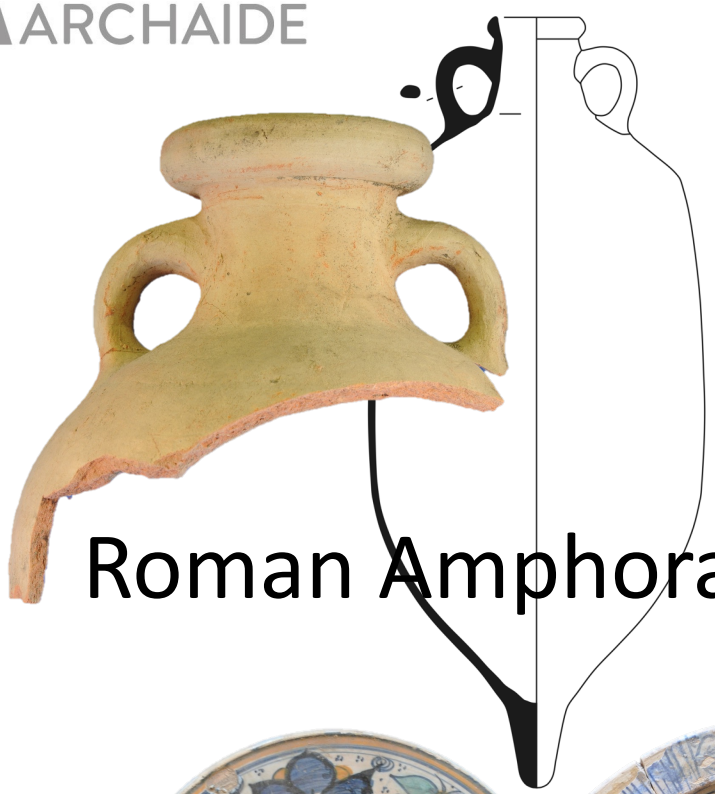
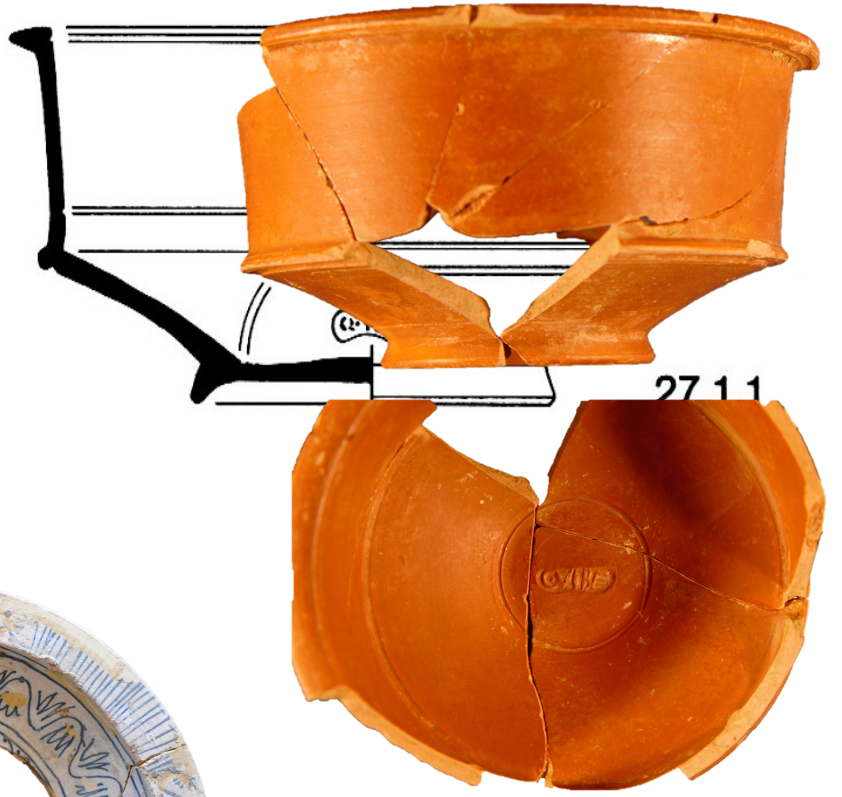
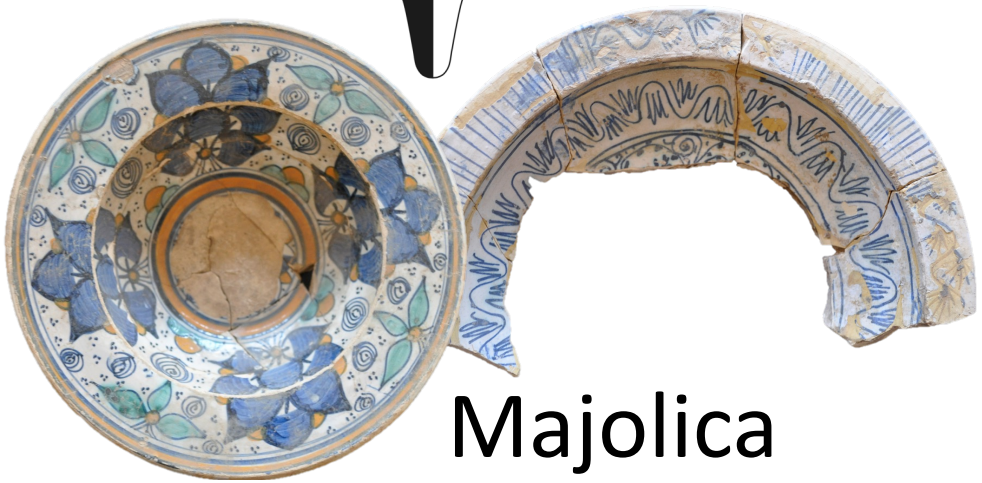


Roman Amphorae

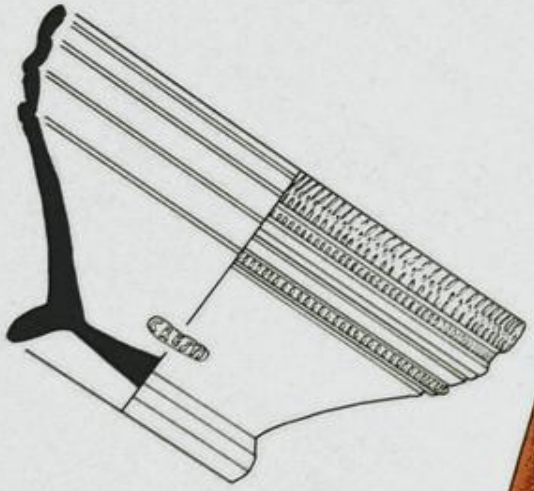


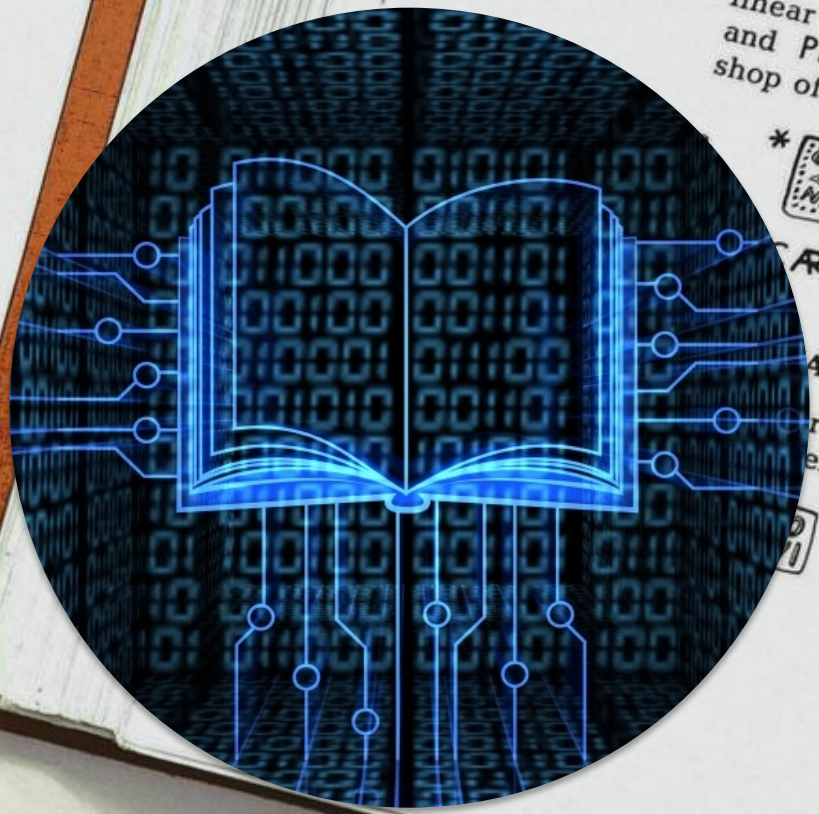
Terra Sigillata

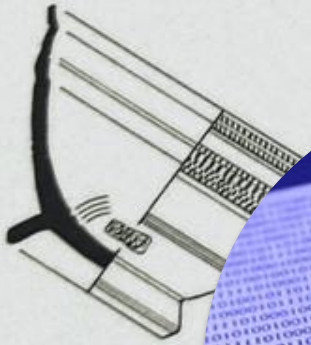


Majolica

[catalogues]





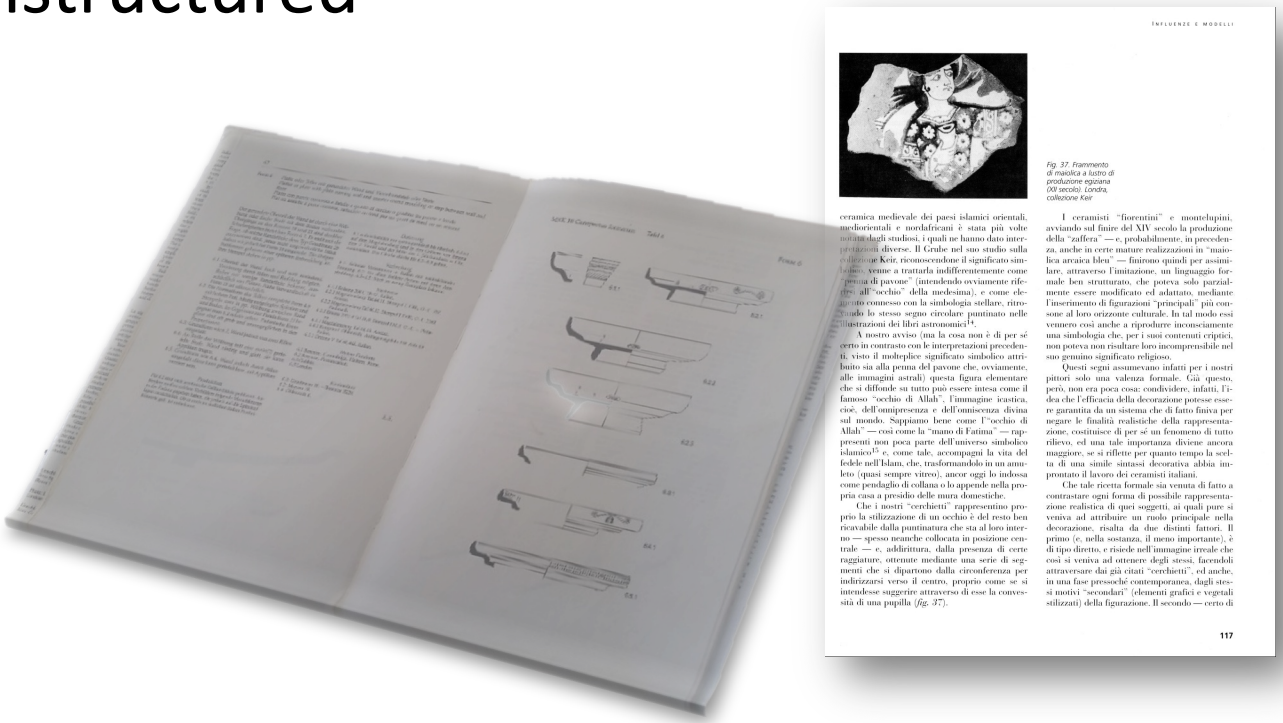


[Digitisation]

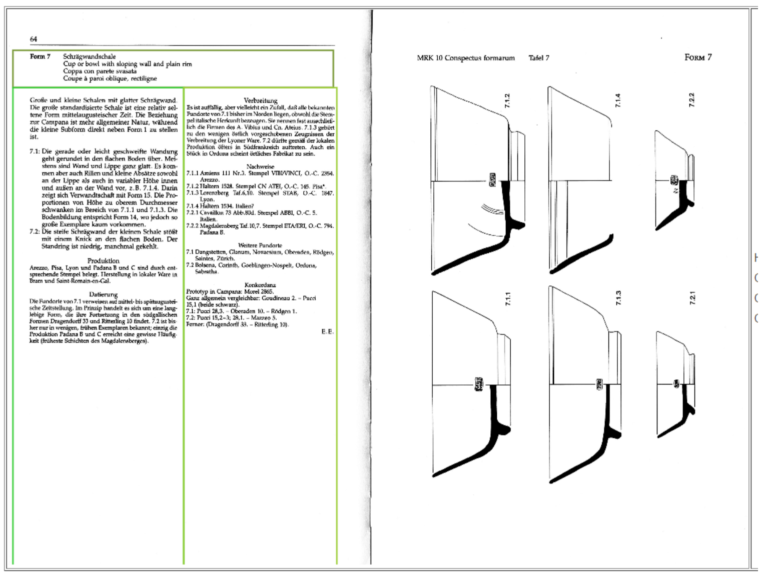
- Multiple approaches to creating digital reference collections for the app:
  - Incorporated existing digital reference catalogues
  - Created new tools to digitise paper catalogues
  - Analysed and extracted information from reference drawings to create new resources (3D)
  - Created new reference data with photography campaigns
  - Populated the database with the resulting reference typologies

Digitising from catalogues

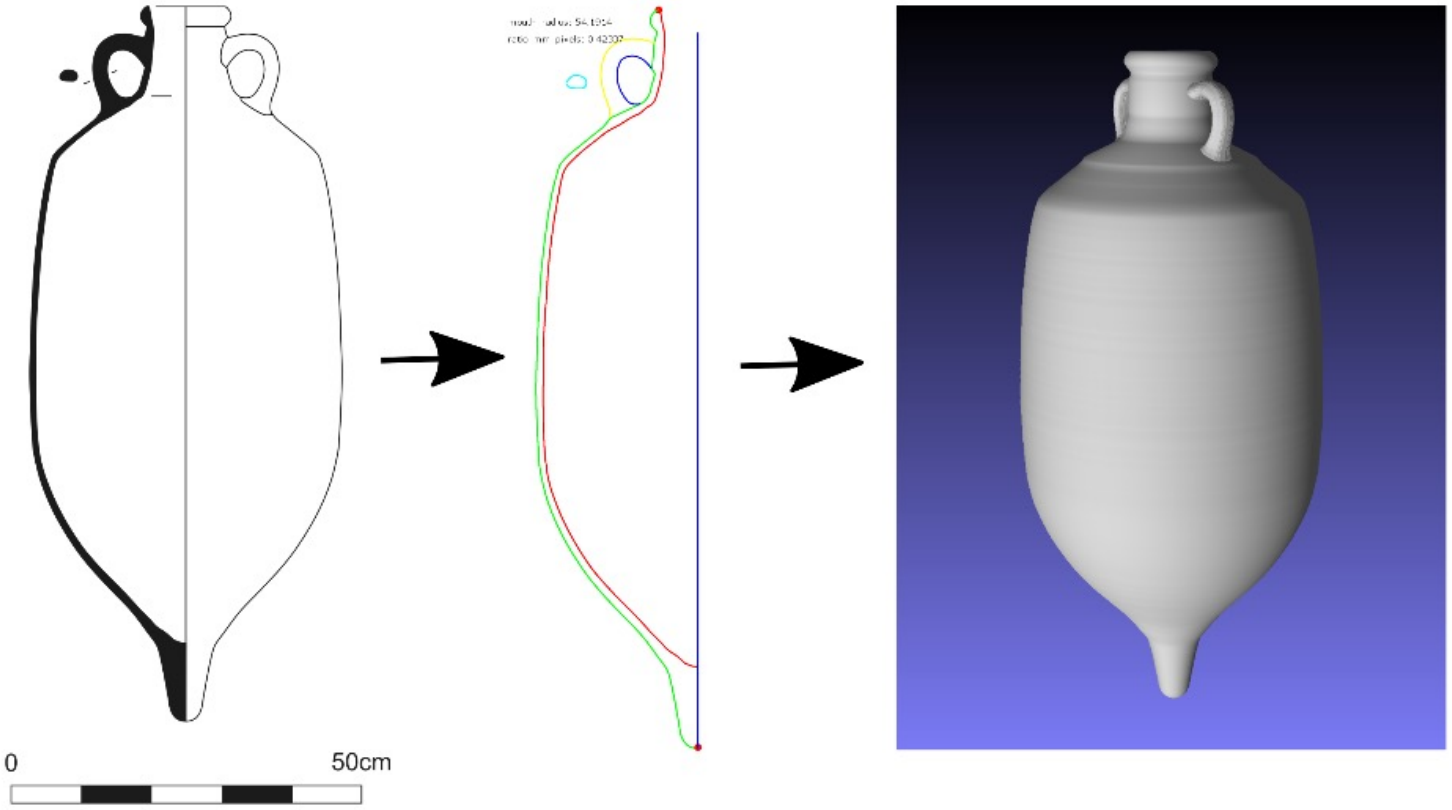
Much variability in textual data, even within a single publication: from very structured to totally unstructured



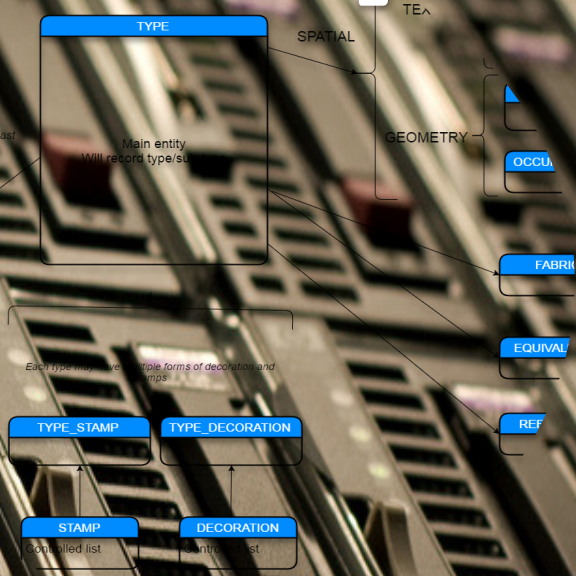
(Assisted) manual and automatic text digitisation



From drawings digitisation to 3D models



[database]

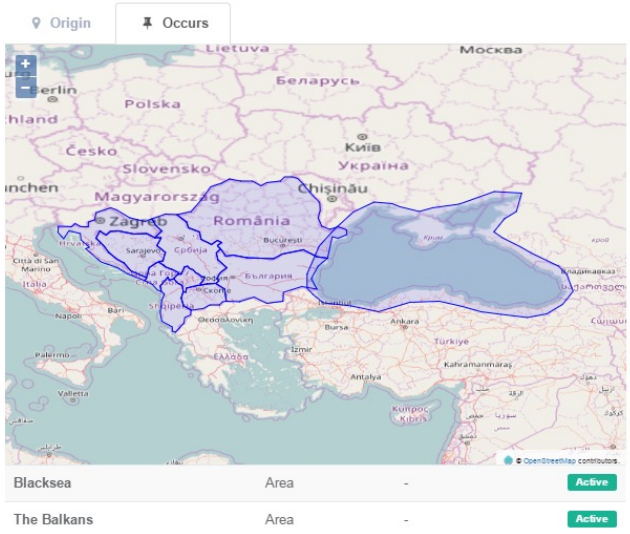

TYPE
SPATIAL
GEOMETRY
Main entity
Will record type/su
will have at least
1 depiction
TYPE_STAMP
TYPE_DECORATION
STAMP
Controlled list
DECORATION

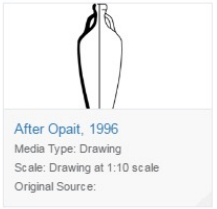
Database design

The database is designed to:

- Hold images, shape models and descriptive data from the comparative collections
- Allow the recognition technologies developed to be applied
- Incorporate data from users

- Database capable of holding spatial geometries (polygon and point)
- Principally uses country (Geonames), but also Pleiades for ancient placenames and Getty TGN for particular places.





Multilingual vocabularies

- Allows mapping of concepts rather than terms by archaeologists
- Different recording traditions may not only use different words, but concepts may only be mapped at different levels of granularity.
- Concepts are mapped to the Getty AAT as a ‘neutral spine’ to allow interoperability with other resources.

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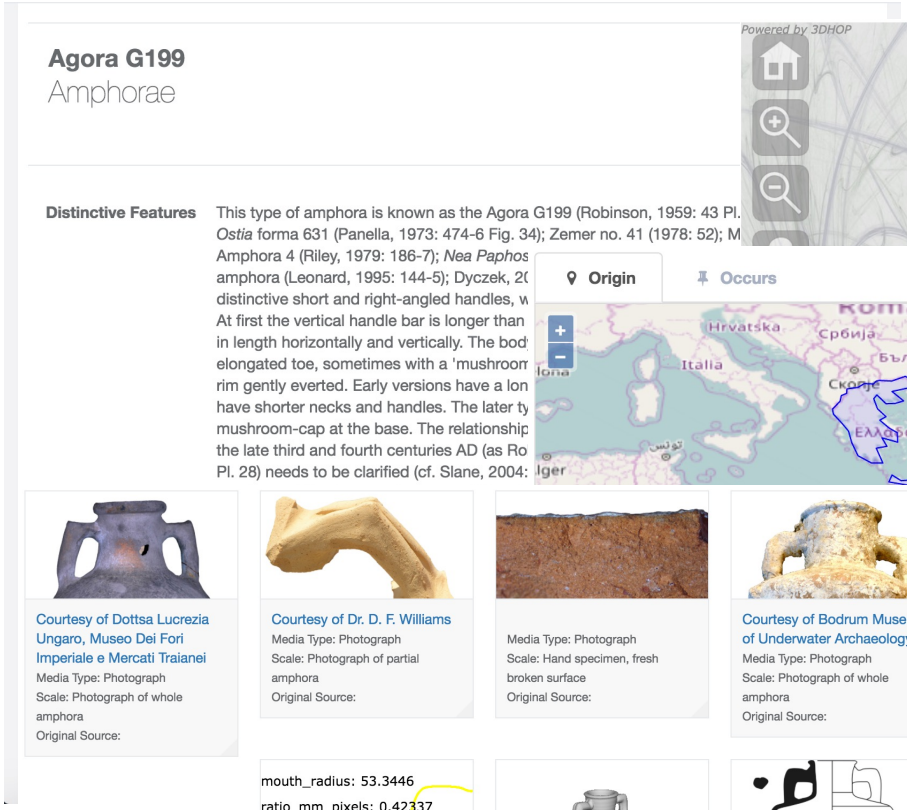
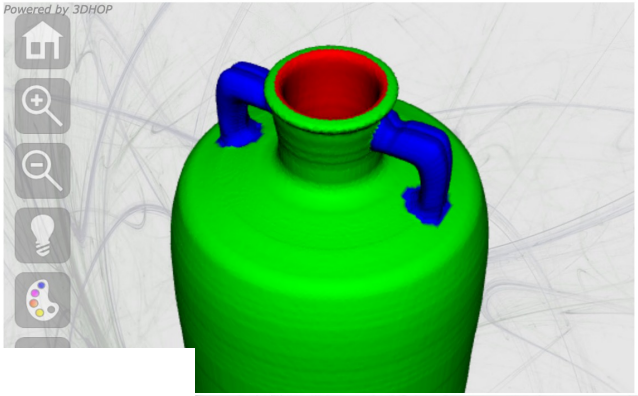
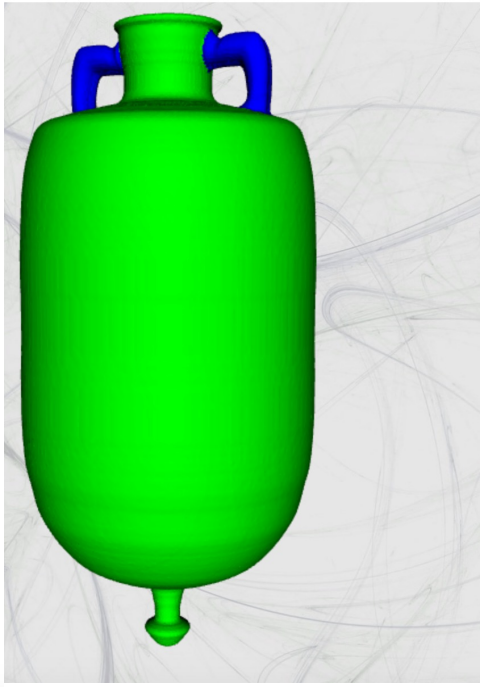
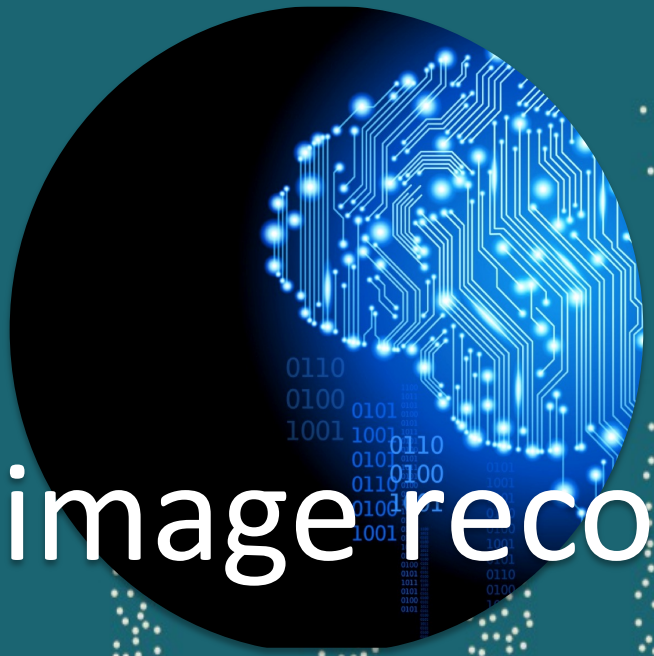
Database implementation









[image recognition]

DEEP LEARNING

[appearance and shape based similarity search and retrieval]

Appearance based recognition

Decoration

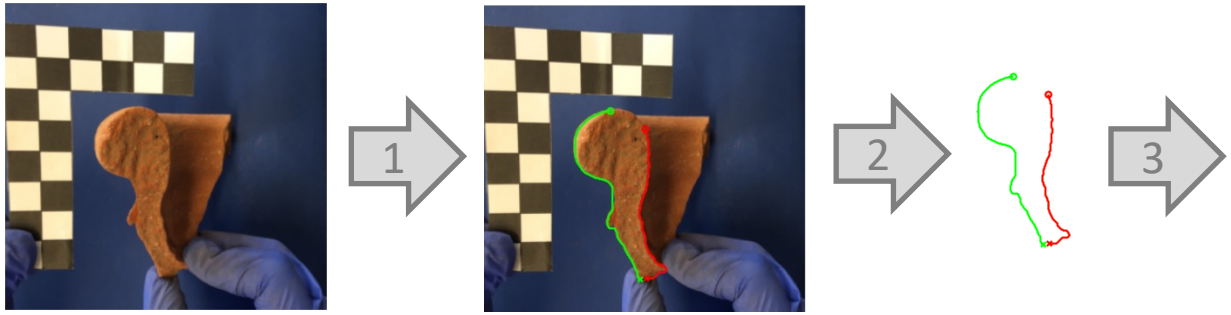



Stamps



Shape based recognition

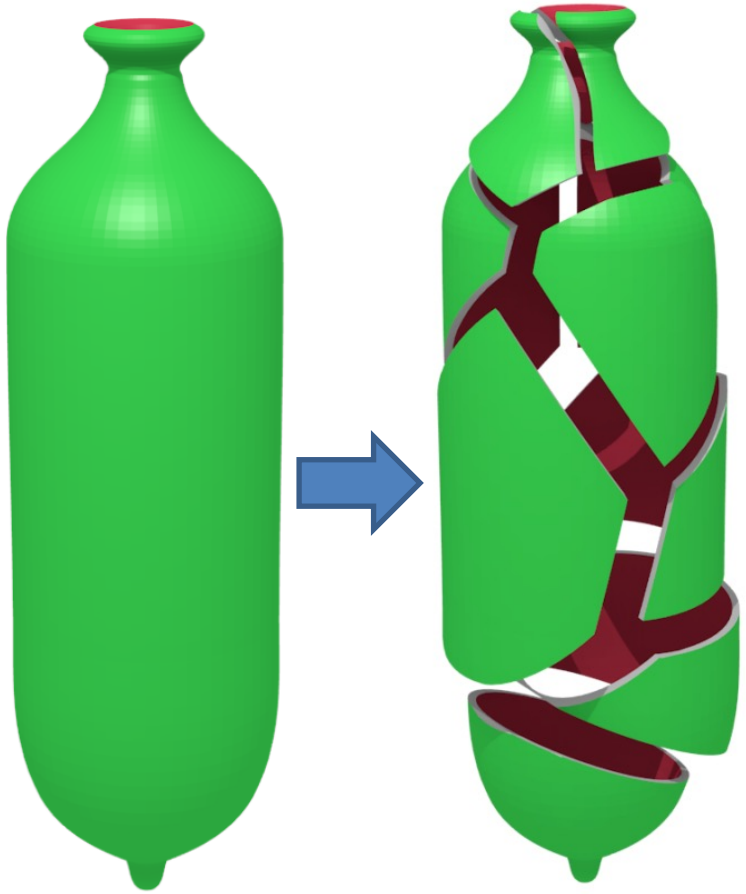
- Following discussion with pottery specialists, a methodology was defined on how the data should be classified



1. The user annotates a profile on a picture
2. The shape is extracted from the annotation
3. This shape is used for finding similar profiles, and ranking them by relevance

The main steps for building the shape-based system are:

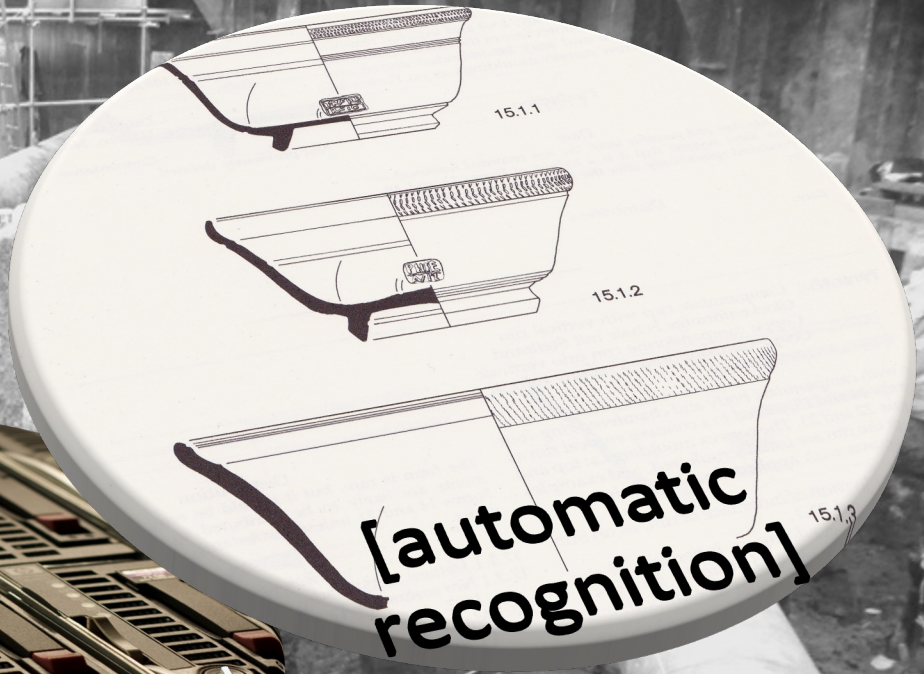
- Extract pottery profiles from the catalogues
- Reconstruct 3D models of the pottery from the profiles
- Generate a database of synthetic sherds for each class
- Extract the fracture shapes from the sherds
- Train the neural-network to learn how to classify the sherds by their fractures



[ArchAIDE System]

https://www.flickr.com/photos/wwarby/

[workflow]



https://www.flickr.com/photos/londonmatt/

Genere 34. Fascia con bleu graffito. 38
Il genere 34 è detto fascia "con bleu graffito" poiché essa si incentra sulla realizzazione di una parte pienamente campita

Genere 40. Motivi vegetali della "famiglia bleu" 34
Alla prima fase produttiva della "famiglia bleu" appartiene il decoro già definito da Galeazzo Cora "a forma di mezzaluna

Genere 9. Floreale Bleu 31
L'uso dell'ossido di cobalto arricchito da piombo, artificio usato per far rigonfiare il pigmento bleu, sino a fargli assumere un rilievo

Genere 18. Fasce Geometriche 31
La tipologia che abbiamo definito "fascia a triangoli" ci fornisce uno dei casi più emblematici di trasformazione e costruzione di

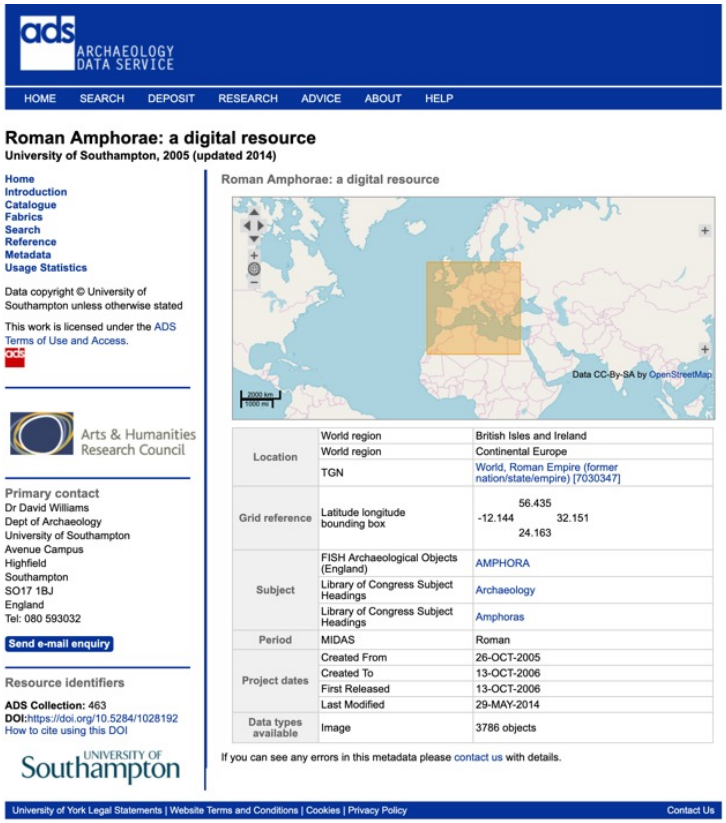
Genere 17. Derivati dell'imitazione della foglia valenzana. 29
Il Genere 17 è caratterizzato dal motivo che echeggia la foglia d'edera, la quale si sviluppa come elemento costitutivo di decoro

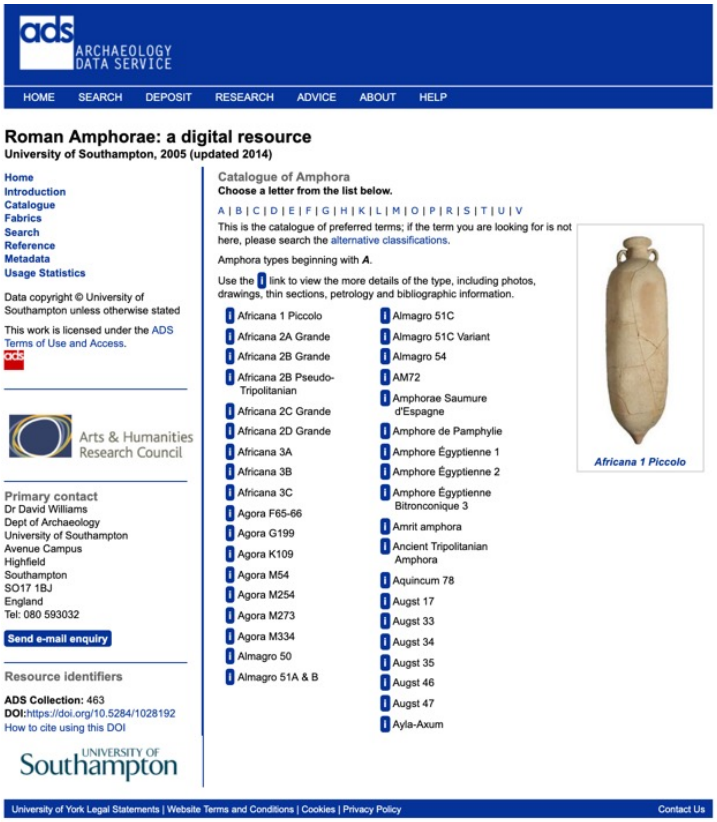
Nothing good? Tap to add manually.

[Data preservation]

https://www.flickr.com/photos/129657698@N02/

Roman Amphorae: a digital resource





Roman Amphorae: a digital resource

University of Southampton, 2005 (updated 2014)

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Arts & Humanities Research Council

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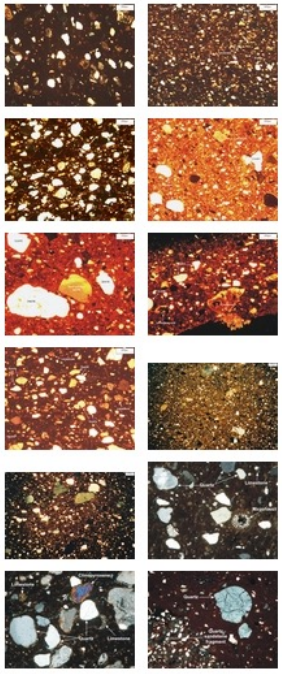
Resource identifiers

Africana 1 Piccolo

next amphora type

details | characteristics | pictures | drawings | petrology | specimens | bibliography

Click on the image to see larger versions of each image.



Comments specific to this amphora type
Equivalent to: NAF AM 1 of the National Roman Fabric Reference Collection (Tomber & Dore, 1998: 101)

Tunisian fabric

Visual characteristics

The normal Tunisian fabric is brick red or orange in section (2.5YR 6/6), hard fired, granular, and the external surface has a white or cream (10YR 8/3) skin resulting from the use of saline water. This is often smoothed with quite carefully smoothed (so-called 'steccature' : vertical tooling marks on the body). Material from the Carthage region is similar to central Tunisian products but is generally red in colour and lacks the visible inclusions of limestone or white reaction rims which are a common feature of the latter. It is very difficult to distinguish between known kiln products. The only ones that are easily recognisable come from Sullecthum (Salakta) and are characterised by a grey and red fracture, a myriad of small white inclusions, and a rough, grey external surface.

Petrology

North African fabrics are rather generic and poorly distinguishable from each other. In general, the inclusions are composed mainly of quartz, whose aeolian features are evident in the coarser grains (some hundred microns to more than 1 mm in size), that show a rounded shape and opaque surfaces. Sometimes the quartz is associated with variable amounts of calcareous microfossils and limestone fragments and other occasional metamorphic or volcanic components. However, the study of several Tunisian productions (mainly based on kiln wasters) has revealed the existence of some variability in the textural characteristics and the accessory petrographic components of the fabrics that allow them to be identified at the sites to which they were imported (Bonifay et alli, 2002; Capelli, 2005). 1) Sidi Zahruni The matrix is iron-rich and homogeneously oxidized. The (natural) temper is moderately to poorly-sorted. The lower granulometric fraction (< 0.15 mm) is

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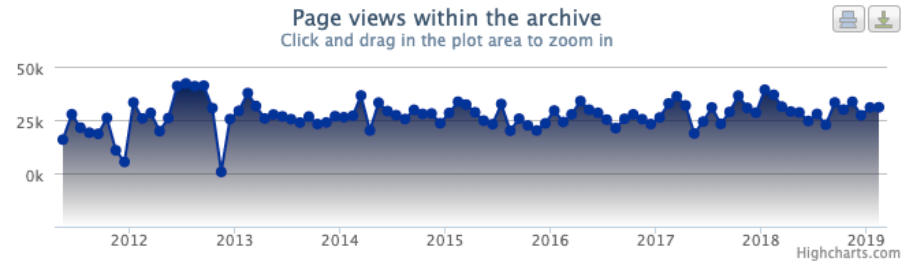
Resource identifiers

ADS Collection: 463
DOI:https://doi.org/10.5284/1028192
How to cite using this DOI

UNIVERSITY OF Southampton

A download is a click on a link to something other than a web page, file extensions include: csv, doc, docx, gif, jar, jpg, jpeg, mp3, mp4, mov, odb, odt, pdf, png, ppt, pptx, txt, wav, wma, wmv, wpd, xls, xlsx, xml, zip but this is not an exhaustive list.



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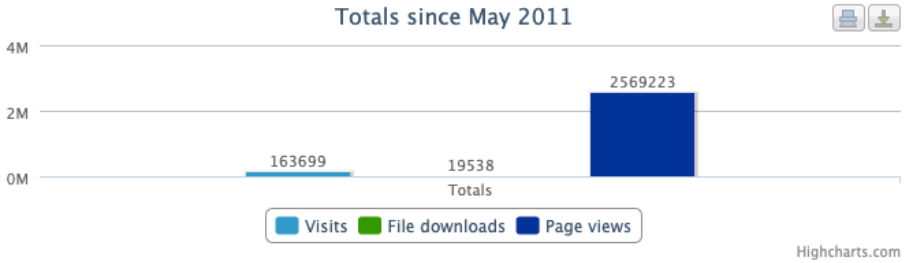

Statistics start from May 2011 but if the values are zero to start with they are not shown. Zero values after the start of use for the archive are shown.

Download figures as CSV file

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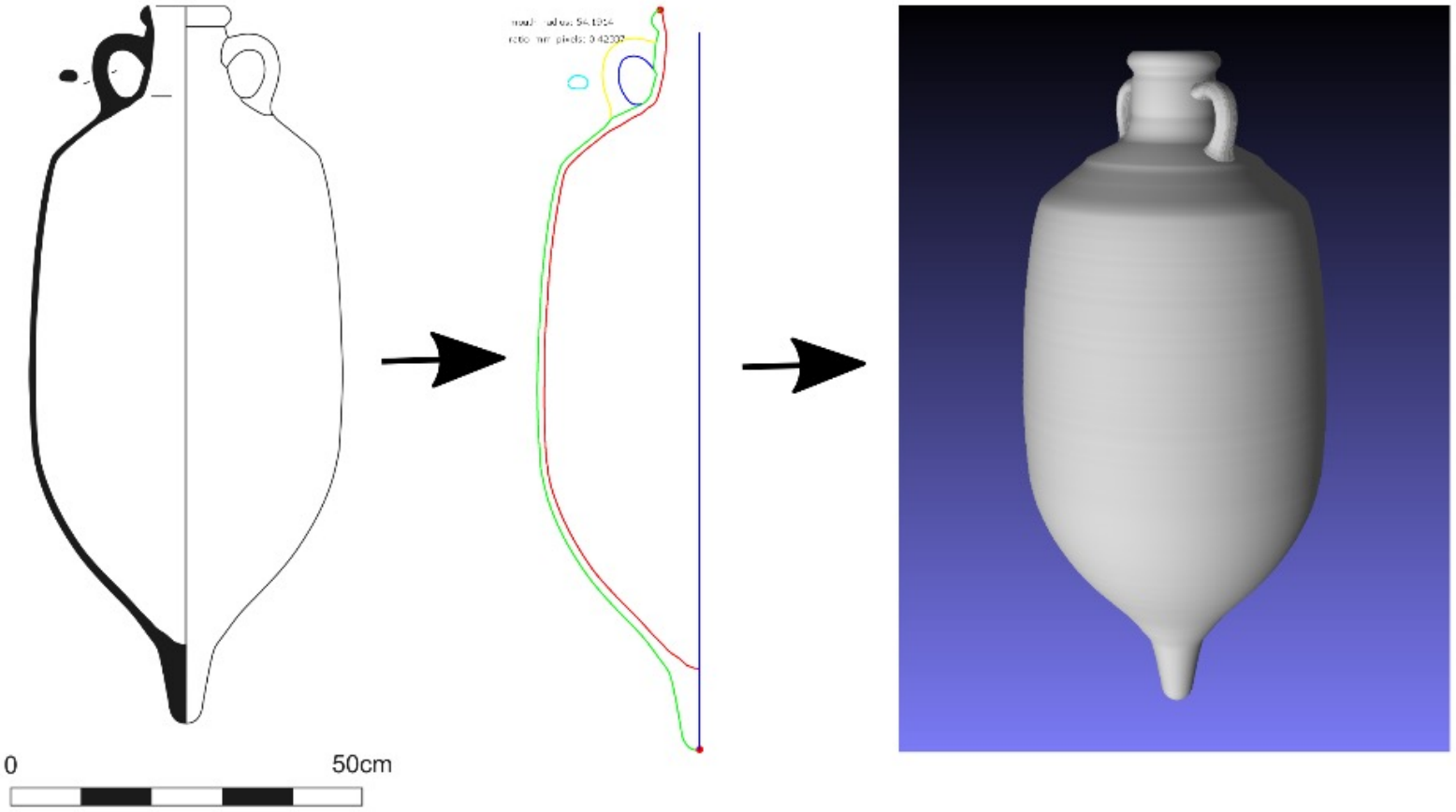

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ARCHAIDE Portal for Publications and Outputs

ARCHAIDE, 2019

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ARCHAEOLOGICAL AUTOMATIC INTERPRETATION AND DOCUMENTATION OF CERAMICS

Introduction

ArchAIDE is a European Union Horizon 2020 research and innovation programme which aims to create a new system for the automatic recognition of archaeological pottery from excavations around the world.

The archaeological partners of the consortium are the MAPPA Lab at the University of Pisa (coordinator) which has a relevant experience in mathematical and digital application in Archaeology, and archaeological communication; the Material Culture and Archaeometry research unit at the University of Barcelona, which is focused on promoting studies of material culture, especially on archaeological ceramics, and archaeometric approaches; the Digital Archaeology Laboratory at the University of Cologne, which manages ARACHNE, a highly structured object database in partnership with the German Archaeological Institute (DAI); and the Archaeology Data Service (ADS) at the University of York, which is the world-leading digital data archive for archaeology. The consortium involves also two private companies carrying out preventive and development-led archaeological investigations: Baraka Arqueólogos S.L., which is experienced in the study of archaeological ceramics, and Elements S.L which is experienced in the application of digital technologies related to ceramic studies. Finally, the consortium's technical ICT partners are the Visual Computing Lab at CNR-ISTI, an institute of Italian CNR devoted to research on Visual Media and Cultural Heritage; the School of Computer Science at Tel Aviv University, which is ranked 20th in the Shanghai ranking of all Computer Science departments in the world; and the private software company, Inera s.r.l, which has experience in the field of protocols and web apps.

Every day, archaeologists from around the world are working to discover and tell stories around objects from the past, investing considerable time, effort and funding to identify and characterise individual finds. Pottery is of fundamental importance for the comprehension and dating of archaeological contexts, and for understanding the dynamics of production, trade flows, and social interactions. Today, this characterisation and classification of ceramics is carried out manually, through the expertise of specialists and the use of analogue catalogues held in archives and libraries. The goal of ArchAIDE is to optimise and economise this process, making knowledge accessible wherever archaeologists are working.

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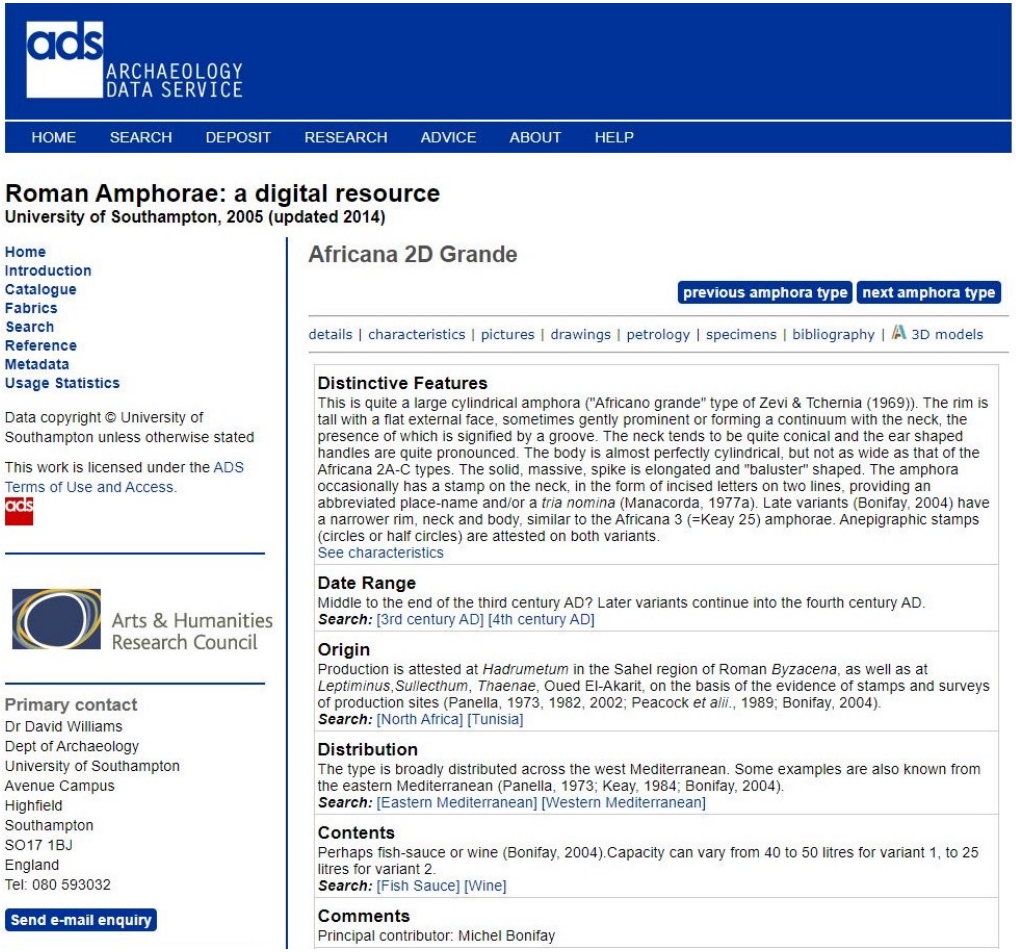

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Roman Amphorae: a digital resource
University of Southampton, 2005 (updated 2014)

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Africana 2D Grande

previous amphora type | next amphora type

details | characteristics | pictures | drawings | petrology | specimens | bibliography | 3D models

Distinctive Features
This is quite a large cylindrical amphora ("Africano grande" type of Zevi & Tchernia (1969)). The rim is tall with a flat external face, sometimes gently prominent or forming a continuum with the neck, the presence of which is signified by a groove. The neck tends to be quite conical and the ear shaped handles are quite pronounced. The body is almost perfectly cylindrical, but not as wide as that of the Africana 2A-C types. The solid, massive, spike is elongated and "baluster" shaped. The amphora occasionally has a stamp on the neck, in the form of incised letters on two lines, providing an abbreviated place-name and/or a *tria nomina* (Manacorda, 1977a). Late variants (Bonifay, 2004) have a narrower rim, neck and body, similar to the Africana 3 (=Keay 25) amphorae. Anepigraphic stamps (circles or half circles) are attested on both variants.
See characteristics

Date Range
Middle to the end of the third century AD? Later variants continue into the fourth century AD.
Search: [3rd century AD] [4th century AD]

Origin
Production is attested at *Hadrumetum* in the Sahel region of Roman *Byzacena*, as well as at *Leptiminus*,*Sullecthum*, *Thaenae*, Oued El-Akarit, on the basis of the evidence of stamps and surveys of production sites (Panella, 1973, 1982, 2002; Peacock *et alii*., 1989; Bonifay, 2004).
Search: [North Africa] [Tunisia]

Distribution
The type is broadly distributed across the west Mediterranean. Some examples are also known from the eastern Mediterranean (Panella, 1973; Keay, 1984; Bonifay, 2004).
Search: [Eastern Mediterranean] [Western Mediterranean]

Contents
Perhaps fish-sauce or wine (Bonifay, 2004).Capacity can vary from 40 to 50 litres for variant 1, to 25 litres for variant 2.
Search: [Fish Sauce] [Wine]

Comments
Principal contributor: Michel Bonifay

License:

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Resource identifiers

ADS Collection: 3369
DOI:https://doi.org/10.5284/1050896
How to cite using this DOI

Choose a letter from the list below:
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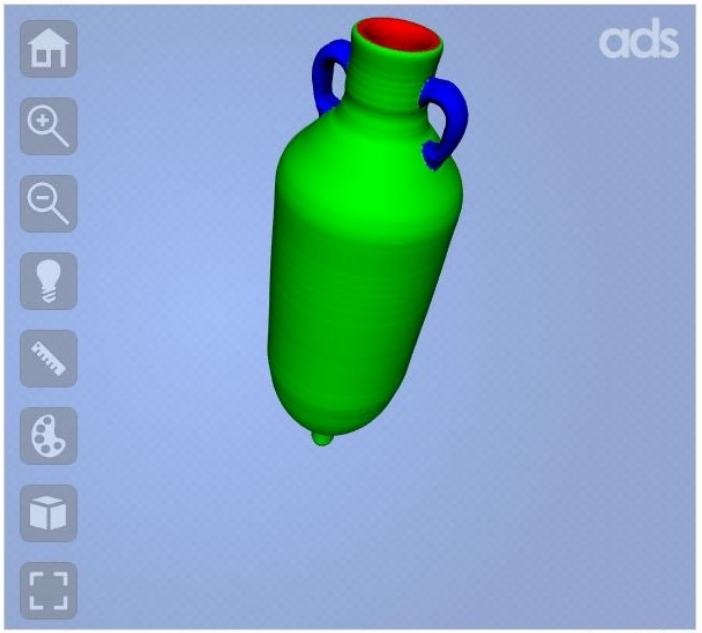
Africana 2D Grande DR148

- View full record in: *Roman Amphorae: a digital resource*
- Return to type: Africana 2D Grande

Preview



Powered by 3DHOP

3D Model

3D model metadata (all files)	CSV	245 Kb
Africana_2D_Grande_DR148	OBJ	14 Mb

SVG Profile

Vector metadata (all files)	CSV	96 Kb

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internet archaeology

Developing the ArchAIDE Application: A digital workflow for identifying, organising and sharing archaeological pottery using automated image recognition

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Current ArchAIDE Experimentation

- Critical aspects of the ArchAIDE framework now obsolete (TensorFlow1.x with ResNet101) making it difficult to compile and change, as many libraries have now been abandoned.
- Updated and enhanced ArchAIDE using PyTorch development framework. PyTorch allows better (and dynamic) control of graphs and nodes and easier code management, which can be rewritten more easily due to its modular architecture.
- Also experimented with the neural network; interesting results obtained using Google Inception_v3, increasing accuracy on the validation set from about 65% with ResNet101 to about 80%.
- ArchAIDE is a rigid system which can only recognise the ceramic classes for which it has been trained, so experiments have also been undertaken using Continual Learning (Lomonaco-2021).

Lessons Learned

- Comparative data must be derived from a variety of sources, each with different advantages and restrictions.
- Tools to help digitise the authoritative paper catalogues were developed, but ArchAIDE doesn't hold the copyright. Showing publishers how their content can be actively reused can open discussion about the importance of making their resources available in new ways, furthering discourse around making research data open and accessible.
- Important to have decision points in the workflow so that humans can validate the decisions made by the algorithm and produce data research data they can trust.
- We must create a community of practitioners working together to create and share training data, and develop best practice around documentation optimised for use by AI applications.

COST Action
Managing Artificial Intelligence in Archaeology (MAIA)

MAIA will create a community of archaeologists, digital archaeologists and computer scientists who will work together to develop a shared understanding of AI applications in archaeology.

This will include meetings, workshops and short-term scientific missions, bringing together researchers who wish to create or use digital collections and training data. Key to this will be training opportunities in the field for documenting archaeological resources optimised for AI research allowing **researchers to work across borders to understand how to create comparative and training data.**

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[Thank you for your attention]

www.archaide.eu

ARCHAIDE
ARCHAEOLOGICAL AUTOMATIC INTERPRETATION AND DOCUMENTATION OF CERAMICS

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