

# ARCHAIDE

ARCHAEOLOGICAL  
AUTOMATIC INTERPRETATION  
AND DOCUMENTATION  
OF CERAMICS

**Holly Wright**

Archaeology Data Service  
University of York

**Arch-I-Scan Workshop**

**21 April, 2023**

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and innovation programme under grant  
agreement No 693548



# ARCHAIDE

ARCHAEOLOGICAL  
AUTOMATIC INTERPRETATION  
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OF CERAMICS

**Funded by EU H2020**

Research and Innovation Action

Duration: **36 months**

June 2016 to May 2019

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cooking



storage



illumination



eating and drinking



transportation



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



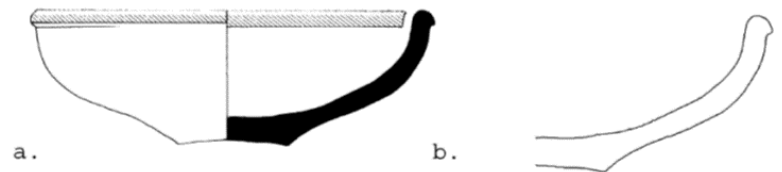
Analysis of sherds:

(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**)

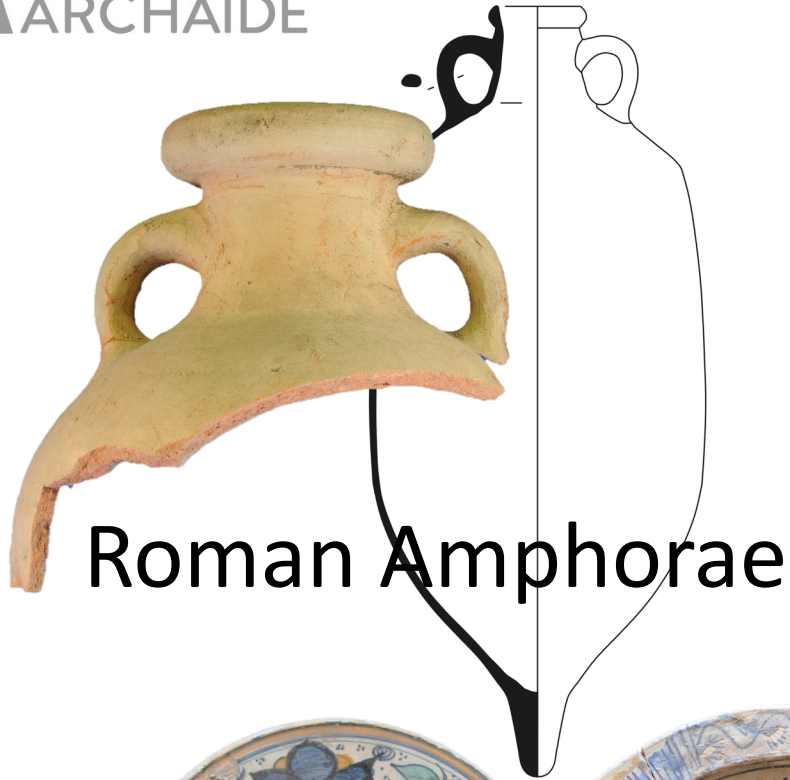


**ArchAIDE** developed a prototype app for tablets and smartphones to speed and support the ceramic classification and interpretation work of archaeologists, during both fieldwork and post-excavation analysis.

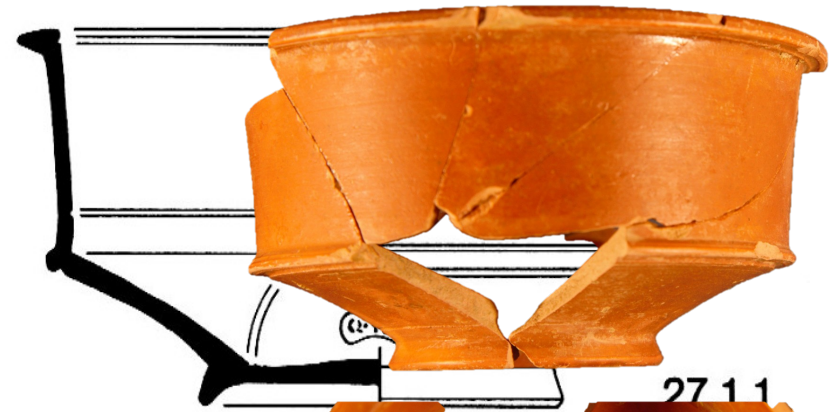


We wanted to speed tasks for experienced archaeologists and pottery specialists and help new researchers learn more about pottery identification, using a modern **computer-aided approach**, but keep the *overall methodologies* used by archaeologists to ensure the app complements existing workflows.





Roman Amphorae

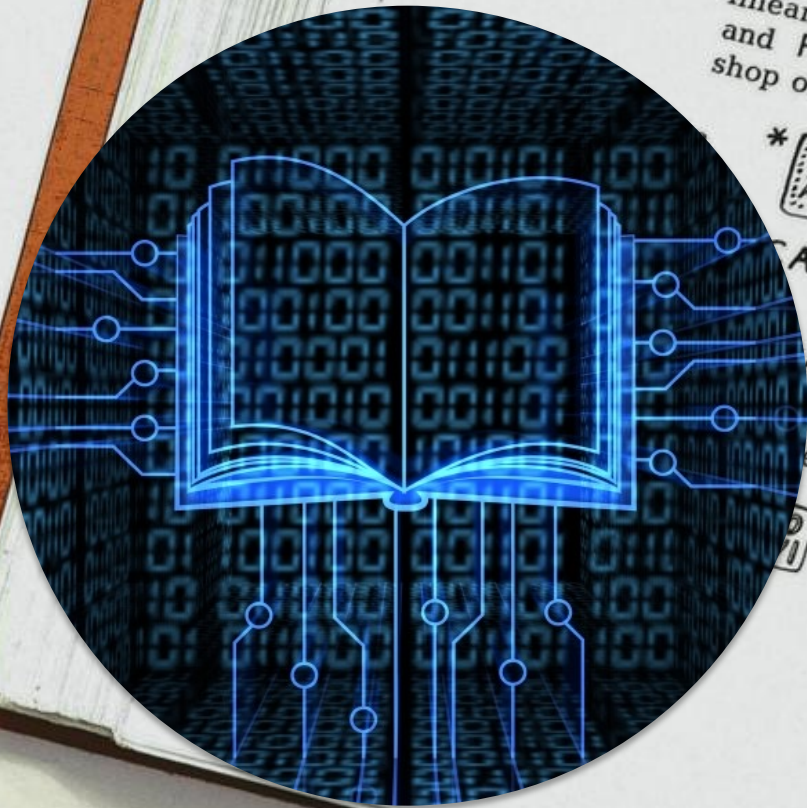


Terra Sigillata



Majolica

# [catalogues]



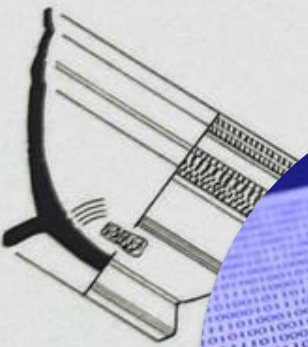
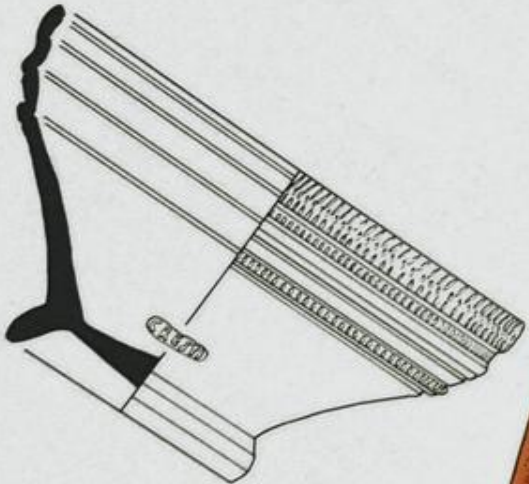
Alexandria (Mu 2  
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stamp of a Gaulish  
10010 455, VII 13  
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linear stamps such a  
and PRI· VIII were  
shop of Naevius.



CARBON

NÆVI

Berlin Altes Mu  
exx.



25.1.1



# [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

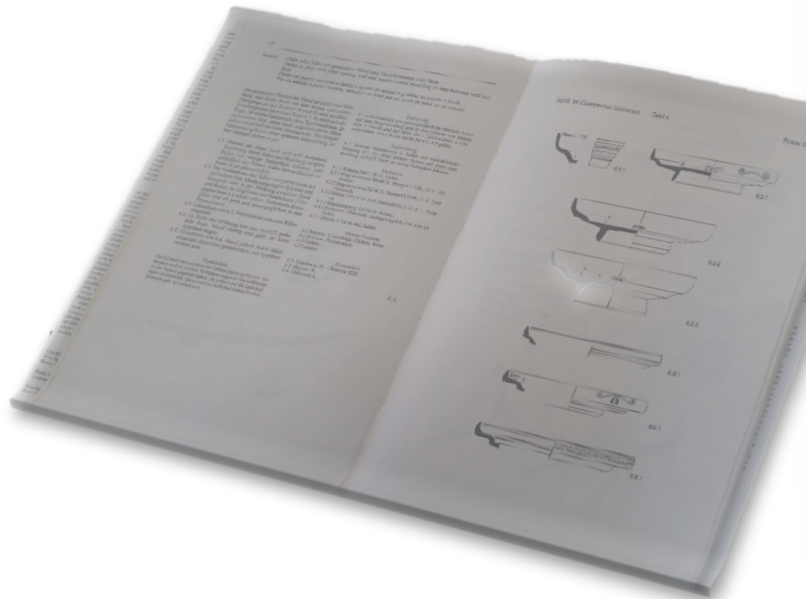


Fig. 37. Frammento di maiolica a tutto di produzione egiziana (l'elenco: Londra, collezione Keir

ceramica medievale dei paesi islamici orientali, mediorientali e nordafricani è stata più volte sintetizzata dagli studiosi, e quindi ne hanno dato interpretazioni diverse. Il Grube nel suo studio sulla ceramica Keir, riconsiderando il significato simile, come si trattava indifferenziate come "ceramica di pavone" (intendendo ovviamente riferirsi all'"occhio" della medesima), e come elemento connesso con la simbologia stellare, ritraeva lo stesso segno circolare puntinato nelle illustrazioni dei libri astronomici<sup>14</sup>.

Il nostro avviso (ma la cosa non è di per sé certo in contrasto con le interpretazioni precedenti, visto il modesto significato simbolico attribuito sia alla penna del pavone che, ovviamente, alle immagini astrali) questa figura elementare che si diffonde su tutto può essere intesa come il famoso "occhio di Allah". Immagine iconica, cioè, dell'onnipresenza e dell'onniscienza divina sul mondo. Sappiamo bene come l'"occhio di Allah" — così come la "mano di Fatima" — rappresenti non poca parte dell'universo simbolico islamico<sup>15</sup> e, come tale, accompagni la vita del fedele nell'Islam, che, trasformandolo in un amuleto (quasi sempre vitreo), ancor oggi lo indossa come pendaglio di collana o lo apprende nella propria casa a presidio delle sue dimostre.

Che i nostri "cerchietti" rappresentino proprio la stilizzazione di un occhio e del resto ben riconoscibile dalla puntinatura che si al loro interno — spesso anche collocati in posizione centrale — e, addirittura, dalla presenza di certe rigature, ottenute mediante una serie di segmenti che si dipanano dalla circonferenza per indirizzarsi verso il centro, proprio come se si intendesse suggerire attraverso di esse la convessità di una pupilla (fig. 37).

INFLUENZE E MODELLI

I ceramisti "fiorentini" e montepulpani, avviando sul finire del XIV secolo la produzione della "zaffera" — e probabilmente, in precedenza, anche in certe mature realizzazioni in "maiolica arcaica bianca" — finirono quindi per assimilare, attraverso l'imitazione, un linguaggio formale ben strutturato, che poteva solo parzialmente essere modificato ed adattato, mediante l'inserimento di figurazioni "pennellate" più o meno al loro orizzonte culturale. In tal modo essi vennero così anche a riprodurre inconsapevolmente una simbologia che, per i suoi connotati eripici, non poteva non risultare loro incomprensibile nel suo genuino significato religioso.

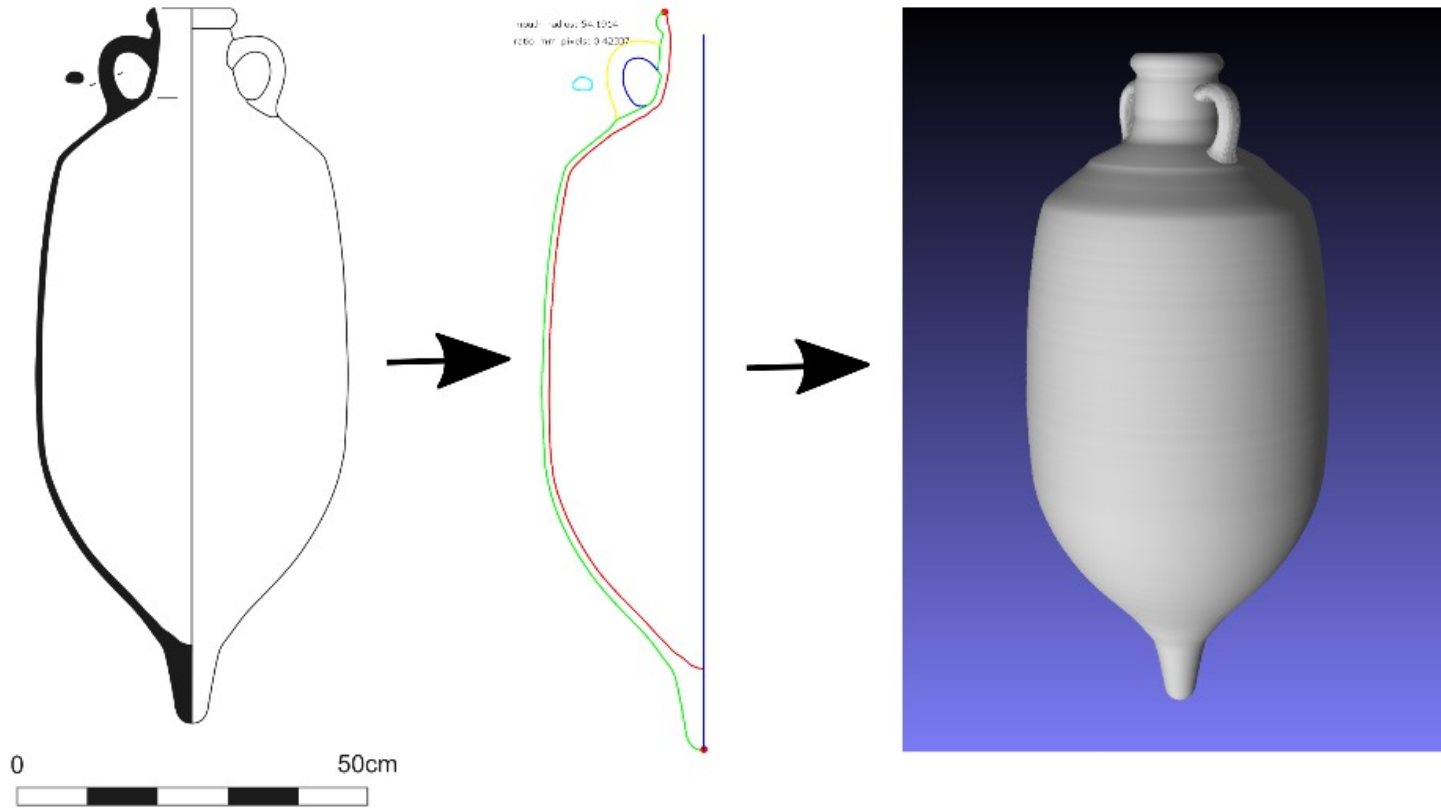
Questi segni assommano infatti per i nostri pittori solo una valenza formale. Già questo, però, non era poca cosa; condividere, infatti, l'idea che l'efficacia della devozione potesse essere garantita da un sistema che di fatto finiva per negare le finalità realistiche della rappresentazione, costituisce di per sé un fenomeno di tutto rilievo, ed una tale importanza diverse ancora maggiore, se si riflette per quanto tempo la scelta di una simile simbiosi diventava abbia improntato il lavoro dei ceramisti italiani.

Che tale ricerca formale sia venuta di fatto a contrariare ogni forma di possibile rappresentazione realistica di quei soggetti, ai quali pare si veniva ad attribuire un ruolo principale nella devozione, risulta da due distinti fattori. Il primo (e, nella sostanza, il meno importante), è di tipo diretto, e risiede nell'immagine irreal che così si veniva ad ottenere dagli stessi, favorevoli attraverso dai già citati "cerchietti", ed anche, in una fase pressoché contemporanea, dagli stessi motivi "secondari" (elementi grafici e vegetali stilizzati) della figurazione. Il secondo — certo di

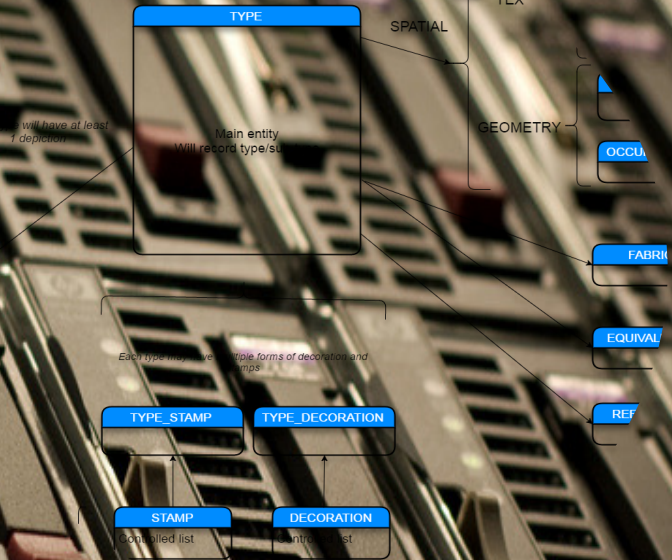




# From drawings digitisation to 3D models



# [database]



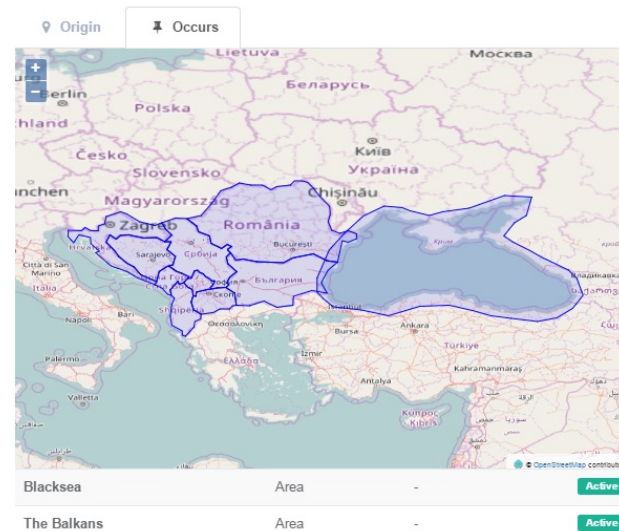
# Database design

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.



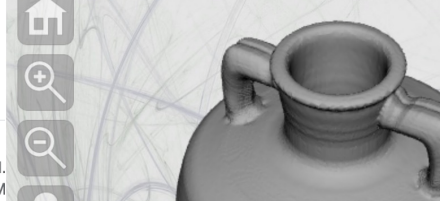
# Database implementation

### Agora G199 Amphorae

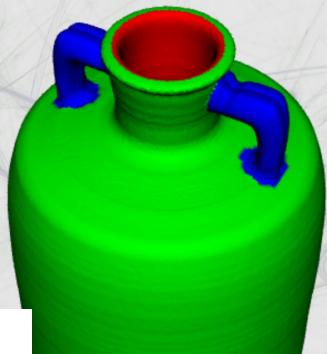
#### Distinctive Features

This type of amphora is known as the Agora G199 (Robinson, 1959: 43 Pl. Ostia forma 631 (Panella, 1973: 474-6 Fig. 34); Zemer no. 41 (1978: 52); M Amphora 4 (Riley, 1979: 186-7); *Nea Paphos* amphora (Leonard, 1995: 144-5); Dyczek, 2010: 20). It is characterized by distinctive short and right-angled handles, with the vertical handle bar longer than the horizontal one. At first the vertical handle bar is longer than the horizontal one, but later it becomes elongated. The body is elongated and the toe is sometimes with a 'mushroom' rim gently everted. Early versions have a long neck, but later they have shorter necks. The relationship between the late third and fourth centuries AD (as Robinson, 1959: Pl. 28) needs to be clarified (cf. Slane, 2004: 100).

Powered by 3DHOP



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Origin Occurs



Courtesy of Dottsa Lucrezia Ungaro, Museo Dei Fori Imperiali e Mercati Traianei  
Media Type: Photograph  
Scale: Photograph of whole amphora  
Original Source:

Courtesy of Dr. D. F. Williams  
Media Type: Photograph  
Scale: Photograph of partial amphora  
Original Source:

Media Type: Photograph  
Scale: Hand specimen, fresh broken surface  
Original Source:

Courtesy of Bodrum Museum of Underwater Archaeology  
Media Type: Photograph  
Scale: Photograph of whole amphora  
Original Source:

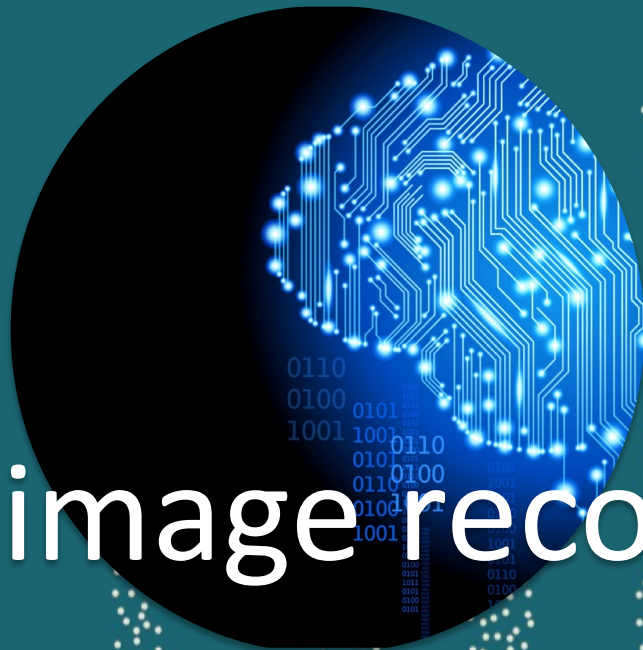
mouth\_radius: 53.3446  
ratio\_mm\_pixels: 0.42337

Profiles\_SVG\_DR167  
Media Type: Drawing  
Scale:  
Original Source:

3D\_Model\_DR167  
Media Type: 3D model  
Scale:  
Original Source:

After Sciallano & Sibella, 1991  
Media Type: Drawing  
Scale: Drawing at 1:10 scale  
Original Source:

- 199 fabric Active
- Active
- Active
- Active



[image recognition]



DEEP LEARNING

[appearance and shape based similarity  
search and retrieval ]



# Appearance based recognition

## Decoration

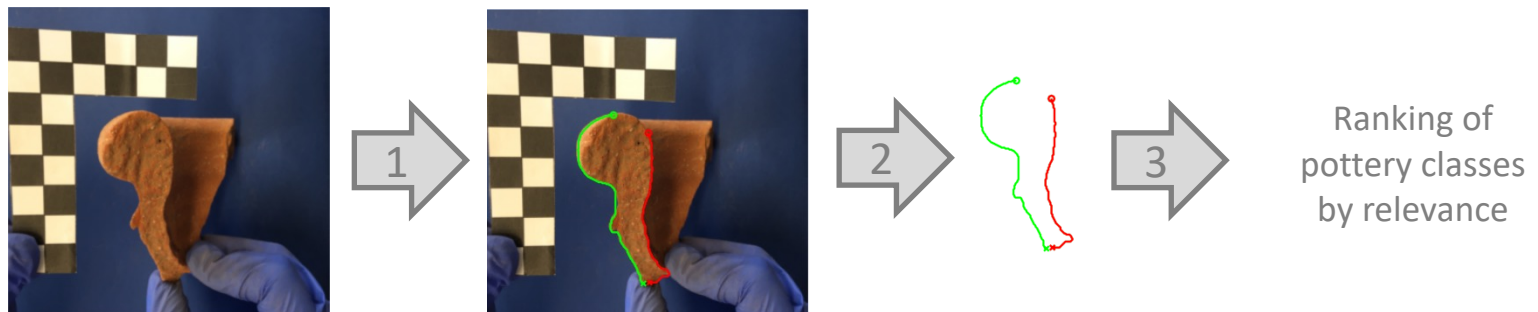


## Stamps



# Shape based recognition

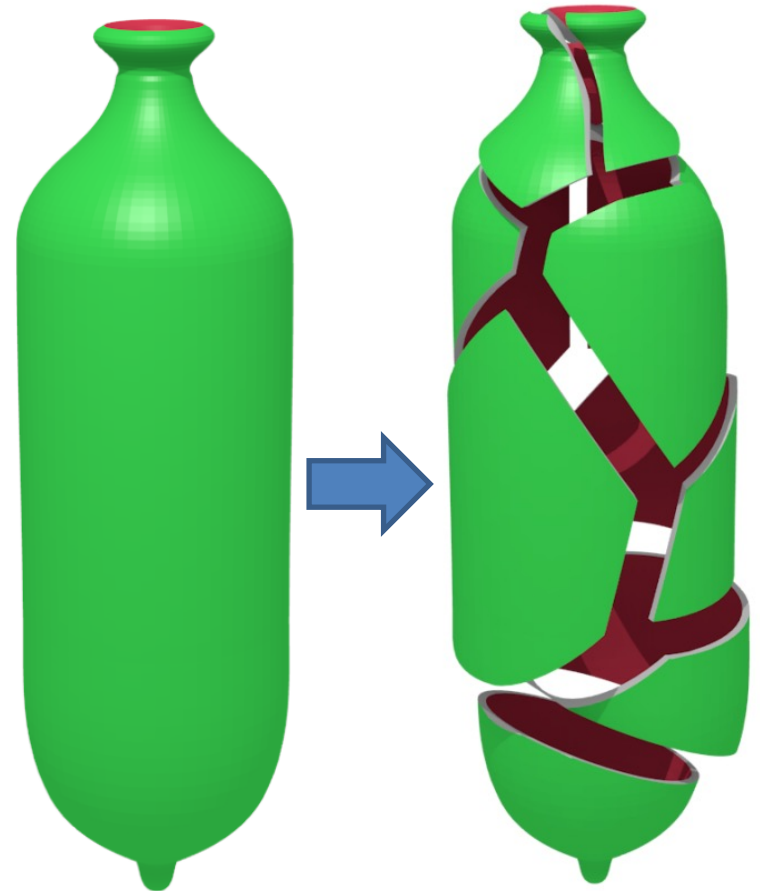
- Following discussion with pottery specialists, a methodology was defined on how the data should be classified



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



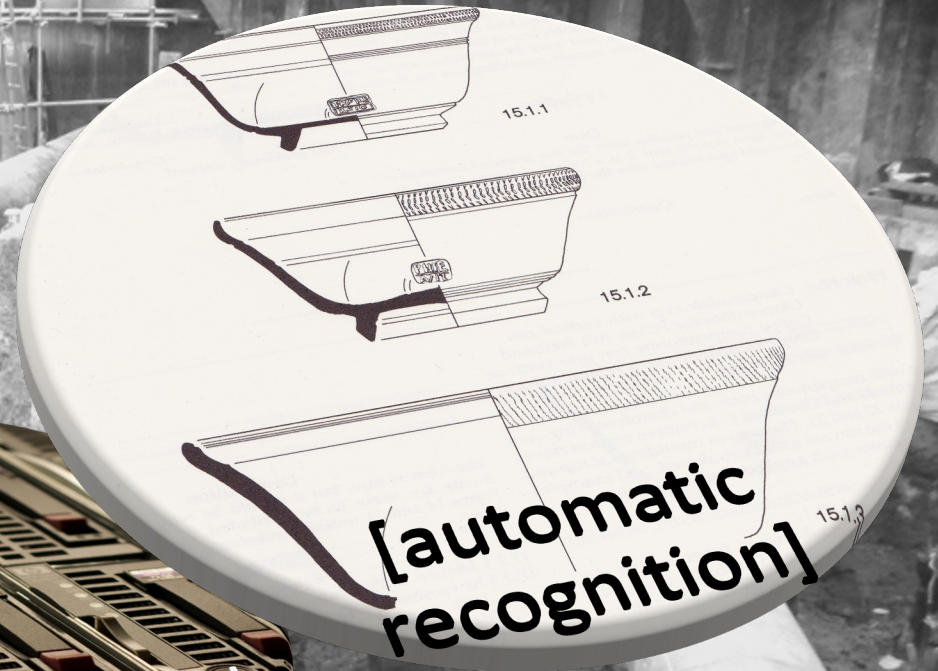




# [ArchAIDE System]



# [workflow]







**Genere 34. Fascia con bleu graffito.**

Il genere 34 è detto fascia "con bleu graffito" poiché essa si incentra sulla realizzazione di una parte pienamente campta

38



**Genere 40. Motivi vegetali della "famiglia bleu"**

Alla prima fase produttiva della "famiglia bleu" appartiene il decoro già definito da Galeazzo Cora "a forma di mezzaluna

34



**Genere 9. Floreale Bleu**

L'uso dell'ossido di cobalto arricchito da piombo, artificio usato per far risonare il diamante bleu. sino a farli assumere un rilievo

31



**Genere 18. Fasce Geometriche**

La tipologia che abbiamo definito "fascia a triangoli" ci fornisce uno dei casi più emblematici di trasformazione e costruzione di

31



**Genere 17. Derivati dell'imitazione della foglia valenzana.**

Il Genere 17 è caratterizzato dal motivo che echeggia la foglia d'edera. la quale si sviluppa come elemento costitutivo di decoro

29

Nothing good? Tap to add manually.





[Data preservation]

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Location	World region World region TGN	British Isles and Ireland Continental Europe World, Roman Empire (former nation/state/empire) [7030347]
Grid reference	Latitude longitude bounding box	56.435 32.151 -12.144 24.163
Subject	FISH Archaeological Objects (England) Library of Congress Subject Headings Library of Congress Subject Headings	AMPHORA Archaeology Amphoras
Period	MIDAS	Roman
Project dates	Created From	26-OCT-2005
	Created To	13-OCT-2006
	First Released	13-OCT-2006
	Last Modified	29-MAY-2014
Data types available	Image	3786 objects

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Primary contact  
 Dr David Williams  
 Dept of Archaeology  
 University of Southampton  
 Avenue Campus  
 Highfield  
 Southampton  
 SO17 1BJ  
 England  
 Tel: 080 593032

[Send e-mail enquiry](#)

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Catalogue of Amphora  
 Choose a letter from the list below.

A | B | C | D | E | F | G | H | I | J | K | L | M | O | P | R | S | T | U | V


This is the catalogue of preferred terms; if the term you are looking for is not here, please search the alternative classifications.

Amphora types beginning with A.

Use the [i](#) link to view the more details of the type, including photos, drawings, thin sections, petrology and bibliographic information.

- [i](#) Africana 1 Piccolo
- [i](#) Africana 2A Grande
- [i](#) Africana 2B Grande
- [i](#) Africana 2B Pseudo-Tripolitanian
- [i](#) Africana 2C Grande
- [i](#) Africana 2D Grande
- [i](#) Africana 3A
- [i](#) Africana 3B
- [i](#) Africana 3C
- [i](#) Agora F65-66
- [i](#) Agora G199
- [i](#) Agora K109
- [i](#) Agora M54
- [i](#) Agora M254
- [i](#) Agora M273
- [i](#) Agora M334
- [i](#) Agora M50
- [i](#) Almagro 51A & B

- [i](#) Almagro 51C
- [i](#) Almagro 51C Variant
- [i](#) Almagro 54
- [i](#) AM72
- [i](#) Amphorae Saumure d'Espagne
- [i](#) Amphore de Pamphylie
- [i](#) Amphore Égyptienne 1
- [i](#) Amphore Égyptienne 2
- [i](#) Amphore Égyptienne Bitronconique 3
- [i](#) Amrit amphora
- [i](#) Ancient Tripolitanian Amphora
- [i](#) Aquincum 78
- [i](#) August 17
- [i](#) August 33
- [i](#) August 34
- [i](#) August 35
- [i](#) August 46
- [i](#) August 47
- [i](#) Ayla-Axum



*Africana 1 Piccolo*

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Primary contact  
 Dr David Williams  
 Dept of Archaeology  
 University of Southampton  
 Avenue Campus  
 Highfield  
 Southampton  
 SO17 1BJ  
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#### Primary contact

Dr David Williams  
Dept of Archaeology  
University of Southampton  
Avenue Campus  
Highfield  
Southampton  
SO17 1BJ  
England  
Tel: 080 593032

[Send e-mail enquiry](#)

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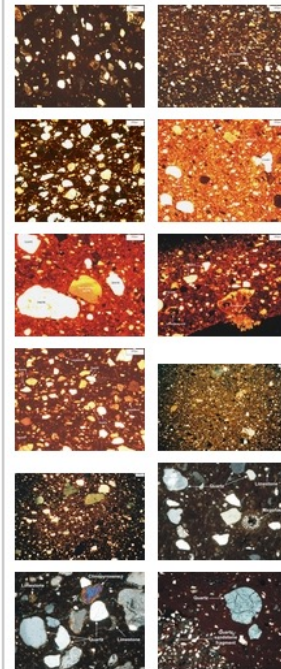
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### Africana 1 Piccolo

[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 Sullectum (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 alii, 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



Dr David Williams  
 Dept of Archaeology  
 University of Southampton  
 Avenue Campus  
 Highfield  
 Southampton  
 SO17 1BJ  
 England  
 Tel: 080 593032

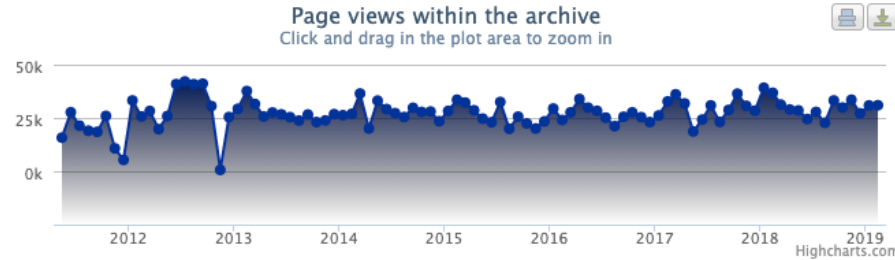
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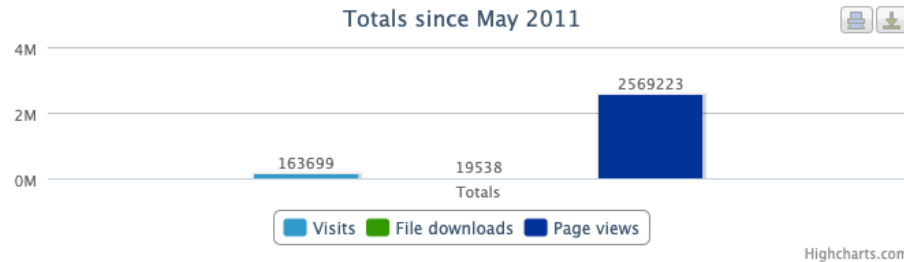
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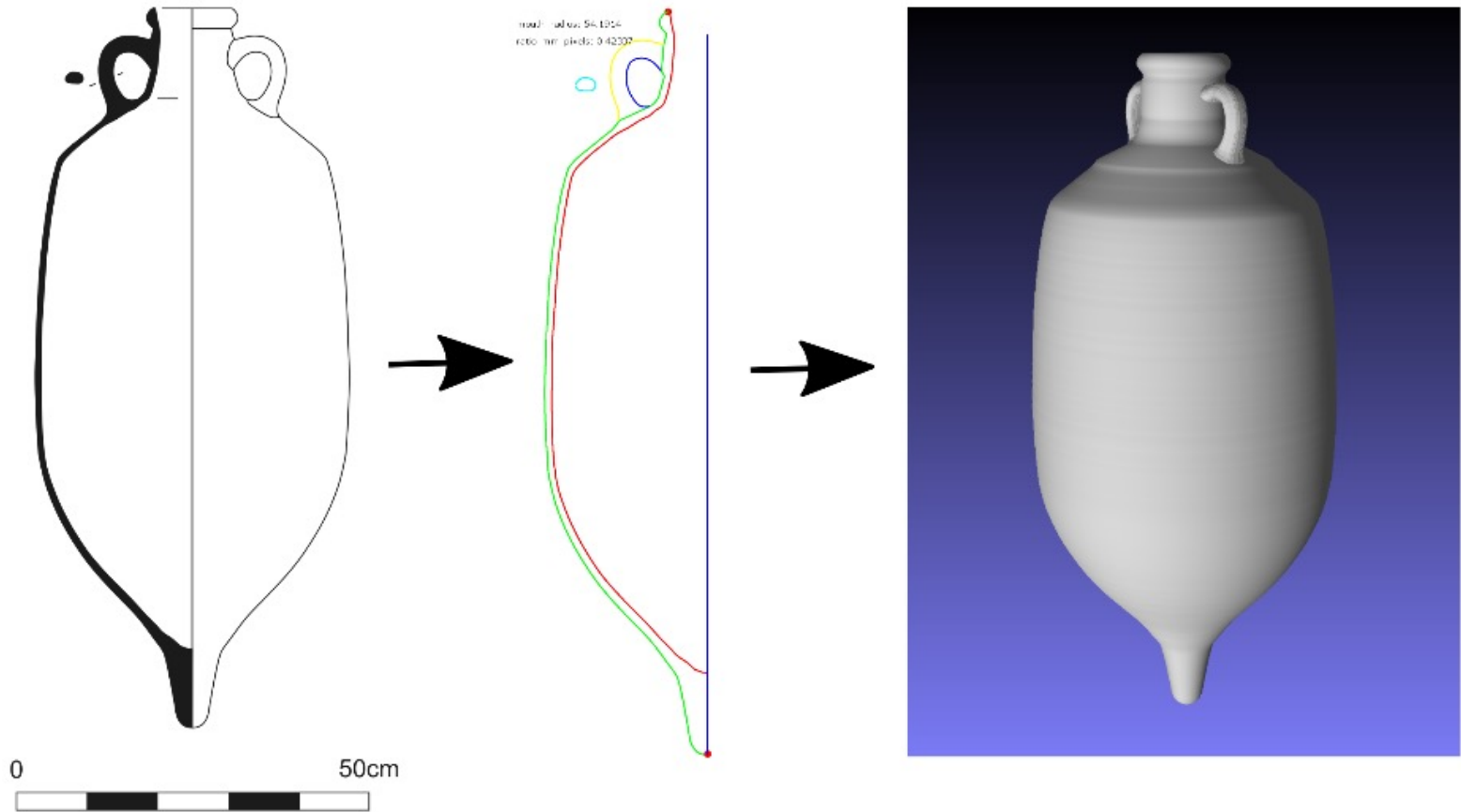


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#### Introduction

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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Arts & Humanities  
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#### Primary contact

Dr David Williams  
Dept of Archaeology  
University of Southampton  
Avenue Campus  
Highfield  
Southampton  
SO17 1BJ  
England  
Tel: 080 593032

[Send e-mail enquiry](#)

### Africana 2D Grande

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#### 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 *Byzacaena*, 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

LICENCE:



### Primary contact

Gabriele Gattiglia  
Senior researcher  
Universita di Pisa  
Dipartimento di Civiltà e Forme del Sapere  
Via Trieste 40  
Pisa  
56126  
Tel: +39 050 2215228

[Send e-mail enquiry](#)

### Resource identifiers

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



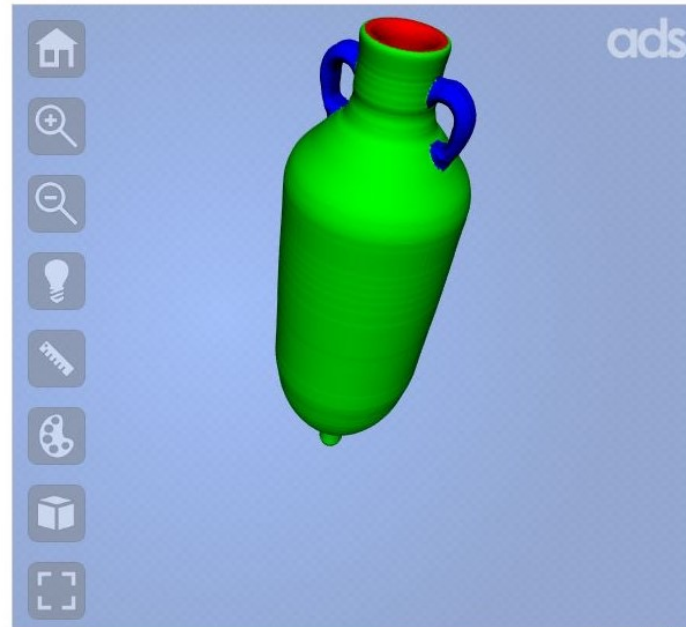
Choose a letter from the list below:

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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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[NEXT](#) [CONTENTS](#) [SUMMARY](#) [ISSUE](#) [HOME](#)

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

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Francesca Anichini<sup>1</sup>, Francesco Banterle<sup>2</sup>, Jaume Buxeda i Garrigós<sup>3</sup> , Marco Callieri<sup>4</sup> , Nachum Dershowitz<sup>5</sup>, Nevio Dubbini<sup>6</sup>, Diego Lucendo Diaz<sup>7</sup>, Tim Evans<sup>8</sup> , Gabriele Gattiglia<sup>9</sup> , Katie Green<sup>10</sup> , Maria Letizia Gualandi<sup>11</sup> , Miguel Angel Hervás<sup>12</sup>, Barak Itkin<sup>13</sup>, Marisol Madrid i Fernandez<sup>14</sup> , Eva Miguel Gascón<sup>15</sup> , Michael Remmy<sup>16</sup> , Julian Richards<sup>17</sup> , Roberto Scopigno<sup>18</sup> , Llorenç Vila<sup>19</sup>, Lior Wolf<sup>20</sup>, Holly Wright<sup>21</sup> , Massimo Zallocco<sup>22</sup>

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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.**

**Notification: 16 May**

# [Thank you for your attention]

[www.archaide.eu](http://www.archaide.eu)



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The views and opinions expressed in this presentation are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission.