## Natural Sciences examines Ancient Art (i) facts

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## ARCHAEOLOGICAL EXCAVATION TO REVEAL ANCIENT MONUMENTS & ARTIFACTS



The Moments of discoveries...during the dig....(Kastrouli 2016-2020)

## Artifacts go to the Laboratory or the portable Lab goes to the Artifact in the Site/Museum!



#### THE NATURAL SCIENCES RETRIEVE IMPORTANT INFORMATION FROM ARTIFACTS

#### Where?

**Prospection** (underwater, underground, from above) localization without excavation by surface measurements that, as an underground X-Ray imaging, depict the shape of buried antiquities.

#### When?

Radiochronology — age determination on artifacts and monuments.

#### How/What?

#### Why?

-----Construction depending on the shape and usage, the use and the orientation of the monument etc.

#### Mobility-ancestry?

Ancient DNA of human bone remains

### (STATISTICAL) ERRORS IN ARCHAEOMETRY



Axiom 1<sup>st</sup>: No measurement can produce a worthy result, if not accompanied (shadowed) by an error

Axiom 2<sup>nd</sup>: Increasing the level of exactness in measurement & statistics, increases the level of information, facts, knowledge

### ANCIENT ...ART(I)FACTS ARTIFACTS ARE FUNDAMENTAL ART OBJECTS





















## Instrumentation-Spectroscopy, nuclear, microscopy, electromagnetic....





## Selective examples of data obtained from artifacts through the natural sciences

## Stone tools (flint, obsidian)

# O CHRONOLOGY O CHARACTERIZATION & PROVENANCE

#### OPERATIONAL SEQUENCE











## OBSIDIANS

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#### Cross Pollari (PLM) Image

Un outil d'oBoirdethHydratationé



### OBSIDIAN SOURCES IN MEDITERRANEAN & SPHERES OF INFLUENCE DURING LATE PREHISTORY (OZDOGAN 2018, SPRINGER)



## Biplot of Sr vs. Ti. Aegean samples, Sardinia, Asia Minor



## Other examples of Hierarchical methods of clustering





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#### Obsidian Hydration Dating by Secondary Ion Mass Spectrometry (SIMS).

>Ion radiation of hits the surface of the sample

 $\geq$  Obsidian dating method based on the concentration of H in H<sub>2</sub>O versus depth

Detection of Cations, Isotopes, organic molecules (Liritzis et al 2008 Surf. Interf Analysis; Nucl. Inst. Meth Phys Res B; Liritzis 2006 Archaeometry)



## SIMS dates Vs Archaeological age





Liritzis 2006, Archaeometry, 48(3))

## Radiocarbon Dating of murals, wood, bone, parchment, textiles,....

## RADIOCARBON: HOW DOES IT OPERATE? IN ATMOSPHERE, Absorbed, Consumed, Decays....Half-life 5700 yrs



#### Otzi the Ice man: bow/arrow et.c...3300-3100 BC







- > Found in North Italy 1991 with all his outfit
- Wooden Bow & arrow, Bones, plant, material, hairs, dated by C14
- Time of early archaeometallurgy in Europe

## **Turin Shroud**

- They assumed that it was the shroud that wrapped Jesus Christ
- In the 1980s the Archbishop of Turin gave permission to date.
- ➤it dates to the middle of the 14th century







## Luminescence dating & authenticity of ceramic fabric

### AUTHENTICITY IN ART BY TL/OSL (FIRING, ZIRCON)

Modern firing gives zero luminescence

Simulating natural irradiation in the laboratory (zircon-quartz)

Using some ancient parts...needs careful sampling! drilling into the clay body in several locations to verify that that the overall figure is of the same date and origin.







#### Han Dynasty, 206 BC – 220 AD

TL age: 400 BC - 500 AD



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#### STENCIL ART IN THE KIMBERLEY REGION AUSTRALIA.

The superimposed Bradshaw painting was overlying by **Wasp Nest sediment,** which was dated by OSL giving a min 17,000 BP for art-work!



### Painting: mural, vases, panels/icons, statues Non-destructive methods





## The principle of painting analysis with reflectography (UV, VISIBLE, IR)



investigation of painted surfaces via VIS, IR, UV

Images of old manuscript with MSI Comparison in VIS, IR, Pseudocolor in IR Difficulty in re

Surface dest thickness ar with photo i force microscopy.



inscriptions

ved re revealed Ray



blackening (in pa : Preferred the im

techniques in overpai nd pigment analysis

## CASE STUDY: Archimedes Palimpsest and a page



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## The Chronicle

- A Palimpsest of Archimedes works (174 pages or 5 Books 7 monographs of Archimedes, rhetorician Hyperides, works of neoplatonic philosopher and other) was found in Constantinople from parchment by a 10th century scribe.
- This is the earliest known copy of the work of Archimedes (3<sup>rd</sup> c BC)
  200 years later the parchment was reused after cleaning the original text with weak acid and pumice and turned it into a Christian prayer book
  The reuse was done in a superficial way and there is the possibility of distinguishing the first writing.

### MSI Images in Red & Blue



The Archimedes text appears faint in RGB, And disappears via red channel of RGB



UV emits in blue of visible spectrum. Text appears and geometrical designs too

## Combined reception of Red and Blue fluorescent channels of RGB

- Perchment appears <u>white</u> as it reflects red and blue
- Overprinted Prayer book is <u>black</u>, as absorbs both R & B
- Underlied text appears <u>red</u> as it absorbs blue and reflects red.



#### **PIGMENTS + DATING** Lascaux Cave, France, ~ 15,000 BC-Charcoal & Ochres

- 600 rock paintings and 1500 engravings dating from the Paleolithic era have been recorded in the cave.
- Pigments: charcoal, red+yellow ochres
- The animals depicted are horses, bulls and deer. The "Hall of the Bulls" with the rock paintings **dates back to about 15,000 years BC. with radiocarbon.**
- How?
- From the minute quantities of charcoal used to draw the figure!
- → cave-museum and economic activity in the surrounding area



#### Documentation of Museum objects-Pigments, overpainted panels, binders, preparatory layer etc



## Some artifact analysis from Delphi Museum: Decorated ceramics, powder, glasses by pXRF

miniature ceramic vases

vessel with pink powder



glass vessels from Delphi







Pink powder.... tomb of a "theatre actress" excavated at Delphi and dated in 400–350 BC(Liritzis et al.,2018)

- It is a clay cylindrical pyxis with lid and it retains its light pink powder content (psimythion).
- The identification of Sulphur (S) and Mercury (Hg) but Pb as well clearly identifies the powder as cinnabar, that is HgS a red pigment very commonly used since antiquity, mixed with PbO white lead. For make-up of actress face.
- The 4th c. BC Greek author Theophrastus mentioned three different sources of cinnabar: from Spain, from Colchis in present-day Georgia, and in Ephesus in Asia Minor.
- Used in ritual blessings and burials and as a cosmetic in many parts of the world for thousands of years
- Toxic & Leathal!

## Ceramic vases grouping



## Glasses: Delphi fall within Theban field



## Bronze cylindrical compass with lid and powder inside



- The Bronze cylindrical compass AMA 3692 with lid was derived from a cist
- Found to be bronze (oreichalcus) Cu-Zn (81.8%-14.6%) with some Pb (1.06%) and Sn (1.68%).
- Powder within this metal vase was Cu with lower content in Zn, Ca and Fe, indicating corrosion.

Annunciation Church, Amfissa, Greece, painted by Papaloukas 1892-1957

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### <u>CONSERVATION PROGRAMM</u> OF MURAL PAINTINGS AMFISSA CATHEDRAL



Composition of organic and inorganic substances of pigments, binders, Preparatory layer/mortars

Recognition of past rescue operation

## **METHODS THAT WERE APPLIED:**

<u>RAMAN</u> ex. pigments and binders (red polish- red ochre- ultramarine)

> <u>Infrared Photoacoustic</u> <u>Spectroscopy</u> (IR-PAS) – for the first time

Infrared Spectroscopy (FTIR) Organic and inorganic substances ex. pigments, varnishes, Protective oils etc, resin, Gypsum. kaolin

#### X – Ray Florescence

Inorganic pigments, υπόστρωμα There were identified: chrome oxide, yellow – iron oxide, black- red ochre lead white, Prussian blue - βαρίτης

<u>Chromatography</u> with mass spectrometerorganic substances as binders (aminoacids) egg tempera, casein, animal glue

> <u>X – Ray Diffraction</u> minerals, as lapis lazuli, calcite, quartz, βαρίτης, hematite, gypsum, υδροκερουσίτης.

#### Mural painting of Church near Delphi Examining artist's painting technique and palette FTIR & Raman, Organic and inorganic

#### substances

#### Methods

- FTIR:.....Fourier Transform Infrared Spectroscopy
- RAMAN SPECTROSCOPY
- SIMS:.....Secondary Ion Mass Spectroscopy
- XRF:.....X Ray Florescence
- XRD:.....X Ray Diffraction
- CHROMATOGRAPHY

#### (Liritzis & Polychroniadou 2007 ArchéoSciences )



Spectrace 9000 TN PXRF measuring mural paintings of modern artist Spyros Papaloukas from the Amfissa Cathedral, near Delphi



 Provide the necessary knowledge of artist's palette & for conservion work

## **CONCLUSION:**

Spyros Papaloukas a emarkable figure of Greek Expressionism for his experiments used:

-a wide palette, various chromatic layers from different materials and binders (hematite, red and yellow ochre, carbon, ultramarine, Prussian blue, gypsum, casein, egg tempera, glue).

### pXRF in Museum artifacts













Digital Archaeology & History of Art Implementation <u>of computer systems</u> in the field of Heritage aertifacts











## ARCHAEOMETRY

- Interdisciplinarity
- Human Past-Our Memory
- In Remote Past we Meet our Future
- Sustainability-Growth
- Ecumenical Values



## ARCHAEOMETRY is the Heart in the present in which past and future meet.....



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