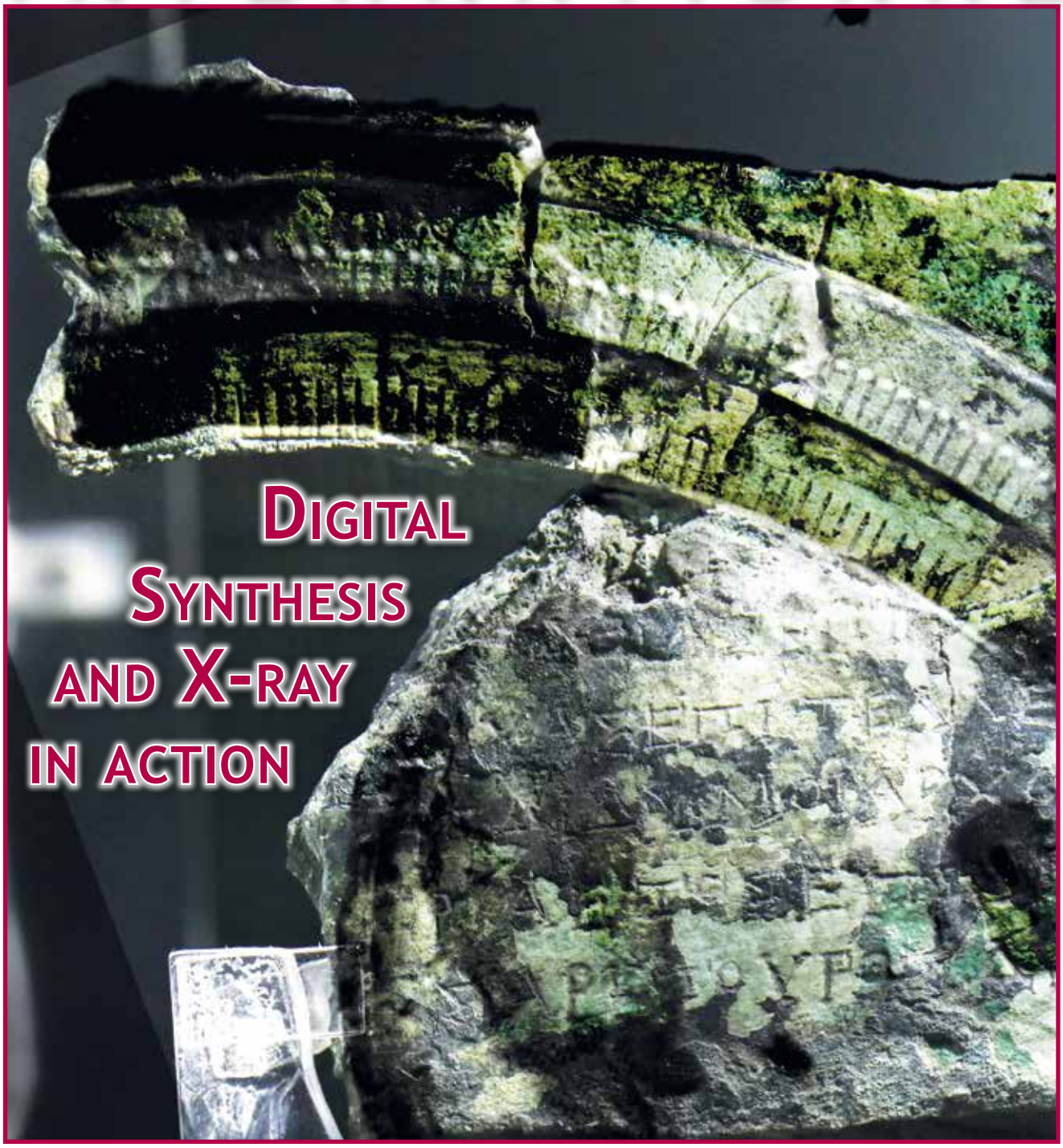
Quarterly Magazine, Volume VIII
Issue 3 Special Supplement

DECEMBER 2017

Cultural Heritage Technologies

ARCHEOMATICA INTERNATIONAL



DIGITAL SYNTHESIS AND X-RAY IN ACTION

OSTIA BEFORE AND AFTER E42

APPLICATION OF MICRORAMAN SPECTROSCOPY

PROJECT COBRA

GEOPORTAL OF NURAGHE

Archeomatica
ISSN 2037-2485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ARCHEOMATICA INTERNATIONAL SECOND TIME

It's a pleasure to announce the digital publication of the second special issue of Archeomatica International. In this number we host a variety of articles dedicated to many fields of the scientific research: *the new findings from Antikythera Mechanism front plate astronomical dial and its reconstruction, the COBRA Project: a successful technology transfer and scientific divulgation method, the Nurnet Geoportal, Aerial Ostia - before and after E42 and Application of micro-Raman spectroscopy for conservation projects in art and archaeology with a case study on Cappadocia rock-hewn wall paintings.*

Aristeidis Voulgaris, Andreas Vossinakis and Christophoros Mouratidis present their latest "findings" about the Antikythera Mechanism and the state-of-the-art of their investigations developed on this mechanism. In particular, the authors investigated the astronomical calendar-dial display of the Antikythera Mechanism Front Plate. The ancient prototype has been analysed through special photographs which provided new information on the functioning mechanism of the front dial. The authors conclude that the users of the device were able to easily perform astronomical calculations.

Beatrice Calosso and Roberta Fantoni describes the CO.B.RA Project: an Italian project developed for the dissemination of methods, technologies and advanced tools for the Cultural Heritage conservation, which has been implemented by the divisions of the *Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile* (ENEA). The main goal of the project is the dissemination and transfer to SMEs (operating in the cultural heritage sector) of the ENEA skills and Research Center Laboratories tools.

The Geoportal Nurnet is an open access webGIS dedicated to the Bronze Age Culture in Sardinia.
The authors Valentina Spanu, Eva Barbara Lorrai, Laura Muscas e Roberto Demontis describes the potentiality of the geoportal to promote the Pre-Nuragic and Nuragic civilizations, which also provide a large variety of geo-information for the study of this civilizations.
Developed and released in 2014 by the Center for Advanced Studies, Research and Development in Sardinia (CRS4) and the Nurnet Fondation, the Geoportal represent one of the first initiative of this type on the Nuraghe's field.

Massimiliano David, Gian Piero Milani and Roberto Cassanelli analyse the evolution of the archaeological area of Ostia from the aerial photography: fifteen photos coming from the archive of the Aerofototeca Nazionale, which cover a time range from 1911 to 1983, have been studied within the Ostia Marine Project, an archaeological mission of the University of Bologna active on the field since ten years.

The last article describes an overview of the applications of micro-Raman spectroscopy for cultural heritage, with a special eye on the case study of rock-hewn wall paintings in Cappadocia (Turkey), presented as exemplificative of application of Raman techniques for the knowledge of the materials, it's conservation and for the identification of degradation processes.

Archeomatica is actually recorded in many databases, as the ISI Web of Science and the DOAJ directory of open access journal. Published quarterly in the Italian version with an International special issue published every year in English language, is actually the reference journal for the dissemination of technologies applied to cultural heritage to readers, not only scientist, but belonging to all the professional, institutional and academic field devoted to fruition, valorisation and conservation of cultural heritage.

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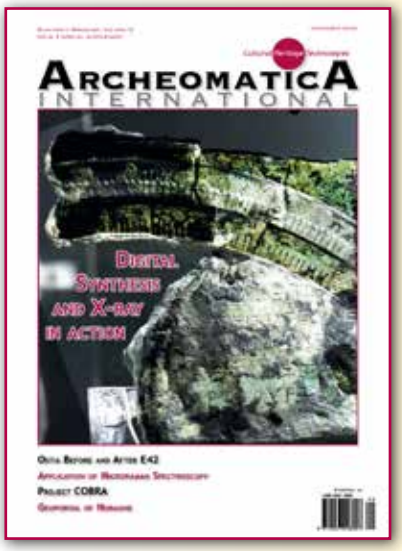
SUMMARY



In the cover a representation by a digital synthesis of the Egyptian calendar ring mechanism with the front plate astronomical dial found in Antikythera.

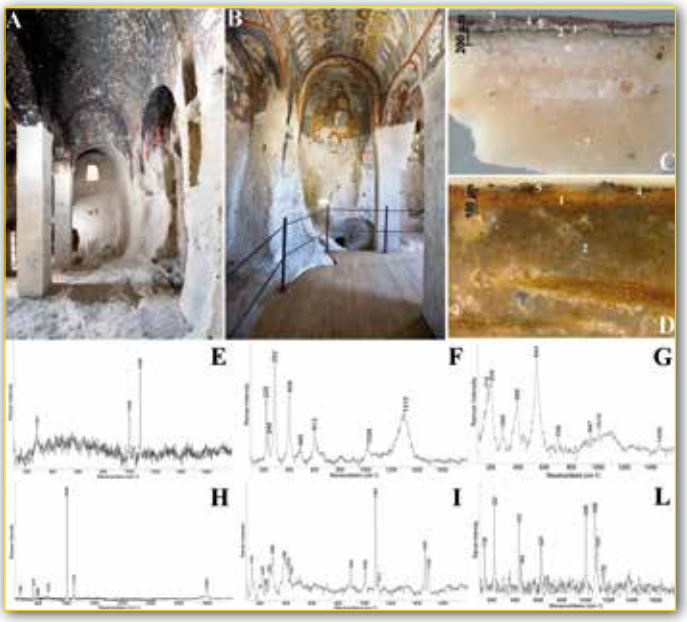
REVELATIONS

DOCUMENTATION

ARCHEOMATICA
CULTURAL HERITAGE TECHNOLOGIES
Quarterly Magazine, Volume VIII - Issue 3 Special Supplement December 2017

Archeomatica, quarterly published since 2009, is the first Italian magazine for dissemination, promotion and exchange of knowledge on technologies for the preservation, enhancement and enjoyment of cultural heritage. Publishing about technologies for survey and documentation, analysis and diagnosis, restoration and maintenance, museums and archaeological parks, social networking and "smart" peripherals. As a reference point in the field is the sharing media for the industry, the professionals, the institutions, the academia, including research institutions and government agencies.

RESTORATION



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Publisher
MediaGEO soc. coop.
Archeomatica è una testata registrata al Tribunale di Roma con il numero 395/2009 del 19 novembre 2009
ISSN 2037-2485

Printed by
SPADAMEDIA S.r.l.
Viale del Lavoro 31 - 0043 Ciampino (Roma)

The new findings from Antikythera mechanism front plate astronomical dial and its reconstruction

by Aristeidis Voulgaris, Andreas Vossinakis, Christophoros Mouratidis

Fig. 1 - Extreme ''depth of field'' images, of the back face of Fragment C. The fossilized Lunar Disc on the back face of the front plate is clearly detectable. Credits: National Archaeological Museum, Athens.
A. Voulgaris - Copyright © Hellenic Ministry of Culture & Sports/Archaeological Receipts Fund.

This paper refers to the investigation of the Zodiac scale and the Egyptian calendar ring of the Antikythera Mechanism front plate, based on the known surviving fragments of the Mechanism, mainly of Fragment C (National Archaeological Museum, Athens, inventory number X.15087). Fragment C is the preserved part of the front plate of the Antikythera Mechanism, located in front and above the large gear *b1*. Until now, only a portion and other isolated smaller fragments of the front plate survive.

The front plate dial was the cadran of the Annual and the Astronomical – calendar of the Mechanism. The manufacturer engraved on the front plate the information about the recurring events of every year on the Egyptian calendar ring and the Zodiac scale. During its revolution (1 turn/year), the pointer of the *Golden Sphere - Sun (Gnomonion)* pointed on the Egyptian Calendar ring, traversing the 12 months with 365 subdivisions and simultaneously the 12 zodiac constellations, engraved in arcs with subdivisions around the inside ring, just next to the Egyptian ring. The pointer - *Gnomonion* of the Sun – *Golden Sphere* (a bronze sphere with a pointer, which was possibly placed close to the perimeter of the annual gear *b1) (*Voulgaris et al 2018*)*, as it traversed the two rings, informed the user about the position of the Sun on the sky, (on Zodiac Constellation), during the corresponding Egyptian month and day.
Ophthalmoscopic examination of Fragment C shows that the front plate had a large hole in the center (Bitsakis and Jones 2016). Two plates with engraved inscriptions of the parapegma were on the top and on the bottom of the front plate of the Mechanism (Anastasiou et al 2013; Freeth and Jones 2016; Bitsakis and Jones 2016). In Fragment C, an

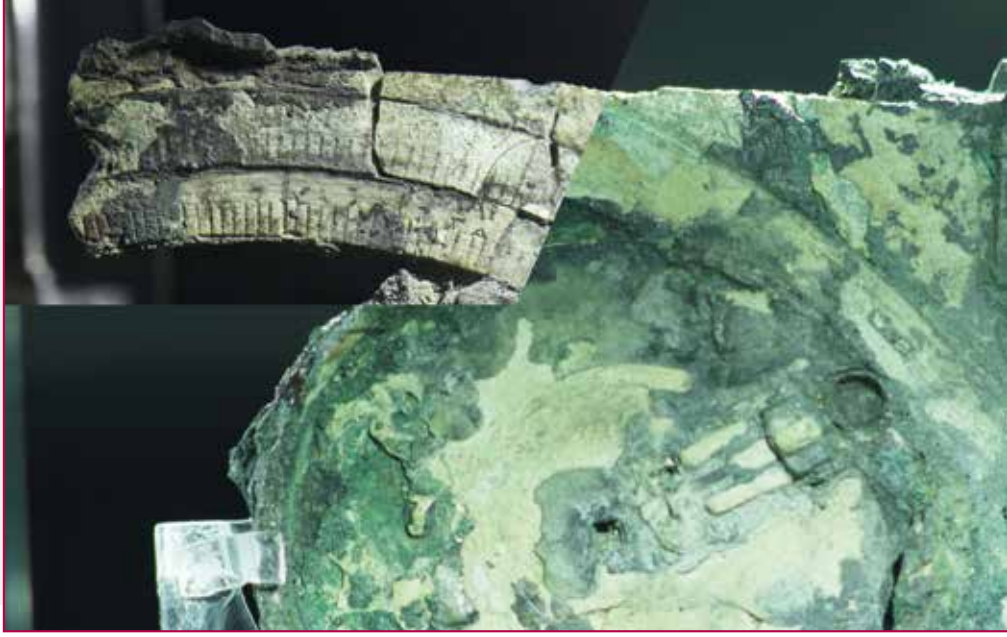

Fig. 2 - In the Isogeometrical-Multilayer Image, are presented parts of the front and rear faces of Fragment C. On the left of the image are clearly seen the two dial rings and on the right, the Bearing Base ring. It is evident that only the half width of the Egyptian calendar ring is supported on the Bearing Base ring. Close to the ''Moon Sphere'' the only one preserved staple is detected. Right above is clearly seen the sliding catch. Credits: Copyright © Hellenic Ministry of Culture & Sports/Archaeological Receipts Fund, A. Voulgaris

almost well preserved part of the parapegma inscriptions, is situated fossilized in front of the surviving dial rings and the Lunar Disc (Ptolemy; Wright 2012 notes; Carman and Di Cocco 2016). On the back side of Fragment C, lies the Lunar Disc, also fossilized (Fig.1), which was at the center of the mechanism before the ancient artifact was destroyed. By hand rotating the Lunar Disk (Voulgaris et al 2018), the user was also informed about the phases of the Moon, looking at the Moon Phases Sphere.

DATA MINING

Critical and determinant for our investigation, was the design and construction by A. Voulgaris of an optomechanical device with a modified camera lens, mounted on a micro moving x-y-z axes for tilting and aiming of the lens. This setup is capable to capture images of the fragments with extremely different position angles up to 83˚, eliminating the defocusing problem arising from the limited depth of field, which is strongly detected in conventional-non modified camera lenses (Fig. 1, 4, 5).

We also captured high resolution – *''isogeometrical''* images of the front and rear faces of Fragment C. We named our images *''isogeometrical''* because the capturing was done with the same optical system, in almost the same distance and perpendicularity from the well detected center of the fragment, so the parallax is the same and totally minimized on all of the images. So the images of the front and the rear faces are all of about the same scale and orientation. After the digitally processing (*mirror invert* in y axis) by the one the two images, we adding together and we constructed the *Master Isogeometrical, Multilayered - high resolution - (visual) Image* (Fig. 1,5). Then we added some of the corresponding AMRP X-ray tomographies (Figures 3,7). The very accurate-precise aligning of the set of these images was achieved by aligning on some distinctive - sharp areas of the boundaries of the fragment and especially the side to side mechanical (perpendicular on the plate) holes and other formations, avoiding aligning on the random cracks of the material or deformed areas. Therefore the *Master Isogeometrical Multilayer Image* offers the simultaneous selective observations of the front and rear areas of Fragment C.
After the digital processing, some very important new data about the design, the construction of the astronomical dial of the front plate, the handling and the using of the Mechanism were detected. Also some crucial differences from the published bibliography about the design and the role of the front plate dial have resulted.

THE DESIGN OF THE ANTIKYTHERA MECHANISM FRONT PLATE DIAL

The information about the annual astronomical events was engraved in the front plate of the Antikythera Mechanism (parapegma) and also in the two concentric rings: the Egyptian months ring and the Zodiac Constellations ring. The front plate of the Antikythera Mechanism was divided into three separate sections: the two *Rectangular Sections*, where the star events of the parapegma were inscribed

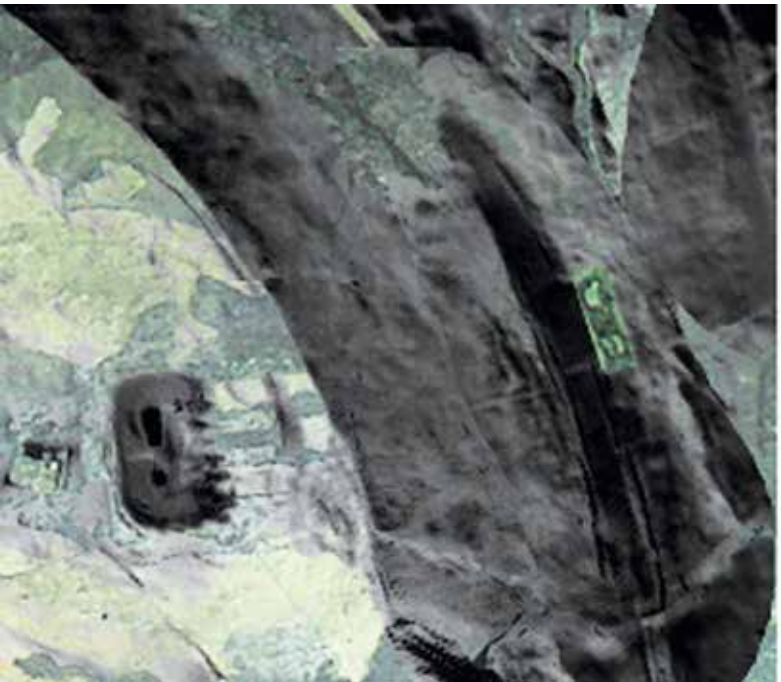

Fig. 3 - The Multilayer Isogeometrical Image of the Fragment C, in combination with corresponding (multi combined) CT of the AMRP. On the left it is detectable the stabilizer of the Egyptian calendar ring (front face) and the position of the staple (rear face). On the right are presented the form of the stabilizer. Credits: Copyright © Hellenic Ministry of Culture & Sports/ Archaeological Receipts Fund, A. Voulgaris-©AMRP.

Fig. 4 - Extreme ''depth of field'' image, shows the two rings which are located in the same level with the Middle Section of the front plate. Credits: National Archaeological Museum, Athens, A. Voulgaris. Copyright © Hellenic Ministry of Culture & Sports/Archaeological Receipts Fund.

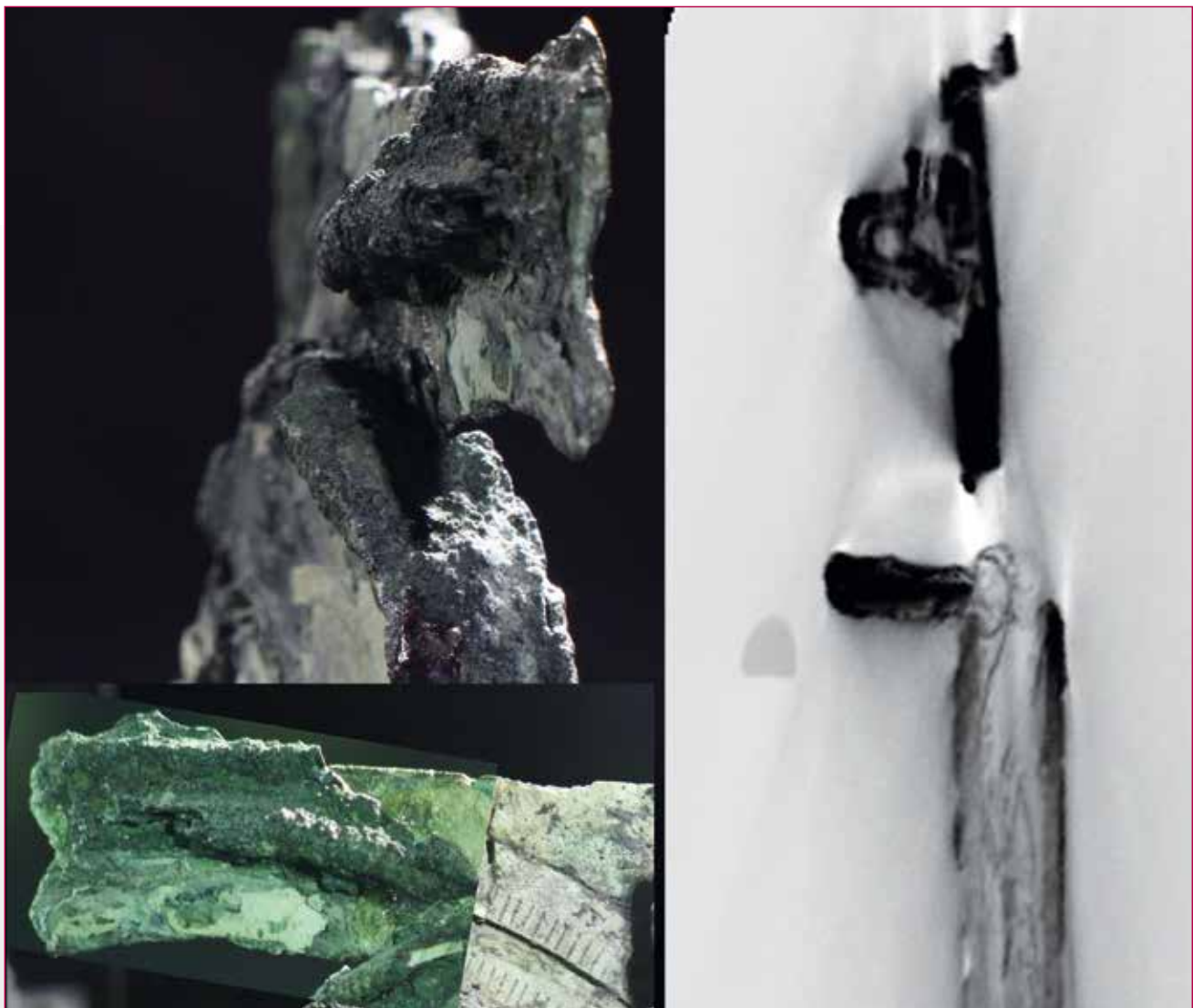

Fig. 5 - On the top left: the Fragment C image with extreme depth field of view. The equal level of the two dial rings is shown and the rear stopper with a central hole. On the right: AMRP X-ray tomography in sideways direction. Bottom left: the stopper position compared to the boundaries of the two dial rings. Credits: National Archaeological Museum, Athens, A. Voulgaris. Copyright © Hellenic Ministry of Culture & Sports/ Archaeological Receipts Fund and ©AMRP.

Fig. 6 - Left: A clock cadran digital composition of eleven frames on time 30s-31s, 35s-36s, 40s-41s, 45s-46s, 50s-51s and 55s. The pointer of the seconds it is not in the correct aligning in relation of the 6th, 7th, 8th and 9th subdivision of the cadran, because the lack of the calibration. The clock cadran needs an offset CCW rotation about 1.5°, so the distinct positions of the pointer of the seconds to be aligned with the corresponding subdivisions. Right: On the ''24 hours clock'', the two pointers are in opposite ''line'' direction (i.e. 12 o clock), but the clock cadran needs an offset CCW rotation about 6°, so the positions of the two pointers to be aligned with the corresponding subdivisions (24th and 12th). A. Voulgaris Collection.

(Anastasiou et al 2013; Freeth and Jones 2016; Bitsakis and Jones 2016) and the almost square *Middle Section*, with the central hole (Bitsakis and Jones 2016; Wright 2012). Around the central hole of the *Middle Section*, the Egyptian calendar and the Zodiac Constellations were engraved in circular distribution. As shown in Fig.2, from the *Master Isogeometrical Multilayer Image* of Fragment C, three totally independent rings surround the central hole of the Middle Section:

The *Bearing-Base ring* (Wright shows this as not in dependent from the *Middle Section* and present this as a sink digged on the Middle Section, (Video presentation at 50:55'' and 50:58'').

b) The inlaid Egyptian calendar ring

c) The *Zodiac Constellations ring* (totally independent), (Wright shows in https://www.youtube.com/watch?v=cSh551cdIEY at 50:55'' and 50:58''and also Bitsakis and Jones (2016) and Jones (2017) refer to this, as a not independent part from the *Middle Section*, i.e. a ''solid body'' with the *Middle Section*).

The detection from CTs that the *Zodiac Constellations Ring* and the *Bearing Base ring* is an independent ring, it is not easy, because of strong fossilization, which transformed the rings as ''one body'' with the Middle Section. The Bearing-Base ring is stabilized to the almost square *Middle Section* by staples, from which only one from the four survives (Fig.2). As detected from the *Master* Isogeometrical Multilayer Image and the composition of the corresponding CT by the AMRP, this staple is the rear edge of (one of the four, preserved and detected in CTs (Bitsakis and Jones 2016) peripheral stabilizers of the Egyptian calendar ring Fig.3. These stabilizers prevent the Egyptian Calendar ring from falling outside.

In X-ray CT scans, out of a possible total of 365 holes, 87

Fig. 7 - A digital synthesis of front face of the Fragment C with the corresponding X-ray CT by AMRP. The preserved ''day'' holes of the Bearing-Base ring are located between the subdivisions of the Egyptian calendar ring. Credits: Copyright © Hellenic Ministry of Culture & Sports/Archaeo logical Receipts Fund, A. Voulgaris - and © AMRP

have been detected on the *Bearing-Base ring* with diameter 0.7mm - 0.8mm (Wright 2012; Evans et al 2010). These holes well drilled by the manufacturer in a circular allocation on the *Bearing-Base ring* with excellent accuracy (Fig.7).
Some of these holes were also detected in our visual photographs of Fragment C, with the help of the X-ray images.
From our photographs with extremely sideways capture angle, it is evident that the *Zodiac Constellation and the Egyptian calendar rings* are on the same level with the *Middle Section* of the front plate Fig.4 (Wright Video presentation; Bitsakis and Jones 2016; Jones 2017). About half of the width of the Egyptian calendar ring is positioned on the half of the width of the *Bearing-Base ring* Fig.7, while the *Zodiac Constellations ring* does not have any contact with the *Bearing-Base ring*. It is of course mandatory that the *Zodiac Constellations ring* is somehow supported.
In Fig.5 behind the two rings, just at their contact boundaries, a formation is detected, which seems it could well be one of four (or three) rear stops. This elongated formation-stopper has a cylindrical perforated cross section and it is curved following the circular boundaries between the contacts of the two rings. This formation could be stuck (soldered?) on the rear face of the *Zodiac Constellations ring* (or on the Egyptian calendar ring, but it is not easily evident from the tomographies), preventing this ring from falling outside (or inside). We also assume that of 3 or 4 stops acting also as little pointers (needles), stuck on the front side of the *Zodiac Constellations ring* (or on Egyptian calendar ring) were necessary to prevent this ring from falling inside (outside). These totally necessary front and back stops placed the *Zodiac Constellations ring* on the same level with the Egyptian calendar ring and allowed its free rotation.
The free - independent rotation of the *Zodiac Constellations ring*, offers the ability of the very precisely aiming and calibration of the ring, in relation to the positions of the *Golden Sphere- Sun pointer* and the *Lunar Disc pointer* (see chap…..). It also offers the ability of correction of the Callippic calendar which requires the subtraction of one day every four Metonic cycles (Theodosiou and Danezis 1995; Freeth et al 2008): after four Metonic cycles, the user can rotate the independent *Zodiac Constellation Ring* CCW by one subdivision (one day). A similar ability can be detected on the clocks cadran: after the assembling of a clock, it is possible that the pointer of the seconds does not coincide exactly with the clock's cadran subdivisions (usually 1 subdivision/5 sec-min) (Fig.6). The clock maker must calibrate the clock: he can rotate the clock cadran CW or CCW to achieve the absolute coincidence of the pointer of seconds with the subdivisions of the cadran.
The three rings of the front plate of the Mechanism, had engraved measuring scales with subdivisions or holes, so it is logical to assume that they were sequentially made by dividing, engraving, drilling machines (Voulgaris et al 2017; Irby 2016). According to our precise measurements about the drilling process of these holes, the dividing error must be $< 0.3^{\circ}$ to avoid overlapping of the holes. Even today the dividing and drilling of 365 holes with a diameter of 0.8mm with mechanical conventional tools, is an arduous work and requires extreme accuracy and attention. The *FRAMe Project* team designed and constructed the conventional cutting-dividing-drilling machine for the *Bearing-Base ring* and studied the procedure and the duration of the drilling on the *Bearing Base ring*.
The central section of the front plate was secured with four sliding caches (Wright 2012; Bitsakis and Jones 2016), of which only one is preserved. The sliding pin was secured on the rear face of the two rectangular parts of the parapegma (upper and bottom). In Rehm's photograph of Fragment A,

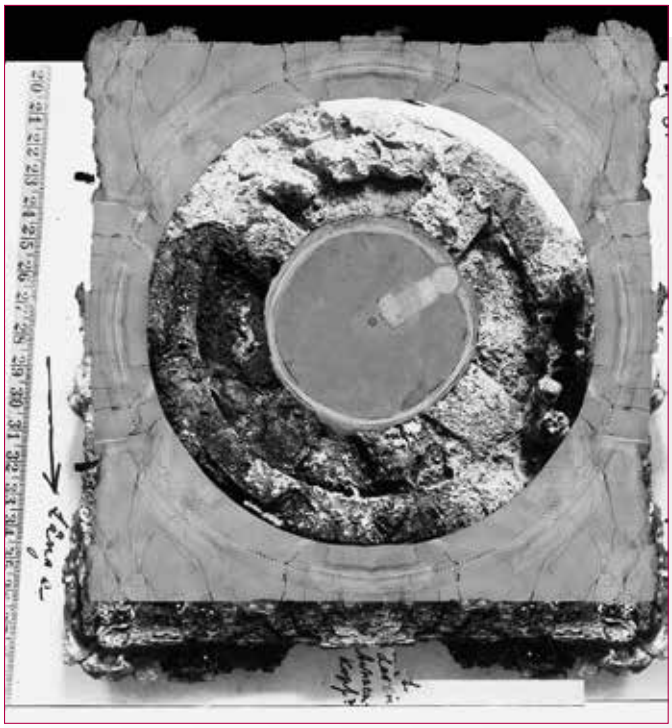

Fig. 8 - Digital reconstruction of the Middle Section (AMRP radiography) of Fragment C, in relative scale of Rehm's image of the Fragment a (Bayerische Staats bibliothek Rehmiana III/9). In Rem's image we also added digitally the (lost) wooden outline on the right part. From this reconstruction it is obvious that the Middle Section is not supported on the lower part of the wooden outline and supported on the left-right wooden outline. On the lower part of the wooden outline is supported the parapegma rectangular plates.

taken on 1904/5 (Rehm 1906), some preserved wooden linear formations, in vertical and horizontal positions (a part of wooden outline there is Fragment F via radiography of AMRP) (Fig.8) (Wright 2012). Based on the preserved Fragment C photographs and CTs, we digitally reconstructed the possible view of the Middle Section of the ancient prototype Fig.8. In this digital reconstruction, we also added Rehm's reconstructed photograph of Fragment A. In Figure 8 it seems that the vertical fossilized wood acts as a bearing spacer between the Front Middle Section and the Medium plate. The lower boundaries of the Middle Section plate are not matching with the wooden horizontal outline formation. The horizontal wooden outline formation acted as a bearing spacer of the lower Rectangular Section (parapegma).
By measuring the dimensions of the preserved deformed, distorted and incomplete parts of the Mechanism, the possible true dimensions of the Front Plate of the Mechanism (including the partially preserved wooden outline, as detected from the radiographies of the Fragment B) were at least 200mm X 330mm. In our functional models we chose the ratio of the sides equal to the golden ratio φ=*1.618*, which was used by ancient designers, sculptors, mathematicians and applied in a lot of constructions in ancient Greece (Hambidge 1924; Euclid).

THE EGYPTIAN CALENDAR RING

The inlaid freely rotating ring represented the Egyptian months ΘΩΘ (*Thoth)*, ΦΑΟΦΙ *(Phaophi)*, ΑΘΥΡ *(Athyr)*, ΧΟΙΑΚ *(Hoiak)*, ΤΥΒΙ *(Tybi)*, ΜΕΧΙΡ *(Mechir)*, ΦΑΜΕΝΩΘ *(Phamenoth)*, ΦΑΡΜΟΥΘΙ *(Pharmouthi)*, ΠΑΧΩΝ (*Pachon)*, ΠΑΥΝΙ *(Payni)*, ΕΠΙΦΙ *(Epiphi)*, ΜΕΣΟΡΙ *(Mesori)* of 30 subdivisions each (days) and 5 induced (epagomenai) days. According *Figure 2* the Egyptian calendar ring was adapted onto the *Bearing Base ring* (see the previous chapter)

and was held in place by four peripheral stabilizers (Bitsakis and Jones 2016). Setting the disc in a given position, the fixation was probably done by inserting one (or two) pins, applied in one (or two opposing) of the 365 peripheral holes of the *Bearing-Base ring* (Wright 2012). The user removed the pins every four years or 53.4 full rotations of the *Lunar Disc* (sidereal months), rotated the Egyptian calendar ring anticlockwise by one hole and placed the pins back, thus accounting for the slide of the Egyptian calendar ring relative to the solar year.

The Egyptian calendar had 365 days per year and did not account for a correction over the actual duration of 365.25 days. This meant that it preceded the actual year by one day, every four years or 6 months in 720 years and essentially the seasons and the risings and settings of the stars did not occur in the same Egyptian date overtime. Every 1460 years, namely during a *Sothic Cycle* (Theodosiou and Danezis 1995) or *Canicular Period* (Murray 1828), the Egyptian calendar would return to its original starting position. The *Sothic Cycle* began with *1st Thoth* (the first month of the Egyptian calendar) at the first day of the morning rising of Sirius. Censorinus and Theon of Alexandria report that on July 19, 139 AD (Theodosiou and Danezis 1995), a new *Sothic Cycle* began on the morning rising of Sirius (when the Sun was at 24th day in the constellation of Cancer). The start of the previous *Sothic Cycle* was on July 9, 1321 BC (according to the *Starry Night* planetarium software program), when Menefres Ramsey I or one of his successors, Seti II or Meneftha II, was the pharaoh of Egypt.

The gap between 139 AD and 150 BC (an hypotethical date of construction of the Mechanism), is 289 years. So, *1st Thoth* of 150 BC should point at the third subdivision of the month ''Χηλαί'' (Libra). By examining the surviving fossilized Egyptian calendar ring and the *Zodiac Constellations scale ring* of the Fragment C, *1st Payni* points to 18th subdivision (day, see next chapter 2.3) of Libra and this correlation happened on 569 BC (see also Price 1974).

The position of the Egyptian calendar ring does not affect and is not related with the measurement system of the Mechanism, the pointers or with the gears. Its role is ''more passive'' and its position depended entirely from the other scales-calendars.

As described below, the Mechanism was constructed so it could be readily used at any given date and year and it is possible that it was set to this specific date by the user and the Egyptian calendar ring position followed the position of the rest rings and pointers.

THE ZODIAC MONTHS SCALE - RING

Concentric to the Egyptian Calendar ring, was the smaller inlaid and freely rotating *Zodiac Constellations ring*. On this ring were engraved the zodiacal constellations *Libra (*ΧΗΛΑΙ*), Scorpio, Sagittarius, Capricorn, Aquarius, Pisces, Aries, Taurus, Gemini, Cancer, Leo and Virgo*. Of the 12 zodiacal constellations, *Libra* (by naked eye) and *Scorpio* (by CTs) are completely preserved in Fragment C, with 30 subdivisions each and also parts of *Virgo* and *Sagittarius* survive (Bitsakis and Jones 2016). Because of the existence of the subdivisions, this ring was also a measuring scale.

According to Price 1974, the Zodiac scale was probably divided into 12 equal arcs, with 30 subdivisions each, therefore was divided into 360 subdivisions i.e. degrees (Wright 2002b). If the Zodiac scale was divided into 360 equal subdivisions, then the solar anomaly could not be represented (Evans et al 2010).We will argue that the Zodiac ring was divided into 365 (equal) subdivisions (or less possibly in 364 divisions + 1.25, a more extended one) i.e. days (and not degrees), with 12 zodiac (unequal arcs) months, with an uneven number of days, depending on the duration of each zodiac month, for the following reasons:

Fig. 9 - The old analog multimeter with the concentric scales and the common pointer. The three inside scales (black, red and red arcs) have equal subdivisions of Volts/milliamperes (DC-AC). Note that the concentric scales of Ohms and Decibels do not have equal subdivisions.

1) The fact that the rotation of the *Lunar Disc* and the revolution of the *Golden Sphere-Sun* with its pointer, traced the 365 subdivisions-days of the Egyptian calendar ring, indicates that the Mechanism acted as an astronomical calendar-time measuring device. Thus, in the front plate, the quantum unit of the front dial measuring system was one day (time unit) and in the back plate was one synodic lunar month.

   The *Egyptian Calendar ring* and the *Zodiac Constellations ring* seem to be concentric and both of these have engraved subdivisions. The pointer of the *Golden Sphere* traced simultaneously the subdivisions of the two scales during its revolution.

   A characteristic paradigm of a measuring machine - device with two concentric scales with a common central pointer is the old analog voltage-current multimeter Fig.9. An analog multimeter measures the electrical current in Amperes (A) and with the addition of some electrical resistances it can also measure the voltage in Volts (V). The current and the voltage scales with equal subdivisions are in concentric circular arcs. The center of the common pointer is placed on the center of the two circular scales. Using the multimeter for a measurement, the angle declination of the pointer from the ''zero'' position, is given by the equation $\varphi^V = k*V$ *(1)* for the Voltage measurement and $\theta^A = n*A$ *(2)* for the current measurements (where *k* and *n* are constant numbers). By dividing the equations *(1)* and *(2)* we argue that $\varphi^V/\theta^A = k/n * V/A \rightarrow \varphi^V/\theta^A = k/n * R$ *(3)* (V/A=R, Resistant). This ratio *(3)* is a constant number. So the two arc scales can be concentric with a common pointer, because their ratio is a constant number i.e. the two scales are related with a constant ratio or they have the same units.

   Because the *Zodiac Scale* and the *Egyptian calendar ring* of the Mechanism are circular and concentric with a common pointer (*pointer-Golden Sphere*), the ratio of their measuring units (subdivisions) must be a constant number. If the measuring unit of the Egyptian month dial ring is *days* (t^{days}) and the zodiac scale units is *x*, the ratio $t^{days}/x^{(units)} = a$ *(4)* must be a constant number. If we assume that the zodiac scale had 360 subdivisions i.e. angle degrees, the equation *(4)*

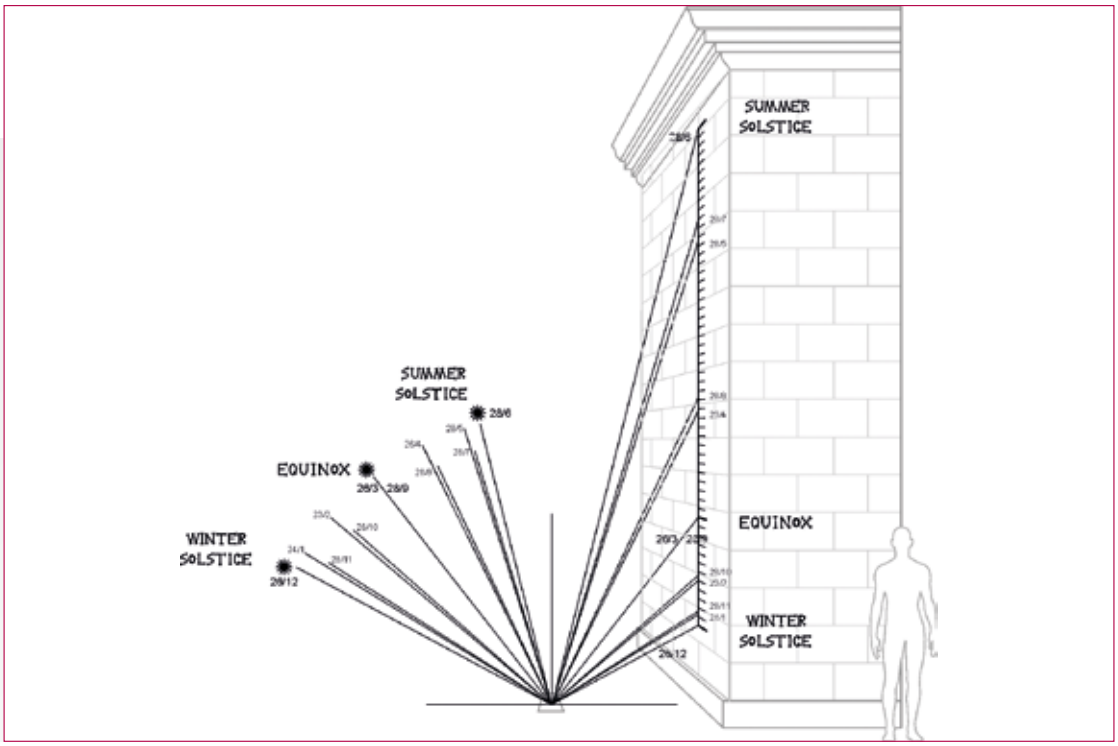

Fig. 10 - Representation in relative scale of a possible set up of the Meridian Wall that could be used by Meton and Callippus, for measuring (at the wall) the height of the sun at noon during the seasons, using a mercury mirror.

is written in an analog function: $(x^{degrees}) = a*t^{days}$ *(5)*. The time (t^{days}) that the Sun takes to cross an angular distance of d° in the zodiac circle in the sky, is given by the equation

$t^{days} = d^{\circ}/v^{sun}$ (6). Because of the solar anomaly, Sun's velocity v^{sun} is not constant, so the equations *6* and *5* cannot be constant. Therefore, the hypothesis that the zodiac scale had 360 equal subdivisions of degrees is not correct.

2) The parapegma of the Mechanism (Anastasiou et al 2013) referred to observations on specific dates (i.e. days) when the risings/settings occurred. The manufacturer engraved the numbering of the risings/settings of the stars of the parapegma, on some of the subdivisions of the zodiac scale with index letters (in Fragment C, 12 index letters are preserved on some zodiac scale subdivisions) (Bitsakis and Jones 2016). The user read the index letters on the zodiac subdivisions and simultaneously these letters were engraved on the beginning of each parapegma corresponding sentence of the star event.

We do not think that the manufacturer converted the dates of the star events (days) in the corresponding degrees and then engraved the letters on the subdivisions of the zodiac scale, using a different scale unit than days. The ratio 365 days/360° = 1.01388888 days/degree and this conversion creates periodically errors during the dividing-engraving of the subdivisions, because of the rounding error, which downgrades the accuracy: in the beginning of the two scales (Egyptian-days and Zodiac-''degrees''), the subdivisions are coincident, but as the subdivisions proceed the two scales

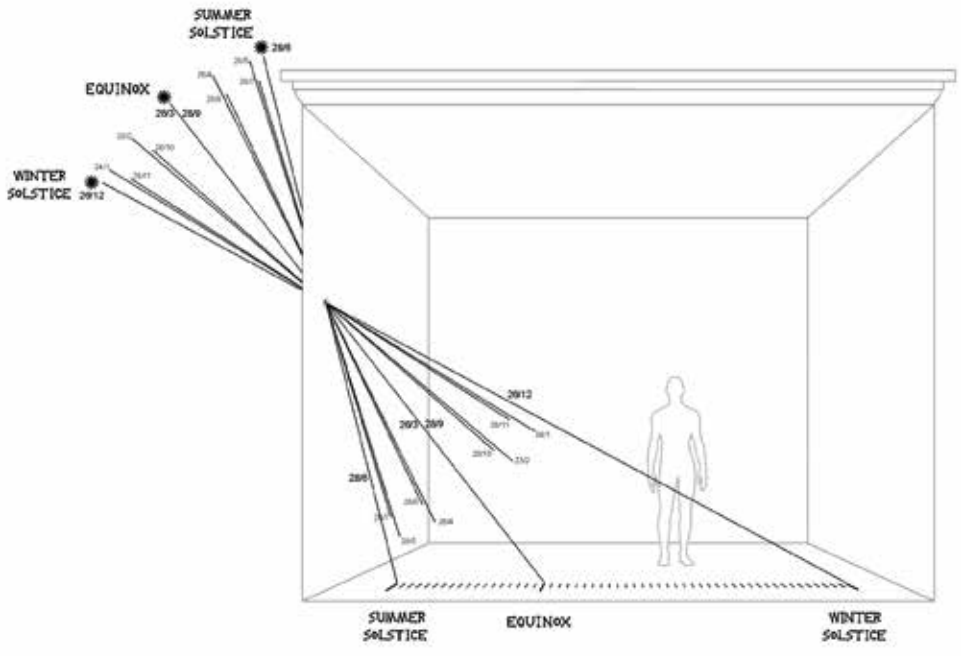

Fig. 11 - Representation in relative scale of a possible set up, that could be used by Meton and Callippus, for measuring (at the floor) the height of the sun at noon during the seasons, using a camera obscura-pinhole camera.

Seasons	Era 432 BC	Days	Era 330 BC	Days	Era 130 BC	Days	Era 80 BC	Days
Autumn Season	28/9-25/12 (perihelion 29th Noe)	89	27/9 - 24/12 (perihelion 30th Noe)	89	26/9 - 23/12 (perihelion 1st Dec)	89	26/9 - 23/12 (perihelion 30th Noe)	89
Winter Season	26/12-25/3	90	25/12 - 24/3	90	24/12 - 22/3	89	24/12 - 22/3	89
Spring Season	26/3-27/6 (aphelion 29th May)	94	25/3 - 26/6 (aphelion 30th May)	94	23/3 - 24/6 (aphelion 31st May)	94	23/3 - 25/6 (aphelion 30th May)	95
Summer Season	28/6-27/9	92	27/6 - 26/9	92	25/6 - 25/9	93	26/6 - 25/9	92

Tab. 1 - The dates of the Solstices and Equinoxes and the duration of the seasons for different Eras.

diverge, e.g in 73th day the difference is 1 subdivision (73rd day= 72˚).

3) Taking into consideration the constructional techniques at that time, it would be more precise and easy to simultaneously divide and engrave two concentric rings, attached to a common center. The probable divisional machine of the manufacturer was already calibrated in 365 subdivisions for engraving the ring of the Egyptian months and for drilling the 365 holes on the *Bearing Base ring*. If the zodiac scale had 360 subdivisions, then he would need to recalibrate the dividing machine tool for 360 divisions. This task at that time was quite painful and slow.

4) If the Zodiac scale had 360 subdivisions in degrees, then to account for the solar anomaly, it would require 360 unevenly distributed subdivisions (closer spaced at the months that the Sun's velocity is faster). We consider this hypothesis unlikely, because we must assume more hypotheses and more structural-constructional modifications of the front plate (Evans et al 2010). This contradicts *the principle (philosophy) of the fewest assumptions*, as first stated by pythagoreans philosophers and later known as the Occam's razor (https://plato.stanford.edu/entries/logical-construction).

Therefore, the hypothesis that since both the two surviving constellations, *Libra* and *Scoprio*, were divided in 30 subdivisions, then all of the remaining constellations would also be divided in 30 subdivisions (degrees) is neither necessary, nor mandatory for the proper functioning of the Mechanism. Instead it hinders the functionality of the Mechanism. There is no reason to divide the zodiac scale in 360 subdivisions, since the dividing into 365 subdivisions is simplest, easier,

ZODIAC CONSTELLATION	Date on 130 BC	Equinoxes and Solstices	Duration of the Zodiac Months
Libra	27 September-26 October	Autumnal equinox	30 (Fragment C)
Scorpio	27 October -25 November		30 (Fragment C)
Sagittarius	26 November-24 December (perihelion on 1st December)		29
		autumn season duration	89 days duration
Capricorn	25 December - 22 January	Winter Solstice	29
Aquarius	23 January -21 February		30
Pisces	22 February -24 March		30
		winter season duration	89 days duration
Aries	25 March-24 April	Vernal equinox	31
Taurus	25 April-26 May		31
Gemini	27 May-26 June (aphelion on 31st May)		32
		vernal season duration	94 days duration
Cancer	27 June-27 July	Summer Solstice	31
Leo	28 July-27 August		31
Virgo	28 August-27 September		31 (parapegma inscriptions)
		summer season duration	93 days duration

Tab. 2 - The duration of the Zodiac Months.

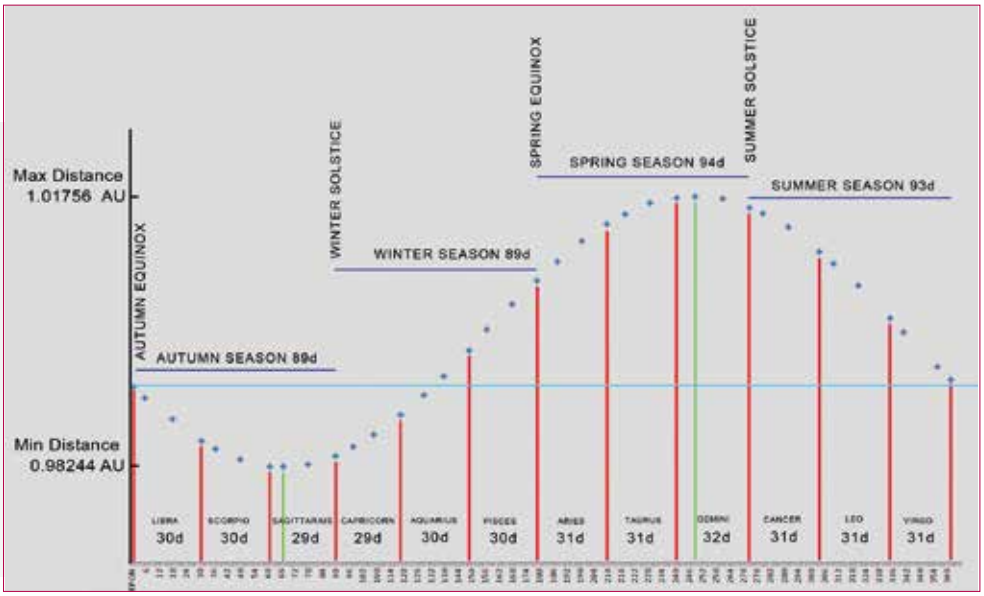

Fig. 12 - The sinusoidal graph represents the variable distance of the Sun-Earth, in Astronomical Units, during the year, through the zodiac months, for the era of 130 BC (according to ''Starry Night'' program). The graph starts from zodiac month of Libra, in date of the Autumn Solstice. Because of the 2nd Kepler's law, during the minimum of the distance, the ''solar velocity'' and also the angular velocity is maximum.

without errors and fully functional.
So we believe that the Antikythera Mechanism was a time measuring machine and not a machine like a sextant (for angles measuring).

THE ANCIENT MEASUREMENTS OF A SEASONAL DURATION

The unequal duration of the seasons and also the different duration of each zodiac month were known in ancient Greece, from observations of *Meton* and his partner, *Euktemon* (Pavel 2006; Jones 2017). The calculation of the dates of the solstices and the equinoxes, was done from the hill of Pnyka in Athens, using their invention, the *Heliotropion* or *Helioscopion*. Meton identified the repetition of the positions of the Sun and Moon in relation to the sky (stars) in the era of about 432 BC, known as the 19 years Metonic cycle (Freeth et al 2008; Theodosiou and Danezis1995). About one hundred years after *Meton*, around the era of 330 BC, *Callippus* continued the observations and improved the accuracy of the calculation of the duration of the seasons and the dates of the Solstices and Equinoxes.
One possible setup of the *Helioscopion* and a method for calculating the dates of the solstices and equinoxes in ancient time, could be based on the use of an East-West aligned oblong container, filled with mercury, which acted like a permanent leveled mirror reflecting the sun's light Fig.5 (mercury as *cinnabar* was in use in ancient Greece and Egypt for the separation of gold ore) (Theophrastus). The observer secured the container to a fixed place on the ground in some distance from a wall several meters high (e.g. *The Horologion of Kyristos* - Ωρολόγιον του Κυρρήστου, known also as the *''Tower of the Winds''* in Pnyka of Athens, was 12m high) (Noble and Price 1968). By making observations for a few consecutive days and recording the maximum daily height of the reflection of the sun rays on the wall, he could determine a point of the ''reflected'' local meridian. Next, by using a plumb line cord *(''*Σταφυλίς- *Staphylis''*) (Orlandos 1955), he drew the local meridian on the wall, as a vertical line. The reflected sunrays from an oblong mirror have also oblong form, thus making the measurements easier and more accurate. The lowest height of the solar reflection was during the date of the *Winter Solstice* (Sun's Declination -23.4˚) and the highest during the date of the *Summer Solstice* (Sun's Declination +23.4˚). Using trigonometry (calculations on the *Meridian Wall* or using the local latitude), the observer could calculate the point on the *Meridian Wall* at the dates of the equinoxes (Sun's Declination 0˚). He could also design-mark other useful information of the celestial sphere e.g. the projection of the Ecliptic in different dates. If the distance between the two solstices on the wall was about 5m (i.e. the distance of the mirror from the wall was about 2.5m), the scale on the *Meridian Wall*, would be about 0.1˚/1 cm. This scale offers a resolution of about 4 arc min, enough for precise calculations. In this manner, also some nighttime lunar observations could be performed.
A second idea of how *Helioscopion* could be implemented is the pinhole camera-(*camera obscura*). The pinhole camera was known in Ancient Greece since Aristotle (Gatton 2016; Aristotle; Euclidis; http://paleo-camera.com/) . In a dark room with a small hole on the wall, located towards the meridian, the Sun's image was projected on the floor and the projection of the solstices was inverted: the Summer Solstice closest to the wall with the hole and the Winter Solstice farthest (Sutter 1964, https://www.youtube.com/watch?v=MnnntOVHw4Y) . The distance of 2.5m between of the hole and the floor offers the same resolution with the

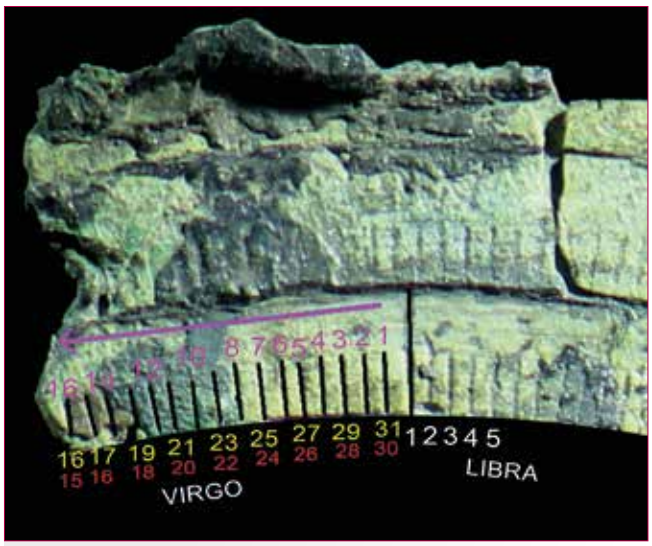

Fig. 13 - The numbered preserved part of Virgo zodiac Month. With purple numbers is the numbering beginning from the end, with red numbers the ''false'' measurement and with yelow the correct measurement of the subdivisions.

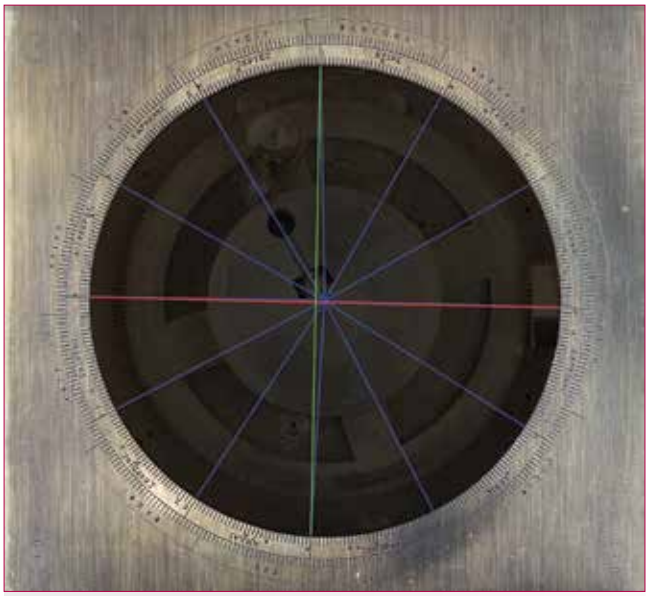

Fig. 14 - The Zodiac Months ring of the FRAMe model of Antikythera Mechanism. We correct align by tilting, our front plate model in an optical bench. The red line represents the line of solstices, the green line represents the line of equinoxes and the yellow line represents the line of apsides (perihelion-aphelion). The blue lines show the unequal central angles of the zodiac months with respect to the center of rotation of the Sun - Golden Sphere (and the Lunar Disc) i.e. Earth, which is also the center of the two dial scales. Because autumn and winter seasons had 89 days each, the line of Equinoxes is perpendicular to the line of Solstices, but their intersection does not coincide to the common center of the two dial scales, because of the solar anomaly.

Meridian Wall.
Moreover, if the distance between the pinhole and the projected image on the floor is large enough, then it is even possible to measure the diameter of the solar image (as a pinhole camera solar projection). For example for a hole-floor distance of 10m, the projected solar image has a diameter about of 93.5 mm on perihelion or about 90.5 mm on aphelion i.e. sufficient enough for someone to realize and measure the change of the apparent solar diameter from perihelion to aphelion.
We consider unlikely the possibility that the *Heliotropion,* designed-constructed and used by the excellent geometer-engineer *Meton,* could be only a high pillar, because the projected shadow on the ground is of too much low contrast with very extensive and blurred limits.

THE ZODIAC MONTHS RING RECONSTRUCTION

The division of the *Zodiac scale ring* into 365 equal subdivisions (days) converts it to a *Zodiac Months ring*. Each Zodiac Month begins when the Sun transits (projected on) the Zodiac Sign of the corresponding Zodiac Constellation and its duration is measured in days. The 12 arcs of zodiac months are not equal, because they have a different number of days, due to the solar anomaly. Of course we don't know which data, astronomical map, zodiac signs, observations and calculations about the duration of each zodiac month the manufacturer used.
We assume that on the ancient astronomical map used by the manufacturer, the Ecliptic was divided in 12 equal arcs of 30° each. Each of the 12 zodiac constellations began with its zodiac sign, as usually inscribed on most ancient astronomical/astrological maps of Babylon, ancient Greece and even on most recent maps until today (Theodosiou and Danezis 1995; Rogers 1998; Powel 2006).
For the calculation of the duration of each zodiac month in era of 130 BC (the possible era of the Mechanism's construction) (Freeth et al 2006), we firstly calculate the duration of each seasonal period.
Each seasonal period of three months, started with the date of the corresponding solstice or equinox. According to the ancient Greek calendar (Theodosiou and Danezis 1995), the beginning of every day was the time of the sunrise and for our calculations we used the exact time of sunrise (about 6 a.m. ±1 hour, depending on the season). Using the re-calibrated astronomical planetarium software *Starry Night*

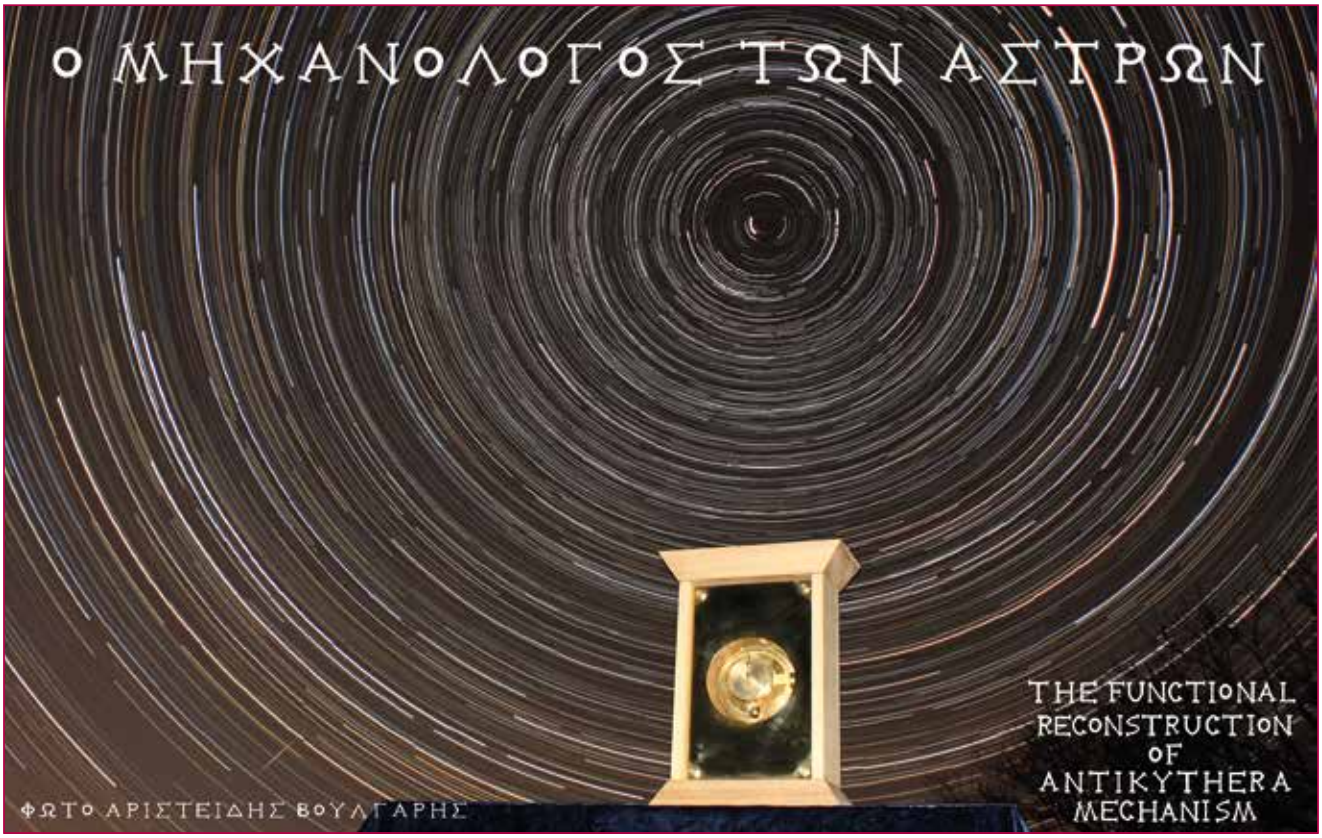

Fig. 15 The Mechanologist of the Heavens. Because of the Earth's rotation the star trails are visible. The total exposure time is about 3 hours.

(https://starrynight.com), we calculated the durations of the seasons and the perihelion/aphelion dates for the years 430 BC (Metonic Era astronomical observations), 330 BC (Callippic Era astronomical observations), 130 BC (possible era of the construction of the Mechanism) and 80 BC (possible era of the shipwreck) (Freeth et al 2006), (Table 1).
As seen from Table 1, the same seasonal period, calculated in different eras, has a different duration, because of the Precession. In every year, each seasonal period has a different duration, because of the solar anomaly. Afterwards we calculated the duration of each Zodiac Month, for 130 BC (Table 2-Fig.12).
In the era close to 130 BC, the autumn season duration was 89 days. The two zodiac months Libra and Scorpio fully preserved on Fragment C, each have 30 subdivisions-days (Bitsakis and Jones 2016). So the duration of Sagittarius (the third zodiac month of the autumn season) must be 29 days. In this way the zodiac month of Sagittarius, has the smallest duration in days, which is in correlation with the fact that it includes the date of perihelion i.e. the date when the Sun's velocity is in its highest value (so the duration of this zodiac month must be shorter).
The duration of the winter season is also 89 days. The duration of the three missing zodiac months of the winter season, were chosen to be of 29, 30 and 30 days respectively. These numbers were chosen because of the gradual decrease of the sun's velocity after the date of perihelion. As a result, the duration of each month of the winter season is in mirror - axial symmetry to the corresponding months of autumn season.
The spring season has duration of 94 days and the summer season of 93 days. In the same manner, we keep the pattern of the axial mirror symmetry of the duration of months with respect to the *line of apsides* (and also close to the Solstices). The month with 32 days (to account for the extra day of the spring season) was chosen to be the zodiac month of *Gemini*, because this month includes the date of aphelion, when the Sun's velocity is in its lowest value. The rest two months of spring season were chosen to be of 31 days each. Also for the summer season duration of 93 days we chose the duration of each month to be 31 days so that the axial mirror symmetry of the duration of months with respect to the *line of apsides* continues to apply.
Another proof of the above calculations is the crucial observation from the Front Dial inscriptions (Bitsakis and Jones 2016). In the preserved part of Fragment C of the constellation of *Virgo*, Bitsakis-Jones report the detection of two subdivision letters (index letters), Ψ on the 19th subdivision engraving and Ω on the 21st. The part of Virgo constellation arc with engraved subdivisions 1-14 is missing and the numbering of the index letters Ψ and Ω was calculated from the existing end of the month, counterclockwise, assuming the presence of 30 subdivisions (for Ψ, *30-12=19th sub. and for* Ω, *30-10=21th sub.*).
On the preserved Fragment 28, detected individual letters may be associated with the constellation of Virgo. Parts of words and two (date) numerals {IC and K[A,B….]} are preserved on fragment 28 (Bitsakis and Jones 2016):
Line 1: *[Zodiacal constellation begins ris]*ing [A]
Line 2: …… (male attribute) *[rises/sets in the even]*ing IC (i.e. in 16th subdivision of the zodiac month scale)
Line 3: …… (female attribute) *[rises/sets in the even]*ing K [A,B…]
Line 4: Rising …… …….E…[K+1, KA+1, KB+1,…]
Bitsakis and Jones suggest the following star events associated with Fragment 28:
Line 1: Virgo begins to rise [A]
Line 2: …… (male attribute) *[rises/sets in the even]*ing IC (i.e. in 16th subdivision of the zodiac month scale)
Line 3: Capella (Αίξ-Αίγα) rises in the evening K or K[A,B…] (20th or 21th, 22nd,…. subdivision of the zodiac month scale) for ''Ψ'' index letter
Line 4: Arcturus rises in the morning [KA or K(B,Γ…..)] (21th or 22nd, 22nd or 23rd, ….) for ''Ω'' index letter
The correlation between Fragment 28 and the preserved index letters of Virgo in Fragment C, leads us to the conclusion that the index letters Ψ and Ω must be at the 20th (K) (Line 3) and the 22th (KB) (Line 4) respectively engraved subdivisions and not at 19th and 21st subdivision. So in the Zodiac Month scale, the arc sector of Virgo, must had 31 subdivisions i.e. 31 days (Fig.13).
If the zodiac month of *Virgo* has a duration of 31 days, then the two previous months should also have at least 31 days each (see below) (because they are closer to the date of aphelion). As a result, the summer season had a duration ≥ 93 days. The 93 days of the summer season is valid for 130 BC, but not for 432, 330 and 80 BC (see Table 1) and also not for the era of 150 BC (according to *Starry Night* program). So the astronomical data used for the construction of the *Zodiac Month scale* by the manufacturer, must originate from observations made at about 130 BC (or a few years later) (Hipparchus age c. 190-c. 120 BC). At that time the access to astronomical information was slow and delayed for a few years, since the publication of the observations was time consuming and expensive. So we believe that the date of the construction of the mechanism was between 125 and 100 BC.
According to Table 2, we reconstructed the *Zodiac Months ring*. The division of the *Zodiac Months ring* scale into 12 zodiac unequal months and 365 equal subdivisions creates unequal arcs of the zodiac months, depending on the number of days in each zodiac month. Therefore with this design, the calculation of the solar anomaly is included in the Antikythera Mechanism mechanical model, without any other assumptions. Figure 14 shows the possible representation of the *Zodiac Months ring* of the front plate with 365 subdivisions of the 12 unequal zodiac months.
Because the *Zodiac Months Ring* was free to rotate, it is obvious that the position of the four seasonal columns of the parapegma does not correlate with the preserved position of the *Zodiac Months Ring* (Price 1974; Freeth and Jones 2016; Bitsakis and Jones 2016). So it is possible that on the top left position of the parapegma, the summer season star events were engraved (*Cancer, Leo, Virgo*) and not the winter season star events, because the Callippic Cycle started at the Summer Solstice (Theodosiou and Danezis 1995, Evans 1998).

ANTIKYTHERA MECHANISM AS A TIMELESS COMPUTER

As we mentioned above, the Zodiac Months Ring was also independent and free to rotate. Although the manufacturer could engrave the zodiac months around the perimeter of the central hole in a fixed position, he did not do so.
The mechanical system of the engaged gears that moved the Moon and the Sun was fixed (''closed'' system), therefore it was impossible to accurately rotate the *Golden Sphere* independently to the *Lunar Disc-Moon* Sphere to any position (date), without disengaging some of the gears. It is obvious that the manufacturer designed the Zodiac Months-Sky, as an independent ring, so that he could quickly set the front plate dial to a specific date (by turning *''the sky''* of the Mechanism) starting the mechanism in any desired date, as a perpetual computational calendar mechanism with very extensive time limits. With this process, it seems that the mechanism had the ability of fast recalibration and of necessary minor adjustments, to account for mismatches

between the actual calendar date and front plate dial indications caused by mechanical errors (Edmunds 2011; Jones 2017) and also the subtraction of the one day in every Callippic cycle (Freeth et al 2008).
Moreover, to move forward in Time, the Mechanism should be rotated clockwise from the *Lunar Disc*. For the past dates, the user needed to rotate the *Lunar Disc* counter clockwise. This change in the direction of the rotation introduced some mechanical problems between the teeth of the gears, a lot of ''backlash effects'' and aiming errors of the pointers (especially in ''slower'' pointers) (Edmunds 2011). All of these errors disappear, if the *Lunar Disc* was continuously rotated (only) clockwise, as the Time moves forward: for a desired date of the Past, the user rotated the *Zodiac Months ring* (just on the desired date) and then continued the clockwise rotation of the *Lunar Disc*.
For example the ancient user could start the Mechanism from the date of the total solar eclipse on 15th August of 310 BC (i.e. during the 20th year of the first Callippic cycle, the first day of the third synodic month of the ancient Greek calendar, in the corresponding 18th day of Zodiac Month of Leo, for 310 BC), known as the *eclipse of Agathocles* (https://eclipse.gsfc.nasa.gov/SEsearch/SEsearchmap.php?Ecl=-03090815 ; www.mreclipse.com ; Stephenson 1997). Firstly the ancient user, via clockwise rotation set the pointer of the *Lunar Disc*, aiming to the *Sun-Golden Sphere* (New moon). Then he rotated the independent *Zodiac Months ring* up to the pointer of the Golden Sphere aiming to the 18th zodiac day of Leo. After this calibration, he started the back dial plate calibration (Voulgaris et al under writing). Finally he rotated the Egyptian calendar ring to the corresponding date. After the calibration of the Egyptian calendar ring, the user knew the dates of the equinoxes /solstices on the corresponding Egyptian dates.
The Mechanism was a *''time measuring machine computer''* (Fig. 15), designed and constructed so as to minimize all the mechanical and calendrical errors. Because of the engraved days on the *Zodiac Months Ring* and its freedom to rotate, we argue that the tropical year was known and in use (as a measured part of the 1/19 of the Metonic Cycle) in Ancient Greece, but the synodic month was more usable in that era. We strongly believe that the Mechanism was constructed for some governmental or administrative authority of that era. This hypothesis is enhanced by the detection of the pointer and the indications of the Stephanites Games, engraved at the back plate of the Mechanism (Freeth et al 2008): several synodic months before the starting date of the *Olympic Games*, the *''spondophoroi messengers''* (Σπονδοφόροι Αγγελιοφόροι) traveled to the Greek cities to announce the starting date of the Olympic Games on the 2nd full moon after the Summer Solstice (Perrotet 2004).
The new findings of the front astronomical dial, shows us that the Mechanism could calculate the positions of the Sun, the Moon and also the Moon Phases and that it entailed all of the astronomical knowledge known in antiquity (Moussas 2009), like a ''bronze astronomical book'', equipped with all the parameters required to perform astronomical calculations, thus making it a real astronomical calendar-time computer.

ACKNOWLEDGEMENTS

We are very grateful to the AMRP for the permission to use the CT X-rays images. Thanks are due to the National Archeological Museum of Athens for the permission to photograph and study the fragments of the Mechanism and the Bayerische Staads Bibliothek for the photo permission of A. Rehm. We would also like to thank Prof. T. Economou of Fermi Institute, University of Chicago, for his suggestions in CTs, prof. E. Vanidhis Optics Laboratory of Aristotle University of Thessaloniki, Greece for his suggestions about the construction of our optomechanical systems. Last but not least to K. Papathanassopoulos and M. Aspridis for supplying some of the raw materials.

Abstract
The present study aims to investigate the astronomical calendar-dial display of the Antikythera Mechanism Front Plate. The design, position and role of the Zodiac ring, are investigated and discussed. Special photographs taken from the ancient prototype, give us new information about the design and operation of the front dial. From these new findings about the Zodiac ring, we conclude that the user of the mechanism was able to easily perform astronomical calculations at any selected time - of past or future date. Based on the new findings during ''The Functional Reconstruction of Antikythera Mechanism Project'' (FRAMe), we reconstructed the new bronze front plate and we placed it in our functional model of the Antikythera Mechanism.

Keywords
Antikythera Mechanism; Front Plate; Zodiac Month; Zodiac Ring Front Dial; Egyptian calendar ring

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COBRA Project: a successful technology transfer and scientific divulgation method

ENEA opens its labs to improve cooperation with SMEs and CH Institutions

By Beatrice Calosso, Roberta Fantoni

The main objective of CO.B.RA Project is to develop and disseminate methods, technologies and advanced tools for the conservation of Cultural Heritage (CH), based on the application of radiation and enabling technologies.

Fig. 1 - Church of San Costanzo in Ronciglione: a detail first and after laser cleaning.

ENEA leads the project as the only institution funded by the Lazio Region to carry out all the activities which started on July the 21st 2015 and will end on December the 20th 2017.
The laboratories involved are dislocated in the Lazio Region ENEA (Frascati and Casaccia) research centres and in Rome Headquarters (STUDI unit); the former belong to 3 Departments:

- Energy Technologies Department
- Fusion and Technology for Nuclear Safety and Security Department
- Territorial and Production Systems Sustainability Department.

The results obtained by COBRA project include: diagnostic activities on sites, prevention of natural and human hazard, new way of fruition CH, performed upon specific intervention requests by stakeholders. Instruments and technologies have been adjusted to the solicitations of end-users, technology transfer demonstrators have been realized and put at disposal of Small and Medium Enterprises (SMEs). The implementation of ICT facilities made easier conserving the acquired data and exchanging the obtained results.
The effectiveness of COBRA has been demonstrated through the results obtained during the experimental campaigns carried out in these sites:

1. Church of Costanzo Martire in Ronciglione: Laser spectroscopic diagnostics and Laser Cleaning on frescoes by Cavalier D'Arpino atelier.
2. Forum Traiani Museum: 3D reconstruction of marble frieze pieces by structured light scanner and photogrammetric relief; Laser cleaning of stone fragments.
3. Roman Domus Valeriorum archeologic site: laser spectroscopic characterization and laser cleaning of frescoes fragments.
4. Bell Tower of the Cathedral and Theatre in Rieti: Structural monitoring by fiber optic sensors.
5. Priscilla Catacombs in Rome: 3D photogrammetry and 3D reconstruction and image processing with SfM technique; 2D / 3D laser imaging of frescoes.
7. Temple of Minerva Medica in Rome: Dynamic structural characterization of the monument monitoring structural risk caused by environmental vibrations; non-destructive investigations.
8. Saint Alexander Catacombs in Rome: Compositional and structural characterization of two frescoes; Photogrammetry; Thermography; vibrometry.
9. Etruscan Necropolis in Tarquinia: Acquisition of the 3D color model by laser scanning and photogrammetry; Laser spectroscopic characterizations of painted walls.
10. Etruscan Necropolis in Veio: acquisition of 3D model by Photogrammetry; Spectroscopic characterization of painted walls; Non-destructive testing application.
11. National Museum of Musical Instruments in Rome: Radiography of wooden historical instruments.
12. Roman National Museum in Rome (Altemps Palace): study of the state of conservation and renaissance restoration works on three roman sculptural groups.
13. Museum of Sarcophagi - San Sebastian Catacombs: laser spectroscopic characterization of Orantorum Sarcophagus prior to a restoration campaign.
14. Aurelian Walls Museum in Rome: data collection via high resolution laser scanner in the guard tower where hardly observable historical inscriptions and graffiti are located.

In this article the methodological instruments used into the project in order to create a new "shared space" - both real and virtual - where Research Organizations, Cultural Institu-

tions and SMEs cold better comprehend and work with each other, are described. Within this shared space, from now on it should be easier to:

- create a common language that combines scientific, technological and humanistic knowledge with the craftsmanship and application expertise;
- meet needs of each other, interacting directly on site, before and during the restoration activities, in order to better plan the intervention and to adapt technologies to suit some specific needs.

In details, the benefits of creating this "shared space" are:

- for SMEs: increasing the supply of innovative technology tools; updating internal skills, by training on the job; accessing laboratories, in order to use instruments which may be expensive or unique, often made available only by public research organizations such as ENEA is.
- For CH Institutions: increasing the methods to investigate artworks through the use of technologies for diagnostic measures; improving the monitoring of the state of monuments “health” in order to prevent risks; reducing maintenance costs thanks to planning focused restoration, due to diagnostic measurements available; access to a long-term repository of row and post-processed data about all the restorations carried out; updating promotional strategies for CH.
- For Research Organizations: approaching CH by working directly on artworks and monuments with restorers: only in this way it is possible to learn about the pragmatic lacks and necessities expressed by both Institutions and SMEs working on sites; testing-phase conduced on site, to develop more effective tools; simplify technologies by creating user-friendly tools (Demonstrators) that meet the capabilities and skills of restorers and experts.

The shared space is formed by:

1. Project Website
2. Demonstrators
3. Open Labs
4. Cloud and Data Storage
5. Focus Group.

It is important to stress the complementarity of these various tools, which firstly provide access to knowledge and information at different levels of details.

Project Website

The website www.cobra.enea.it achieves the aim to provide, with a synthetic and informative language, a valid support to the knowledge about demonstrator's tools and technologies developed in ENEA's laboratories, as well as about the results of their applications. It addresses not only the project end-user (SMEs) and stakeholders (CH Institutions), but also a wide-ranging public. It has been developed using the Content Management System (CMS) open-source Plone, since it has been used for years in ENEA, and also because it allows us to manage the ongoing updating of contents via web.

In the process of designing its main architecture, to define the main areas issues, all the information about the main characteristics of labs involved have been collected by interviewing the ENEA experts researchers and technicians. In order to simplify the scientific contents, the experts were asked to fill a form with fixed fields with specific but brief information about how labs and technologies work.

Therefore, the “National Confederation of Crafts and Small and Medium Enterprises (C.N.A)” was asked to evaluate these laboratories' forms. Thanks to the feedback received from C.N.A., the contents and the website areas have been set up to meet the suggestions collected by SMEs: first focusing on the application and usefulness of tools, and then linking a contact person to email directly.

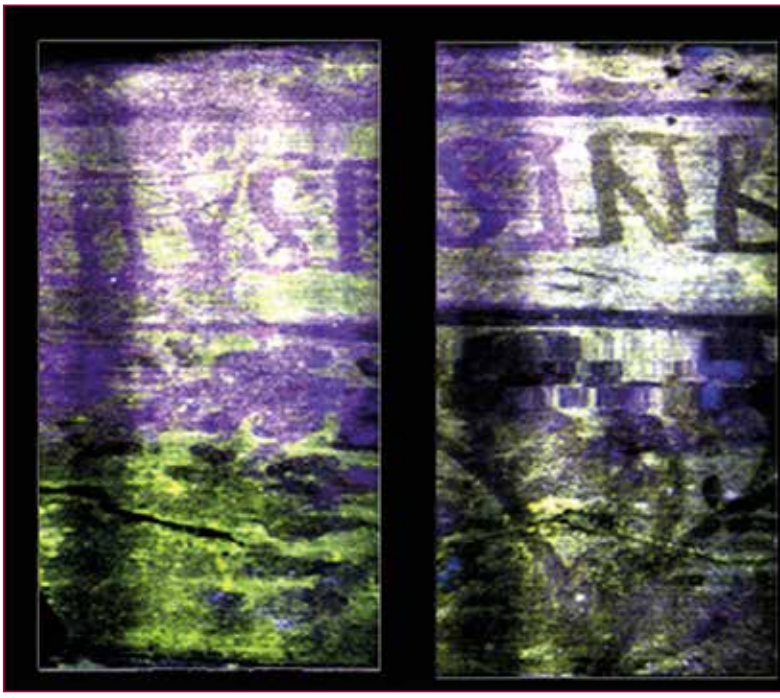

Fig. 2 - Catacombs of Sant'Alessandro in Rome: laser induced fluorescence (LIF) on an inscription.

During the first project workshop, the level of interest of SMEs to the service of ICT provide by ENEA have been surveyed by a questionnaire. The most SMEs had expressed interest to an easy access to information, first of all about instruments and services available. Therefore, even the website's contents have been editing to satisfy these requests.

This website has managed to fill an ENEA internal communication gap, creating a single web point to access the most of technologies and skills on CH in Latium Region.

The website section Laboratories was structured as follows:

- Laboratories for diagnostic investigation;
- Laboratories for the structural characterization and protection from natural hazards;
- Laboratories for the materials and surface's treatment.

Fig. 3 - Priscilla catacombs in Rome: 3D model of the Greek Chapel.

To better describe activities and results two additional sections have been created:

- Interventions: includes forms filled with information about all the campaigns of measures carried on CH, which have been also highlighted on a multimedia map implemented using Web GIS Application.

- Demonstrators: includes forms about technical characteristics of some instruments developed in the project and designed to be used by SMEs on sites. These forms describe also the demonstrarors' innovative functions, situated in laboratories available to SMEs.

Between the site's main sections - Laboratories, Interventions and Demonstrators - there is a close connection, which is pointed out by the numerous internal reference links. In order to explain better Demonstrators' functioning and applications, some available Tutorial's videos have been produced.
The offer of instruments by enterprises collaborating with some labs, is in the section about the Showroom: a staged room (inside Frascati Research Centre) where laser systems are made available of SMEs for laser cleaning texts and experiments. In order to make easier the cooperation with SMEs, a "request for action" form has been designed and it is available on the website Home Page: filling out this, the SMEs and CH Institutions located in Lazio Region can ask ENEA to cooperate on a specific intervention.
For foreign public relevant pages have been translated in English.

Fig. 4 - Mercati di Traiano - Museum of Imperial Forums in Rome: 3D reconstruction of the Sphinx Frieze by structured light scanner.

DEMONSTRATORS

User-friendly prototypes have been implemented during the project in order to be used by SMEs' restorers and technicians. New functionality, applicability and usability are the main features of these instruments. In some case, Demonstrators are manufactured for specific actions which need new and mobile instruments, easier to be used than the most advanced technologies already available at ENEA. In other case, fixed tools available only in labs, have been customized to fit the most common way-of-working for CH professionals. The companies interested to test them and to learn their functions can contact directly the developers.
List of Demonstrators:

1. COBRAKIN: 360 degree and 3D real-time video for monitoring and surveillance of internal environments (e.g.: museums)
2. SPRITZ: Terahertz Imaging Spectrometer, for morphological and chemical characterization
3. Dynamic and structural monitoring by optical fiber sensors FBG
4. J-SYSTEM SMART - optical fiber sensors integrated into structural elements for permanent monitoring
5. CALIFFO: Laser induced fluorescence measurements
6. PIXE: Particle Induced X-ray Emission, based on proton accelerator
7. LIRA: Laser Induced Breakdown Spectroscopy and RAMAN Spectroscopy Integrated System
8. LINAC: LINear Accelerator for volume treatments to remove biodegradation and organisms on the first layers of artefacts (paper, canvas and wood).
9. SAGACE: Software for Algorithms for Management, Statistical Analysis, Comparison and Elaboration of spectrographic data in image format.
10. DREAM: Multiple Excite Raman Demonstrator.
11. Demonstrator of handling and transportation of art works.
12. Demonstrator of tests on vibrating table.

OPEN LABS

Since some ENEA labs are not usually open to everybody, due to safety and security matters, another goal of the project has been to make possible sharing of technologies and remote fruition of experiments. Thus, a network of webcams has been supplied into the labs to allow video and data streaming on the web. Moreover, the integration between streaming and archiving systems will allow everyone to see experiments in a delayed time.
Structural Dynamic, numerical Simulation qualification tests and vibration Control - DySCO is the first example in Italy of Virtual Lab for remotely shared experimental tests on a network platform consisting of two large scale oleo dynamic seismic tables and two electro dynamic shakers. Within COBRA project a 3DVision system was recently updated with new NIR cameras and ICT tools were integrated to improve data sharing and streaming by the Cloud E3S.(Mongelli, 2016).
Cloud E3S ENEA Staging Storage Sharing System
E3S is a Staging Storage Sharing System for Data Handling in a multisite laboratories and organizations designed by ENEA ICT experts, in order to meet the needs of researchers, technicians and specialists working on CH. In large organizations the laboratory experiments produce a huge amount of data and their processing and storage management are a challenging issue. Cloud architectures are exploited for storage solutions and data sharing as well, in order to realize a collaborative worldwide distributed platform. Whilst large experimental facilities manage themselves ICT resources such as: compute, networking and storage, small experimental laboratories are demanding more and more resources for their

own scientific instruments aided by data acquisition and control systems, especially in terms of storage and sharing/publishing data solutions. E3S system has been developed over the ENEA GRID infrastructure using OwnCloud as architectural component for file syncing and sharing. E3S provides a homogeneous platform able to store and share heterogeneous data produced by many different laboratories geographically spread on several sites and working on collaborative tasks. The systems for CH diagnostic include computer aided instruments, producing a huge amount of raw data that need post-processing analysis. The different diagnostic instruments generate a large variety of data, spanning from slow time-series to high frequencies sampling, to 2D and 3D scans and so on. Experiments are often carried out on the CH site and the data acquisition systems are remotely controlled. The structure of the raw and post-processed data of all diagnostic instruments has thus a high complexity, and designing a common data model for an uniform data access is not a convenient strategy. A solution was designed in order to hide the data structure complexity allowing users to store data in local staging areas and synchronize there with distributed filesystems for worldwide sharing. In this way the data integrity is guaranteed, whereas the security is provided by the single-signed on authentication/authorisation system that includes also the Access Control List for storage areas (Iannone, 2017, pp. 1-3).

Access via data-sharing by authorized external users through the cloud-sharing system is guaranteed by the middleware node, accessible from any location. The E3S interface allows the data manager to define the data sharing policies in a simple and secure way. This architecture fits well with the CH needs, where the results of the experiments have to be shared - in a safe way - with a number of different subjects: authorities, restorers, students, etc. The actual data repository over time can also be threatened by the rapid obsolescence of technologies. To overcome this future problem the data have to be accompanied by metadata about format, acquisition equipment and software used in post-processing. These solutions include also physical backup strategies and proper disaster recovery procedures (Calosso, 2016, pp. 24-29).

FOCUS GROUP

Since the project is addressed to implement different ways to engage technical collaboration with regional end-users, meetings were held using the Focus Group (FG) approach. During three FG meetings the actors of the CH chain have been given the opportunities to face and discuss altogether specific issues about the use of technology.

The FG methodology is based on interactions, focused on a given subject, between selected groups of people, by interviews aimed at an in-depth exploration of opinions, motivations and attitudes, highlighting the elements of convergence. It is a very common technique used in social research, usefull to have an overview of a given situation in a short time and with low investment.

REFERENCE SCENARIO

THEMATIC AREAS	SCENARIO 1 TECHNOLOGICAL ACCELERATION POLICIES	SCENARIO 2 TECHNICAL TRANSFER POLICIES	SCENARIO 3 INNOVATION DRIVERS ENTERPRISES	SCENARIO 4 COMPANY NETWORKS
Development and management policies sector	Main solutions from the public sector	Main solutions from the public sector	Main solutions from the private sector	Main solutions from the private sector
Economy and market	PA subsidies and rewards in the most innovative technology announcements.	PA subsidies to create business networks and to access technologies at low cost.	Companies fund research and get technological innovation.	Companies aggregate in competitive multiservice networks.
Innovation and technology transfer	Technological innovation key role. Public research speeds up.	the public sector helps strategic organization of knowledge and skills	Technological innovation key role. Private research speeds up.	Strategic organization of knowledge and skills made by companies.
Impact on PAs and companies	The most innovative companies remain on the market; small non-specialized operators disappear. PA invests in upgrading and training specialists.	Business networks become industry lobby. PA defines new professional figures.	More forward-looking companies innovate and operate on a global scale. PA adjusts to progress.	Companies adjust to technological innovation as needed. PA more receptive to innovation.

Through COBRA FG it has been possible to identify problems and barriers to the development of a successful technology transfer process, looking for their causes and then plan actions for overcoming them. In fact, the analysis of opinions has been aimed, in one hand, at comprehending the level of acceptance of the new technologies already established and, on the other hand, at exploring what are the new tools that CH operators really need.

Stakeholders operating on Lazio Region have been pre-selected to participate to FG Cobra from the following lists:

- National Institute for Conservation and Restoration (ISCR)
- Italian Restorers Association (ARI)

Fig. 5 - Roman National Museum: Two Demonstrators during measurements on sculptures: imaging system and line scanning system.

- Italian Association for Architectural, Artistic and Urban Restoration (ASSORESTAURO)
- National Anti-Corruption Authority (ANAC)
- The list of enterprises available on the website “Lazio Futouring” of the Technological District for Cultural Heritage and Activities of Latium Region.

THE FIRST FG

An investigation on existing and potentials networks of SMEs and other relevant stakeholders in CH was conducted. Thus, it was possible to analyse dynamics that can affect the transfer of technological innovation.
Because of one of the FG's success requirements concerns the presence of well-informed participants, before the FG two project workshops were organized: the 1st workshop main purpose was to present the project aims; the 2nd was about the preliminary results of activities carried on artworks. Before and during these workshops a survey was done to better know who were the end-users and the stakeholders, in order to subdivide FG participants into three homogeneous groups:

1. ICT companies, fruition, valorisation and technical
2. Restoration and construction companies
3. CH Institutions and Research.

Each group worked with the help of a facilitator and with the support of some ENEA experts involved in the project. In the 1st phase each participant was asked to illustrate the role and weight the technologies currently have in his work. Therefore, the advantages and obstacles perceived about the use of technology were talked about. Then, the results of the work made by each group was shared with all the other 2 groups with brief presentations.
The 2nd phase started with the presentation, made by ENEA experts, about:

1. Diagnostic analysis aimed at treatment of materials and surfaces
2. Structural characterization and preservation by natural hazards
3. Fruition of 3D models and digital data storage.

The participants were divided into 3 groups focused on these 3 research areas. First the "concrete" interest in these areas, and then the barriers that the specialists could encounter using the related tools and technologies were highlighted. The debate was very useful, since relevant clarifications were provided by ENEA.
Finally, all the participants were asked to suggest some solutions for an efficient technology transfer strategy: creation of a database; easy access to application experiences; a greater adaptability of equipment to various contexts of use; a stronger support for training about upgraded tools and a real valuation by public administration (PA) of technological instruments in use.

THE SECOND FG

It has focused on the definition of a scenario shared between participants at a regional scale, in order to define a future technology transfer common strategy. The methodology used was the “Planning Scenario”: a strategic method that organizations use to make their long-term plans flexible. It allows us to imagine what might happen to be ready to face or address problems and variations. It does not concern the prediction of the future but rather intends to describe what is most likely to happen based on the status quo assessment. It allows us to associate specific problems with those who have the responsibility to resolve them. It is the only method of participation officially recognized by the European Commission with a registered trademark: European Awareness Workshop Scenario, EASW®.
Few days before the FG, some Reference Scenarios were preliminarily proposed at all the invited participants:
At the beginning, participants were divided into 2 groups, each of whom were asked to imagine being in 2027 and to assume that through the COBRA project the technical-scientific outcomes have been successfully transferred to Lazio Region's SMEs, enhancing their ability to compete. Each group discussed about what strategies have been activated and by whom, for economy, market, innovation and technology transfer. Finally, the participants were able to elaborate their specific scenario for the medium to long term, with actions and indicating who can take the responsibility to promote their realization.

THE THIRD FG

The Logical Framework Approach (LFA) methodology was used in order to identify the priorities to be implemented in a scenario which was shared with all the operators. LFA was developed in the second half of the 60's by the US Agency of International Development to improve the planning and evaluation system of projects. It is currently widely adopted by the EU Commission for the identification of strategies and projects within the Community.
The LFA method involves two phases:

1. SWOT analysis of the present situation: a strategic planning tool used to evaluate strengths, weaknesses, opportunities and threats, based on which it is possible to imagine how the situation could develop in the future.
2. Plan of actions necessary to achieve future goals, to ensure the feasibility and sustainability of the scenario. In this phase, the European Awareness Workshop Scenario (EASW) method is used to find an agreement between stakeholders.

The work, articulated in 2 groups, was based on the results and, above all, on the scenarios already shared in the second FG. Each group worked on 2 strategies:

- Group A
  Strategy 1: Support for the aggregation process of operators;
  Strategy 2: Promoting innovation and technology access by SMEs.
- Group B
  Strategy 3: Increased investment and demand for "highly qualified" interventions with high technological know-how;
  Strategy 4: Create a DB; training specialists with a multidisciplinary approach.

Then, for each strategy were identified general objectives (long-term benefits for CH and society), specific objectives and the activities, through which the strategy will be implemented by actors, and also the beneficiaries.
Finally, each strategy was shared with both groups. It is important to emphasize that the shared scenario is at the base of the synthetic document "Acts on strategic and shared actions for innovation and technology transfer in the cultural heritage sector of Latium Region". This document may support the Region in drafting new funding calls for projects on "Technologies for CH".

CONCLUSIONS

The project is concluded, thus, we are able to say that all its goals have been achieved thanks to the technology transfer methods and scientific divulgation instruments used. In particular, into the “shared space”, both real and virtual, which has been created, even after the end of COBRA, it will be easier:

- The interaction between SMEs, Research Organizations and CH Institutions, in order to better plan different interventions on monuments and artworks
- The development of specific scientific skills and new and more efficient technologies for CH
- The construction of a bigger network made up of labs integrating interdisciplinary skills and tools, that has to be opened to enterprises, researchers and public institutions, for instance within the new DTC of Latium Region.

Meanwhile the ENEA labs are becoming an hub for, on one hand, the institutions which need much specific and high level interventions and, on the other and, for the SMEs which are not strong enough to make research by themselves.
In conclusion, the method used to create this "shared space" could be easily reused and replied also in other local and national contests, even with different historical and CH conservation issues.

ACKNOWLEDGEMENT

The participation to the COBRA project of Salvatore Almaviva, Giulia Bazzano, Irene Bellagamba, Francesca Bonfigli, Fabio Borgognoni, Luisa Caneve, Michele Caponero, Sofia Ceccarelli, Massimiliano Ciaffi, Monica Cimino, Francesco Colao, Rosaria D'Amato, Gerardo De Canio, Mauro Falconieri, Andrea Fidanza, Vincenzo Fioriti, Massimo Francucci, Serena Gagliardi, Gabriele Giovanetti, Massimiliano Guarneri, Francesco Iannone, Flavio Miglietta, Silvio Migliori, Marialuisa Mongelli, Rosa Montereali, Laura Padovani, Ester Palombo, Antonio Palucci, Antonio Perozziello, Franca Persia, Samuele Pierattini, Adriana Puiu, Andrea Quintiliani, Roberto Romano, Ivan Roselli, Claudio Seccaroni, Valeria Spizzichino, Angelo Tatì, Monia Vadrucci, Maria Aurora Vincenti made possible to achieve the results here presented.
The support from Ecoazioni (Massimo Bastiani and Virna Venerucci) is acknowledged for the Focus Group actions.

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Abstract

The article describes the technology transfer methods and scientific divulgation instruments through which COBRA project has achieved its main goal: the diffusion and transfer to SMEs, operating in the field of Cultural Heritage into the Lazio Region, of ENEA technologies and skills available in the laboratories at the regional research centres, by developing also specific instruments. Most of these instruments have already been applied with success in interventions on different types of artworks, such as archaeological sites and frescos.

Keywords

Technology Transfer; Open Labs; Cloud; Focus Group

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NURNET - GEOPORTAL

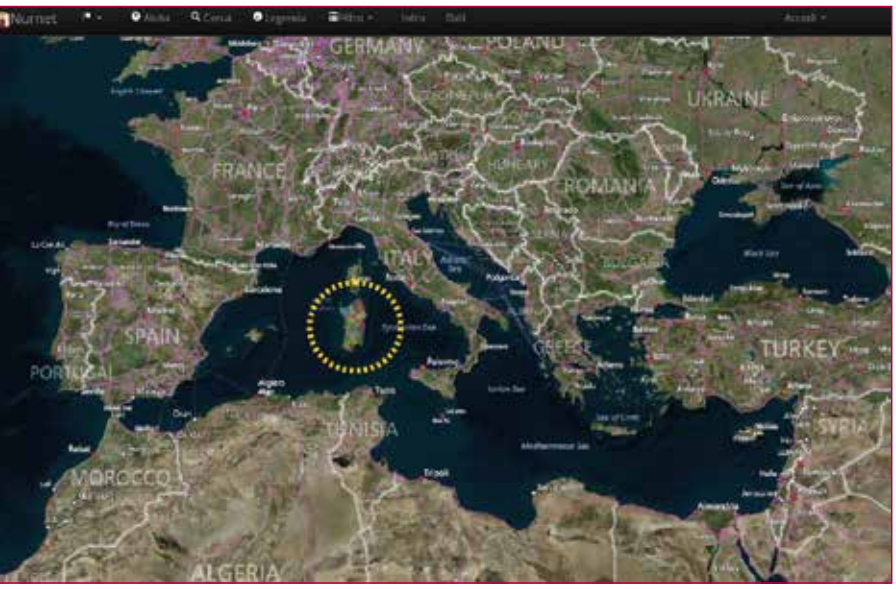


Fig. 1 - The island of Sardinia in the centre of Mediterranean basin.

by Valentina Spanu, Eva Barbara Lorrai, Laura Muscas, Roberto Demontis

The scope of this paper is to explain how the Geoportal Nurnet (net of Nuraghes, the typical Sardinian building from the Bronze Age) has been developed to manage, share and promote the Bronze Age culture in Sardinia, identified in the Pre-Nuragic (3200–2700 BC) and Nuragic (up to the 2nd century AD) civilization .

A cultural heritage landscape is defined geographical area of cultural heritage significance that has been modified by human activities and is valued by a community. A cultural landscape involves individual heritage features, such as structures, spaces, archaeological sites and natural elements that together form a significant type of heritage form, distinctive from that of its constituent elements or parts (Ontario Heritage Trust, 2012).
The promotion and protection of cultural heritage landscape are an inseparable binomial. Thanks to sophisticated programs and the web, the main goals of cultural inheritance conservation and the accessibility to the historical knowledge are easier than before. It is very important to make data available to the public and/or to help the production of new knowledge. For this topic, CRS4, by means of GIS, developed the Geoportal Nurnet. Here, the users may have an active role improving the quality and quantity of existing data. A mobile app has been designed to run on Android smartphones and allow the user to get information also when the device is offline. As a main goal, Nurnet wants to empower the identity link between local population, the relative cultural heritage landscapes and the awareness of their different possible interpretations; this would be impossible to reach without a proper data collection: the philosophy of the project is working with open GIS data. Other two objectives aim to provide useful information to mobile application via API (Application Protocol Interface) and to provide new information and feedbacks from tourists.

THE CHOICE OF A GEOPORTAL TO PRESERVE/PROMOTE SARDINIAN HISTORY

The Nuragic civilization developed in Sardinia from the Bronze Age (18th century BC) to the 2nd century AD. The name comes from the most distinctive expression of their architecture, the tower-fortresses, 'nuraghes' (Fig. 1).
It is estimated that there are about 8000 Nuraghes, more than 2400 Domus de Janas (literally "house of the fairies", pre-Nuragic chamber tombs) have been discovered, more than 50 holy wells, 800 giants' graves, more than 300 menhirs, and 78 dolmens (https://en.wikipedia.org/wiki/Nuragic_civilization; Lilliu 2006; Dyson and Rowland 2007).
The use of digital map libraries and so called 'geo-portals' as tools for the conservation of cultural heritage is relatively new (Fernández-Wyttenbach et al. 2007; Cuca et al. 2012; Karabegovic et al. 2012) but it is already giving positive results, demonstrating the multiple advantages of the Web Map Services (WMS) (Cuca et al. 2013).
The creation of the geoportal Nurnet was aimed at several benefits: a more accurate database of the Nuragic archaeological sites of Sardinia, facilities to retrieve internet information concerning this topic, make use of the strengths of Participatory GIS (PGIS) and Crowdsourcing, so providing local governments with a concrete base on which to plan and set up activities to protect and promote the historical heritage, improving services for tourists and visitors.
The Nurnet Geoportal, accessible via the web and provided with functionalities allowing citizens, tourists, associations, institutions an interactive access to the data in a PGIS perspective, has been created as a tool for the management and sharing of knowledge about the Nuragic and pre-Nuragic cultural heritage of Sardinia. Through the portal it is possible to visualize all the elements in the map, consult information regarding selected elements, let confirmed users modify the current information,and add new elements (nuraghes, menhirs, giant's graves, etc.). It is distributed with Creative Commons Attribuzione 4.0 Internazionale Licence.

WEBGIS AND CROWDSOURCING

The use of WebGIS and crowdsourcing for research is a new practice, but it is gaining in popularity given the facility in

collecting and cross-checking data (Ballatore and Bertolotto 2011; McCall et al. 2015). It has been shown to be extremely useful in monitoring processing in several fields: vegetation cover (Guidry 2011), collecting and recording local names for rural areas (Rampl 2014), promoting environmental awareness and change (Spanu et al. 2015), and providing timely data that may otherwise be unavailable to policy makers in soil and water conservation management (Werts et al. 2012).
The case study of Nurnet presents multiple reasons supporting the use of these technological resources to reach the main goal of the promotion and protection of cultural heritage in Sardinia. Firstly, there is an absolute need to collect better information in a territory where numbers and data are still imprecise.
Data collection of the historical heritage of Sardinia of the Bronze Age is a constant 'work in progress'; oftentimes the only way to get more information is to elicit local knowledge and gather the 'historical memory' of the people, seeking to understand the connections between names and places, that is, the relevant science of "toponomy", defined by the UNGEGN, the United Nations Group of Experts on Geographical Names, as "Place names as intangible cultural heritage" (UNGEGN 2015).
The people who know the territory most comprehensively and who can provide accurate information are the local people. Through webGIS and crowdsourcing therefore it is possible to collect detailed information about what is called "cultural natural landscape", testifying to those places that represent the "combined works of nature and of man" (WHC 2015) and embracing a diversity of manifestations of the interactions between humankind and our natural environment. Information collection from local people is needed, in order to record the history and memory of the traditional cultural landscapes (WHC 1972). This cooperation between the two sets of actors, experts and local citizens, leads to another key point that is also one of the key statements of the project: the cultural identity of the local people, which is a component of cultural heritage and its protection. Indeed, while they are helping in the process of information collection, the local participants can rediscover their own roots and keep alive their cultural heritage, cultural landscape and memory (McCall et al. 2015), also making it available to younger generations. Consequently, the preservation and the monitoring of the historical sites also benefit.

Preservation and monitoring

In the operationalization of the Nurnet platform, the processes of preservation and monitoring of the archaeological sites are performed both by experts and local volunteers. Experts collect data and information, record the state of conservation of specific sites, structures and artifacts, monitor the various types of tourism and the expectations of visitors, analyse the impacts of visitors on sites and structures and the risks of deterioration and degradation, and suggest protection measures for the public bodies in charge of conservation.
Local people and tourists contribute considerably to these processes: local people supplement and complement the basic information about the archaeological sites, but also because they live in the locality, they are the first people to recognize the state of conservation and any changes in the sites which require maintenance from technicians; tourists contribute to the preservation and monitoring processes as well, specifically because they have fresh eyes and externally-formed opinions. Because they visit a site for the first time or only occasionally, they notice things from an external (visitor's) point of view: the state of conservation, comparisons with other places they have visited, hints on how a place might be valued by other visitors, services needed to allow

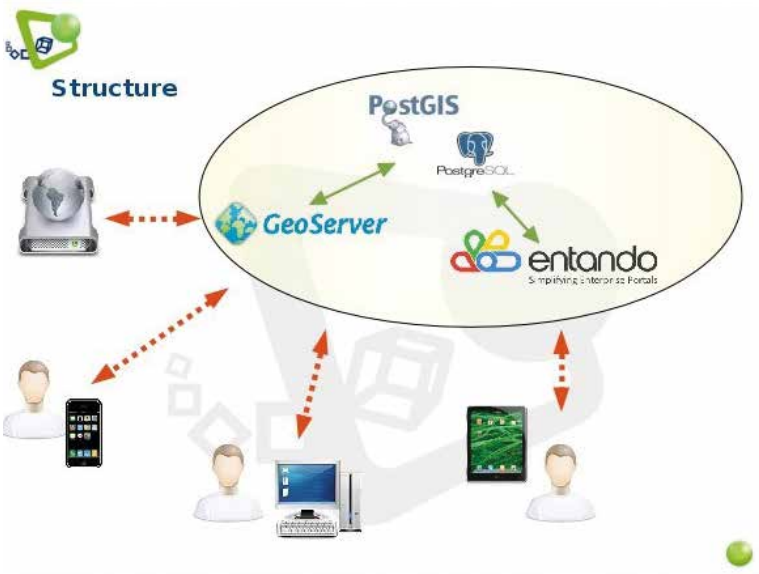
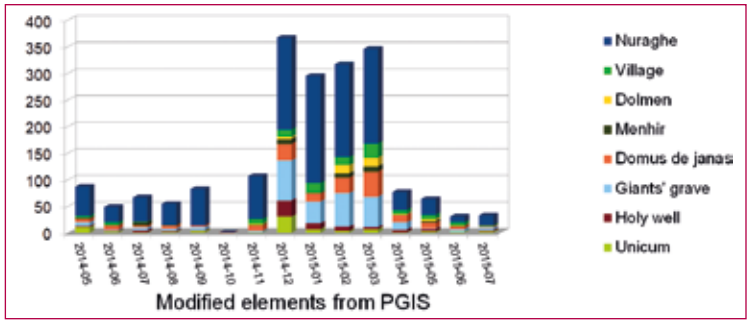


Fig. 2 - Structure of the Web Portal: a CMS based on the Entando platform with the support of the PostgreSQL DBMS and Geoserver for the Web-GIS interoperability.

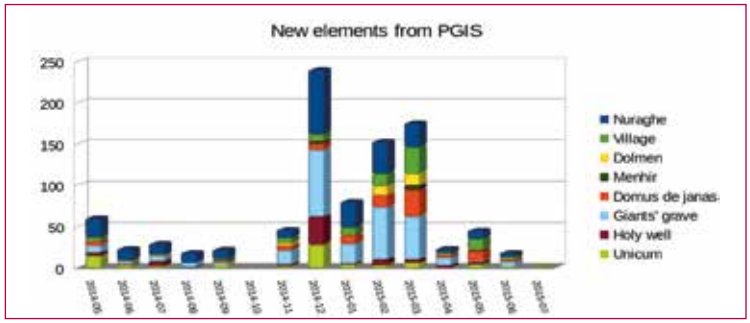
better access for e.g. elderly people, disabled, children. Tourists are actually the actors perceiving the archaeological site as users of goods and services, so their perception and feedback are extremely significant for protecting and monitoring the historical sites as places of touristic attraction. The Nurnet apps for smartphones can thus contribute to monitoring whilst they are being used for exploring the historical landscape.

OPEN SOURCE, OPEN DATA AND OPEN SERVICE

Implementation of the Nurnet Geoportal is in line with the "Open source" philosophy - the software used to realize it is open source, and the published data are open data available via open services.
The choice of the "Open" philosophy is derived from the choice of Participatory GIS as the engine of the Geoportal. The participation of local people and visitors in making and sharing the knowledge implies an open infrastructure that is able to involve a large number of people so as to ensure a significant data set.



Tab.1 - New elements created in the period May 2014--July 2015.



Tab. 2 - Modified elements in the period May 2014--July 2015.

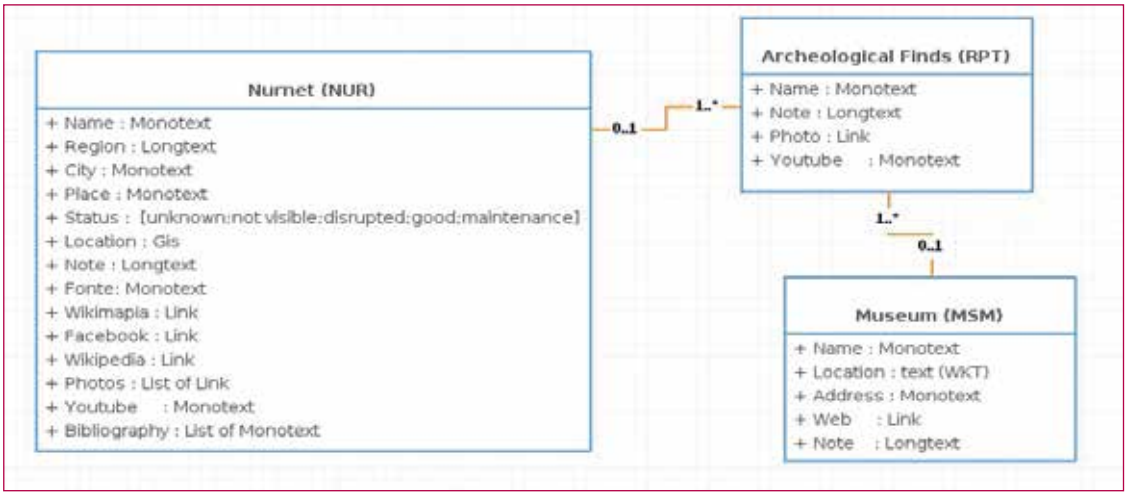


Fig. 3 - Structure of the entities and their relations.

Applying an "open philosophy" approach by itself does not guarantee the quality of the data. For this reason, after their input in the portal by the users - who are also editors - the data items will be validated by an expert before being published. The validation mechanism is similar to that used in Wikipedia for instance, though somewhat more restrictive.

ORGANIZATION OF THE WORK AND STRUCTURE OF THE GEOPORTAL

The idea of a geoportal was born in the beginning of 2014. After a first stage of data collection and project design , it was implemented and published on-line in beta version in June 2014. The interest that this instrument generated was immediate, thanks also to the Nurnet Foundation activities. This indicates that participatory solutions benefit from the direct involvement in data management of local people, local organizations and visitors.

The organization of the work for the development and management of the Geoportal has been structured as following:

1. data collection from all available sources (databases of Regione Sardegna (http://www.sardegnageoportale.it/webgis2/sardegnamappe/?map=base) and Wikimapia (http://wikimapia.org/#lang=it&lat=39.622615&lon=9.225769&z=9&m=b&tag=37157), cross checking, filtering and cleaning from imprecise data or double records,
2. new data model definition,
3. extraction, transformation and loading of collected data into a geodatabase
4. planning and implementation of the Participatory GIS web instruments
5. deployment of the Geoportal
6. monitoring and promotion

The virtual machine where the system resides has 24GB of ram and 500 GB of disk storage. The operating system is a Linux Ubuntu Server 14.04.

The portal (Fig. 2 shows the structure) is essentially a CMS (Content Management System) based on the Entando Platform (http://www.entando.com/) with the support of dbms PostgreSQL (http://postgresql.org/) and PostGis (http://postgis.net/) functionalities.

The CMS allows the dynamic management of the data model in terms of: taxonomy, the categories of contents; content types, the content structure; and relations between contents and languages for textual description. At the same time the presentation layer is easily modifiable.

DATA MODEL AND DATA SHARING

The Data Model consists of three types of entity: "Nurnet" the archeological site, "Museum" and "Archeological Finds". The relations between entities are shown in Figure 3 where the attribute of "Mono Text" is a non-translatable text, "LongText" is a translatable text with a maximum of 500 characters, "Monolist" is a list of elements, "Link" is a web link. The attribute "Youtube" in the "Nurnet" entity contains a Youtube video code. Currently no data are collected for the "Museum" and "Archaeological Finds" entities. Each "Nurnet" entity has a category. As shown in Figure 4 there are 8 macro categories and 14 sub categories.

The Geoportal is multilingual, so all the textual attributes can be inserted for any chosen language.

In the realization of the Geoportal, special attention has been placed on the mechanisms and instruments for data publishing. Firstly, the Nurnet API was created for data sharing and management. Later the Geoserver (www.geoserver.org), an Open GIS Consortium (OGC) Web Service Compliant application, has been added. Obviously all the available data have metadata that describe their genealogy and properties. An example of the use of Geoportal data in mobile device is the "Nurnet Map" App developed for the Android environment. The App can be found in Google Play Store (https://play.google.com/store/apps/details?id=cordand.nurmap).

RESULTS AND SUSTAINABILITY

One year since beginning activities Nurnet Geoportal has 96 editors of content and 15 validators. The number of daily unique users of the data is around 50, with peaks of 200 and more in periods near to festivals. The total number of catalogued archaeological sites is 7800, of which 2032, approximately 25%, have been edited and validated.

The archaeological sites and structures, categorized by type, are shown in Tab. 1 and Tab.2. They show the editing activity, using PGIS, from May 2014 to July 2015. In particular, Tab.1 shows the new elements created and Tab.2 those added to the Geodatabase.

Note: in October 2014 only one log-in to modify elements was registered because the server was under maintenance.

Even though it is based on open source software, the system nevertheless has costs, both in terms of financial resources and people with appropriate skills for its management. In order to guarantee the long-term sustainability of the project it is necessary to consider some forms of support. The main cost is the maintenance of the portal that requires certain competencies.

At the moment, the sustainability of the Geoportal Nurnet is guaranteed by voluntary work and research activity but it is clear that a web solution with a discreet favour (successful application of web services) also has some intrinsic potentials if it is possible to apply analytic tools similar to Google analytics. It is clear that the users' data request to data indicates an interest to a specific archaeological site

of Nuragic and pre-Nuragic period. Furthermore, a user data request can have his geolocation.
The analysis of the user data requests can contribute to the development and selection of indicators regarding the attractiveness of the sites, other than only the site-accessibility indicator; and this can help identify their potentials as economically-valuable touristic resources.
This approach to evaluating the attractiveness of the archeological sites is essentially empirical, therefore CRS4 and the Nurnet Foundation are working to implement a statistical model based on structured data related to tourist access and available tourist services.

FUTURE DEVELOPMENTS AND CONCLUSIONS

Main objective of the Geoportal is the promotion of the cultural heritage landscape in Sardinia.
Future works may include providing more than one language for the textual descriptions and the implementation of a statistical tool, a sort of decision support system, to help the managers of archeological sites to diagnose the attractiveness of a site, the changes over time, and comparisons with managed and unmanaged sites. Finally the API of the geoportal will be extended to better manage the feedback from users.
There are many social webs that permit to create and share GIS data (e.g. Wikimapia, OpenStreetMap, Google, etc.). The main idea of Nurnet Geoportal is to create a more accurate and reliable database with a better taxonomy and descriptions of the sites, which will be built on the inputs of the population living in the territory.
The results obtained highlight that the participatory process is a bottom-up approach: it is linked to a local territory and to an issue realized through the direct involvement of local NGOs in the data management and they will be the organizations who will use the data in order to manage a sustainable tourism in the sites interesting from an archaeological point of view. It is also very important to detect where the tourist attractions are not easily accessible to people (Demontis et al. 2013). This approach gives positive results in terms of quantity and quality of the data, and in terms of involving the local population in the production of the data, and thus helping to empower them.
The methodology employed is flexible and replicable for other territories and for other topics.
Finally the Geoportal can be managed in a cloud environment at a relatively low cost. Its success in terms of user access can generate a lot of useful information for the analysis of tourism flows and for regional spatial economic management.

Fig. 4 - Nurnet archeological features type as listed in the Geoportal legend.

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ABSTRACT

CRS4 (Center for Advanced Studies, Research and Development in Sardinia) developed the Geoportal Nurnet (http://nurnet.crs4.it/nurnetgeo/) to manage and share information about the Bronze Age in Sardinia (Italy).
The scope of this paper is to explain how the Geoportal Nurnet (net of Nuraghes, the typical Sardinian building from the Bronze Age) has been developed to promote the Bronze Age culture in Sardinia, identified in the Pre-Nuragic (3200–2700 BC) and Nuragic (up to the 2nd century AD) civilization. It is fed by a net of conventional social connections and social web networks empowered by private citizens, agents and public administrations sharing the same goals and interests.

KEYWORDS

cultural heritage landscape; public participatory gis; geoportal; Sardinia; archaeology

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Aerial Ostia. Before and After E42

by Massimiliano David, Gian Piero Milani, Roberto Cassanelli

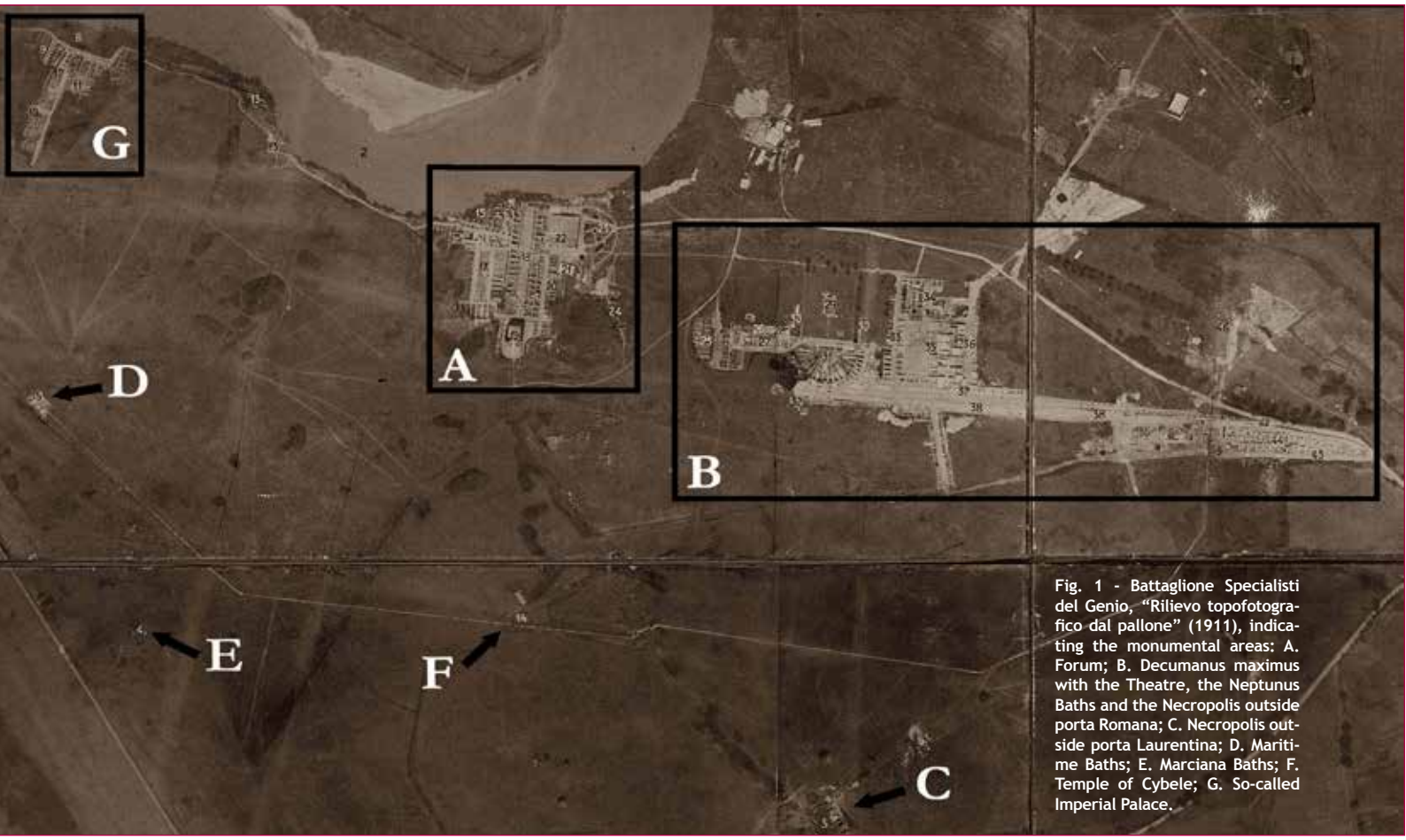

Fig. 1 - Battaglione Specialisti del Genio, "Rilievo topofotografico dal pallone" (1911), indicating the monumental areas: A. Forum; B. Decumanus maximus with the Theatre, the Neptunus Baths and the Necropolis outside porta Romana; C. Necropolis outside porta Laurentina; D. Maritime Baths; E. Marciana Baths; F. Temple of Cybele; G. So-called Imperial Palace.

The research hereby presented on the history of Aerial Photography of the site of Ostia (Rome) has been carried out in the framework of the activities of the Ostia Marina Project, archaeological mission of the University of Bologna, active by ten years in Ostia[1].

This paper aims to analyze the development of aerial photography in Ostia, with a particular focus for the importance of such material for the study of the evolution of the archaeological area, of its surroundings and of its landscape. During an extensive research in the funds of the *Aerofototeca Nazionale* of the Italian Ministry of Cultural Heritage[2], fifteen photos have been identified, covering a time range from 1911 to 1983.

THE MATERIAL

Between the end of the XIX and the start of the XX century, Italian archaeology gets acquainted to the new technology of aerial photography. After the groundbreaking experience of Giacomo Boni in the Roman Forum from 1899 onward, along with the development of specific abilities in the Photographic Section of the Military engineering division[3], aerial photography started to be systematically used for the study of sites like ancient Ostia and Pompeii (Stefani 2008).

For the history of aerial photography at Ostia 1911 is the starting point, with the *Rilievo Topofotografico dal Pallone* ('Topophotographic relief from balloon') (Fig. 1): a huge photomosaic carefully studied by Elizabeth Jane Shepherd (Shepherd 2006).

Ostia will see another campaign of aerial photography in 1934 by the SARA company, and during WWII will be covered twice by the runs of the British Royal Air Force (RAF), in 1943 and 1944. In the second half of the XX century we have three photographic campaigns by the SARA company under different names: ETA in 1953; SAF in 1964; again SARA in 1983. The Geographic Institute of the Italian Aviation has covered the area of Ostia in two different runs: 1957 and 1960.

Catalogue of the studied material

Year	Author	Frames
1911	Italian Army	1
1934	S.A.R.A. (Società per Azioni Rilevamenti Aerofotogrammetrici)	2
1943	British Royal Air Force	1
1944	British Royal Air Force	1
1953	E.T.A.	2
1957	Italian Air Force	1
1960	Italian Aviation	2
1964	S.A.F.	3
1983	S.A.R.A.	1

DANTE VAGLIERI AND THE RILIEVO TOPOFOTOGRAFICO

The arrival, in 1907, of Dante Vaglieri[4] to the direction of the Office for the excavations at Ostia starts a new chapter in the history of the research in the site[5]. Vaglieri arrives in an area which has seen for century spoliations, depredations and by the XVIII century excavations conceived as treasure hunts to feed the enormous market of antiquities, whose fortune increased impressively with the spread of neoclassical taste[6]. The result of the activities carried out in the area for centuries was a site marked by the presence of isolated groups of ruins, separated by hills shaped by the still interred buildings, with a substantial lack of knowledge of the urbanization and history of the ancient city in its complex.

The answer of Dante Vaglieri to this condition consisted in the development of a real program of works, enunciated in his foreword to Lodovico Paschetto's book *Ostia colonia romana* (Paschetto 1912). "My program is threefold, and under these three points of view I will consider this excavation: 1) complete the excavation of the partially digged out buildings, taking care in the meanwhile of the preservation of all the ruins previously unearthed; 2) connect isolated groups of ruins; 3) through deep excavations and through analysis, bring light on the development of the history of Ostia"[7].

Dante Vaglieri, well fitting in the cultural milieu of positivism, was particularly enthusiast of technological novelties: needing for his project a detailed knowledge of the site and its topography, he made request in 1911 to the Ministry of War of a 'topophotographic relief' of the site, such as the one realized during the year before in Pompeii, suitable also as cartographic base.

By the analysis of this huge photomosaic, we can individuate the different isolated nuclea of ruins: the area N of the Forum along the *Cardo Maximus* [1]; the area around the *Decumanus Maximus* with the Theatre, the Baths of Neptunus and the necropolis outside *porta Romana* [2]. Easily recognizable are as well: the tombs of the necropolis outside *porta Laurentina* [3], digged by Carlo Lodovico Visconti between 1855 and 1857, and under further investigation at the time of the relief; the *Terme Marittime* [4], built along the track of the republican walls; the *Terme della Marciana* [5] (digged by the Scottish painter Gavin Hamilton between 1774 and 1775[8], and again by Giovanni Pietro Campana between 1831 and 1835), still called with the traditional name of *Porta Marina*, even if in the photomosaic the walls appear clearly distant; the temple of Cybele [6] (digged by Visconti between 1867 and 1869), even if the whole complex is still not recognizable in its integrity; the enormous complex of the so-called *Palazzo Imperiale* [7], digged out by Visconti as well.

fIG. 2 - "Rilievo topofotografico dal pallone" (1911), with the Dead River ('fiume morto') pointed out.

E42: THE BIRTH OF THE ARCHAEOLOGICAL AREA

As Vaglieri couldn't fulfill his program (he died while working in his office during the night between December 12th and 13th 1913), for some years there is no progress in aerial photographic documentation. With the only interruption of the years of WWI and the immediate aftermath, the methodic exploration of the ancient city was continued by Guido Calza[9] (director of the site by 1924 onward) and Italo Gismondi[10]: an archaeologist and an architect, whose joint efforts and vision gave to Ostia the shape that we still can see visiting the site. The progresses after the first decade of Guido Calza as director can be seen in a zenithal photograph of 1934 by SARA, when the *drachenballon* was already over, due to the success of airships and airplanes (Fig. 2).

In the perspective of the continuation of the program of Dante Vaglieri to connect isolated groups of ruins, we see that the nuclei of the Theatre (in the meanwhile partially renovated, with the rebuilding of the cavea[11]) and of the Forum (in the previous twenty years extensively excavated with its surroundings). Furthermore, also the *Horrea Epagathiana*, the *Terme dei Sette Sapienti*, and the *Terme della Marciana* have been digged out.

Only few years after, Ostia will attract the attention of the fascist government. For the Universal Exposition foreseen to

Fig. 3 - "Rilievo topofotografico dal pallone" (left) and SARA photograph, 1934 (right). Theatre and Forum area.

Fig. 4 - Ancient Ostia, SARA photograph, 1934.

Fig. 7 - I. Gismondi, Scale model of ancient Ostia; Rome, Museo della via ostiense.

take place in 1942 in Rome, the regime will project the building of a *new Rome* and the excavation of the ancient Ostia. The original project, presented on the occasion of the symposium for the conclusion of the celebrations for the two thousandth anniversary of the birth of the emperor Augustus in 1938[12], consisted in the excavation of the so-called *monumental centre* of the city (Fig. 3), operated in continuity with the program of Dante Vaglieri. The idea was to extend the digged area toward S, following the path of the so-called *Decumanus Maximus*, to reach the already digged *Terme della Marciana*; toward SE to the temple of Cybele with its complex; and toward SW to the *Terme dei Sette Sapienti*.
The aerial photographs taken during WWII by the British Royal Air Force (RAF)(Fig. 4) bring evidence of how in some cases the digging has gone beyond the original project, completing the excavation of buildings or blocks only half-way explorated, such as for the complex of the *Case a giardino*. In other cases the foreseen objectives have not been reached, mostly for the interruption of the activities due to the start of WWII, this is in particular the case of the *insula* IV,ix, currently investigated by the Ostia Marina Project.

NEW URBANISTIC ELEMENTS

The high quality of the aerial photographs taken by the RAF (especially of the frame 4072 of the strip of the year 1944) allows to evaluate not only the progression of the excavations in the years 1938-1942, but also to develop some reflections on the urbanization of the city. In particular appears worth of mention the SE area of the city, around the gate in the city walls at the end of *via del Sabazeo*. The crucial importance of this area will emerge afterwards thanks to the research of the German Archaeological Institute, that here will identify the Christian episcopal group.[13] In an ETA photograph of 1953, it is possible to read clearly the marks of the two roads bringing to the aforementioned gate (Fig. 5).

Fig. 5 - The foreseen excavation areas by the E42 project, as reported on the RAF aerial photograph of 1944.

Fig. 6 - Excavation project of the "monumental centre of ancient city": highlighted in pink the already excavated areas, in yellow the areas to be excavated, in light green the areas with grass, and in dark green the areas to be planted with trees (with changes, from CALZA 1938).

MODERN (MOSTLY DESTRUCTIVE) ROADS

If by one side, as it has been already illustrated, the history of the landscape of Ostia has been deeply influenced by the vision of Dante Vaglieri of a unique archaeological area, by the other side ironically the needs of the work for the circulation and the urbanization of the surroundings, decade by decade have cut out some sites from the main archaeological area. Aerial photography is in this case a privileged instrument for the study of such a phenomenon.

Part of the E42 Project was the realization of a branch of the Rome-Ostia highway, the so-called "via panoramica", just along the border of the archaeological site with a new access to the area for the foreseen tourists. The "via panoramica" cuts out from the site the Necropolis outside porta Laurentina, an extremely important funerary area explored already during XIX century under the papal government; as the original plan of the E42 project shows, the Necropolis was originally even meant to be reinterrated and planted with trees as part of the landscaping of the site.

In the decade before the Olympic Games of Rome (1960), the borders of the archaeological park were interested by two interventions: the first one was the construction of the new bridge over the Tiber toward the *Isola Sacra* (the so-called "Ponte della Scafa") with the isolation of the ruins of Tor Boacciana, previously connected to the site with a large curve of the road; the second intervention, even more important, has been the construction of the highway SS269 for the new international airport of Fiumicino, a work that has meant the destruction of the part of the site overlooking the ancient seashore and of part of the via Severiana (Fig. 6). The works for the connection of the SS269 with adjoining roads in 1961 led to the discovery of the Synagogue of Ostia,[14] eventually included in a photograph of 1983.

THE STRENGTH OF THE TIBER

The 1911 "relief" allows to evaluate impressive changes of the natural landscape and in particular the variations of the course of the Tiber,[15] with the so-called "Fiume Morto" (Dead River)(Fig. 7), the ancient course of the river before the flooding of 1557, survived until the XX century as a swamp, and to evaluate the erosive strength of the Tiber, that surely impacted the crucial area of the in-river harbor of the ancient city with consequences that it's still difficult to determinate.

The need to control the river and limit the erosion that threatened to endanger the "castrum", the originary heart of the ancient city, is reflected in the redesign of the left embankment visible in the 1934 photographs: works meant to safeguard both from erosion and the danger of floodings such as the one occurred in 1892, with the reuse of land from excavations to strengthen the levee.

A NATURALISTIC OASIS

Air photographs allow also to observe and follow the development and diffusion of vegetation in Ostia as part of the landscaping.[16] The 1911 "relief" documents the first two gardens of the site: a French garden at the "Casone del Sale" (headquarter of the archaeological site) and another garden in the "Foro delle Corporazioni". These gardens, studied by Massimo de Vico Fallani,[17] were meant to recall ancient gar-

Fig. 8 - Photo-mosaic of ancient Ostia, ETA photographs, 1953.

Fig. 9 - Photo-mosaic of ancient Ostia, Aeronautica Militare photographs, 1960.

dens, and they fit well in the architectural taste of the early XX century.
The SARA photographs of 1934 show the systematic planting of pines along the path of the Decumanus Maximus (Fig. 8-9).
The turning point happened with the E42 project, that joined to the extensive excavation of the ancient city an ambitious landscaping program, overseen directly by the architect Michele Busiri Vici[18] which was meant to include originally massive plantings of trees, both to provide shadow and relief from the sun to visitors and to help in the readability of some monuments, such as the harbor supposed on the left embankment, to be recalled by a wood that was never realized.
Afterwards cypresses will be used to recall the original position of the lost columns of the Forum outside porta Marina, as appears in a SARA 1983 photograph.

CONCLUSIONS

This review of the aerial photograph imagery of Ostia over a period of more than seventy years, allows to carry on different readings, ranging from the analysis of the geomorphological features of the area to the assessment of the impact of the works of the archaeologists. It is particularly interesting to evaluate this last factor of human influence: while we usually think to excavation as the systematic analysis of layers, this study does shed light on the footprint of such activities. Archaeological activities emerge therefore as the last (and still today visible) layer of an incredibly complex palimpsest. In the case of Ostia it is possible to see this footprint in the selective diggings and in the extensive works aimed at the preservation and landscaping of the site.
Another crucial aspect that must be noted is the different approach to aerial photography that archaeologits have taken over time. While in the first period (and in particular for the 'rilievo' by Dante Vaglieri) aerial imagery has been approached chiefly as topographic tool for the management of sites, in the decades after WWII the interest has shifted toward landscape studies.
For sure the turning point matches the development of Aerial and Landscape Archaeology after the war, and can be linked to the specific interest for such disciplines of former Allied pilots. A particular mention must be given to John Bradford: former RAF pilot, photographer and photo-interpreter, after the end of wartime operations, being attached to the University of Oxford, he did pioneer archaeological landscape studies with an extensive use of the Allied material.[19]
After the war aerial photograph imagery will be used also to look for elements useful for the understanding of the topography of Ostia and Portus, the most famous example being the search for traces of the harbour of Claudius.[20]
Overall Ostia is, among the archaeological sites, one of the most covered by aerial photographs in Italy during XX century, allowing aerial imagery to be a privileged instruments for archaeologists to study the birth and development of the site itself, its natural landscape, and try to read in the soil some marks whispering us the stories that one day those hills and fields will tell us (Fig. 10).

Fig. 10 - Photo-mosaic of ancient Ostia, SAF photographs, 1964.

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ENDNOTES

1. The Ostia Marina Project is active particularly in the suburban area along the ancient seacost outside the gate of the city walls called Porta Marina; for an overview of the activities of the OMP see (David 2009), (David 2013a), (David 2013b), (David 2014).
2. For an overview of the collections of the Aerofototeca Nazionale see (Guaitoli 2003) (Ceraudo, Shepherd 2010) and (Boemi 2011).
3. The historical and cultural environment in which aerial photography developed in Italy from 1899 onward is focused by (Ceraudo 2004) that remains crucial for the understanding of the phenomenon and its implications; for some details on the technology see (Tardivo 1911).
4. The centennial of the death of Dante Vaglieri has been celebrated with a conference promoted by the Italian Ministry of Culture, whose proceedings (De Vico Fallani, Shepherd 2014) provide a complete overview of the biography, work and achievements of Vaglieri.
5. The last years of his life, spent at the direction of the excavations of Ostia, have been studied by Paola Olivanti with particular attention for the cultural environment to which the figure of this archaeologist belongs (Olivanti 2014).
6. A concise history of the excavations at ancient Ostia can be found in the first chapter of (Calza 1953); more details can be found in (Bignamini 2003) for the period up to 1801; for the XIX century and the first years of the XX see (Marini 1998), (Olivanti 2001) and (Marini Recchia 2002).
7. (Vaglieri 1912), translation from the authors.
8. Gavin Hamilton has been the first digger of Ostia of whom we have some detailed knowledge about; his biography has been recently published along with the corpus of his letters (Cassidy 2011).
9. A contribution to the debate on aerial archaeology in the first two decades of XX century has been given by Guido Calza, in an article published in 1920 (Calza 1920).
10. (Filippi 2007) with bibliography.
11. For the Theatre and its rebuilding see (Shepherd 2005).
12. (Calza 1938).
13. For the Episcopal Group see (Bauer 1999).
14. (Floriani Squarciapino 1964), (Olsson 2001).
15. The variations of the course of the Tiber have been studied extensively by Antonia Arnoldus-Huyzendveld: (Arnoldus-Huyzendveld 1995), (Arnoldus-Huyzendveld 2000).
16. The gardens of Ostia have been studied by E.J. Shepherd (Shepherd 2008).
17. (De Vico Fallani 2014)
18. For other details on the figure of Busiri Vici see (Natoli 2001).
19. Bradford 1957, see vii-xi on Allied imagery.
20. Meiggs 1960, pl IV-V.

ABSTRACT

During the XXth century, numerous studies were carried out in the site of ancient Ostia, also thanks to the support of aerial photography. Starting from the "Topophotographich survey" realized by the Italian Army in 1911, up to the "Atlante di Ostia antica" realized in 1996, Ostia has become one of the most photographed from up high among archeological sites all around Italy. The analysis of aerial photographs allows to develop a research structured in two main branches: the study of the ancient city and of its urban development, and the transformation of the landscape conceived by archaeologists during the last century. Through aerial photographs it is possible to understand the impact of the extensive excavations carried out from 1938 onward under the will of the fascism on the occasion of the Universal Exhibition foreseen for 1942 in Rome (E42).

KEYWORDS

ANCIENT OSTIA; AERIAL PHOTOGRAPHY; E42

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CAPTIONS

Unless otherwise indicated, the images come from Aerofototeca Nazionale, Rome

THE IMPORTANCE OF MONITORING AIR QUALITY IN CONSERVATIVE ENVIRONMENTS

The study of air quality in the cultural heritage sector: a wide selection of accurate data acquisition systems will allow monitoring the exhibition and conservation spaces at all times of the day, ensuring the control of the main environmental parameters involved in the deterioration processes of artwork.
Air pollution is one of the main causes of damage to human health and to materials exposed both outdoors and inside buildings. Currently, the interest of the international scientific community in the study of air quality in confined environments is mainly linked to the health effects caused by exposure to toxic or potentially harmful substances. However, the control of the indoor environment has repercussions not only with regard to public health and workers but also in the cultural heritage sector. Controlling the air quality in contact with the museum object means not only containing the concentration of the gaseous and particulate pollutants present in the air but also knowing the damage that each pollutant can cause on the single object exposed.
In particular, the effects that pollutants have on the materials with which they come into contact are different: discoloration, stains, yellowing, loss of gloss and shine, corrosion of metals and glass, embrittlement, oxidation, phenomena of hydrolysis of organic materials etc. The interactions that occur between artifacts, the surrounding environment and pollutants are therefore very complex and depend mainly on:
- exchange phenomena between indoor and outdoor air
- modalities of diffusion of air masses and therefore of pollutants in the internal environment
- chemical-physical reactivity of pollutants in indoor air
- adsorption and deposition processes on surfaces

Particular attention must be paid to the conditions of presence of high relative humidity or condensation water which are the best conditions for a rapid deterioration of materials, favoring both the action of pollutants and the damages due to the physical stress of materials.
Scheme with the possible vehicles of pollutants in museum environments.
In particular, the deposition of atmospheric particulate on surfaces, besides being a potential risk for the initiation of harmful chemical processes, can also cause aesthetic damage, causing blackening of the same and altering the visual perception. The particulate suspended in the atmosphere can be transported directly inside the public, or it can penetrate through any type of opening towards the outside.
Long-term monitoring and precise measurements of the concentration of atmospheric pollutants are not easy to perform, as they require specific equipment normally managed by specialized technical personnel. Ascisse S.r.l., a company specializing in the field of measuring instruments for environmental control, offers a wide selection of accurate data acquisition systems dedicated to the Cultural Heritage sector, always offering the right compromise between functionality and aesthetic requirements. In addition to providing the instrumentation, specialized technicians will analyze and interpret the data collected, providing an overall assessment of the state of the premises from the point of view of air quality.
An environmental control that is not limited only to the monitoring of the hygrothermal parameters, but also takes into account the quality of the ambient air, is essential to optimize both the conservative conditions of the collections and to better support the curators who deal with the management museum.

For more information on the systems and services offered, visit www.ascisse.it

RESTORATION, MUSEUMS AND CULTURAL BUSINESS INTERNATIONAL TRADE SHOW

From March 21th to 23rd, the Restoration, Museums and Cultural Business International Trade Show, supported by MiBACT – the Italian Ministry of Cultural Heritage and Tourism – will be back in the historical premises of Ferrara for its XXV year.
Three days of celebrations for the achievement of this important twenty-fifth anniversary with an unmissable calendar of exhibitions, meetings, events and conferences, in the attempt to promote the cultural and environmental heritage, in all its dimensions.
One of the greatest news this year is the international ISF certification from the Euro Fair Statistics Bureau, as a celebration of the strategic key role played by the Trade Show in the international world of fairs.
The Trade Show looks to new market strategies, to opportunities and to the country's need to change in the belief that the historical, artistic and environmental heritage is its main asset. An asset that should find synergic places, opportunities and professional skills that can enhance and turn into an important chance for national economy. This is what the fair wants to show every year as the go-to showcase of cultural business.
Through the active involvement of leading companies and institutions, the Trade Show will showcase and address the most topical and urgent issues, the technology, innovation and results providing updates on the most important restorations and redevelopments of the cultural and environmental heritage.
As usual, this year the Trade Show will be there in the format developed with MiBACT, the Italian Ministry of Cultural Heritage and Tourism, historical partner of the event, which found there the perfect stage for the Italian network of Museums in all its entirety and complexity.
There will be the 30 most important Italian museums, the self-governing institutes and the regional museum facilities.
With a view to embracing the new dimensions of the Italian museum world, pride of place will be given to those companies that interact with public and private museums, working in lighting engineering, climatology, transport of artworks, software and technology, reception, security, catering, bookshops and merchandising, which will be supporting the usual exhibitors.

The full programme of the event and a list of exhibitors will be available at www.salonedelrestauro.com.

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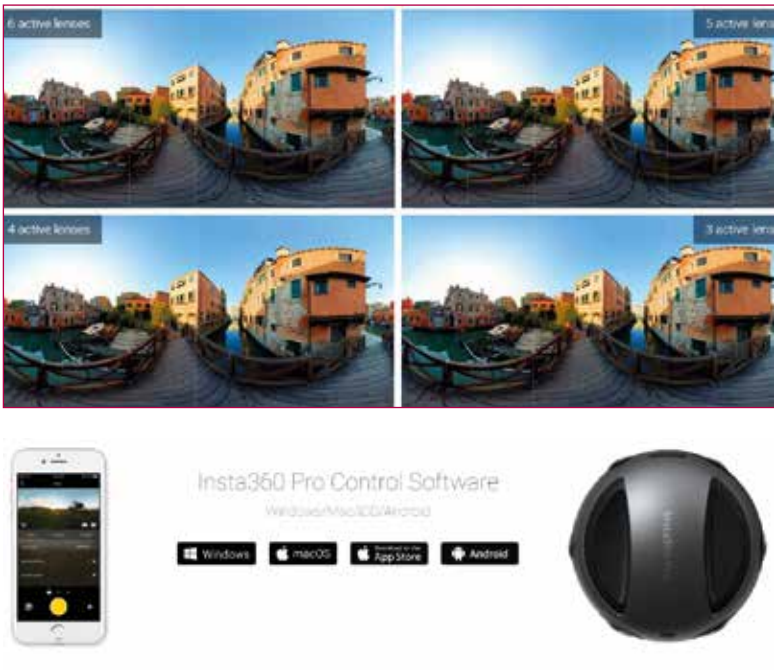
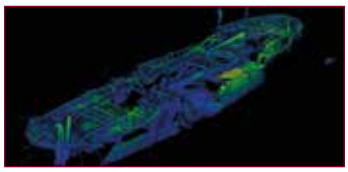


PRESERVATION OF UNDERWATER WORLD HERITAGE SITES: AN INNOVATIVE 2G-ROBOTICS WILL CREATE AN HIIGH RESOLUTION 3D MODEL OF THE TITANIC SHIPWRECKS



OceanGate Inc., a provider of manned submersible services and 2G Robotics, a global leader in underwater laser scanners, have formed a strategic alliance to capture laser data of the RMS Titanic shipwreck and debris field. 2G Robotics dynamic underwater laser scanner, the ULS-500 PRO, will be installed on OceanGate's Cyclops 2, the first manned submersible to survey the Titanic since 2005.
The six-week Titanic Survey Expedition will depart from St. John's, Newfoundland in June with scientists, content experts, and mission specialists joining the crew in a series of week-long missions. The innovative 2G Robotics equipment will generate real-time 3D models with millimetric resolution. Using the highly accurate laser data, the team will overlay 4K images captured throughout the expedition to create a detailed 3D virtual model of the wreck. This model will serve as an objective baseline to assess the decay of the wreck over time and help to document and preserve its submerged history.
"Laser scanning provides maximum detail in less time than other techniques," notes Stockton Rush, OceanGate CEO. "2G Robotics has provided us with a solution that will generate an entirely new perspective of the Titanic."
Cyclops 2 will be outfitted with 2G Robotics' ULS-500 Pro. This dynamic underwater laser scanner is significantly quicker and delivers fine-scale dimensional features not captured by other methods. The scanner will document the present-day condition of the historic site without any need for physical interaction. Documenting the debris field and creating a nearly lifelike digital model without disrupting the habitat or any artifacts is of top priority to OceanGate. "We recognize that the entire site is a memorial and we undertake our expedition with great respect for those who died in the sinking", said Rush. The expedition is to be conducted in accordance with NOAA and UNESCO guidelines for the preservation of underwater world heritage sites. "From a young age, I dreamt about underwater exploration and archaeology and it is this passion that 2G was built upon," states Jason Gillham, 2G Robotics CEO. "So, for our team, contributing to the preservation of one of the most culturally significant maritime sites is an exciting culmination to over a decade of hard work. We are extremely proud to be a part of the Titanic Survey Expedition."

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PIX4D ANNOUNCES ITS PRESENCE AT THE ROMA DRONE CAMPUS EVENT

Pix4D is a dynamic and rapidly expanding software company with headquarters in Lausanne, Switzerland, and local offices in San Francisco, Shanghai and Berlin. The company develops a line of end-to-end mapping solutions which convert images into georeferenced maps and models. Using advanced algorithms based on computer vision and photogrammetry, Pix4D offers survey-grade accuracy, as well as a unique bundle of desktop and cloud processing.
Pix4D will be present at Roma Drone Campus Event from February 21-22 with a specific professional oriented workshop and with a presence at iDRONI booth, commercial partner of Pro S3.
The two days workshop is tailored for professionals using photogrammetry, orthomosaics, 3D modelling and UAVs in their practice. During this in-person training, the users can learn how to create accurate maps and models, as well as improve your results, from mission planning to cloud processing and desktop integration.
The detailed agenda: https://pix4d.formstack.com/forms/rome
Gabriele Ruggiero
Key Account Executive
Pix4D headquarters
Lausanne (Switzerland)

Application of micro-Raman spectroscopy for conservation projects in art and archaeology with a case study on Cappadocia rock-hewn wall paintings

By Pietro Baraldi, Cecilia Baraldi, Claudia Pelosi

Micro-Raman technique is today widely used in cultural heritage investigation both for inorganic and organic analysis. This paper would make a short review about possible applications of micro-Raman with a special focus on the results obtained on the wall painting materials of Cappadocia rupestrian churches.

AN OVERVIEW ON RAMAN SPECTROSCOPY

Raman spectroscopy has been proposed as a reliable, sensitive, specific, non-destructive technique ideal in the examination of artwork materials [1-2]. Raman spectroscopy is a relevant technique for knowledge of the techniques in artworks [3-6], for conservative purposes [7-10], for authentication assessment [11-12].

Raman technique probes molecular and crystal lattice vibrations and therefore is sensitive to the composition, bonding, chemical environment, phase, and crystalline structure of the sample materials [2]. The technique is based on the effect of scattering process in a sample irradiated with a monochromatic photon beam. In particular, the inelastic scattering of the monochromatic radiation is at the base of the technique [13]. Raman spectroscopy had some intrinsic limitations that in the past prevented a wide use of this technique, especially in cultural heritage applications. In fact, the Raman scattering gives rise to weak signals, which sometimes are covered by broadband fluorescence emission from samples. These limitations, coupled with the high costs of instrumentations clearly limited the use of the technique in respect to other molecular spectroscopies such as FT-IR. The introduction of new optical configurations and CCD detectors improved a lot the sensitivity of modern Raman spectrometers also reducing the costs [14-15]. Moreover, the introduction of near-IR lasers together with dispersive or interferometric spectrometers further removed the limitations due to fluorescent materials samples [1, 16]. Furthermore, the coupling of a Raman spectrometer to an optical microscope further increased the versatility of the method making possible the analysis of components of heterogeneous samples on a micrometre scale and by reducing greatly the amount of sample required from precious materials [2, 17].

Further development in Raman spectroscopy derived from the use of portable instruments, particularly suited in art and archaeology applications, even if these spectrometers have several limitations mainly due to their low sensitivity in detecting low scattering materials [18], and in SERS (Surface-enhanced Raman scattering) a specific technique useful in enhancing weak Raman signals (from 10^8 to 10^{15} times) or decrease the fluorescence broad-bands [19].

The SERS effect is mainly due to the enhancing of the electromagnetic field in correspondence of a surface that has been made appropriately nano-rough or of metal nano-structured systems (nanoparticles of Au, Ag, Pt, Cu, etc.). The different kinds of supports for this technique are called SERS substrates. In the last fifteen years, several substrates have been developed thanks to the nanotechnologies [20-21].

In the field of cultural heritage the most used substrates are silver colloids prepared according to various techniques [22-24]. SERS technique have be employed for identifying organic dyes, binders, resins, in textiles, paintings, ancient cosmetics, inks, with a quick detection of low concentrations of molecules, until 10^{-5} M [25-26]. The method is based on the application of few microliters of colloid suspension to the surface to be analysed or otherwise the sample solution could be mixed with the colloid sometimes with the addition of aggregating agents improving the contact between the analyte and the Ag nanoparticles [25, 27]. In case of complex matrices, a pre-treatment of the samples could be useful such as the extraction of the dye compound from the sample mixture [24]. So, SERS can be considered a micro-invasive and micro-destructive technique.

In this contribution, a case study about rock-hewn wall paintings in Cappadocia (Turkey) will be presented, as relevant example of application of Raman spectroscopy to investigate in depth the constituent materials and their change in use during the mediaeval centuries for knowledge and for conservative purposes.

EXPERIMENTAL

The Raman analysis were performed by a Labram Model spectrometer of the Horiba JobinYvon with a spatial resolution of 1 μm and the possibility of fast detection owing to the use of a CCD detector with 1026 x 256 pixels cooled to -70°C by the Peltier effect. The spectral resolution was 1 cm^{-1}. The exiting wavelength was the 632.8 nm red line of a He-Ne laser. Integration times varied between 10 and 20 s with 5 accumulations. The output power for the He-Ne laser was 5 mW.

Identification of pigments, minerals, and others was performed by comparing the experimental spectrum with

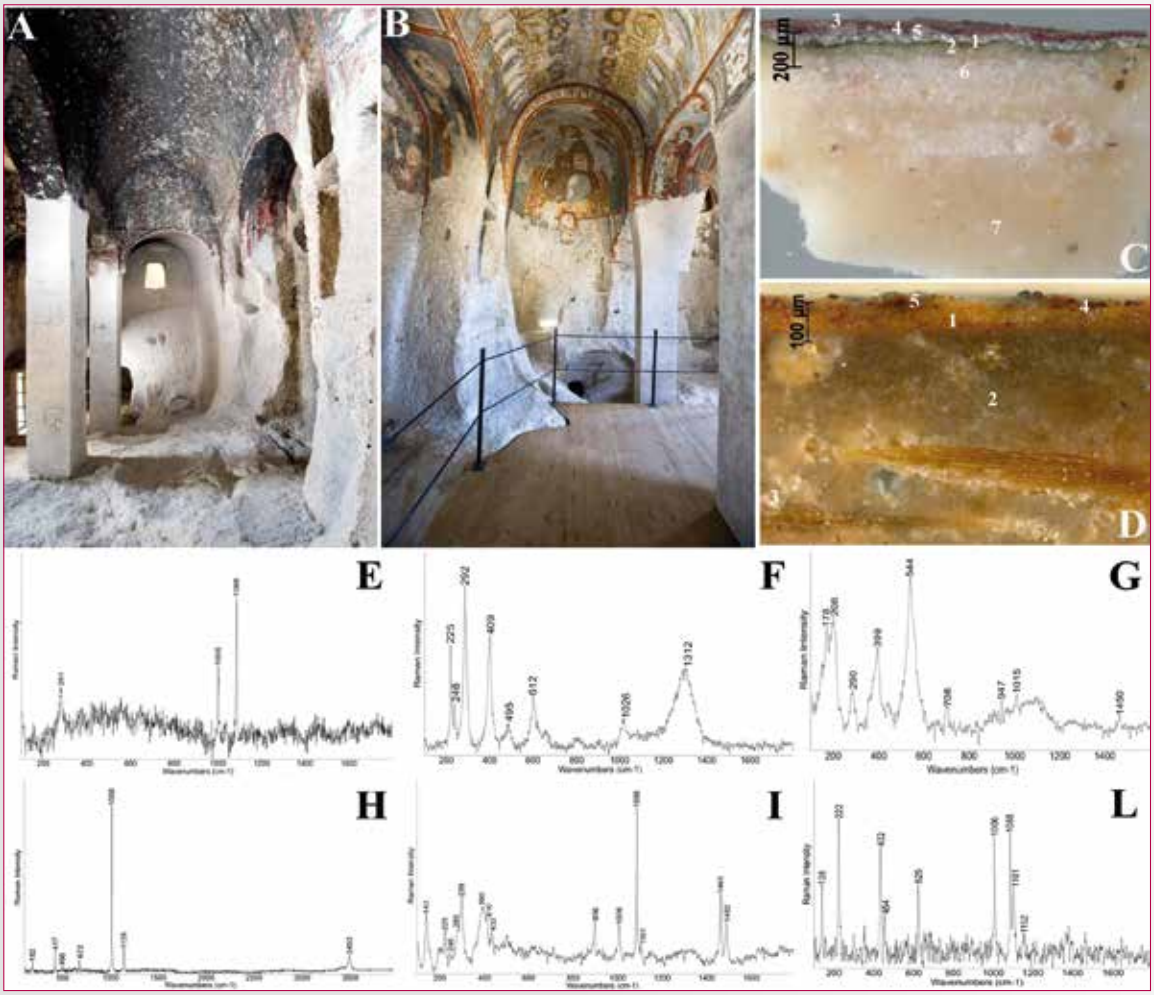

Fig. 1 - the Forty Martyrs church at Şahinefendi (Cappadocia, Turkey): A) a view of the interior of the church before the restoration; B) a view of the interior of the church after the restoration; C) cross section of a sample including three painting phases of the wall decoration with the points analysed by micro-Raman spectroscopy; D) cross section of the fourth phase (13th century) with the points analysed by micro-Raman spectroscopy; E) Raman spectrum of point 6 in C) showing calcite (band at 1088 cm^{-1} and 281 cm^{-1}) and gypsum (band at 1008 cm^{-1}); F) Raman spectrum of red layer, points 3 and 4 in C), showing all main bands of hematite (Fe2O3) and traces of anhydrite (band at 1026 cm^{-1}); G) Raman spectrum of green layer, point 2 in C), with the characteristic bands of green earth; H) Raman spectrum of point 5 in C) with the bands of high crystalline gypsum; I) Raman spectrum of point 5 in D) showing the presence of hematite (bands at cm^{-1}: 225, 246, 410), goethite (bands at cm^{-1}: 299, 390), lead oxide (band at 143 cm^{-1}), calcium oxalate (bands at cm^{-1}: 896, 1465, 1492), jarosite, $KFe_3(SO_4)_2(OH)_6$, (bands at cm-1: 432, 1006, 1101) calcite and gypsum; L) Raman spectrum of point 1 in D) showing the presence of all main bands of jarosite.

those found in the main database available on-line [28-31] or with spectra obtained in our laboratories during the years of work on different artefacts.

RESULTS - ROCK-HEWN WALL PAINTINGS IN CAPPADOCIA

Since 2006, an Italian group has been entangled in a project on "Rupestrian art and habitat in Cappadocia (Turkey) and in central and southern Italy. Rock, excavated architecture, painting: between knowledge, preservation and enhancement", directed by Prof. Maria Andaloro. The project has been developed thanks to the funding of Italian Ministry of Education, University and Research (PRIN 2010) and the permission granted by the Turkish Ministry for Culture.

Within this project, an important part was devoted to the study of the materials and techniques in Cappadocia's churches, both of the support rock and paintings [6, 32-33] with different aims: at knowing these never studied materials, at understanding their degradation phenomena, at finding the most appropriate methodologies to preserve them as extraordinary heritage (UNESCO heritage).

In this regards, micro-Raman spectroscopy was widely used as powerful technique to study pigments, mortar binders, degradation products. More than fifty churches were studied starting from 2006 until today so gathering a deep knowledge of the materials and techniques of the rock hewn wall paintings of Cappadocia region through the Middle Ages centuries.

An interesting characteristic of Cappadocia paintings is the use of gypsum rich mortars or of gypsum as setting layer for paintings (Fig. 1). This was supposed due to the use of a so-called "sweet plasters" by adding lime to that rock containing calcium sulphate [34]. Gypsum or gypsum rich mortars are well preserved in Cappadocia due to the quite dry climate that prevents the solubilization of calcium sulphate. Sometimes, anhydrite was also found in the wall paintings to testify the dry environmental conditions (Fig. 1F). A mapping of gypsum was made by using micro-Raman spectroscopy directly on the cross-sections resulting in a clearly presence of this compound associated to calcite (Fig. 1E) or as high crystalline material (Fig. 1H).

Micro-Raman spectroscopy was particularly useful to characterize pigments allowing defining the palette employed in Cappadocia rupestrian paintings.

A wide use of ochre and earth based pigments was found. These materials are often constituted by very pure crystalline compounds, such as hematite, goethite and jarosite (Figs. 1F, I, L). A peculiarity of goethite based pigments from Cappadocia is their extreme stability to laser irradiation during Raman analysis. In fact, usually goethite undergoes transformation into hematite due to laser irradiation. Also green earths in Cappadocia paintings give well defined Raman spectra even if the red line of He-Ne laser has been used (Fig. 1G).

Apart traditional pigments of medieval wall paintings, in Cappadocia also other compounds were found such as lead-based pigments, especially in the oldest churches, indigo, ultramarine blue, red lakes, often applied by *a secco* technique.

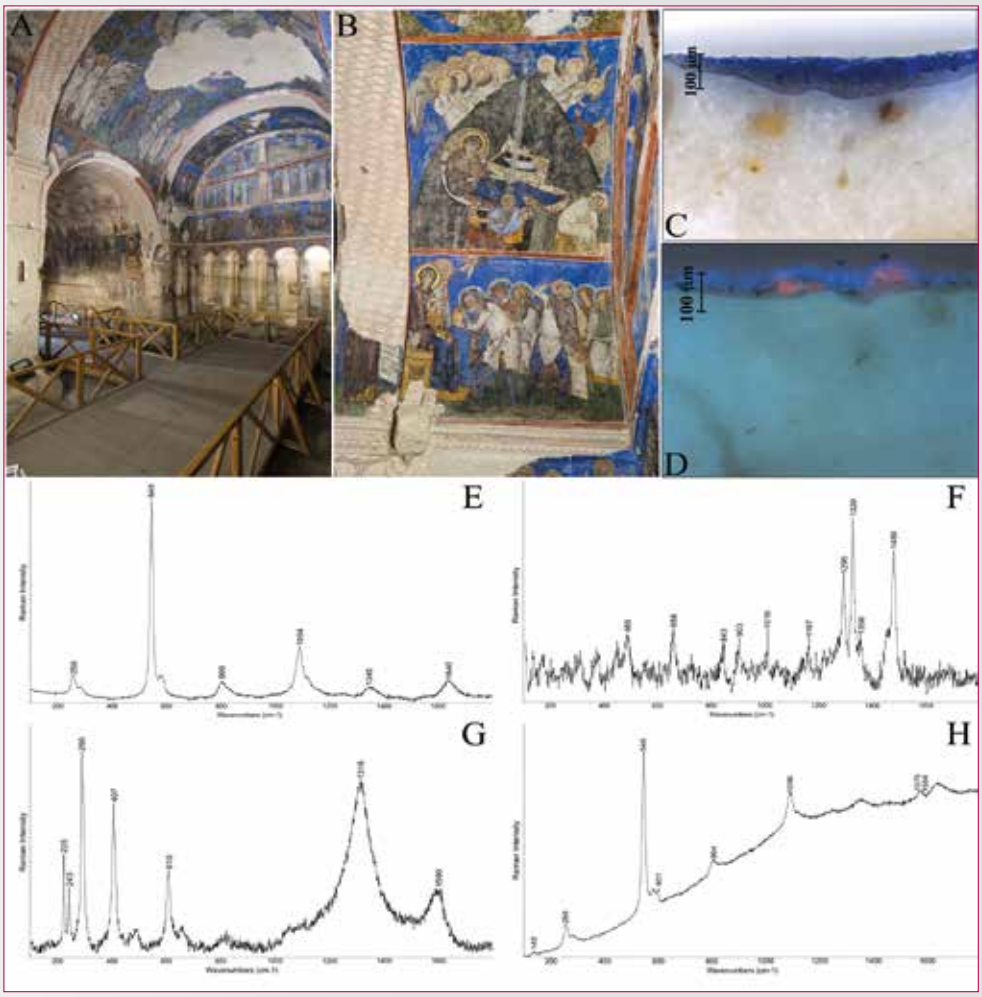

Fig. 2 - The Tokalı church at Göreme (Cappadocia, Turkey): A) a view of the interior of the church; B) a detail of the paintings showing the extraordinary use of ultramarine blue; C) cross section of a sample from the blue background in B) showing the presence of a grey setting under ultramarine blue; D) cross section of a sample from the north wall, visible in A), under ultraviolet radiation showing a red fluorescent organic dye; E) Raman spectrum a blue pigment showing the typical pattern of pure and crystalline ultramarine blue; F) Raman spectrum of the red organic dye, showing the bands of alizarin-type compound; G) Raman band of a dark red area showing the presence of hematite and carbon black bands. This last material has two broad bands at about 1340 and 1590 cm^{-1}, the first one partially overlapped with that of hematite at 1312 cm^{-1}; H) Raman spectrum of a dark blue area exhibiting the presence of the ultramarine bands associated to weak peaks due to indigo, a natural organic dye (cm^{-1}: 140, 601, 1575, 1584). Indigo was found also in other samples from the Tokalı church.

High purity ultramarine blue (Fig. 2) was widely used in the Tokalı church (10th century) for backgrounds, garments, haloes giving extraordinary wall paintings. In the backgrounds ultramarine was used on a grey setting layer made of gypsum and carbon black (see Fig. 2C). Often, pigments are found to be mixed with carbon black in order to obtain darker hue (Fig. 2G). In the Tokalı church organic dye were also found such as indigo and red lake (Figs. 2F, H). Indigo was found in mixture with ultramarine in dark blue areas (Fig. 2H).

Lead-based pigments are used especially in the archaic churches in different forms: lead white (basic lead carbonate), red lead (lead tetra-oxide) and litharge (lead oxide). For example, in the church of Karşibecak (6th-7th century) the red aniconic decoration are made of red lead and hematite on a gypsum setting layer (Fig. 3). The careful micro-Raman investigation on pigment powders sampled from a blackened area (Fig. 3B), allowed for discovering the presence of different compounds: red lead associated with anglesite (Fig. 3C); hematite associated with magnetite, anglesite and gypsum (Fig. 3D); plattnerite, a dark brown compound generally produced by alteration of lead based pigments (Fig. 3E); anglesite associated to gypsum (Fig. 3F). Plattnerite is a very low Raman scattering compound giving a quite noisy spectrum.

CONCLUSIONS

This paper tried to outline the principles of Raman spectroscopy with a general presentation on the main methods used in investigating cultural heritage materials, on the base of authors' experience in the specific field.

The case study proposed offers a clear evidence of how micro-Raman spectroscopy is a powerful technique able to study pigments, binders, minerals etc. both on powders and cross sections so giving valuable information on the constituent materials, on the execution techniques and on the conservation state of the artefact.

The project in Cappadocia was a great opportunity to apply a work methodology based on a multidisciplinary approach to deepen the knowledge of the rupestrian habitats and, specifically concerning Raman analysis, to create a database of spectra for materials never investigated before by this technique.

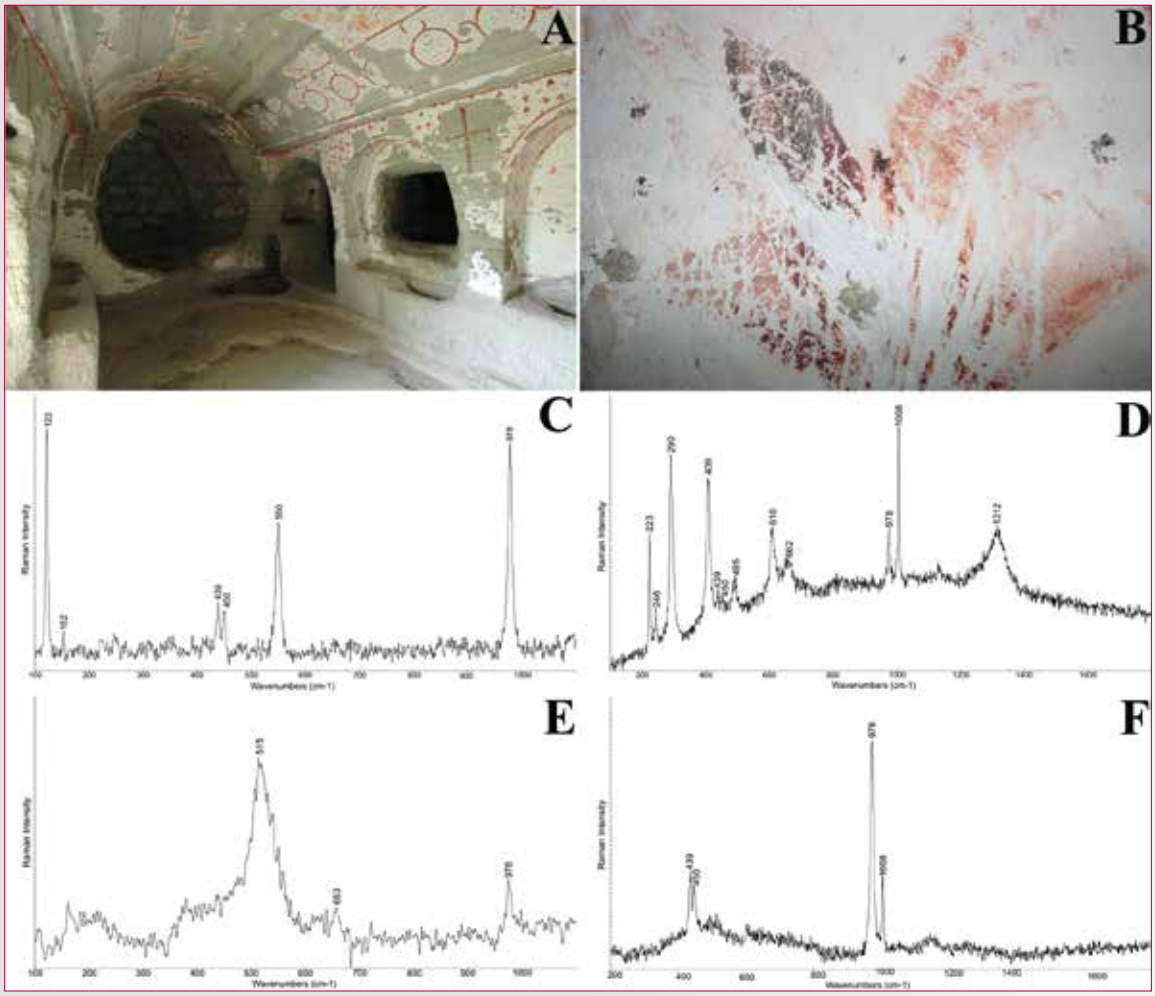

Fig. 3 - the Karşibecak church (Cappadocia, Turkey): A) a view of the interior of the church; B) a detail of the paintings with a clear darkened area; C) Raman spectrum of a red-orange grain in powder microsample taken from B) area showing the bands of red lead (Pb_3O_4, cm^{-1}: 122, 152, 550) and anglesite ($PbSO_4$, cm^{-1}: 439, 450, 978); D) Raman spectrum of a red grain in powder microsample taken from B) area showing the bands of hematite, magnetite (662 cm-1), gypsum and anglesite; E) Raman spectrum of a dark brown taken from B) area showing the bands of plattnerite (PbO_2) F) Raman spectrum of white grains in powder microsample taken from B) area showing the bands of gypsum and anglesite.

ACKNOWLEDGMENTS

The Raman analysis was performed within the project PRIN 2010 “Rupestrian art and habitat in Cappadocia (Turkey) and in central and southern Italy. Rock, excavated architecture, and painting: between knowledge, preservation and enhancement” directed by Prof. Maria Andaloro. The project could not have been carried out without the kind permission granted by the Turkish Ministry for Culture. The photographs of the churches shown in Figures 1-3 were taken by Gaetano Alfano.

Abstract

This paper aims at reporting an overview of the principles and applications of micro-Raman spectroscopy in cultural heritage. Micro-Raman was used for characterizing painting pigments, inorganic binders, degradation materials in artworks with different goals: to know the materials and so the execution technique, to investigate the state of preservation, to establish the authenticity of the artefacts. The micro-Raman analyses were often performed on the occasion of conservative projects and they were able to supply valid and useful information to the conservators during their work. As case study, the project on the investigation of rock-hewn wall paintings in Cappadocia (Turkey) will be shortly presented as exemplificative of application of Raman techniques for the knowledge of the constituent materials, for supporting the conservation work and for detecting degradation products. The analysis was performed in the Interdepartmental instrument Center of Modena and Reggio Emilia University by a bench top system equipped with a microscope allowing for studying in non-destructive way different kinds of samples: powders, cross and thin sections, pre-treated samples.

Keywords

micro-Raman spectroscopy; Surface Enhanced Raman Spectroscopy; cultural heritage; pigments; conservation; Cappadocia wall paintings

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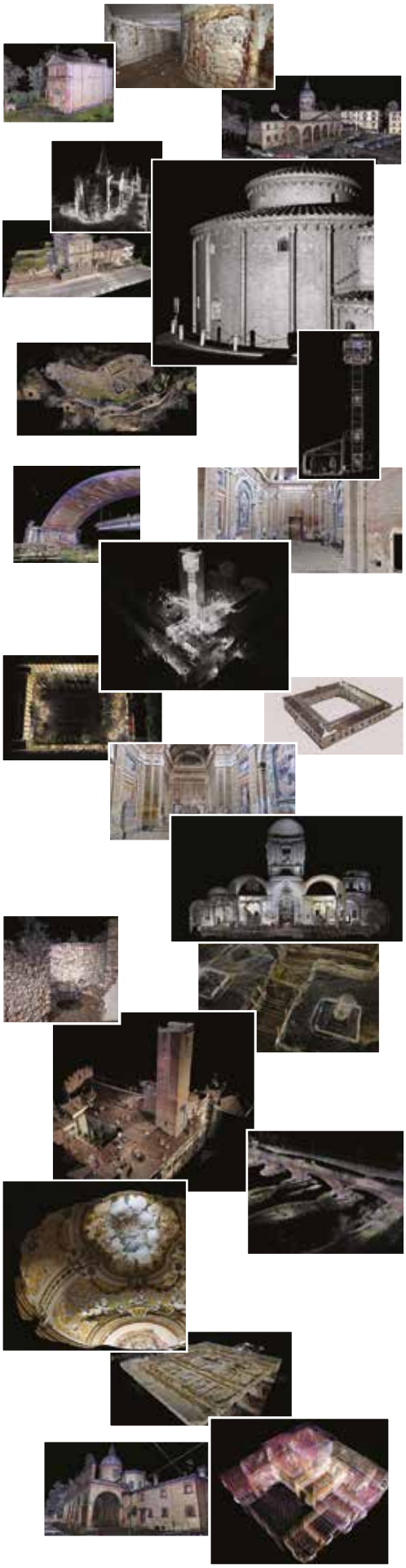

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The Italian Archaeometry Society turns 25... and the 10th Congress is looking very youthful indeed!-The Italian Archaeometry Society (Associazione Italiana di Archeometria - AIAr) is presently the main Italian association of scholars and researchers involved in the scientific investigation of the tangible Cultural Heritage. The Association aims at promoting and developing research, education, training and professional activities addressed to further the knowledge and the preservation of Cultural Heritage through scientific methods and techniques. Within this framework, it encourages synergies between the sciences and the humanities in order to face the various emerging issues in the conservation and the study of materials in the Cultural Heritage domain, from archaeological sites to modern art museums".

The 10th AIAr National Congress will be held from the 14th to the 17th of February in Torino (Italy) and will be a celebration of the 25th anniversary of AIAr's constitution. The organizer of such a unique event is a team of researchers from Universities and Institutions of the Italian North-West that are already involved in the field of archaeometry: five departments of the Università di Torino as well as the Politecnico di Torino and the Università del Piemonte Orientale, and several research institutions (CCR, INFN, CNR-INRiM and the scientific laboratory of the Valle D'Aosta Region). TecnArt srl, a past-spin off of the Università di Torino and presently active member of the AIAr network of enterprises, is also among the organizers.

More than 150 contributors will participate to the congress, which is expected to be very rich, judging from the high scientific level of the abstracts that have been submitted. In the afternoons and after the closing remarks, a number of social events will provide an informal environment to share ideas and experiences among participants. As a side event, twenty young graduates in either the sciences or the humanities will attend the 2nd AIAr school "Archaeometry and/is multidisciplinarity: common issues and different approaches". The title is a pun - and it does work in Italian! -, because it highlights the synergy among various fields of expertise involved in the study, conservation and enhancement of the material cultural heritage.

Three invited lecturers will open each of the three days of the congress. They will illustrate their research activity in a multidisciplinary environment, from museums to informatics. In more detail, dr Christian Greco (director of the "Museo Egizio" of Torino, the second most relevant museum in the world entirely devoted to the ancient Egyptian Culture) will report on the "archaeology of the invisible", Sofia Pescarin (Institute for Technologies Applied to Cultural heritage) will discuss state-of-the-art digital technologies in museums and prof Matthew Collins (University of Copenhagen and York) will give a lecture on the "Ancient Biomolecule Revolution".

Importantly, early-stage researchers will be central in the congress. Several oral presentations are scheduled for young researchers and professionals who are presently involved in the Cultural Heritage sphere. These young minds contribute strongly to the development of the field, adding value and novelty with their ideas, and yet they are still lacking a clear professional/institutional recognition.

Info: http://www.associazioneaiar.com/wp/eventi/x-congresso-nazionale/

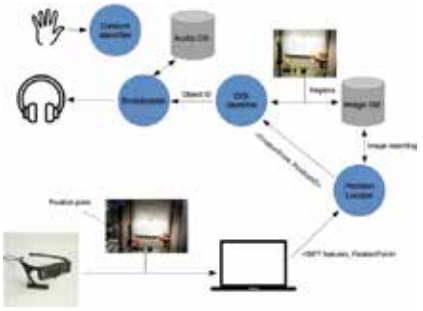
Visual Heritage 2018 - Digitize: Research - Record - Reactivate - Reconstruct

The next edition of CHNT (Cultural Heritage and New Technologies - www.chnt.at) will be organized in cooperation with the EG GCH (Eurographics Symposium and Graphics Cultural Heritage) and other partners (will be announced soon) in the City Hall of Vienna Austria.The aim of this federated event is again to bring different communities in the same venue, to share experiences and discuss methodologies concerning digital visual media and their use in the context of heritage applications, to document digitally on at-risk archaeological sites, historical buildings, museums… and their texts, books, paints, pictures, objects …all records of through collecting original image collection's source.

The 2018 edition will be a special event, since 2018 has been declared by the European Commission the "European Year of Cultural Heritage". The event will also take place during the Austrian Presidency of the Council of the European Union, at 2nd half of 2018.

Therefore, Visual Heritage 2018 will be an ideal context for discussing European policies on digital heritage and digital humanities.

Visual Heritage 2018 hosted by CHNT 23 2018 - (Vienna, Austria - November 12 - 15, 2018)



The eye tracker as a potential natural interaction device in a museum audioguide system - Scholars Moayad Mokatren, Tsvi Kuflik and Ilan Shimshoni used and examined a mobile eye tracker, as a natural interaction device, in an audioguide system for museum visitors. Use as a pointing device allows the system to reasonably reflect on user attention and provide relevant information as needed.

To accomplish this goal, the researchers integrated a technique based on image matching for indoor positioning and an eye-gaze detection technique to identify the focus of user attention in two different versions of a mobile audio guide: (1) a proactive version that automatically provides the information whenever a user's interest is detected and (2) a reactive version that notifies users of the availability of informations, thus giving it greater control over the transmission of information. In addition, they have developed a mobile guidance system for visitors to conventional museums using a smartphone and low-energy Bluetooth beacon for positioning; this guide has been used as a reference system.

The three visitor guides were evaluated in realistic settings at the Hecht Museum, a small museum located at the University of Haifa, which has both archaeological and artistic collections. The experimental evaluation compared the contribution of the three versions of the audio guide to the visiting experience. The results showed that the mobile eye tracking technology, although not familiar and perhaps even immature, was accepted by the participants. The mobile eye tracker audioguide was perceived as preferable to the traditional museum guide, particularly as regards learning during the visit. Moreover, as regards the proactivity in context-aware systems, the results showed that participants like to have control and that most of them preferred the reactive version of the mobile eye tracker audio tracker compared to the proactive one.

The collection of animal mummies from the Egyptian Museum of Turin: diagnostics, restoration and conservation

The collection of the Egyptian Museum in Turin contains within it a large number of animal mummies. These are complex products, consisting mainly of materials of organic nature, such as fabrics (mainly linen), skeletal remains and sometimes soft tissues and residues of substances used for mummification, in addition to the foreign material used for the padding (canes, sticks of wood, palm leaves, sand, etc.).
The study and conservation project of this collection, promoted and financed by the Egyptian Museum, under the protection of the Superintendence of Archeology, Fine Arts, Landscape for the Metropolitan City of Turin, has been entrusted for the different phases to TecnArt Srl (diagnostics), Cinzia Olive (restoration) and Consorzio Croma (realization of supports). It aims to increase the knowledge of this particular category of artifacts and to apply conservation strategies to improve the aspects related to the enhancement of this significant collection. Finally, the study will convene in a catalog drawn up by Professor Salima Ikram.
Initially, most of the findings were subjected to radio / tomographic surveys, which allowed the contents of the bundles to be known and studied in a non-invasive way. In the case of animal remains present within them, the study will be investigated in such a way as to be able to identify animal species.
Subsequently, the diagnostic plan was oriented to obtain useful information on various aspects, currently still little studied for animal mummies. The use of different scientific techniques will allow, for example, to deepen the study of the different types of bandage, the knowledge of the materials and techniques used for the realization of the decorations, as well as the materials used in the embalming process and to improve the information in on the chronology of these findings.
The second phase of this project consists of the intervention of maintenance and restoration, currently underway in a laboratory set up within the museum, of a hundred artifacts that present particularly precarious conservative conditions. In fact, on these finds, there can be a collapse of the structure, of the decorative module and of the external fabrics. Almost always there are gaps in the fabric, with the consequent spilling of the vegetable fibers, often used in the padding, or even the organic fragments of the animal kept inside the wrapper. These factors make the restoration phase particularly complex: it will be necessary to restore solidity to the structure and restore the correct reading of the finds, in view of their future exhibition location and/or storage.
Once the restoration is finished, in fact, most of the animal mummies will find a place in the windows dedicated to the warehouses that can be visited, within the new exhibition itinerary.

http://www.tecnart.unito.it/about.html

4th International Conference on Metrology for Archaeology and Cultural Heritage

Invited to submit papers for the 4th International Conference on Metrology for Archaeology and Cultural Heritage to be held in Cassino, Italy.
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http://www.salonedelrestauro.com/

26 - 29 MARZO 2018
3rd International Conference on Innovation in Art Research and Technology - inArt 2018
Parma (Italy)
http://www.inart2018.unipr.it/

17 - 20 APRILE 2018
Archiving 2018
Washington (Usa)
http://www.imaging.org

2 - 5 MAY 2018
Archaeology Channel - Conference on Cultural Heritage and Media
Oregon (Usa)
https://goo.gl/a3KVZg

16 - 17 MAY 2018
Esri Italia Conference 2018
Roma (Italy)
http://www.esriitalia.it

16 - 18 MAY 2018
Salone dell'Arte e del Restauro di Firenze
Firenze (Italy)
http://www.salonerestaurofirenze.com/restauro/2018/

16 - 18 MAY 2018
International Conference Florence Heritech - The Future of Heritage Science and Technologies
Firenze (Italy)
http://www.florenceheritech.com/

23 - 25 MAY 2018
YOCOCU 2018 - Dialogues in Cultural Heritage
Matera (Italy)
http://www.yococu2018.com/

24 - 25 MAY 2018
16th KUI Conference "Culture and Computer Science"
Berlin (Germany)
https://inka.htw-berlin.de/kui/18/

3 - 7 JUNE 2018
ISPRS Symposium Towards Photogrammetry 2020
Riva del Garda (Italy)
http://www.isprs.org/tc2-symposium2018/

18 - 20 GIUGNO
Museum Next Europe 2018
London (Uk)
http://www.museumnext.com

24 - 27 GIUGNO 2018
Salento AVR 2018
Otranto (Italy)
http://www.salentoavr.it

3 - 6 JULY 2018
XXXIV° Science and Cultural Heritage Conference
Bressanone (Italy)
http://www.scienzaebeniculturali.it/

22 - 27 JULY 2018
Scientific Methods in Cultural Heritage Research
Castelldefels (Spain)
https://goo.gl/xNwJfw

12 - 15 NOVEMBER 2018
Congress Visual Heritage
Vienna (Austria)
http://www.chnt.at/

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