ASSOCIAZIONE ITALIANA DI ARCHEOMETRIA

X CONGRESSO NAZIONALE AIAR

14-17 FEBBRAIO 2018 TORINO

VENTICINQUE ANNI DI AIAR

ABSTRACT BOOK

UNIVERSITÀ DEGLI STUDI DI TORINO
DIPARTIMENTO DI SCIENZE DELLA VITA E BIOLOGIA DEI SISTEMI
VIA ACCADEMIA ALBERTINA, 13
TORINO

ORGANIZZATORI

UNIVERSITÀ DEGLI STUDI DI TORINO

POLITECNICO DI TORINO

UPO UNIVERSITÀ DEL PIEMONTE ORIENTALE

INFN CHNet Istituto Nazionale di Fisica Nucleare Cultural Heritage Network

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

Région Autonome Vallée d'Aoste Regione Autonoma Valle d'Aosta
Assessorat de l'Éducation et de la Culture
Assessorato Istruzione e Cultura

CENTRO CONSERVAZIONE RESTAURO LA VENARIA REALE

TecnArt Tecnologia e ricerca per l'Arte

CON IL CONTRIBUTO DI

UNIVERSITÀ DEGLI STUDI DI TORINO

Fisica Torino

INFN TORINO Istituto Nazionale di Fisica Nucleare Sezione di Torino

BRUKER

Be sure. testo

LOT QuantumDesign

KONICA MINOLTA

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PATROCINI

MiBACT Ministero dei beni e delle attività culturali e del turismo

CITTA' DI TORINO

Società Chimica Italiana
Divisione di Chimica Ambiente e Beni Culturali

G.A.BE.C. GEOARCHEOLOGIA · AMBIENTE · BENI CULTURALI SIMP Società Italiana di Mineralogia e Petrologia

MUSEO EGIZIO

museo galileo Istituto e Museo di Storia della Scienza

Lungo l'arte di Stato

CON LA COLLABORAZIONE DI

DBios

chimica

Dipartimento di Scienze della Terra Università degli Studi di Torino

Gruppo Archeologico Torinese

Si ringrazia Lorena Canottiere per la realizzazione del logo del Congresso

COMITATO SCIENTIFICO

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Selena Viel

SESSIONI	CODICE
Caratterizzazione e Diagnostica	C&D
Conservazione Preventiva e Restauro	CP&R
Materiali Innovativi e Nanotecnologie	MI&N
Provenienza e Datazione	P&D
Tutela e Valorizzazione	T&V
Bioarcheologia & Interazione Uomo-Ambiente	B&IUA
Diffusione e divulgazione scientifica nei Beni Culturali	DDSBC
Innovazione tecnologica	ITec

Mercoledì 14 Febbraio 2018

Dalle ore 10.00 Registrazione

Aula Magna

14.00 - 14.30 Saluti istituzionali

14.30 - 14.50 Apertura lavori - Carmine Lubritto "AIAr oggi e domani"

14.50 - 15.50 Conferenza a invito - Christian Greco "Archeologia dell'invisibile"

15.50 - 16.20 Pausa caffè

16.20 - 18.20 Sessioni orali parallele

Aula Magna - Caratterizzazione e diagnostica

Chair: Sabrina Grassini

16.20	J. Vernet, G. Ghiara, P. Piccardo, G. Voland	Tin oxides inclusions in early archaeological bronzes can be a marker of metal recycling?
16.40	M. Capris, M. Bortolotti, L. Lutterotti, B. T. Marcinik, D. Martorelli, G. Pepponi, S. Gialanella	A multi-analytical approach to the study of ancient coins: the case of the Venetian “sesino”.
17.00	M. Di Fazio, A. C. Felici, F. Catalli, C. De Vito	Study of dezincification in orichalcum Roman coins
17.20	D. Di Martino, C. Cucini, E. Perelli Cippo, G. Gorini, M. P. Riccardi	Bulk and point measurements as tools for the reconstruction of ancient metallurgical techniques: the filigree of the Chiaravalle Cross and the nails of the archaeological site of Valle delle Forme (Val Camonica, BS)
17.40	A. Elsayed, E. Angelini, S. Grassini	Microstructural and morphological characterisation of ancient bronze coins from the archaeological site of Al-Fustat city in Egypt
18.00	G. Berruto, E. Diana, R. Giustetto, M. Venturino	Sea treasures and ancient trade: archaeometrical investigation on Iron Age bronze fibulae with inserts

Aula B - Conservazione preventiva e restauro

Chair: Rosa Boano

16.20	L. D’Alessandro, S. Sottile, C. Pelosi, G. Calabrò, C. Colantonio, M. Melis	Hyperspectral Imaging system for Cultural Heritage diagnostics: an innovative study for copper painting application
16.40	G. Gregori, M. Rossani, P. Del Vesco, M. Borla, A. R. Zink, A. Paladin, C. Wurst, F. Maixner, M. Cibin, K. Sterflinger-Gleixner, G. Pinar, M. Samadelli	Studies aimed at the preservation of the mummified remains of the Museo Egizio in the framework of Mummy Conservation Project
17.00	C. Oliva, S. Aicardi, M. Borla, D. Angelici	The animal mummies of the Museo Egizio: study and conservation
17.20	Z. Vangelatos, M. Delagrammatikas, O. Papadopoulou, P. Vassiliou	A Computer Simulation Study of Free and Constraint Steel Clamps in a Marble Wall of a Classic Period Monument
17.40	M. Monego, G. Targa, C. Previato, A. Menin, V. Achilli	Integration of geomatic methodologies applied in a multidisciplinary approach to the study, conservation and valorization of Cultural Heritage: the case study of the Sarno Baths (archaeological site of Pompeii)
18.00	L. Bertrand, I. Joosten, K. Keune, A. Simon, F. Zanini	Best Practices for a Safe Analysis of Paintings and Painting Materials with Ionizing Radiation

Aula C - Provenienza e Datazione

Chair: Alessandro Lo Giudice

16.20	LI. Casas, E. Tema	Investigating the precision of archaeomagnetic dating during the last 3000 years
16.40	A. Galli, M. Caccia, M. Martini, L. Panzeri, F. Maspero, S. Fiorentino, M. Vandini, E. Sibilia	Thermoluminescence dating of glass: applying the “pre-bleached with blue LEDs” protocol to Umayyad mosaic tesserae
17.00	L. Liccioli, G. Fabiani, S. Barone, M. Fedi, M. Togni	Radiocarbon wiggle matching as a high-resolution dating method: the example of Villa Rucellai in Florence
17.20	A. M. Gueli, V. Garro, O. Palio, S. Pasquale, G. Politi, G. Stella, M. Turco	The chronology of the Valcorrente site in Belpasso (CT) obtained by ThermoLuminescence
17.40	M. Ferrante, G. Pardini, S. Nisi, P. R. Trincherini, M. L. Di Vacri	Precise lead isotope ratios measurements for geographic attribution of some ancient coins
18.00	S. Omarini, R. Fontana, J. Striova, P. Baraldi, P. Zannini, M. E. Fedi, M. Galeotti	Notes on Vestorius’ blue – New findings and investigations

19.00-20.00 Museo Egizio: visita a porte chiuse con egittologi in sala

20.00-22.00 Museo Egizio: Apericena nella Galleria dei Re

Giovedì 15 Febbraio 2018

Aula Magna

9.00 - 10.00 Conferenza a invito - Sofia Pescarin "Applicazioni digitali e musei: stato dell'arte e prospettive future"

10.00 - 11.00 Sessione FOCUS

Innovazione tecnologica

Chair: Carmine Lubritto

10.00	M. Gironda, R. Alberti, R. Tagle, C. Vailati	XRF Mapping, the experience from industry
10.15	S. Paziani, J. Jussila	Hyperspectral imaging on-site: world first portable push-broom hyperspectral camera
10.30	A. Pili	Climate monitoring systems for the conservation of cultural assets
10.45	R. Tagliapietra	Raman spectroscopy latest techniques in archaeological and historical artifacts studies

11.00-11.20 Pausa caffè

11.20-13.00 Sessioni orali parallele

Aula Magna - Caratterizzazione e diagnostica

Chair: Maurizio Aceto

11.20	A. Impallaria, L. Volpe, F. Petrucci, F. Tisato	The artistic palette of Carlo Bononi, Baroque artist of Ferrara
11.40	R. Caliandro, V. Toson, L. Palin, E. Conterosito, M. Aceto, V. Gianotti, E. Boccaleri, E. Doorhyee, M. Milanesio	New hints on Maya Blue formation process by PCA-assisted in situ XRPD and optical spectroscopy analysis
12.00	N. Odisio, A. Idone, N. Seris, M. Calabrese, S. Migliorini, A. Glarey, L. Appolonia	Creation of a database of restoration products on different supports with portable NIR-FORS
12.20	P. Pallecchi, G. Giachi, E. Pecchioni, P. Santo Alba	Etruscan Paintings of the Demoni Alati Tomb in the Sovana Necropolis (Southern Tuscany, Italy)
12.40	A. Piccirillo, T. Poli, V. Rosciardi, G. Afruni, O. Chiantore, E. Diana	Formation of metal soaps in painting layers: a study on kinetics and reactivity

Aula B - Diffusione e divulgazione scientifica nei beni culturali

Chair: Emma Angelini

11.20	T. Pasciuto, M. Di Fazio, F. Di Turo	The Challenge of Divulgation: an experiment called “Research for Cultural Heritage”
11.40	E. C. Portale, S. Aiosa, E. Caponetti, D. Chillura Martino, M. Cultraro, M. de Cesare, M. L. Saladino, L. Sineo	Dialogue and dissemination: Science and Archaeology. The experience of the project "Science and Archaeology: an effective combination for the dissemination of scientific culture".
12.00	A. Gori, E. Angelini	The Galileo Museum of Florence an actor of social inclusion
12.20	C. Fantoni, A. Gori, E. Angelini	Experiencing the scientific divulgation in the medioeval Poppi Castle
12.40	S. Fiorentino, M. Bernadette Melis, M. Vandini	Communicating conservation science through CONCEPT: The case of Palazzo Guiccioli in Ravenna

Aula C - Materiali innovativi e nanotecnologie

Chair: Roberto Giustetto

11.20	A. Veneri, P. Pogliani, G. Agresti, C. Pelosi	Tattoo Wall®: study of the stability of an innovative decorative technique and possible application in the restoration of paintings in outdoor and hypogeum environments
11.40	A. Giordano, V. Rotolo, E. Di Carlo, F. Palla	Novel esterase - microemulsion for the bioremoval of glue residues
12.00	P. Davit, A. Idone, M. Gulmini, E. Calà, M. Aceto	Evaluation of the stability and reproducibility of Ag colloidal pastes as Surface Enhanced Raman Spectroscopy (SERS) substrates for the analysis of natural dyes in archaeological and historical textiles
12.20	L. Iannucci, S. Grassini, E. Angelini, M. Parvis, J. F. Rios Rojas	Electrochemical characterization of innovative hybrid coatings for metallic artefacts
12.40	B. Campanella, T. Cavaleri, S. Legnaioli, E. Grifoni, A. Idone, G. Lorenzetti, S. Pagnotta, A. Piccirillo, F. Poggialini, C. Ricci, M. Borla, V. Turina, V. Palleschi	Surface enhanced Raman spectroscopy and nanoparticle enhanced laser induced breakdown spectroscopy for the study of historical textile dyes and mordants

13.00-13.50 Light lunch

13.50-15.00 Sessione POSTER

15.00- 16.40 Sessioni orali parallele

Aula Magna - Caratterizzazione e diagnostica

Chair: Susanna Bracci

15.00	G. Fiocco, T. Rovetta, M. Licchelli, M. Malagodi, F. Zanini, G. Lanzafame, A. Re, A. Lo Giudice, M. Gulmini	Synchrotron radiation micro-CT for the investigation of finishing treatments in ancient bowed stringed instruments: issues and perspectives
15.20	F. Antonelli, V. Iebba, L. Calvo, V. Licursi, P. Tisseyre, S. Ricci, F. Guerrieri	Characterisation of the black patina of the Tiber's embankments by Next-Generation Sequencing
15.40	J. La Nasa, J. J. Lucejko, M. P. Colombini, E. Ribechini	Lipids in archeology: oils and fats characterization by HPLC/ESI-Q-ToF
16.00	R. Mentesana, G. E. De Benedetto, E. Margapoti	Utilization of living space in Early Bronze Age Sicily: results of an interdisciplinary study in Santa Febronia (Italy).
16.20	F. Nardella, M. Colombo, M. Serradiminghi, C. Tozzi, I. Degano, E. Ribechini	Gas chromatographic and mass spectrometric investigations of bitumen from Neolithic flint flakes recovered from archaeological excavations in Central-Southern Italy

Aula B - Tutela e valorizzazione

Chair: Mauro Francesco La Russa

15.00	G. Vidorni, A. Sardella, P. De Nuntiis, F. Volpi, A. Dinoi, D. Contini, V. Comite, C. Vaccaro, P. Fermo, A. Bonazza	Air pollution impact on stones in urban environment: a multidisciplinary approach
15.20	A. Marengo, E. Bittarello, L. M. Gallo, E. Costa	The meteorites held at the Regional Museum of Natural Science of Turin: conservation, valorisation and fruition of a historical scientific collection
15.40	F. Gambino, C. Ricci, M. Nervo, A. Piccirillo, A. Scarcella, A. Borghi	Conservation of urban heritage and stone deterioration patterns in the city of Torino (Italy)
16.00	M. Radis, P. Iacomussi	Influences of optical characteristics of protective varnish on glossiness of painted artefacts
16.20	C. Ricci, F. Gambino, M. Nervo, A. Piccirillo, F. Zenucchini, A. Scarcella, A. De Stefanis, J. S. Pozo-Antonio	Comparison of cleaning procedures for ornamental stones against graffiti vandalism

Aula C - Caratterizzazione e diagnostica

Chair: Celestino Grifa

15.00	A. Arcudi, V. Crupi, M. F. La Russa, D. Majolino, M. Osanna, R. Pace, S. A. Ruffolo, M. Ricca, N. Rovella, N. Ruggeri, V. Venuti	Tituli Picti in the archaeological site of Pompeii: diagnostic analysis and conservation strategies
15.20	R. C. Ponterio, G. Anastasio, E. Caponetti, V. Mollica Nardo, V. Renda, C. S. Vasi, M. L. Saladino	"Miracula in vitro": in situ spectroscopic study on the largest Italian collection of reverse glass paintings
15.40	C. Grifa, C. Germinario, M. Mercurio, A. Langella, F. Izzo, S. Di Mauro, G. Soricelli	Technology in the production of Red Slip Ware in Campania (Italy): a comparison between Terra Sigillata from Puteoli and Campanian Orange Ware from the Bay of Naples
16.00	L. Angeli, A. Brunetti, S. Legnaioli, C. Fabbri, B. Campanella, E. Grifoni, G. Lorenzetti, V. Palleschi, G. Radi	Analysis of the Middle Neolithic Trichrome pottery: characterization of the decoration using XRF and Raman
16.20	M. Reboldi, E. Tema, E. Ferrara, R. Giustetto, E. Diana, M. Venturino	Archaeometric study of the protohistoric baked clay artefacts from the archaeological site of Villa del Foro (AL)

16.40-17.00 Pausa caffè

17.00-18.00 Aula Magna - Assemblea soci

18.00-19.00 Passeggiata "TOURinSTONES"

Dalle 19.00 Cena sociale & festeggiamenti 25 anni AIAr con quartetto musicale jump swing

Venerdì 16 Febbraio 2018

Aula Magna

9.00 - 10.00 Conferenza a invito - Matthew Collins "The ancient Biomolecule Revolution"

10.00 - 11.00 Sessioni orali parallele

Aula Magna - Caratterizzazione e diagnostica

Chair: Maria Luisa Saladino

10.00	S. Bracci, E. Cantisani, M. Coppola, D. Magrini	The tomb of Seti I (KV17) in the Florence Archaeological museum. Integrated non-invasive methods to document, characterize materials and define the conservation assessment
10.20	E. Calà, M. Aceto, A. Agostino, G. Fenoglio, V. Capra, F. Porticelli, F. Manzari, S. Fiddyment	The Messale Rosselli: scientific investigation on an outstanding 14th century illuminated manuscript from Avignon
10.40	C. Ruberto, A. Mazzinghi, C. Czelusniak, L. Palla, S. Mangani, L. Castelli, P. A. Mandò, F. Taccetti, F. Giuntini	Identification of pigments, inks and gilding decorations of an illuminated medieval parchment, exploiting the LABEC INFN-CHNet XRF scanning system

Aula B - Bioarcheologia e interazione uomo-ambiente

Chair: Franco Palla

10.00	B. Demarchi, M. Collins	Birds in ancient societies
10.20	M. Baldoni, G. Scorrano, M. Alexander, F. R. Stasolla, L. T. Marsella, O. Rickards, C. Martínez-Labarga	The Medieval Population of Leopoli-Cencelle: Dietary Pattern Reconstruction through Stable Isotope Analysis from Bone Collagen
10.40	S. Varano, F. De Angelis, G. Amicucci, A. Battistini, S. Di Giannantonio, F. Zavaroni, P. Catalano, C. Lubritto, P. Ricci, S. Altieri, V. Gazzaniga, C. Martínez-Labarga, O. Rickards	Diet and Society: isotope evaluation of Imperial Rome communities (1st-3rd cent. CE)

Aula C - Caratterizzazione e diagnostica

Chair: Alessandro Re

10.00	E. Di Francia, R. Lahoz, D. Neff, E. Angelini, S. Grassini	ToF-SIMS analyses on laser cleaned bronze coins
10.20	F. Di Turo, N. Montoya, J. Piquero-Cilla, C. De Vito, F. Coletti, G. Favero, M. T. Domenéch-Carbò, A. Domenéch-Carbò	Archaeometric analysis of coins from the Magna Mater Temple: metals characterization and electrochemical dating
10.40	C. Petiti, J. M. Welter, B. Salvadori, S. Vettori, S. Goidanich	The colossus of San Carlo Borromeo in Arona (NO, Italy). On site characterization of the metallic materials

11.00 - 11.20 Pausa caffè

11.20-13.00 Sessioni orali parallele

Aula Magna - Caratterizzazione e diagnostica

Chair: Ferruccio Petrucci

11.20	M. F. Alberghina, G. Germinario, M. La Russa, A. Macchia, G. Milazzo, A. Casanova Municchia, S. Ruffolo, S. Schiavone, L. Sabbatini, A. Sodo	MonS REALIS - Monreale Sculptures: REIief, Analytical Laboratory investigations and Integrated Studies
11.40	M. Bellato, J. Li, A. King, L. Robbiola, M. Thoury, C. Moulhérat, A. Thomas, P. Guériau, P. Galtier, M. Gulmini, L. Bertrand	Novel approach for characterising archaeological textiles exceptionally preserved in a mineralised formbased on 2D and 3D synchrotron micro-imaging
12.00	C. Greco, F. Aliotta, L. Arcidiacono, M. Borla, D. Di Martino, F. Facchetti, E. Ferraris, G. Festa, G. Gorini, J. Kelleher, D. Micieli, T. Minniti, C. Perelli Cippo, R. Ponterio, G. Salvato, R. Senesi, V. Turina, C. Vasi, W. Kockelmann, C. Andreani	New results from the ARKHA Project. ARchaeology of the invisible: unveiling the grave-goods of KHA
12.20	D. Miriello, L. Barba, J. Blancas, A. Bloise, M. Cappa, M. Cura, D. De Angelis, R. De Luca, A. Pecci, M. Taranto, G. M. Crisci	Archaeometric study of Hagia Sophia (Istanbul, Turkey): compositional, geophysical and thermographic approach
12.40	E. Costa, M. E. Moschella, M. Cristellotti, A. Marengo, R. Giustetto	The decay of the “Rivellino degli Invalidi” Subway Fortifications in Turin – a Case Study in Diagnostics and Conservation.

Aula B - Bioarcheologia e interazione uomo-ambiente

Chair: Beatrice Demarchi

11.20	C. Principe, A. Gogichaishvili, S. Arrighi, M. Devidze, S. La Felice, A. Paolillo, D. Giordano, J. Morales	Archaeomagnetic dating of Copper Age furnaces at Croce di Papa village and relations on Vesuvius and Phlegraean Fields volcanic activity
11.40	J. Sakalauskaite, F. Marin, B. Demarchi	Biomolecular identification of prehistoric shells
12.00	B. Triozzi, S. Valenzuela-Lamas, M. Ferrante, P. Nystrom	Strontium Isotope analyses to investigate the mobility of the Iron Age Vestini population of Loreto Aprutino, Abruzzo, Italy
12.20	P. Ricci, M. I. García-Collado, S. Altieri, T. Campos, N. Sarasola, J. A. Quirós Castillo, C. Lubritto	Palaeodietary reconstruction of two coastal medieval settlements from the Basque Country (northern Spain)
12.40	F. Modugno, J. J. Lucejko, S. Braovac, M. P. Colombini	Analytical methods for the chemical investigation of archaeological waterlogged wood

Aula C - Provenienza e datazione

Chair: Lucia Liccioli

11.20	K. Hellemans, S. Cagno, L. Bogana, M. Mendera, K. Janssens	LA-ICP-MS labels early medieval Tuscan finds as late natron glass
11.40	L. Panzeri, E. Sibilia, A. Galli, M. Martini, F. Maspero	Rehydroxylation: researches and results from Milano-Bicocca laboratory
12.00	E. Tema, E. Ferrara, E. Panero, S. Giachino	Archeomagnetic dating in Italy: an example of a baked clay kiln excavated at Santhià, Northern Italy
12.20	L. Maritan, L. Zamparo, C. Mazzoli, I. Bonetto	Punic black gloss ware: a history of importation and imitation from Carthage
12.40	M. S. Cellai, L. Chiarantini, A. Corretti, P. Costagliola, A. Dini, M. D'Orazio, V. Gassner, R. Manca, S. Marchionni, M. Paolieri, M. Benvenuti	The Sn-W enrichment of iron ores from Elba Island: a powerful marker of ancient iron trade routes in the Mediterranean region

13.00-14.00 Light lunch

14.00 - 15.00 Sessioni orali parallele

Aula Magna - Caratterizzazione e diagnostica

Chair: Francesca Alberghina

14.00	J. J. Lucejko, J. La Nasa, F. Modugno, C. McQueen, S. Braovac, M. P. Colombini	Protective effect of linseed oil varnish on archaeological wood treated with alum
14.20	M. Missori, A. Mosca Conte, O. Pulci, L. Teodonio, S. Dominijanni, S. Puteo, S. Iannuccelli, S. Sotgiu, M. L. Sebastiani	Optical reflectance spectroscopy allows non-destructive monitoring of molecular modifications in restoration of works of art on paper
14.40	P. A. M. Triolo, F. Locardi, M. Spingardi	Pratical application of visible induced luminescence and use of parasitic IR reflectance as relative spatial reference

Aula B - Conservazione preventiva e restauro

Chair: Lorenzo Appolonia

14.00	R. Genta, C. Tricerri, M. Trento, A. Piccirillo, T. Poli	Executive techniques “unveiled” by the conservation treatment: the case-study of the B54 japanese armour from the Armeria Reale in Turin
14.20	M. Caroselli, G. Cavallo, A. Felici, S. Luppichini, G. Nicoli, L. Aliverti	The use of gypsum in the Ticinese stucco artworks of the 16-17th century: motivation, characterization, provenance and induced degradation
14.40	S. Ferrarese, D. Bertoni, V. Dentis, L. Gena, M. Leone, M. Rinaudo	Microclimate analysis in a scientific museum: the case-study of the Physics Museum of Turin University

Aula C - Caratterizzazione e diagnostica

Chair: Simone Cagno

14.00	M. L. Amadori, N. Macchioni, G. Adami, C. Capretti	Woodcut blocks of the “Scuola del libro” of Urbino: a scientific approach for conservation
14.20	T. Rovetta, C. Invernizzi, G. Fiocco, M. Albano, M. Licchelli, M. Gulmini, A. Daveri, M. Vagnini, M. Malagodi	The identity of Stradivari violin ex-San Lorenzo: is it still preserved?
14.40	A. Idone, N. Odisio, D. Vaudan, N. Seris, P. Croveri, L. Appolonia	Identification of yellow pigments and their degradation products in the palette of a 15 th century alpine painter

15.00-16.00 Aula Magna - Premiazioni e chiusura

16.30-18.00 Passeggiata “Torino quadrata”

Sabato 17 Febbraio 2018

8.30-19.00 Gita sociale ad Aosta

Ore 8:30 - Ritrovo e partenza con bus ore 8:45 in Piazza Carlo Emanuele II (Piazza Carlina)
Ore 10:30 - arrivo ad Aosta, visita al complesso della Cattedrale di Aosta
Ore 13:30 - pranzo libero (possibilità di pranzo con menù tipico a prezzo fisso)
Ore 15:30 - visita del Parco archeologico e Museo dell’area megalitica di Saint-Martin-de-Corléans
Ore 17:30 - rientro a Torino (arrivo previsto intorno alle ore 19:00)

Sessione poster

Cod.	Autori	Titolo contributo
B&IUA-P1	V. Comite, P. Fermo, L. Barbagallo	Analysis of black crusts from the Church of Santa Maria delle Grazie al Naviglio Grande (Milan): A challenge to deepen the understanding of the relationship among microstructure, microchemical features and pollution sources
B&IUA-P2	L. Gaspari, F. De Angelis, C. Martínez-Labarga, P. Catalano, C. Caldarini, R. Mosticone, W. Pantano, C. Lubritto, S. Altieri, P. Ricci, V. Gazzaniga, O. Rickards	Mobility in the Empire: oxygen isotope survey of two roman communities
B&IUA-P3	M. Romboni, F. De Angelis, F.Cortese, L.Pandolfi, M. F. Rolfo, O.Rickards, L. Alessandri	Life, death and pathogens: a morphological and molecular study about “La Sassa” cave (LT) community
B&IUA-P4	S. Varano, F.De Angelis, L.Gaspari, C. Martínez-Labarga, O.Rickards	If These Bones Could Talk: The Tales Human Skeletons Can Tell Us
C&D-P1	M. Aceto, E. Calà, S. Cantamessa, A. Agostino, G. Fenoglio, V. Capra, G. Brun	An unusual blue-turquoise pigment found on a painting at Novalesa abbey (Piemonte)
C&D-P2	M. Monego, A. Rossi, V. Achilli	The Formagliaro Mill (Castelfranco Emilia, Italy): 3D survey of an historical and architectural heritage
C&D-P3	M.F. Alberghina, A. Merra, G. Milazzo, S. Schiavone, F. Spatafora	The non-invasive investigations to assist the conservation of the three wall paintings: new archaeological remarks about the "House of Masks" of Solunto
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C&D-P11	M. Borla, E. Caponetti, C. Greco, V. Mollica Nardo, G. Nasillo, R. Pitonzo, R.C. Ponterio, M.L. Saladino, A. Spinella, V. Turina, C. Vasi	Spying on beauty secrets in ancient Egypt: a multi-analytical approach
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C&D-P15	A. Gašpar, B. Mir Makhamad, J.Petřík, P. Fojtík, J.Mirão, M. Beltrame, A. M. Cardoso, N.Schiavon	A multi-analytical archaeometric approach to study white inlay decorations in Bell Beaker pottery from Broudek u Prostějova (Czech Republic)
C&D-P16	C. Germinario, F. Izzo, A. Langella, M. Mercurio, A.R. Russo, V. Petta, C. Grifa C.	Banded and partially glazed fine wares from Etruscan-Samnite necropolis of Pontecagnano (Campania region, Italy): preliminary archaeometric data
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C&D-P21	F. Catani, R. Manca, L. Chiarantini, A. Mazzinghi, V. Palleschi, C. Ruberto, V. Volpi, M. Benvenuti	Non-destructive analysis of ancient coins by portable XRF spectrometers: a methodological approach
C&D-P22	L. Maritan, E. Gravagna, J. Rius, A. Crespi, O. Vallcorba, L. Casas Duocastella	Secondary phases in ancient ceramics: mineral composition by synchrotron through-the-substrate microdiffraction
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C&D-P32	P. Ricci, M.E. Fedi, C. Germinaro, F. Izzo, M. Mercurio, A. Langella, C. Grifa, V. Salvatierra Cuenca, I. Montilla Torres, C.A. Garzonio, S. Barone, E. Cantisani, C. Lubritto	Mortar Radiocarbon Dating: The role of the characterization of materials in the sample preparation
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CONSERVAZIONE E DIAGNOSTICA

ORALI: C&D-O
POSTER: C&D-P

MonS REALIS
Monreale Sculptures: RElief, Analytical Laboratory investigations and Integrated Studies

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The Cathedral of Monreale has been included by UNESCO in the World Heritage List in July 2015, within the serial heritage site "Arab-Norman Palermo". The recent restoration work on the Major Portal, aimed at preserving and improving the knowledge of precious decorated surfaces, confirms that this unique work of art, documented through a 3D modelling relief [1], represents a set of architectural sculptural artifacts of great artistic value, perhaps among the most significant of this era. During the conservative process, various traces of original final treatments of marble surfaces have been detected and investigated with various micro-destructive or non-invasive techniques, both in situ and on sample, even if in some cases they were removed or altered by the previous restorations. No written documentation of the past restorations it is known. The only legible evidence is today represented by the materials added over time on sculptural surfaces which represent the only ones able to reconstruct the history of material culture that begins in the 12th century till our days. In order to provide the necessary information to address the methodologies and materials for restoration work, to deepen the original executive technique and to evaluate the state of conservation, an integrated and multi-analytical scientific investigation has been carried out. The diagnostic project has concerned the characterization of materials and the identification of past restoration treatments. A big effort was dedicated to identify the presence of polychromes and finishes of the carved marble portions. IR thermography was used in different phases of the project to provide a mapping of thermal anomalies (detachments, cracks, different construction materials), providing an effective support the operations for securing and consolidating the surfaces carved or affected by mosaic decoration. A cover meter relief allowed to locate in a quick way internal metal elements of support and/or junction of marble elements. XRF investigations were performed to preliminary identify elements and to select the sampling area. Different areas were samples and cross-sections were prepared. Samples were investigated by XRD and SEM-EDS to discriminate original, degradation and restoration surfaces. Moreover, Raman analysis were performed in order to confirm the identification of a red-brown layer present on the marble substrate; ionic chromatography was used to determine the soluble salts; FT-IR and Py-GC-MS analyses were applied to characterize organic materials due to previous restoration works. The diagnostic investigations allowed to identify the degraded protectives applied over time on the surfaces, to distinguish the original portions from those due to restoration and to support the stylistic reconstruction of the original appearance of the precious carved marble.

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Novel approach for characterising archaeological textiles exceptionally preserved in a mineralised form based on 2D and 3D synchrotron micro-imaging

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As most organic materials, textiles fibres are perishable in archaeological contexts. Nevertheless, in specific environments they may be preserved over millennia, for example in contact with metal objects. The corrosion of the metal support can enable an exceptional preservation of textile remnants in a process called "mineralisation" by archaeologists. The underlying physico-chemical mechanisms have been the subject of a very limited number of studies. An in-depth understanding of the causes and the conditions of this phenomenon, as well as of the variability of the involved processes, is yet to be achieved.

We report the study of mineralised linen fabrics identified at the surface of copper-based artefacts coming from Mesopotamia (Telloh and Susa sites, 5th–2nd millennium BC) and in the Indus areas (Nausharo site, 4th millennium BC; Gonur-depe site 3rd–2nd millennium BC), currently conserved and under study at the Louvre and the Quai Branly museums. In Mesopotamia, these finds are major direct testimony of textile manufacturing from the corresponding cultures, otherwise uniquely known from cuneiform texts.

2D and 3D synchrotron-based micro-imaging techniques were carried out to characterise in a non-destructive way these organic textile remnants in connection with the inorganic corrosion compounds. We performed and optimised synchrotron X-rays micro-computed tomography to identify and locate the distinct copper corrosion phases formed, on the basis of difference in their density. Preliminary tests using high-spatially resolved synchrotron UV/visible photoluminescence spectral imaging were performed to investigate the heterogeneity of individual mineralised bundles of fibres. We reveal the internal structure of these mineralised textile fibres in connection with the corrosion phenomena, and discussed the different mineralisation facies observed.

The present work illustrates the potential of 2D and 3D synchrotron micro-imagery to study mineralised textiles in association with metal objects.

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Sea treasures and ancient trade: archaeometrical investigation on Iron Age bronze fibulae with inserts

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In the VII century BC in Piedmont was common the use of a particular type of bronze fibulae, with circular inserts of whitish paste (De Marinis R.C., 2000; Faudino V. *et al*, 2014). In the archaeological literature these inserts are identified as constituted by red coral (*Corallium rubrum*). However, scientific analysis on this topic are scarce and generally make use of inaccurate methods (De Marinis R.C., 2000; Perrin F., 2000; Schvoerer M.*et al*, 2000). Red coral fishing has been carried out since ancient times. This material was imported since the III millennium BC and its trade increased during the Iron Age. Starting from the VI century BC it was imported by Celtic populations, through the mediation of the culture of Golasecca and then of *Massalia* (Perrin F., 2000).
Raman Spectroscopy is the most effective technique in the characterization of this material. It allows to identify the carotenoid pigments contained in *Corallium rubrum* (Schvoerer M.*et al*, 2000). Recent studies on Iron Age materials from Central Europe have applied this technique on the characterization of whitish decorations (Fürst S.*et al*, 2016).
Some samples of piedmontese fibulae decoration were collected to better understand the manufacturing techniques and the trading system in which Northwest Italy was inserted in the Iron Age. The artefacts investigated come from three different archaeological sites: Brignano Frascata (AL), Castelletto Ticino (NO) e Villa del Foro (AL). In some cases the whitish paste decoration is preserved, expecially when placed in holes, but in most cases this pattern is no longer visible and can be only hypothesized, both in holes or engraved lines.
43 samples collected from 33 fibulae were subjected to FT-IR analysis and, when possible, Raman and XRPD investigations. The simultaneous application of different analysis techniques has allowed to obtain excellent results in the characterization of the materials considered. It was possible to obtain rapid results using a very small quantities of sample. The analysis led to the recognition of calcite in many cases and sometimes allowed a more precise identification of carotenoid pigments (*Corallium rubrum*).
In some case it was possible to identify the presence of calcite signals even within the engraved lines decorations. This is an interesting result because this feature has never been considered before.
Furthermore almost all the samples reveal signals referable to the presence of organic material. The artefacts examined were not generally subjected to restauration. The organic traces could therefore be related either to manufacturing techniques or to a surface treatment made in the past.
The obtained results permitted to include these areas in a large trading system. They also allow us to better understand the ancient production techniques. The results even contribute to better defining this issue, providing significant information based on accurate archaeometric analysis.

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The tomb of Seti I (KV17) in the Florence Archaeological museum. Integrated non-invasive methods to document, characterize materials and define the conservation assessment

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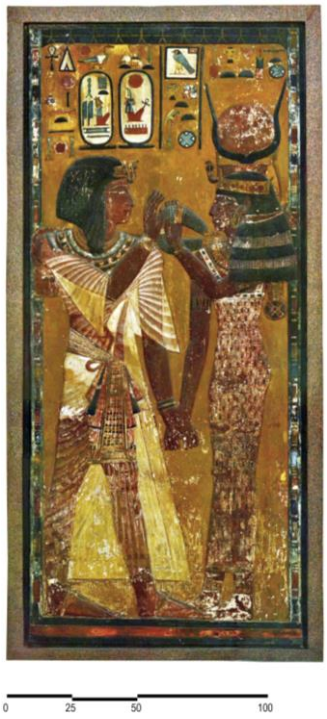
The tomb of Seti I (KV17), located in the Valley of the Kings, is a great example of New Kingdom funerary architecture. It was discovered in 1817 by G. B. Belzoni (1).The investigated fragment of KV17 belongs to gate jamb connecting the chamber F to the corridor G and was removed during the franco-tuscan expedition under the direction of J. F. Champollion and I. Rosellini in 1829 (2). During this campaign the severe degradation of paintings, just few years after the discovery, was outlined and it was decided to take portions of painted reliefs that were sent to France (Louvre) and to Tuscany, in the collections of the future Archaeological Museum of Florence (established in 1855). The fragment (238 x 105 x 23) is on display in room V (n. 2468).

In the framework of a collaboration among the Archaeological Museum in Florence, the University of Florence and ICVBC-CNR a campaign based, at least as first approach, completely on non-invasive techniques on the fragment was performed in the museum. Several repaintings, retouches and protective treatments dealing to previous conservation treatments are visible.



The primary goal of the analytical survey was to achieve the best level of documentation, knowledge of the materials and conservation assessment. Preliminary results highlighted the conservation history of this fragment, from its realization to the present. The digital documentation represented a strategic instrument for mapping and the management of the collected information. The diagnostic essay performed and the preliminary results obtained proved that the combination of the imaging techniques together with elemental and molecular spectroscopies is a powerful tool for the knowledge of the materials. The project is still on-going and preliminary results will be shown.

Fig.1 - Wall fragment on display in the museum in its current condition

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The *Messale Rosselli*: scientific investigation on an outstanding 14th century illuminated manuscript from Avignon

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The manuscript D.I.21 kept at Biblioteca Nazionale Universitaria in Torino, better known as *Rossell Missal* or *Messale Rosselli*, is one of the richest fully illustrated Missals surviving from the mid-14th century. It was produced for the Aragonese cardinal Nicolas Rossell (1314-1362), as indicated both by the *colophon* at the end of the manuscript, where the scribe Alamannus states that the book was completed in 1361, and by a beautifully decorated note at the beginning (Manzari, 2006). This was drawn in coloured inks by a pen-flourisher recognisable throughout the Missal and in other manuscripts produced in Avignon, identified as the illuminator Bernard de Toulouse (Manzari 2014). The vast illustrative programme, painted in tempera by a different workshop, is based on historiated initials introducing the masses in the liturgical year, while the most important festivities are highlighted by fully illuminated borders. The Missal stayed in the Avignon curia after the patron's death, passing into the hands of cardinal Guillaume de Bragose and of archbishop Pierre II de Cros, before 1383 (Manzari, 2006).
The *Messale Rosselli* has recently been the object of a thorough interdisciplinary study, involving full characterisation of the colourants with non-invasive techniques (FORS, fluorimetry, XRF spectrometry, optical microscopy). The full set of colourants was identified, highlighting the systematic use of precious pigments such as lapis lazuli, cinnabar and gold, a feature reinforcing the symbolic value of the manuscript; in addition, less valuable but interesting dyes such as brazilwood and folium were also identified, used either pure or in a mixture with pigments in order to obtain a wide range of hues. The overall palette has been evaluated according to the availability of raw materials in the geographic area around Avignon, finding that most of the colourants could be at easy disposal of the artists.
Information has also been obtained concerning the preparation of the parchment and the volume itself. The systematic measurement of the width of folios allowed hypothesising the number of the animals slaughtered to produce parchment, and the way of using skins. XRF analysis on the folios suggested that two different preparations were used, one with clay material and one with white lead. Finally, using ZooMS (ZooArchaeology by Mass Spectrometry), a non-invasive technique able to provide information on the animal species from which parchment was produced (Fiddyment *et al.*, 2015), it was found that both calf and goat were used to produce the parchment in the *Messale Rosselli*.

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A multi-analytical approach to the study of ancient coins: the case of the Venetian "*sesino*".

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The material study of ancient coins is very often rendered particularly challenging by several factors: the presence of surface alteration products; the occasional or deliberate, e.g., forgery, changes in the composition of the base alloy; the misleading information deriving from literature sources.
In this study, we present a multi-analytical approach to the study of ancient coins. The selected test samples are coins widely used in the Venetian Republic over a time span ranging from the second half of the 15th until the early years of the 16th century: the so-called "*sesino*". The high availability of these coins has allowed us to develop our methodology by both destructive and non-destructive investigations. The rationale was to establish through this approach a model, taking into account the layered structure of the surface region of the coins, that once validated can be used for a fully non-destructive characterization of similar items.
The destructive part of the research work has been conducted using a metallographic approach, based on optical and scanning electron microscopy techniques. This latter has been used in association with energy dispersive X-ray microanalysis. The non-destructive measurements are based on the combination of X-ray diffractometry and X-ray fluorescence spectrometry.
The results are very promising and are going to be tested on a number of samples of historical and archaeological interest.

Study of dezincification in orichalcum Roman coins

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A group of orichalcum Roman coins, from private collections, have been studied for this research. Numismatic examination[1,2] indicated that they are asses, sestertium and dupondius, minted from Julius Caesar to Nero. Orichalcum is an ancient copper based alloy with a variable percentage of zinc[3].
The aim of this study was to investigate the process of dezincification from the external layers to the core of the samples. Furthermore, the research was aimed to disclose the real chemical composition of the orichalcum alloy.
In scientific literature is reported that the percentage of zinc in the alloy is related to the age in which the coin was minted[4].
The samples were firstly analysed by means of X-ray fluorescence spectroscopy to obtain information about the elemental composition (qualitative method) of the external layers. This non-invasive analysis allowed to discriminate coins made with zinc alloy from the bronze ones.
Because of the degradation of the external layers of orichalcum[5] and the dezincification[6] process, other analysis were also carried out on cross section of some zinc based samples, such as scanning electron microscope (SEM-EDS) and electron micro probe analyser (EMPA). The first technique was useful to investigate the depth of corrosion and dezincification processes and to examine alloy's microtexture (e.g. *segregation micro-domains*); the second one permitted a quantitative chemical analysis of major, minor and trace elements composing this ancient alloy, understanding the difference of chemical compositions between the unaltered core and the altered layers.
All the techniques performed both on the cross sections and on the external layers of the coins revealed that other metals, i.e. Fe, Sn, Pb, As, were also present in the alloy.
Finally, results were chronologically ordered and compared with literature's data.

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ToF-SIMS analyses on laser cleaned bronze coins

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Cleaning of unwanted surface layers in Cultural Heritage conservation is a critical action, that requires high accuracy and high material selectivity: for these reasons, laser cleaning treatments have been systematically investigated to assess their feasibility for cleaning bronze artefacts [1,2,3]. The attention has been focused on the study of the laser/material interaction, which is an important step in the optimisation of self-limiting and non-destructive cleaning treatments. As a matter of facts, setting the experimental parameters (pulse duration, power, irradiance, etc.) of the laser treatment is still a critical point for removing the corrosion products without affecting the metallic substrate.
In this paper, pulsed laser cleaning treatments have been performed in different experimental conditions by means of a NIR Q-switched Yb:YAG fibre laser. The treatments have been previously performed on a set of Cu-based reference samples, artificially patinated both electrochemically and by immersion in chlorides solutions, and then on some bronze ancient coins.
In particular, laser treatments have been carried out in ^{18}O rich atmosphere in order to investigate if the laser beam could induce a re-oxidation on the metallic surface during the ablation of the corrosion products.
ToF-SIMS analyses have been performed to detect the composition of the cleaned surface and the presence of ^{18}O isotope after the laser treatment, to evidence if any interaction occurs between the metal and the atmosphere induced by the laser. Fig. 1 shows, as an example, the ToF-SIMS maps of Cu, O and Cl collected on a bronze coin after the laser treatment in ^{18}O rich atmosphere. ToF-SIMS analyses confirm that the laser treatment removes most of the dangerous oxy-chlorides compounds from the patina, without modifying the cuprite film grown in contact with the metal. Therefore, even if Cl^- ions are still present, cuprite (Cu_2O) can act as a protective layer, preventing the interaction of reactive copper oxy-chlorides with oxygen and humidity and avoiding the cyclic copper corrosion process. Further analyses are in progress to confirm these preliminary results.

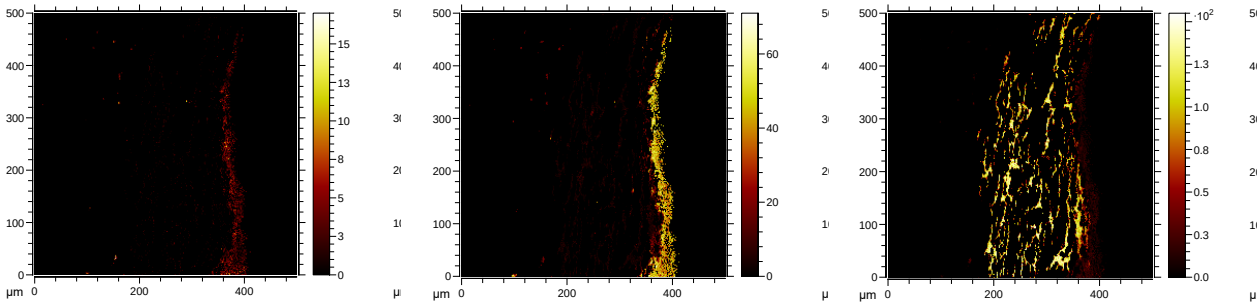

Fig. 1. ToF-SIMS maps of Cu, O and Cl collected on a bronze coin after the laser cleaning treatment.

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Bulk and point measurements as tools for the reconstruction of ancient metallurgical techniques: the filigree of the Chiaravalle Cross and the nails of the archaeological site of Valle delle Forme (Val Camonica, BS)

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Archaeometallurgy is a wide domain, combining scientific and historical issues: from metallurgy, studying the technological evolutions in the working processes of metals, to archaeology, trying to infer relevant indications on historical and cultural connections.

The production and manufacturing techniques of metals involve many expertise, and the study of ancient artefacts relies on interdisciplinary skills.

Metalworking processes used in the production of jewellery masterpiece can for example give indications on the provenance of an ancient object of unknown origin. While, excavated samples, from well known archaeological sites, can be studied in order to derive routes of metals extraction, and manufacturing techniques and their evolution.In this regard, two different case studies will be presented. On one side, a golden filigree coming from the Chiaravalle Cross (a beautiful processional cross, of very complex structure, .dating to the XIII century) [1], while, on the other side, a wide set of medieval iron nails, coming from Valle delle Forme (BS), very important in the study of iron metalworking techniques [2].

In both cases, a combination of bulk and point measurements was applied. Neutron based experiments (like prompt gamma activation analysis and neutron diffraction) returned the bulk elemental and mineralogical composition, while SEM (scanning electron microscopy) analyses, evidenced very important details in the manufacturing techniques.

Historical developments in metallurgy can be found in these two different examples of past cultures.

Pictures of two significative samples: part of the golden filigree from Chiaravalle Cross (on the left side), and one of the rusted medieval iron nails (on the right side).

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Archaeometric analysis of coins from the *Magna Mater* Temple: metals characterization and electrochemical dating

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The *Magna Mater* Temple, dedicated to the Phrygian divinity Cybele, was inaugurated in 191 B.C. and lately destroyed by fire twice. The site, rebuilt by Augustus, was reused until the 17th century. These historical data conjointly with archaeological findings and their stratigraphy, have contributed to the elaboration of a coherent periodization aimed at establishing timelines, original usage, changes and final destination of the site in which the studied coins were found. In particular, the coins of the *Magna Mater* cover the entire Imperial Roman period, becoming of great relevance for the history of the site and for the questions related to the reuse of the materials. Regarding the stratigraphy of the site, the coins resulted older than the deposition's date, gathering around the first half of the 4th century. The archaeologists explained this chronology for the prolonged use of the Roman emissions. The aim of this study is to evaluate the possible existence of different types of coins, especially for age and/or provenance and/or stratigraphy, on the basis of the analysis of the electrochemical response of the patina. In order to achieve these results, the coins have been studied using the voltammetry of immobilized particles (VIMP) methodology, a technique which provide responses depending on the composition of the base metal (alloy of copper, tin and lead). Characteristic voltammetric patterns of corrosion products were recorded: cuprite in the primary and secondary corrosion patina and tenorite only in the secondary patina for submicrosamples of the corrosion layers of coins. The ratios between different pairs of peak currents recorded under fixed electrochemical conditions were used for grouping the coin samples: this electrochemical classification correspond to different archaeological strata confirming also the dating of the coins. In order to ensure a multi-analytical approach, fundamental for studying archaeological samples, VIMP data have been complemented with Electrochemical Impedance Spectroscopy (EIS), Raman spectroscopy and Focusing Ion Beam Field Emission Scanning Electron Microscopy with Energy Dispersive X-Ray Detection (FIB-FESEM-EDX) for screening monetary emissions and characterize the surface of the coins. In particular, FIB-FESEM-EDX enable to study the microstructure, generating trenches of 10 μm into the patina and the coupling with EDX allows carrying out a semi-quantitative analysis inside the trenches. The data obtained can be considered consistent with the hypothesis of the reuse of the coins during the later periods as a result of the economic difficulties associated to the fall of the Roman Empire. In conclusion, the electrochemical discrimination of the corrosion products, which depends on their usage history, allows the grouping of the studied samples on the basis of their location in the stratigraphic sequence of the archaeological site [1]. Therefore, the methodology can be a useful tool for archaeologist in order to validate and compare the historical data of the samples.

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Microstructural and morphological characterisation of ancient bronze coins from the archaeological site of Al-Fustat city in Egypt

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This paper deals with the microstructural and morphological characterization of some ancient bronze coins excavated in the Al-Fustat archaeological site. Al-Fustat is the first capital of Egypt in the Islamic civilization. It was built by Amr Ibn Al-As in the year 641 AD on the east bank of the Nile and replacing ancient Memphis to the west.

In the ancient Egypt, two main manufacturing methods have been generally used for coins' production: casting into moulds or the hammering technique generally used to imprint an image on the coin surface. Different manufacturing techniques lead to different metallurgical features of the bronze coins, which together with the chemical composition and the physical properties of the soil in which the artefacts have been buried for long time, can significantly affect their conservation state.

Five coins which have dimensions in the range of 1.23 to 2 cm, and weight in the range of 1.27 to 4.02 g, have been characterised by means of optical microscopy (OM), X-ray diffraction (XRD) and field emission scanning electron microscopy equipped and energy dispersive X-ray spectroscopy (FESEM+EDS). The micro-chemical, micro-morphological and microstructural analyses have been performed to investigate the manufacturing technique and to study the corrosion mechanisms affecting the bronze coins, with the final aim of developing tailored conservation procedures for these important artefacts of the Egyptian history.

As an example the microstructure of a bronze coin etched in $FeCl_3$ solution is shown in fig. 1. The metallographic observations indicate the absence of a texture in the polycrystalline alloy and the presence of equi-axed grains and twinned. These results allow concluding that the bronze coins have been produced by hammering in mould.

The FESEM observations of the coin cross-sections put in evidence that these artefacts are coated by quite thick corrosion products layers (300-500 μm) with a complex stratified microstructure composed by Cu oxides and oxy-chlorides. Furthermore, in some cases, the presence of copper chloride corrosion products, directly in contact with the metallic core, which have a detrimental effect on the long-time preservation of the artefact, has been detected.

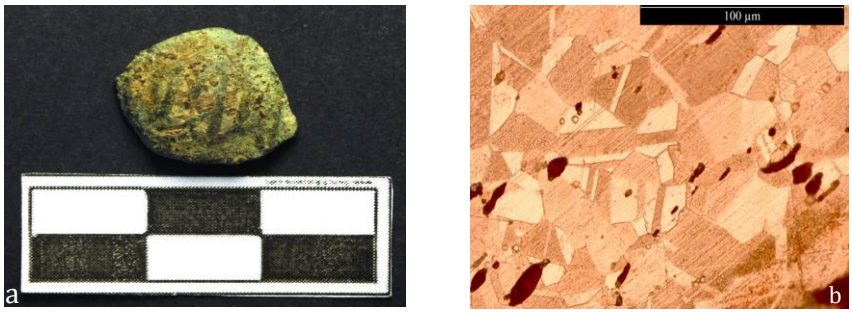

Fig. 1 – (a) A bronze coin and (b) Optical image of the bronze alloy etched in $FeCl_3$ solution.

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New results from the ARKHA Project. ARchaeology of the invisible: unveiling the grave-goods of KHA

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The ARKHA (ARchaeology of the invisible: unveiling the grave goods of KHA) project aims to investigate a selection of artefacts preserved in the Museo Egizio di Torino through the use of non-invasive and non-destructive chemical and physical techniques, using light and neutron probes. The project combines competences of interdisciplinary teams of scientists, *i.e.* curators, conservators, archaeologists, Egyptologists, chemists and physicists.
The investigated objects came from the intact tomb of 'the director of works' Kha and his wife Merit, found by the Italian Archaeological Mission in 1906: the findings form the richest and most complete non-royal grave goods (1425-1353 BC) ever found; it is housed in a museum outside of Egypt and includes alabasters and sealed pottery containers, metallic vessels, wooden boxes and chests, food and wine containers, containers of oil, powders and precious perfumes.
Here we present the results of the morphological reconstruction of the of inner part of the alabaster vases obtained via neutron radiography and tomography - and the elemental and phase analysis obtained via PGAA and neutron diffraction performed on the new Imaging and Materials Science & Engineering (IMAT) beamline and neutron diffraction studies performed on ENGIN-X beamline, both located at the pulsed neutron spallation source ISIS, Rutherford Appleton Laboratory, U.K.

Synchrotron radiation micro-CT for the investigation of finishing treatments in ancient bowed stringed instruments: issues and perspectives

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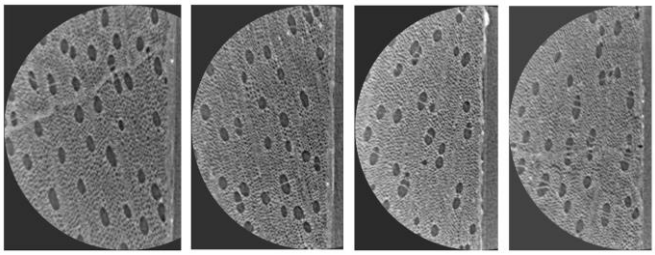
Several materials have been used during the centuries by violin makers to treat and varnish the wood surfaces [1]. Recipes for the finishing materials were kept secret by the violin makers and traditional methods passed down from master craftsmen to apprentices. Information about lost procedures is crucial for supporting the conservation and the restoration of the valuable historical instruments, and it can be possibly recovered indirectly by scientific investigations. The scientist's direct their focus toward facing difficulties related to the presence of multi-layered structures, where several inorganic and organic materials have been variously combined. Presently, the main methods to study such a complex stratigraphy requires samples to be detached from the artwork, following a micro-invasive procedure which is seldom allowed by the curators. Within this frame, the recovering of information by non-invasive procedures such as X-Ray computed tomography (CT) represents an extraordinary opportunity for scientists to reveal procedures and materials employed by the ancient masters.

In this research, the high spatial resolution and imaging properties of phase-contrast Synchrotron Radiation X-ray computed microtomography (SR μCT) have been employed on 1) a set of model samples prepared in order to mimic the various situations that may be encountered when investigating finishing layers in ancient bowed string instruments and 2) a set of fragments detached from historical instruments during past restorations and selected from a larger set on the basis of their chronological attribution (i.e. between 1650 and 1750).



The model samples have been prepared by spreading inorganic (silicates and sulphates) and organic (varnish coloured with a madder lake pigment) treatments on maple wood. They have been employed to optimize the instrumental settings and to guide the interpretation of the data obtained from the set of the historical fragments. These have been previously investigated by portable and bench-top analytical and morphological techniques (XRF, FTIR, SEM-EDX, Optical microscopy [2]). SR μCT volumes and images have been coupled with the information previously obtained on the historical fragments, allowing to identify how the main morphological and compositional properties of the finishing layers influence the 3D reconstructions and the 2D images.

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Technology in the production of Red Slip Ware in Campania (Italy): a comparison between *Terra Sigillata* from *Puteoli* and Campanian Orange Ware from the Bay of Naples

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Between the 20 BC up to the second half of I century AD, the ancient *Puteoli* (modern Pozzuoli, Italy) was among the several sites of production of Italic *Terra Sigillata*, the famous fine ware with a red and compact slip, often reporting the potter' stamp. In the same period some workshops located in the Bay of Naples, as pointed out by few kiln wasters found in Naples and the distribution of their vessels, produced a similar Red Slip ware that largely circulated along with the *Terra Sigillata* from *Puteoli*. Such production is named Campanian Orange Ware or "Produzione A della Baia di Napoli".

Although they were simultaneously produced in close workshops, they significantly differ in the morphological *repertoires* as well as in their technological properties. Actually, clay body, red slip features (sintering degree) and the stamps permitted a distinction between the two productions in two archaeological contexts from *Rione Terra* and in the immediate suburbs of the city of *Puteoli,* dated back from 10 BC up to the middle I century AD. Here, Puteolan *Terra Sigillata* and Campanian Orange Ware were unearthed along with sporadic imports from the Eastern area and extra-italic contexts.

This research is focused on 21 ceramic samples of Red Slip Ware covering the entire range of forms and stamps. Specimens have been analysed using archaeometric techniques (PLM, ATR-FTIR, TG/DSC-FTIR(EGA), SEM-EDS, ICP-MS) aiming at the archaeometric characterisation of such fine wares.

Mineralogical and petrographic features of ceramic bodies and slips suggest different processes adopted for the two productions. Both attest the levigation of high CaO clays for manufacturing vessels that, however, were undergone to different firing conditions (firing temperatures and/or soaking time). Moreover, a more accurate application of the slips for the *Terra Sigillata* pottery was observed with respect to the Campanian Orange Ware.

The samples of *Terra Sigillata* were characterised by a fine-textured paste, red to creamy in colour, with scarce skeleton particles of quartz, feldspar and mica and abundant remains of carbonate fossil shells. FTIR spectra also evidenced the occurrence of newly formed Ca-silicates (diopside and/or gehlenite) that suggested the achievement at least of 850°C in those samples in which gehlenite and diopside coexist and of 950 °C in those specimens in which only diopside occurs. Such firing temperatures were supported by the vitrification structures observed by SEM, which attested an extensive vitrification stage. The well preserved ceramic slips showed a red colour and appeared weakly anisotropic or isotropic, with a constant thickness of ca. 20-30 μm. SEM observations confirmed their complete sintering.

As well as the Campanian Orange Ware is concerned, the ceramic body, reddish and anisotropic, showed a fine texture, with prevalent micas, lower quartz and feldspar particles and scarcer remains of fossils shells with respect to the *Terra Sigillata*. Moreover, rare volcanic phases (e.g. clinopyroxene, k-feldspar, juvenile volcanics) also occurred. The slip appeared orange in colour, anisotropic, thinner (ca. 10-15 μm) and less vitrified. Mineralogy and micro-texture of ceramic bodies and slips suggested lower firing temperatures and/or soaking time experienced by the vessels. Actually, FTIR spectra showed the infrared signatures of newly formed diopside and/or gehlenite only in the second derivative spectra and SEM observations showed sintering structures were less developed with respect to the Terra Sigillata. Therefore, firing temperatures lower than 950 °C were supposed.

Characterisation of the black patina of the Tiber's embankments by Next-Generation Sequencing

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Black patinas are a very common deterioration phenomenon of lapideous artworks in outdoor environments. These substrates, exposed to sunlight, atmospheric and environmental agents (i.e. wind and temperature changes), represent an 'extreme environment' and can be colonised by microorganisms characterised by a huge versatility and adaptability (Isola et al., 2016; Krumbein, 2002; Urzì et al., 1995). It is known that black patinas are made of a wide variety of microorganisms (i.e. cyanobacteria, microalgae and melanised fungi) (Urzì et al., 1995) but the morphological plasticity of most of these microorganisms not always allows the identification by optical microscope observation. The knowledge of the taxa present in the patina and of their ecological requirements is necessary for the choice of appropriate conservation treatments. Taking this into account, the present study tested Next-Generation Sequencing (NGS) for the characterisation of the black patina of the travertine *muraglioni* (embankments) of Tiber river in Rome (Italy). 20 samples (called N) were collected from areas where there was no biological colonization other than the black patina (i.e. mosses, lichens, plants). 20 controls (called B) were sampled from uncolonized areas. The samples were observed through optical microscope (Leica DM RB) and then NGS was utilized to identify the microbial communities. Total genomic DNA was extracted from each sample using Maxwell Instrument (Promega). V3-V4 region of 16s rRNA gene and ITS2-ITS4 fungal region were amplified and then subject to library preparation (according to Illumina's instructions) and sequencing by Miseq and Nexseq500 Illumina platforms. OTU cluster analysis and the classification were carried out using Mothur v1.95 and Python 2.7. Metagenomic sequencing of the bacterial 16S rDNA and fungal ITS sequences were used to analyse the diversity and community richness of 40 samples. Hierarchical Cluster Analysis (HCA) of bacterial and fungal library evidenced a significant separation among cohorts B and N ($P<0.001$). The results indicated the presence of predominantly Firmicutes and Verrucmicrobia Phylum in B samples, whereas Cyanobacteria (mainly Chroococcales) and Planctomycetes were enriched in N cohort. For what concerns Fungi Phylum, it was found an overrepresentation of Ascomycota in N samples, among these interesting is the presence of microcolonial fungi (MCF) (e.g. *Coniosporium apollinis*) known to be among the main constituents of black patinas (Isola et al., 2016; Urzì et al., 1995).
The high-throughput sequencing results in this study highlighted the rich diversity of bacterial and fungal communities of black patinas. The high-throughput sequencing method allowed us to detect also culture-independent species and to have more convenient and informative measures of the total microbial community. Thus, NGS could be a useful method to characterise black patinas before the conservation and restoration interventions.

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Identification of yellow pigments and their degradation products in the palette of a 15th century alpine painter

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Giacomino da Ivrea was an alpine painter who worked in the north-western region of the Alps (mainly in Aosta Valley, Piedmont and Savoie) in the 15th century (about 1425-1465 AD). His work has been documented in more than twenty mural paintings throughout this area. Even though his pictorial language is mostly naïve, without displaying the affectation of the International Gothic, in some aspects of his painting technique he was indeed an experimenter.
In 1984 Laboratorio Analisi Scientifiche (LAS) began investigating the palette of this artist's works in Aosta Valley and continued this analytical work over the years. Moreover, the improvement of the portable and bench-top instrumentation of the laboratory over the last years allowed for deeper investigation of the use of certain unusual pigments. Among these, lead-based yellow pigments are of paramount importance to understand this artist's technique. Four out of five pictorial cycles investigated with a modern multi-analytical approach (e.g. employing p-XRF, FORS, Vis- and UV-OM, micro-Raman, SEM-EDX) displayed the presence of Lead-Tin Yellow type II, which was employed as a substitute for golden foils to embellish halos, crowns, cups and other precious details. Due to its relevance in Giacomino's palette, this pigment has been thoroughly investigated using the above mentioned techniques. Additionally, these data were compared with reference materials and the existing literature [1].
During the recent analytical campaigns, the red-brownish parts in the areas painted with Lead-Tin Yellow type II form the mural paintings of San Michele Chapel in Verrayes and of Santa Maria Maddalena Chapel in La Salle (located in proximity of Aosta, Italy) were considered. The cross sections obtained from samples taken in these areas clarified that this red-brown colour does not belong to a coloured ground layer, which was found in the yellow samples to be often employed by the artist to support the fresco-secco painting and to confer particular hues to the yellow surface layer. This red-brown colour is instead included in the yellow layer and it can be considered, to the best of the authors' knowledge, as the first evidence of a degradation product of Lead-Tin Yellow type II. Micro-Raman and SEM-EDX investigations allow us to hypothesise the composition of the red-brown areas and to associate their formation with the unusual composition of the Lead-Tin Yellow type II pigment employed by Giacomino da Ivrea in his works.
Furthermore, the dark background of the crosses depicted at the bottom of the scenes in San Michele Chapel showed high counts of arsenic when analysed with portable XRF. However, no identification of an arsenic-based pigment resulted from using other techniques on the various layers under consideration. Mapping with SEM-EDX allowed to locate arsenic on the surface and in the ground layer of the cross section, with a top-bottom trend from higher to lower counts. The particular distribution of this element, combined with the results from previous works on the degradation of arsenic-based pigments [2], allow us to suppose that an orpiment layer was originally present over the actual surface layer and thus to identify the original colour of the crosses' background.

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The artistic palette of Carlo Bononi, Baroque artist of Ferrara

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The aim of the *in situ* XRF analysis on the canvas "Incoronazione della Vergine" (Fig. 1) was devoted to characterise the palette of Carlo Bononi (Ferrara, 1569-1632), who is a not well-known artist of the first Baroque in Ferrara, but relevant in the field of the Este court school.

The canvas of large dimension (2,8 m of diameter) has been depicted by Bononi between 1616 and 1620 for the Santa Maria in Vado church.

More than one hundred points have been collected by means of XRF spectrometer, but the presence of many overlapping painted layers have leaved some doubts about the preparation or the background layers. The SEM-EDS analysis on some samples have resolved many of these doubts.

The results obtained indicate typical seventeenth-century pigments, such as Cinnabar covered with an Earth for the darker areas. The different correlations discovered between Fe and Mn suggest the use of more than one Umber Earth. Furthermore, for the yellow pigments, the artist used in some cases the Yellow Ochre, while in the others the Lead and Tin Yellow. Almost all the pigments have been identified and they are the first step forming the technical apparatus in order to understand the *modus operandi* of the Ferarese artist.

Figure 1. Carlo Bononi, *Incoronazione della Vergine*, canvas, diameter of 2,8 m, Santa Maria in Vado, Ferrara

The "Incoronazione della Vergine" is exposed in the Santa Maria in Vado church in the exhibit "Carlo Bononi. Immagnificus Commotor" [1], which is parallel and related to the exhibition in Palazzo dei Diamanti "Carlo Bononi. The last dreamer of the Ferarese School" until the 7th of January 2018.

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Lipids in archeology: oils and fats characterization by HPLC/ESI-Q-ToF

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A novel biomarker approach entailing the detection of acylglycerols (the main constituents of oils and fats) in archaeological ceramic and stone vessels, with the aim to identify the original presence of lipids and to indirectly establish how such vessels were used. The identification was carried out by liquid chromatography coupled with high resolution tandem mass spectrometry (HPLC-ESI-Q-ToF) and to maximize the extraction of lipid residues from the archaeological artefacts, the samples were subjected to microwave-assisted extraction. Given that this extraction approach is highly efficient means that smaller samples can be used. It is also more efficient than using a traditional ultrasonic bath, although the material is polymerized or oxidized as expected with archaeological lipids. The use of high resolution mass spectrometry proved to be fundamental for lipid profiling, since HPLC is generally unable to separate the positional isomers of acylglycerols. Adopting this lipid profiling approach, we studied the residues from several archaeological vessels from different archaeological sites.

Analysis of the Middle Neolithic *Trichrome pottery*: characterization of the decoration using XRF and Raman

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Trichrome painted wares spread out during the Middle Neolithic (between 5000-4500 cal. BC) along the Adriatic side of the Italian Peninsula. The pottery production was characterized by a very fine-granulated paste defined *figuline* and by a decoration painted with red and black colours.
This research reports the results of X-Ray Fluorescence (XRF) and micro-Raman spectroscopy analysis focused on the decoration of the ceramics from two distinct geographical areas, corresponding to *Ripoli culture* in Abruzzo [1-2] and *Serra d'Alto culture* in Basilicata [3-4].
The production of Ripoli *figuline* pottery includes cups with vertical handles and plastic applications on the top, bowls and jars with narrow neck and four small handles under the rim. Red bands (referring to the previous tradition of Catignano culture), delimited by black lines and black spots or by black geometric lines, characterize the painted decoration.
The production of Serra d'Alto *figuline* pottery includes jars, hemispherical and with long neck cups with handles and zoomorphic plastic applications on the top. The thickness of the vessels is particularly thin while the decoration shows geometric patterns painted in black.
A representative set of samples belonging to the two cultures has been studied. XRF and micro-Raman analyses reveal that black decoration was obtained using a black pigment based on manganese-iron oxide, whereas the red one includes iron oxides. The results, together with the data achieved on samples of Serra d'Alto *figuline* from Matera's sites, allow to confirm the *figuline* production hypotheses [5-6]. In particular, a technological evolution is proven by the selection and control of raw materials to the technologically advanced firing system. Moreover, the choice of a manganese pigments is a further technological connotation of *figuline* potteries.

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Protective effect of linseed oil varnish on archaeological wood treated with alum

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The Viking Age wood artifacts recovered in the early 1900s from the Oseberg mound and treated with alum, are today highly degraded, a condition attributed to the effects of the alum-treatment and of the reactivity of alum and derived salts (McQueen 2017). Some of the artefacts from Oseberg collection which were treated with alum, were also coated by linseed oil. Although the linseed oil did not fully penetrate the wood in many cases, these artifacts appear to be better preserved with respect to those not treated with linseed oil regarding their visual condition.
In order to assess the effect of the presence of linseed oil on wood preservation, alum treated woods coated with linseed oil were investigated. Fragments were sampled at different depths from the surface. Three analytical techniques, giving relevant information about the molecular composition and state of preservation of both archaeological wood and aged linseed oil, were adopted: gas chromatography coupled with mass spectrometry (GC-MS), pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) and high-performance liquid chromatography coupled to electrospray ionisation and quadrupole time-of-flight mass spectrometry (HPLC-ESI-Q-ToF).
Specifically, Py(HMDS)-GC/MS was applied in order to assess the state of preservation of the main wood components in the presence of linseed oil and the alum treatment, while GC-MS and HPLC-ESI-Q-ToF were used to perform the lipid characterization and to investigate the lipid degradation and oxidation processes.
The results showed that although the wood was highly depleted of carbohydrates (Braovac 2016), it was better preserved with respect to those artefacts not coated with linseed oil. Results from GC-MS and HPLC-ESI-Q-ToF together with those from Py-GC/MS suggested that the linseed oil played a mitigating role towards wood degradation. The behavior of the lipid material, more oxidized on the wood surface respect to the depth section, suggested that the selective oxidation of the oil instead of the wood components in the aerobic environment leaded to a better preservation of the material

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WOODCUT BLOCKS OF THE "SCUOLA DEL LIBRO" OF URBINO: A SCIENTIFIC APPROACH FOR CONSERVATION

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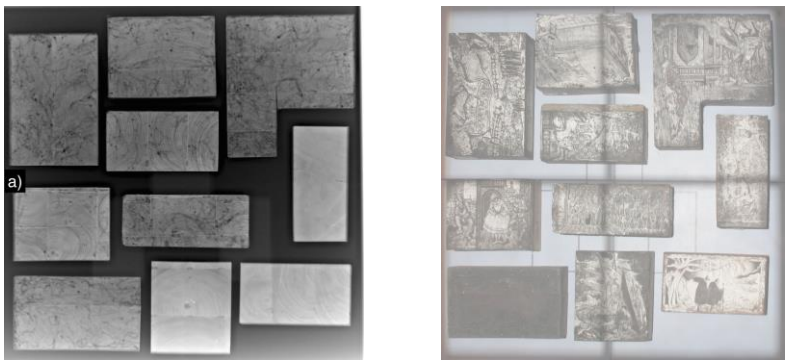
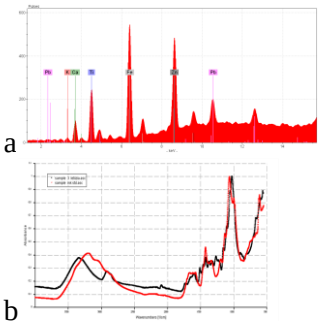
The woodcut blocks studied, despite being created by mostly unknown authors, are the testimony of a great activity that in the first half of the 20th century has characterized the Institute of Fine Arts for the Decoration and Drawing of the Book of Urbino. The institute soon called "Scuola del Libro" has allowed the formation of significant personalities in the field of illustration, artistic engraving and graphic.
An interesting woodcut blocks fund consisting of just over one hundred pieces is preserved in a deposit of the Institute. Preliminary scientific analyses were carried out to characterize the constitutive materials and the executive technique and to evaluate the conservation status, both non-invasive and micro invasive, according to a modality frequently used on panels and prints but rarely carried out on this type of objects.
The aim of this research is the knowledge and the valorisation of a category of untrained artistic artefacts, taking as a case study the matrices of Urbino. Specifically, the following diagnostic methods were performed: X-ray on a plate (45KeV); scanning electron microscopy (SEM); environmental scanning electron microscopy (ESEM) with EDX microprobe; energy dispersive X-ray microfluorescence spectrometry (ED-μXRF); infrared spectrophotometry in total attenuated reflectance (FTIR-ATR); Raman spectroscopy; microbiological investigations. The use of boxwood (*Buxux sempervirens* L.) and sorb (*Sorbus* spp.), both characterized by very fine texture and high surface hardness, allowed both obtaining a very precise engraving and making the printing without spoiling the block itself.
The presence of iron gallate, due to the ink, and of coal has emerged. The high content of zinc and lead could be referred to aqueous-based modern ferrogallic ink used for prints until the early decades of the twentieth century. The investigations allowed to highlight the presence of tunnels and exit holes made by xylophage insects, as well as the presence of fungal spores on the matrices.



a) Radiography of the matrices showing the tunnels and the exit holes of the xylophagous insects; b) References to the matrices



Ink sample: a) *Spectrum ED-μXRF; b) Spectrum FTIR-ATR*

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Utilization of living space in Early Bronze Age Sicily: results of an interdisciplinary study in Santa Febronia (Italy).

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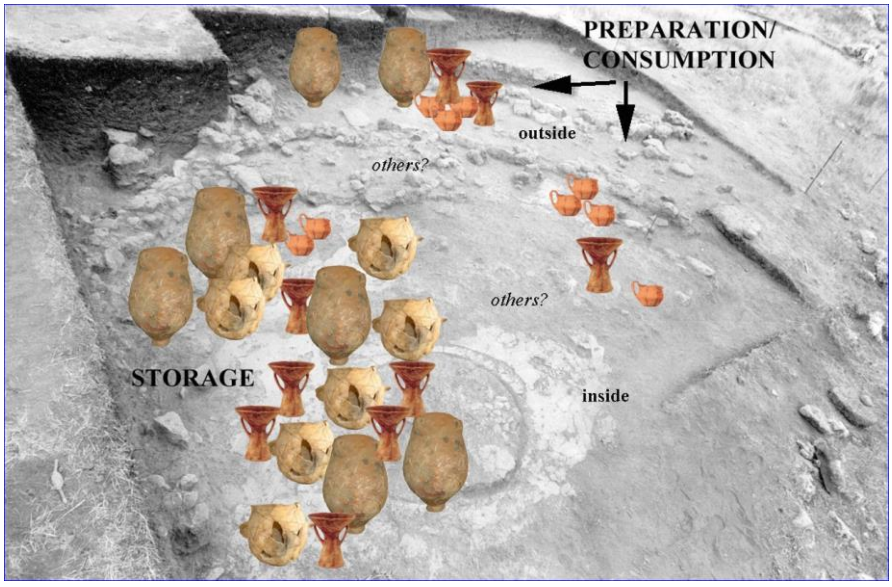
This paper explores the use and the organization of space in an Early Bronze Age settlement (ca. 2200-1450 BCE) in Sicily. The purpose is to identify the connection among the food consumed, the vessel shape and the space in which food related activities took place. This study integrates organic residue analysis of the vessel and GIS spatial analyses in order to understand vessel use in direct correlation to the settlement space.

The hill site of Santa Febronia (Catania, Italy) includes the remains of an Early Bronze Age hut that was found destroyed by a fire, leaving a sealed deposit with a large quantity of artefacts in their original position (Maniscalco 1998). During the excavation, the artefacts' position was recorded in details, creating an ideal scenario for spatial analysis of artefact using GIS platform. In addition, chemical residue analysis was carried out with GC-MS to extract and identify absorbed lipids within ceramic vessels. The GC-MS results were used to establish relations between the food processed, the vessel shape and the depositional space.

The study reveals a multi-functionality of both space and vessel types as well as the presence of specific patterns in vessel and space use. Storage areas can be distinguished from those devoted to the preparation and consumption of food and large containers seem to be used for long-term storage of cereals/seeds while lipids coming from meat/milk sources seems characterizing small vessels. In conclusion, this study shows the ways in which *function* and *use* of vessels and space can be re-assessed by tackling the materials with an interdisciplinary approach.



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New hints on Maya Blue formation process by PCA-assisted *in situ* XRPD and optical spectroscopy analysis

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Maya Blue (MB) is a famous artificial pigment discovered by Merwin in 1931, used by ancient Mesoamerican cultures as early as about I millennium AD and therefore already known in pre-Spanish period. The technology of production is lost but its charm has attracted the attention of many scientists in the last sixty years. It is considered as an ancestor of modern host-guest complexes and one of the first nanostructured materials. The peculiar brightness and hue, ranging from bright turquoise to dark greenish blue, the remarkable durability and chemical stability are among its intriguing aspects. Its composition and recipe remained a mystery for long time and still the scientists consider it as an "unsolved puzzle", made by the mineral palygorskite and indigo.
In order to give insight into the production methodology of MB, in situ XRPD data were collected during its formation process, using different inorganic substrates (palygorskite, zeolites, sepiolite etc.) and organic guests (indigo, isatin, fuchsin etc.). The dataset were analysed separately by PCA to unravel the kinetic trends and then jointly by correlation analysis. PCA was able to discriminate between reversible and non-reversible reactions, depending on the starting mixture (Figure 1). TGA was carried out on previously treated samples, and compared to NT or non-treated ones, and it highlighted that during the first thermal treatment of a "fresh" mechanical mixture the non-reversible phenomenon, suggested by *in situ* XRPD, is related to the replacement of water by indigo molecules. Then, *in situ* UV-Vis diffuse reflectance (DRUV) spectroscopy, carried out from RT to 200 °C, followed by 2 hours in isotherm and a cooling and RT, highlighted at first that the Maya Blue formation starts at 110°C with a maximum speed at 150°C. Above 175°C, during the thermal treatment, the oxidation process occurs on the indigo moiety with both colour changes and differences in the affinity for water. Moreover, during cooling to RT the rehydration process is of paramount importance to change the environment of indigo, and of its distribution and penetration of indigo into palygorskite channels. In details after a treatment at 150°, the second treatment causes the continuation of the Maya Blue formation. Other reactions occur after the treatment at 175°C, leading to a Maya Blue sample with a different hue and hydrophobicity features. Even the time of treating is able to change such features, less dramatically than temperatures. These data, together with TGA, DRUV and bleaching experiments indicated at first the importance of the thermal history of the Maya Blue materials, both of historical and modern origin, explaining the various and different proposed recipes to obtain Maya Blue, with different colours, hues and stability.

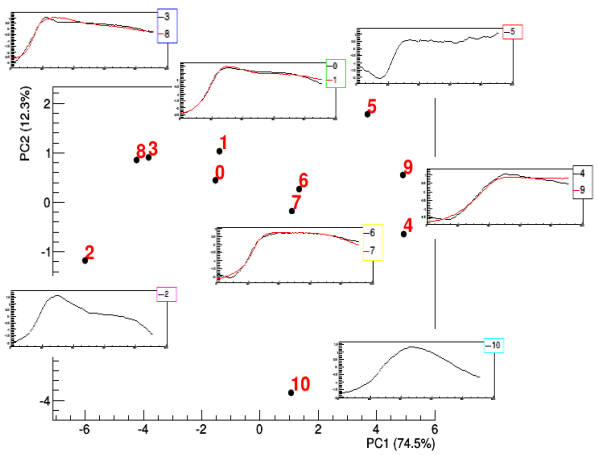

Figure 1. PCA-assisted classification of the reactivity of the mixtures, based on the PCA analysis of the first principal component scores of Figure 1, before (top) and after (bottom) the selection of datasets.

Archaeometric study of Hagia Sophia (Istanbul, Turkey): compositional, geophysical and thermographic approach

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This work shows the results of a broad project focused on the diagnostic of Hagia Sofia (Istanbul, Turkey), performed by an interdisciplinary team including the University of Calabria and the National University of Mexico. Hagia Sofia is one of the most important monuments of the antiquity, with a very long and complex history (Mainstone 2009). The original building was built in the 4th century AD, in an area near the current location, but this first church was completely destroyed by a fire in 404. A second church was built, by Theodosius II, in 415 AD. However, during the Nika revolt in 532 AD, another fire caused the destruction of the building. The construction of a new church began under the emperor Justinian I. It was inaugurated in 537 AD, but in 558 AD the dome collapsed, due to damages caused by previous earthquakes. The reconstruction of the dome, completed in 562 AD, was performed whit lighter materials than those previously used, changing the profile of the dome and giving to the building its present appearance. During the following centuries, the building suffered other serious damages and was the object of a number of restoration, reconstruction and consolidation works, many of which are still in progress.
The multidisciplinary study carried out on Hagia Sofia, involved different analytical techniques. Some of them, such as 3D laser scan, thermography and georadar, were applied directly in situ to identify the possible anomalies of the constructive tissue and the causes of the structural deformations of the building (Cappa et al. 2016; Barba et al. 2016). Other analytical techniques, such as optical microscopy (OM), X-ray powder diffraction (XRPD), X-ray fluorescence (XRF), scanning and transmission electron microscopy combined with analytical electron microscopy (SEM-EDS and TEM-AEM) were used to analyze 20 samples of mortars (Miriello et al. 2017) and 29 samples of brick coming from different areas of the building. These analyses allowed to provide new and detailed data on the petrographic, mineralogical and chemical composition of the materials, obtaining information about the constructive phases of the building and the production technology of the artificial materials employed in its construction. Data produced by all these analyses were, finally, collected and inserted in a 3D GIS (Geographic Information System) interactive platform, creating a three-dimensional georeferenced space model of Hagia Sofia where all data were interpolated.

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Optical reflectance spectroscopy allows non-destructive monitoring of molecular modifications in restoration of works of art on paper

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The discoloration of paper, due to the development of oxidized groups acting as chromophores in its chief component, cellulose, is responsible for severe visual degradation of works of art on paper.
By adopting a non-destructive approach based on the combination of optical reflectance measurements and time-dependent density functional theory (TD-DFT) *ab-initio* calculations, it is possible to describe and quantify the chromophores in cellulose fibres in a non-destructive way.
Since paper is an optically inhomogeneous materials whose optical response is strongly governed by scattering effects, in order to recover the absorption coefficient of cellulose fibres from *in-situ* non-invasive reflectance measurements a specific approach based on Kubelka-Munk (KM) two-flux theory must be applied. In order to simulate the optical properties of cellulose by using TDDFT, an infinitely extended crystal of cellulose in the crystallographic phase called I_β was considered. Oxidation was simulated by including several kinds of carbonyl groups (ketones, aldehydes, and carboxylic acids) within the □-D-glucopyranose units of pristine cellulose and calculating their electronic transitions. The concentration of carbonyl groups acting as chromophores was obtained by fitting the experimental optical absorption spectra to those simulated computationally by using TDDFT-based calculations.
This approach was applied for monitoring the conservation interventions of the great format engraving "Le Nozze di Psiche" by Diana Scultori (1613, BIASA Biblioteca di Archeologia e Storia dell'Arte - Roma) as well as two contemporary artworks by Renato Guttuso, "La verità nuda" (1947, Biblioteca Nazionale Centrale - Roma), and "Studio per Crocifissione" (1940, Archivi Guttuso - Roma). All artefacts were affected by chromatic deterioration due to a strong oxidative degradation of the paper and washing and/or reducing treatments were applied at the IC-RCPAL.
The experimental absorption spectra of cellulose fibres of the artworks showed clear changes after the different conservation treatments performed due to chromophores decreases and particulate removal from paper substrates. Graphic signs, instead, showed no spectral alteration as well as the structural properties of paper as evaluated by the KM scattering coefficient. TDDFT simulation provided the amount of chromophores concentration decreasing after restoration and showed different behaviour of the different kinds of carbonyl groups as a function of the specific protocol performed. This is fundamental information in order to improve the conservation treatments of works of art on paper.

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The decay of the "*Rivellino degli Invalidi*" Subway Fortifications in Turin – a Case Study in Diagnostics and Conservation.

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Recent excavations, aimed at constructing a parking lot in Turin, brought to the daylight the ancient fortifications of the so-called "*Rivellino degli Invalidi*" galleries – a sophisticate complex of countermine subways built in the XVII century and used in 1706 to defend the city during the dramatic siege held by the French army (that also brought to the famous Pietro Micca's sacrifice). The evident and inexorable deterioration of these structures – marked by a loss in consistency of the original mortars and plasters, after more than three centuries below the actual soil level – coupled to their historical and archaeological relevance, brought the local authorities to plan an intervention aimed at identifying the causes of decay and applying a feasible approach for their conservation. Samples of plasters, mortars and underlying materials were therefore collected from the decaying walls and analysed with a suitable archaeometric approach (including optical microscopy in PL, SEM-EDS, Raman and XRPD), so to acquire information about the nature of the constituent materials and the decay products, while trying to understand the dynamics of the related, intermediate reactions. Preliminary investigations showed that the manifested loss of consistency should be mainly ascribed to an intervened solubilisation and consequent leakage of the binding agents in the constituent materials, after repeated and prolonged water infiltrations. This depauperation of the ligands in mortars and plasters – by now extremely poor in adhesion and rich of intergranular voids – suggests that specific dissolutions occurred, followed by recrystallization of various substances. This phenomenon – observed on thin sections at SEM-EDS – caused an intra-pore crystallization of new phases in the cavities, mainly represented by carbonates. SEM observations were also performed on entire wall fragments with no preliminary treatment (thus avoiding interferences due to sample preparation), showing that the newly formed carbonate crystals have a prismatic habit, possibly typical of aragonite (Fig. 1). The same approach also evidenced presence of a superficial felt of silica-rich material, with an atypical fibrous habit, deposited in the pores and on the fragment surface, whose nature and origin are currently under investigation (Fig. 2). This archaeometric survey will pave the way for an apt consolidation procedure, aimed at rendering the structure its original sturdiness. After the recovery, the archaeological complex will be inserted in a museological setting and exposed to the public, so to valorize and emphasize its historical importance.

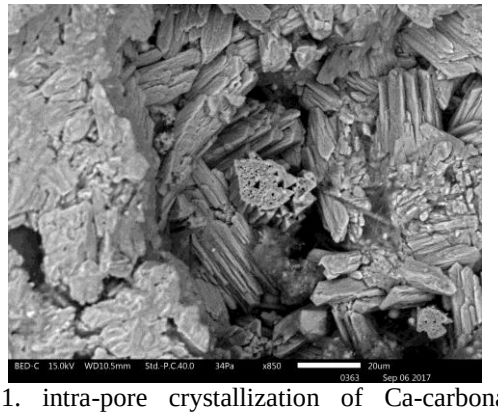

Fig. 1. intra-pore crystallization of Ca-carbonate, probably aragonite (BSE-SEM, 850X, 50 Pa).

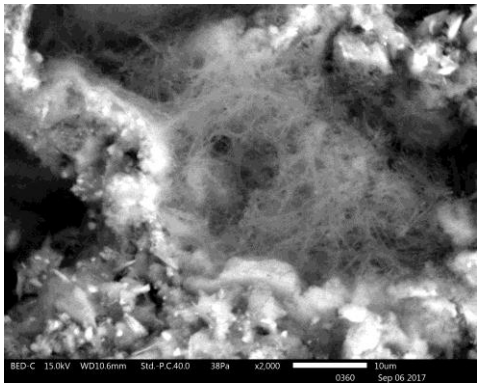

Fig. 2. intra-pore crystallization of SiO_2-rich fibers (BSE-SEM, 2000X, 50 Pa).

Gas chromatographic and mass spectrometric investigations of bitumen from Neolithic flint flakes recovered from archaeological excavations in Central-Southern Italy

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The accessibility and distinctive chemical-physical properties of bitumen have made it one of the materials of choice since antiquity as adhesives, hydro-repellents, coating and sealing agents to produce stone tools, ceramic vessels, ornaments and works of art. Bitumen belongs to the class of fossil materials formed by the evaporation of volatile components, polymerization and maturation reactions over geological timescale. This kind of fossil substance is particularly present in the Middle-Eastern region. Nevertheless, deposits of bitumen of different geological eras can be also found all over Europe. From a chemical point of view, bituminous materials are complex mixtures of long-chain acyclic hydrocarbons, cyclic compounds such as hopanes and steranes, and aromatics. The composition of the bitumen varies depending on the area of origin, this means that the chemical characterisation of an archaeological bitumen can allow us not only to draw hypotheses on the possible function of tools/objects from which the bitumen is sampled, but also to obtain information on the geographical origin of the bitumen.
This paper will present the most important results regarding the characterization of bituminous residues sampled from Neolithic flint flakes recovered from archaeological excavations in Abruzzo and Puglia (Italy). Because of the chemical complexity of such organic substances, analytical procedures based on gas chromatography and mass spectrometry (GC/MS, Py-GC/MS, EGA-MS) have been chosen. The analytical protocol has been optimized and primarily tested in the study of bituminous materials (used as reference materials) from rocks and sediments of Central-Southern Italy, and subsequently used to characterize the archaeological bituminous materials recovered from the Neolithic stone tools.

Creation of a database of restoration products on different supports with portable NIR-FORS

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Identifying modern restoration products with portable instrumentation would enable conservators and restorers to obtain useful information in a shorter time span and at a reduced cost compared to the micro-destructive techniques (e.g. FTIR or GC-MS) that are usually employed. Previous works on this subject focused on the identification of painting binders through Near-Infrared spectroscopy [1, 2]. LAS is deeply involved in SIP (Sistemi Integrati e Predittivi), a FESR-FSE project whose aim is to develop predictive systems for the ageing of original and restoration materials, while providing tools to monitor the conservation state of artworks. The project required the creation of a spectral database of restoration products to determine their composition and to verify whether their identification is possible with non-invasive techniques. In particular, portable Near-Infrared Fibre Optics Reflectance Spectrometry (NIR-FORS) was employed as a diagnostic tool to identify the diagnostic spectral regions for the considered products. This information is crucial to both extend the analytical power of LAS equipment and to provide the specifications to realise a multi-band camera for monitoring purposes. Following the input of the Aosta Valley Superintendence's restorers, the restoration products were selected among the most commonly used industrial products in the field of cultural heritage. More than thirty products were applied in different concentrations on different substrates (e.g. marble, mortar, polychrome plaster, modern mural painting). The mock-up samples were investigated through Vis-NIR-FORS in the 350-2200 nm range. In addition, the restoration products were analysed using micro-Raman and FTIR to verify their composition. Considering the high number of spectra collected and the similar chemical composition of certain products, a robust statistical approach was needed to correctly identify the signals. OAVdA, with the support of LAS, applied statistical multivariate techniques and modern Machine Learning algorithms to the entire database, with the aim of analysing single features, quantifying the degree of correlation among different spectra and ultimately increasing the signal-to-noise ratio. A first test of the strength of our database was performed by selecting two mural paintings dating to the 11^{th} and to 15^{th} century, which underwent restoration using acrylic and vinyl resins. The data obtained with respect to these artworks were more complex than those previously acquired on mock-up samples, as the spectra showed the combined presence of NIR signals from the support, the pigments, the resins and possibly the decay products. In addition, the restoration products are often present in low concentration and can be altered; the spectra looked very noisy due to the irregularity of the surface. Nevertheless, identifying some characteristic bands from the restoration products was possible in both case-studies, thanks to the combined use of our spectral database and advanced statistical tools.
These tests highlight how employing portable NIR-FORS and treating data using robust statistical methods permit the correct identification of the restoration products *in situ*, thus leading to more precise mapping of these products. This non-invasive approach can be an essential part of the standard procedure to monitor conservation treatments, which allows a step-by-step revelation of the correct removal of previous restoration products.

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Etruscan Paintings of the Demoni Alati Tomb in the Sovana Necropolis (Southern Tuscany, Italy).

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The Demoni Alati tomb in the Sovana necropolis (Southern Tuscany, Italy) was discovered only recently; at the end of the nineties, some excavations revealed the rest of an aedicule tomb, carved into a red tuff, which for a long time remained covered by soil. Part of the monument was still *in situ* whereas other blocks were found all around the area. Thanks to the excavation work, a surprising finding was made; the most interesting figurative element of the tomb, an all-around male figure, representing a defunct in a banquet, was found. The discovery appeared even more exceptional because the defunct maintained most of his original polychromy. The finding of the Demoni Alati tomb permitted to underline an essential aspect of the Etruscan artistic production until now overlooked: the use of colour on sculptures and architectural elements. In the Demoni Alati tomb different techniques were used depending on the characteristics of the surfaces showing different details and sculptural depths (Barbieri et al., 2013); in particular, the oldest technique consisted in the application of colour on the smooth stone surface of the wall while successively the stone was covered with a carbonatic basic plaster and the colour was applied over a thin white preparation layer (lime based); in the sculpture, inside the niche, the colours were applied on two finishing white layers of similar composition (lime based) while in the decorations of the sculptured surfaces outside the niche, the colours were laid on a thin white amorphous silica based layer. Furthermore, the colour palette of the tomb was extremely varied, and not only the primary colours but also their different nuances were used. A detailed study of the preparation layers and the different colours used on the Demoni Alati tomb was undertaken through the use of complementary traditional and innovative techniques, and we report in this paper the obtained result.

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The colossus of San Carlo Borromeo in Arona (NO, Italy). On site characterization of the metallic materials

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The so-called *San Carlone*, a colossal statue dedicated to San Carlo Borromeo, built in Arona (NO, Italy) during the XVII century, is a unique monument.
With its 23.5 meters of height, it is constituted by an internal structure of iron bars, fixed on a massive central stone tower, and by a "skin" of hammered and embossed copper sheets. After 40 years from the last restoration, a conservation intervention may be planned in the near future. It is therefore important to investigate and characterize the materials of the monument, in order to evaluate their state of conservation. One of the main concerns is related to the fact that copper and iron are very likely to create galvanic coupling, and thus the iron could be corroded very quickly. However, the iron bars appear in quite good conditions in most parts of the statue. It is therefore interesting to study the materials in order to enrich the knowledge of the know-how of the XVII century, and to support the ongoing conservation project.
The studies and characterisation of San Carlo started in October 2017, with a multi analytical approach, that includes a large variety of non-invasive in situ measurements to be associated with laboratory analysis of micro-samples. The following in-situ analysis were performed on the statue, both inside and outside: portable digital microscopy, spectrophotometry in visible light, electrochemical measurements (LPR and EIS), US thickness measurements of the copper sheets, thickness measurements of the surface protection coating and corrosion layers with eddy currents, electrical conductivity measurements, infrared spectroscopy and x-rays fluorescence analysis.

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Formation of metal soaps in painting layers: a study on kinetics and reactivity.

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One of the major concerns among conservation scientists is today represented by a class of compounds mostly found in oil paintings, the metal carboxylates, also called metal soaps. Their formation is linked to several degradation processes but, despite their widespread diffusion, little is known about these mechanisms and processes [1]. Therefore, in this work, the reactions involved in the decay of two historically important pigments (smalt and zinc white) have been simplified and studied. The case of smalt is particularly interesting since the soaps formation can be considered one of the main causes of the pigment discoloration. The course of simplified reactions of saponification has been followed through the collection of several FT-IR spectra in order to understand the kinetics and the different steps involved in the process. Attention has been focused on two simplified systems. The first system consisted in a mixture of palmitic acid with potassium hydroxide (KOH) and smalt pigment or zinc white (ZnO), alternatively. In the second group, linseed oil is mixed with KOH, smalt pigment or ZnO. KOH has been chosen since potassium is supposed to be the cation involved in the saponification of smalt pigment (a cobalt glass). The course of each reaction was followed through the continuous acquisition of 50 FT-IR spectra, 1 every 15 minutes. For the reactions showing a slower kinetics, the acquisition continued (once a week) until the soaps formation occurred. The potassium carboxylate formed in the KOH/palmitic acid system has been characterized thanks to a sharp IR band centered on 1562 cm^{-1}. The same band was found (slightly shifted at 1564 cm^{-1}) in the KOH/oil system, suggesting that probably the two formed soaps had, at least initially, a very similar structure. The carboxylate band resulting from the smalt/palmitic acid and the smalt/oil reactions was expected to be at similar wavelengths, while the experiment showed the formation of a broad band at higher wavenumbers centred around 1580 cm^{-1}, which corresponds to the (metal soaps) absorptions observed in real paintings. The difference of almost 20 cm^{-1} can be explained by the presence of different potassium carboxylates: some still partly coordinated with the particle of smalt and others more free (far from pigment surface) or produced from the reaction with potassium leached from smalt because of moisture). In both cases, anyway, the metal carboxylates resulting from the reactions with palmitic acid and oil appeared to have identical spectral features (similar wavenumbers and shapes), suggesting that the participation of different fatty acids in saponification reactions do not particularly affect the carbonyl position of the salt. The reactions involving the ZnO showed a different behaviour, since the broad band assigned to the carboxylate resulting from the reaction with the palmitic acid was centered around 1540 cm^{-1}, while the band assigned to the one resulting from the reaction in oil was centred around 1590 cm^{-1}. In this case the difference is probably related to the divalent nature of the zinc cation that can lead more complex fatty acids structures as ionomers [2]. In the KOH/palmitic acid system a band at 1392 cm^{-1} which appeared later than the carboxylate one and corresponds to the formation of a carbonate has also been identified, suggesting that when the availability of acid fraction decreases the reaction with atmospheric CO_2 becomes a competitive process. Further studies will investigate this aspect, since metal carbonates are frequently found in the protrusions formed by the metal soaps of real painting samples [3].

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" *MIRACULA IN VITRO*": *in Situ* Spectroscopic Study on the Largest Italian Collection of Reverse Glass Paintings

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Any analytical investigation into archaeological finds should be non-invasive due to their uniqueness, and this main demand is fully satisfied by using mobile instrumentation. The information gained about the state of conservation and the nature of the constituent materials can help during (or before) a restoration and, at the same time, allows to confirm or disprove provenance hypothesis.

In this paper, for the first time, the simultaneous application of three complementary portable techniques on reverse glass paintings is shown. Reverse painting on glass is an old decorative technique used since the Roman time consisting in applying a cold paint layer on the reverse side. The Sicilian Regional Museum of forestry and pastoral traditions "Giuseppe Cocchiara" in Mistretta (Me) houses the largest collection of reverse glass paintings in Italy with a total of 195 artworks. The main problem of these artifacts is the fragile paint adhesion to the substrate. The use of a suitable painting technique is an issue of central importance, as is the strenght of the medium that binds the pigments to the support. Damage to the paint layer can be caused by a number of factors, ranging from the way in which the pigments and media are used, to storage and handling conditions. These damages generally arise through the detachment of paint layers, loss of colour and fragmentation, and are strongly tied to the painting technique, the pigments employed and the binding media. Very few study are present in the literature regarding this kind of objects, and, in particular, no one study was performed at now in a systematic way and with different complementary portable techniques.

The goal of this work is twofold: the investigation of the materials used in realization of the paint itself and the investigation of the nature of glasses used as substrate. A combination of non-invasive analysis by using three complementary portable spectroscopic tecniques was performed on a consistent number of reverse glass paintings and a simultaneous measurements campaign was planned.

X-ray Fluorescence (XRF), FT-IR and Raman handled spectroscopy were used to investigate the nature of the supports (glass), preparation layer, pigments, binders, glues and varnishes. All diagnostic operations were previously performed than the restoration intervention and the spectra were directly recorded on the artwork in a totally noninvasive way.

Archaeometric study of the protohistoric baked clay artefacts from the archaeological site of Villa del Foro (AL)

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In the present work, a multidisciplinary investigation on baked clay artefacts, dated back to VI-V century B.C., has been carried out. The studied materials come from the protohistoric site of Villa del Foro, near Alessandria (Italy) and were brought into light after several archaeological campaigns coordinated by the Soprintendenza Archeologica del Piemonte. They consist of donut-shape rings made of baked clay (*Fig.1*), found in large quantities in different areas of the archaeological excavation. This type of productions is of great archaeological interest as similar objects have been also found in other Italian and French settlements of the Iron and Final Bronze Ages. The particular shape and significant number of such artefacts, make their archaeometric investigation very interesting to understand the technological conditions of their production and their original use. The preliminary results of a combined morphological, archaeomagnetic and X-Ray Powder Diffraction (XRPD) analysis, applied on representative baked clay ring samples, are presented here.
A morphological investigation carried out on 266 samples from the 2091 trench (where most ring artefacts were found) showed inhomogeneity in their dimensions, colour, form, and clay purity. Thermal demagnetization of the natural remanent magnetization (NRM) performed on 7 samples, demonstrated a well-defined secondary magnetization component in 3 cases, identified between 340 and 460 °C. The determination of the magnetic inclination through principal component analysis showed that the presumed upper surface of the rings (as determined from their morphological examination) had been instead used as a laying surface during their last heating. Thermomagnetic curves obtained after repeated heating/cooling circles at increasing temperatures are characterized by good repeatability up to 500-600 °C, indicating slight magnetic mineralogy changes up to this temperature. XRPD analysis was tentatively used to characterize all constituent materials in crystalline form. The data obtained showed recurrent presence of calcite, dolomite and chlorite, together with the systematic absence of high temperature mineralogical phases. These results suggest that the investigated ring-shaped artefacts had not been exposed to temperatures higher than 700-750 °C during their manufacture and/or use. The archaeometric results obtained so far, although preliminary, suggest that the use of ring-shaped baked clay artefacts of Villa del Foro was probably related to firing activity, involving temperatures lower than 700 °C. Partial re-heating during their use at temperatures around 350-450 °C is also detected and should be considered as a useful indication of their possibly, subsequent employment as support (or basis) for cooking purposes. These evidences apparently exclude the involvement of such artefacts in the production of pottery, which would require much higher temperatures.

Fig. 1. Representative donut-shape baked clay rings found at the archaeological site of Villa del Foro (AL).

The identity of Stradivari violin *ex-San Lorenzo*: is it still preserved?

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Historical musical instruments, especially violins, are witnesses of centuries-old stories and events, passing from hand to hand among musicians, collectors and restorers. Historical last wills as well as trading documents allowed to reconstruct the movements around the world of the decorated *ex-San Lorenzo* violin and its story throughout its owners. The history of this precious violin started in 1718 in the Cremonese Stradivari's workshop; it represents the ultimate development of the Master's "golden age period" (1700 to 1720) and a unique example for the emblematic inscription "GLORIA ET DIVITIAE IN DOMO EIUS" adorning the centre ribs [1]. The *ex-San Lorenzo* violin was property of the virtuoso Mauro D'Alay (1687-1757) and then of the violinist G.B. Viotti (1755-1824), before being sold to the Duke of San Lorenzo, from whom the musical instrument took the name [2]. Several non-invasive imaging (endoscopy, stereomicroscopy SM, VIS and UVIFL photography, X-ray radiography RX, XRF mapping) and spectroscopic techniques (FORS, FTIR in reflectance mode, FTIR, Raman, XRF) were used in order to: (i) evaluate the preservation status of the violin, (ii) characterize the likely original materials such as those composing the varnishes and the wood treatments, (iii) identify restoration compounds.

From the multi-analytical approach, the reconstruction of the original stratigraphy appeared to be limited to the top plate of the violin, where a proteinaceous filler and an aged siccative oil- and terpenic resin-based varnish were identified. Additionally, recently-laid waxes and possible benzoin resin were detected in few areas. The back plate as well as the ribs and the scroll, instead, underwent large restoration and maintenance treatments: the surface, in fact, is mostly covered by a polysiloxane material (e.g. silicone oil) often found together with shellac resin, both commonly used modern polishes in the musical instrument field. Signals of Fe and Mn, probably associated to red earth pigments, were investigated on the whole instrument [3]. Interestingly, traces of Br can be ascribed to bromomethane for woodworm fumigations in the last century.

These results, mostly related to non-documented restoration processes, should be considered a valid starting point to open the debate about what should be preserved of a musical instrument and how to perform it.

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Identification of pigments, inks and gilding decorations of an illuminated medieval parchment, exploiting the LABEC INFN-CHNet XRF scanning system

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The subject of this work is a large fragment of an Antiphonary, dating back to about AD1340. This illuminated manuscript, consisting of a vellum sheet, is a musical notation composed of a system of six tetragrams on each page, with neums and text of the chant written in *littera rotunda* and it is decorated with calligraphic initials and a figured illuminated letter. It was partly restored at an unknown date by replacing a missing or damaged portion of parchment.

For the material investigation of book decorations and miniatures, analysis is particularly problematic and only strictly non-invasive techniques can be used, because it is not possible to sample even tiny fragments of paints, what may be allowed in some cases for the analysis of panel, canvas or wall paintings. Therefore, X-Ray Fluorescence (XRF) imaging technique is very well suited for this task, as it allows for non-invasive, non-destructive and *in-situ* analyses, providing detailed elemental distribution maps which can give crucial information on the composition of the whole analysed area.

In particular, for this work we exploited the XRF scanning spectrometer, developed at the LABEC laboratory of the CHNet -INFN (Cultural Heritage Network - National Institute of Nuclear Physic) in Florence. This instrument was improved with a dynamic positioning system, which automatically keep the scanner-to-sample distance constant (~6 mm) during the scan. This feature allows performing analyses on non-planar sample geometries, with good data quality and no risks for the analysed works. This is particular relevant for illuminated artworks, since most of them do not have flat and planar surfaces, owing to aging and/or degradation phenomena, as is the case of the illuminated parchment object of the present study.

The results here reported refer to the material characterisation and in some cases to the evaluation of their conservation state. Indeed, thanks to the XRF imaging, it was possible to identify the painting palette, the nature of the inks and the gilding techniques. As to the last, the elemental distribution maps allowed us to discriminate traces of original materials (gold metal foil), hidden by the most recent restoration pigment (purpurin, a yellow tin-based pigment used since the late XIV century), thus achieving a deepened understanding of this refined artwork.

Pratical application of visible induced luminescence and use of parasitic IR reflectance as relative spatial reference

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Visible induced luminescence represents actual standard non-invasive diagnostic imagery to perform recognition of some pigments such as the Egyptian blue and its declination of the Roman cultural sphere.
Traditional VIL (Visible Induce Luminescence)(1) requires absence of parasitic light in order to acquire only infrared luminescence produced by areas characterized by the presence of these pigments, while the rest of the subject remains completely dark and undetectable by the CCD sensor of a IRUV modified camera.
With the aim of ensuring a relative spatial location, it was decided to introduce a quantity of parasitic infrared light, using a unique system of light irradiation. By relinquishing the use of the LED, which represents the ideal VIL source of irradiation, a conventional flashlight was used to emit both visible and infrared radiation. This was subjected to a system of filters arranged in series that progressively excluded the presence of parasitic light to obtain a correct VIL. Subsequently the filters were changed or removed to aquire image data characterized by a progressive increase in the descriptive capacity of the not characterized by Egyptian blue pigment areas.
In order to make the technique widely applicable, irradiation instruments and optical reference in use are easy available: the conventional flash allows operating outside equipped laboratories, the filters and the reflectance and luminescence references are all commercially affordable. The filter series made it possible to adapt the amount of parasitic light to the actual acquisition capability of CCD sensor to the VIL response of the individual item analyzed, avoiding resorting to the "DARK" image for digital subtraction of the disturbance component during post-production. The acquisitions were also carried out on objects inside museum glass cases with the aim of testing a use of the VIL with parasitic light as spatial reference even on objects not directly exposed, to verify if the analytical capacity could be compatible with the minimum invasiveness (absence of contact and displacement of the subject). The technique has been adapted and applied also in the field of computational applications such as RTI (reflectance transformation imaging)(3) or three-dimensional photomodelling: in the first case, the descriptive capacity has been improved compared to the usual practice, avoiding effects of excessive contrast. In the second case, a direct three-dimensional modeling was carried out without resorting to the replacement of the texture on a previously captured in visible light model. The use of the technique with parasitic reference light has made it possible to limit the disparity of contrast, reconstructing the subject in all its surfaces that can be acquired, compatibly with a through the case acquiring set.

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Tituli Picti in the archaeological site of Pompeii: diagnostic analysis and conservation strategies

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In the archaeological site of Pompeii, several epigraphs on stone, in Oscan and Latin language, have been surveyed by different authors. Although there are several publications concerning the building materials and artefacts of Pompei, the scientific literature lacks of studies regarding the knowledge and conservation of such paints.
This diagnostic and conservation project is aimed at determining the execution technique, as well as at defining the state of conservation of the epigraphs on the yellow tuff. In addition, the study will provide experimental data useful to suggest proper conservation procedures, mainly in terms of protective and consolidating products to be used.
The diagnostic plan included the analysis of the stone, the determination of the composition of the epigraphs, as well as the characterization of the paint/stone interface. Preliminary results carried out by means of microscopic observations, micro-elemental analysis and non-destructive techniques (portable XRF and portable Raman) revealed that the painted layer had been applied on the stone surface, without any preparation layer, moreover the presence of red ochre as pigment has been detected. On the contrary, it is still unclear if any substances were used to bind the pigment on the stone substrate. The other stage of the project includes the reproduction of such epigraphs in laboratory. Then, several conservation procedures will be tested in order to establish the most suitable intervention protocol to carry out *in situ*.

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Tin oxides inclusions in early archaeological bronzes can be a marker of metal recycling?

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Bronze artefacts from Early Bronze Age often contain white inclusions, identified as tin oxides (SnO_2). These inclusions are generally mixed with more complex oxidized inclusions containing sulphur, antimony, arsenic, silver, nickel and cobalt, which are interpreted as un-smelted residues coming from the copper ore. The nature, shape and distribution of these partially smelted tin inclusions gives information on the preparation of the alloy from the pure metal. Depending on the technological context and the geographical areas, the presence of such inclusions might indicate that the material has been produced by selecting and supplementing of raw materials containing SnO_2 or *Cassiterite*.

The methodologies of development and spread of metallurgical practices, along with supplying procedures of some elements (as tin), still remain important issues in archaeometallurgical studies. In addition, considering that recycling in ancient casting practices occurred, the presence of tin oxide inclusions can be a marker for ancient metallurgical productions?

With the aim to understand the role of tin oxide inclusions in the production of bronzes and possible recycling procedures, an crosscutting investigation has been carried out, based on both archaeometry and experimental research.

The first part of this study focuses on the metallographic characterization of several artefacts made of low alloyed tin bronze presenting different metallurgical states. Every corpus comes from hoards discovered in Europe and date Early Bronze Age:

- a selected corpus of 20 axe-ingots in the as-cast state, discovered in a hoard in Loyettes (Estern France);
- a selected corpus of 18 valaisan-type armbands made of hammered and decorated sheets (Western Switzerland);

The second part consists of laboratory casting sessions in order to produce low tin bronzes from pure metallic copper and cassiterite powders. Several steps of melting and casting have been performed with systematic metallographic examination of the as-cast ingots and a working protocol has been defined considering parameters as melt and pouring temperatures, dwell time of the melt, etc.

Results show that tin oxides do not completely react with copper to form an alloy after the first casting but after several re-melting cycles (recycling) whose number is deeply correlated with the temperature reached by the molten alloy and the residence time at that temperature before casting.

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An unusual blue-turquoise pigment found on a painting at Novalesa abbey (Piemonte)

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In the analysis of paintings it is always interesting to compare the colourants identified with the recipes reported in ancient treatises. In many cases, it is possible to find a good correspondence between the materials characterised and the descriptions contained in the recipes.
There are cases, however, in which a colourant is identified on a painting for which it is not possible to find any confirmation on ancient literary source. This is definitely the case of a blue-turquoise pigment found on a 12th century mural painting at the abbey of Novalesa (Piemonte), an ancient Benedictine settlement funded in 8th century AD along the route that crosses the Moncenisio pass between Italy and France. The abbey and its chapels host a very rich heritage of mural paintings datable to 8th-15th century, attesting the vivid cultural and artistic activity of the abbey along this period.
In the cloister of the abbey, a wonderful lunette (see right) contains a *mandorla* with the Pantocrator Christ. *In situ* non-invasive measurements with X-ray Fluorescence spectrometry (XRF) and UV-visible diffuse reflectance spectrophotometry with optic fibres (FORS) identified the presence of natural ultramarine blue in the vast bright blue background area, a feature indicating the remarkable wealth of the commissioners.

The borders of the *mandorla*, however, coloured in blue, turquoise and green, told us a completely different story. *In situ* XRF measurements detected only Fe together with Si, Al, K and Ca, all common elements in a mural painting. FORS analysis highlighted an apparent absorbance maximum at ca. 900 nm which suggests the presence of Fe^{3+} ion in a chemical environment similar to goethite, but with an apparently different colour. In the end, the pigment used on the borders has no correspondence with any known blue or turquoise. At least, it was possible verifying that the green hue was obtained with a mixture of the blue-turquoise pigment and yellow ochre.
In order to elucidate the chemical nature of this anomalous pigment, micro samples were taken to perform more powerful measurements. Raman analysis highlighted the presence of a thin upper layer made of gypsum, possibly laid in order to tune the colour; in fact the same layer was not found on other painted areas. The spectrum of the underlying blue-turquoise area only suggested that a silicate material was present. Relatively more interesting was the information provided by Scanning Electron Microscopy-Energy Dispersive X (SEM-EDX) analysis. In fact, elemental maps collected on a sample confirmed the presence of gypsum only on the uppermost layer, while in the blue-turquoise layer a clear correlation between Fe, Si, Al, K, Mg and Ca was found, allowing hypothesising that the pigment could be a clay-like material. Further measurements by means of X-ray Diffraction are in progress in order to identify the exact structure of the clay minerals. This information will be interesting with concern to the identification of the possible source of the material and will send light on the artists working at Novalesa in that period.

The Formagliaro Mill (Castelfranco Emilia, Italy): 3D survey of an historical and architectural heritage

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The historical "Formagliaro" mill is an ancient building situated in Castelfranco Emilia (Modena, Italy) in the protected natural area of Manzolino. Its architectural relevance is primarily represented by the original oldest part, where in the past was mounted the wheel of the mill, that was built in the Medieval Age (1050 b.C.). Along the centuries the building has been expanded and many parts were reworked, intended for other uses and modified concerning the different purposes. A recent project of revaluation and restoration is born with the objective of conservation of the building and its heritage and conversion in a structure that could provide accomodation service and cultural initiatives about the local history and the surrounding environment.
The first step in order to collect a dataset of spatial informations about the mill is the survey phase.
It has been conduct through the integration of different geomatic methodologies. A reference network of 4 vertices, measured with total station and georeferenced by GNSS static acquisitions, has been created. Then a TLS survey (by phase-shift laser scanner) of the external part of the building, has been executed with the use of sphere and planar target as references.
In a second time the survey was completed with the 3D laser scanning (with a time-of-flight scanner) of the internal parts, with 32 scans that, summed with the 11 scans of the outside, compose a total of 43 scans for the 3D global model.
It allows a detailed characterization of the architecture of the structure, above all in the areas with difficult way of access and concerning damaged or irregular walls and other elements that require a particular attention for the project phase.

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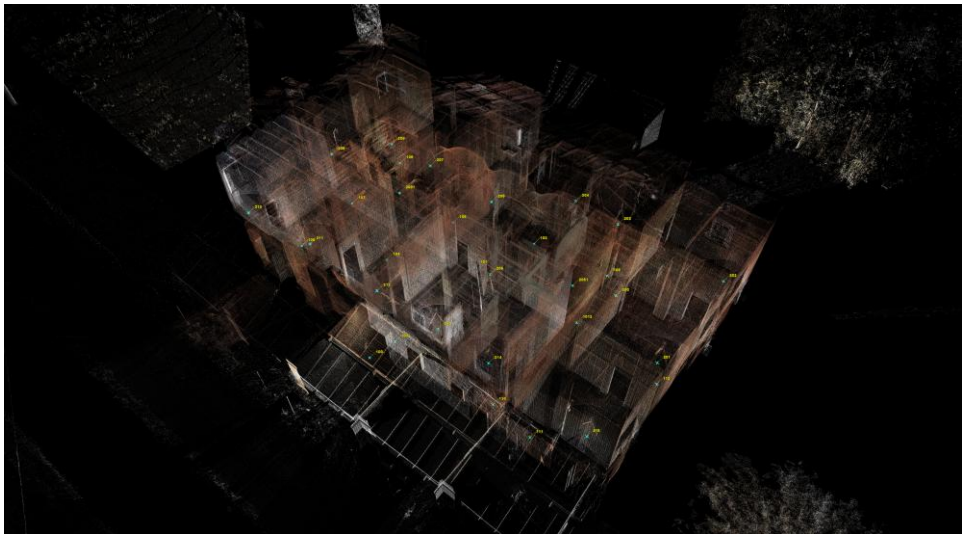

The non-invasive investigations to assist the conservation of the three wall paintings: new archaeological remarks about the "House of Masks" of Solunto

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The "A. Salinas" Archaeological Museum of Palermo (Sicily) has recently presented the results of the restoration of three wall paintings coming from the "House of Masks" of Solunto archaeological site.
Solunto's paintings, examples of the Pompeian style dating back to the first century. B.C. which constitute the most significant example of wall painting of the Roman Republican era discovered until today in Sicily, will be placed in the new exhibition of the Salinas Museum.
The cycle of paintings presents rich garlands of fruits, pine cones and spikes from which hang theatrical masks linked to the cult of Dionysus, god of wine and theater. The house of Masks was a luxurious private house built on two floors and articulated around a peristyle. The frescoes decorations embellished all the walls of a room of representation used for the banquet (*oecus*). During the archaeological excavation carried out by Giovanni Patricolo, from 1868 to 1869, these beautiful wall painting were found. In the 1872, Salemi Pace published the discovery of the frescoes in Solunto describing the frescoes with colorful garlands and theatrical masks, suggesting to scholars the definition of "House of Masks". Five panels of frescoes were detached from the walls for improving their conservation in 1874 and moved to the Royal Museum of Palermo.
The careful cleaning of the pictorial surfaces and the diagnostic investigations carried out during the restoration intervention revealed unusual details on the pictorial technique and new painted subjects.
Scientific investigations have been carried out to identify the original pictorial pigments, to provide preliminary hypotheses on the chromatic alterations and to improve the iconographic reading of some unknown details. Moreover, the diagnostics have given a fundamental contribution for several conservative measures, especially for the removal of the aged covering applied on the surface.
Infrared reflectography acquisitions have given back considerable details of the technique of execution showing the high quality of the paintings, the remarkable of the chosen subjects with their chromatic and *chiaroscuro* effects used for achieving them. Finally, the IR imaging allowed to support new remarks about some details of the masks and musical instruments, proposed by archaeologists and conservators, hidden until now.

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Roman opaque red glass from the Lucius Verus Villa, 2nd century A.D.. The secret of colour

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This work aims to characterise the chemical and structural composition of Roman opaque red glass, especially during the 2nd century A.D. [1]. Due to the lack of technical historical sources regarding this period, a multi-disciplinary approach allows investigation of the technological method used by Roman glassmakers.

Aims:

Bibliographic research and the collection of previous analyses on this colour produced during the Roman age is the first part of this project. More than hundred analyses were found, which show the complexity of the production of this colour. In spite of the large amount of studies, many questions remain open.

Red glass tesserae in several hues (fig.1a) decorated together with other colours the Imperial Villa of Lucius Verus (161-169 A.D.) in Rome. The glass was cut in different shapes and applied in the *opus sectile* technique (fig. 1b). Red glass samples are monochrome (fig.1a) and polychrome, some of which imitating the precious stones used in the Imperial architecture during the Roman age.

A multi-analytical approach of a selection of this samples is in progress to categorise the base glass, to identify the chemical and structural composition of the colouring particles and to shed light on the role played by oxides (iron, antimony, tin and lead ect.) in different redox state [2].

The reproduction of the different hues of red will support the investigation of the productive process, the effect of the different base glass and of the different compounds for enabling the success of the final colour.

This project helps to enrich the few specific works on this type of glass in the early-Roman period. This work also clarifies the methodology adopted for the reproduction of opaque red glass and some preliminary results.

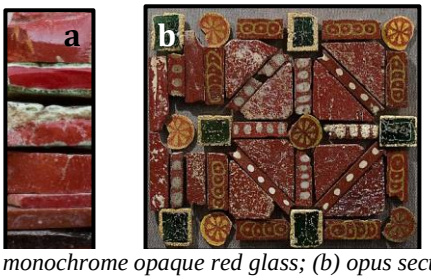

Figure 1(a) monochrome opaque red glass; (b) opus sectile panels.

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Non destructive Archaeometric investigation of Architectural Slabs

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The research, of which we show here the preliminary results, has the aim to characterize the pigments used in the painted decoration and to assess the authenticity, by means of the provenance determination, of important archaeological materials. These are fragments of painted architectural slabs probably derived from the Etruscan archaeological site UNESCO of Cerveteri.
The slabs analyzed are data back to the second half of the VI century B.C. (10,11,13,14b,15,16) and to the first decade of the V century B.C. (2,3,4), period in which a stylistic change occurred in the architectural slabs production in Cerae; evolution that was also technological, with new colours used for the decorations (Bellelli, 2011). A group of slabs come from the Carlsberg Glyptotek of Copenaghen and another was confiscated in Ginevra to R. Syme. The hypothetic provenance from Cerveteri is supported by the large amount of architectural slabs attributed to this site and generally not found in their primary deposition.
Unfortunately, the available bibliography is limited to the polychromy of two slabs of the Etruscan Museum of Villa Giulia and to the *pinax* of the Cerii Warrior (e.g. Bordignon et al., 2006). The slabs are characterized by a creamy engobe and show a polychromatic decoration dominated by male figures in geometric frameworks. To make comparison with samples of certain attribution some architectural terracotta coming from Cerveteri and Veio, with similar decoration and attributed to the same period, have been investigated.
Considering the uniqueness of the remains, we decided to use a non destructive approach. By means of a portable XRF we analyzed all the surface of the samples, in order to have a representative chemical characterization of the ceramic bulk. It was possible to distinguish two groups of terracotta because of the different content in CaO (>20% in the slabs 1,2, 3 and <10% in the slabs 4-10). It is interesting also the existing correlation among different oxides, as SiO_2 and Al_2O_3, TiO_2 and Fe_2O_3, MnO. Due to these differences we can suppose the use of different raw materials.
The RAMAN analysis were employed instead to the polychromy investigations, each colour was analyzed separately. It was possible to identify the use of Hematite for the red hues, mixed with other components according to the final hues desired; it was discovered indeed the use of vegetable Carbon and of Pyrolusite (MnO) for the darker areas. Other preliminary results are the identification of Iron Oxides and Pyrolusite for the violet and the black colours. These data are confirmed by the large variation in the MnO abundance that was revealed by means of pXRF. Nevertheless we have to consider also the possible manganesiferous alteration after burial.
To confirm the slabs provenance from Cerveteri, further investigation are in progress.

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Sample combustion by elemental analyser for radiocarbon dating of carbonates

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In radiocarbon dating, acid digestion is typically used to collect CO_2 from carbonates samples, as shells or mortars: orthophosphoric acid is employed to dissolve the samples, producing CO_2 as a result of the reaction. The possibility to extract carbon dioxide from carbonates through combustion in an elemental analyser has not been widely investigated so far. Here we present the work done using the experimental combustion and graphitization set-up used at LABEC (INFN-CHNet), in Florence.

The CO_2 yield and its linearity according to the burnt masses were studied. The configuration of the elemental analyser was adapted to the combustion of carbonatic samples instead of "conventional organic" ones. Different reagents to fill the combustion column were exploited: copper oxide was used to guarantee the complete oxidation of the gases developed during the reaction; electrolytic copper was used to reduce the NO_x gases produced in the oxidation process to N_2. Moreover, a quartz inset was added in the combustion column, in order to collect ashes, which can be very abundant in the combustion of carbonates, and remove them easily from the column.

For this study, three shells were analysed. They were pre-treated by washing them with deionised water in an ultrasonic bath, then with H_2O_2 to remove the outer layers. Later, the shells were crushed, obtaining very small fragments with similar sizes. Actually, since it is expected that the CO_2 yield of the combustion is influenced by the sizes of the fragments, it is very important that these fragments are very similar one to another. A fraction of each crushed sample was used for X-ray diffraction analysis, so that the mineral composition of the burnt material was characterized as well.

The linear relation between the burnt mass and the CO2 yield was verified by burning different portions of the same shell. In addition, portions of the other two shells were burnt, verifying the reproducibility of the process. These data were used to estimate the mass to burnt to produce CO2 samples from carbonates with a mass similar to the "standard" samples at LABEC. This estimated mass may be also used as a reference to check the "purity" of more complex samples, such as mortars.

Distillation and use of birch bark tar at the Late Neolithic pile-dwelling of Palù di Livenza (north-eastern Italy) revealed by X-ray microCT and synchrotron Fourier-transform infrared spectroscopy

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Recent excavations carried out at Palù di Livenza, a pile-dwelling UNESCO site close to Pordenone (north-eastern Italy), have led to the identification of a well-preserved Late Neolithic deposit dated between 3,950 and 3,650 cal. BC. Among the abundant organic material, three small lumps displaying clear teeth imprints (P1-P3) and a larger amorphous organic sample (P4) have been identified.
These samples have been analysed by X-ray computed micro-tomography (microCT) at the Multidisciplinary Laboratory of the "Abdus Salam" International Centre for Theoretical Physics (Tuniz et al. 2013) in order to collect information about their inner microstructure. P1-P3 are made from a very homogeneous and low-density material, containing few very small denser impurities mainly detected in sample P3. The larger sample has revealed a rolled-up structure made from layers showing slightly different densities.
Very small samples (about 1 mm large) have been taken to identify their chemical composition. Fourier-transform infrared spectroscopy (FTIR) measurements have been performed at the Chemical and Life Sciences branch of the SISSI beamline at Elettra - Sincrotrone Trieste (Lupi et al. 2007). Samples have been flattened to an ideal thickness for transmission analysis using a diamond compression cell. FTIR measurements have been performed in transmission mode with a FTIR VERTX 70v interferometer equipped with KBr beamsplitters and room temperature wide-range DLaTGS detector. The main peaks of the obtained spectra match well those of birch bark tar, used mainly as adhesive from Paleolithic onwards.
The tooth marks visible on the surface of P1-P3, and observed in many other prehistoric tar lumps, suggest they were chewed to soften the tar prior to use as adhesive or for therapeutic purposes. The larger sample with a scroll-up structure can be, instead, interpreted as a residue of distillation process. Experimental attempts at tar manufacture, using both aceramic and ceramic technology, are based on heating of birch bark rolls. The amorphous P4 sample most probably corresponds to a bark roll from which tar was extracted as suggested by structure and organic remains identified by FTIR on its surface.
The birch bark tar remains from Palù di Livenza, dated to the first half of the 4th millennium BC, are so far the oldest evidence of distillation and use of this substance in a waterlogged Italian site.

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Raw materials and technologies of mortars at Hierapolis (Turkey)

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A mineralogical and petrographic study of Imperial age mortars used in the public monuments of Hierapolis archaeological site (Turkey) was realized in the framework of the "Marmora Phrygiae" project financed by the Italian Ministry of University and Research (project FIRB MIUR).
Mortars with different functions (bedding mortar for ashlars, grouting, filling, wall cladding mortars, plaster and stucco work) were sampled in order to identify the raw materials and technologies used to realize the binder and the composition of the aggregate. A total of 33 microsamples were taken by different buildings (Sanctuary of Apollo, Ploutonion, Stoà of the Springs, Great Building, Theatre, Nympaeum of Tritons).
The raw materials used to produce the binder are travertine and marbles. The firing of travertine to produce lime is attested throughout the imperial age, while the firing of marble is strictly linked to the construction sites set up after important demolition phases. The use of earth mixed with lime was found only in some samples of the Stoà of the Springs.
As for the aggregate, it is composed of river sands with different degrees of selection and rounding depending on the composition of the sample. Fragments of marbles, travertines, schists, are frequently founded in the aggregates. Fragments of magmatic rocks, most likely with a gabbroic composition forming part of the ophiolithic complex, are rarely found. Considering the geological characteristics of the Hierapolis area, the closest sources for the supply of river sands are the beds of the Gök Dere (which runs 1 km to the north of the city), Suini Dere (just north-east of the limit of the urban area) and Kadı Dere (350 m south of the southern limit of the city) streams.
The use of *cocciopesto* as an aggregate is very interesting, not only in hydraulic mortars certainly used to clad basins, but also as a bedding mortar for marble slab cladding. This latter case is found in rooms where there was water or intense humidity, but also in monuments that apparently had no relationship with water, such as the *Pavonazzetto* cladding of the Logeion in the Theatre and perhaps the Central Hall of the Stoà of the Springs .

The historical buildings in the Marche region damaged by the 2016 seismic events: a GIS-based archive for mortars

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We investigated the construction materials of the historical buildings in the heart of the Marche region (Central Italy), strongly affected by the 2016 seismic events, where the major catastrophic earthquakes of Norcia (Mw 6.5 and Mw 5.3), Visso (Mw 5.9 and 5.4), and Accumuli (Mw 6.0), were followed by 30.000 events above Mw 3 in just 2 months (November - December 2016). Only in the Marche region 69 towns were heavily hit, damaging the majority of houses and civil constructions, as well as most of the historical buildings, many dated since IX century. In an effort to recover the cultural heritage history of an entire region, large efforts should be devoted to a comprehension of the building materials and ligands used in time, with the hope to be able to restore, at least in part, the cultural heritage, preserving it for future generations.

The research started from the study of the historical centers of Caldarola, Camerino, San Ginesio, San Severino Marche, Sarnano, Pievetorina and Visso, all located in the Macerata area and heavily hit by the seismic events. In a first sampling for the definition of the project, we decided to study monuments characterized by different historical periods (from IX to XV sec.) and different building materials (sandstones, bricks, limestones, travertines), all characteristic of this area of the Marche. The final purpose of the investigation is to determine the characteristics of the mortars, put them in relation with the building materials and the technical response of the building to the earthquakes.

In particular, the mortars have been investigated by powder X-ray diffraction and optical microscopy, to determine their mineralogical composition, petrographic characteristics and technical preparation. Grainsize analysis, aggregate:ligand ratio, porosity, have been determined and used as parameters to draw observations and make comparisons with the architectural characteristics of the buildings. Preliminary results indicate that, in general, the stone-built monuments were more heavily damaged by the earthquakes compared to those built with bricks. The stone-built monuments are characterized by the presence of aerial ligands with abundant rounded carbonatic aggregates, a low quantity of quartz and low ligand content, showing also low tenacity. The mortars used in the bricks-built monuments are instead characterized by the presence of aggregates which include angular quartz and cherts fragments, a higher ligand content, showing in general higher tenacity. Slightly hydraulic mortars were sometimes found, and expecially used for arches and vaults.

Starting from the preliminary results obtained from this study and the interest of engineers to gain information on mortars for the restauration projects, a GIS-based archive was built, from which to draw information on: a) comparing mortars from buildings of the different historical periods, providing information on their technical evolution over time, b) determine how the geological availability of geomaterials was affecting the mortars preparation, c) determine how these characteristics affected the stability of the monuments.

Given the extensive damage produced by the earthquakes to the cultural heritage of the Marche region it is expected an extensive and very long restoration process. Therefore information gained on mortars and building materials inserted in a georeferenced archive containing also all the relevant data (geological, archeometrical, historical…) could be a useful tool for the definition of any reconstruction and/or restoration work to take place on the historical buildings.

Identification of organic residues and petrographical analysis in underwater amphoras from Porto Palo, Sicily

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The results of chemical, petrographic and mineralogical analysis performed for the detection of organic residues and identification of raw materials and firing conditions of 6 underwater amphorae from Porto Palo di Menfi, Sicily are presented.

The samples were studied by applying several analytical techniques such as GC-MS, polarized optical microscopy, XRF and XRD. The results of organic residue analysis revealed Pinaceae resin biomarkers in all studied samples, confirming the wide use of these resins for coating purposes. Some saturated and unsaturated fatty acids were positively identified in the amphorae. Petrographic characterisation on thin and stratigraphic sections showed the presence of metamorphic and carbonatic rocks fragments along with great amount of quartz in most of the samples, whereas mineralogical analysis revealed cryptocrystalline mineral phases which suggest high firing temperature of analysed amphorae. Chemical analysis employing XRF revealed high concentration of Fe and Ca elements suggesting the use of calcareous clays for the preparation of a paste.

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Spying on beauty secrets in ancient Egypt: a multi-analytical approach

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In the 1906 the Italian Archaeological Mission (MAI) discovered, in the necropolis of Deir el-Medina (Luxor, West Bank) the intact tomb of the "Work Director" Kha and his wife Merit. It contained the richest and most complete non-royal burial assemblage dated to the New Kingdom (1425–1353 BC) housed in a museum outside Egypt. It includes the mummy and the coffins of both individuals, many wooden boxes, alabasters, pottery, metallic vessels, textiles, food and oil containers.

Some containers of the funerary equipment has been studies in order to better understand their function combining competences belonging to different disciplinary fields. We focused our attention on an alabaster vase (Suppl. 8448) whose content in unknown. The vase is sealed and carefully covered, on the top, with linen strips. Nevertheless, some the liquid substance is exuding from inside, covering the outside part of the linen strips. To determine the elemental composition of the content we analyzed, with a multi-analytical approach, a sample of this exuding liquid substance collected on a polyethylene film.

In order to obtain information about the **inorganic components** of this substance, XRF Spectroscopy and TEM Microscopy have been applied. Al, Si, Ca, Ti, Fe, Cu, Zn and As elements were identified in the XRF spectrum. Particles of various shape and size have been observed in TEM micrographs. The EDS spectra acquired on the different particles showed a different elemental composition.

In the meanwhile, to identify the **organic component** (oils, fats and waxes), the same substance was extracted by sonication using deuterated chloroform and analysed by high resolution ^{1}H and ^{13}C NMR spectra and 2D NMR COSY, HSQC and HMBC techniques. Considering the identified signals, the sample consists of esterified fatty acids and diacids. The high value of the integral of the signal at 1.26 ppm also indicates that these fatty acids are mostly long chain (up to C16). The presence of diacids in the sample proves that the sample is oxidized. No resonances at 5.3, 5.2 and 2.0 ppm related to fatty acid unsaturation has been identified, indicating that a cross linking due to aging occurred.

In addition, GC-MS techniques coupled with mass spectrometry after solvent extraction at various polarity were applied. Three fatty acids have been identified in the form of methyl esters of palmitic acid, oleic acid and stearic acid. Derivates of pimelic acid, suberic acid, azelaic acid and sebacic acid have been also recognised.

Summarising the results, the sample is made by inorganic and organic components. The inorganic components are ascribable to minerals such as iron oxides, copper oxides, which could impart the brown colour to the sample, mixed with silica or silicates. The organic component is ascribable to triglycerides of various kinds, but since they are very oxidized, it is not possible to assert if they come from vegetable oil or animal fat.

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Pictorial techniques on Greek vases: an Attic white-ground crater and the "Centuripe" ware

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In this contribution the results of a scientific survey on a white-ground vase exhibited at the P. Griffo Archaeological Museum of Agrigento and two Centuripan vases exhibited in the A. Salinas Archaeological Museum of Palermo are presented.
The white-ground vase, a fine crater of the Phiale Painter (450-440 BC), has been selected to enrich and support the interpretative archaeological framework (de Cesare et alii, 2018).
The two Centuripan vases, a pyxis and a lebes gamikos, have been selected to deepen the knowledge about the color palette, the painting technique and to shed some light about the authenticity of the vases and their paintings (Portale et alii, 2018).
The survey has been based on the use of a standard operating procedure (Saladino et alii, 2017) and spectroscopy (X-ray and TR-FTIR fluorescence) and imaging (macrography in Visible light (Vis) and Ultra Violet (UV), Optical Microscopy (OM)) techniques have been applied.
The used approach allowed to:
- to confirm the technology of production of the white-ground crater coherently with the archaeological knowledge about this class of Attic vases. The decoration of the two sides is different as both iconography and materials. Particularly intriguing is the evidence of an organic phase, probably bee wax, observed on the surface. This aspect, as well as the composition of black pigments is currently under investigation.
- to evidence precious pigments (Egyptian blue and cinnabar) on the two Centuripan vases. Their use was intentional to highlight some details of the iconography that is peculiar for each vase. Moreover, decorations are rendered by gold leaves applied on red bolo. It was particularly relevant the evidence of bassanite as calcium sulphate phase. This indicates a post-firing thermal treatment that underwent the vases during their manufacturing and could be used as a discriminatory criterion about the authenticity of these archaeological findings.

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Mineralogical and geochemical characterization of clay deposit from the Lipari Islands (Aeolian Archipelago) and implications for archaeometric study of ancient ceramics

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Clays have different properties that allow their use in various fields of application. Considering the historical and cultural heritage of our territory, it is important to gain a better inside into the wide use of this geological resource as raw material for the ceramics production. The wide diffusion of ceramics since very remote times, brings numerous and very useful information for reconstructing contacts and trades between peoples and to evaluate the technological level reached by the ancient cultures. In Sicily, the discovery of large amount of ceramic finds and pottery workshops besides the increased availability of archaeological data on local production, are in contrast to the still poor information on the compositional features of the used raw materials. With the aim to broaden the scientific knowledge on ancient ceramic materials, and to provide a valid tool for solving some archaeological problems, we propose the results of a study aimed to the mineralogical and geochemical characterization of the never studied clay deposit outcropping at Fossa del Fuardo, in the western sector of the Lipari Island. This area was interested by intense hydrothermal activity, which in different stages, affected the lavas and the pyroclastic deposit of Monte S. Angelo originating the outcropping clay deposits (Fossa del Fuardo; Kaolinite quarry). The collected samples have been analyzed by X-ray powder diffractometry (XRPD), to define the mineralogical species, and X-ray fluorescence (XRF), to determine the major and trace element composition. To define the distinctive features, the mineralogical and geochemical data obtained for the Fossa del Fuardo clays have been compared with the available literature data related to clay deposits outcropping over the Messina province (Triscari et al., 2007), which use as raw materials for local ceramic production, has been already recognized. As a result the clays from Fossa del Fuardo are characterized by a mineralogical composition which includes: the phyllosilicate montmorillonite $[(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH_2O]$, member of the smectite group; the hydrous sulfates jarosite $[(KFe^{3+}{}_3(OH)_6(SO_4)_2]$ together with gypsum ($CaSO_4 \cdot 2H_2O$) and quartz (SiO_2). This composition significantly differs from that of the Messina Province clays, studied by Triscari et al. (2007). Concerning major and trace element content, the Lipari clays show lower CaO and K_2O and high SO_3 values (4.32-18.91 wt%) as well as impoverishment in incompatible trace elements (LILE, HFSE and REE) and higher amount of vanadium compared to the Messina province clays, in which SO_3 is absent.
Established reference groups on the base of mineralogical and geochemical markers, provides opportunities for a better understanding of the local ceramics production and the exchange pattern within the Aeolian area and between the adjacent regions. We hope that the obtained results provide a reference either for the ongoing evaluations of Hellenistic materials and for future studies aimed to better define local ceramic productions.

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A multi-analytical approach to assess the impact of air pollution on marble surfaces through the analyses of passive PM samplers

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The surfaces of architectural heritage in urban environment are exposed to degradation due to the interaction with atmospheric pollutants both in gaseous and in particulate phase [1]. Monuments located in the historic centres of large cities are subjected to typical anthropogenic emissions. The precise identification of the main substances responsible for the surface degradation phenomena, in particular leading to blackening, erosion of carbonatic matrices and disintegration [2], is essential for the definition of conservative intervention and maintenance strategies, as well as for the development of emission reduction policies on a larger scale. The methodological approach for the characterization of potentially harmful species can be based on the sampling of atmospheric aerosols and gaseous pollutants [1] or on the analysis of particulates present both in deposits on materials [3], and incorporated within the crystalline matrices of the black crusts. In the present study Candoglia marble specimens and quartz fiber filters (gravitational deposition sampling) have been exposed at the façade of Milano Cathedral (Duomo di Milano). PM and stone specimens have been analyzed by a multi-analytical approach including FT-TIR spectroscopy, Raman spectroscopy, ion chromatography and SEM electron microscopy. The characterization of the carbon fraction (organic carbon, OC, and elemental carbon, EC) was performed using a new approach based on a thermal protocol [4]. Colorimetric monitoring of the specimens was performed by spectrophotometry in VIS light.
Oxidative potential (OP) of ambient particles has been also evaluated.
Data acquired on both stone specimens and quartz fiber filter have been compared with those collected by the regional environmental protection agency (ARPA Lombardia), bearing in mind that the monitored fraction consists mainly of PM10.

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A multi-analytical archaeometric approach to study white inlay decorations in Bell Beaker pottery from Broudek u Prostějova (Czech Republic)

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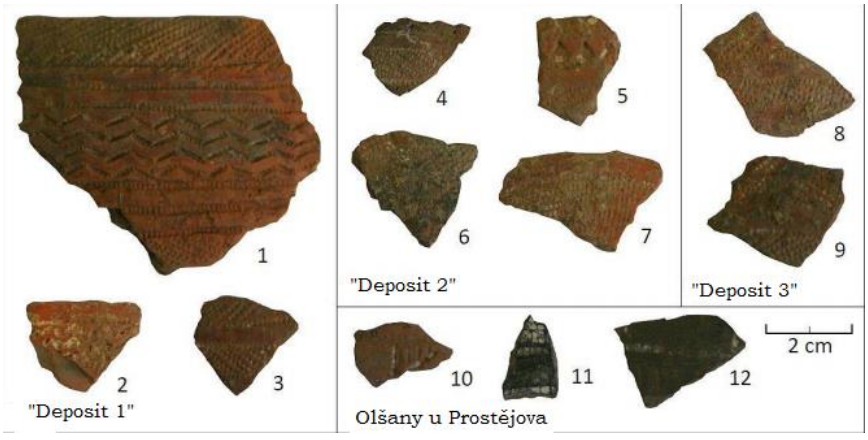
Aim of this study was to analyze white inlay decorations found on pottery from 3 cenotaph deposits dated to the Bell Beaker culture (2500-2200 BC). The cenotaph deposits were found during a rescue excavation campaign carried out in 2015 close to Broudek u Prostějova in Central Moravia region. The cenotaph deposits were related to an original wooden monumental structure. Metal (gold, silver), jade and bone (beads) objects, stone wrist guards and arrow heads, an amphora wrapped in the textile and a number of other ceramic artefacts with typologies pertaining to the Bell Beaker culture were found at the site. These findings suggest rich male graves from the older phase of Bell Beaker culture (Grömer et al 2016). While engraved decorations on pottery showing a characteristic white inlay material are a common feature present on Bell Beaker vessels, the materials and the manufacturing process to produce the white decorations may have been different locally from one place to the other. Within the context of the Bell Beaker culture in the Morava river catchment, the use of kaolin, bone material, carbonates, gypsum plaster or mixtures of some of these materials have been reported (Všianský et al 2014). In this study, a multi-analytical protocol combining micro- XRD, micro-FTIR and SEM-EDS techniques was used. Preliminary results indicate the white inlay to be made of mainly Ca-phosphate (hydroxyapatite: $Ca_5(PO_4)_3(OH,F,Cl)$ and calcite and suggest that the most likely production process of the white decorations in the Central Moravia region involved crushing bone material to create a slurry which was then applied to the vessels.



Pottery from cenotaphs deposits in Broudek u Prostějova and analogy from settlement site in Olšany u Prostějova

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Banded and partially glazed fine wares from Etruscan-Samnite necropolis of Pontecagnano (Campania region, Italy): preliminary archaeometric data

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The Etruscan-Samnite settlement of Pontacagnano (Campania region, southern Italy) was considered the "border site" between the Italic and Greek world, representing the last Etruscan colony along the coast. Archaeological surveys have been unearthed remains dated back from the first Iron Age up to the 5th century A.D., attributable to both the urban settlement and three necropolis. Here, a large amount of pottery, covering the entire time span, were recovered.
This study is focused on fine and decorated wares dated back between 6th and beginning of 4th century B.C., discovered in the Etruscan-Samnite necropolis, with the aim of defining the typological features and technological process adopted for their production.
In particular, the archaeological evidences identified two main chrono-typological groups, constituted by banded one-handled cups and partially glazed *olpette*. The first group (Group A) encompassed ceramic samples constituting the grave goods of Late Archaic tombs (middle of the 6th - middle of the 5th century B.C.) whereas the second group (Group B) was constituted by samples dated back from third quarter of the 5th century B.C. up to the beginning of 4th century B.C. The latter, unearthed around tombs showing peculiar burial custom (the use of *fibule ad aeroplano*) likely attributable to first groups of Samnites settled in Pontecagnano, replaced the production of the pottery constituting the Group A during the second half of the 5th century B.C.
This research aims at studying of such potteries in order to identify the technological and decorative choices adopted for these local productions that adopted a specific typological *repertoire* for about two centuries. Changes occurred in the local workshops in fact, could be reflected the general rearrangement of the social and political dynamics that involved southern Campania during the second half of the 5th century B.C.
To this aim, 27 specimens of both pottery groups were preliminarily investigated by means of ATR-FTIR spectroscopy. Such preliminary approach allowed inferring interesting information on base clay composition and firing temperatures experienced by vessels. Actually, along with quartz and feldspar, likely representing skeleton particles in the ceramic bodies, FTIR spectra detected newly-formed and residual mineralogical phases that suggested the exploitation of high-CaO clays for manufacturing the majority of vessels.
Second derivative spectra of ceramic artefacts, in fact, highlighted the occurrence of gehlenite and/or diopside, the latter often already recognisable in the absorbance spectra. Spectral feature of calcite were also observed in some samples, as well as the infrared bands of iron oxides. Mineralogical assemblages of the ceramic vessels suggested that firing temperatures ranging from 800 and 950 °C were experienced by the vessels. In particular, in those samples in which gehlenite and diopside coexist a firing temperature between 850 and 900 °C was estimated; conversely, when only diopside occurs, the achievement at least of 950 °C was supposed. Moreover, in those samples in which calcite was detected along with gehlenite, lower firing temperatures (800 - 850 °C) were reached.
On the other hand, some samples of cups and *olpette* seemed to be made with low-CaO clays, as highlighted by the absence of newly-formed Ca-silicates and the occurrence of residual phyllosilicates, along with quartz, feldspar and iron oxides. Such mineralogical assemblage suggested a firing temperature lower than 900 °C.

An archaeometric key to gain knowledge in still complex matters: technology, provenance, painters and workshops of Apulian red figure ceramic from Daunia, Peucetia and Messapia.

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Our research group -for several years already- has been studying the technological features of Apulian red figure production with the main aim to seek differences/similarities with the Attic one and manufacturing peculiarities within the Apulian production, possibly leading to identify workshops and distinguish painters. Up to now, the results obtained have pointed out that two different technologies coexisted in Peucetia and Messapia during the 4th cent. BCE, the former following the traditional approach by Attic potters, the latter carrying on a different manufacturing characteristic[1-5]. The extension of the research to Arpi (Daunia) has highlighted differences both in the technological production process and in the raw materials used in Daunia compared to other areas of the region, providing an objective parameter of regional production discrimination.
Moreover, compositional and technological uniqueness in samples stylistically attributed to diverse painters were observed, offering objective evidences about active workshops, painters and their sphere of activity in Apulia.
Ceramic bodies, red and black areas and overpaintings were analysed by a multi-technique approach (MO, SEM-EDS, FTIR, XRD and ICP-MS) and compositional data of ceramic bodies were treated by different multivariate statistical methods.

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New X-ray diagnostic tools for Cultural Heritage: the NEXTO project

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The NEXTO project funded by Compagnia di San Paolo aims to develop new portable X-ray based instruments for non-invasive analysis of materials in Cultural Heritage. Information obtained by means of these new apparatus will be useful mainly for preservation, restoration and authentication of Cultural Heritage and to answer to specific archaeological questions.
The NEXTO project will enhance the capabilities of a portable instrumentation developed inside INFN-CHNet network [1]. Nowadays the mobile laboratory is able to perform analysis by means of scanning X-Ray Fluorescence (XRF) and X-Ray Luminescence (XRL). The NEXTO project aims to strongly integrate Digital Radiography (DR) in the pre-existing instrument, developing a dedicated control/analysis software able to merge data from different techniques, thus obtaining combined information not easily available performing separate analyses. Moreover, to analyze 3D objects, micro-CT (Computed Tomography) and photogrammetry techniques will be implemented, making the apparatus a powerful and versatile tool for on-site analysis. The apparatus will be tested on site on real case studies in collaboration with local museums, conservation centers and an academic spin-off of the University of Torino operating in the field of diagnostics applied to Cultural Heritage.
To achieve these results, the project will exploit the ten-year experience reached in this field by the interdisciplinary research team of the University of Torino [2-4] and will take advantage of the infrastructures of the INFN Torino section, having a well-established expertise about the development of instruments that are beyond the state of the art. Moreover, a substantial contribute will come from public and private entities, that not only will make available works of art to test the instruments, but will also assist the team in the instrument design, on the basis of actual requirements, and will cooperate in public engagement initiatives.
In this work an outline of the project and the expected results are presented.

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Micropaleontology as a tool to help identifying the provenance of an Egyptian artefact

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Calcareous rocks, i.e. lithified ancient marine sediments, have been widely used in historical monuments and artefacts. They often contain both macro- and microfossils of marine organisms, such as calcareous nannofossils: calcite platelets (coccoliths) produced by marine algae since the Triassic. Coccoliths are very small (few microns across) and are common constituents of marine sediments. Due to their abundance in the rock record, to their fast evolutionary rate and their resistance to diagenesis, they are widely used in geological studies for age determination of the stratigraphic successions, besides paleoecological, paleoclimatic and paleoceanographic studies. Only a very small amount of sediment (<1 g) is needed to perform a reliable analysis at the light microscope. A larger piece of rock is needed for SEM-EDS analysis, but this is not essential for age determination. These characteristics all point to a very successful use for age determination and provenance identification of stone material widely used in historical monuments and artefacts (e.g. Young et al., 2009).
Stela RCGE 18088 is a rectangular, round-topped (approx. H. 38.8 cm; W. 22.6 cm; Th. 7.3 cm), Egyptian stela belonging to the collections of Museo Egizio, Torino. It is a calcareous stone stela (split in two fragments), characterized by three painted registers, that entered the Museum collections at the very beginning of the twentieth century. Its provenance is unknown, but stylistically the stela can be ascribed to the early Middle Kingdom (between 2000 BC and 1750 BC). In the frame of a multidisciplinary conservation/restoration project (Iacono 2017), microsampling and peeling of the stone material allowed to better focus on its characterization. The stela is made out of a chalky limestone that contains fossil gastropods and bivalves, together with abundant coccoliths, as shown by the SEM-EDS analysis.
The calcareous nannofossil assemblage contained in the stela consists of common *Watznaueria barnesiae*, *Broinsonia* sp., *Arkhangelskiella cymbiformis*, and rare *Micula* sp.. The co-occurrence of the species *Prolatipatella multicarinata* (Campanian to Maastrichtian in age) and of *Micula* sp. allows to assign a Late Cretaceous (Campanian-Maastricthian) age to the limestone of the stela. The stone could have been quarried along the Nile in several sites where Upper Cretaceous rocks crop out, such as a) few km to the West of Giza (underlying the Eocene Nummulitic Limestone that was used for the Giza pyramids); b) in the area between Idfu and Kom Ombo; c) in the Western Desert (to the West and North-West of Dakhla Oasis; to the West of Assuan); d) in the Eastern Desert (to the East of the Luxor – Idfu line; to the East of the meridian 32°E, from the Galala Plateau to Qena); e) in the Central-Northern Sinai. Based on available preliminary data, we discuss the "Menkaure quarry", located some 200 m to the South West of the Menkaure pyramid at Giza, as a possible site for the provenance of the stela RCGE 18088 stone material.

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The examination of dynamics of oak wood degradation process in the wet peat and lake water conditions

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The archaeological site of Biskupin (Poland) is a prehistoric settlement dated back to 8th century BC, situated on a marshy island of about 2 ha. Excavations started in 1934 and a considerable amount of wood artifacts was found sunken in the water of the lake. The ancient village was reconstructed and nowadays the site is an open-air museum (Museum of Biskupin), whereas the archaeological wood is still kept underground.

Storage of archaeological wood in natural environment (in situ) is very common in Poland, but it is often done without considering factors endangering wood and without answering to the question how quickly wooden remains will undergo destruction.

The aim of this research was first to assess the degradation state of archaeological oak wood and secondly to plan a monitoring strategy, in order to describe dynamics of degradation processes in the early period of deposition.

Different techniques were used to assess the physical and chemical degradation of the oak-wood. Physical properties, such as moisture content and conventional density were determined on the basis of the mass of absolutely dry wood and the volume of the sample in the state of maximal saturation. Morphology was observed by scanning electron microscopy (SEM). The chemical state of conservation was evaluated by XRD spectroscopy, classical wet chemical analysis (TAPPI methods) and analytical pyrolysis coupled with gas chromatography and mass spectrometry (Py-GC/MS) with in situ silylation, which has the main advantage to provide information at a molecular level.

The results highlighted that the external parts of archaeological wood had undergone loss of the polysaccharide components, whereas the internal part were in a relative good state of conservation. A certain degree of oxidative degradation was also noticed, probably occurred before the submersion.

For the monitoring program samples of sound oak wood were put into two stations (wet peat and lake water). The analysis described above were performed on the sound wood and on samples taken after 2, 4, 6, 8 and 10 years of deposition in the stations. The results showed that during ten years only little differences can be noticed, proving that degradation processes have already started but they slightly affected wood. In addition the wet peat conditions seemed to accelerate degradation in comparison with lake water conditions.

The monitoring will be continued in the following years hoping that the obtained knowledge will be helpful for the planning of in situ conservation of wooden objects.

Non-destructive analysis of ancient coins by portable XRF spectrometers: a methodological approach

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Scientific analysis of coinage can provide relevant information on social and economic processes of ancient societies. Thanks to its non-invasivity and capability to provide semi-quantitative results, XRF spectrometry has been extensively used in recent years for the characterization of archaeological coins.
In this work, three different portable XRF spectrometers have been used in order to compare their performance and evaluate the accuracy and reliability of the results obtained: *i*) the commercial handheld spectrometer Innov-X Delta™ by Olympus IMS; *ii*) the commercial Elio portable XRF Analyzer by XGLab; *iii*) a scanning XRF spectrometer developed in-house by the LABEC-INFN of Florence. Eight coins from two different archaeological sites were analysed: six copper coins from Sumhuram (south-Oman, 4th cent. BC-2nd cent. AD) and two Ag-Cu coins from Vetricella (southern Tuscany, 10th-11th cent. AD). Both a qualitative and a semi-quantitative evaluation of the composition of the metal alloys was carried out. Qualitative analysis of the XRF spectra obtained with the three instruments permitted to determine the elemental composition of the coins. Results are in good agreement with those obtained by SEM-EDS and EMPA analyses in a previous study [Chiarantini and Benvenuti, 2014]. The use of the LABEC scanning spectrometer allowed us to obtain a clear and quick picture of the elemental distribution in the coins' surface [Ruberto et al. 2016]. Moreover, this instrument was employed to estimate the extent of silver enrichment (due to blanching) at the surface of a Ag-Cu coin from Vetricella. By comparing the relative intensities of the Cu K-lines and Ag L-lines we calculated that the thickness of the silver-enriched layer was around 3.4 µm, which is consistent with previous SEM-EDS analyses [Benvenuti et al. 2016].
We have also made a comparison between semi-quantitative results obtained with the commercial spectrometers on the coins from Vetricella and two certified standards (MBH Analytical Ltd). The former spectrometer, Innov-X Delta™, provides (semi)quantitative data thanks to the pre-built *Innovi-x Systems* software. On the other hand, the quantitative analysis on the spectra obtained with the Elio portable XRF spectrometer was performed by means of the open-source *Pymca* software, which uses the ''fundamental parameters method" for quantitative analyses and must be calibrated by the user [cf. Arias et al., 2017]. Results are discussed in the paper.

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Secondary phases in ancient ceramics: mineral composition by synchrotron through-the-substrate microdiffraction

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Secondary phases in archaeological ceramics represent the products of post-depositional processes or contamination related to the pottery use. The study of these phases can therefore supply important information on the physical-chemical conditions of the burial environment and its changes over the time (Maritan et al., 2004; Secco et al., 2011), or the type of use of the pottery.
In most of the cases, secondary phases precipitate in the voids of the pottery and are therefore located in specific and often sub-millimetric, or even micronmetric sites. They can crystallize as proper mineral phases or be present in form of amorphous precipitation. Due to their small size and the fact that in most of the cases they are present in very little quantities, they cannot be therefore mechanically isolated for the ceramic body for being separately investigated. Only micro-analytical techniques, such as micro analysis at the scanning electron microscope or at the electron microprobe, can characterise their chemical composition. But, the definition of their mineralogical nature is more difficult, since the analytical methods normally used (X-ray powder diffraction) are based on large amount of material with respect of that represented by the secondary phases in the pottery. The dilution effect of the ceramic body, for instance in the case of XRPD analysis, determines that the secondary mineral phases are in most of the cases under the detection limit of the technique. Only punctual mineralogical analysis can solve this problem, such as micro-Raman and micro-diffraction.
The use of synchrotron through-the-substrate microdiffraction (tts-μXRD) was applied to the study of secondary mineral phases of different composition (phosphates, silicates) identified in a series of archaeological ceramics from different periods (Mesolithic, Bronze age) and sites (Italy, Sudan). This technique, in fact, allows to make punctual analysis in thin section, using a spot size of few micronmeters.
The results indicate that, although the chemical composition of some secondary phases showed an almost stoichiometric composition, they were composed of an amorphous phase. Moreover, for the first time some mineral phases, the occurrence of which was previously defined only on the basis of a chemical composition at the scanning electron microscope (Costa et al., 2012) or at the electron microprobe (Maritan and Mazzoli 2004; Maritan et al, 2009), were univocally mineralogically identified. The synchrotron through-the-substrate microdiffraction therefore represent a valid method for properly determine the mineralogical nature of secondary phases in pottery, but also in all the archaeological materials.

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Mass spectrometry to investigate degradation phenomena of mod-ern oil paintings in JPI project: “CMOP-Cleaning of Modern Oil Paint"

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The aims of the Heritage+ JPI European project: “CMOP-Cleaning of Modern Oil Paint” (2015-2018) [1] is advancing the knowledge on the molecular causes and mechanisms related to the condition of modern oil paintings.

Traditionally oil paints were prepared in artists' ateliers directly from raw materials, according to traditional recipes. With the industrial revolution technological changes affected the production of artists’ materials. Modern oil paint included both traditional drying oils, and new drying and semi-drying oils in the formulation, together with industrial oleo-chemicals such as hydrogenated or partially transesterified oils. Metallic salts, metal soaps, and a variety of dispersion agents, plasticizers, fillers, surfactants could also be added to paint formulations.

The diversity of artists’ uses of oil paint from the 20th century included impasto and diluted paint media, together with the preference for unvarnished paintings, leaving the surface exposed and vulnerable to deterioration from environmental influences.

Modern oil paintings present specific conservation problems including colour change, formation of medium skins on the surfaces, efflorescence, protrusions, dripping paint and paint delamination [2]. These paintings can also exhibit water and solvent-sensitivity, however the causes of these phenomena are not yet fully understood.

We investigated the chemical composition of modern oil paints that exhibit water sensitivity during cleaning using water. New analytical methods employing a combination of gas chromatography/mass spectrometry (GC/MS) [3] and liquid chromatography/mass spectrometry (HPLC/MS2) [4] were developed for the characterization of mixtures of free fatty acids, glycerides and metal soaps in paint samples. These methods proved suitable to provide detailed data on changes in the molecular composition of oil paints constituents upon curing and ageing.

GC/MS and HPLC/MS^2 together with direct infusion electrospray ionization mass spectrometry (ESI-MS) were used to investigate oil binders in selected oil paintings, in paints from Talens, Old-Holland and Winsor & Newton naturally aged for 10 years and submitted to artificial ageing, and in water sensitive Winsor & Newton paint swatches from 1945-2003 [5].

The results showed that the processes involved in paint curing, oxidation and polymerisation, including their dependence on the pigment and the particle size, as well as hydrolysis and saponification, all appear to play a fundamental role in determining the water sensitivity of modern oil paints.

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The first 3D and topographic surveys of the archaelogical remains of an ancient city in Kimolos Island (Cyclades, Greece): preliminary results.

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The Kimolian Earth Project concerns about the study, that started in 2016, of the ancient remains of an old city in Kimolos Island and, in particular, in the area of the Ellinika bay.
Archaeological and topographic analysis has carried out and is nowadays in progress in order to understand and interpret the evidences of this human settlement.
A necropolis with different kinds of tombs is present along the current shore line, old remains of buildings are submerged by the sea, other structures are situated in the island of Agios Andreas, just in front of the bay.
All these areas require a detailed mapping so it could be possible to place the structures and correlate them.
First of all a network of vertices has been created with a distribution that goes from the shore, to the top of the hill behind, from the island to the access road of the bay. The network has been measured with total station and GNSS acquisitions have been executed to georeference the whole survey.
The reference network is the base for all the surveys that have been performed: 3D laser scanning for the tombs carved into the sandstone and the surrounding areas, detailed measurements of TLS reference spheres, targets, and other specific parts of structures and remains, both on the mainland and on the island.
All these data and the related data processing have allowed the creation of the first update mapping of the remains, with the purposes to continue the work of discovery and correlate and interpret the different parts in the mainland, in the sea, in the small island of Agios Andreas.

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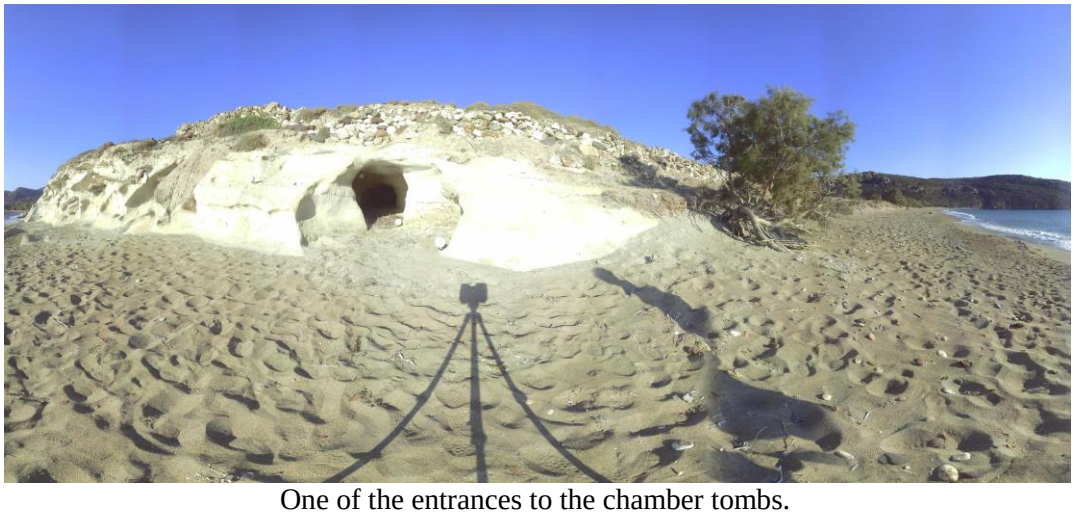

One of the entrances to the chamber tombs.

A tomb from the necropolis of Villalfonsina (Chieti, Italy): materials and anthropological data

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The area called Morandici near Villalfonsina (Chieti, Italy) revealed a new necropolis containing 18 tombs of archaic and late archaic age. The area of Villalfonsina has been already known since the seventies, when some objects coming from a burial area and belonging to an extended period of time (IX-VII century BC until IV century BC) where shown at the Chieti National Museum. They included also materials from sites of ellenistic and first imperial age, thus demonstrating the presence in the location of different populations in a long period of time.

The excavations carried out in 2008-9 revealed a necropolis located at a depth of 100-270 cm below surface, and under other archeological remains, demonstrating that it was connected probably to the first inhabitants of the area. Since very little is known about the populations occupying these territories, their habits, rituals, technological competences and commercial exchanges, is seemed particularly important to study the human remains and burial objects of the tombs.

The necropolis, not entirely excavated yet, shows the tombs belonging to women usually located towards the North, whereas the men are in the Southern part. The inhumations consisted in locating the body with burial objects, covered with sandstone pebbles and sometimes light-colored clay with a molding made of darker color clay. Sometimes wooden planks or shingles have been used to cover the tomb and the sides of it. Unusual objects inside the tombs comprehend: bones and cherts fragments, bronze objects, a large belt (near the body, on top of it or weared).

The first tomb investigated in this study (tomb 37) showed a skeleton in supine position in a pit burial, with hands on the hips. Bronze and iron ornaments of various shapes were found on the body, like rings and fibulas, on the arms, on the stern or near the head, as ornaments. An iron spit was on the side, on top of a ceramic monoansate vase. The rest of the ceramic vases, in a pile, was found near the left foot. A necklace made of vitreous paste and amber grains, was left on the right side of the body, not weared.

The skeleton of the tomb 37 has been atttributed to a woman, for which the full anthropological investigation is still ongoing. Regarding the burial objects, the archeometrical study was carried out to determine the composition and manifacture of the metallic pieces and of the ceramic vases, as well as the characteristics of the necklace by Scanning Electron Microscopy, reflecting light microscopy, X-ray Diffraction and polarized optical microscopy. The purpose of carrying out this study was dual: on one side to proceed to an identification of the materials composing the objects and their possible usage in life, on the other side shed some light on the population which produced or used them. For example, the use of the metals revealed to be very various and tecnhnologically advanced which demonstrated a high mastery of the use of metals, whereas the necklace revealed commerces to obtain the desired amber. The archeological information about the burials suggests complex rituals different from those found in the tombes belonging to the older and younger necropolis in the area.

This work is therefore just the first step towards a full comprehension of this population, which will still remain obscure without a large-scale investigation of the necropolis.

Provenience and characterization of mosaic *tesserae* of *Villa del Tellaro* at Noto (SR)

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The *Villa del Tellaro* (Noto, Siracusa), located in the south-eastern Sicily, represents one of the most exquisite examples of Late Roman Senate and Imperial Villas, having comparisons in other great buildings such as *Villa del Casale* (Piazza Armerina) and *Villa di Patti* (Messina). These great architectural complexes often exhibit similarity in construction features, architectural and decorative models, so that a circulation of routines, materials and even craftsman's can be hypothesized through the Mediterranean network.

Recent archaeological excavations carried out in the *Villa del Tellaro* brought to the light new structures consisting in a wide perystile and several rooms enriched by mosaic floors, dated back to IV century [Voza, 2013] on the basis of numismatics studies on coins discovered along with the mosaics. The decorative motifs and the intense polychrome of mosaics have comparisons with other structures occurring in Sicilian as well African Late Roman Villas [Voza, 1982], so that possible relation among the concepts of these structures can be hypothesised. However, even if stratigraphic and archeological investigation might improve knowledge about construction phases and historical interpretation, issues as raw materials provenance and manufacture technology can be investigated only with the support case of archaeometric analysis [Cantini et al., 2017; Lezzerini et al., 2017].

In this prospective, thanks to a sampling campaign carried out on the *Villa del Tellaro*, a set of 23 *tesserae* representative of the difference color nuances occurring in the mosaics have been collected and studied by archaeometric micro-destructive and nondestructive techniques with the aim to characterize the materials and obtain provenance information.

Tesserae exhibit a wide range of colors, from white to red, from yellow to gray; white marble and colored decorative stones are mainly used, even if orange nuances are obtained by using ceramic paste. Preliminary nondestructive PIXE analysis have been performed in order to obtain information on chemical composition and possible discriminate stones [Barone et al., 2013]. Additionally, petrographic investigation, along with identification of litho-microfacies and isotopic analysis have been carried out on colored and white marble, respectively, with the aim to define provenance of raw materials.

The obtained results have been employed to support archaeological questions about possible materials and artisans routes, providing interesting insight on the relation among *Villa del Tellaro* and the Mediterranean area in the late antiquity.

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The characterization of magnesium binder: experimental approach to the study of the components

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In this contribution an experimental approach aimed to characterized the binder produced by burning dolomitic rocks and some case studies will be presented.

In our research a dolomitic stone composed by 31.5% of CaO and 23.5% of MgO_2 and with low amounts of Al_2O_3, Fe_2O_3 and SiO_2 (<1%) was burned at 950°C for one day. A quick lime composed by CaO and MgO was obtained. After slaking and curing of the binder for about 9 months in order to favour carbonation, the XRD (X ray diffraction), TGA (thermogravimetric) and FTIR (Infrared Spectrophotometry in Fourier Transform) analyses revealed an abundant amount of $Ca(OH)_2$ (portlandite) and $Mg(OH)_2$ (brucite) together with calcite. Despite the partial carbonation the physic and mechanical data of the material, showed the formation of a porous material with good mechanical resistance.

The main problem in this experimental approach is the time of curing, which must be necessarily long because the introduction of any accelerating agent, such as a flow of CO_2, can modify the reaction kinetic and also the stability of the carbonate phases such as amorphous carbonate and aragonite.

Together with this experimentation, mortars from Tuscan historical sites, realized with a magnesian binder were studied with a mineralogical and petrographic approach using X-ray diffraction and optical and electronic microscopy. In particular the mineralogical and petrographic data acquired on binders and lumps of some Argentario Towers (XVI century) showed the relevant presence of brucite, hydromagnesite and calcite with traces of magnesite. The chemical analyses on electronic microscopy (SEM) evidenced an homogeneous distribution of Mg in the binders.

In the case of the bedding mortars of Medieval site of Montarrenti (Siena), the binder was realized by burning dolomitic rock of the Montagnola Senese, and the only presence of hydromagnesite and calcite was evidenced.

The formation of hydromagnesite and brucite inside the magnesium binder could to be responsible of good mechanical characteristics of the mortars.

Laser Scanner Technology and Ground-Penetrating Radar for the Survey and 3D modelling of ancient *Krésie Pipi* (Reggio Calabria)

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The aim of this work is to show the potentiality of the combined use of technologies such as laser scanner and Ground Penetrating Radar (GPR) in the field of cultural heritage. The development of new detection technology has allowed to do great steps in the acquisition of spatial data for various applications. Among them, the scanner technology allows rapid and comprehensive capture of data, furthermore with the help of GPR is possible to analyze the ground below and in the surrounds of the structure. The combined application of these particular and interesting techniques shows its importance in the cultural and architectural context, in particular in the survey of buildings, archaeological sites and monumental structures. The survey carried out, in this study, was devoted to the church of "Our Lady of the Poor" (*Krèsie Pipi*), located in the city of Reggio Calabria. It represent a good study case, the church, in fact, is a religious building dating back to the tenth century built with a Byzantine style and its location should be part of the acropolis of the city of Reggio Calabria. The equipment used consists of a Faro Laser Scanner Focus3D, which allowed the survey of internal and external surfaces of the church with a high density of points, supported by a photographic survey carried out by the instrument itself. The use of GPR (Ground Penetrating Radar) allowed to investigate the subsoil and to identify the ancient underlying structures.

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The black stones at the Leopardi's childhome (Recanati, Italy): a LIBS and portable XRF characterization of the rock-artefacts

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A LIBS and portable XRF survey was performed on two roughly egg-shaped and two irregularly-shaped polished rock-artefacts, which are exposed in the famous library of the childhome of the poet Giacomo Leopardi, at Recanati (Italy). They are known as the "damned" black stones as a popular idiom says these rocks would have put a curse to those persons touching them, excepting for the Leopardi dynasty. This popular belief probably derives from the mysterious atmosphere around these stones because of their exotic appearance, being very far from the colour and features of the sedimentary rocks nearby Recanati.
Historical data on their provenance are lacking. Most probably, they reached Recanati starting from the second half of the XIX century, since they are not recorded in the detailed catalogue of rare objects written by Monaldo Leopardi (1776-1847), father of the famous poet.
From a macroscopic investigation, we can define these black stones as fine-grained metamorphic rocks of the same lithology mostly formed by mafic minerals. They are characterized by different size: two with the same weight of 16.9 kg whereas the two smaller ones of 5.6 Kg each. These weights roughly correspond to five roman drachmae (i.e. 17.04 kg; 1 roman drachma = 3.408 kg) and five roman scrupuli (i.e. 5.68 kg; 1 roman scrupulum = 1.136 kg) respectively. This correspondence to standard roman weights, coupled with their lithological similarity to what already known as Lapis aequipondus or Lapis martyrum, considered "nefrites" (Corsi, 1845; Borghini, 1998; Pullen, 2016) firstly lead us to consider the investigated "damned" black stones as counterweights. This is also supported by the presence, on the rock surfaces, of harness grooves (up to 1 cm wide) in order to use these artifacts as counterweights. Flattened balls, rather than egg-shape, are the typical forms of Lapis aequipondus, which are present in some churches of Rome such as Santa Maria in Trastevere, Santa Sabina, San Lorenzo and Santa Maria in Cosmedin (Corsi, 1845; Pullen, 2016). Other samples of Lapis aequipondus are also present at Musei Capitolini of Rome and S.Angelo church of Perugia (Pullen, 2016).
With the permission of the Count Vanni Leopardi, a representative chemical analyses of the four stones were performed using a Modì LIBS system made by Marwan Technology (Pisa) and a portable XRF instrument by XG-Lab (Milano). The results of the analyses will be discussed and compared, in order to show the utility of coupling two techniques for chemical investigations in the field of cultural heritage.

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Use-wear traces and wood tar residues on Funnel Beaker culture flint harvesting tools: a case study from south-west Poland

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Prehistoric harvesting tools made from lithic materials are easily distinguished amongst the archaeological assemblages. Lithic sickle inserts bear macroscopically visible traces of use. Cutting cereals causes edge rounding and highly reflected polish with flat topography cut through striations of various frequency (Gijn 2010). However, a location of polish and other associate traces show only which part of a lithic specimen served as a working edge, but the reconstruction of a complete sickle is not possible. More data, such as handles or residues of glue - wood tar or pitch - are necessary.
The technology of manufacturing adhesives for hafting arrowheads and projectiles had been known as early as in the Palaeolithic (Colombini 2006) and the Mesolithic (Aveling 1998). From the Neolithic European sites whole lumps of wood tar or post-production residues inside vessels or spoons are reported (Pietrzak 2010). The use of wood tar or pitch for hafting stone or bone tools by the Neolithic people is less documented. So far, no flint artefacts with macroscopically visible resinous substances are reported from SW Poland. The only proof of wood tar production in the Neolithic in this part of Poland are the remains of probably tar kiln with charred birch bark in the bottom (Wojciechowski 1969).
Microscopic use-wear analyses of flint tools from the archaeological site Polwica-Skrzypnik in south-west Poland, dated back to the Funnel Beaker culture (TRB, late Eneolithic), revealed brawn or blackish substances on the surfaces of a few retouched blades. Specimens had been used for cutting cereals or other siliceous plants. The combined Fourier Transform infrared spectroscopy (FTIR) and gas chromatography coupled with mass spectrometry (GC-MS) study showed that dark substances are residues of wood tar or pitch - adhesives used for hafting. For the first time flint artefacts with macroscopically visible resinous substances are reported from this part of Poland. Resinous matter covers almost whole surface of tools. Location and distribution of use-wear traces clearly show that tools were used in longitudinal motion. Microscopic study together with residue analysis reveal the manner of use of the late Eneolitic sickles and the hafting mode.

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Chemical characterization of archaeological samples from Banbhore (Pakistan) by spectroscopic, gas chromatographic and mass spectrometric techniques

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The site of Banbhore (Pakistan) rises at the mouth of the Indus deltaic region on the northern bank of the Gharo creek, midway on the route from Karachi to Thatta, ca. 30 km from the present shoreline. It consists in a “citadel” encircled by bastions, and a vast area of extra moenia ruins – harbour structures, urban quarters, suburbs and slums, warehouses, workshops, artificial barrages. Altogether, the citadel and the surrounding quarters cover a surface of ca. 65 hectares. The importance of the site is linked to its strategic position and the surrounding environment. As a matter of fact, various historical sources inform us about a harbour town at the mouth of the Indus delta which, due to its strategic position, played a central role since about the 3rd century BCE.
Here, we show the results of the chemical characterization of several organic remains found at the archaeological site of Banbhore. The samples under investigation were brought to light during the archaeological excavations of 2015, among the remains of a stone building with a trapezoidal shape that dates back to the ninth century AD. The characterization was carried out by FT-IR, GC-MS and Py-GC-MS. Results allowed us to identify such remains as bitumen and in one case we found a fossil resin.

Mortar Radiocarbon Dating: The role of the characterization of materials in the sample preparation

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Absolute chronology of archaeological contexts is mostly based on the radiocarbon dating of organic materials, even if, in the last few years, a particular effort in exploiting mortars as a potential material for radiocarbon dating has been done.
Mortars are heterogeneous building materials composed of a mixture of inorganic and/or organic binders and sandy-sized aggregate. Actually, the lime binder of the mortar can be used for dating the archaeological structures since carbon dioxide absorbed during the setting of the mortar likely reflects the content of ^{14}C existing in the atmosphere at that time.
In this paper a multi-analytical approach has been carried out in order to highlight the importance of the characterization of the technological properties of the mortar samples to use in a efficient way the *Cryo2SoniC* radiocarbon dating protocol of mortars (Marzioli et al., 2011).
In detail we show results obtained in the application of this multidisciplinary approach (characterization of mortars + radiocarbon dating preparation protocol) in two different archaeological context: Andalusian castles (Spain) and Battistero of Firenze (Italy). The characterization of the samples has been carried out using different techniques (optical microscopy, FTIR, thermogravimetry coupled with evolved gas analysis) in order to control "contamination effect" that could affect age estimation (Lubritto et al., 2017). Moreover an improvement to the *Cryo2SoniC* method is proposed, mainly based on differentiating both ultrasonic time and sieving size. Results coming from these experiments confirms the validity of *Cryo2Sonic* method for particular typologies of mortar, different between them in petrographic and geological characteristics.

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Magna Graecia heritage in Southern Italy: an archaeometric study on amphorae and common pottery

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Vibo Valentia area (Calabria, Southern Italy) was an important centre of Magna Graecia. In fact in the past it was a strategic point for the commercial trades in the Mediterranean basin, thanks to the presence of the ancient port from III cent. BC until VI cent. AD. This intense activity is linked to a prosperous manufacturing of ceramic handcrafts, especially *amphorae* for transport of wine, *garum* and oil, produced widely in the region.
Studies on the technological details of the manufacture of pottery can yield important archaeological information allowing the determination of trading patterns and the daily habits.
The complementary use of archaeometric methodologies such as optical microscopy and X-ray powder diffraction analyses (XRPD) provided useful data about the composition of the artefacts.
The observation of thin sections (Fig.1) by the means of optical microscopy provided textural and compositional features of the ceramic pastes according the criteria suggested by Whitbread (1995). XRPD allowed to determine the mineralogical phases and to estimate roughly the firing temperature reached.
Thirty samples were analyzed, they show similar inclusions such as quartz, feldspar, pyroxene and dissolved fossils but very heterogeneous microstructure relative to the abundance of these components, their sorting and features of the groundmass. XRPD revealed in some samples the presence of diopside suggesting firing temperature more than 850°C (Rovella et al., 2016; Cultrone et al. 2001).

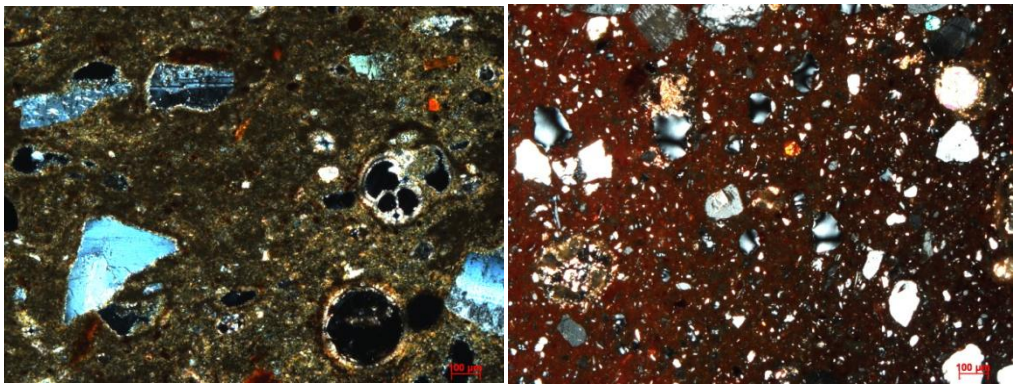

Fig.1: Thin sections observed in Optical Microscopy (Crossed Nicol view) of two pottery samples

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A multi-technique insight into pleated dresses from the Museo Egizio

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The textile collection of the Museo Egizio in Turin holds a large number of pleated linen textiles [1] from tunics dated from the VI to the XII dynasty. The textiles have been already studied during conservation-restoration to highlight weaving and tailoring techniques. On the other hand, the amazing technique for pleating the linen, which has fixed the folds over millennia, still remains a mystery.

Preliminary scientific instrumental investigations performed with scanning electron microscopy (SEM) and Fourier-Tranform InfraRed Spectroscopy (FTIR) suggested the possible presence of organic compounds that might have played a role in keeping the pleats in position [2].
In order to obtain more precise information on the organic component (oils, fats and waxes), the samples were extracted by sonication using deuterated acetone and analysed by high resolution 1D and 2D NMR COSY techniques. In addition, chromatographic techniques coupled with mass spectrometry after solvent extraction at various polarity were applied.

Pleated fragment S 16792 (detail)

From the analysis of the NMR spectra the samples seem to contain triglycerides (~5% molar), free fatty acids (~65%, both saturated and some monounsaturated), fatty acid esters (wax esters, ~15%) and probably some fatty alcohols (another ~15%). Unknown signals, tentatively attributable to hydroxyl compounds, would support the presence of beeswax, as signals form aromatic components – which are detectable for other waxes - are not present in the spectra.
In addition, micro-Raman, FT-Raman, XRF Spectroscopy and XRD diffraction patterns were performed with the aim to gain information on the nature of the textiles and on the inorganic components like minerals (calcite and earths).

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Thanks to Dr. Apostolos Spyros of University of Crete for his help ion the interpretation of NMR data.

Insight into Baccio da Montelupo's wooden crucifix. A multi-analytical approach

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The Jesus Christ wooden crucifix hosted in the Church of San Casciano Val di Pesa, near Florence, is an exquisite example of the Italian Renaissance polychrome sculpture (Fig. 1a). It was created at the beginning of the XVI century and it is attributed to the Florentine sculptor Baccio da Montelupo. In the early months of 2016, a thorough restoration started for conservative and aesthetic purposes, aimed at uncovering the original pictorial surfaces hidden by old retouches and aged varnishes, and intervening against the attack of xylophages insects. A diagnostic project was set up to characterize the materials used, the artistic technique, the state of conservation and the internal structure of the statue through non-invasive methods. The surface was documented with UV photographic imaging, while pigments and varnishes/binders were investigated with portable instrumentation by using X-ray fluorescence (XRF) and Fourier-Transform Infrared (FT-IR) spectroscopy, respectively. The presence of repairs and metallic structures, as well as the assembly of the wood panels, were also investigated with Computerized Tomography (CT, Fig. 1b). The cleaning steps were monitored repeating photographic UV documentation and FT-IR analyses (Fig. 1c-d).
The UV photographic essay showed the abundant presence of a strongly fluorescent varnish, that makes completely invisible the underlying materials such as the blood on part of the forehead and on the chest and the decoration of the *perizoma*. However, elemental analysis performed by XRF highlighted the presence of high counts of lead (Pb), related to the use of *biacca*, excluded the use of cinnabar on the blood drops and showed how the decorations on the *perizoma* were made of gold. CT images revealed, inside one leg, hyperdense and probably metallic structures, whose function is still not clear. From FT-IR analysis it was possible also to hypothesize the presence of siccative oils as binders, a natural resin as varnish and a wax-based protective coat.

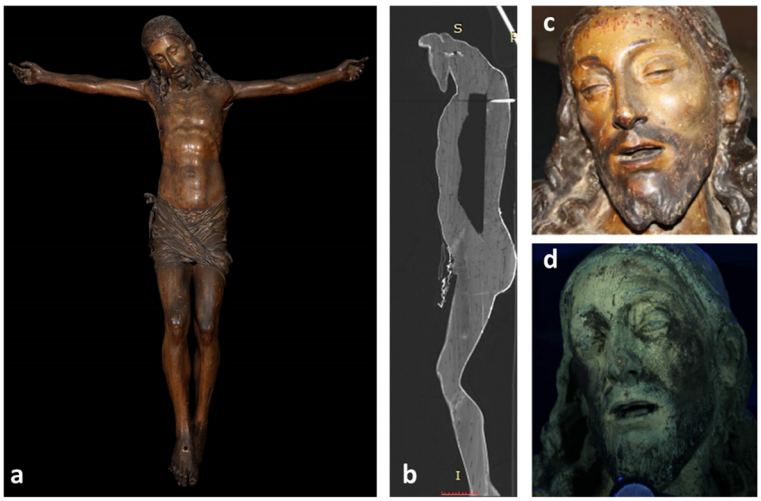

Figure 1. (a) The Jesus Christ polychrome crucifix; (b) CT sagittal reconstruction image. Christ's face in (c) visible and (d) UV light. Images a), c) and d) are taken before the restoration intervention.

The Francisco Pizarro's Banner of Arms: a multi-analytical approach contributing to Latin America history

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The authenticity of the so-called Francisco Pizarro's Banner of arms stored at the National Museum of Colombia in Bogotá has been the subject of intense debate amongst historians and conservators for the last two centuries (fig.1). The banner was transferred from the cathedral of Cuzco in Perù to Bogotá in 1825 by General Antonio Jose de Sucre during the military campaigns against Spanish rule. General de Sucre was the first person to associate the banner with the arrival of Francisco Pizarro in the New World. In order to provide for the first time analytical evidence on the material used for the making of the banner and to support its authenticity, a set of 25 micro samples from different areas were collected and characterized by Optical and Scanning Electron Microscopy and Energy Dispersive microanalysis (OM, SEM-EDS), High Performance Liquid and Chromatography Mass Spectrometry (HPLC-MS), Pyrolysis Gas Chromatography Mass Spectrometry (Py-GC-MS) and Raman Spectroscopy. Seven samples were also analyzed by Accelerator Mass Spectroscopy (AMS) for radiocarbon dating. Results obtained allowed to identify as silk the textile used in the elaboration of the Banner's fabric, as well as the use of natural dyes for dyeing the fibers used on the emblem: use of cochineal and brazil wood as a source of red, luteolin plant-based for yellow color, indigotine plant-based for blue, and a mixture of yellow and blue dyes for green were identified. Similarly, animal glue and rag paper were also used in the manufacturing process. The metal threads study from the Banner confirmed the use of a silver core wire gilded with a thin gold sheet, being flattened and entwined with silk threads (Fig. 2). The AMS results indicated a Banner manufacturing date between the XV-XVI century with restoration interventions with the addition of new textile materials in modern times. The analytical results are consistent with the hypothesis of a European manufacture at the time of the conquest process of the New World by the Spanish Crown.

Fig.1

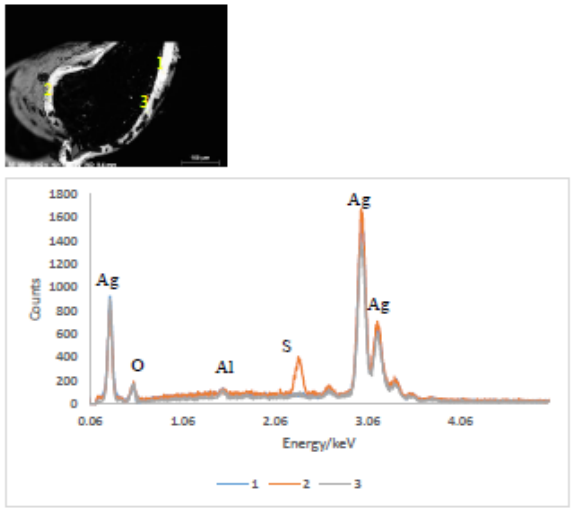

Fig.2

Islamic and post Islamic ceramics from the city of Santarém (Portugal): an archaeometry study on production and trades

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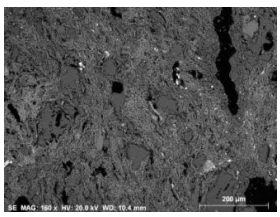
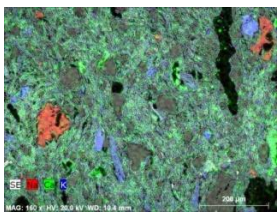
This work presents the results of an analytical program carried out on common, painted and glazed Islamic and post Islamic (Christian) ceramics from the city of Santarem. The city is located in the center of the nowadays Portuguese territory, in the Tagus valley at 90 km from the city of Lisbon. It is important to mention that from the military point of view, the conquest of Santarém by Dom Alfonso Henriques (1147 A.D.) was a crucial step during the "Reconquista" of the future Portuguese kingdom, and the study of the ceramic material is very important in order to establish commercial circuits and trades during this period of political instability.

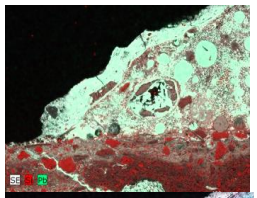
Samples were selected from several archaeological sites, in particular from productive and habitational contexts, covering a chronological period which span from the Xth to the XIIIth centuries. All the selected shards were analyzed at the Hercules Laboratory of the University of Évora using the classical methodology for the characterization of ceramic materials like XRF spectroscopy, X-Ray diffraction, FT-IR, petrography and microstructural analysis by SEM-EDS of the ceramic matrix and of the decoration (glazed or painted). ICP-MS and LA-ICP-MS (of the glazed decoration) were utilized in order to evaluate rare earth chemical elements.

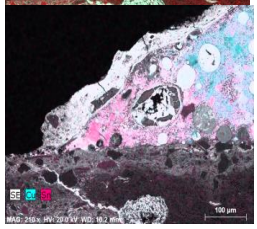
Results obtained have been treated in order to collect information concerning ceramic characteristic, the production technology and the presence or not of imported decorated glazed artifact. In particular it was possible to understand the city economy during the Muslim domination and how the city's integration in the Christian political dominium influenced local pottery production and its circulation.

VALA 37, polychromatic glazed ceramic, Islamic

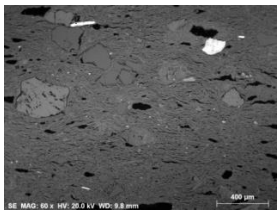


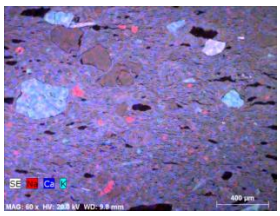






91/1980, unpainted ceramic, pan, post Islamic





Green lead silica glaze

Atmospheric Corrosion of Cast Iron Metalworks in the European Street Furniture

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Cast iron played a central role in the development of historical street furniture. Historical street furniture was composed by all elements (e.g. street lamps, benches, fountains and gazebo) that eased the life in the city and concurred to adorn the landscape. The diffusion of these objects was related to the Industrial Revolution (1760-1840 CE) and to the history of cast iron foundry [1].
Cast iron has good corrosion resistance: the rate of atmospheric corrosion of cast iron is lower than that of mild steel, especially in the presence of high concentrations of pollutants [2]. The historical street furniture was usually exposed to atmosphere for 50 or even 100 and more years, but for the majority of its exposure the surfaces were usually protected by paints [3].
Our study investigated the state of conservation of five painted, mostly corroded cast iron metalworks dating back to the XIX and the XX centuries and coming from cast iron foundries located in Italy and France. The experimental activity was conducted in collaboration with "Fondazione Neri – Museo Italiano della Ghisa" (Longiano, FC, Italy).
The samples were first observed by a Leica MZ6 stereomicroscope. Analyses of the corrosion products on the surface of each sample were carried out by X-ray diffractometry (XRD) and a ZEISS EVO MA 15 scanning electron microscope (SEM) equipped with an Oxford X-Max 50 energy dispersive microprobe for semi-quantitative analyses (EDS). To determine the microstructure of alloys, longitudinal sections (parallel to the metal surface) and cross-sections (perpendicular to the metal surface) of the samples were prepared, mounted in resin, polished and analyzed by a Leica MEF4M optical microscope. The stratigraphy of both patina and varnishes was investigated by SEM/EDS on the cross-sections embedded in cold mounting resin to avoid the alteration of the corrosion products.
The experimental results showed that the cast iron metalworks were characterized by lamellar graphite of Type B (rosette grouping with random orientation, according to UNI EN ISO 945-1:2009 [4]) and with lamellae between 0.06 and 0.25 mm in length. In all cases, the microstructure was pearlitic with high steadite and manganese sulphides contents.
The corrosion processes involved the graphitization of cast iron, which occurred in the presence of acid rainwater where the base metal was left unpainted for long periods [5]. As the ferrous alloys corroded, the porous graphite residues were impregnated with iron oxides/hydroxides. Affected surfaces showed thick layers of graphite, rust and impurities, retaining their appearance and shape, but weakening structurally. Concerning the varnishes applied for metal protection, all metalworks were covered by a Pb-rich rust preventing layer and finished with a layer of paint mainly containing S, Ti, Ca, Ba and Zn.

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On the use of magnetic measurements as indicator of the equivalent firing temperature of ancient baked clays: New experimental results

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We present here new experimental results on the variation of the magnetic properties of baked clays as a function of the temperature. Such experiments, including continuous monitoring of the magnetic susceptibility and the magnetic moment versus temperature, were applied to a set of natural clays experimentally heated at the laboratory at 200 °C, 400 °C and 600 °C as well as to archaeological baked clays collected in two archaeological sites in Northern Italy (Santhià and Carbonara Scrivia). The aim of this study is to investigate the reliability of the magnetic properties to identify the equivalent firing temperatures of ancient baked clay artefacts based on the reversible behavior of thermomagnetic diagrams (Fig. 1). The results obtained indicate that the magnetic properties do not always succeed to estimate the firing temperature of the baked clays, mainly when clays have been heated only once and at relatively low temperatures e.g. less than 300-400 °C. On the contrary, magnetic properties of ancient clays that have been repeatedly heated in the past at temperatures higher than 400 °C seem to be more stable and representative of the equivalent firing temperature. This study points out that caution should be exercised on the use of the reversibility of thermomagnetic diagrams for the determination of the equivalent firing temperatures of ancient ceramics. Their reliability, in fact, depends on the maximum temperature experienced by the samples in the past as well as on several other parameters such as the initial mineralogy of the clay, the thermal stability obtained during ancient firing, and other features as the reductive/oxidative conditions maintained in the furnace during the heating treatments.

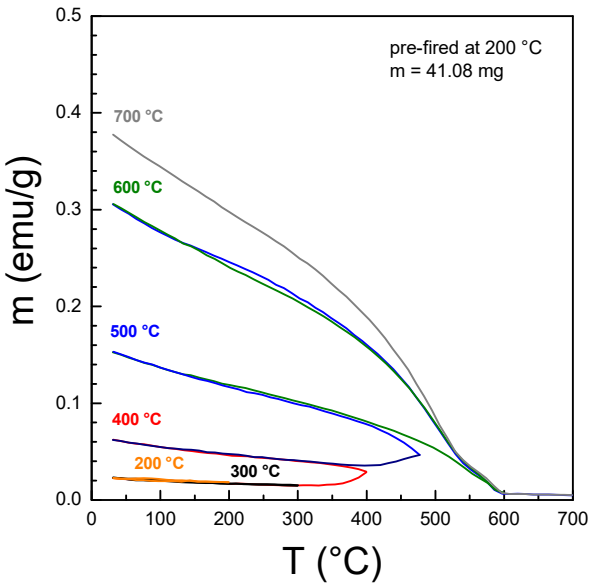

Fig. 1. Continuous thermomagnetic curves obtained after heating/cooling circles at increasing maximum temperatures (from 200 to 700 °C) for a clay sample experimentally pre-fired at 200 °C.

Lichen colonization influencing stone durability

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Lichens are a large group of fungi (mycobiont) symbiotically living with populations of minute green algae or cyanobacteria (photobiont). They colonize diverse substrates, including stone (saxicolous lichens), on which they determine physico-chemical deterioration processes: their growth may thus turn into an issue for the conservation of stone cultural heritage [1].
The interaction among lichens and stone surfaces has been analysed and widely debated throughout the years. Available studies are mostly headed towards the analysis of the space of lichen-rock interaction – *i.e.* the patterns of hyphal penetration within the substrate –, the chemical deterioration of original minerals and the production of neoformation minerals caused by the secretion of lichen metabolites [2]. These factors likely influence the total equilibrium among biodeterioration and bioprotection effects of lichens on stone surfaces [3]. However, relationships between the patterns of lichen-rock interaction and their consequences on physical properties relevant for surface durability (as porosity and hardness) have been poorly characterized, and mostly for carbonate rocks [4].This research aimed to extend such investigative approach to sandstones. In particular, we focused on the Cortemilia sandstone, a sublitharenite with calcite cement which has been widely used for building in southern Piedmont.
The hyphal penetration of epilithic and endolithic lichens within this lithology was characterized through the microscopical observation of cross-sections stained with Periodic Acid Schiff (PAS). The impact of colonization on the surface hardness was analysed with sclerometric measurements by the Equotip hardness tester.
All the examined species (*Verrucaria macrostoma, Xanthocarpia crenulatella, Sarcogyne regularis, Diplotomma hedinii*) displayed a layered hyphal penetration. Down to approx. 200 μm beneath the colonized surfaces, hyphae were organised in bundles (diameter up to 50 μm), and surrounded the clasts as a network. Hyphae not organised in bundles (diameter approx. 5 μm) were massively present around clasts down to 1 mm in depth, and sporadically down to 3 mm. Sclerometric measures of rock hardness beneath *Verrucaria macrostoma* showed values significantly lower than the measures detected for adjacent rock volumes covered by biofilms of cyanobacteria and black fungi or uncolonized (control 1), and for fresh controls (control 2).Such results indicate that lichen colonization and penetration within the Cortemilia sandstone negatively affect its hardness. This finding will be discussed with respect to previous results on limestone [4], considering the need for *ad hoc* investigations for each lithology to evaluate the impact of lichen colonization on surface durability.

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XRF Analysis of a Ceramic Collection from Bukhara, Uzbekistan

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An XRF scanner, developed in collaboration with the research group at LABEC in Florence, is being used at NYU Abu Dhabi for cultural heritage investigation. We present preliminary result from the analysis of a subset of a ceramic collection obtained from a survey expedition to Bukhara, Uzbekistan. This geographic region has been inhabited for millennia, and was located along the Silk Road, which rendered it as a prominent center for trade and cultural exchange. The ceramic collection will most likely contain samples representing different epochs, and regions, precisely because of this trade. We analysed the surface elemental composition of the samples looking for hints that would allow for an initial characterisation.

Discerning between natural and artificial pozzolanic materials by FTIR spectroscopy

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Discerning between natural (i.e. *pozzolana*) o artificial (i.e, crushed bricks or ceramics) pozzolanic materials in hydraulic plaster and mortars is usually performed by means of Optical Microscopy (OM) thin section observation, by thermal techniques (TGA-DTA) and XRD analysis. (Chiari et al., 1992; Moropoulou et al., 2005, 1995).

In the present work a new option based on FTIR spectroscopy is proposed. FTIR spectra collected on geological material (Pozzolana di Torre del Greco, Museo Regionale di Scienze naturali) and a certified reference material (SARM69 powdered ceramic, MINTEK**,** Johannesburg, SA) indicate the possibility of discriminating between *pozzolana* and ceramic materials in typical 1170-470 cm^{-1} frequency range.

Analysis of archaeological mortar fragments, containing *pozzolana* and crushed ceramic respectively, confirms the suitability of the proposed FTIR technique in discerning between natural and artificial pozzolanic materials on real samples. Nature of the pozzolanic aggregate in these samples was previously ascertained by mean of OM, XRD, TGA and SEM-EDX.

FTIR is a fast and economic technique, both in sample preparation and analysis and could be usefully applied when a great number of samples has to be examined, as an alternative to the XRD technique in the case of disaggregated samples or when pozzolanic materials are present in the form of fine particle, i.e. below the resolving power of the OM. Finally, a scale-up to portable equipment could allow *in situ* determinations leading to the mapping of the different technological horizons in an archaeological site or complex.

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Brick technology in the roman *villa* (I-III c. AD) of Costigliole Saluzzo (Piedmont, Italy)

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The excavation of the *villa rustica* of Costigliole Saluzzo – one of the largest rural settlements of north-western Italy during the Roman age – brought to light a huge quantity of building materials pertaining to the different parts of the *villa* and to other adjacent constructions.
Among the ceramic materials, tiles, curved tiles and north-Italian *sesquipedales* bricks are very common. Other artifacts are less diffused, like a specific kind of brick which is unparalleled in other sites of Roman Piedmont so far: it is usually less compact and hard in comparison with other building materials, and shows differences in color and composition (*e.g.*, a particular concentration of vegetal elements in the fabric). Moreover, the fire which caused the destruction of the *villa* was responsible for the excellent preservation of many parts of the wall structures made in perishable materials in the technique of *opus craticium* (*e.g.*, fragments bearing the traces of the original *incannucciata*, reed structure).
EDX determination revealed a non-calcareous paste for all the analyzed samples, the composition of the *incannucciata* samples show slight differences from all the other samples, quite homogeneous. The overall original firing temperatures evaluated by means of a multitechnique approach (XRPD, SEM, TGA and FTIR) could be assumed between 800 and 1100 °C for all the intentionally fired materials, on average higher than those reported by other authors. A higher temperature in the firing process of this kind of materials results in a mechanical strength increase, suggesting technological advanced knowledge and capability. Moreover, SEM examination of fresh fractures allows ascertaining relict voids of vegetal fragments burnt during the firing step in samples pertaining to the rare type of bricks described *supra*, usually occurring in the foundations and in the bases of few structures related to the *pars urbana* of the building. It seems plausible that the increasing thermal insulation and/or enhancing the freeze-thaw resistance of the final product was the final aim of this technological choice. The expedient of creating voids in the clayey structure to increase thermal insulation and resistance in archaeological building materials was never described before, to the authors' knowledge. The physical mechanism bestowing these characteristics to the bricks was evidently not known, but its effect had been certainly observed, since the procedure of adding straw to limit shrinkage and avoid cracks formation is attested in analogous materials. The adoption of this procedure would suggest good technological knowledge and skills and particular attention in the evaluation and planning of the long-term features of the buildings.

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Archaeometric study of painted plaster from the Church of St. Philip in Hierapolis archaeological site (Turkey)

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The analyses and study of fragments of Byzantine wall paintings regarding the Sanctuary of the Apostle Philip, in Hierapolis of Phrygia, one of the great Hellenistic, Roman and Byzantine cities of south-western Turkey (Pamukkale, Denizli Province), was carried out in the framework of the "Marmora Phrygiae" project financed by the Italian Ministry of University and Research (FIRB MIUR).
The plasters decorated the Byzantine church with three naves built over the tomb of the Apostle. The recent archaeological investigations inside the church of St Philip have recovered the fragments of plaster from the apses and the narthex.
This study was firstly performed using a protocol including non-invasive techniques based either on imaging (Ultraviolet fluorescence (UV) and Visible Induced Luminescence (VIL)) or single spot analyses (Fiber Optic Reflectance Spectroscopy (FORS) and portable X-Ray Fluorescence (XRF) spectrometry). This first set of measurements applied on the fragments of mural paintings was conducted directly in situ, at the deposit of the Italian Archaeological Mission in Hierapolis where all the excavated materials were stored. In this way, it was possible to have a first characterization and to group by type all investigated fragments.
Then, the most representative and interesting samples were sampled for further studies with laboratory techniques such as optical and electronic microscopy, micro-Raman, FTIR and X-ray diffraction.
Regarding the plasters, laboratory's techniques were carried out to understand composition and technological features.
The archaeological and archaeometric approach paves the way to a better documentation of the various building phases of the church and it also offers, despite the extremely fragmentary nature of the analysed material, a reconstruction of some decorative motifs. The analyses highlighted some differences between the proto- and middle byzantine plasters and documented the composition of the pigments as well.

The Perception of Risk and Hazard in the Analysis of Historical and Cultural Samples

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The concept of "risk" and how its meaning is related to that of other concepts such as "danger", "hazard", "safety" and "uncertainty" has been studied for almost a century [Bonholm 2012]. Maybe the most appropriate suggestion about the semantical difference between "risk" and "danger" has been given by the sociologist Niklas Luhmann [Luhmann 1993]: "risk" refers to potential failure loss as a consequence of a decision, while "danger" is a potential loss resulting from something external. Another important concept to consider is the so called "risk factor", which is the probability of something happening multiplied by the resulting cost or the benefit if it does.
When risk is involved, human decisions are conditioned by the different perception and elaboration of the relevant information connected to the choice process. For example, positive and negative feedback about past risk taking can affect future risk taking. In an experiment, people who were led to believe they are very competent at decision making saw more opportunities in a risky choice and took more risks, while those led to believe they were not very competent saw more threats and took fewer risks [Kruger & Dickson 1994].
During the preparation of an experiment on samples of historical and cultural importance, a deeper awareness of these concepts should be taken into consideration, as well as an informed knowledge of the mechanisms of decision making in presence of a possible damage to the sample under analysis [Sibilia & Zanini 2017].

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CONSERVAZIONE PREVENTIVA E RESTAURO

ORALI: CP&R-O
POSTER: CP&R-P

The use of gypsum in the Ticinese stucco artworks of the 16-17th century: motivation, characterization, provenance and induced degradation

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In the frame of the project "The Art and Industry of Ticinese *stuccatori* between the 16-17th century", the use of gypsum in the stucco paste has been fully investigated considering different but complementary points of view. As far as the artistic technique is concerned, stucco is a composite material made of lime and/or gypsum binder with aggregate (mostly river sand or marble powder). The gypsum addition to the lime binder is due to need of accelerating the setting of the 3D stucco elements, to avoid the shrinkage of the mortar and to reduce the considerable weight of the statues (Cavallo et al. 2016, Caroselli et al. 2016, Folli & Bugini 2001). With the aim of understanding the preparation technology, as well as the proportion of the mix and the raw materials used for the stucco production, the results from technical-scientific investigations were crossed with the information provided by the historical documentary sources. About 150 samples of stucco taken from artworks of the Ticino and Insubric region were analysed in stratigraphy, identifying their chemical and mineralogical composition. The gypsum presence was determined with PLM (Polarized Light Microscopy, for the characterization of gypsum binder related particles), XRD (X-ray Diffraction, for the identification of the mineralogical phases), FTIR (Infra Red Spectroscopy, to individuate the sulphate compounds) and SEM-EDS (Scanning Electron Microscope, to study the morphology of the crystals). Considering the lime/gypsum ratio, TG (Thermo Gravimetric analysis) appears to be the most appropriate technique, even though our results showed that the gypsum amount did not follow precise recipes or fixed proportions (Arcolao 1998). In general, in the ground layer, the quantity of gypsum was considerably high, while in the finishing, its use was often excluded. The preparation of the gypsum-based mixtures should have followed two different procedures: i) to be used immediately: the gypsum powder is spread on a already prepared mixture of lime, sand and water; ii) to be used up to two days (high plasticity mix): once the stucco paste (lime, sand and gypsum) is set, it is re-hydrated with water. The mix of a Mg-lime (Cavallo & Biondelli, 2012) with gypsum has also important implications in the decay mechanisms and consequently in restoration treatments. The water solubility of gypsum ($CaSO_4 \bullet 2H_2O$), in combination with the presence of Mg within the binder, led to the formation of epsomite ($MgSO_4 \cdot 7H_2O$) a high soluble salt, that makes very difficult the conservation of sculptures, if exposed to weathering.

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Hyperspectral Imaging system for Cultural Heritage diagnostics: an innovative study for copper painting application

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In the last few years, new non-invasive diagnostic technologies have become increasingly relevant in Cultural Heritage restoration because of their improvements in acquisition velocity, portable arrangement and more affordable costs.
A new hyperspectral imaging system, developed by small Italian SME "Profilocolore S.r.l" in 2016, has been applied for diagnostic investigation of two 17th century small paintings on copper coming from San Giuliano monastery in L'Aquila to support their restoration process committed to Lorenza D'Alessandro from Restoration Laboratory of Tuscia University.
The Hypercolorimetric Multispectral Imaging (HMI)([1]) system allows to acquire accurate spectral reflectance measurements of the paintings surface between 300nm (UV spectral region) and 1000nm (NIR region) to obtain seven monochromatic very high-resolution images together with the visible image which were later post-processed with Profilocolore "Viewer" original software.
Image processing was managed by the application of specific mathematical tools to run Principal Component Analysis (PCA), pattern recognition, contrast enhancement and edge detection. Combining calibrated images of different spectral regions acquisitions it was possible to extract relevant information about the state of conservation of the two paintings on copper and more significant details were readable compared with the data coming from each single acquisition. In the painting representing the Virgin and Child, contrast enhancement operations matching the UV and the induced-fluorescence images have put in evidence all the punctual discontinuities in the painted layer which are mostly concentrated along the edges of the small copper board, where the original frame was still before restoration procedures began.
The HMI acquisitions were taken in a short time (few minutes is enough) during cleaning actions to remove the brown coat (probably an altered varnish), which entirely covered the outward painting layer. A significant alteration, not easily remarkable in visible (VIS) vision, on the right side of the Virgin veil was highlighted in this post-processing as well as in the elaboration of IR2 image (registered at 750nm) with the PCA analysis of the fluorescence digital photography. By virtue of the possibility to have a spectral reflectance measure for each pixel of the image, digital image processing tools as edge detection and pattern recognition algorithms were applied to develop degradation maps, which represent a precious decision making tool for restorers.
In the second copper painting representing a Virgin holding a book, the PCA analysis on UV-induced-fluorescence acquisition revealed a residual of organic material on the upper part of Virgin veil and on some letters of the writing in the left upper corner of the painting, both not valuable in the VIS image. Probably it is a remain of the altered patina removed by restorers; so also in this case HMI analysis proved itself to be an important aid instrument for restoration process.
In conclusion, HMI analysis is a non-invasive, rapid and reproducible diagnostic technique that can be repeated *in-situ* after restoration, to best address restoration actions and monitor the state of conservation of Cultural Heritage objects.

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Microclimate analysis in a scientific museum: the case-study of the Physics Museum of Turin University

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The Department of Physics hosts the Museum of Physics of the University of Turin, preserving a collection of physics instruments that were formerly part of the old Cabinet of Physics of the University. The origin of the Cabinet collection dates back to the early 1700s. The instruments now preserved by the Museum are over 1,000, catalogued in part. About 45% of them are exhibited in 23 display showcases, along the ground and 1st floor corridors of the old Institute of Physics, and in 23 showcases in the Wataghin Hall.
The microclimate analysis has been performed starting from this room (figure 1) where some of the most ancient instruments are exposed and old journals are preserved. The building is massive with thick walls and the room is quite large (9m x 7m) and routinely used for meetings, lessons and exams. The scientific instruments are housed in wooden and glass showcases. The measurement campaign started in March 2017 and it is still in progress, using 11 thermo-hygrometers and a dust monitor. The thermo-hygrometers have been installed inside some showcases at different heights, and outside the showcases, in the room. Outdoor microclimate data have been measured on the roof of the building by a meteorological station (http://www.meteo.dfg.unito.it/).
The daily and monthly averages, the daily excursion and the performance index were computed of temperature, relative and specific humidity for all sites and then compared with the normative UNI 10829 (1999) (figure 2) though in this normative the scientific instruments are not considered.

Figure 1: Wataghin Hall, University of Turin

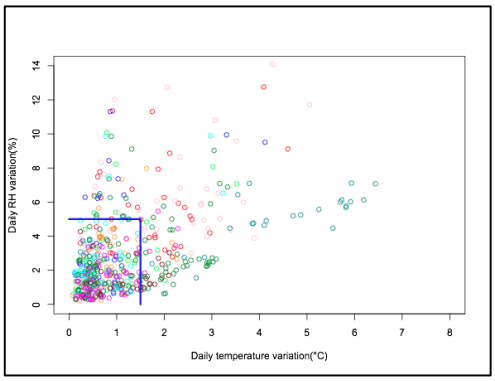

Figure 2: Temperature and relative humidity excursion: comparison with the UNI 10829 normative

The results show that the showcases reduce the daily cycle and introduce a time delay; the microclimatic conditions in the showcases depend on the outdoor meteorological conditions and on the events in the room. Besides, the microclimatic conditions are not the same in the different showcases deriving by the position of the showcase in the room. At a more general level, this study has significant implications for the issue of conservation of the historical scientific heritage in a scientific museum setting.

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Studies aimed at the preservation of the mummified remains of the Museo Egizio in the framework of *Mummy Conservation Project*

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Given the increasing attention among scholars in the mummified human remains conserved at the Museo Egizio in Turin, a collaboration has been established between the museum, the Institute for Mummy Studies of Eurac Research, the Soprintendenza Archeologia, Belle Arti e Paesaggio per la Città Metropolitana of Turin and the Horus Team, to the purpose of furthering knowledge of mummy conservation techniques and critically assessing them to strive to improve them.
This objective has been pursued in a combined investigation to the purpose of minimizing stress on the mummified remains. A range of different tests were carried out, including a Water Activity Test (AW), an identification of possible biological attacks (spores, moulds), CT scans of human mummies and sampling of them, performed, where necessary, by means of an endoscope in order to analyze DNA and obtain samples for C14 testing.
In view of the Museo Egizio and Eurac Research's common interest in developing know how for the preservation of all the mummies in the Egyptian Museum – both those on display and those in storage – special emphasis was placed on Water Activity testing, a parameter that affects the pace of biochemical decay in organic tissues. The presence of water on the surface of organic objects can be quantified by detecting the AW level. Levels above a certain AW threshold prove that microbial and fungal life has developed. This important parameter is significantly affected by temperature and relative humidity in the conservation environment.
AW testing is crucial for the attainment of an optimum standard of preservation, since the comparison of different levels of AW allows accurate determination of the peculiar correlation between an object and its environment, allowing for water volatility.
In this study project, special attention has been devoted to determining the presence of moulds and spores. Micro-samplings of surface biological materials were taken from areas of the mummies' bodies where direct observation was insufficient to determine the nature of the observed phenomena. Samples of both textiles and skin were taken using swabs containing two different culture mediums, prepared specifically for the detection of certain species of moulds and spores.The ongoing laboratory analysis will yield accurate identifications of the microorganism species causing the biological degradation.
To obtain complete and in-depth knowledge on the current environmental conditions the mummies are presently experiencing, the researchers also took samples of spores present in the air inside the museum storage area, in a showcase in the permanent galleries, and in the sample lab where the research operations were carried out.

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A Computer Simulation Study of Free and Constraint Steel Clamps in a Marble Wall of a Classic Period Monument

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Steel clamps and dowels inserted in the marble blocks of the Athens Acropolis monuments have maintained the structural integrity of the walls and other architectural parts from 5th century BC until 1687, when the bombardment of the Parthenon resulted to the partial collapse of the building structures and exposure of the metal elements to the corrosive environment. During restoration interventions in the beginning of the 20th century many of the original metal pieces were replaced by modern steel (sometimes as reinforcement of concrete). Both original and restoration steel were severely corroded by the atmospheric environment that prevailed during the sixties as a result of the industrialization of Athens and the extensive use of high sulphur fuels, which caused sulphation of the marble surface and intense corrosion of the metals. The Ministry of Culture decided to remove these metals and replace them by titanium alloy metal clamps and reinforcements. Steel clamps, ancient and modern are still being removed from the walls of the monuments as the restoration program of the Acropolis monuments proceeds.

In the present work, a computer simulation is used in order to present scenarios of mechanical failure of the restoration steel clamps. The marble-metal system response, where -as a worst case scenario- the corroded metal that has lost half of its original thickness and is constrained by OPC mortar within the marble, is examined under static loading and modal frequencies. In a previous study a similar computer simulation was employed to foresee the steel behaviour without the effect of the entrapment by mortar and marble. The data fed to the simulation were obtained by experimental curves of stress-strain tests from metals that have been removed and from bibliographic data on the pentelic marble properties.

In the work the analysis and the metallographic examination of the metals tested are also presented and compared to the analysis and metallography of the ancient metals.

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Integration of geomatic methodologies applied in a multidisciplinary approach to the study, conservation and valorization of Cultural Heritage: the case study of the Sarno Baths (archaeological site of Pompeii)

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This work aims at showing the fundamental role that the integration of geomatic methodologies and a specific multidisciplinary approach could have in the study, conservation and valorization of cultural heritage in Italy and in the world, by presenting some results of a research project regarding one of the most important city of the ancient world, that is Pompeii (MACH project, Multidisciplinary methodological Approaches to the knowledge, conservation and valorization of Cultural Heritage). This project involved three different research units of the University of Padua that deal with survey and structural analysis (ICEA Department), archaeological studies (Department of Cultural Heritage), study of materials (Department of Geosciences). The Archaeological Superintendence of Pompeii has supervised all the phases of the project and has provided part of the data. The project aims at studying the Sarno Baths complex, located in Regio VIII, 2, civic numbers from 17 to 23. The Sarno Baths are composed by a set of buildings, the main of which is made of five floors, leans against the southern rocky front of the city and has a façade which is about 20 meters high and 40 meters wide. After the verification of the data acquired from the Superintendence, it has proved necessary to execute a new 3D survey of the façade and a reference topographic network was created, measured and georeferenced. A set of related spatial data and ortho-images were produced, for the architectural and archaeological studies. Moreover, a static altimetry monitoring of a series of control points in the façade and a photogrammetric survey, with both classical and *structure from motion* approach, were performed. The obtained data contributed to a substantial improvement of the available information about the building and helped the archaeologists to study and to better understand its building features and constructive phases. In particular, the orthophoto of the main façade has been used to read the wall stratigraphy and to define its construction phases. Furthermore, the orthophoto has been vectorialized and then used as a precise basis to indicate the points where the stone and mortar samples were taken and also to create a lithological map of the façade. In addition, the data collected by laser scanning were used to extract plants and sections of the entire building characterized by a high metrical precision like never before. These data were subsequently checked and integrated directly *in situ* with those elements not registered by laser scanning. The MACH project has shown how the integrated approach of different disciplinary skills is essential for the knowledge of the archaeological heritage and the adopted research protocol constitutes an effective model that can be exported to other archaeological contexts.

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The animal mummies of the Museo Egizio: study and conservation

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The collection of animal mummies of the Museo Egizio in Turin consists of more than 200 items. They are complex artefacts, principally consisting of organic materials: textiles (mainly linen made from flax fibres), skeletal remains and sometimes soft tissues and extraneous material used for stuffing (reeds, wooden sticks, palm leaves, sand and mud). Of course, there are also residues of embalming substances [1-2].

Through an interdisciplinary approach, our project aims to enhance knowledge about this particular category of artefacts, as well as to apply conservation strategies to improve visitor enjoyment of this significant collection.

To begin with, X-ray and CT-scans were performed, allowing to know and study in non-invasive way the contents of the mummy bundles. Consequently, the scientific investigation was carried on including different techniques – such as optical and electron microscopy, chromatographic analyses and radiocarbon dating– in order to obtain information on various aspects: from the materials and procedures used for decorative features to mummification techniques and chronology.

As regards the conservation phase, it was divided into two areas: restoration and maintenance, depending both on the condition and the future display of each artefact. The idea of "minimum intervention" is now widely accepted as the best approach to archaeological textiles in order to preserve both the artefact and all the technical information related to its original function, production technologies and provenance. But different problems often have to be faced which require different solutions, which sometimes means having to stray away from a strict minimum-intervention strategy [3-4]. The first step of the conservation work was to identify and study the number of different textiles that were present in each artefact. A record card was filled in for each textile found on the mummies, providing all the relevant technical information. Then the work proceeded with cleaning and consolidation in order to stabilise the preservation of the mummies. The choice of cleaning and support methods was determined not only by the fragility of the artefact, but also by its dimensions, the presence of different materials (textile, vegetable fibres, organic remains, etc.) and the future "museum life" of each artefact. Special attention was paid to mechanical support in order to avoid invasive treatments as much as possible, and to allow future studying, public access and safe/correct handling during storage and/or display.

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Executive techniques "unveiled" by the conservation treatment: the case-study of the B54 japanese armour from the Armeria Reale in Turin

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The conservation treatment of the B54 Japanese armour, belonging to the collections of the Armeria Reale in Turin, is the outcome of the complex work of an inter-disciplinary team, which aimed at the setting up conservation methodologies tailored to the different types of materials present in the artefact: metal alloys, lacquer, leather, textiles. The conservation treatment has involved both conservators of different fields of expertise, and the staff of the Scientific Laboratories of the CCR "La Venaria Reale".
Special attention has been paid to the treatment of the valuable textile used to cover some parts of the armour (*kote*/vambrace, *suneate*/greaves, *erimawashi*/collar), which was unfortunately only partially visible in the overview of the assembled armour. The textile is a rare example of *kinran* dated at the XVIII century, characterized by blue satin and supplementary wefts made of golden paper which form decorative motifs of peonies, dragons and birds. The bad state of conservation of the textile, showing numerous losses of original material, has allowed to provide evidence of the executive technique and of the layering of the materials used to make the different parts of the armour. The deterioration meant as lacunae, therefore, has represented a "guideline" for conducting the conservation treatment: a system of textile supports made of specifically dyed silk *crepeline* has fulfilled the function of stabilizing the deterioration processes and of protecting the fragile surface of the textile. In the most complex parts, such as the *erimawashi*-collar, the transparency of the veils used in the conservation treatment has left visible the layering of the several original materials used for the padding, made of paper and cotton wadding.
Therefore, the conservation treatment aimed at the exhibition of the individual parts of the armour in specific show cases in order to allow a better appreciation and understanding of Japanese techniques which include the use of precious and well-finished materials even in the hidden parts of the armour.

Detail *erimawashi*/collar before restoration

Detail *erimawashi*/collar after restoration

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Best Practices for a Safe Analysis of Paintings and Painting Materials with Ionizing Radiation

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Intense radiation sources are commonly used for detailed analysis as well as treatment of delicate paint samples and paintings, which requires protocols to ensure optimal analytical safety conditions. This was the focus of 40 experts across multiple disciplines who attended a Technical Meeting of the International Atomic Energy Agency in the Netherlands to develop and identify best practices for examining and treating paint materials with ionizing radiations. At the meeting, entitled "Developing Strategies for Safe Analysis of Paintings and Paint Materials", radiation specialists, physicists, chemists, material and accelerator scientists, conservation scientists and curators, worked jointly to better understand the effects of ionizing radiation on paintings and paint materials and to identify the least altering conditions to perform analysis. Reports concerned the use of intense photon, electron, ion and neutron beams produced by particle accelerators and research reactors for analysis of paintings from the past, such as to scan whole paintings or image small fragments of paint samples and learn more about manufacturing techniques, history and conservation status.
The meeting participants developed a risk assessment strategy document entitled "Irradiation History Wizard", which documents several aspects of the analysis, such as its benefits and risks, and alternate routes to minimize material alteration while optimizing the analytical data produced. This document aims at creating awareness and helping both the scientists who are conducting the irradiations and the owners of the heritage materials or objects to better understand and predict the possible side effects of irradiations.
The results of this meeting, organized in collaboration with the Cultural Heritage Agency of the Netherlands, the Rijksmuseum Amsterdam and the IPANEMA laboratory in Paris–Saclay, was designed not only to spread awareness but also to provide Member States with practical recommendations, and suggest development of new tools for the safe analysis of materials in ancient paintings. The event was supported by the IPERION CH programme of the European Commission. The IAEA's role in developing the applications of nuclear techniques in the field of cultural heritage artefacts covers both analysis (exploration and forensics) and preservation. In order to ensure the safety of heritage materials when radiation-based methods are used for analytical purposes, the IAEA has initiated activities focusing on 'safe analyses', concerning several categories of art, archaeological and paleontological materials. Such activities enhance the collaboration and exploit synergies between the extended community working on the effects of irradiation and the heritage science community.

Study and restoration of lombard artefacts: the male grave goods in Tomb 50 of Momo Necropolis (Novara)

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The grave goods in tomb 50, originating from the Lombard necropolis of Momo (Novara province), was the centre of the study and restoration debated in this work. A knife and a sword, collected together with their respective earth, are the main elements of the grave goods; moreover, some other small iron artefacts are present, probably part of the leather belt from which the weapons were pending.
After a preliminary visual analysis, the artefacts displayed traces of terrain and corrosion of the iron, which, seeping through the fibres of the many organic elements, allowed them to maintain their morphology.
All of the artefacts were submitted to a radiographic and tomographic X-ray analysis in order to determine the shape of the items, their execution technique, their preservation state and the arrangement of the artefacts inside the soil blocks. Different instruments were used in order to evaluate their potential for the study of archaeological artefacts. Besides, by the observations in optical microscopy, it was possible to integrate the previous results: specifically, it was possible to distinguish two types of fabric (twill and canvas), identify the species of wood and even locate traces of leather and fur inside the sword's sheath.
The micro-excavation of the soil blocks was carried out with the help of tomographic analysis, which was essential to guarantee a better control of the removed materials. An in-depth graphic, photographic and video-graphic documentation allowed to maintain the exact positioning of all of the removed evidences.
In order to better preserve the fragile and deteriorated organic material, it has been necessary to carry out some consolidation treatments. The objects were mechanically cleaned with different methods (probes, scalpels, a diamond-cutter microdrill, an ultrasounds scaler and a microblaster with glass microbeads), conducting the work under the lens of an optical microscope in order to get a better control of the cleaning.
The radiographic and tomographic images were fundamental to address the restoration operations, since they were able to show an advanced state of deterioration of the iron, which corroded the artefact inside, creating cavities and making the structure more fragile. Moreover, as usual, the metallic surfaces displayed a remarkable accretion if compared with the original levels. During the cleaning operations, several traces of decorations with metal insertions were discovered, barely detectable through radiographic investigation; besides, it was possible to study the artefacts' production techniques and morphology. Finally, the evolution of the degradation of organic materials was inspected, especially regarding the different alterations of leather. All of the observations were documented and deepened through stereo microscope images, SEM and RTI analysis, in order to highlight the surfaces' morphologies.
The conservation treatment ended with the stabilization, the integration and the protection of the iron elements, in order to guarantee a better preservation and fruition of the artefacts.

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A new life for old laser data: the case of the Insula of Centenary in Pompeii

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Under 'Insula del Centenario' Project, an agreement stipulated in the framework of 'Pompeii Law' between the Archaeological Superintendence of Pompeii and the University of Bologna, the DICAM Department has contributed sharing the knowledge in structural and topographical field. In the years 2007-2008 an integral laser survey of the whole Insula was performed. In the survey we used two instruments: the laser Leica HDS-3000 and the laser Riegl LMS-Z420i, about 180 scans were performed with the Riegl laser and 40 scans with the Leica laser. For the treatment of point clouds, the Leica Cyclone software was used, where the various point clouds created by the two instruments were combined. The recent evolution of software for processing point clouds obtained with laser technology (such as ReCap by Autodesk) allows an ever greater autonomy from the proprietary software of the laser equipment producers and distributors, with the consequent reduction of costs and learning period. Moreover, it facilitates the exportation and direct processing of the point clouds in CAD environments, typically AutoCAD by Autodesk, with a greater simplification of the 2D output of all the technical composition for documentation, analysis and planning. An additional advantage is the possibility to return the surfaces 3D shapes, complete with textures, in a cloud environment, freeing oneself from the necessity of owning powerful processing hardware. Lastly, the possibility to obtain 3D prints of the survey point cloud has become easier, thus opening new horizons in the field of documentation and publishing. In this work, it then shows the process of reusing data from old scans reconverted into the Autodesk ReCap environment.

Figure 1 – View from est of the peristilium's aligned point clouds.

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Environmetal monitoring in the cultural heritage field

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The conservation state of culture heritage assets (museum artefacts, statues, historical buildings, etc.) can be severely affected by the environmental conditions. Many different monitoring systems have been developed for environmental monitoring measurements [1], [2]; however, most of them are usually devoted only to specific applications and present a lack of flexibility. The proposed monitoring system [3], developed at Politecnico di Torino, is able to measure temperature and relative humidity. It has been designed in order to maximize flexibility and to satisfy the most of constraints required in the cultural heritage field: minimal visual impact, long operative life, data quality assurance, easiness in the arrangement and in the maintenance of the monitoring system itself. The system is based on small battery-powered nodes able to continuously measure environmental temperature and relative humidity. The nodes can transmit the data to a dedicated receiver using a wireless radio link working with a proprietary protocol in the 2.4 GHz band. The wireless range goes from 10 m to more than 30 m, according to the environment and the presence of obstacles. It is also possible to implement a remote data access based on a dedicated cloud infrastructure when a power supply and an Internet connection are available in the monitored location.
New activities employing the proposed monitoring system have been recently started in Colombia in the frame of a Joint Project for the Internationalization of Research between Italy and Colombia. In particular, six sensors have been placed in the National Museum of Colombia (Bogotá, Colombia) and two sensors have been placed at the Puente de Boyacá (Colombia). Preliminary data recorded at the National Museum during the first week of in-situ monitoring are shown in Fig. 1. The data clearly highlight the circadian variations of temperature and relative humidity collected in the different locations. Such data can be of great importance for museum curators in order to improve the conservation state of the artifacts.

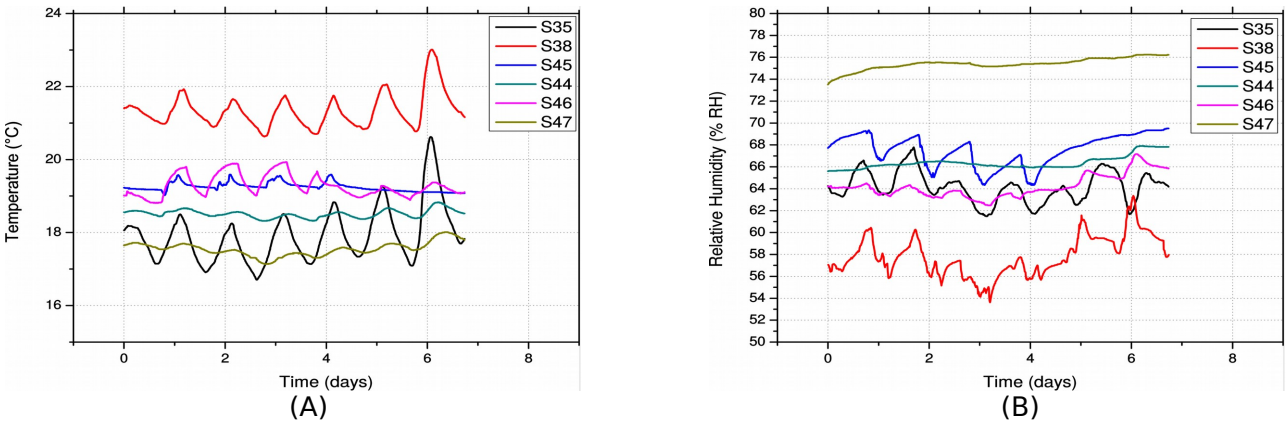

Fig 1: Temperature (A) and relative humidity (B) recorded by the six sensors placed at the National Museum of Colombia (Bogotà), during a week of in-situ monitoring.

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MATERIALI INNOVATIVI E NANOTECNOLOGIE

ORALI: MI&N-O
POSTER: MI&N-P

Surfaceenhanced Raman spectroscopy and nanoparticle enhanced laser induced breakdown spectroscopy for the study of historical textile dyes and mordants

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Dyes are among the most significant components in works of art and archaeological findings. In the examination of historical artefacts, the identification of natural dyestuffs is a challenging task, due to the complexity of their chemical composition and the possible presence of mixtures of chromophores. Moreover, most of the natural dyestuffs used for the preparation of organic pigments are of the mordant type and are co-precipitated with an inorganic substrate to form a lake, in which they form very stable and difficult to dissociate complexes. Generally, reverse-phase liquid chromatography is the method of choice for the analysis of dyes after a wet sample treatment, since most of their chromophores are polar and water-soluble compounds. Optical spectroscopic techniques cannot be compared with liquid chromatography, in that they do not separate the various components of a dyestuff, nevertheless their ability to rapidly analyze much smaller samples is remarkable in a museum context.

In this study, several natural organic dyes used in antiquity, especially in textile dyeing, were analysed by surface enhanced Raman scattering (SERS) spectroscopy and by nanoparticle enhanced laser induced breakdown spectroscopy (NELIBS). Together with the identification of the organic dye, the assessment of the inorganic components can indeed yield important information for dating a work-of-art or locating its geographical origin.

In the developed procedure, silicon wafers ($0.5\times0.5 cm^2$) were easily functionalized with silver nanoparticles by galvanic displacement. Silicon oxide layer was removed by etching with dilute HF present in the same solution of silver nitrate used to form the silver nanoparticles. The morphology of the deposited silver nanostructures was assessed by SEM measurements.

For the analysis, the model samples were micro-extracted with a mild aqueous treatment, and the liquid fraction deposited and pre-concentrated on the functionalized silicon substrates.

The effectiveness of the SERS and LIBS procedures will be demonstrated for the identification of dyes and mordants in real samples of Coptic textiles coming from Museo Egizio (Turin) and of different colours: blue (from textile n. inv. S.17491-bis), red (n. inv. S. 17491-tris, **fig. 1)**, light red (n. inv. S. 17311), yellow and brown (n. inv. S. 17310).

Fig. 1 Fragment of Coptic textile, Museo Egizio, Turin (n° inv. S.17491-tris).

Evaluation of the stability and reproducibility of Ag colloidal pastes as Surface Enhanced Raman Spectroscopy (SERS) substrates for the analysis of natural dyes in archaeological and historical textiles

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Surface-Enhanced Raman Spectroscopy (SERS) represents an ideal analytical technique to detect and identify dyes in artworks. Nanometric noble metal surfaces constitute the perfect SERS substrates, leading to enhanced Raman signals, quenching the interfering fluorescence generated by the dye and offering a highly specific molecular identification. Chemically reduced Ag colloids are among the most popular SERS substrates, e.g. the colloids produced according to Lee and Meisel [1] with sodium citrate as a reducing agent. After the synthesis step, the nanoparticles aggregation may be achieved by centrifugation, obtaining the so called "silver colloidal pastes" [2]. On-fiber SERS employing Ag colloidal pastes [2] can be very appropriate in the study of valuable objects, because it strongly reduces the amount of sample and does not require an extensive preparation. On the other hand, SERS is extremely distance dependent and is highly influenced by other factors, such as the morphology of the hot spots and the relative orientation of the molecule with respect to the SERS surface.

In the last few years, our research activities evidenced this variability of the spectroscopic behaviour both on different Ag paste batches synthesised at different times and on the same batch as a function of time. To evaluate the stability and reproducibility of the system, the synthesis of different Ag paste batches was carried out to examine: 1) the stability of different batches, by acquiring SER spectra on the same batch at different aging times, 2) the reproducibility of the SERS response within the same batch (*intra*-batch) and among different batches (*inter*-batch) at the same aging time, 3) the effect of a modification of the synthesis procedure and 4) for each batch, the comparison of the spectroscopic response obtained on samples prepared at the moment of the acquisition at different aging times (NEW) with those on the same sample prepared at the moment of the synthesis and acquired at different aging times (SAME). For each of the previous points the SERS responses of both Ag pastes and a wool sample dyed with cochineal and used as a reference material were evaluated.

The overall results suggest a substantial difficulty in obtaining completely predictable systems and this observation is partly consistent with the inherent characteristics of the SERS technique. On the other hand, the data give precious information on the optimal sample preparation procedure, indicating that the paste efficiency reaches a maximum after some time from the synthesis step and guaranteeing the possibility to analyse (and, eventually, re-analyse) the samples even after several weeks from the moment of their preparation.

Some of the Ag pastes were then used for the analysis of dyes in archaeological and historical textiles. The results highlighted that, in addition to the characteristics of the Ag paste, the intrinsic characteristics of the material under investigation may play a role on the possibility of registering an informative SER spectrum.

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Novel esterase - microemulsion for the bioremoval of glue residues

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Biotechnology provides countless innovative strategies for conservation of cultural assets, safely for restorers and environment, straight to green-conservation strategies in a sustainable restoration prospective.
Particularly for *biocleaning - bioremoval* procedures, we showed successful applications representing valid and encouraging alternatives to classical strategies.
In the recent years the activities performed at the University of Palermo in collaboration with other research laboratories allows the isolation, characterization and application of novel bioactive molecules, extracted from marine organisms or plant tissue.
Particularly from marine organisms, new cold-active enzymes (hydrolyses) have been isolated and applied to remove undesired-matter from artifacts surface. These enzymes are interesting for their specificity of action, stability and activity at low temperature, besides the possibility to work safely in a short timeframe (5-30 minutes), without heating the enzymatic solution or the surface on which they have been applied, representing a *green strategy* safe for artifact, operator and environment.
In this study the removing of adhesive-tape glue residues, revealed on specific areas of an acrylic paint on canvas, was performed by a microemulsion of *Velvesil Plus*® and a novel marine-organism esterase.
We demonstrate that the Esterase can be merged into the Velvesil Pus® gel (without any negative effect on enzyme activity) and applied for the removal of the undesired layers. The contact between enzyme and the undesired layer has been performed by gently moving the microemulsion, by a soft-brush, on cleaning area for 2-5 minutes.
These results allow us to hypothesize that such kind of microemulsions offer the advantages of water-based cleaning systems, limiting the risks associated with exposure to aqueous solutions and performing a finely controlled procedure.

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Electrochemical characterization of innovative hybrid coatings for metallic artefacts

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Protecting metallic artefacts from degradation is an important issue in the cultural heritage field and innovative coatings are always under investigation in order to provide improved barrier properties against the aggressive agents present in the environment. Hybrid organic coatings, thanks to their microstructure, in which a nanometric filler is dispersed in the polymeric matrix, provide interesting and promising barrier and mechanical properties [1], together with the possibility to design a multi-layered structure with an easily removable layer in contact to the artefact surface ensuring this way the reversibility of the protective treatment. Two different epoxy-based formulations containing TEOS (tetraethoxysilane) and Graphene Oxide as filler, respectively, have been studied. The hybrid coatings have been deposited on a set of iron coupons and characterized by means of Electrochemical Impedance Spectroscopy (EIS) and Scanning ElectroChemical Microscopy (SECM). EIS and SECM measurements have been performed in aerated 0.1 M NaCl solution as a function of the immersion time in order to assess their protective effectiveness and to investigate their degradation mechanism. Fig. 1 and Fig. 2 show the EIS spectra and the SECM graphs collected on the hybrid coating with 15wt% TEOS and the one with the Graphene Oxide.

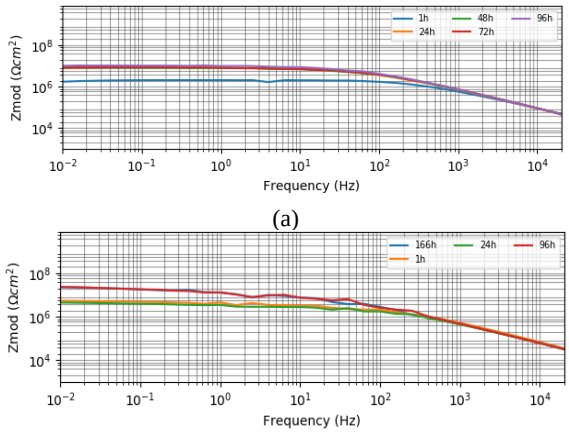

Fig. 1 EIS Spectra for (a) 15wt% TEOS and (b) Graphene Oxide hybrid coating.

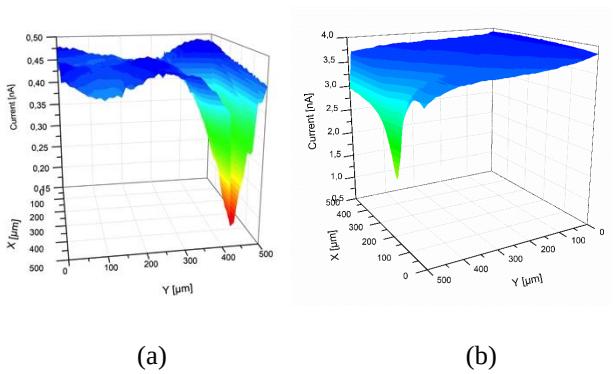

Fig. 2 SECM graphs (a) 15wt% TEOS and (b) Graphene Oxide hybrid coating.

The EIS results highlighted the good protective behaviour of both formulations. However, the SECM analysis has been able to highlight the susceptibility of TEOS containing coatings to the presence of defects. Moreover it has put in evidence that the lamellar structure of Graphene Oxide increases the diffusion path of aggressive species thus decreasing the diffusivity of the coating and improving its barrier property.

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Tattoo Wall®: study of the stability of an innovative decorative technique and possible application in the restoration of paintings in outdoor and hypogeum environments

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This paper presents the results obtained during an experimental study on the Tattoo Wall®: an innovative decorating technique that involves transferring digital images on wall surfaces through a transfer paper with solvent-based ink and fixative.
The digital image processing allows respecting Brandi's theory, as it is possible to obtain different kinds of re-integration such as *sottotono*, *tratteggio*, and *puntinato* or even a chromatic reconstruction suitable for archaeological restoration.
The main purpose of this work was to analyse the different methodological and practical aspects of this new technique, especially the possible changes due to ageing artificially induced by extreme humidity and/or solar irradiation.
Tattoo Wall® is applicable to any type of wall painting (fresco and *secco*) in indoor, outdoor or hypogeal environments. Moreover, this technique could be particularly useful also in archaeological contests interested by extreme climatic conditions.
For the experimental tests, we chose to work on a colour scale as wide as possible, to test each single colour, and on different materials. In particular, two kinds of mortars were chosen: a traditional one, made of lime and marble powder, and a hydraulic mortar, containing marble powder combined with Ledan C30, particularly suitable for restoration in environments with high relative humidity (RH%).
For each sample mortar, two different types of protective were applied: a bi-component product, P3-R1 supplied by Graphic Report, which can be used in indoor and outdoor environments, and a nanoprotective, Nanoprotec, mainly suitable for exterior use. The different samples were aged under UV irradiation and in a close box with 92% of RH. To obtain the UV ageing, samples were placed in a Solar Box chamber under the following conditions: temperature 55 °C, irradiation power 550 W/m², and UV filter at 280 nm. Six cycles of 168 hours were performed. Moisture ageing was obtained by placing the sample in a box with RH% fixed to 92% thanks to the presence of salts (sodium sulphate *deca*-hydrated) for compressively two years. After each cycle of ageing, colour measurements were performed through a reflectance spectrophotometer operating in the visible range, to determine the variations induced by artificial ageing. Before starting the aging tests, samples were investigated by Fourier transform infrared spectroscopy (FT-IR) in diffuse reflectance modality.
Testing enabled us to verify the high stability and durability of Tattoo Wall® under extreme solar irradiation and high relative humidity, with almost no chromatic alterations. Thanks to the effect of the mortar and matte protective, the final aesthetic result appears very close to a fresco, we suggest the possible application of Tattoo Wall® on wall paintings.
Testing could and should be conducted also on different surfaces and materials (paintings on canvas and wood, oil on wall, etc.) to make it as complete as possible and guarantee the use of Tattoo Wall® in most cases of pictorial reintegration, reducing the risk of human error.

Consolidation of mural paintings exposed in harsh conditions: the Luxor temple case study"

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In this contribution, the results of an extended experimentation on consolidation and protection of mural paintings affected by different kind of decay has been reported. Numerous fragments of plaster at risk of paint layer detachment have been treated with nanomaterial hybrid system. These treatments, based on nano-silica dispersions, are recognized as consolidating compatible systems obeying the principle of authenticity for mural painting. The tested consolidation procedures based on nanosilica and tetraethyl orthosilicate (TEOS) are the following:

- TEOS
- TEOS + Nanosilica 1%
- TEOS + Nanosilica 2%
- TEOS + Nanosilica 3%

The main goal of this study is to estimate the consolidant effects by investigating the modifications of the morphological characteristics and of the physico-chemical and mechanical properties of mural painting samples collected from boulders detached from roman frescos in Luxor temple. Preliminary results have been obtained by SEM-EDX and XRD.

Fig. 1. Luxor temple North side wall showing mural painting (area of collected samples).

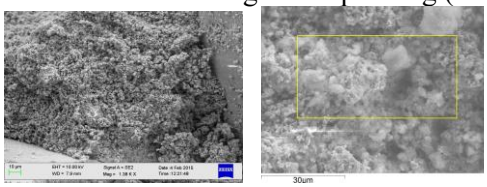

Fig. 2. SEM image of the untreated sample (left) and of the sample treated with nanosilica and TEOS dispersion (right).

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The MaTACoS project: new perspective in the conservation of underwater cultural heritage

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Restoration of underwater archaeological sites requires the adoption of sustainable and affordable solutions with the primary aim of preserving them in situ. Most of the work carried out in this field has been performed by removing artefacts from the marine environment and storing them in museums after restoration. This type of intervention is expensive and it is impossible to be adopted for extensive archaeological complexes. Different studies have been carried out to restore in situ the artefacts and many innovative methods have been proposed, although the removal of biological colonization, as well as its continuous reformation represents an unresolved issue. The biofouling, which affects the surfaces exposed to underwater environment, can quickly induce a rapid degradation of the surface. Recently, some studies have been carried out to setup methods against the biodegradation of submerged stone structures, although these achievements need more improvements to increase durability, applicability and efficacy. The MaTACoS Project "*Materiali e Tecnologie avanzate Applicate alla Conservazione Subacquea*" is focused on the development of new cleaning methods, new antifouling mortars and system for conservation and restoration of archaeological sites located in the underwater environment.
To achieve these objectives, the key points of the project will cover:

a) Making of innovative mortars for the protection of underwater artefacts having bio inhibiting features.
b) Development of alternative and innovative techniques for the cleaning procedures.
c) Development of a monitoring system to check the biological colonization and its development over time.
d) Development of real-time monitoring system to evaluate the conservation state of artefacts and the efficacy of the restoration products and procedures.

These outputs will allow to define the planned and targeted maintenance, leading to a strong impact from an economic point of view.

Acknowledgements

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PROVENIENZA E DATAZIONE

ORALI: P&D-O
POSTER: P&D-P

The Sn-W enrichment of iron ores from Elba Island: a powerful marker of ancient iron trade routes in the Mediterranean region

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The geographical location of Elba Island (southern Tuscany, Italy) and the easy access to the iron ores (mostly outcropping along the eastern coast) greatly favoured the extensive trade of iron mined from the island throughout the Mediterranean region and elsewhere from the Antiquity to modern times.
Recent studies on mineralogy, major- and trace-element composition of iron ores from Elba Island revealed that hematite ores display prominent enrichment in both W and Sn [Benvenuti et al., 2013]. These authors found that micrometric crystals (<1-5 μm) of W–Sn mineral phases (ferberite, scheelite and cassiterite) are disseminated throughout the hematite-rich matrix. A comparison with iron ores from other Italian and European mining districts (exploited in ancient times) suggests the uniqueness of such a geochemical pattern. Moreover, experimental smelting of this ore type confirms the presence (in the smelting slags) of these elements in phases of their own, either relic and/or newly formed, whereas the W-Sn enrichment is barely observable in smithing products [Benvenuti et al., 2016]. Therefore, the W-Sn signature represents a strong provenance marker for Elba (hematite-rich) ores, which—as we know from both documentary and archaeological evidence—were traded over great distances from the island, to be smelted in iron-working sites around the Tyrrhenian Sea. Application of these tracers can, for example, help to verify on a more reliable basis the provenance from Elba of ore fragments discovered in ancient sites (e.g., Pithecussa/Ischia), mainly suggested in the past without a proper geochemical and mineralogical characterization.
Following the method proposed by Benvenuti et al. (2013) for the analyses of hematite ores, samples of ores and slags from Elba Island and the nearby Etruscan ironworking centre of Populonia were dissolved with a mixture of $HF+HNO_3$ and analysed by ICP-OES at the Department of Earth Sciences, Univ. of Florence.
In addition, fragments of hematite and/or smelting/smithing slags from several archaeological sites of Tuscany, Latium and Campania, ranging in age from Archaic to Classical periods (San Piero a Grado, Pisa; Castellina del Marangone, Civitavecchia; Pithecussa/Ischia, Napoli; Velia, Salerno) to the Middle Ages (Vetricella, Grosseto; San Genesio, Pisa) were analysed. A study of reproducibility of W-Sn analyses carried out on internal reference standards showed good *intra*-laboratory results. Notwithstanding a lower *inter*-laboratory reproducibility, the order of magnitude of W-Sn contents is in good accordance, thus allowing us to clearly detect the "Elban signature" in ore fragments (and, in a few cases, smelting slags) from some of the investigated sites (Ischia, Velia, Vetricella, S, Piero a Grado, S. Genesio). More difficult is the interpretation of data obtained from the smithing slags.

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LA-ICP-MS labels early medieval Tuscan finds as late natron glass

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In this study, in the framework of a wider study on transition periods in glassmaking at the University of Antwerp, we focused on the late antique/early medieval age in Central Italy. This context is well suited to verify the implications of the end of the natron glass supplies, and to explore the beginnings of the new plant-ash glass technology.

In particular, this paper presents the results of a LA-ICP-MS analysis campaign conducted on archaeological glass finds excavated at the *Santa Maria della Scala* hospital site in Siena and in Donoratico. This provided us with major, minor and trace element quantitative data for 49 glass samples belonging to drinking vessels and lamps, dated between the 5th and the 11th century.

On the basis of these data, we have sought to identify the working processes and possible glassware trade that are reflected in the glass composition. Major and minor element contents revealed that most samples, even at the later boundary of the explored timeframe, fit well within known late Roman glass classifications (*e.g.* HIMT, Levantine I). Trace element analysis provided further information on the raw materials that were used in the glassmaking process, indicating the use of Eastern Mediterranean sands as a silica source and allowing us to formulate different hypotheses on the materials used for the colouring process.

Investigating the precision of archaeomagnetic dating during the last 3000 years

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Archaeomagnetic dating is a dating technique, based on the comparison of the Earth's geomagnetic field's direction and intensity, registered by baked clay archaeological artefacts, with reference Secular Variation (SV) curves that describe the changes of the Earth's magnetic field in the past. The technique is based on the ability of some materials to acquire a thermal remanent magnetization (TRM) when heated at high temperatures and cooled in the presence of the Earth's magnetic field. This data can be then used to obtain an estimate of age of their last heating. As in any other dating method the question that immediately arises is: how precise can be the obtained date?

Accuracy and precision in any dating technique are much desired properties and usually refer to the sampling procedure and measuring setup. Quality assurance and experimental assessment of these properties are eventually performed through laboratory tests, measurement of reference materials and interlaboratory trials. In archaeomagnetic studies it is possible to determine the direction and intensity of the Earth's magnetic field (EMF) in the past as registered by the archaeological material. The success of such experiments is usually expressed by the α_{95} angle of confidence for the direction and the standard deviation (sd) for the intensity studies. Low α_{95} and sd values imply successful experiments but they are not the only parameters that affect the success and the precision of the obtained dating.

Besides field work and experimental measurements, the precision attainable by archaeomagnetic dating depends on i) the uncertainties of the reference SV curve used; ii) the rate of change of the geomagnetic field evolution in a given time. The highest precision achievable disregarding sampling and experimental sources of error has been measured using the SCHA.DIF.3K geomagnetic field model as reference SV. Inherent uncertainties were calculated for every year during the last 3000 years and all over Europe. We measured the period of time with the same values as the corresponding component of the EMF (declination, inclination and intensity) within the confidence limits (Fig.1). This produced several dynamic maps that were used to give an estimation of the highest precision attainable by archaeomagnetic dating during the last three millennia. The results will be presented and particular attention will be given to describe the obtained data for Italy (Fig.2).

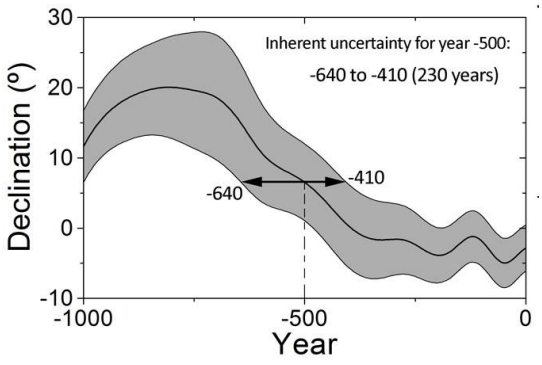

Fig. 1. Detail of inherent uncertainty of declination calcultated for year 500 BC in a given location.

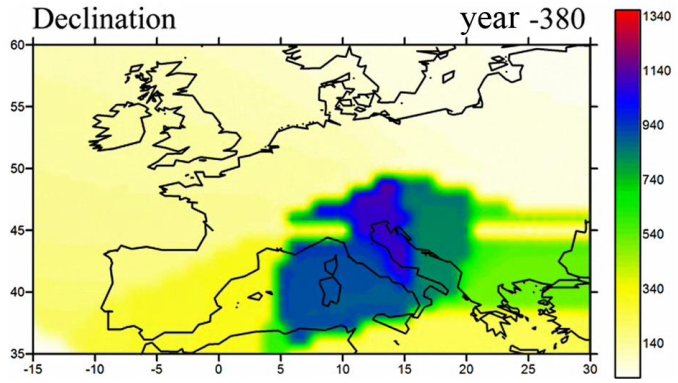

Fig. 2. Distribution of dating uncertainty (expressed in years) using declination data for year 380 BC, this is a year where the model offers a very poor dating precision in Italy.

Precise lead isotope ratios measurements for geographic attribution of some ancient coins

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The study of the isotopic ratios of lead may be used to provide information about the mine, and therefore the geographical provenance, of the metal used to prepare coins or make manufactured products of various types. As three of the four lead isotopes (^{206}Pb, ^{207}Pb and ^{208}Pb, but not ^{204}Pb) are produced in the natural decay chains of uranium (^{235}U and ^{238}U) and thorium (^{232}Th), and are associated in turn in different quantities with the mineral from which the lead is extracted, naturally variable isotopic compositions are produced which make it allow to compare the isotopic compositions of the minerals with those of the manufactured products. More sensitive indicators that are generally used in the archaeometric context, ^{206}Pb/^{207}Pb and ^{208}Pb/^{206}Pb, can be obtained from the measurement of the three isotopic ratios ^{206}Pb/^{204}Pb, ^{207}Pb/^{204}Pb and ^{208}Pb/^{204}Pb. In this work, using Thermal Ionization Mass Spectrometry (TIMS) for precise lead isotope ratio measurements it was possible to get information useful to distinguished geographic origin of ancient coins but also understand in a better way the differences between original issue and imitations. In particular, the measurements on Spanish area coins and Campania imitation coins, from Hellenistic and Late-Republican period, will be discussed.

Fig. 1. 1-4: AE coins from Ebusus (Groups VIII, XII, XVIII & XIX); 5: AE Campanian imitation (with 'rudimentary' Bes).

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Thermoluminescence dating of glass: applying the "pre-bleached with blue LEDs" protocol to Umayyad mosaic tesserae

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This paper deals with a Thermoluminescence (TL) study of ancient mosaic tesserae from the *qasr* (winter residence) of Khirbat al-Mafjar, amazing palace of the Islamic caliphs located in the plain of Jericho. So far, works dealing with the dating of mosaic tesserae usually rely on the dosimetric properties of the microcrystalline inclusions in the silica matrix rather than on the matrix itself. On the other hand, in the last decades, commercial glasses have been demonstrated to be suitable for retrospective accidental dosimetry. In this work, we apply a protocol widely used for the mobile phones' glasses, the so-called "pre-bleached with blue LEDs" protocol, to evaluate the archeological absorbed dose by some Khirbat al-Mafjar tesserae in order to confirm their dating based on archaeological evidence. Like in the case of commercial glasses, the TL signal from ancient tesserae presents anomalous fading and it is light sensitive. The experimental protocol circumvents these problems isolating the thermally more stable TL signal with an optical pretreatment and allowing for the determination of a fading curve for each analyzed sample. Using an integrative approach, we estimated the fading correction for these tesserae and we recovered their ages. The results are partially in agreement with those hypothesized on historical ground and show good potentialities for the dating of amorphous glassy materials in the case of Umayyad mosaic glass findings.

Radiocarbon wiggle matching as a high-resolution dating method: the example of Villa Rucellai in Florence

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In the case of radiocarbon dating of wood, a single ^{14}C date could not be so accurate, i.e. could be even much older than expected, especially if the dated sample is collected from an inner tree ring. Adding some independent information to the measured radiocarbon data, thus using a Bayesian approach to analyse those data, can improve the "quality" of the results, their precision at least. When dealing with wood, if it is not possible to have any information about the part of the tree trunk (heartwood or sapwood), an useful strategy is collecting more than one sample at known tree rings, corresponding to known year gaps. In this way, wiggle-matching dating can be applied to increase the precision.
In this work, this procedure was applied to two sequences collected from one truss and one beam (*capriata*1 and *trave*1) in "friars' library" of Villa Rucellai in Florence. The radiocarbon dating of the wooden structures was part of a wider research project aimed at, first, understanding the construction process and, eventually, the restoration of the historical complex, now belonging to University of Florence. Indeed, the origin of the Villa was a medieval structure which, during the centuries, has been subjected to many transfers of ownership and has undergone more than one renovations.
A tree rings sequence was identified in each one of the two architectural elements; each sequence consisted in three samples collected at known gaps: the radiocarbon concentration was measured in the wooden fragments and the data were processed using OxCal 4.3 software, applying the wiggle matching model. In both cases, this approach allowed us to refine the precision of the measurement. Data pointed to two very different historical periods. In particular, in one of the two wooden structural elements (*capriata*1), the results of measurements support the hypothesis of a re-use of truss, already present in the medieval building, while the beam seems to have been in place in more recent time.

Punic black gloss ware: a history of importation and imitation from Carthage

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This contribute presents the results of the archaeometric analysis of Punic black gloss ware found at the "Roman Temple" site of Nora (south-western Sardinia, Italy) in the frame of the Mediterranean Sea exchanges of materials, ideas and production skills.
On the basis of the chemical composition (X-ray fluorescence), the black gloss ware from Nora can be traced back in part to the Northern African area and in part to Tharros (western Sardinia), a site located one hundred fifty kilometres north-western of Nora, on the western Sardinia coast. None local production was identified.
The petrographic and microstructural analysis at the scanning electron microscope (SEM) clearly indicated that different bases clays were used for the two groups of samples, indicating a different geological origin. Moreover, on the basis of both the mineralogical composition and the microstructural features, samples produced in Northern African area and in western Sardinia, definitely differ in terms of firing temperature.
Therefore, on the basis of these results, new data better define the commercial traffic active in the Western Mediterranean and in the town of Nora between the end of the IV century and the first half of the II century BC.
In time, Sardinia, thanks to its Phoenician, Punic and Italic influences, became an incubator of ideas, techniques and production knowledge that, from the interaction of the preceding cultures and their influences, gave life to many local productions, which were part of the greater phenomenon of Punic black gloss ware in the Western Mediterranean (Sardinia, Sicily, Northern Africa and the southern coasts of the Iberian Peninsula).

Notes on Vestorius' blue – New findings and investigations

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The finding in Pozzuoli of a crucible containing Egyptian blue still in glass form has intensified research into this very ancient pigment. Egyptian blue is an artificial pigment and, according to Vitruvius, it was manufactured by the Egyptians until a certain Vestorius, who came precisely from Pozzuoli, started manufacturing and selling it. The objective of this research was to analyse the object from a chemical and physical point of view and thus also from that of the production methods, not least in the light of the instructions left from ancient times by Vitruvius and Pliny. Comparisons were conducted with other finds (from Ercolano, Bolsena and Pompei), with data in works written on the subject and with reference samples put together for this purpose in order to attempt to correlate any potential sources and commercial flows. Naturally, in thinking about their sources or at least the possibility of linking several of the samples analysed to the same factory, the parameters on which attention was concentrated were those regarding the manufacturing process, such as temperature and temperature-residence time, and the presence of minor ingredients. The employed technologies were: PIXE (particles induced X-ray emission), XRF (X ray fluorescence), FORS (fibre optics reflectance spectroscopy 380 – 1700 nm.) and Electron Microscopy (EVO ®MA 25 Zeiss, probe EDS X-MAX 80 Oxford in point version).
Only samples of material not used as paint but only in powder form or still in glass form were considered. The result was a great variety of substances utilised probably in line with what the manufacturer had available at that moment and, even if it followed the guidelines on production deriving from glass-making techniques, the production is on a local basis and with minor, non-indicative chemical elements. This led us to the conclusion that it is very difficult to determine with certainty the origins of the Egyptian blue samples other than the findings.

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Rehydroxylation: researches and results from Milano-Bicocca laboratory

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Rehydroxylation (RHX) dating has been proposed as a new chronometric tool for use on fired-clay archaeological ceramics. The term RHX is used to describe the chemical recombination of fired-clay ceramics with environmental moisture. The related expansion and the associated mass gain varies with the fourth root of the time. If the RHX mass gain is measured and the mass gain rate is determined, then the estimated RHX age is the ratio between the mass gain and the mass gain rate to the fourth power.

For each material, the mass gain rate varies with the temperature, the mineralogy, the maximum firing temperature and the duration of firing. The main parameters of this technique have been studied in earlier works, highlighting the strong points and its weaknesses mainly due to the sensitivity to environmental and experimental conditions,, especially the temperatures at which the analysis is performed and the evaluation of the mean lifetime temperature. The adsorbed water mass is evaluated as difference between the gross mass of the sample and the mass after a heating step (500°C for 4 hours). A drying step (105-110°C for several hours) is usually added before the first mass measure to remove the physisorbed and weakly-bound water fractions.

This work will show experimental evidences that an amount of weakly bound water remains in the ceramic structure even after the 105-110°C drying step. On the other hand, a temperature of 400°C starts to remove the RHX water. The behavior of the measured mass versus drying temperature and a dating attempt with the new procedure are shown.

The chronology of the Valcorrente site in Belpasso (CT) obtained by ThermoLuminescence

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The prehistoric village of Valcorrente di Catania rises among the modern towns of Belpasso and Paternò. It was the subject of archeological researches and excavations between 2012 and 2015, following a brief survey in 2005. Huts and craft structures related to three major chronological phases, each divided into at least two sub-phases, were brought to light: (1) Late - Final Neolithic (FN) (phase of Diana - Spatarella), (2) Final Copper Age (FCA) (phase of St. Ippolito or Pellegriti - Marca); (3) Early Bronze Age (EBA): Early Castelluccio and the Late-Final Castelluccio - Rodì Tindari Vallelunga (RTV) facies. In order to confirm this chronology, a series of pottery were dated by thermoluminescence (TL) methodology.
The ceramic samples selected for the research come from a sequence of Stratigraphic Unit (SU) of a trial Trench 2 evaluation.
These are 46 samples mostly belonging, on the basis of typological criteria, to the EBA with some exceptions represented by a fragment of the archaeological facies of Diana (FN) and some samples related to the Final Copper Age. Most of the samples related to domestic or coarse ware cannot be dated only on typological and stylistic basis. In this case, the ThermoLuminescence dating method provides interesting insights into the chronology of classes of pottery that generally not datable.
TL measurements were performed with the fraction of sieved and treated fine grains using the additive dose technique. The procedure, useful to obtain the paleodose values, includes a sensitivity recovery test to determine appropriate annealing conditions depending on the characteristics of each sample. Annual dose rate was determined from internal radioelement concentrations of samples measured by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and the environmental and cosmic contribution obtained by in situ measurements.
The obtained results are in agreement with the chronological hypothesis and with C14 dating of the same periods also for Sicilian and Peninsular sites.
The possibility to verify the chronologies known from the archaeological literature by absolute TL dating of Valcorrente enriches the newest chronological data of the prehistory of this part of the island especially for the terracotta samples that cannot be dated by typological and stylistic criteria

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Archaeomagnetic dating in Italy: An example of a baked clay kiln excavated at Santhià, Northern Italy

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We present the results of a detailed archaeomagnetic investigation of a baked clay kiln excavated at Santhià (via Castelnuovo, Cascina Madonna), Northern Italy (Fig. 1). During the archaeological excavation, carried out by the Soprintendenza Archeologica del Piemonte, a total of 25 brick samples were collected for archaeomagnetic analysis. All of them come from the combustion chamber of the kiln and were oriented *in situ* with a magnetic compass and an inclinometer. Magnetic mineralogy experiments were carried out to determine the main magnetic carrier of the samples and to check their thermal stability. Such measurements suggest the presence of a low coercivity mineral, most probably magnetite. Standard thermal demagnetization procedures were applied to isolate the direction of the Characteristic Remanent Magnetization (ChRM) acquired by the baked clay during the kiln's last firing. The obtained results show a single-component, very stable and well defined remanent magnetization. The mean ChRM direction, calculated based on a Fisherian distribution, is: D= 10.9˚, I= 63.8˚, alpha-95= 2.1˚, k= 267. The mean declination and inclination values obtained were used for the archaeomagnetic dating of the kiln, after comparison with the reference secular variation curves calculated from the SCHA.DIF.3K European geomagnetic field model (Pavón-Carrasco et al., 2009). The reference curves have been directly calculated at the geographic coordinates of Santhià and have been used for the calculation of probability density functions separately for declination and inclination. The final dating of the kiln is obtained after the combination of the separate density functions, suggesting that the kiln was abandoned around 1543 ± 52 AD, at 95 % of probability. This age is in very good agreement with the archaeological evidence available for the site as well as with the independent dating information based on thermoluminescence analysis performed on the same kiln (TecnART). These results show the high potential of archaeomagnetic dating of baked clay archaeological structures in Italy, mainly for the last three millennia for which a detailed reference secular variation curve is available.

Fig. 1 Photo of the studied kiln excavated at Santhià

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Provenance of obsidian artifacts from Latium territory by LA-ICP-MS

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Obsidian was used as raw material for stone tools, both in the prehistoric period and in recent times, due to its numerous qualities – physical and aesthetic alike. Researchers can develop and test models concerning prehistoric interactions, access to resources, and trade, by studying obsidian findings and by identifying the sources of obsidian employed for artefacts.
The present research reports the result of a geochemical study on archaeological obsidian findings collected on various sites in Latium (Italy) on an area ranging from the South-East of Rome to the boundary with the confining Abruzzian territory.
Aiming at reconstructing the supply mode and the obsidian transport from extraction to settlements in Latium, during the Neolithic period, the samples were analysed with SEM-EDXS and LA-ICP-MS (Inductively Coupled Plasma Mass Spectrometry associated with Laser Ablation) methods to determine major and trace elements composition. To assign obsidian provenance, the results obtained on those archaeological findings were compared with analytical data of geological obsidian sources, described in literature and obtained by the same analytical techniques.
This experimental research indicates that sources of obsidian in the peri-Tyrrhenian area are found only in a limited number of places: specifically in the islands of Lipari, Pantelleria, Palmarola and Sardinia.
In particular, the variations among trace element concentrations of the four geological sources of the peri-Thyrrenian area allow to distinguish seven compositional groups: three of these can be attributed respectively to the Lipari, Palmarola and Pantelleria islands, the other four groups belong to the Monte Arci complex in Sardinia (subgroups called SA, SB1, SB2 and SC).
Trace elements and most of the REE can be applied to distinguish the sources, using binary plots of simple two-element or element ratio *vs.* element. In particular, the analysed artefacts, collected from the settlement of Casale di Vallerano, plot in distinct areas and must be considered extracted from two of the four Mediterranean sources: Lipari and Palmarola, while Pantelleria and Sardinia, can be clearly excluded as extraction quarries.
These results also confirm the usefulness of LA-ICP-MS analyses for provenance assignment as already enhanced by other researches and they highlight, once again, that the islands of Palmarola and Lipari were the principal supply sources for obsidian in Southern Latium during the final-Neolithic and Aeneolithic period

Provenance of late Republican Roman pottery from north-eastern Italy and western Slovenia revealed by geochemistry of volcanic minerals

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Remains of a large Late Republican Roman military fortification has been recently identified on the San Rocco hill, close to Trieste (north-eastern Italy; Bernardini et al. 2015). Several amphora shards, including a rim belonging to late Greco-italic type, handles and wall fragments showing a pink-orange paste rich in black sand particles, have been discovered. According to macroscopic observations, the black and shiny particles correspond to mineral grains. Several minerals have been extracted from the surface of 12 shards from San Rocco and analysed by means of electron microprobe. For comparison other crystals have been extracted and analysed following the same procedure from pottery remains found at other late Republican sites, nowadays in Slovenia. In detail, samples have been taken from two Greco-italic and a Dressel 1A amphora rims form Sermin (Horvat 1997), a coastal archaeological site north of Koper with a chronology similar to San Rocco, and from two baking dishes found at Mandrga site close to Razdrto pass (Horvat, Bavdek 2009), occupied between the end of the 2nd century BC and the beginning of the 1st century BC. Microprobe analysis has allowed the identification of olivine, clinopyroxene, feldspar and garnets. According to their geochemical signature, mainly considering clinopyroxene and garnets, the samples from San Rocco and Sermin show similar features indicating a likely common provenance from Campania. The samples from Mandrga, on the contrary, show a different composition suggesting, in accordance with their slightly younger chronology, a different origin.

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Improvements of the analytical protocol of lapis lazuli provenance: first study of Myanmar samples

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The study of lapis lazuli, a semi-precious blue stone, is important to find out information about the provenance of a material used since Neolithic Era (VII millennium BC) for the manufacturing of precious carved artefacts. Moreover, this kind of study helps historians and archaeologists to reconstruct trade routes especially for the ancient times when written testimonies are scanty or absent at all.
The main sources of lapis lazuli in ancient times are widely considered the Badakhshan deposits in Afghanistan. However, other quarries could have possibly been exploited since antiquity.
To solve this issue, we started in 2008 a long-term research, involving an interdisciplinary team, and only recently we presented a protocol to determine the provenance of lapis lazuli rocks used for carved artefacts by means of non-invasive techniques (Lo Giudice et al., 2017).
The aim of the present study is to increase the number of information in our protocol and to find out other significant either petrographic or minerochemical markers. In particular, this study was carried out by a multi-analytical approach on 12 rocks bought in Myanmar, which are most likely coming from the quarry district near Mogok in the Mandalay Region.

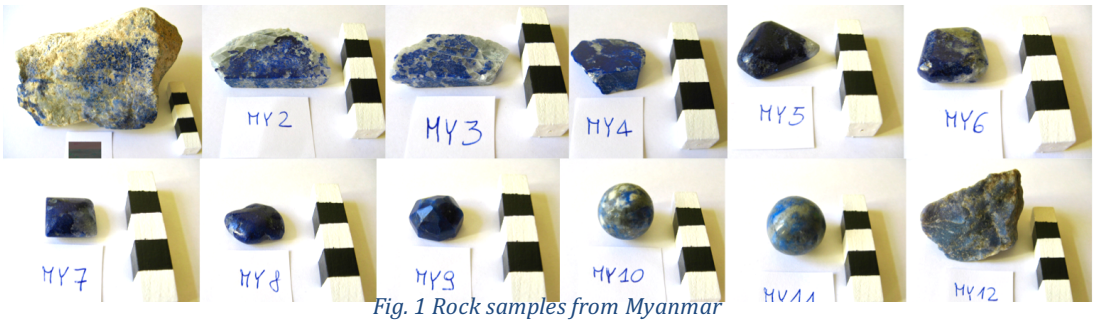

Fig. 1 Rock samples from Myanmar

At first, we used optical microscope and Scanning Electron Microscopy to perform a detailed petrographic and minerochemical characterisation and to determine the texture and the mineralogical assemblage of the rock samples: the lazurite-diopside association and the presence of amphiboles were recognised in addition to Pyrite, Apatite, Calcite and Pitchblende. Moreover, lazurite phases found in these samples seem to be richer in Na content and poorer in Ca content than lapis lazuli rock from Afghanistan, Siberia and Tajikistan.
These data were integrated with measurements performed by means of a micro-XRF system (Eagle III-XPL) to perform quantitative analysis on trace elements in two mineral phases: diopside and pyrite. The variable contents of the trace elements occurring in diopside (Ti, V, Mn, Cr) and pyrite (Ni and Cu), are significant and peculiar for these type of the lapis lazuli rocks.
The proposed approach, being a non-invasive technique and therefore suitable for Cultural Heritage studies, will be finally applied to small Egyptian artefacts for provenance identification of the semi-precious blue rocks.

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Thermoluminescence for dating Myanmar monuments: a new local laboratory and first measurements

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Among the wide range of analytical techniques useful for investigating cultural heritage, thermoluminescence (TL) is one of the most reliable for dating since 1970s [Aitken,1985; Fleming, 1970]. The TL method allows the measurement of the time elapsed since a clay object was last heated to a few hundred degrees Celsius, meaning that the manufacturing moment for porcelain, pottery, bricks, bronze cores, fired clay, etc. can be determined. Heating at high temperatures causes in fact the emptying of the electronic trapping levels of some minerals contained in clay, such as quartz or feldspars; these "traps" are filled in time with charged particles induced by naturally occurring radioactivity, hence the recorded luminous signal is proportional to the radiation dose absorbed by the artefact since its last "zeroing" by heat.
Nowadays many TL laboratories operate all around the globe, although some countries rich in ceramic cultural heritage are not even familiar with the technique. Myanmar is famous for its magnificent pagoda buildings, entirely manufactured with clay bricks and so perfect for a huge dating campaign by means of thermoluminescence. Since 2014, TecnArt, with the support of the Physics Dept. of the University of Turin, INFN (National Institute of Nuclear Physics), Ipses S.r.l. and Lerici Foundation, started an international collaboration with the Myanmar Ministry of Culture for the realisation of a fully operational TL laboratory in Pyay, along with the training of qualified local researchers. In the last three years the laboratory has been set up and sampling was performed at Sri Ksetra, one of the UNESCO Pyu Ancient Cities, and Bagan, the world-famous archaeological site. First dating measurements, along with a material characterisation, were carried out on samples from the early Bagan period (11th century) Paung Gu Pagoda [Hudson, 2008], in particular on fragments collected from the base and the middle of the structure. Preliminary results on the effective dose will be presented, also validated by a comparison with TL analysis performed on the same samples in the TL laboratory at the Physics Dept. of the University of Turin.

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Building archaeology in *Principatus et Terra Beneventana* (Campania, Italy): the case study of the *domus* built by Frederick II

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During his reign, Frederick II built a series of representative fortified constructions in Southern Italy and after reinforcing the defence line of the border with the State of the Church, he decided to build many residential estates called in the medieval textual sources *domus* or *palacium*.
One of these buildings is placed in the present area of Benevento (Contrada Cubante-Calvi) on a strategic point along the path of the old Roman Via Appia, near Ponte Rotto (also called Ponte Appiano). It is mentioned in the Angevin Register "*Statutum de reparatione castrorum*" as "*domus domini imperatoris Apicii*".
The structure of the domus is partially changed from the past: the eastern tower shows evident architectural changes that belong to the 1970, whereas the opposite part of the building appears as a ruin but the southern wing was reassessed and it became an agriturism.
Thanks to the methodology of Building Archaeology together with the material analysis, documentary and iconographic sources it is possible to know the history of the structure and every changes during the centuries. It has been in constant use for 700 years from 1240 to present.
The methodological approach of Building Archaeology involved stratigraphic analysis applied to the study of the standing architectural remains. This discipline has achieved excellent results in the critical analysis of architectural contexts, and it has also achieved a prominent position in the protection and restoration of built architectural heritage. In this regard, new digital recording systems play a crucial role in collecting data. The present project included testing of a photogrammetric survey technology (application of UAV system based on the use of a drone helicopter Dji Phantom 3 Professional) which allowed us to generate textured three-dimensional RGB point-cloud models with high photographic resolution. These digital products are very useful for recording observations and suggesting hypothetical reconstructions, and they can also be used in future for conservation and restoration projects.
The *domus* was investigated with two objectives: clarifying the relationships between individual building elements and identifying the construction activities that have affected it over the time. In spite of demolitions and renovations, analysis of material structures allowed the identification of seven phases, grouped in five main periods (I-construction phase by Fredrick II, II-Angevin phase, III-Aragonese phase, IV-1700's restoration, V- contemporary phase).
This type of investigation has provided at the moment a relative chronological sequence along with a characterization of the main building techniques, useful tools for an initial typological and chronological comparison.
In order to confirm or deny the archaeological hypotheses about the reconstruction of building phases, a preliminary mineralogical and petrographic characterization of mortar-based materials (collected from the Late Medieval period to 18 century) was carried out by means of Fourier Transform Infrared spectroscopy (FTIR) and Optical Microscopy (OM). Although the composition of binder (lime) and aggregate (locally supplied lightweight volcanic sand) is almost the same for all samples, clear differences in mix-design (e.g., binder-to-aggregate ratios) were observed, encouraging future new sampling and further analyses.
These results, although partials, fit within the history of the studies and serve to increase our knowledge of the technological and architectural environment of the Late Medieval South Italy, and in particular of *Principatus et Terra Beneventana* region.

Instrumentation and technique developments at the thermoluminescence dating laboratory of the University of Turin

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In the last decade, a thermoluminescence (TL) laboratory for dating and authentication of ceramic archaeological artefacts has been developed at the Physics Department of the University of Turin, in collaboration with INFN (National Institute of Nuclear Physics) and currently operating within the INFN-CHNet network.
The TL technique allows to obtain the age of a clay object by measuring the radiation dose absorbed since its last firing in some of its compositional minerals (e.g. quartz and feldspars), that is due to natural occurring radioactivity and proportional to the luminous signal emitted by the material when heated at a few hundred degrees Celsius in laboratory [Aitken, 1985]. This means that not only the absorbed dose (paleodose) is to be known, but also the dose rate at which the artefact has been subjected in time (annual dose), that depends from the conservation conditions and varies with the geographical area; the age can be consequently calculated by the simple ratio between the two quantities. A lot of measurements are therefore required for a complete dating: first of all, the evaluation of the paleodose by TL signal acquisitions, obtained via increasing artificial irradiation of samples using beta and alpha sources. In the last few months, our laboratory installed a new beta irradiation system, designed also for the recently established TL laboratory in Pyay (Myanmar) within an international cooperation, equipped with a $^{90}Sr/^{90}Y$ source with nominal activity of 1,48 GBq that allows faster and completely automated irradiation of four samples in series. This has been a great improvement for the augmented statistics of measurements and their repeatability. The data needed for the calculation of the annual dose are then collected by the measure of the alpha activity (caused by decay chain events of Uranium and Thorium atoms contained in the clay matrix), the quantification of the environmental dose rate using LiF dosimeters collocated *in situ* and/or by gamma spectroscopy on a burial ground sample and finally the ICP-OES measure of ^{40}K isotope concentration in the material (in collaboration with the Chemical Dept. of the University of Turin). In addition, further corrections for water absorption, supralinearity and anomalous fading are performed.
Thermoluminescence is an invasive technique, that needs the sampling of a minimal amount of ceramic powder (up to 1-2 grams) for the preparation of samples by the fine grain technique [Aitken, 1985]. Clay material from archaeological objects is often contaminated by organic matter and carbonates (the latter enhanced by long time-spans spent in highly-humid burial grounds). This requires a chemical pre-treatment of the powder before the fine grain; in our laboratory the procedure described in [Vieillevigne et al., 2007] was initially adopted, then, learning by experience, we became able to balance the use of each chemical step (reagent and time of use) depending mainly on the available quantity of material and the knowledge of the clay composition and provenance. The new standard procedure, employing mainly HCl and CH_3COOH, will be presented, along with some applications in recent case studies of dating and authentication.

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Archaeological site of Vetricella: chronology and anthropic and natural landscapes

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In this paper we show results concerning the chronological and landscape reconstruction of Vetricella (Scarlino, GR) archaeological site. This is one of the most important goal of the ERC (European Research Council) research project " nEU-Med: Origins of a new Economic Union (7th to 12th centuries): resources, landscapes and political strategies in a Mediterranean region", This site is situated in the centre of the coastal plain crossed by the river Pecora, near Scarlino Castle. It was discovered in 2005, by aerial archaeology reconnaissance, when their exceptional three concentric circles were recognized (Fig.1), followed by excavation investigations conducted from 2007 to 2012, and resumed in 2016 just due to "nEU-Med" project.

The research work is based on a multidisciplinary strategy: the high variety of material remains discovered, as numismatic, ceramics and vitreous finds, and the analyses of numerous archeometallurgical, archeozoological and archaeobotanical remains, permitted to reconstruct the economic and productive activities, datable from at least the 7th to the 11th century.

On the other hand, the stratigraphic sequences permitted to recognize the signs of 4 distinct periods of presence, which can be divided into a chronological period between the 7th - 8th century and the first half of the 11th century, due the type of the recovered finds.

Finally radiocarbon dating of some organic remains (bones and charcoals) confirms the chronological periods resulted from the previous hypothesis .

Among the most significant data highlighted by this multi-analytical study, there is certainly the reduced time frame within wich the "birth" and the greater development of the site are allocated, corresponding to the end of the 9th and the end of the 10th century.

Fig. 1. Three concentric circles reconnaissance of Vetricella site.

Thermoluminescence study of the clay-cores of the Colossus of Barletta: dating its fusion phases

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The Colossus of Barletta is a large bronze statue, more than 5 meters high, currently located at the left side of the *Basilica del Santo Sepolcro*. The statue symbol of the town is said to represent a Roman emperor, and is reported to be found on a shore, after a Venetian ship sank returning from the Fourth Crusade in 1204 (but possibly even much earlier). The identity of the Emperor is also debated. The first certain news about the statue date back to 1309, when parts of it were used to cast bells. The missing parts were probably remade shortly after. Thanks to recent restorations, the interior of the statue was accessible, giving the opportunity of sampling the different inner clay-cores remaining after the lost-wax casting activities. This work reports the results of the dating campaign, which gave interesting indications on the fusion phases. A statistical approach will be reported, taking into account the lack of information on the history of the statue before the shipwreck and its recovery.

"Richborough 527" amphorae from C.da Portinenti (Lipari - ME) archeological site: archaeometric constraints from a multi-technique study

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In the archaeological site of C.da Portinenti, at Lipari, a pottery workshop for amphorae and a deposit containing both good quality and waste products has been found (Borgard et al., 2003). The context was dated from the 1st century BC to the IIIrd century AD. Some of the discovered Roman amphorae belong to the "Richborough 527" type are conserved at the Lipari Museum. These amphorae were used to transport local volcanic products throughout the Roman Empire, such as alum (Borgard et al. 2003) or pumices, both variously used in the leather tanning industry. In order to resolve the issue raised by archaeologists about the possible employment of local raw materials in the production of the "Richborough 527" amphorae, a multidisciplinary study has been carried out. Five specimens selected among the waste products of the pottery workshop were investigated through mineralogical, petrographic, micro-paleontological and geochemical approaches, using X-Ray Powder Diffractometry (XRPD), Scanning Electron Microscopy (SEM-EDX) and X-Ray Fluorescence (XRF) techniques. Micro-paleontological analysis highlighted the presence of prevalent planktonic foraminifers, ascribable to marine clays deposited in the lower Pleistocene. The petrographic investigations evidenced the presence of volcanic inclusions and microfossils in all the studied samples. SEM-EDX and XRPD analyses allowed clarifing the nature of the volcanic inclusions by correlating the mineral compositions of the main phases of the volcanic inclusions - as feldspars and pyroxenes - with those of the magmatic products outcropping in the area. Wollastonite and diopside micro-crystals have been identified in the ceramic groundmass as newly formed mineral phases. Major and trace elements XRF data put in evidence the presence of high amount of CaO and of incompatible trace elements such as HFSE, LILE and REE in the ceramic samples.
Comparison of these data with those relative to the clay outcrop of Fossa del Fuardo (Lipari) (Bueti, 2017) and to clay deposits from the Messina Province (Triscari et al., 2007) allowed to identify the provenance area of the used raw material. The overall results suggest that: i) the volcanic materials outcropping at Lipari were used as temper in the production of the studied ceramic objects, being the igneous mineral phases identified in the ceramics consistent with the mineralogical features of the outcropping rocks in Lipari Island; ii) the clays used for the ceramic production were not local, but come from the Pleistocene marine deposits outcropping in the Messina Province; iii) the high-temperature mineral phases identified inside the ceramic bodies, the corrugated and vitrified surfaces of the studied waste products, are all evidences of a poor control of the firing temperature during the production.

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Archaeometric study on the so-called "*coppe a medaglione*" from the Hellenistic-Roman site of *Finziade* (Ag)

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Finziade (Agrigento, Sicily), founded in 282 BC from the tyrant of Agrigento, Finzia, represents the last Greek foundation of Sicily. Between the end of the III and the half of the I cent. BC the city gained the role of important commercial port, also mentioned by Cicerone, in the sorting of Sicilian agricultural products of hinterland destined to Rome. The site is rich in artefacts of the III-I century BC which have contributed to increasing the Sicilian historical and artistic heritage. The presented study aims to characterize the discovered ceramics of Finziade during the excavations conducted between 2003 and 2015. The excavations have brought to light a considerable quantity of ceramic material, and evidence that, Finziade, in the period between the second and the mid-first century BC was part of a vast commercial network relations with the other Sicilian centres, with the Tyrrhenian area of Campania, and in a minor form with the Punic and Iberian world and with the Greek world, in particular Rhodes and Kos. Excavation investigations and surface surveys clarified many aspects of urban planning and land extension, identifying residential neighbourhood and necropolis areas. Among the various ceramic classes found of particular importance are the so-called *"Medallion-bowls"* probably of local production. The present work aims to verify, with the support of a combined archaeometric study, the hypothesis of the existence of a production centre of this ceramic class at the Finziade site. A considerable number of ceramic fragments and samples from local clay quarries were analysed by FT-IR and XRF spectroscopy with aims to verify the hypothesis of the existence of a production centre of this ceramic class in Finziade site.

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Igneous millstones in the *Caput Adriae* from Protohistory to Roman time

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The review of the already available data about igneous grinding stones from *Caput Adriae* (Horvat, Župančič 1987; Antonelli et al. 2004; Bernardini 2005), integrated with the petrographic and geochemical analysis of newly discovered protohistoric and Roman artefacts mainly from western Slovenia, is here presented in order to define the main groups of grinding stones in the investigated area from protohistory to Roman time. For the first time a volcanic grinding stone probably belonging to the Bronze Age has been discovered allowing the identification of a previously undetected raw material. On the other hand the large use of saddle querns made from Euganean trachytes in the coastal Karst and Istria, a reflection of Venetic cultural influence in the study area approximately between the 7th to the 5th century BC, has been confirmed. However, the accurate re-examination of trace elements has revealed that the most probable source of these artefacts corresponds to Mts. Cero/Murale and not to the Mt. Altore and Rocca Pendice as previously suggested. It is likely not a case that Este, the most important Venetic centre, is located in correspondence of Mts. Cero/Murale, suggesting its central role in the exploitation of trachytes and in the production and distribution of saddle querns. Relatively rare artefacts made from Etnean volcanites discovered in the Karst and Istria probably reflect the Greek Adriatic penetration during late protohistory. During the Roman time, Euganean trachytes are still exploited for the production of rotary millstones but the available data clearly show the start of new quarries within the Mt. Rosso area and the abandon of the exploitation areas close to Este. During the imperial age, additional volcanic raw materials from multiple sources were used and in particular tephriphonolitic lavas from the comagmatic Roman Province and Etna and Pantelleria basalts.

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TUTELA E VALORIZZAZIONE

ORALI: T&V-O

Conservation of urban heritage and stone deterioration patterns in the city of Torino (Italy)

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Nowadays the deterioration of historical buildings in urban areas is due to many factors, one of the most relevant being graffiti vandalism. Therefore, the study of stone deterioration in architecture, the protection of surfaces, the removal and cleaning of those graffiti turn into a conservation issue [1].
In this research project, we considered the case study of Torino, which shows an extraordinary richness in terms of variety of ornamental stones. In fact, more than 50 different lithotypes are employed both as structural element and coverings in the Historical and Modern Architecture Heritage. This richness in materials is certainly due to the different geological nature of Piemonte region [2].
The first phase of the project consisted in a site survey performed in the city centre, mapping the most employed ornamental stones and graffiti materials and colours. Based on this survey, we selected five lithotypes, characterized by different mineral paragenesis, structures and colours. We also considered different surface finishes. We finally selected: polished granite and diorite (respectively *Granito rosa di Baveno* and *Diorite di Vico*), both representative of intrusive rocks; an orthogneiss (*Pietra di Luserna*) as an example of metamorphic rocks, with a rough surface; a polished limestone (*Botticino*) and a travertine (*Travertino romano*) with a porous surface, both representing sedimentary carbonate rocks.
These mentioned lithotypes were used for the preparation of two sets of specimens in order to perform different laboratory tests (with invasive and non-invasive tecniques) regarding the effectiveness of different cleaning and protection procedures.
Moreover, during the survey the state of preservation of the ornamental stones subjected to graffiti attacks was also assessed. The deterioration patterns observed include deposit, discoloration, exfoliation, abrasion and bursting. The environmental conditions that affect stone heritage are typical of an urban context: pollution, humidity, wind flows, freeze-thaw cycles, etc. [3,4]. In particular we looked for correlations between exposition of stones and their deterioration patterns; this aspect is relevant in the case of Torino where there are both half-exposed surfaces, for example below the arcades, and completely exposed elements.
This research project aims to characterize and investigate in detail the state of preservation of ornamental stones employed in the historical palaces and monuments in the city centre of Torino.

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The meteorites held at the Regional Museum of Natural Science of Turin: conservation, valorisation and fruition of a historical scientific collection

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Among cultural heritage topics, we can surely include the study of museum collections, particularly when these are made of objects of historic and scientific significance. This work presents the rediscovery, and the valorization processes of the historic Meteorites Collection hosted at the Regional Museum of Natural Science of Turin (MRSN). The early samples of the collection were acquired by the former Mineralogical Museum of the University of Turin in the first half of the XVIII century, when the scientific community started to acknowledge the extraterrestrial nature of meteorites, arousing interest towards this kind of items. In the *Meteorites Catalog of the Mineralogical Museum* (1891) there were listed around 50 meteorites, a considerable amount at that time. Due to unfortunate events, in the last 80 years, the collection was not easily accessible and only few researchers knew about the existence of this thematic Collection. At present the Meteorites collection counts one hundred items, attributable to 64 worldwide meteorite falls. It also comprehends several Italian meteorites, e.g. Alessandria, Alfianello, Assisi, Cereseto, Collescipoli, Motta di Conti, Orvinio, Siena, Trenzano and Vigarano. Some of these are important by a scientific point of view because, like Vigarano (a carbonaceous chondrite), are linked to the study of the formation of the Solar System. Since 2007 the collection has been entirely revisioned by the MRSN staff and a team of experts who updated the Museum Catalog and verified the conservation status of each item. During the revision, the team also examined, arranged and archived all the historical documents preserved, acquiring photographic documentation of the samples and updating museological and classification data of specimens with modern criteria. In the last decade, MRSN developed new communication approaches based on exhibitions of those collections that were under-represented in its permanent exposition carrying out specific out-reach initiatives within the context of minerals and rocks trade shows. In 2009, in the *International Year of Astronomy* promoted by the International Astronomical Union (IAU), the Museum organized the exhibit: "Meteorites. Stones from the sky" where the whole *Meteorite Collection* was displayed to the public for the first time, successively meetings and seminars were organized aiming at the general non-specialist public and, lastly, an educational book was published (Bittarello et al., 2009). In 2017, as the final result of the rearrangement of the collection, a *Meteorites Catalog* was published by the MRSN (Costa et al., 2017). The revision and rearrangement of the collection also led to the estimation of the conservation status of each item. Several sample were found in good conditions, whereas others suffered of surface alterations: from a slight oxidation to strong modifications of the specimen; according to the different cases, actions were undertaken to slow down or interrupt the deterioration processes whenever it was possible.

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Influences of optical characteristics of protective varnish on glossiness of painted artefacts

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The *Appearance* of an artefact is related to the interaction between light and the object (and the observer). CIE (International Lighting Commission) a scientific organization devoted to the study of light, in Publication CIE 175 considers to the following physical quantities related to the main perceived object qualities:

- Specular reflection at given angles (gloss quantity) related to the perceived surface glossiness ;
- Spectral reflectance in given geometrical condition (45/0; 8/d) [CIE 15] related to colour;
- Transmittance related to transparency;
- Roughness related to perceived texture.

Obviously, the definition of a mathematical model of Appearance based on measurements of physical quantities is a challenge for several fields, including Cultural Heritage especially for studies on exhibition design able to enhance the perception of the works of arts.

The physical quantities aforesaid are measured singularly and evaluated with dedicated measurement methods and instruments. In the metrological framework this approach is correct: each quantity has its own definition and disseminated with reference material realized to be representative of the quantity in a given reference condition. But this approach is not applicable in real life behaviour (industrial object) or in cultural heritage framework: gloss, colour, texture and transparency are always present and objects need to be evaluated in their whole appearance. A reference material for colour is not transparent, nor textured and has a given glossiness (full glossy of full matt). A paint has all of them: the measured values of the related quantities are useful for a non-invasive evaluation of conservation and for the design of an exhibition able to assure the desired perception.

This paper is about the study of paint samples with natural protective varnishes with different glossiness: the quantities measured are the spectral reflectance and the gloss. The spectral reflectance has been measured in reference conditions [CIE 15] and different measurement conditions with a goniometer able to measure the material BRDF (Bidirectional Reflectance Distribution Function), i.e. the property describing the geometrical distribution of material reflectance in the whole space. The knowledge of BRDF is fundamental for the design of exhibition as well for virtual reconstruction. The gloss has been measured with a glossmeter, an instrument able to evaluate the specular reflectance at given angles (20°, 60° and 85° as said in ASTM D523). The shape of the specular peak has been measured too.

The results of samples representative of cultural heritage materials show how the interactions between the physical properties directly influence the measured results of usually supposed unrelated quantities. From the appearance point of view colour and glossiness are related qualities, this is well known in works of art, paint masters of the past choose the varnish able to achieve a desired colour perception. But metrology considers the relationship between colour and gloss only in one direction: the gloss influences colour, but not the opposite. This is why the reference materials for colour are fully glossy or fully matt. But our study shows that, for painted artefact at different glossiness, the gloss quantity is influenced by the colour too. If these provisional results will be confirmed for other investigations, the first consequences will be on the reliability of the measurements of cultural heritage related quantities, measurement methods and Appearance model.

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Comparison of cleaning procedures for ornamental stones against graffiti vandalism

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In the field of conservation of monuments and historical and modern architecture, the identification of suitable cleaning procedures is a topic of great interest. Currently, graffiti paints as vandalism acts are one of the most serious threat for the conservation of cultural heritage stones worldwide because they can produce harsh deterioration of stone [1, 2].
In particular, we considered the cleaning of ornamental stones from graffiti vandalism in the city centre of Torino (Italy), which is a peculiar case on a national scale due to the variety of materials employed. Within a wider research project concerning the decay of urban heritage, we set up a non-invasive multi-analytical protocol for the comparison of the cleaning results obtained by using different procedures.
In fact, it is important to underline that cleaning techniques (traditionally chemical and mechanical procedures, but also the more precise and selective laser ablation) can sometimes cause serious alterations on the natural stones, clearly unacceptable in the field of preservation of cultural heritage: e.g. dissolution and deeper penetration of the graffiti paints through the fissure systems, mechanical and/or physical changes of the mineral grains (increase of the roughness, corrosion of some minerals, colour changes, etc.) [2, 4].
We prepared several stone specimens, selecting five different lithotypes (a pink granite, a diorite, an orthogneiss, a limestone and a travertine), depending on their genesis, abundance and distribution in the architecture of the historical city centre of Torino, as well as their surface finishes with different roughness levels. In addition, different graffiti paints and colours, applied as spray, dabbers or markers, were considered.
In this contribution, we focus on the comparison between cleaning procedures performed by using chemicals (both commercial graffiti remover products and solvent mixtures specifically recommended by restorers due to their effectiveness, solubility and non-toxicity features) and laser ablation (based on the application of different laser systems). The cleaning evaluation considered the effectiveness in the removal of the graffiti paint, but also the damage possibly induced.
According to the results accomplished using each cleaning procedure, we found the suitability of combining chemical and laser techniques, achieving optimal results.

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Air pollution impact on stones in urban environment: a multidisciplinary approach

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Air pollution is the major responsible for the formation of damage layers on stone monuments and historic buildings in urban areas (Bonazza and Sabbioni, 2016). Among widely used building materials, marble and limestone were selected in previous studies on pollution impact, thanks to their chemical homogeneity (mainly composed by calcium carbonate) and low porosity. The effects of pollution have been heretofore assessed by analyzing samples collected from historic buildings or performing tests in simulation chamber and/or in field but gaps still remain in measuring deposition fluxes on materials and developing proper tools for long-term management of cultural heritage. Moreover, the possible effects on built heritage of the current atmosphere poorer than in the past of SO_2 but richer of NO_x and organic compounds (mainly released by vehicular traffic) should be considered.

Field exposure tests with model samples are currently under execution in Italian cities characterized by different environmental conditions as a non invasive methodological approach for studying the impact of urban pollution on carbonate stones. The methodological approach selected for this investigation as well as first available results are here discussed. Marble (Carrara Marble) and limestone (Red Verona Marble) were selected as model samples as they were widely used as construction and ornamental elements in historic Italian architecture. They will be exposed at least for 2 years in Bologna, Ferrara, and Florence. Preference for samples exposure were given to sites located outdoor, partially sheltered from the rain wash-out, in areas strongly affected by pollution due to vehicular traffic. Galvanized metallic racks was prepared to host samples with different exposure orientations: horizontal, oblique (tilted with 45° slope) and vertical, in order to identify how positioning may reflect on deposition and removal of pollutants. The exposed samples will undergo mineralogical, petrographic and geochemical analyses (Optical Microscopy, Scanning Electron Microscopy coupled with Energy Dispersive X-ray Analysis, Inductively Coupled Plasma Mass Spectrometry, Ion Chromatography analysis and Thermal-chemical methodology using a CHNSO combustion analyzer (Ghedini et al., 2006)) at predefined time intervals to characterise the products derived from pollutants-stone interaction in terms of typology, origin and impact on stone. Moreover, the integration with colorimetric analysis will allow to identify a connection between the deposited soluble and carbon fractions and changes of colorimetric parameters, for setting up damage functions. Simultaneously passive sampling of aerosol has been designed by the exposure of filters while seasonal environmental monitoring campaigns of particulate matter will allow to compare the quantity of soluble ions and carbon fractions present into atmosphere with that actually accumulated on samples surface. Additionally, monitoring campaigns of bioaerosol has been planned in Bologna in order to quantify the microbial load (fungi and bacteria) in air. Data of environmental monitoring campaigns as well as results of analyses carried out after the first year of exposure will be also reported.

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BIOARCHEOLOGIA & INTERAZIONE UOMO-AMBIENTE

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POSTER: B&IUA-P

The Medieval Population of Leopoli-Cencelle: Dietary Pattern Reconstruction through Stable Isotope Analysis from Bone Collagen

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The medieval period in Europe was a time of significant social, climate and political changes as well as of unprecedented social complexity that affected also human diet.
The present study aims to the molecular characterization of dietary patterns by stable isotopes analysis from bone collagen extracted from 75 humans and 6 faunal samples of Leopoli-Cencelle (VT, Italy). The medieval town of Leopoli-Cencelle (VT, Italy) dates back to 9^{th}-15^{th} centuries CE, the leading fraction of the population was represented by craftsmen and traders, but there were also farmers and shepherds. Notwithstanding the historical sources provide us some information about the inhabitants of this community, to date no biomolecular data, regarding this community, have been published. Therefore, the obtain data will enhance a better understanding diet and food distribution during the Medieval era in Italy.
Collagen extraction was performed following the Longin modified protocol (Brown et al. 1988; Scorrano et al. 2014).
Both human and faunal bone remains yielded satisfactory collagen quality and showed an atomic C/N ratio within the acceptable range according to van Klinken (1999).
The obtained results showed an enrichment of the $\delta^{15}N$ of 3-5‰ when compared to animals reflecting a high trophic-level; the $\delta^{13}C$ results for the human bone remains underlined the lack of marine food sources but they seem to suggest the dietary habits was mainly based on terrestrial resources both animals and vegetables. As regards vegetables some individuals show isotopic signature compatible with C4 plants consumption. diet. No statistically significant difference between sexes were detected (Kolmogorov-Smirnov *p-value* >0.05; Mann-Whitney *p-value* >0.05).
The present finding revealed a clear scenario of subsistence strategies in this community adding useful data about diet and standards of living during Middle Ages helping reconstructing a very interesting page of Italian history.

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Birds in ancient societies

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The complex relationship between humans and birds is one of the great unknowns of the human past . Birds and their eggs are universal motifs in religion and myth, symbols of creation and rebirth, and feature prominently in prehistoric and historic iconographies (Serjeantson 2009). In today's world, they are increasingly dominating the food market, being kept as pets and fuelling birdwatching tourism. But how were birds hunted, kept, eaten, domesticated, sacrificed, revered and ritualised throughout human history? Extensive iconographic representation of birds can be used to glean information on birds in ancient societies, but disentangling symbolic and practical roles requires integration with the evidence preserved in the archaeological record.

However, the scarcity of bird remains and challenges of identification have meant that the development of avian zooarchaeology has lagged behind that of (for example) domestic herbivores. Given the symbolic, and spiritual importance of birds, and the nutritional value of eggs, eggshell is arguably the most under-used resource in archaeology. It is abundant, surviving well in non-acidic soils, is easily retrieved by sieving and flotation, it preserves paleoenvironmental information and can now be identified using novel biomolecular methods (palaeoproteomics or "ZooMS"; Stewart et al. 2013/4; Demarchi et al. 2016; Jonuks et al. 2016; Fothergill et al. 2017; Presslee et al. in press.).

This contribution focuses on the retrieval and the study of ancient protein sequences embedded and preserved in the eggshell mineral matrix using mass spectrometry. We highlight the crucial role of Natural History museums and their curators in providing samples and, crucially, expertise, for developing new archaeological methodologies based on "-omics" technologies. At the same time we discuss the relevance of "humble" materials such as eggshell, often collected in archaeological excavations but rarely studied due to economic and time constraints. Case studies from the European Paleolithic and Neolithic records, as well as the Middle Ages, will show the potential for this research to change our understanding of how our ancestors interacted with their surrounding environment.

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Analytical methods for the chemical investigation of archaeological waterlogged wood

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The chemical analysis of degraded archaeological wood is an important step for the assessment of its preservation state and for the identification of occurring degradation phenomena, in order to assess the best preservation strategy. The literature reports the application of several different analytical techniques to get information on the molecular composition of wood and to measure the extent of wood decay. In particular, the ratio between holocellulose and lignin content (H/L ratio) is a commonly used parameter to evaluate the degradation state of archaeological wood in terms of loss of wood components.
The H/L ratio, or an estimation of it, can be determined using different techniques, such as TAPPI methods, FTIR, NMR and Py-GC/MS. However, the simple estimation of the H/L ratio is not sufficient in some cases to correctly reflect the chemical variations in the states of preservation of archaeological samples. Waterlogged archaeological wood usually needs to be consolidated and most of the consolidating agents are not reversible, thus the evaluation of the degradation state of consolidated archaeological wood is in some cases complicated by the presence of the consolidating agent.
Py-GC/MS is a successful tool to address this issue: this technique permits to identify the molecular pattern of pyrolysis products and their distribution. Performing a categorisation of holocellulose and lignin pyrolysis products, information about the degradation reactions undergone by wood components can be obtained. Thus, the interpretation of the data in terms of relative amounts of pyrolysis products divided into categories allows to integrate the information obtained by the calculation of the H/L ratio and sometimes to correct misleading observations.
Analytical pyrolysis method based on Evolved Gas Analysis (EGA-MS) and Py-GC-MS with in situ silylation using hexamethyldisilazane (HMDS) are suitable to establish the degradation state of wood even in presence of consolidating agents. EGA-MS allows to identify the principal zones of thermal degradation of the different materials simultaneously present in a composite sample. It is then possible to perform several single-shot pyrolysis experiments at different temperatures on the same sample, thus selectively thermally degrading the different components.
Examples of the successful application of pyrolysis based analytical techniques in the investigation of archaeological wooden artefacts include: “L’Aimable Grenot”, a corsair boat dating back to the 18th century, the Roman shipwreck “Lyon” (part of sixteen wrecks discovered during the salvage excavations of the Parc Saint-Georges in Lyon, France), the Oseberg Viking collection (Museum of Cultural History, Oslo, Norway), the Nydam Boat (Gottorf Castle in Schleswig, Germany).
The presented data were obtained in the framework of the ArCo project (2014-2016 JPI-JHEP) and of the Saving Oseberg project (2016-2020, funded by the Norwegian Ministry of Education and University of Oslo).

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Archaeomagnetic dating of Copper Age furnaces at Croce di Papa village and relations on Vesuvius and Phlegraean Fields volcanic activity

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Metallurgic furnaces, discovered in the archaeological site of Croce di Papa, Nola, at 15 km NE from the Vesuvius summit, were dated here by using archaeomagnetic technique. They are positioned between the deposits of the Vesuvius eruption of Pomici di Avellino and of the Phlegraean eruption of Agnano-Monte Spina. A revision of available age data and associated uncertainties for these two eruptions was carried out in order to provide constraints on the Croce di Papa furnaces age determination. The adopted archaeomagnetic technique provides an accurate age of 3136–3027 BCE corresponding to 5085 to 4976 a BP that represents the upper age limit of the Agnano-Monte Spina eruption. This study provides evidences for the existence of human settlements in the Campanian Plain in the first century of the forth millennium BC and allow to assess the limited impact of the Agnano-Monte Spina eruption on climate and human settlement.

Palaeodietary reconstruction of two coastal medieval settlements from the Basque Country (northern Spain)

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This contribution presents the results of palaeodietary reconstruction based on carbon and nitrogen stable isotopes of two medieval populations located in the coast of the Basque Country. Nowadays both Gorliz (Biscay; Campos et al., 2009) and Zarautz (Gipuzkoa; Ibáñez, 2008) are middle-sized towns. Recent archaeological excavations at both of them have revealed their origins as medieval villages, comprising their primitive churches and cemeteries. The isotopic analyses performed both on the faunal assemblages and the human populations recovered from these two sites, when combined with the information driven from osteoarchaeological and zooarchaeological studies, give us the opportunity to deepen into the diachronic evolution of diet, as well as into the factors that determine the access to specific food resources. At a collective level, taking advantage of the long lifespan of the both sites considered, this presentation will explore the importance over time of key foodstuffs such as C_4 resources and marine fish. In the same direction, the precise dating of the cemetery excavated in Zarautz will let us explore the influence of the concession of royal Chapter (*fuero*) to Zarautz in the beginning of 13^{th} century on the access to and distribution of new food resources. At the individual level, we will try to understand the interaction between diet, age and sex, tackling topics such as gender-based access to certain food resources, infant diet and weaning patterns. Finally, we will compare the dietary patterns of these two coastal sites with those of inland settlements from the same region already analysed (Lubritto et al., 2017). In this way, we will explore the importance of the ecosystem in the configuration of collective and individual dietary patterns throughout Middle Ages.

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Biomolecular identification of prehistoric shells

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Mollusc shells found in archaeological sites are the direct evidence of how humans exploited their environment in the past. Shells represent one of the most widespread and iconic raw materials used in prehistory to make jewelry. However, they do not typically attract the full attention of the archeometrist as a "cultural heritage" item and are rarely considered for comprehensive analysis using the latest and novel technologies. Yet, shells can reveal interesting information regarding the long distance trades between the communities and most importantly - social status of people in prehistoric societies: shells encode the oldest symbolic behaviour in humans [1], which, in other terms, makes them the oldest form of cultural heritage item. Different species of shells underwent consistent exploitation as far back as early prehistory (e.g. *Nassarius* in Middle Stone Age site [2]) thus the use of certain species and the ornaments' typology can be used as a proxy for reconstructing patterns of cultural diversity, cohesiveness of local communities and changes in past societies [3]. This would in turn help to untangle the complex processes that have contributed to the shaping of present-day European cultural and biological population diversity.

Taxonomic identification of shell ornaments among prehistoric artefacts remains challenging, due to the fact that working the material (e.g. polishing) and/or degradation during burial may have disguised or altered diagnostic morphological features [4]. This hinders the possibility of building large datasets of securely-identified ornaments which can be used to reconstruct past environments as well as trade and exchange networks.

We exploit novel technological advances in biomolecular archaeology (analysis of proteins using mass spectrometry, i.e paleoproteomics or "ZooMS", stable isotope geochemistry) and state-of-the-art spectroscopic techniques (for microstructural and morphological studies) and focus on the identification of shells that have been notably important for European prehistory, including Unionoidae (freshwater bivalves, source of mother- of- pearl), Nassariidae and Spondylidae from Upper Palaeolithic, Mesolithic and Neolithic sites. Our research shows great potential even for small, heavily degraded or fragmentary shells and ornaments; this could yield precious insights into patterns of landscape use and human mobility against a changing environmental backdrop during the Pleistocene and the Holocene, revealing possible routes for the exchange of materials and ideas.

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Strontium Isotope analyses to investigate the mobility of the Iron Age Vestini population of Loreto Aprutino, Abruzzo, Italy

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Strontium isotope analyses were used to investigate the mobility of a selected group of people inhabiting the piedmont area of Abruzzo, Central-Italy during the late Iron Age period (6th - 4th c BC). This Vestini population was one of the eleven groups settled in Abruzzo during the Iron Age. Their territory occupied regions on either side of the Gran Sasso mountains. This aspect is of particular interest because by tracing the mobility it is possible to determine whether the natural barrier, the Apennines chain, was effectively a barrier between the two sides or not.
Second molars were collected from the skeletons (N=16) of the archaeological site of Loreto Aprutino, Cappuccini quarter. This study focus on the understanding of the direct person's place of origin and it explores the correlations between age and sex and potential migration.
The $^{87}Sr/^{86}Sr$ values fall within two different ranges, 0.70701-0.7090 and 0.70901-0.71100 which, according to present-day baseline data, reflect the signals of the piedmont and mountain areas of Abruzzo. The results suggest that seven individuals (3 females and 4 male) originated from an area with Mesozoic sediments (Fig1). This kind of bedrock is present in the mountains between Loreto Aprutino and L'Aquila. Six individuals (4 females and 2 males) have a strontium signature that is compatible with the local middle Pliocene – early Pleistocene bedrock of the Loreto Aprutino site. Among the unsexed sex individuals, two potentially originated from the Mesozoic bedrock, and one from the local middle Pliocene – early Pleistocene.
While females appear to show a greater range of isotopic signatures, and thus potentially greater range of mobility, this difference is not statistically significant to the male values. When age is included, data are too fragmented and therefore no pattern is visible.
This research on mobility using strontium isotopes from human remains is the first ever done on the skeletons of Loreto Aprutino and in the Abruzzo region. The study provides valuable data for the growing of the stable isotopic Italian database to better understand people mobility in relation to the natural environment and culture.

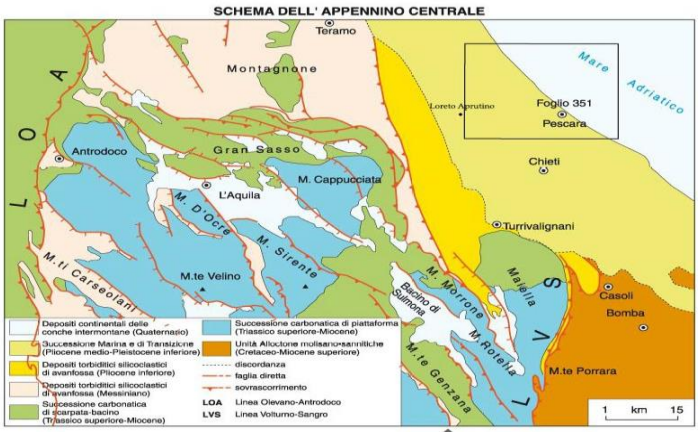

Fig 1. Geological map of Central Appenine chain with the location of the archaeological site of Loreto Aprutino (http://www.isprambiente.gov.it/Media/carg/351_PESCARA/Foglio.html).

Diet and Society: isotope evaluation of Imperial Rome communities (1st-3rd cent. CE)

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In the last decades, thousands of burials dated back to the Imperial Age (1st-3rd centuries CE) have been discovered in the Roman *Suburbium*, allowing us to shed light on the lifestyles and health conditions of the inhabitants of the greatest city of the Ancient World.The aim of this study is the characterization of ancient Roman's prevalent dietary patterns by the evaluation of more than 250 human bones and 40 faunal remains pertaining to several Imperial necropoleis (Castel Malnome, Quarto Cappello del Prete, Casal Bertone Mausoleum, Casal Bertone Necropolis, Casal Bertone Area Q, and Via Padre Semeria) through carbon and nitrogen stable isotopes. The isotopic evaluation suggests that Rome inhabitants followed a quite heterogeneous diet, mainly based on terrestrial ecosystem. The nutritional pattern seems to be marked by a plentiful consumption of C3 plants derived carbohydrates, supplemented by protein foodstuff from different sources, such as freshwater fish and meat. Worthy of consideration is the lack of C4 consumption traces despite literary sources stressed its usage for *puls* preparation, the ancient Roman staple food. Moreover each community seems to be featured by specific dietary preferences that could be mainly ascribed to environmental constrains, supporting the idea that archaeological and ecological characterization of every community should be mandatory for a proper dietary habits reconstruction.
Selected pathological cases have been chosen to dissect the role of nutrition in the onset of specific diseases. Specifically, osteological analysis suggested that some people suffered from gout and this hypothesis seems to be isotopically supported by a high $\delta^{15}N$ values recorded for these individuals and by their nutritional reconstruction, characterized by a great meat and fish consumption. Other people share a more vegetarian diet, with the outstanding characterization of an individual suffering from a complete ankylosys of the jaws that makes him unable to chew. This inability forced him to eat semiliquid foodstuffs that could be introduced in his mouth through a voluntary teeth avulsion witnessing the community healthcare provision.
The overall results are consistent with the idea that diet should be considered a valuable proxy to holistically interpret the cultural and social identity of a community, representing a useful tool in the characterization of ancient human population.

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Analysis of black crusts from the Church of Santa Maria delle Grazie al Naviglio Grande (Milan): A challenge to deepen the understanding of the relationship among microstructure, microchemical features and pollution sources

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Air pollution is one of the most important causes of surface decay in urban environment. Among the degradation processes due to airborne pollutants, the formation of black crusts is one of the most dangerous one. Currently, emissions from mobile combustion sources are the main agents responsible for pollution, although a significant decrease is expected in Europe within the next decade. During the crust formation, particulate matter, which contains mainly amorphous carbon and several heavy metals, can be embedded into the gypsum, providing then, the characteristic black colour. In particular, EC (elemental carbon) and OC (organic carbon), including hundreds of organic substances of different natures) are the two main constituents of particulate matter (PM) carbonaceous fraction. OC is emitted by combustion processes as a primary pollutant but it has also a secondary origin and can form starting form gaseous organic precursors (i.e. volatile organic compounds, VOC). Both OC and EC have been identified in the black crusts together with metal oxides that can catalyze the oxidation of SO2, promoting formation of the crust itself. Several authors showed how the analysis of trace metals into black crust, as well as the characterization of the carbon, can provide insights on the influence of the pollution sources in the formation processes of this degradation product, moreover, they can be act as passive samplers of air pollution (Barca et al., 2010, 2011, 2014; Belfiore et al., 2013; La Russa et al., 2013, 2017; Fermo et al., 2015; Ruffolo et al., 2015). This research deals with the characterization of black crusts collected from the Church of Santa Maria delle Grazie al Naviglio Grande of Milan, built in 1901 and located on the Naviglio Grande. This city suffers pollution from the industrial area, combustion processes (including biomass burning) as well as from the vehicular traffic. Black crusts can be considered as a passive sampler of pollutants. In particular, the monument was selected because it showed the formation of degradation surfaces on different substrates than the usual carbonate (marble, calcarenite). In fact, black crust samples were taken from surfaces such as mortars and bricks (Fig.1), materials commonly used for building churchs. For this reason, in order to fully characterize those samples, several techniques were used, including scanning electron microscopy, thermogravimetric analysis, laser ablation with inductively coupled plasma mass spectrometry, infrared spectroscopy and ion chromatography. This integrated approach allowed us to gain information about the mineralogical phases and elements and species present within the crusts giving the possibility to identify the pollution sources causing the surface decay within the buildings, as well as the variability in composition depending on the exposure of the analysed surfaces.

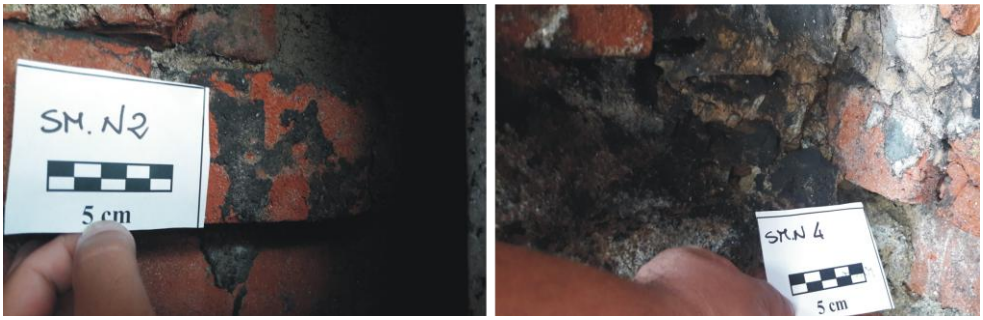

Fig.1 Some representative pictures of the black crusts collected from the church of Santa Maria delle Grazie al Naviglio of Milan.

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Mobility in the Empire: oxygen isotope survey of two roman communities

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This paper aims to contribute in the quantitative reconstruction of migratory flows in Roman Empire (1st-3rd centuries CE) in order to identify allochthonous people coming to Rome from elsewhere.
To assess migration to Rome within a scientific framework, oxygen isotope analysis was performed on selected individuals from two cemeteries scattered throughout the Roman Suburbium: Castel Malnome and Quarto Cappelo del Prete.
The whole sample is related to people buried in the area outside the Aurelian walls and, to the best of our knowledge, it represents one of the leading survey for this ancient population whose biomolecular data are currently scanty.
The enamel from every individual with an intact first molar was assessed for oxygen stable isotopes ratio.
The outer layer of each tooth was cleaned using a diamond drill and an enamel sample of around 15 mg was extracted from the thickest section of the tooth wall.
The obtained data fall within the $\delta^{18}O$ values previously obtained from a roughly synchronic sample for close topographical area. Converting enamel $\delta^{18}O$ to estimated $\delta^{18}O$ of drinking water consumed during enamel formation shows that the great part of these data are roughly in line with reference ratios for Rome area as well as its eastern and southern aqueduct water sources, even though some individuals are significantly different from the average values.
The comparison of isotopic and osteological data allows us to dissect people geographic origin to contribute in answering to the question "Who immigrated to Rome?".
The availability of specialist spreadsheets for each burial guarantees the scoring of all taphonomic features and this methodology will aid in the definition of putative differential aspects in cultural behavior towards the death in different people.
Notwithstanding this study generated new data supporting hypothesis related to people who were not born at Rome, much more information is needed to fully contextualize questions about mobility in Imperial Rome to push in employing bioarchaeology in Roman migration studies.
This study is supported by grant from the M.I.U.R., PRIN Project 2015-prot. 2015PJ7H3K.

Life, death and pathogens: a morphological and molecular study about "La Sassa" cave (LT) community

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"La Sassa" is a cave located close to Sonnino (LT), featured by a complex stratigraphy ranging from Pleistocene up to contemporary levels, where the Eneolithic/Copper Age layers return a lot of human bones, firstly discovered in 2015 suggesting the sepulchral use of the cavity.
In spite of the large number of human bone fragments, no single burial could be detected and the ceramic goods are very scanty to properly interpret the cultural frame the community could pertain.
The extensive excavation of the cave started in 2014 as the onset of a collaboration between the Groningen Institute of Archeology of the *University of Groningen* and the Chair of Paletnology of the *University of Rome Tor Vergata*. In 2016 the Center of Molecular Anthropology for the study of the ancient DNA of the *University of Rome Tor Vergata* has been engaged for the physical and molecular evaluation of the human findings, and the ongoing research seem to be very promising to contribute in the biological characterization of people buried in "La Sassa" cave.
Notwithstanding the poor dating evidence, a preliminary radiocarbon-dating survey allows us to considerthe human bones to be restricted to Copper Age timeframe. The recruitment of the human bones lead to start a systematic anthropological evaluation to be able to identify the minimum number of individuals and their demographic and osteological parameters, up to perform some molecular evaluations. The latter aspects are currently devoted to the nutritional characterization through carbon and nitrogen stable isotopes analysis of bone collegen and the results could be considered a valuable proxy in the identification of skeletal fragments suitable for genetic analysis by ancient DNA typing.
Specifically, this analytic approach has been currently pursued in selected individuals showing peculiar skeletal alterations that could be linked to an unbalanced nutritional uptake and suffering from putative domestic-related pathologies, whose molecular characterization would represent a significant information broadening related to the economic strategies characterizing the community.

If These Bones Could Talk: The Tales Human Skeletons Can Tell Us

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Cultural Heritage is an expression of the lifestyle developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values. Thus Cultural Heritage is a wide concept where several features could be hosted. Frequently its definition has been restricted to cultural practices inspired by disciplines such as sculpture, picture or poetry even though biology is beginning to represent a valuable tool in the field. Human remains constitute themselves the main documents of their living conditions, food consumption and generally the activities through which humans ensure their existence or manifests their culture. The human skeleton is one of the archaeological material that could be scientifically analyzed to deepen our knowledge on the lifestyle of past populations, through its organic and inorganic components.
Detailed chemical-physical analysis on inorganic fraction could be useful to understand the ritual practices used to be performed by past populations, as well as their critical evaluation aids in determining bone preservation state.
Organic component analysis allows us to perform Stable Isotopes Analysis on several prehistorical and historical samples: ^{13}C and ^{15}N should be considered reliable proxies to ascertain food preferences and diet. Spectrometric analysis has been extended to strontium and oxygen isotopes that are able to record the geobiology of humans, giving astonishing hints about both demic migrations and individual movements to support molecular analysis through ancient DNA. The provided results represent only a selected instance of the skeleton potential as a huge source of Culture about our ancestors.

DIFFUSIONE E DIVULGAZIONE SCIENTIFICA NEI BENI CULTURALI

ORALI: DDSBC-O
POSTER: DDSBC-P

Dialogue and dissemination: Science and Archaeology. The experience of the project "Science and Archaeology: an effective combination for the dissemination of scientific culture".

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In this contribution the experience accrued through the activities organized within the project "Science and Archaeology: an effective combination for the dissemination of scientific culture" will be presented.
The project is derived from the needs to develop a framework for strengthening the scientific interest among young students addressed to humanities studies. To pursue this aim, the activities were based on an inquiry approach that implied the identification of selected case studies and the involvement of the students in the whole scientific process, starting from the preliminary knowledge and questions to the collecting, processing and evaluating the data from an interdisciplinary point of view. Some wall paintings, vase paintings, human skeletal remains and stone tools apt for an enquiry through analytical tools were selected in collaboration with the "A. Salinas" Archaeological Museum of Palermo and the "P. Griffo" Archaeological Museum of Agrigento. The activities were thought for high school, bachelor and PhD students. To overcome the problem of the various levels of knowledge, all students attended at some starting lessons. This allowed building a minimum level of knowledge about the basic of archaeology as well as archaeometry. The subsequent activities were organized based on the Vygotskij Model of proximal learning: higher-level students worked as peer review for low-level students. The practical activities were delivered on site, in the museums, by using portable instrumentation. Within these activities students faced themselves with museums personnel and restorers. These activities were accompanied by technical visits to archaeological sites and to university laboratories. Students were involved in data elaboration and interpretation. The continuative brain-storming with the project team produced some valuable deliverables like brochure, videos, power-points that were presented in a final workshop where specialists discussed the archaeological and archaeometry aspect of the items studied within the project.
In our opinion, this experience could constitute a valid model to develop an inquiry based-science education within humanities high schools. Moreover, it constituted the proper context to strengthen a proficient cooperation between various professional figures and it had the added value of having compelled developing a simpler and common language between archaeologists and scientists.

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Experiencing the scientific divulgation in the medioeval Poppi Castle

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The Castello di Poppi is a wonderful medieval castle located in Poppi, in the Casentino Valley of Tuscany[1]. The castle, formerly the property of the Conti Guidi noble family, is visited by thousands of visitors a year, attracted by the mighty stone structure as well as the elegance of its overall shape and of some of its architectural elements such as the tower, the merlons and the two-lights windows decorated with noble coats of arms. The cooperation between the Castello di Poppi and the Galileo Museum of Florence, with the contribution of the Politecnico di Torino, allowed to widen the visitors expectations with respect to the spread of scientific knowledge. The first activity is the exhibition "La visione del Cielo da Dante a Galileo" organized in the Poppi Castle, in June 2017, inside the halls of the Rilliana Historical Library, Fig. 1.

Fig. 1 - Poppi Castle (from left to right): the exterior, the interior of the castle with the entrance of the exhibition "La visione del Cielo da Dante a Galileo", the library with the replicas of the Galileo Museum.

The exhibition aims to link and compare two different conceptions of the Universe, admirably exhibited by two exceptional figures, Dante and Galileo. Through the exhibition of historically and artistically significant editions of Dante's Comedy, accompanied by appropriate captions, it is possible to appreciate how the Aristotelian-Ptolemaic conception of the cosmos, typical of the poet's era, was not merely a description of the motion and of the arrangement of the planets, but a part of the ultramundane reality and "place" through which the will of God is mediated downwards. In the second part of the exhibition, the focus shifts on Galileo and on the replicas of his instruments, granted by the Galileo Museum. In particular, the armillary spheres and the telescope constitute a fundamental point of contact between ancient and modern: the use of the first ones has been documented since Antiquity and continued in the Middle Ages and in modern times. The telescope, which first Galileo had the revolutionary intuition of pointing towards the sky, served to demonstrate that the uneven brightness of our satellite was due to the differences in its surface, clashing with centuries of philosophical - religious tradition who wanted the Moon, like the other celestial bodies, perfectly smooth and spherical. The exhibition of the most beautiful illustrations of the scientific books belonging to the Rilliana library collection, together with the exhibition of instruments for the astronomical-mathematical calculation, the use of digital frames by the public, offers a complete and gratifying experience.

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Communicating conservation science through CONCEPT: The case of Palazzo Guiccioli in Ravenna

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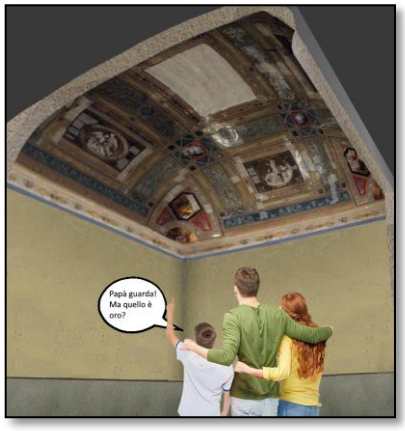
The opportunity of improving public engagement through conservation science is among the most discussed topics in the international scientific community, as it is of primary and crucial importance for the future of this field of research [Lithgow 2015].
Between 2014 and 2017, the collaboration on a research project focused upon Palazzo Guiccioli (Ravenna, Italy) made us aware of the necessity to stretch our "comfort zone" beyond the traditional media that convey scientific information, as well as to develop innovative ways in which disciplines contributing to the knowledge and conservation of our heritage can be effectively communicated to a broaden non-specialist audience to endorse public engagement.
Owing its fame to the poet Lord Byron, who used to reside there during his stays in Ravenna, Palazzo Guiccioli was named after the count Alessandro Guiccioli, who bought the building in 1802 by the Osio family. In 2015, a massive conservation project of the whole building was started: under coatings of modern varnishes, overlapping layers of paintings were discovered on walls and vaults, witnesses of different occupation phases of the building. By a multi-analytical approach (OM, SEM-EDS, micro-FTIR, micro-Raman, XRPD), a characterisation of both degradation patterns and painting techniques was carried out: apart from sustaining the conservation work, obtained data also supported the historical study of the decorative programme, leading to the emergence of relevant insights into the possible attribution to specific workshops [Melis 2017].



In 2018, Palazzo Guiccioli will be opened again, intended for hosting the Risorgimento and Lord Byron Museum. To prevent obtained results from only being shared within experts, we have developed CONCEPT (CONservation scienCE for Public engagemenT), a model built in accordance with the available recommendations concerning effective communication for cultural heritage [Lithgow 2015, Ingram 2011, UNESCO 2007, Tilden 1957]. Based on an intuitive questions and answers interface, CONCEPT is an easily approachable virtual space intended to avoid sterile information and guide people to interpretation through evidence, by using interactive layered data to provoke and stretch the public. CONCEPT will let the palace, its building materials and decorative programme speak for themselves, by "answering" questions prepared for the visitors. In this presentation, authors will show how results obtained by merging historical research and scientific analyses will dialogue together and with the public by using CONCEPT, with the main aim to make people aware of how heritage can enormously benefit from an interdisciplinary research and to propose a model where engagement is made with the public.

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The Galileo Museum of Florence an actor of social inclusion

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In recent years the Museo Galileo is moving from a place mainly devoted to the conservation of collections and historical research to an educational and training center where, by understanding the needs and expectations of visitors, the spreading of the history of science becomes the main goal[1]. To make the teaching proposals increasingly interesting, it is essential to build networks and systems that work in synergy to strengthen the link between schools, museums and associations. The Museum promotes intercultural dialogue between different audiences through events, shows and theatricalizations, thus becoming a place of social exchange in which the visitors do not come exclusively to see the wonderful scientific collections, but also to meet people with whom share knowledge, opinions and new interests. To project outwards, itinerant educational activities have been designed; the intent is to share the educational experiences of the Museum but also to listen to and receive the requests of those who do not have the opportunity to visit the museum.
In the museum spaces events, theatrical performances and debates are carried out; the Museum thus becomes a meeting place that calls for constructive dialogue, exchange and comparison between individuals and different communities. On Sunday morning, the educational section offers "Breakfast at the Museum. The ancient shops of science" a series of workshops focused on the recovery of the historical memory of the ancient Florentine artisan shops and their very close relationship with the scientific knowledge.

Fig.1- Activities of the Galileo Museum (from left to right): Galileo with the students in a scholastic visit in the museum, the replica of an armillary sphere touched by a blind visitor, replicas in an exhibition at Politecnico di Torino

In other activities an operator in the role of Galileo tells the life and the discoveries of the scientist, Fig. 1: the XVII century language and the costume bring visitors back in time provoking a strong attraction. Recently, the multimedia section of the Museum has created a software application for smartphones and tablets that allows to explore the entire collection making the exhibition path fully comprehensible even to non-specialist public thanks to the possibility of accessing hypertext cards, animations and biographies[2]. Moreover in order to make our collections increasingly accessible to those who have visual problems, a Braille guide with tactile reproductions of some scientific instruments has been created in collaboration with the blind and partially sighted Italian Union and the Braille Printing House of the Tuscany Region.

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The Challenge of Divulgation: an experiment called "Research for Cultural Heritage"

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Divulgation is a fundamental tool to get closer to the world of Science. In this context, Science applied to the Cultural Heritage suffers of a lack of knowledge by the public with a consequent confusion regarding the figure of the Conservation Scientist. Most people believe that diagnostic activities and the restoration procedures on artworks are the same thing: this confusion arises because of the absence of a specialized and educational communication about the Science for Cultural Heritage.

This is the primary reason why the blog "Research for Cultural Heritage" was created, aimed to the divulgation of the main topics related to the diagnostic of Cultural Heritage.

In order to obtain the widest possible dissemination, it has been fundamental to develop a simplest language, leaving technicalities in scientific papers already published. Moreover, due to the interdisciplinarity of the Sciences applied to the Cultural Heritage, the articles thought for this blog include different topics: in this way, clarifying the complexity of this kind of studies with a simple language, it is possible attract a larger audience of interested and curious too.

In the blog are planned different kind of sections: first of all, general articles about the arguments related to chemistry, analytical techniques applied to artworks, colours and conservation of every type of material, from painting to bones. These topics are necessary in order to clarify the term "diagnostic" and explain the common techniques used for the analysis.

In addition to the previous one, it is planned a section titled "News in Diagnostic Word" where the recent investigations are presented, in order to show the progress into the research; this section is important to divulge and demonstrate the applicability of the science on the art materials and the incredible archaeometric information that may emerge employing the diagnostic approach.

Finally, the "Book&Art" section is focused on books reviews related to the world of art and, generally, about scientific subjects, aiming to impassion people at these topics.

Currently, the digital platform of "Research for Cultural Heritage" is managed by PhD students, Conservation Scientists and students of "Sciences applied to the Conservation of Cultural Heritage", animated by the passion for their work and for the research, willing to help the knowledge of a sector of science word yet almost unknown in Italy.

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Research for Cultural Heritage: http://researcheritage.blogspot.it/

The dyes of the ancients: a coloured approach for a didactic sequence in chemistry

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The project was born in the occasion of the *Notte dei Ricercatori* and was later developed in the frame of the *Piano Lauree Scientifiche (PLS) – Azione Formazione insegnanti* and, in this last context, includes a lecture and a practical activity in the laboratory.
The aim of the classroom-taught lesson is to introduce the topics that will be further developed during the experimental activity, presenting the types, the characteristics and the main properties of the most important natural dyes used in the past and the different procedures adopted for their application on textiles, depending on the dye (direct, mordant or vat) category.
The subject is particularly suitable for building a chemistry didactic sequence starting from the macroscopic concept of chemical substance (and, to follow, of chemical mixture), dealing with the atomic structure microscopic description, the concepts of chemical element, chemical interaction and chemical bond, the chemical formalism for naming of substances (chemical formula), ending up with chemical transformations and the concept of chemical reaction.
This sequence also represents an opportunity to face some food of thought on the general use of conceptual tags, on the importance of appropriating of and correctly using conceptual tags in the scientific language and on the difficulty of building formal concepts. This is particularly problematic in studying chemistry due to the continuous turnover, in the chemical line of reasoning, between different levels: not only from macroscopic to microscopic, but also to sub-microscopic and to figurative, without forgetting the influence of the previous (informal) knowledge on the process of building concepts, which often leads to the emergence of misconceptions (e.g. the concept of "natural").
Finally, the laboratory activities are devoted to:

i) the preparation of at least one dye bath for each dye category (direct, mordant and vat), recalling the concept of chemical transformations;
ii) the procedure of applying the different dyes on the textile fibres, focussing on the interactions (bonds) between the dye molecules and the textile substrate.

Interactive geo-educational tours with the app *Tourinstones* for the enhancement of ornamental stone materials employed in the centre of Turin (NW Italy)

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The links between construction stone materials, their geographical provenance, geological origin, physical and chemical properties, superficial finishing, the architecture and the history of a city or a region, are very interesting topics that need to be highlighted, with both students and tourists. The field of the Conservation Science crosses all these aspects and can be therefore useful for educate people about the architectural "geo-heritage", and its tangible and intangible value.

The Environmental education and research laboratory *GeoDidaLab* of the Earth Sciences Department of the Turin University is proposing educational tours in the centre of Turin (NW Italy) to high schools, in order to make students discover the most important lithotypes employed in the historical buildings and monuments of the city. A problem-posing problem-solving approach is applied, and explicit connections with the local environment are shown, in order to stimulate students' interests and curiosity (Magagna et al., in press; Dessart and Triquet, 2015).

The tour starts in Piazza C.L.N., where students (in groups) are asked to recognise different materials; they observe and touch, becoming familiar with the tangible aspect of stones, as well as with their different superficial finishes. Starting from the answers of students, a variety of informations are therefore given: the type and the genesis of the rocks, the state of preservation, the petrographic and commercial names, their importance for architecture and the choice of construction materials during different historical periods.

The tour continues in Piazza San Carlo, where students could observe the different degradation between the *Granito rosa di Baveno* and the white marble in the façade of the St. Carlo Church. *Granito rosa di Baveno* is observed throughout the tour in different stops, where the state of preservation linked with the exposure and the superficial finish is compared. Thereafter, students move towards St. Federico Gallery, in Via Roma, and, after some stops, in Piazza Carlo Alberto. Here they use *Tourinstones*, an application for smartphones that allows walking in the centre of Turin discovering Alpine rocks used in palaces and historical monuments. It consists of 26 historical sites of interest, where ornamental stones can be observed in detail. By a numbered list of stones, users can access specific data, such as quarry location, petrographic description and utilization in Turin. By merging the previous explanations with the information given by the app, each group of students investigates a specific rock of Palazzo Carignano and completes a form. At the end of the tour, each group expose its findings, by performing a guided visit to the entire class. This educational initiative is having positive feedbacks, since it allows high schools performing an interdisciplinary tour involving both Science and Art teachers. The interactive approach and the use of the app engage students and allows them to perform a similar visit by themselves in the future. For these reasons, the same strategy is going to be tested with university students. The dissemination of technical-scientific data about ornamental stone materials, combined with the cultural aspects of a territory, represents an innovative way for performing activities in line with the objectives of the Italian University "Third Mission" (Scamuzzi and De Bortoli, 2012).

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"Scheletri nell'armadio" - An interactive dissemination activity for kids and young students

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Human remains are unique items in the context of cultural heritage: they show very specific conservation requirements and often raise questions from an ethical, religious and social point of view. Nevertheless, they may be an incomparable source of information about people who lived in the past: they can reveal details about one single individual (sex, age at death, stature, pathological conditions or injuries, diet) [1] and sometimes provide clues about social organization, traditions and funerary practices.

Complete skeletons, bones and teeth are frequently found in archaeological sites, ancient cemeteries and churches: the search of an appropriate and effective way for their exhibit and the dissemination of related scientific data to the public is not always simple and, often, even a delicate topic of debate. Nowadays, photographic and photogrammetric techniques may be of great help in the development of good communication strategies for the involvement of broad audience and the planning of educational and dissemination activities.

In recent years, archaeologists discovered under the floor and in proximity of the cathedral of Alba, Piedmont, several burials dating back to 8^{th}-15^{th} centuries. Either complete or uncomplete skeletal remains were collected and studied by the researchers of the University of Torino, providing useful information about the local community in the city of Alba, during a long historical period [2].

In October 2016, thanks to the support of the Department of Life Sciences and Systems Biology of the University of Torino and the public authority (i.e. Soprintendenza archeologia, belle arti e paesaggio), the Association "Apriti Scienza" planned an interactive activity of dissemination mainly addressed to school groups (ages 7-18). This activity aimed to introduce scientific analyses usually carried out by anthropologists and archaeologists and the evidence provided by the study of human remains.

More specifically, three of the tombs from the site of Alba were selected (t.276, t.163, t.287): photos of all bones were taken; moreover, photogrammetry was performed on two male skulls coming from one of the tombs (t.276). This multimedia material was then arranged in order to be shown (with no conservation risks for the original skeletal remains) to kids and young students, together with the results of the scientific study carried out: the identity, age, health conditions and diet of the buried individuals were revealed.

This workshop, whose title is "Scheletri nell'armadio" (i.e. "Skeletons in the closet"), consisted also of a preparatory game, aiming to improve students' knowledge of human skeletons. In addition, all participants were guided to fill in an observation form, focusing on morphological features of bones.

"Scheletri nell'armadio" has involved around 1200 kids and students (ages 7-18) until now, mostly on the occasion of events such as "Festival della Scienza" (Genova, October 27^{th} – November 6^{th} 2016) and "#WikiMuseo" (Pinerolo, September 9^{th} 2017) and in some schools of Torino and surroundings.

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One day at the Abatellis museum in Palermo discovering the "Trionfo della Morte" fresco: "Arte è Scienza" confirms to be one of the best practice to diffusion of the scientific culture on CH field

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A photo of the laboratory session

The "Trionfo della morte", a detached fresco dated at the half of XV century, coming from Palazzo Sclafani (Palermo) and now exposed in the Abatellis Palace Regional Gallery - Palermo [1], has been focused during the exhibition Arte è Scienza promoted by AIAr, which involved simultaneously 13 sites in Italy.

This work of art has proven to represent a very effective example to demonstrate how useful and productive can be a scientific approach aimed to the dissemination and valorisation of the Cultural Heritage.

The large size of this wall paintings and the almost total absence of historical or artistic captions and conservative information creates in the observer, in front of this as well as many other typical examples of the Italian museum, a missed opportunity for improvement of knowledge at different levels or for specific targets.

This opportunity could today be recovered through the suggestions provide from the constituting materials and executive techniques to be obtained from scientific analyses useful if integrated with historical and artistic studies. This approach places the visitor in a constructive attitude in front of a work of art. The visitor participates in a (always) new discovery together with the conservation scientist that provides the interpretation of the analytical data, accompanying him in an experience that is very different from the traditional museum visit.

In the case of "Trionfo della morte" fresco the application of a multi-analytical non-invasive investigation has allowed several visitors to discover in real time some iconographic details no longer visible to the naked eye, to thinking about the use of pictorial materials for the complex wall painting and the choices of the artist, to mapping the precious "a secco" details. Moreover, the possibility to retrace the conservative history through the localization of the different pictorial integration methods permitted to highlight the complex history of the past restorations

X-Ray fluorescence analysis, FT-IR spectroscopy, UV-Vis spectrometry and multispectral imaging have been selected to show in integrated manner the possibility to obtain different information on the same investigated area of a art of work. This point of view has more clearly demonstrated as the radiation-matter interaction can allow to obtain beneficial information, giving the occasion to more easily explain principles of physics to people who normally do not have the opportunity to reflect on the practical aspects of applied sciences.

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INNOVAZIONE TECNOLOGICA

ORALI: ITEC-O

XRF Mapping, the experience from industry

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In recent years, commercial relatively compact macro-XRF scanners have become available, opening the way to a new research field and establishing the technique as one of the most powerful non-invasive method for the investigation of polychrome surfaces.
Chemical maps related to the elemental distribution within the analyzed area may provide crucial information for the definition of a proper conservation campaign. Moreover, the possibility to scan large surfaces with a reduced acquisition time allows a reliable documentation of the investigated artwork, reducing costs of the measurement and enlarging the number of possible applications.
In the presentation three important measurement campaigns are included highlighting different measurement challenges and different approaches developed in the gamma of products present in Bruker Macro XRF portfolio.
The products used are: ELIO, CRONO and Bruker M6 Jetstream that present key feature and portability differences resulting in specific and dedicated ways to address a measurement campaign.


In the images: ELIO, CRONO and M6 Jetstream

A non common excitation wavelength for Imaging

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The use of UV light (emission peak at 365 nm) to study objects of Art is in place since several decades, from the time the Wood light became available(1,2), recently other light sources were suggested (3,4)
to be used to generate Visible Induced Luminescence (VIL) , here we investigate the results using a source in the 440-460 nm range, not only capable to produce VIL images but also Visible Induced Fluorescence.
The chosen Wavelength is well known in the field of forensic investigations for its ability to detect organic and biological traces. (5)
The first results are encouraging further investigations, with a bigger interest on modern or contemporary Art, due to the organic and synthetic materials/pigments used by these.
The used source is based on filtered LED emitters, allowing a portable use (battery operated)
The novel light source could become an other useful tool in the Preventive Diagnostic, to better understand where, eventually, to perform a more specific or invasive test.

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Hyperspectral imaging on-site: world first portable push-broom hyperspectral camera

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Hyperspectral Imaging has gained a major role in several applications from research (food, environmental science, forensics, diagnostic for cultural heritage, microbiology, etc.) to on-line quality control and process monitoring in industry (in sorting in food or waste, pharmaceutics, chemicals, mining, on-line quality control, etc.).
Compared to more familiar black and white or RGB–imaging it provides more detailed chemical, physical and biological information.
Push-broom instruments are based on matrix camera and spectrograph to form a line imaging device where one axis of the detector registers spatial position from a line and the other axis spectral information in each spatial position. This assures that resulting spectrum is perfectly co-registered so that all spectral bands are measured simultaneously and from the exactly same sample position.
Current main competing technologies are tunable filter, variable filter instruments and multispectral sensors. All of them suffer from difficulty in getting co-registered spectrum and/or wasting most of the illumination energy due to operation principle. Co-registration problems lead to difficulties in data processing, unreliable spectral signatures and delayed processing results.
What push-broom technology has suffered up to now was the lack in portability (need to scan, size and weight), which makes hyperspectral cameras uncomfortable to be used on site.
Specim has recently launch a new hyperspectral imaging push-broom camera which is really portable, hence enabling users to perform hyperspectral measurements where it is needed and to analyse data and to get results immediately.
We will go through a little hyperspectral imaging basic theory showing the difference between this technique and similar ones; pros and cons related to the use of a reflective or transmissive imaging spectrograph within the push-broom technique; the technology behind the new Specim IQ hyperspectral portable camera.

Climate monitoring systems for the conservation of cultural assets

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Microclimatic conditions to which materials are subject are strictly linked to physical, chemical and biological processes influencing their deterioration. For this reason, monitoring the quality of the environment surrounding the artwork enables you to identify potentially harmful situations for materials and thus to optimize ambient conditions suitable for conservation. The Wi-Fi monitoring system testo 160, manufactured by the German company Testo SE & Co. KGaA has been specifically designed for museums, libraries and historical archives. It combines in one product a very high level of technology, simplicity, modularity and camouflage.

References

Raman spectroscopy latest techniques in archeological and historical artifacts studies

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Physical and chemical characterization of the materials employed in the works of art, from the original constituents to the degradation products, is becoming and essential tool in the hands of the restoration operator. For more than a decade Raman Microscopy has been playing a major role in this field, due to its characteristics: it is a non-destructive and fast technique, does not need sample preparation and with the aid of optic fibres has met the increasing demand of portability.

To meet the operators' wishes, Renishaw has responded to growing demand of accessories and combined techniques in a multi-analytical approach necessary for the full understanding of the nature of the material. Beside the more traditional Raman microscopy-based techniques, we want to present here how technology innovations in Raman instruments can be applied to the word of art and restoration; various examples will be given to illustrate the advantages of the technique.

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