



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

DEPARTMENT
OF GEOSCIENCES

PROGRAMME 3 **SELF-ASSESSMENT**

coordinator: G. Molin

	PROGRAMME 3
3.1	Title
	Mineralogy, petrography and geophysics applied to cultural heritage
3.2	Objectives and aims
	This program is particularly relevant since some of the disciplines of Earth Sciences have a fundamental role in the Cultural Heritage studies. In particular, these studies focus on the characterisation of the raw materials and their products (therefore with advances in the mineralogical, petrographic and geochemical fields) and the study of shapes, attitude and the structural features using geophysical methods. Some activities on Cultural Heritage started in the 80s, but research became extremely active in the last decade, thanks to funding for research and for PhD and scholarships grants. Moreover, a new teaching activity started in 2001, with the new degree course in “Science and Technology for the Cultural Heritage” at the Faculty of Sciences at the University of Padova and coordinated within the Department of Mineralogy and Petrology. This activity added up to the more traditional teachings, held by part of the body of the Department, within some Humanistic degree courses. In addition, in 2004 the specialised degree in “Science and Technology for the Archaeological and Artistic Heritage” in the Faculties of Sciences, of Arts and Philosophy, and of Engineering was also set-up. Finally, in 2005 a new PhD programme in “Study and Preservation of Archeological and Architectonical Heritage” started, the scientific course of study of which is coordinated within the Department of Geosciences. Therefore, a new bright research activity applied to the Cultural Heritage and based on the criteria and methods used in the basic research in Earth Sciences, established. Of particular importance was the scientific and methodological experience acquired by researchers in the basic research program. Studies on artefacts of archaeological and/or historical and artistic interest were positively influenced by the naturalistic-geological setting posed by the researchers: this particular approach, traditionally focusing on interpretation of the formation of solid phases and relative transformations with changing thermodynamic and kinetic environmental conditions, was particularly valid in achieving the aims described below. In this context, geophysical prospection is an effective supporting tool to the classical investigation techniques mentioned above, as they represent an innovative contribution in their capability of investigating in a “non-invasive” manner bodies and structures at different spatial scales, both in the field of archaeology and in the conservation of structures having historical, artistic and architectural value. The aims of this program are: archaeometry, conservation and geophysical prospection. The former aims at acquiring, on the basis of materials analysis, information regarding the cultural complexity of the ancient world in which artefacts were produced and marketed: it is possible to acquire information on technological knowledge and the socio-economic level of peoples producing and exploiting such objects. The conservative line aims at determining, through the materials and alteration products characterisation, the most suitable operations of conservative restoration and conservation microclimate. Geophysical methods aim at characterizing, through non invasive measurements of physical properties, the structure under investigation, and their variations, savings in time and costs. This type of method is therefore a fundamental starting point both in archaeological prospection and in the conservation of artefacts. In this field, in addition to classical investigation methodologies, was used non destructive geophysical measurements (geolectrical, seismic, GPR, thermographic

	and electromagnetic investigations). As regards type of materials, particular attention is devoted to stone artefacts, composite objects, such as types of mortar and frescoes, and artefacts resulting from thermal transformation, such as ceramics, glass and metal, both in relation to the finished products and to waste products and working discards, which are important markers in archaeometrical study. A particular research field deals with biologic origin materials, such as bone and ambers, and their transformation processes in pedo-geological environments. The specific aims of the Program, generally applicable to the materials studied in the various research lines, are: - identification of raw materials and their sites of provenance; - determination of their production technology, also with the help of experimental simulations; - analysis of alteration processes studying the decay products and, when possible, processing of a suitable model; - identification of buried structures and possible anomalous bodies or cracks in a single artefact.
3.3	Research lines
3.3.1	Line 1: Archaeological materials produced by heat transformations: a) glass, b) metal, c) pottery
	a) Research on glass focuses on the following aspects: - Archaeometric characterisation of glass from several archaeological sites in Italy, dated from the Bronze Age to the First Iron Age. The results obtained on glass from the Early [refs. 40, 61] to Late Bronze Ages [refs. 37, 54] allow new hypotheses to be proposed concerning the introduction and development of glass-making in the Bronze Age, through definition of new classes of types of glass and faïences [refs. 49, 69] having specific compositions and allowing direct correlations with materials of Mediterranean or Central European origin [refs. 39, 43, 45]. - Archaeometric characterisation of Roman-medieval glass from Italian area. Aims are the identification, where possible, of production sites, characterised by different melting and working techniques and the use of specific raw materials, and also identification of major trade routes of raw materials, raw glass and finished articles. Study of Roman and Medieval glass fragments indicate routine glass production processes each time from whichever archaeological site the specimens come [refs. 15, 18, 23, 38, 70]. The combined approach involving analytical statistical and archaeological evidence provides that in Roman period colourless glass was produced by at least two different production methods related to group type [ref. 53] and recycling was practised only for coloured glass. The identification of a change in “glass recipe” from the IX century AD onwards was also identified [refs. 18, 23, 53, 70] and the study of production technologies has led to the experimental production of glass with sand from the Campania littorals demonstrating the reliability of sources (e.g., Pliny the Elder) [refs. 32, 70]. The last subject, heatedly debated in the archaeometric field, opens different perspective as regards production and trade of glass in the Mediterranean area. - Study of mosaic glass tesserae of the palaeo-Christian sacellum of St. Justine (Padova) which represent one of the two palaeo-Christian mosaic cycles of the Veneto. Particular attention was devoted to identification of glass chemical composition and colouring,

	decolourising and opacifying agents, in order to relate the chromatic and optical aspects of the single tesserae. - Parameterisation of alteration processes due to interactions with the environment. In particular study of the glass alteration products in marine environment indicates a relationship between their chemical composition and alteration morphologies [refs. 15, 18, 22, 70]. It was proved that glass/water exchange may be very fast at the temperature of Adriatic sea bottom and equilibrium is reached in less than two thousand years [refs. 11, 18, 70]. b) Research on metals focuses on the following aspects: - The archaeometallurgical research in the last few years focused on: development and diffusion of the very early copper metallurgy in the Alpine area; evaluation of the metallurgical and pyrotechnological knowledge linked to the transition from pure copper to the early copper alloys in Northern-Central Italy; and the tracing of metal diffusion and trade in protohistoric times. The wide-ranging investigation encompassed: (i) the revision and characterization of all archaeological evidences of ore mining and copper smelting in Northern-Central Italy from the Late Neolithic to the Early Bronze Age. All reported occurrences of smelting slags have been re-studied and interpreted [ref. 64]. (ii) the creation of a copper-ore database useful for provenancing studies. Advanced provenancing methodologies based on PCA/discriminant analysis and based on multiple isotopic and chemical tracers have been developed and applied to key studies [refs. 46, 67]. The project is now to be extended to the EU level within a JRA activity aimed to create a network of analytical laboratories sharing common protocols for the measurement and interpretation of ancient metals, starting from the specific focus on prehistoric copper. The activity will also produce a core database of chemical and isotopic parameters for the copper mines. This is a fundamental frame to interpret the provenance and metal-production processes of prehistoric copper metallurgical evidence (slags and metal objects). (iii) the design and carrying out of experimental copper smelting from primary sulphides and secondary copper ores. The laboratory and field experiments aims to the interpretation of copper extraction processes, the measurement of element partition coefficients between metal and slags under different furnace conditions, and the reproduction of archaeological smelting slags [ref. 35]. (iv) the extensive characterization of numerous metal finds dated from the Late Neolithic to the Final Bronze Age, obtained by a combination of metallography, chemical and mineralogical analysis. The early development and subsequent diffusion of arsenical bronzes [ref. 60], multielemental alloys obtained by polymetallic fahlerz ore minerals [ref. 66] and of tin bronze [ref. 62] have been investigated as a function of the age, the typology and the diffusion area of the different objects. (v) the archaeometallurgical investigation of all metal working and alloying products (crucibles, metal scraps, metal drops, ingots and metal objects) coming from a same, well selected, site. The obtained data are important to the understanding of the metallurgical skills of the period [refs. 36, 63]. (vi) the optimization of non-destructive metallographic techniques based on neutron diffraction texture analysis for the reconstruction of manufacturing processes of copper metal objects. The technique has successfully been applied to a number of prehistoric copper axes [refs. 56, 65]. - The archaeometric study of a considerable amount of bronze objects in the pre-roman north-eastern Italian context of Frattesina (RO), in the Po river delta area (1200-800 BC) allowed the reconstruction of the metallurgical production and to hypothesize some
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	possible routes of raw materials [ref. 55]. Compositional results revealed extended availability of tin, at least the use of two different copper ore sources for the production of the tin bronzes and the use of a copper-arsenic alloy for producing traditional tools as the socket shovels. Tuscany appear as one of the strongest trade partner of the Frattesina site, particularly for the production of the pick ingots. The microstructural characterization showed a wide range of textures and, generally, a low quality metallurgical manufacturing. In particular, the socket shovels seemed to be manufactured through casting directly on a mould without shaping. EBSD analysis, applied to a tweezer and a chisel, permitted the development of the textures mapping, including grain boundary characterization, texture characterization, twin boundary characterization and the determination of the deformed/recrystallized volume fraction. The isotopic characterization of three pick ingots, two lead ingots and an arsenical bronze socket shovels, suggested the existence of two reasonable trade route leading Frattesina to Tuscany and Sardinia [ref. 55]. - Chemical, metallographic and isotopic investigations on finished bronze artifacts (plaques and votive discs), semi-worked materials and a lead ingot coming from the sanctuary of Mt. Calvario (Auronzo, Belluno) provided evidence of metallurgical activity and metal trades in the northern boundary of the Venetic-Roman area (II B.C – I A.D.) [refs. 10, 24]. - Chemical and isotopic studies of a roman lead coffin and inscriptions as cover lead of domes of the Basilica di S. Giustina (Padova), as the mineralogical study of alteration products allows to acquire information on the history of the believed tomb of St. Luke the evangelist [refs. 4, 6]. - An archaeometric characterization of slags, founded at the site of Tell Shiukh Fawqani (Northern Syria) and belonging to the Iron Age, were performed with the aim of investigate the presence and type of metallurgical activity in the area. Results proved the existence of refining processes at the site, rather than reduction processes and described the site as a centre of minor metallurgical importance [ref. 2]. - the nature of glass fragments containing metallic spherule inclusions found over a relatively large area in Bavaria (Germany), was ascribed to cast iron slag ruling out the hypothesis of their extra-terrestrial origin (pseudomoldavite) [ref. 34]. c) Research on pottery mainly focused on the following three aspects: (i) archaeometric characterisation of pottery for provenancing and technological studies; (ii) precipitation of secondary phases in pottery in relation to burial environment; (iii) modelling of firing process of clay materials. i) Provenance and technology of production were assessed for the pottery collected in numerous archaeological sites dated from Early Bronze Age to Roman Time, both in Italy (Veneto region [refs. 51, 52]) and abroad (Syria, Saudi Arabia), by analysing mineralogy, petrography, microstructure and chemical composition, and applying adequate multivariate statistical tools. Iron Age pottery from a number of different localities in the Veneto region, resulted to be generally locally produced, with important differences in the firing technology among the various sites, also for pottery so-called of Etruscan-Padan type [refs. 3, 12, 14, 21]. <i>Olla</i>-shaped vessels of Roman Time from the excavation area of the Via Neroniana (Montegrotto Terme, Padova, north-eastern Italy) resulted to cluster into two groups of local origin and one of imported pottery, indicating that extensive trade between various geographic areas also existed for pottery for everyday use [ref. 48]. The archaeometrical study of transport amphorae from Concordia Sagittaria, Padova and Aquileia (north-eastern Italy), dated from the I c. B.C. to the II c. A.D., allowed drawing the main trade lines in the Middle and Northern Adriatic Sea.
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	The archaeometrical characterisation of the Bronze Age and Iron Age pottery from Tell Mishrifeh/Qatna (Syria) showed a variety of petrographic groups and technological aspects, suggesting different recipes which turned out to be related to social and political changes. The studied potsherds are consistent with a local production, with only a few cases of possible similarities with those described for other localities along the Orontes Valley, and in a couple of cases with evidence of pottery exchange with the site of Tell Mardikh/Ebla [refs. 20, 68]. The analysis of kilns also provided the first archaeomagnetic directional data from Syria [refs. 33, 68]. ii) Petrography, microtexture and chemical composition of secondary phosphates, such as vivianite and mitridatite, in Iron Age pottery from Adria and Frattesina (Veneto region, north-eastern Italy), were used for monitoring changes in the environmental conditions after burial. In particular, slag, iron flakes, charcoal, ash, decaying organic matter and depth of burial locally controlled pH, Eh and groundwater composition [ref. 13]. iii) The effect on ceramic products of firing conditions in the presence of abundant organic matter was assessed. Interestingly, in kiln-firing conditions, sandwich structures formed in the ceramics, indicating that reducing conditions occurred in the core, and suggesting sluggish oxygen diffusion within the pottery [ref. 31]. Firing experiments have been also carried out on a clay containing naturally occurring fragments of mollusc shell, revealing systematic changes in the internal microstructure of the shell fragments. Therefore, the analysis of these microstructural features in archaeometric studies offers a good constraint on the estimation of the firing temperature in shell-bearing pottery [ref. 58]. The evolution of iron-bearing phases in the firing of carbonate-rich illite and chlorite clay was also studied, suggesting that changes in physical properties such as pottery colour seem to be related to the microstructural location and grain-size of hematite particles and to the presence of iron in glass rather than in Ca-silicate phases [ref. 59].
3.3.2	Line 2: Raw materials: rocks, mortars, plasters and pigments
	The research activity carried out within this line focused on: 1) Study on the Roman gravestones from Aquileia (Udine, Italy). Roman gravestones from Aquileia, made of limestone, quarried from the sedimentary sequence of the Trieste Karst (Carnican Alps, northeastern Italy), were studied by means of a multi-analytical approach, showing that in Roman Republican time the quarrying of stone suitable for preparing tombstones at Aquileia was limited to a restrict stratigraphic level, comparable with that of the upper part of the 'Roman Quarry' at Aurisina. [ref. 1]. 2) Trachyte pavings in salt-controlled weathering conditions. The main properties of trachyte slabs employed as paving in common pedestrian roads and pavements in salt-controlled weathering environment were assessed experimentally. Results showed a strong control of rock petrography and microtexture on weathering rate [ref. 29]. 3) Recognition of the painting technique by a microtextural approach. This study allowed distinguishing buon fresco and secco fresco painting techniques on the basis of microtextural features observed under optical and electronic microscopy [ref. 25]. 4) Microstratigraphic study on Roman plasters, paints and pigments from Montegrotto Terme (Padova) [ref. 47] and Pompeii. This research permitted to recognise the microstratigraphy and define the composition of aggregates and their relation with the binder. Recipes used for the production of the plasters resulted to be correlated to the age of the building phase. Moreover, microstratigraphy indicated that paintings were made with a buon fresco technique.
3.3.3	Line 3: Geophysical survey in archaeological areas

	One of the most traditional activities of the Department is the use of geophysical prospections in the Cultural Heritage field. It has been known for years how joint use of various geophysical techniques can provide to the archaeological community detailed information about the anthropic structures of the earth's subsurface. The recent introduction to the market of instruments allowing a consistent increase in resolution factors and survey speed, presents an opportunity to verify the full adaptability for the requirements of modern archaeology [refs. 17, 42]. Several instrumental configurations and the most up-dated geophysical methodologies have been tested in the framework of the following projects in co-operation with the Department of Archaeology in Padua: Montegrotto-Terme 2003-05 [refs. 28, 57], Kemerhisar-Tyana (Turkey) 2003 [refs. 9, 19] and Loron (Parenzo, Croatia) 2003-05 [ref. 26]. In order to check new devices, researches have been carried out in the following sites: Lonato-Pozze (Bs) in co-operation with the Soprintendenza Archeologica della Lombardia (2004) [refs. 16, 27] Tell Mishrifeh-Qatna (Siria), in co-operation with the Dipartimento di Storia e Tutela dei Beni Culturali of the University of Udine (2005), Grumentum (Pz), in co-operation with the Dipartimento di Discipline Storiche, Artistiche, Archeologiche e Geografiche of the University of Verona (2006) and Este, in co-operation with Dipartimento di Fisica, Università Roma 3 and Soprintendenza Archeologica del Veneto. For each one of the cases the data processing has been carried out, with achievement of dedicated software for processing and graphic pointing out of the results, subjects of presentations in some national and international meetings and of some publications.
3.3.4	Line 4: Biomineralogical investigations
	Two type of biological-derived materials were investigated: human bones, coming from tombs of historical relevance, and amber. a) The studies carried out on tombs consider the bones as the other findings described in the Research lines 1, 2, 3. The objects of the research are both archaeometric and conservative, according mainly with the problems of the peculiar case. Investigation on the tomb: - Tomb of St. Luke: a minero-crystallographic and geochemical-isotopic study on the coffin and skeleton which, according to ancient tradition, is that of St. Luke Evangelist, in the Basilica of St. Justine was undertaken [refs. 5, 7, 8]. The work aims at reconstructing historical events by characterizing the finding in question. b) Amber Ambers of several Italian deposits have been characterized for the first time. The research aims to create a database of European ambers containing both FTIR and DRIFT data [refs. 30, 41]. The FTIR spectra are easily comparable with the data commonly available in literature, whereas DRIFT analyses are shown to be more useful to characterise the archaeological finds. The provenance archaeological ambers from different Italian sites, dating from the Middle Bronze Age to the Iron Age, have been assessed based on the developed database. The results show that, although the amber have mainly Baltic origin, a minor amount of different amber types is used, depending on the age and the site studied [refs. 39, 45, 30, 41, 44, 50].
3.4	Human resources
	Molin Gianmario – Full Professor

	Artioli Gilberto – Full Professor (Partially) Mazzoli Claudio – Associate Professor Salviulo Gabriella – Associate Professor Zaja Annalisa – Associate Professor Finzi Ermanno – Assistant Professor Maritan Lara – Assistant Professor Ph.D. and post-graduate students: A. Silvestri, I. Angelini, S. Benchiarin, M. Giannetta, R. Piovesan, S. Tonietto, L. Vettore, F. Zaghis.
3.5	Financial resources
	See attachment DG 1.7
3.6	Links with other public or private organizations at local, national and international level
	Main collaborations with national institutes: Università della Basilicata - Dipartimento di Scienze Storiche, Linguistiche ed Antropologiche Università Sannio, Benevento - Dipartimento di Studi Geologici e Ambientali Università di Udine - Dipartimento di Storia e Tutela dei Beni Culturali Università di Verona - Dipartimento di Discipline Storiche, Artistiche, Archeologiche e Geografiche Università di Padova - Dipartimento di Scienze Chimiche Università di Padova - Dipartimento di Archeologia Università di Padova - Dipartimento di Architettura, Urbanistica e Rilevamento Università di Padova - Dipartimento di Innovazione Meccanica e Gestionale Università di Milano - Dipartimento di Scienze dell'Antichità Università di Siena - Dipartimento di Scienze della Terra Università di Siena - Dipartimento di Archeologia e Storia delle Arti Università di Parma - Dipartimento di Scienze della Terra CSG Palladio, Vicenza Soprintendenza Archeologica per le province di Cagliari e Oristano Soprintendenza per Beni Archeologici di Sassari e Nuoro Soprintendenza per i Beni Archeologici della Provincia Autonoma di Trento Soprintendenza per i Beni Archeologici del Piemonte Soprintendenza Archeologica per il Veneto Soprintendenza Archeologica per il Friuli Venezia Giulia Soprintendenza Archeologica per le Province di Napoli e Caserta Soprintendenza al Patrimonio storico artistico e etnoantropologico per le province di Venezia, Belluno, Padova e Treviso Ufficio Beni Archeologici, Provincia Autonoma di Bolzano Comitato Scientifico Iulia Felix Progetto Arte Poli s.r.l., Verona Veneranda Arca di S. Antonio Istituto Italiano di Preistoria e Protostoria Main collaborations with international institutes:

	University of Glasgow (UK) - Department of Archaeology University of Cardiff (UK) - School of History and Archaeology University of Berlin (Germany) - Department of Archaeology Direzione Generale delle Antichità e dei Musei (Siria) Fitch Laboratory, British School at Athens (Greece) Supreme Commission for Tourism (Arabia Saudita) Centre de Recherche et de Restauration des Musees de France, (Louvre, Paris)
3.7	Other activities relevant for the research lines <u>Invited seminars</u> 1) December 2004 Udine (Italy). Title: "Archaeometrical study on Bronze and Iron Age pottery from Tell Mishrifeh/Qatna and archaeomagnetic data", International Congress "Urban and Natural Landscapes of an Ancient Syrian Capital. Settlement and Environment at Tell Mishrifeh/Qatna and in Central-Western Syria" (<u>C. Mazzoli</u>) 2) May 2005 Padova Istituto Tecnico Industriale "G. Natta" Title: "Il vetro dal periodo Romano al Medioevo: tradizione o innovazione?" (<u>A. Silvestri</u>) 3) April 2006 Università di Padova . Title: "La produzione primaria del vetro in area mediterranea: uno o più siti produttivi a partire dal I secolo? Risultati di un'indagine filologico-archeometrica" within "Ciclo di seminari di Archeologia della produzione" (<u>G. Molin</u>) 4) April 2006 Università di Padova Title: "Il processo di alterazione nei vetri archeologici in contesti subaerei e marini: il caso della Iulia Felix" within "Ciclo di seminari di Archeologia della produzione" (<u>G. Salviulo</u>) 5) April 2006 Università di Padova Title: "Il vetro: struttura, materie prime ed evoluzione delle tecniche produttive del periodo romano al medioevo. Studio archeometrico di reperti di area italiana" within "Ciclo di seminari di Archeologia della produzione" (<u>A. Silvestri</u>) 6) December 2006 Berlin (Germany). Title: "Contribution of Scientific Analyses to the Study of Near Eastern Pottery: A Methodological Perspective" International Congress "Recent Trends in the Study of Late Bronze Age Ceramics in Syro-Mesopotamia and Neighbouring Regions" (<u>C. Mazzoli</u>) 7) December 2006 Bohinj – Slovenia. Title: "Roman glass: raw materials and production technology: an experimental and philological study", 2nd International Conference "Management of Cultural and Natural Heritage and former mining sites" (<u>A. Silvestri</u>) 8) February 2007 Padova. Title: "Anfore da olio e anfore da pesce adriatiche: le analisi archeometriche" at the conference "Olio e pesce in epoca romana: produzione e commercio nelle regioni dell'Alto Adriatico" (<u>L. Maritan</u>)

Organization activity, Conferences, School

Internationalisation of training for research

Memberships of scientific committee and organizations

January-December 2006. Scientific leader of the project “L’inizio della metallurgia nell’area alpina: studio analitico delle evidenze archeologiche dell’Italia del Nord”. Progetto Galileo 2006/2007, founded by Università Italo-Francese. Cooperation with David Bourgarit, head of the Metal group in the Centre de Recherche et de Restauration des Musées de France (C2RMF, Louvre, Paris) (**G. Artioli**)

August 2006. Promoter and vice-chairman of micro-symposium on “Crystallography in art and archaeological sciences”. 23rd European Crystallographic Meeting, Leuven (Belgium), 6-11 August 2006. (**G. Artioli**)

September 2006. Promoter and vice-chairman of micro-symposium on “Powder diffraction in the cultural heritage and forensic sciences”, 10th European Powder Diffraction Conference, Geneva (Switzerland), 1-3 September 2006. (**G. Artioli**)

November 2006-November 2009 - Principal investigator of the project “Prehistoric pyrotechnology: insights on hominid behaviour from high resolution study of combustion features”, founded by EU (FP6-2005-Mobility-6) within Marie Curie International Outgoing Fellowship (OIF). Cooperation with Paul Goldberg (University of Boston) (**G. Artioli**)

March 2007-August 2007. Conservation Guest Scholar, The Getty Conservation Institute. (**G. Artioli**)

2006-present. Coordinator of the section in “Science and Technology for the Archaeological and Architectural Heritage” of the PhD Programme for the Study and Conservation of the Archaeological and Architectural Heritage (University of Padova). (**G. Molin**)

2002-2006. President of the first cycle degree course in “Sciences and Technologies for the Cultural Heritage” and of the second cycle degree course in “Science and technology for archaeological and artistic heritage”. (**G. Molin**)

Scientific leader for the Paduan research group in the project PRIN 2004, covering archaeometric topics (geomaterials, production technologies, socio-economic aspects, alteration processes, and conservation strategies) (**G. Molin**)

Peer reviewing

Reviewers for the following international journals:

Applied Clay Science, Microchimica Acta, Archaeometry, Journal of Archaeological Science

3.8

Research products

Summary of research products

	2003	2004	2005	2006	2007	Total
A1	1	5	5	3	4	18
A2	0	0	1	2	2	4
B2	0	1	0	3	0	4
D	9	2	5	17	9	42
Total	10	8	11	25	15	

List of research products

- 2003 A1 MARITAN L., MAZZOLI C., MELIS E. (2003). MULTIDISCIPLINARY APPROACH TO THE CHARACTERISATION OF ROMAN GRAVESTONES FROM AQUILEIA (UDINE, ITALY). *ARCHAEOMETRY*, 45, 3, 363-374.
- 2004 A1 LONGINELLI A., SILVESTRI A., MOLIN G., SALVIULO, G. (2004). 1.8 KA OLD GLASS FROM THE ROMAN SHIP "JULIA FELIX": GLASS-WATER OXYGEN ISOTOPE EXCHANGE. *CHEMICAL GEOLOGY*, 211/3-4, PP. 335-342.
- 2004 A1 MARITAN L. (2004). ARCHAEOMETRIC STUDY OF ETRUSCAN-PADAN TYPE POTTERY FROM THE VENETO REGION: PETROGRAPHIC, MINERALOGICAL AND GEOCHEMICAL-PHYSICAL CHARACTERISATION. *EUROPEAN JOURNAL OF MINERALOGY*, 16, 297-307.
- 2004 A1 MARITAN L., MAZZOLI C. (2004). PHOSPHATES IN ARCHAEOLOGICAL FINDS: IMPLICATIONS FOR ENVIRONMENTAL CONDITIONS OF BURIAL. *ARCHAEOMETRY*, 46, 673-683
- 2004 A1 NODARI L., MARITAN L., MAZZOLI C., RUSSO U. (2004). SANDWICH STRUCTURES IN THE ETRUSCAN-PADAN TYPE POTTERY. *APPLIED CLAY SCIENCE*, 27, 119-128.
- 2004 A1 SALVIULO G., SILVESTRI, A., MOLIN G., BERTONCELLO R. (2004). AN ARCHAEOMETRIC STUDY OF THE BULK AND SURFACE WEATHERING CHARACTERISTICS OF EARLY MEDIEVAL (VTH-VIITH CENTURY) GLASS FROM THE PO VALLEY, NORTHERN ITALY. *JOURNAL OF ARCHAEOLOGICAL SCIENCE*, 31/3, 295-306.
- 2005 A2 FINZI E., MAZZOCCHIN S. (2005). UN'OASI ROMANA IN CAPPADOCIA. *ARCHEO. VOL. XXI-5*, 58-65.
- 2005 A1 MARITAN L., MAZZOLI C., MICHELIN V., MORANDI BONACOSSI D., LUCIANI M., MOLIN G. (2005). THE PROVENANCE AND PRODUCTION TECHNOLOGY OF BRONZE AGE AND IRON AGE POTTERY FROM TELL MISHRIFEH/QATNA (SYRIA). *ARCHAEOMETRY*, 47, 723-744.
- 2005 A1 MARITAN L., MAZZOLI C., NODARI L., RUSSO U. (2005). SECOND IRON AGE GREY POTTERY FROM ESTE (NORTH-EASTERN ITALY): STUDY OF PROVENANCE AND TECHNOLOGY. *APPLIED CLAY SCIENCE*, 29, 31-44.
- 2005 A1 SILVESTRI A., MOLIN G., SALVIULO G. (2005). ARCHAEOLOGICAL GLASS ALTERATION PRODUCTS IN MARINE AND LAND-BASED ENVIRONMENTS: MORPHOLOGICAL, CHEMICAL AND MICROTEXTURAL CHARACTERISATION, *JOURNAL OF NON-CRYSTALLINE SOLIDS*, 351, 1338-1349.
- 2005 A1 SILVESTRI A., MOLIN, G., SALVIULO G. (2005). ROMAN AND MEDIEVAL GLASS FROM THE ITALIAN AREA: BULK CHARACTERISATION AND RELATIONSHIPS WITH PRODUCTION TECHNOLOGIES, *ARCHAEOMETRY*, 47/4, 797-816.
- 2005 A1 ZAGHIS F., MOLIN G., SALVIULO G., CALLIARI I., RAMOUS E., GANGEMI G. (2005). A NEW SETTING FOR THE NORTHERN BORDER OF THE VENETI: METALLIC FINDS FROM THE VENETIC SITE OF MONTE CALVARIO, AURONZO DI CADORE. *ARCHAEOMETRY*, 47, 341-349.
- 2006 A1 MARITAN L., NODARI L., MAZZOLI C., MILANO A., RUSSO U. (2006). INFLUENCE OF FIRING CONDITIONS ON CERAMIC PRODUCTS: EXPERIMENTAL STUDY ON CLAY RICH IN ORGANIC MATTER. *APPLIED CLAY SCIENCE*, 31, 1-15.
- 2006 A1 SILVESTRI A., MOLIN, G., SALVIULO G., SCHIEVENIN R. (2006). SAND FOR ROMAN GLASS PRODUCTION: AN EXPERIMENTAL AND PHILOLOGICAL STUDY ON SOURCE OF SUPPLY, *ARCHAEOMETRY*, 48/3, 415-432.
- 2006 A1 SPERANZA F., MARITAN L., MAZZOLI C., MORANDI BONACOSSI D., D'AJELLO CARACCILO F. (2006). FIRST DIRECTIONAL

			ARCHAEO-MAGNETIC RESULTS FROM SYRIA: EVIDENCE FROM TELL MISHRIFEH/QATNA. GEOPHYSICAL JOURNAL INTERNATIONAL, 165, 47-52.
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