

**WYDZIAŁ CHEMII**

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ANNUAL INTERIM REPORT**NAWA-Canaletto Program PPN/BIL/2018/2/00088*****Multianalytical approach for the dating and authentication of archaeological ceramics***

This report covers the results of bilateral exchange of scientists under the Canaletto Program (*Multianalytical approach for the dating and authentication of archaeological ceramics- Ref. No. PO19MO04*) performed in the last years, 2020 and 2021.

The main goal of the project is the development of a multianalytical protocol for the characterization of archaeological ceramics (from underwater and underground site), able to distinguish original and false objects starting from the knowledge of various objects of the same archaeological site.

Six participants between Professors, researchers and Ph.D students are involved in the Project. In details:

- Prof. Prof. Eugeniusz Zych, University of Wrocław, Faculty of Chemistry (Wrocław, Poland)
- Ms. Małgorzata Sójka, University of Wrocław, Faculty of Chemistry (Wrocław, Poland)
- Prof. Maria Luisa Saladino, University of Palermo, STEBICEF Department (Palermo, Italy)
- Prof. Eugenio Caponetti, University of Palermo, STEBICEF Department (Palermo, Italy)
- Dr. Francesco Armetta, University of Palermo, STEBICEF Department (Palermo, Italy)
- Miss Veronica Ciaramitaro, University of Palermo, STEBICEF Department (Palermo, Italy)

During the 2020 and 2021, due to the **COVID-19 Pandemic**, some **meetings** were organised via webconferencing, to continue the started research work made in cooperation in 2019, even if with some problems due to the difficulty in exchanging of ceramic samples. The scope of the meetings were the discussion in the obtained data and about the finalisation of the goal of the research.

However, for the same reason, the visits planned in 2020 and the relative activities in presence were not performed on scheduled time.

The visits of some participants took place only at the end of 2021 as following:

4-14 November 2021, Ms. Małgorzata Sójka, Visit to University of Palermo

4 November-5 December 2021, Prof. Eugeniusz Zych, Visit to University of Palermo

2-12 December 2021, Ms. Veronica Ciaramitaro, Visit to University of Wrocław

2-30 December 2021, Prof. Maria Luisa Saladino, Visit to University of Wrocław

In details, the meetings were finalised to plan the experiments, to discuss the obtained data on ceramics from underwater and underground, in both Institutions (X-ray Fluorescence data, X-ray diffraction patterns, Thermoluminescence data and treatments with gamma-rays, X-rays, Visible light as the function of temperature).

Data were compared with the studies already reported in the scientific literature on lab-synthesized materials in order to verify the agreement with the state of art and to assume some improvement in the methodology of data analysis.

The visits of the participants have been useful to exchange the idea about the scientific research.

In particular, for the **young researchers** they were key points in their formation because they allowed for practical learning how to approach to the best practices of the research in the field of Archeometry with its specificity and originality. They had the possibility to share knowledge and experience in the field of Archeometry, not only related to this Project but also about their personal experience and skills.

Discussions were also devoted to the best practices to collect the data in a non invasive approach, due to the unicity of the archeological artefacts.

During the visit at University of Palermo **Ms. M. Sójka** learned the fundamentals and the practices about the IR and microIR Spectroscopy of pigmented ceramics. That was fully new experience for her and greatly broadened her skills in materials investigation.

During the visit at University of Wrocław **Ms V. Ciaramitaro** learned the fundamentals and the practices about the Photoluminescence (PL) and Thermoluminescence (TL) techniques. Also for her these were new techniques to learn.

During the **training in laboratory**, before starting with the experiments, the young researchers received a deep training and instruction about the equipments (sources, detectors, dedicated software and so on) and the software management, to learn the best practices for the acquisition of spectra and their evaluation and understanding the information they carry.

Some meetings have also been devoted to the use of external radiations (X-rays, gamma rays and beta particles) to obtain a set of TL spectra, useful for the determination of the archaeological dose, following the traditional methodology of analysis for the investigation of the archaeological ceramics by TL technique. Some details about the security procedures have also been presented and clarified. In fact,

the use of ionising radiations follows a specific protocol and proper training was given to the all participating researchers.

Dissemination

Two seminars of 1 hour each have been given to Professors, researchers, post-Docs, Ph.D students and Master students. In details:

12/11/2021. *“Charge Carriers Trapping in Phosphors”* by Prof. E. Zych devoted to Professors, researchers, post-Docs, and Ph.D and Master students of the STEBICEF Department, University of Palermo (Italy).

7/12/2021. *“Investigation of archeological objects. Challenges for a chemist”* by Prof. M.L. Saladino devoted (on line, due to Covid restrictions) to Professors, researchers, post-Docs, and Ph.D students of the Faculty of Chemistry of University of Wrocław and of Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Wrocław (Poland).

The **seminars** were followed by time for questions and discussion. The mainly questions were about the mechanism involved in the Thermoluminescence and the role of the scientist in the field of conservation of Cultural Heritage and in particular of Archaeometry. Special interest was also given to the multidisciplinary work of this type of research.



Figure 1. Photos acquired during the seminars at STEBICEF Department (up) and at the Faculty of Chemistry of University of Wrocław (down).

In this first part of the Project the international team of researchers submitted 2 abstracts for **Posters**:

1. M.L. Saladino, F. Armetta, E. Caponetti, M. Sójka, E. Zych, "The Canaletto Program: Multianalytical approach for the dating and authentication of archaeological ceramics" XI Congresso Nazionale AIAR, Napoli, 23 - 30 luglio 2021. Poster
2. F. Armetta, V. Ciaramitaro, M. Sójka, M.L. Saladino, E. Zych, "Investigation of archaeological amphorae from the Egadi battles". International conference on Metrology for Archaeology and Cultural Heritage - METROARCHEO 2021. Milano, 20-22 Ottobre 2021. Poster

The rest is planned to be presented at other **two conferences** in order to promote the scientific activities in the framework of the joint Canaletto Program:

- XII Congresso Nazionale AIAR2022 - March 2022, Padova, Italy
- CHEMCH - 6th International Congress Chemistry for Cultural Heritage 2022, 4 July 2022 - 8 July 2022 - Ravenna, Italy

Publications:

1. F. Armetta, V. Ciaramitaro, M. Sójka, M.L. Saladino, E. Zych, "Investigation of archaeological amphorae from the Egadi battles". Acta Imeko 2022 accepted for publication
2. M.L. Saladino, M. Sójka, F. Armetta, V. Ciaramitaro, E. Caponetti, E. Zych, "Thermoluminescence new approach for the investigation of archaeological amphorae from the Egadi battles" **manuscript** in preparation for the submission to the Physical Chemistry in Cultural Heritage.

The articles about the Canaletto Program were published on the **websites** of all participating organisations:

<https://www.unipa.it/persona/docenti/s/marialuisa.saladino/?pagina=ricerca>

<https://www.unipa.it/Canaletto--Concluso-il-progetto-di-collaborazione-internazionale-tra-UniPa-e-University-of-Wrocaw-Polonia/>

<https://www.facebook.com/universitapalermo/photos/a.180307905710163/1202169693523974/>

https://twitter.com/unipa_it/status/1486296115754545152

<https://www.linkedin.com/feed/update/urn:li:activity:6892060596313878528/>

<https://chem.uni.wroc.pl/pl/jednostka-organizacyjna/11/sekcje/34>

From the **scientific point of view**, the results about the research activity, carried out in the laboratories of both Institutions, were in agreement with the literature. For the first time a deepen investigation has been performed on ceramic samples from underwater archeological site, the Egadi's battle, and from underground, the Eolie'island context, which was possible combining the two groups equipment, knowledge and skills.

In Conclusion, the main result of the Canaletto Project was the opportunity to share and enhance knowledge and experience in the field of Archaeometry, to discuss about the cultural exchange and interaction between Archaeology and Archaeometry and about the Luminescence and Thermoluminescence data of this kind of artefacts.

The participants shared the personal experiences in the two Countries and discussed about the possibility to improve the joint collaboration after Canaletto. Some meetings with Professors involved in other programs of exchange of researchers like the Erasmus Program were organised to share the experience of students of both Universities.



Figure 2. Meeting at University of Palermo with Prof. Mauro Ferrante, responsible for the Erasmus Program between University of Palermo and University of Wroclaw (down).

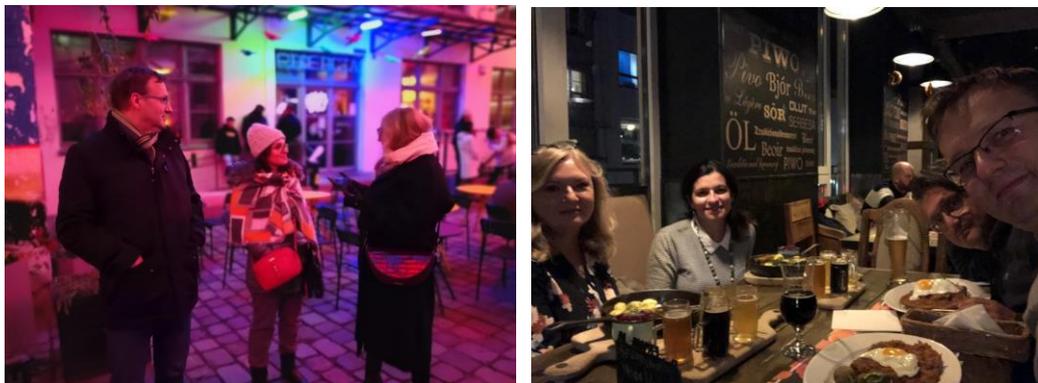


Figure 3. Meeting in Wroclaw with Prof. Barbara Łydźba-Kopczyńska, Head of the Laboratory of Cultural Heritage Studies of University of Wroclaw (down).

Palermo, 26.1.2022

Prof. Maria Luisa Saladino
Italian Coordinator for the Project

Prof. Eugeniusz Zych
Polish Coordinator for the Project

The Canaletto Program: Multianalytical approach for the dating and authentication of archaeological ceramics

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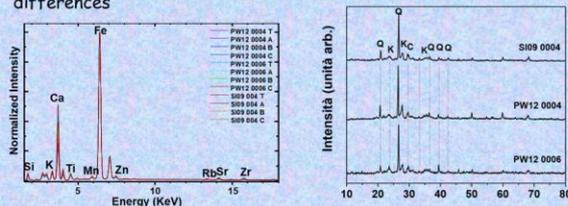
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Archaeological ceramics are considered one of the most important sources of both technological and chronological information. Here, the investigation of some archaeological underwater amphorae from the Egadi's Battle, that decided the end of the First Punic War (241 B.C.), is reported. X-ray Diffraction (XRD), X-ray Fluorescence (XRF), Petrography, and Thermoluminescence (TL) were used to determine the composition of the amphorae and to evaluate the compatibility of their age with the above Battle. Considering the historical importance of the act and the well-defined historical collocation these amphorae represent an interesting archaeometric case study.



It is hypothesized that in the site where the naval battle of the Egadi Islands took place there are approximately more than a thousand amphorae, but more than five hundred have been located. Once they fell into the sea, the amphorae spread over the entire seabed, which helped to outline both the extent of the area in which the battle was fought and the position of the Carthaginian ships compared to the Roman ones. Furthermore, the amphorae proved to be indispensable finds to get an idea of how the battle took place, to have greater knowledge of both the equipment of the soldiers and the disappearance of the ships and to date the site on the basis of their shapes.

XRF and XRD investigation & for the determination of compositional differences



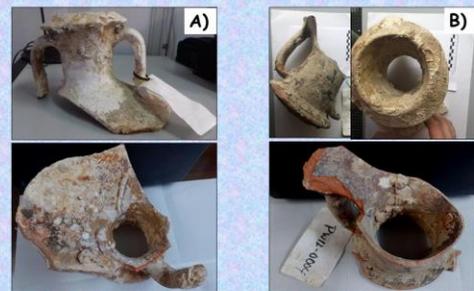
The presence of secondary calcite of high firing temperature or complete cooking of the external layer respect to the inner. The presence of calcite on all samples SI 09-0004 (0.9%) indicates that the firing temperature was under 850° C. The amount of quartz on feldspar is similar for all the samples (around Q ≈ 41% K ≈ 59%).

The mineralogical composition is similar to the ones observed by Capelli et al. [1] for amphorae discovered in the same site and assigned to the Tyrrhenian coast between Tuscany and the Gulf of Naples, even if the compositional and textural/technical differences suggest a diverse productions and workshops location.

The results, part of the Canaletto Program "Multianalytical approach for the dating and authentication of archaeological ceramics" are here presented. This study not only fits the project objectives but also provides results defining compositional and phases features characterizing the ceramics coming from the Egadi's battle site to help archaeologist to better define the site context and the ship cargo provenance. Moreover, thermoluminescence analysis effort clearly defined the place in time of the battle.

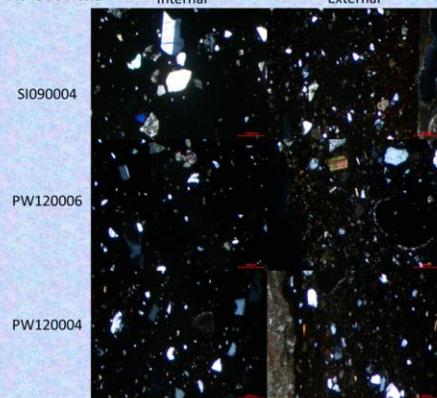
[1] C. Capelli, M. Piazza, R. Cabella, Petrological analysis of amphora samples, in The site of the Battle of the Aegates Islands at the end of the First Punic War. Fieldwork, analyses and perspectives, 2005 - 2015, a cura di J. G. Royal - S. Tusa, L'Erma di Bretschneider, Roma (2019) 195 - 196.

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Four fragments of Greek - Italic amphorae of the MGS V - VI type (PW12 - 0004, PW12 - 0006 and SI 09 - 0004 (A and B) Figure 1) from the Egadi seabed have been studied in order to determine the composition and age of the ceramic. The fragments PW12 - 0004 and PW12 - 0006 have been identified in the PW - A sector, while S. I. 09 - 0004 (A and B) belong to an amphora, perhaps part of the cargo of a sunken ship not far from the site of the war.

Petrographic analysis was performed on ceramic sherds thin-sections



Talking about underwater cultural heritage, the happiness and pride of being the custodians of so much wealth must not make us forget the great responsibility we have in guarding, maintaining and divulging it (Sebastiano Tusa)