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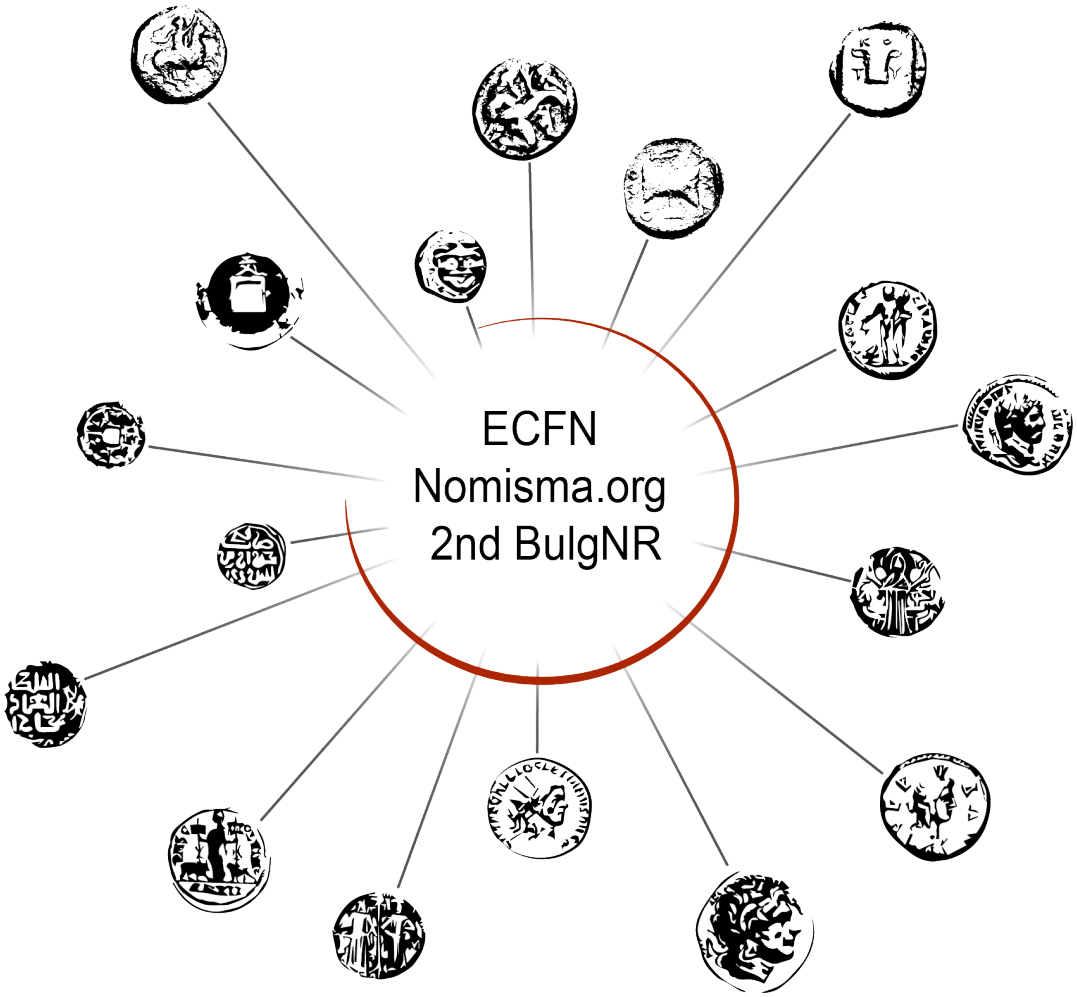
Bulgarian Numismatic Journal, Supplementary Series, vol. 1.

PROCEEDINGS OF THE 10TH JOINT MEETING OF ECFN AND NOMISMA.ORG & 2ND BULGNR TOGETHER



ProVias

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International Conference Sofia, 19 – 23 June 2023

Editors:
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Julia Tzvetkova,
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The present volume includes 27 papers, delivered (as presentations or as posters) at the 10th Joint ECFN and Nomisma.org Meeting & 2nd Bulgarian Numismatic Readings TOGETHER Conference, held at the Sofia University "St. Kliment Ohridski" on June 19th – 23rd, 2023.[1]

This scholarly meeting gave platform to eight ECFN sessions with a total of 40 presentations; three BulgNR sessions with a total of 15 presentations; a panel "The Roman provincial coins of Bithynian mints found in Europe" (organised by Mirjana Vojvoda in a cooperation with Hale Güney and Dario Calomino) with a total of three presentations and five posters; a poster session with 24 posters, each one of them presented also within an intensive science slam; a Nomisma presentation by Andrew Meadows; and three workshops (1. Corpus Nummorum Team, with a total of six presentations, chaired by Ulrike Peter; 2. ACCSN team with a focus on the forgery techniques, chaired by Ilya Prokopov and Dilyana Boteva-Boyanova; 3. Development of a Nomisma data model for a Greek hoard database, chaired by Ute Wartenberg and Andrew Meadows). The program of the event also included visits to ancient Serdica sites and museums in Sofia (National Archaeological Museum and Regional History Museum – Sofia), as well as an excursion to Heraclea Sintica, Petrich Museum of History and Regional History Museum Blagoevgrad; in the latter a numismatic exhibition was organised, including some of the very important coin hoards from the region.

The papers included in this volume have passed blind peer reviews, language proofreading by a native speaker, and scientific editing. In cases of disagreement on debatable subjects between the authors and the blind reviewers or the editorial team, the decision was made to publish the respective texts, in accordance with the original content, and on such occasions the responsibility would lie entirely with the authors.

Sofia, 22.12.2025 The Editors

[1] See the program and the book of abstracts: https://www.bg-numismatic-readings.com/archive/10th-joint-meeting-of-ecfn-and-nomisma-org-2nd-bulgnr-together/program-2/

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Bulgarian Numismatic Journal Supplementary Series

NUMMI DIGITALI: A DATABASE ONLINE FOR THE ENHANCEMENT OF THE NUMISMATIC COLLECTION OF THE A. SALINAS ARCHAEOLOGICAL MUSEUM IN PALERMO

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NUMMI DIGITALI: a Database Online for the Enhancement of the Numismatic Collection of the A. Salinas Archaeological Museum in Palermo

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Abstract: NUMMI DIGITALI is a project which, thanks to the close interrelation between numismatic-archaeological methodologies and the IT approach, aims to enhance the numismatic collection of the Regional Archaeological Museum A. Salinas of Palermo. The main objectives of the project were completed and involved: 1). the creation of a digital database (https://nummidigitali.it/), in open format, which was aligned with the national cataloguing standards of ICCD of the Ministry of Culture (MiC) and the methodological guidelines of the National Plan for the Digitisation of Cultural Heritage (PND), in order to make the data interoperable and shareable, according to the LOD paradigm; 2) the connection of the database with the web through a front-end that guarantees accessibility to the external public and therefore real use through the potential offered by ICT; 3) the activation of interactive communication processes through high resolution images and 3D renderings equipped with points of interest with references to hypertexts and/or multimedia.

Keywords: Digital numismatic, Database, A. Salinas Archaeological Museum in Palermo, Digital 3D models, XRF spectroscopy.

1. The project NUMMI DIGITALI: a database online for the coin collection of the Salinas Museum

NUMMI DIGITALI is a project aimed at the digitisation of the numismatic collection of the A. Salinas Archaeological Museum of Palermo[1] to promote its study and improve its management and enhancement.

The project development was born in 2022 as part of a PON Research and Innovation 2014–2020 funding to support the research activities of the numismatics chair of the University of Palermo, coordinated by the writer, the scientific curator of the project (Sole 2022, 539–547). The project has currently received funding from the University of Palermo as part of the Eurostart 2024 project.[2] The main partners of NUMMI DIGITALI are the Regional Archaeological Museum A. Salinas in Palermo, which keeps the numismatic collection being valorised and which supervises the project, the Webgenesys S.p.A[3] system integrator, which took care of the technological coordination,[4] and the Central Institute for Cataloguing and Documentation (ICCD) of the Ministry of Culture (MiC), which oversaw the validation of the Scheda NU + (NU + data sheet) and led the preparation of the database for the increase of the national SIGECweb database and the sharing of data according to the Linked Open Data (LOD) paradigm.[5] Furthermore, during the develop-

[1] https://www2.regione.sicilia.it/bbccaa/salinas/

[2] The project is part of the objectives of my activities as a researcher in Numismatics (ARCH-01/B) at the Department of "Cultures and Society" of the University of Palermo. It follows that "this work was funded by the European Union – NextGenerationEU – MUR funds D.M. 737/2021 – research project NUMMI DIGITALI towards Europe'

[3] https://www.webgenesys.it/

[4] My thanks go to Elisa Chiara Portale, Full Professor of Classical Archaeology of the University of Palermo, responsible for supervising the development of the project; to Giuseppe Parello, director of the Regional Archaeological Museum A. Salinas of Palermo, for the availability with which it accepted the project to valorise the numismatic heritage of the Salinas and supervising it in collaboration with Elena Pezzini, the official archaeologist of the Salinas Museum, to whom I am grateful for having facilitated in every way my work. Finally, special thanks go to Webgenesys S.p.A. and Giulio Hassan, Business Development Director, and Massimiliano Perri, Senior Presale & Program Manager, for the professionalism, dedication, and attention with which they worked to take care of the technological and IT aspects of the database.

[5] The Scheda NU is a set of suggested field names for recording numismatic information, based on the ICCD cataloguing standards. The Scheda NU+ is the implemented version, developed during the NUMMI DIGITALI project. Similar is the Numismatic Description Standard (NUDS) proposed by the American Nu-

ment phase, we made use of the precious collaboration of the Institute for Chemical-Physical Processes (IPCF) of the CNR of Messina,[6] responsible for the experiments and creation of the 3D models; of the Department of Chemical and Biological Sciences and Technologies Pharmaceuticals (STEBICEF) of the University of Palermo,[7] which carried out the metallographic analyses, and of the Inventory, Cataloguing and Documentation Centre (CRICD) of the Sicily Region, which offered its support as an intermediary in the operations of providing data to SIGECweb.[8]

The main objectives envisaged by the project were completed at the end of 2023 and involved:

- the creation of a digital database in open format, which has been aligned with the national cataloguing standards of the ICCD of the MiC (http://www.iccd.beniculturali.it/it/standard-catalografici; https://github.com/ICCd-MiBACT/Standard-catalografici; Mancinelli 2018, 279–302) and therefore is based on consolidated, certified, and shared parameters;

- the connection of the database with the web through a front-end, which guarantees public accessibility to the collection through the potential offered by ICT and is consistent with the methodological guidelines of the National Plan for the Digitisation of Cultural Heritage (PND) of the MiC (https://digitallibrary.cultura.gov.it/il-piano/),[9] as the data produced are interoperable and shareable according to the Linked Open Data paradigm (https://www.w3.org/DesignIssues/LinkedData; Birozzi et al. 2020, 1127-1345; Veninata 2020, 45-58);

- the release of the database on the web (https://nummidigitali.it/), which is configured as a container in which the needs of scientific research and the management needs of the museum, satisfied in the back-end, meet with the opportunities for disseminating and sharing data, thanks to the front-end tool, which guarantees the user interoperability within the IT system, the search and use of information, and the activation of communication processes interactive through high resolution images and 3D renderings equipped with points of interest with references to hypertexts and/or multimedia.

During 2024, however, the database will be implemented, favouring the entry of data from coins, which lack a systematic collection and often scientific updates.

1.1. The digital database

The digital database tool was modelled on the structure and descriptive ontology of the Scheda NU, a specialist data sheet for numismatic heritage and a cataloguing tool released by the ICCD in 2004 (Arslan et al. 2004), which still maintains the original configuration, as only the visibility on the web was updated (version 3.00: http://www.iccd.beniculturali.it/it/ricercanormative/18/nu-beni-numismatici-3_00). The layout consists of 22 paragraphs and over 250 fields, organised hierarchically into structured fields, subfields and simple fields, which require specific vocabularies and formalised languages that have become an integral part of the data sheet. However, the adaptation of the ICCD standards to the project of the Salinas Museum database immediately highlighted the need to make changes to the data sheet, since the database required a flexible

mismatic Society (http://nomisma.org/nuds). I would like to thank, for the precious collaboration, Maria Letizia Mancinelli, Rachele Aras and Fabrizio Magnani of the ICCD-MiC.

[6] https://www.ipcf.cnr.it/it/ipcf-messina/

[7] https://www.unipa.it/dipartimenti/stebicef

[8] I would like to express my gratitude for the precious collaboration to Rosina Celeste Ponterio (researcher) and to Dario Giuffrida (junior Researcher) of the IPCF-CNR of Messina; to Maria Luisa Saladino (Associate Professor of Physical Chemistry) and to Francesco Armetta (Researcher of Physical Chemistry) of the STEBICEF Department of the University of Palermo; to Laura Cappugi, director of the CRICD.

[9] The National Plan for the Digitisation of Cultural Heritage (PND), drawn up by the Central Institute for the Digitisation of Cultural Heritage - Digital Library of the Ministry of Culture, constitutes a reference document in the five-year period from 2022–2026 to start the process of digital transformation of places of culture of the Italian state and improve the valorisation of cultural heritage. For the guidelines for digitisation processes, see https://docs.italia.it/italia/icdp/icdp-pnd-digitalizzazione-docs/it/v1.0-giugno-2022/index.html; for the guidelines for the drafting of the Data Management Plan by the Central Institute for the Digitisation of Cultural Heritage - Digital Library, see https://docs.italia.it/italia/icdp/icdp-pnd-dmp-docs/it/v1.0-giugno-2022/index.html.

cataloguing base that is easy to use and is suited to the study needs and open on the web.

To this end, we resorted to the flexibility of the *Scheda NU,* whose absolute, contextual, or alternative obligations are actually limited to some fields (Mancinelli 2017, 7–8). A reasoned study was therefore carried out to prepare the changes, oriented on the one hand towards the simplification and elimination of non-mandatory and non-essential paragraphs and fields for the analysis of the monetary document, and on the other, towards the implementation, with the inclusion of fields that are essential for the study of ancient coins, but not included in the layout.

The operation presupposed interaction with ICCD technicians, so that the necessary adaptations respected the compilation rules and did not compromise the possibility of contributing the data to the national operational sharing platform SIGECweb.

At the end of this operational phase, all the proposed customisations were validated by the ICCD and the layout of the final product — which for convenience we usually call Scheda NU+ — was published, so that it was available to the entire scientific community, since it is a more complete cataloguing tool, but, at the same time, more streamlined and flexible than the original model (Sole 2022, 541–545).

The IT transposition of the Scheda NU+ was therefore incorporated into the back-end of the database, which obviously respects the hierarchical structure and cataloguing standards, as illustrated, but is also accompanied by specific tools to facilitate and speed up compilation.

The structure of the database, however, was designed to be modifiable in the future, both in view of any interventions related to the research's progress, and in order to keep the database aligned with the processes of IT evolution.

It is made up of 18 paragraphs in total and, by clicking on each one, the system refers to the descending fields — always ordered hierarchically — of which the fillable ones (145 in total) can be filled using suggestions or using the drop-down menus, which offer choice options based on the vocabularies of the Scheda NU or the possibility of inserting other memorised words, thus simplifying the work of the compiler, guided in the selection and interpretation of the labels (**Fig. 1**).

Fig. 1. The IT transposition of the Scheda NU+ with 18 paragraphs, suggestions, and drop-down menus, which offer choice options.

Among the paragraphs subject to the most significant structural scientific interventions, there are those relating to the context of discovery of the coin, which in the 2004 Scheda NU were represented by a small number of fields or not always associated with explicit labels for the compiler.

The "LA" paragraph, for example, includes data on the "Other administrative geographical locations" ("*Altre localizzazione geografico amministrative*") of the coin, the "historical" locations that preceded the current place of conservation.The subordinate "TLC" field "Location type" ("*Tipo di localizzazione*"), designed to ensure immediate perception of the general data on the context to which the coin belongs, was therefore equipped with explicit captions that facilitate its compilation. It therefore appears clear that, in the case of a coin found in the context of archaeological investigations, the field must be filled with the entry "place of discovery" ("*luogo di reperimento*"), while, in the case of an exemplar belonging to a collection, the item "place of origin" ("*luogo di provenienza*") must be selected.The topographic specifications are entrusted to the subsequent structured fields "PRV" and "PRC". The "PRV" field "Administrative geographic location" (*"Localizzazione geografico amministrativa"*) provides information about the geographical location of the finds on the ground, with the possibility of incorporating links containing georeferencing references, while the "PRC" field "Specific location" (*"Collocazione specifica"*) adapts to exemplars coming from collections and allows to specify, for example, the name and location of the previous collection. In particular, the "PRCM" "Collection name" (*"Denominazione raccolta"*) field contains a complete vocabulary with all the names of the numismatic collections documented at Salinas to facilitate their insertion (**Fig. 2**).

Fig. 2. The "LA" paragraph with data on the "Other administrative geographical locations" ("Altre localizzazione geografico amministrative"), mainly the "historical" locations that preceded the current place of conservation.

The most precise information on the archaeological context of discovery of the coins, however, is contained in the paragraph "RE" "Finding methods" ("*Modalità di reperimento*"), in which numerous customizations have been introduced, functional to offering an information framework that is as complete as possible. To this end, new fields have been introduced, each identified by a URI composed of the acronym of the reference structured field, the acronym NU and a progressive Arabic number (**Fig. 3**).

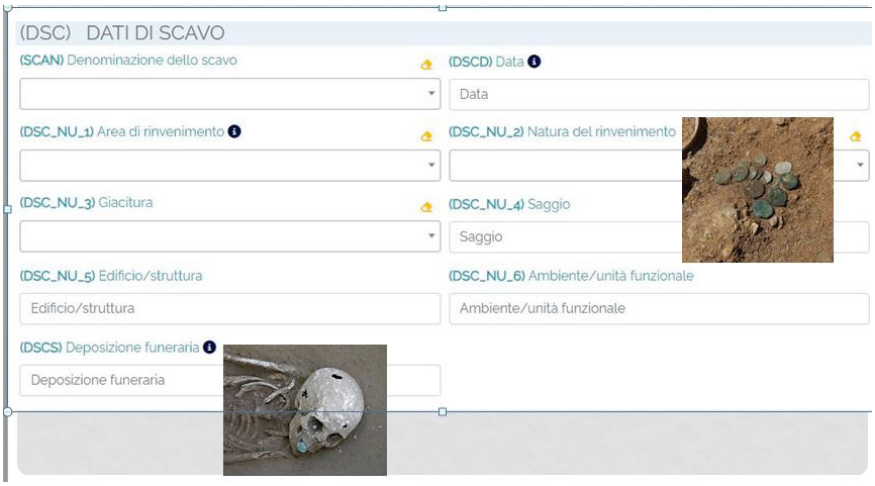

Fig. 3. The Scheda NU + with the customisations: the structured field "Excavation data" ("Dati di scavo").

In particular, the three structured fields, already present in the Scheda NU, have been maintained, namely "Surveys" ("*Ricognizioni*") ("RGC"), "Excavation data" ("*Dati di scavo*") ("DSC") and "Other investigations" ("*Altre indagini*") ("AIN"), to be filled in, alternatively, depending on the method of discovery of the coin, but new fields have been added, descending from "RGC" and "DSC", to qualify the "Area of discovery" ("*Area di rinvenimento*") of the coin and the "Nature of discovery" ("*Natura di rinvenimento*"), and referable only to "DSC", to indicate the type of "Laying" ("*Giacitura*"), the "Essay" ("*Saggio*"), the "Building/Structure" ("*Edificio/Struttura*"), the "Environment/Functional Unit" ("*Ambiente/Unità funzionale*") and the "Funeral Deposition" ("*Deposizione funeraria*") in which the coin is been found. In particular, the label "Funeral Deposition" ("*Deposizione funeraria*") has replaced the original "Tomb Number" ("*Numero Tomba*") label of the Scheda NU sheet, already associated with the "DSCS" code, because it is more suitable for including all the variables of funerary contexts, in which a coin can be documented.

A specific structured field was created for the "Stratigraphic Unit" ("*Unità stratigrafica*"), because the subfield of the same name in the Scheda NU appeared insufficient to contain all the stratigraphic information of a contextual numismatic study (**Fig. 4**). The structured field, on the other hand, involves linking with a series of subfields that allow more precise information to be entered: for example, the characterisation of the US of coin discovery flows into the "Definition" ("*Definizione*") field, the list of contextual materials in the field "Contextual elements" ("*Elementi contestuali*"), and the reference to those dating in the "Diagnostic findings" ("*Reperti diagnostici*") field, while the indications on the chronology deriving from the context in the "Dating" ("*Datazione*") field.

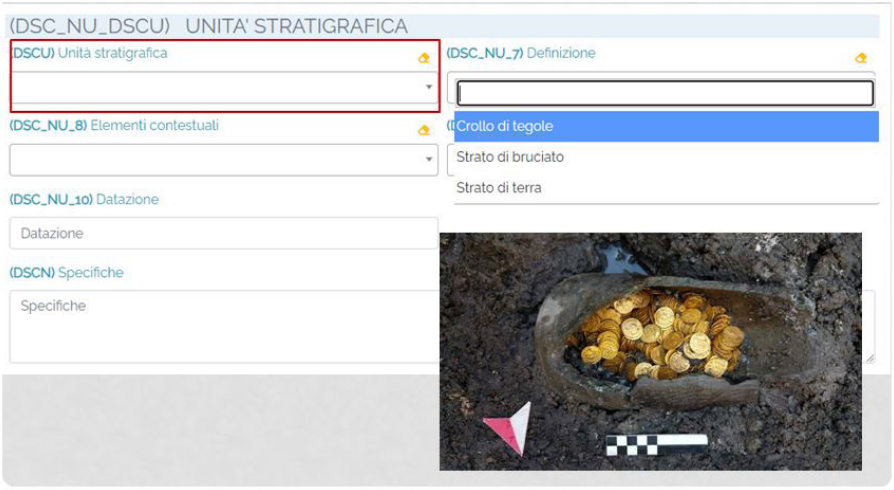

Fig. 4. The Scheda NU + with the customisations: the structured field "Stratigraphic Unit" ("Unità stratigrafica").

Similar implementations were reserved for the ancient manufacturing technique, adding within the paragraph "DA" "Analytical data" ("*Dati analitici*"), two structured fields dedicated to overstriking ("Undertype" = "*Sottotipo*") and testing ("Test" = "*Saggio*"), not covered in the body of the original Scheda NU.

Finally, taking advantage of the suggestions provided by the ICCD Transversal Regulation 4.00 of 2017 (Mancinelli 2017), some labels were changed, such as those relating to the structured field "AUT" "Author" ("*Autore*") (of the dies), within the paragraph "AU" "Cultural definition" ("*Definizione culturale*"), to adapt them to the specialised vocabulary in current use.

The customisations therefore allow the Scheda NU + to adapt to the potential of the numismatic heritage of the Salinas Museum, which preserves coins originally part of eighteenth- and nineteenth-century historical collections and coins from archaeological excavations conducted in central-western Sicily from around 1827 until the 1990s, and of which it is possible to reconstruct the archaeological context of discovery with the help of the documents present in the historical archive of the museum.

The adoption of cataloguing rules shared at a national level also guarantees the inclusion of the NUMMI DIGITALI datasets in SIGECweb (General Catalog Information System), a national operational platform developed and managed by the ICCD for the use and sharing of cultural heritage datasets of public property (Birozzi et al. 2020 and http://www.iccd.beniculturali.it/it/sigec-web) (**Fig. 5**).

Fig. 5. The inclusion of the Nummi Digitali datasets in SIGECweb (General Catalog Information System), national operational platform developed and managed by the ICCD-MiC.

Furthermore, the additional fields, unique to the Scheda NU+, are released in open format, according to the Linked Open Data (LOD) paradigm. Specific ontologies were created for these fields through the collaboration between the ICCD and the Institute of Sciences and Technologies of Cognition (ISTC) of the CNR. In fact, from the cooperation between the two institutes, the ArCo-Architecture of Knowledge project was born, which is a network of ontologies for the "transposition of the cataloguing-descriptive experience of the ICCD into the new paradigms of the semantic web" (Mancinelli, Veninata 2019, 130–134; Mancinelli, Veninata 2022, 479).

Since the NUMMI DIGITALI datasets are transferred to the SICECweb platform, they will be part of interconnected systems that enhance scientific research and institutional collaboration, adhering to the FAIR data principle: Findable, Accessible, Interoperable and Reusable (Wilkinson et al. 2016). Furthermore, SIGECweb, as a ministerial platform, is free from obsolescence and ensures the correct and protected circulation of information.

1.2. The web front-end

Another strong point of the project is the correspondence between the database and the front-end connected to the web (https://nummidigitali.it/), whose interface has been structured to be user-friendly (**Fig. 6**).

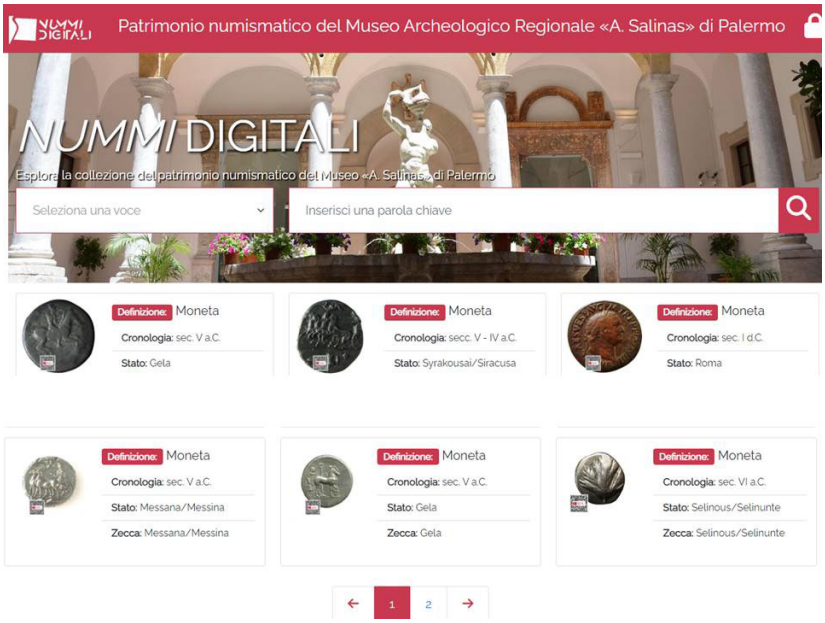

Fig. 6. Nummi Digitali database: the front-end on the web (https://nummidigitali.it/).

In the front-end, the user has the ability to view the Scheda NU+ in a short format, following a reasoned selection of the fields to be displayed and a varied display of some labels, which originally appeared poorly suited to understanding by the user. This choice is motivated by the desire to increase the attractiveness of the collections, reserving it for a wide audience and not exclusively for professionals, and to contribute to the maximum dissemination and accessibility of the data, according to the principles of "Public Archaeology" (Volpe 2020).

The front-end tool also offers the possibility to carry out searches by selecting an item and entering a keyword, and it gives those interested the opportunity to request from the museum the complete version of the data sheets and the related images of the coins after completing a specific form. The requests will reach the Museum Authority in the back-end, where there is a specifically dedicated space where it will be possible to check the list of requests and where the history of processed queries will remain in memory.

Particular attention was paid to the display of the images associated with the coin data sheet, always at high resolution with a large image size, in order to capture the details. Some are in 2D, while others have been rendered in 3D and in augmented form, as they are equipped with points of interest, which refer to specific hypertexts and/or multimedia to activate interactive communication processes with the user (**Fig. 7**).

Fig. 7. The Scheda NU + with the customisations: the structured field "Stratigraphic Unit" ("Unità stratigrafica").

In addition, the results of the investigation of the metallic composition – performed with the XRF spectroscopy – were added. This information is also contained in the points of interest of the 3D models of the coins as functional hypertexts to arouse the user's interest, while the insights from the analysis will flow into the field of the data sheet reserved for analyses.

The unconditional diffusion of images on the web is inhibited by a series of IT measures, such as the impossibility of saving, copying and pasting, showing on another page or tab, as well as by the superposition of a protection QR Code with reference to copyright notes.

The NUMMI DIGITALI project therefore allows the Salinas to be the first museum in Italy to have an accessible and interoperable digital numismatic database, adhering to institutional cataloguing standards to ensure semantic alignment with the ontology proposed by accredited institutions and significant international projects, such as Nomisma.org (http://nomisma.org)[10] of the American Numismatic Society.

In fact, the next development objectives of the portal will concern, in addition to the implementation of the platform, the enrichment of interoperability, the launch of queries, the georeferencing of data, and the semantic alignment with databases that use the Nomisma.org ontology.

[L.S.]

2. NUMMI DIGITALI: a usable, accessible, cooperative by default computer cataloguing web tool

NUMMI DIGITALI represents an IT tool that makes it possible for users and scholars to access cards, timely documentation, photos, and multimedia objects which form the basis for the creation of a digital twin of numismatic funds of museums and institutes relating to the world of culture.

The Web application is characterised by its high scientific value, innovative method of cataloguing, exploitation and dissemination of contents based on modern WEB interfaces, cooperation specifications, and models designed to guarantee flexible management of metadata and catalogued information referring to a specific currency, as objects and structured information that comply with SIGECweb and Semantic Web requirements, i.e. data packages that can also be exploited in the form of LODs.

The system also offers tools to respond with punctuality, reliability, and quality regarding the use of documentary sources and research.

NUMMI DIGITALI takes the form of a cloud solution for the digitisation of the cataloguing process, offering – primarily to the cataloguer – a tool for cataloguing according to ICCD regulations and the contents for compiling NU cards of a numismatic cultural object; secondly, NUMMI DIGITALI is a tool for disseminating and promoting cultural content, a prerogative of researchers and users interested in learning more.

The system is integrated with editing and multimedia content management tools and is designed for interoperability with third-party systems for the management of individual flows to and from SigecWeb, the tool at the basis of the National Catalogue of Italian Cultural Heritage.

The design and development activities are carried out thanks to the creation of a multidisciplinary working group, characterising NUMMI DIGITALI as a powerful IT tool for management, valorisation of the numismatic heritage, and the simultaneous creation of a digital archive, as well as the definition of export and supply procedures of the National Catalogue.

The platform was designed to support the processes of collection, systematisation, and archiving of numismatic cards and the simultaneous valorisation and dissemination of a vast array of textual, photographic, and multimedia information, fully qualifiable come LOD.

Characteristics and constraints underlying the design and development of the NUMMI DIGITALI Platform are as follows:

[10] For the ontology proposed by Nomisma.org (Numismatic Description Schema, NUDS), see: http://nomisma.org/nuds.

- Full compatibility with the current ICCD Cataloguing Standards and with the Knowledge Architecture and Knowledge Graph systems of the Italian cultural heritage.
- Full compliance of the front-end and back-end sections with the Design Guidelines for PA Web Services proposed by AgID (Agency for digital innovation in Italy).
- Compliance with usability and accessibility standards.
- Streamlined, step-by-step content management workflow with identification of editors, content managers, and responsible figures responsible for the publication process.
- Ownership, temporal validity, and cataloguing changes tracked using digital keys (Log).
- Full compliance with SaaS First and Mobile First logics and with the PNRR principles aimed at the digitisation of cultural heritage
- Application stack entirely open source.

2.1. Main features

As a SaaS Platform, NUMMI DIGITALI presents its users with some simple, intuitive features that can be used entirely from the Web. The features in question can be divided into:

- Management and administrative such as allowing profiled users:

  - Collection, census and conservation of numismatic information according to the ICCD NU Cataloguing Standard and the new NU+;

  - Search, extraction, reproduction, and sharing of numismatic cards for each individual access request of interest to scholars and actors in the world of research;

  - Supervision of contents (textual and multimedia) subject to valorisation and sharing.

- Promotional and informative materials intended for Web users and useful for:

  - dissemination of multimedia cards and cards for easy interpretation of the information relating to the individual coins forming part of the find;

  - search for specific objects and subjects using dedicated full text tools for specific fields;

  - assistance and support to allow entitled users to request access and authorisation to reproduce numismatic cards complete in their structure and accompanying images.

Particular attention should be paid to the tools and the information and dataset sharing process integrated into NUMMI DIGITALI.

The system allows the generation, export, and display via dedicated APIs of standard XML paths, characterised by a specific and typical vocabulary and ontologies of the NU form of the ICCD National Catalogue (**Fig. 8**).

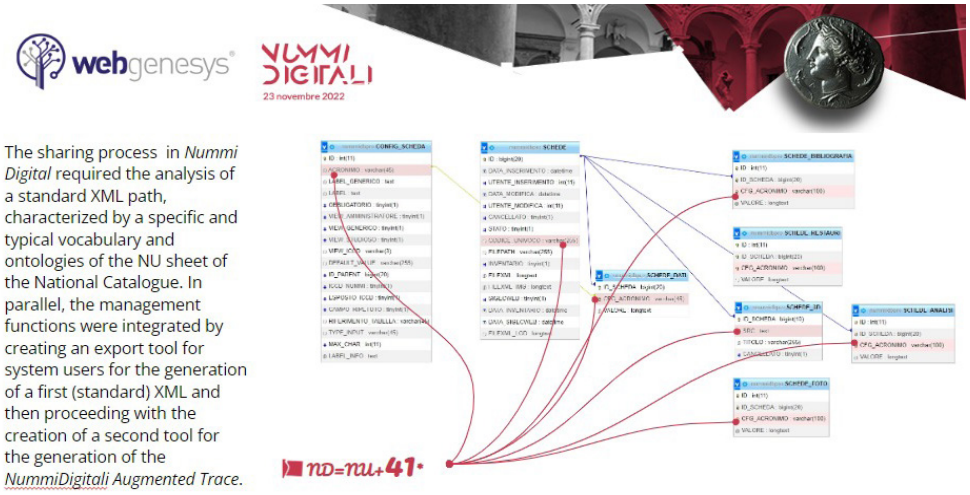

Fig. 8. Synoptic NU – NU+ and LOD.

For similar operations, users do not need to have any specific IT knowledge but rather use only the management functions and the (standard) XML path export tools.

At last but not least to use the service, one needs an Internet connection and the availability of a compatible browser including Edge, Firefox, or Chrome in the current major releases.

The system is deployed on a private cloud; there are no limitations or exceptions to the implementation of the system on other types of cloud, be they public, hybrid, or third communities.

The infrastructure on which the system is currently deployed is attributable to the qualified CSP ACN (Italian National Cybersecurity Agency) OVH Srl and has the following details: Dedicated Server | Type: IaaS | Card ID: IA-1331 | Category: Virtual Datacenter | Qualification Level: QC1.

The system is undergoing certification as a SaaS service on the ACN Marketplace.

[M.P.]

3. Digitisation and 3D modelling of numismatic finds using laser scanning combined and macrophotogrammetry

3.1. Introduction to 3D survey

In the framework of NUMMI DIGITALI the numismatic collection at the Salinas Archaeological Museum was digitised for the first time. The aim of digitisation activities was to preserve these artefacts and improve accessibility through 3D scanning and modelling, since many of these coins are inaccessible to the general public and are difficult for researchers to examine in detail. The high-resolution digital models allow both experts and general users to view and interact with rare coins from different eras in an immersive virtual environment.

Digitising small cultural artefacts like ancient coins poses unique challenges due to their diminutive size and intricate surface details. As summarised in a review of the literature, a key methodological difficulty is capturing the fine textures and geometries of coins in digital 3D models, as they are often less than an inch in diameter (Hess et al. 2018; Zambanini et al. 2009; MacDonald et al. 2017).

Researchers have employed a variety of approaches to address this problem. Multi-modal 2D and 3D imaging methods, coupled with analytical techniques, have been utilised to digitise coins and examine their features.

Moreover, data standardisation has been identified as crucial for advancing computational analysis of coin iconography, by enabling quantitative diachronic studies (Pavlek et al. 2022).

Interactive RTI imaging has been shown as an effective visualisation technique to capture surface details of coins and improve research and public access (Palma et al. 2014).

Several museum curators have increasingly emphasized the importance of digitising ancient coin collections to ensure the accurate recording and effective dissemination of the vast array of historical, economic, and iconographic information embedded in these artifacts.

At the intersection of archaeology, numismatics, computer science, and law enforcement, the World Wide Web has been recognised as playing a key role in coin digitisation initiatives (Jarrett et al. 2012).

A key methodological challenge faced in the project was capturing the intricate details and textures of the ancient coins in the 3D models. As the coins are quite small, often less than an inch in diameter, extremely high precision geometric data and photographic detail was required. Conventional scanning and photography approaches lacked the resolution to adequately capture the level of detail needed.

To address this challenge, IPCF-CNR developed an innovative solution combining cutting-edge laser scanning technology with specialised macro-photogrammetric imaging. This hybrid approach allowed the project to generate highly accurate sub-millimetre resolution 3D meshes representing the shape of each coin, onto which realistic photographic textures extracted from multiple macro-images could be overlaid.

Here, we report in detail the scanning technologies utilised, data processing workflows implemented, and interactive 3D model viewing platforms developed over the course of the NUMMI DIGITALI project to bring these historically significant numismatic artefacts into an accessible digital space.

3.2. Survey methods

The digitisation of numismatic specimens was carried out through a multimodal workflow combining structured-light 3D scanning and macro-photogrammetry, in order to obtain metrically accurate and photorealistic digital replicas.

3.2.1. Laser scanning

A structured-light scanner (ATOS Q 8M, GOM-ZEISS) was employed to acquire dense geometric data. This specialised scanner is typically employed for industrial metrology applications rather than cultural heritage. It provides the sub-millimetre resolution required for capturing minute details on the coin surfaces.

The ZEISS ATOS Q 8M projects a structured pattern of blue light across the object's surface (**Fig. 9**). Sophisticated optics and sensors in the scanner head then analyse the deformations and displacements in the projected pattern as it interacts with the complex 3D geometry of the coin surface. This optical triangulation allows the precise coordinate position of each measured point to be calculated, reconstructing the coin's shape digitally point-by-point.

Fig. 9. Laser scanner Atos Q by GOM (Zeiss) used in combination with a tripod and the GOM ROT 350 rotation table inside the Salinas Museum.

Some key technical specifications of the ATOS Q 8M scanner are:

a) Light source: LED

b) Points per scan: 8 million

c) Measuring area: 100 x 70 mm to 500 x 370 mm

d) Point spacing: Adjustable, 0.04 – 0.15 mm

e) Working distance: 490 mm

The high density of 8 million measurement points per scan, with each point spaced apart by only 0.04 to 0.15 mm, enables extremely detailed resolution of even the smallest engravings and features on coin surfaces.

During scanning, each coin was mounted vertically on a high precision rotating platter using adhesive putty. The platter allows the coin to be smoothly rotated 360 degrees during the scan-

ning process so the scanner can capture overlapping scans of the entire circumference. The coin was then flipped over to scan the opposite side in the same manner. Combining the two sets of vertical scans produced a highly accurate overall 3D data model with precision better than 0.1 mm.

3.2.2. Macro-photogrammetry

While the laser scanning produced highly accurate 3D geometric data, the raw scan data lacked realistic surface colour and texture information (Morris et al. 2022). To capture the fine details and intricate patterns on the coin surfaces, macro photogrammetry techniques were utilised.

A Canon EOS 6D high resolution digital camera paired with a 60mm f/2.8 macro lens enabled extremely close-up photography of the coins with a high level of detail (**Fig. 10**). The macro lens provides a maximum reproduction ratio of 1:1, meaning the coin image projected onto the camera sensor is the same size of the actual coin. This setup allows for effective magnification of surface micro-details.

Fig. 10. In situ photogrammetry set-up including: Canon EOS 7D camera fixed on a tripod, macro lens (Leitz Leica, 1:2.8/60mm), automatic turntable, lightbox, printed markers.

The camera was mounted on a tripod with the coin placed horizontally on a rotating platter marked with printed control points. Control points assist in aligning and scaling the photos during post-processing. For each coin, a total of 32 images were captured with the camera rotated around a full 360 degree revolution in 22.5 degree increments.

Shooting from multiple angles all around the coin provides overlapping surface imagery that photogrammetry processing software can stitch into a seamless texture accurately mapped onto the 3D geometry. The detailed 20 megapixel images from the Canon EOS 6D provide sufficient resolution to capture intricate coin details at a sub-millimetre level while retaining accurate colour and tonality.

Combining the 3D geometry data from laser scanning with the high-resolution colour texture input from macro photogrammetry enabled building highly accurate and realistic 3D digital replicas of the museum's numismatic collection.

3.2.3. Data processing

The separate 3D data captured through laser scanning and photogrammetry needed to be integrated through a multi-stage processing workflow to create the final 3D coin models (Ponterio et al. 2019).

The laser scanning data was processed first using GOM Inspect Pro software. This industrial metrology software was used to align and combine the multiple vertical scans taken around each coin into a consolidated point cloud. The point cloud was then converted into a high-resolution polygon mesh representing the 3D surface geometry.

Meanwhile, the 32 macro photographs captured around each coin were processed in the Agisoft Metashape photogrammetry software. The images were aligned based on common features and the control points added during capture. A dense point cloud was generated through photogrammetric triangulation principles, which was then meshed and textured with the source photos to create a detailed colour 3D model.

The photogrammetry model provided the photographic texture, while the laser scanning model provided more accurate underlying geometry. To leverage the strengths of both, the laser scan mesh was imported into Metashape and precisely aligned to the photogrammetry model using coordinate system matching.

With the models aligned, the photographic texture from the Metashape model was then transferred and reapplied to the more accurate laser scan mesh (**Fig. 11**). This resulted in a 3D model with fine geometric details down to 0.1 mm based on the laser scan data, overlaid with a high-resolution texture map capturing patterns, colours, and imperfections derived from macro photography.

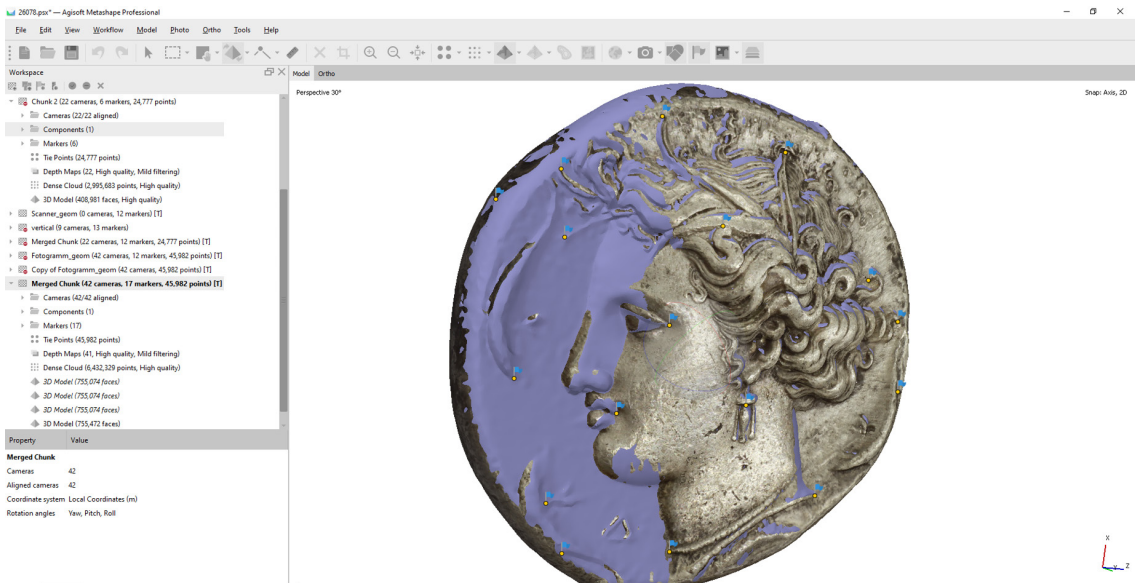

Fig. 11. Coin n. 26118 aligning textured photogrammetry model with laser scanning model using markers.

This optimised data processing and fusion workflow enabled creating highly detailed and photorealistic 3D digital replicas of the museum's numismatic collection for preservation, research, and public access purposes.

3.2.4. Sketchfab integration and online access

To facilitate interactive 3D visualisation and exploration of the digitised coins online, the completed photorealistic 3D models were exported and published on Sketchfab. Sketchfab is a widely used platform for sharing and interacting with 3D models through a WebGL-based online viewer.

A dedicated Sketchfab account was created for the NUMMI DIGITALI project (**Fig. 12**).[11] The high-resolution 3D coin models were exported from the processing software as .OBJ files and optimised for web deployment. The models were then uploaded to Sketchfab and embedded into the custom NUMMI DIGITALI viewer.

[11] https://sketchfab.com/nummidigitali

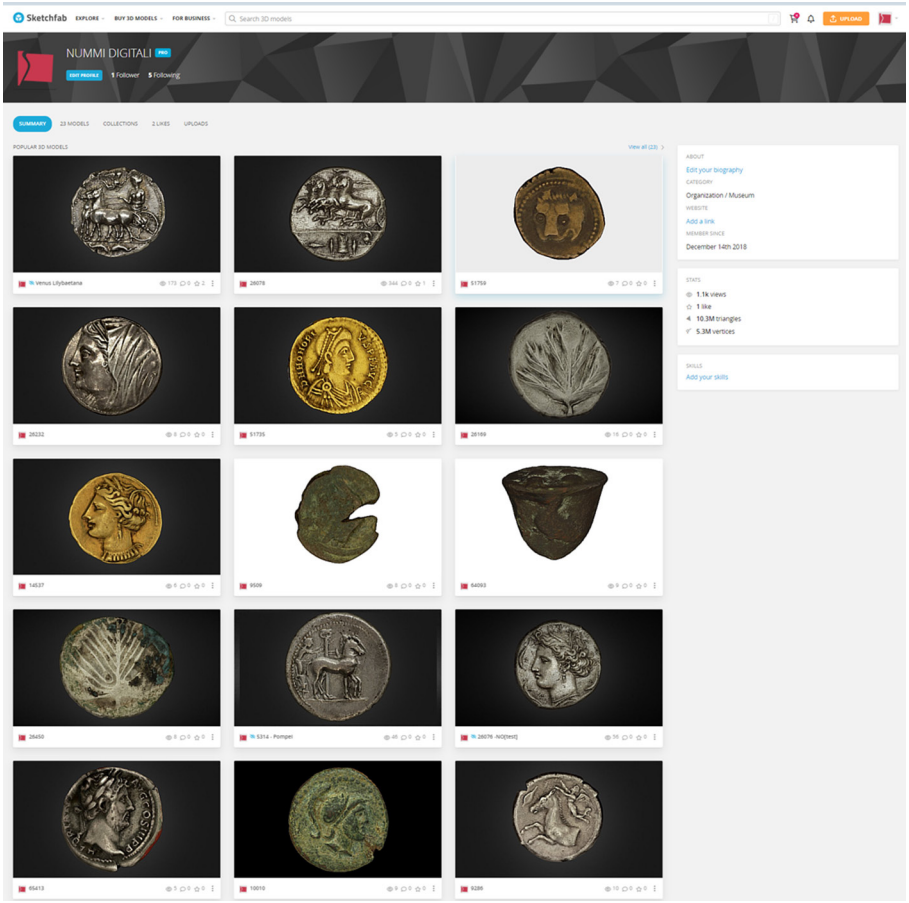

Fig. 12. The dedicated profile for the NUMMI DIGITALI project on Sketchfab with the uploaded 3D models.

Sketchfab provided key functionality for enhancing the online coin viewing experience. Users can interact with the 3D models at high zoom levels, enabling detailed inspection of coin surfaces. Interactive annotations provide contextual multimedia content, including high-resolution images, descriptive text, and video materials (**Fig. 13**), enhancing both specialists analysis and public engagement.

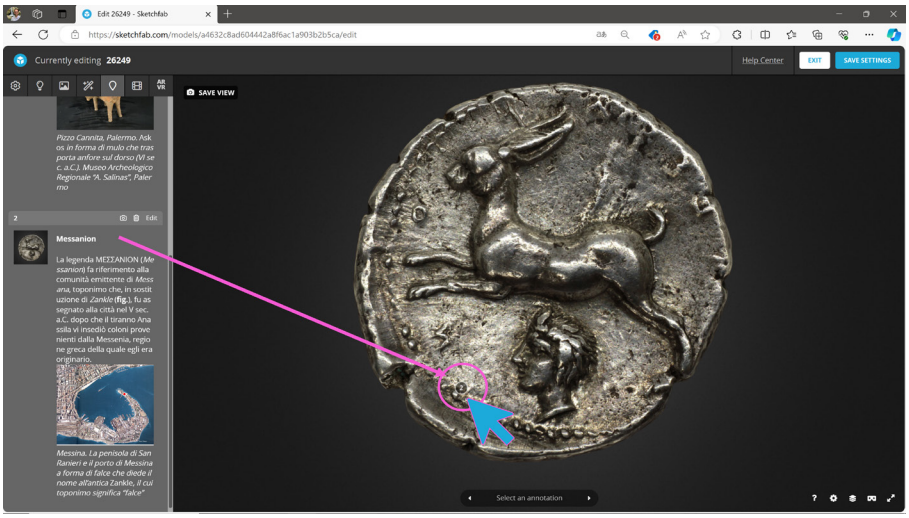

Fig. 13. Interactive points of interest (annotations) enriching the models: info can be accessed by clicking on numbered markers.

Additional functionality like dynamic lighting controls and texture visualisation toggles further augmented the interactive analysis capabilities. Users could adjust directional lighting to illuminate the coin surface from different angles and reveal engraved patterns.

To facilitate public access, the Sketchfab viewer code was embedded into the NUMMI DIGITALI project website developed by Webgenesys.[12] This allowed the interactive 3D coin models to be directly incorporated into the custom web application's virtual museum interface. Users can seamlessly search, browse, and study the digitised collection online, supported by an immersive, multi-media enriched 3D visualisation experience powered by the Photogrammetry-Laser Scanning digitisation approach employed.

4. Investigation of the metal through X-ray fluorescence spectroscopy (XRF)

In the NUMMI DIGITALI project, the investigation of the elemental composition of selected coins housed in the Salinas Museum in Palermo was performed through XRF spectroscopy. XRF spectroscopy is an effective way to carry out a quick and simple multi-elemental analysis, both qualitatively and semi-quantitatively.

The measurement is based on the principle of fluorescence. XRF is a phenomenon in which a material emits X-rays when exposed to high-energy photons, such as X-rays or gamma rays. This emission of X-rays is characteristic of the elemental composition of the material. The basic principle behind X-ray fluorescence involves the excitation of inner-shell electrons in the atoms of a sample. When the sample is bombarded with high-energy photons, some of the inner-shell electrons are ejected from their orbits. The resulting vacancies are then filled by outer-shell electrons, and as they move to lower energy states, they emit X-rays. These emitted X-rays have energies specific to the involved elements, allowing for the identification and quantification of elements in the sample. By analysing the energy and intensity of the emitted X-rays, it is possible to obtain information about the kind of elements present in the investigated area and in their amount. The possibility to use portable XRF spectroscopy made this technique very useful for the investigation of objects of interest in the field of cultural heritage, contributing to their authentication, historical understanding, and preservation. Being a non-destructive elemental analysis, its use guarantees the integrity of the precious archaeological coins, avoiding any transportation outside the museum. Concerning the investigation of coins, XRF spectroscopy is useful because coins are typically composed of various metals, and XRF can quickly determine their elemental composition. This information is crucial for identifying the metal or alloy composition and any surface treatments. This can provide insights into the coin's age, origin, and minting techniques used during a particular period and provide information about the metal sources and trade routes. This can offer insights into the historical context and connections between different civilisations. Understanding the surface characteristics can contribute to the knowledge of a coin's history and preservation. XRF can help in verifying the authenticity of coins by confirming the expected elemental composition. This is particularly important for identifying counterfeit coins that may have a different metal composition than the original ones.

In the NUMMI DIGITALI project, 32 coins in total were analysed from the STEBICEF Department of the University of Palermo. Three were made of gold, 23 of silver, and six of copper. The XRF spectra were acquired in situ by using a Tracer III SD Bruker AXS portable spectrometer. The irradiation by a rhodium target X-ray tube operating at 40 kV and 11 μA and the detection of fluorescence X-rays by a 10 mm^2 silicon drift X-Flash detector allows the detection of elements with atomic number $Z > 11$. A window of 3–4 mm in diameter determined the sampled area. For each measurement the acquisition time was fixed at 30 seconds in order to get a proper signal to noise ratio. A vacuum was not applied at the head of the instrument and the yellow filter, made of a thin layer of titanium and aluminum, were used to eliminate the contribution of the lightest elements. For each coin, two XRF spectra were collected in the two faces of the coins, for a total of 64 spectra.

Data was acquired with S1PXRF® software (Version 3.8.30), while the analysis of spectra was performed using ARTAX7® (Version 7.4.6.1) software in order to assign each peak and estimate the peak's area to perform a semi-quantitative comparison of the spectra. The S1PXRF® software rules the data acquisition. Argon, nickel, palladium, and rhodium signals, due to the atmo-

[12] https://nummidigitali.it

sphere and instrumental components, respectively, are also present in all spectra. The spectra can be divided into three groups as a function of the main recognised elements (**Fig. 14**).

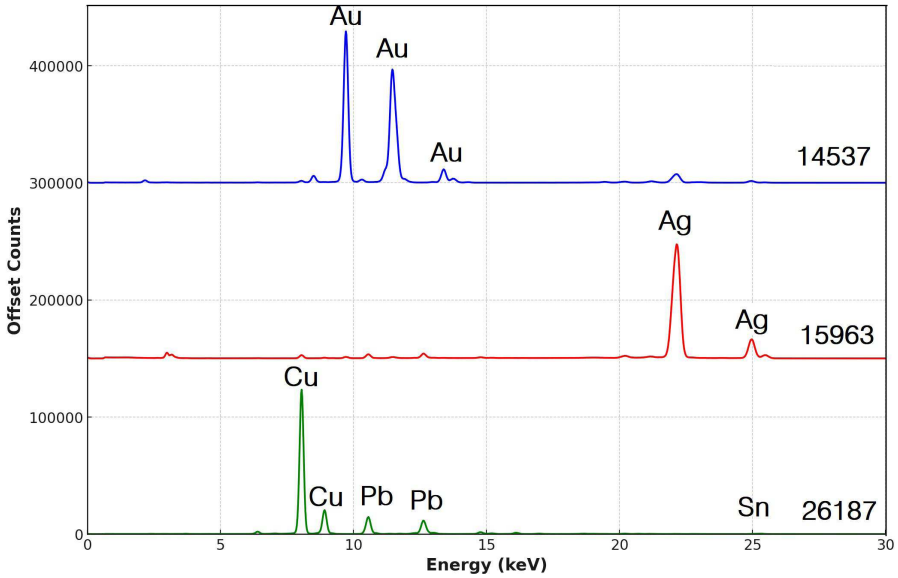

Fig. 14. XRF spectra acquired in the gold (coin N.I. 14537), silver (N.I. 15963) and bronze coins (N.I. 26187).

Concerning the gold coins, the presence of gold (Au) peaks was observed together with small peaks of silver (Ag) and copper (Cu). Concerning the silver coins, the presence of high silver (Ag) and copper (Cu) peaks was observed together with small peaks of gold (Au) and lead (Pb). Concerning the bronze coins, the presence of high copper (Cu) and tin (Sn) peaks was observed together with small peaks of iron (Fe), zinc (Zn), and lead (Pb). The Fe presence is due to environmental contamination and could have originated from the surroundings of the coins. The other identified elements are due to the impurity of the alloy, coming from the used raw materials. The quantitative investigation of all elements also provides information about the amount of the elements in the alloy and can be compared with the ones of similar coins.

At the moment, all the acquired information is not included in the database. XRF spectra and the elemental composition will be added as points of interest in the next step of the project.

The presence of the coin composition in the database is another novelty in this kind of database.

[D.G., M.L.S., F.A., R.C.P.]

5. Conclusions

NUMMI DIGITALI is a project aimed at developing numismatic research, according to the contextual approach and in synergy with the “hard” sciences.

The comparison between numismatic data and archaeological findings, in fact, represents an indispensable source of information for the chronological framing of the coin, to establish its function and its use in antiquity.

On the other hand, the interaction with the “hard” sciences broadens the knowledge relating to the intrinsic aspects of the coin from production to conservation state.

The aim of the project is therefore to improve the study of ancient coinage, through the availability of integrated scientific and interdisciplinary data, and to enhance the numismatic heritage, guaranteeing it a broad social impact, through the mediation of ICT.

The creation of a digital database, based on national cataloguing standards, has made it possible to build an architecture based on consolidated, certified and shared parameters, but at the same time subject to improvements in relation to the needs of modern numismatic research.

The database connection with the web, through a user-friendly front-end, guarantees the interoperability and shareability of research products, according to the Linked Open Data para-

digm. Furthermore, it allows public accessibility to the numismatic collection, promotes research, improves the use of information and activates interactive communication processes through high-resolution images and 3D restitutions, equipped with points of interest with hypertext and/or multimedia links.

The project also represented the opportunity for significant progress in the field of modelling and archaeometric analysis of coins.

For 3D modelling, coins represent complex artifacts because their small size and miniaturized iconography require special detection tools, so that the final product is a replica of the original, functional to research. The modelling technique therefore allowed us to develop 3D models that proved to be valuable tools for studying the types, traces of coin manufacturing and signs related to the use of money in antiquity, while preserving the artifacts through highly faithful representations. They also represent tools for attracting a wider audience, reachable on the web, consistently with the aim of ensuring a strong social impact to a science, such as numismatics, which at first glance appears, but unjustifiably, niche.

Furthermore, the analysis of the metal of the coins, through XFR spectroscopy, has allowed us to broaden and deepen our knowledge of the alloys and metals used for manufacturing, often raising questions about the sources of supply of the raw material, the manufacturing technique and the authenticity of the specimens. All inputs for other future research.

[L.S.]

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WEB RESOURCES

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http://www.iccd.beniculturali.it/it/ricercanormative/18/nu-beni-numismatici-3_00

http://www.iccd.beniculturali.it/it/sigec-web

http://www.iccd.beniculturali.it/it/standard-catalografici

http://nomisma.org/nuds

https://digitallibrary.cultura.gov.it/il-piano/

https://docs.italia.it/italia/icdp/icdp-pnd-digitalizzazione-docs/it/v1.0-giugno-2022/index.html

https://docs.italia.it/italia/icdp/icdp-pnd-dmp-docs/it/v1.0-giugno-2022/index.html

https://github.com/ICCd-MiBACT/Standard-catalografici

https://nummidigitali.it

https://sketchfab.com/nummidigitali

https://www.gom.com/en/products/3d-scanning/atos-q
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https://www.unipa.it/dipartimenti/stebicef
https://www.w3.org/DesignIssues/LinkedData
https://www.webgenesys.it/