

AN OPEN SYSTEM FOR TEXTUAL, VISUAL, AND BIBLIOGRAPHIC RESOURCES: THE OPEN DIGITAL ARCHAEOLOGY HUB

1. INTRODUCTION

The Open Digital Archaeology Hub (<https://open-archaeohub.cnr.it/>) is an advanced platform dedicated to digital archaeology. Developed alongside the Open Digital Epigraphy Hub (ROSSI, SALVADOR 2024), the platform is the outcome of a collaborative project involving interdisciplinary expertise and it represents one of the pilot products of H2IOSC WP7 (Fig. 1). It was conceived as an open and expandable environment, designed to expose collections of textual, visual, and bibliographic data, while also being capable of integration with broader infrastructures at both national and transnational levels. The project aimed to create a user-friendly and accessible tool in which geographic data serves as a primary key to accessing information, an approach aligned with that adopted in major national digital initiatives, such as the National Geoportal for Archaeology (GNA: <https://gna.cultura.gov.it/index.html>) and the Archaeological Territorial Information System of Rome (SITAR: <https://www.archeositarproject.it/>).

The idea of enhancing the archaeological site as a key entry point to information resources was also explored in a previous project, albeit in a different context, using the open-source tool Recogito (<https://recogito.pelagios.org/>). This tool was employed to geographically map the toponyms mentioned in the articles published in «Archeologia e Calcolatori» (A&C) (CANTONE, CARVALE 2019). The aim in that case was to analyse the distribution of toponyms and make them searchable according to the principles of the Linked Open Data paradigm. The data, structured in this way, were integrated into the European infrastructure Pelagios Commons, made accessible through the geographic search engine Peripleo, and cross-referenced with data from other independent databases, primarily epigraphic, that the platform aggregated.

Interoperability and integration were also core objectives in the design and development of the Open Digital Archaeology Hub. Since this is a pilot activity, the information currently used is derived from the A&C repositories, including three types of data: textual, iconographic, and bibliographic. These are complemented by data recently mapped through the DHeLO web app (<https://dhelo.cnr.it/>; MANCUSO, in this special section), which relates to digital archaeological projects, datasets and interactive resources. The focus, therefore, remains on digital archaeology in its many and varied forms. In particular, a number of significant sites and areas have been selected for

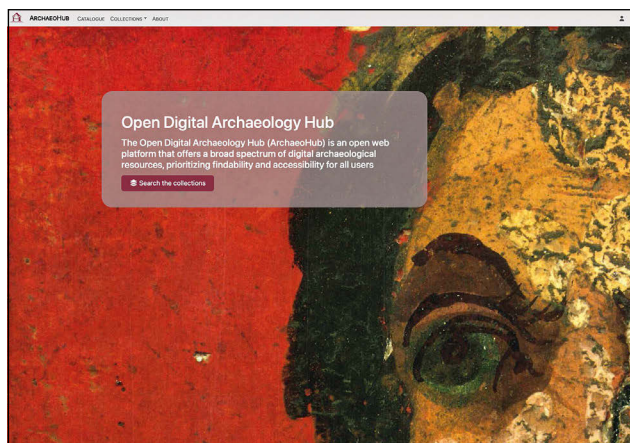


Fig. 1 – ArchaeoHub homepage.

enhancement, both because of the long-standing research tradition associated with our CNR Institute and their importance within the broader context of contemporary archaeological studies.

A key aspect of this approach is the possibility to organise the materials into thematic collections based on geographic and territorial criteria. These groups bring together heterogeneous resources, texts, images, and bibliographic references, related to specific areas or sites of archaeological relevance. This structure not only facilitates targeted exploration and data reuse, but also supports contextual understanding, making it easier to identify connections between digital resources and the research traditions or historical significance of a given area. At present, collections have been completed for Cerveteri, Etruria, Sabina, Pompeii, Sicily, and Sardinia, within a system designed to grow and be continuously enriched through new additions and updates (Fig. 2). The bibliographic references included in the collections have proven particularly valuable, as they are derived from those compiled within the BiDiAr project (Bibliography of Digital Archaeology; MANCUSO, D'EREDITÀ 2024; see §4). Equally significant is the classification of the related images, which was developed based on metadata work carried out in collaboration with another PNRR project in which CNR-ISPC is involved: Cultural Heritage Active Innovation for Sustainable Society (CHANGES), Spoke 8 (BUSCEMI, FAZIO 2024).

The platform is designed to provide access to a large corpus of scientific information and, thanks to its modular and extensible architecture, allows the integration of external textual and iconographic archives from scientific journals, research projects, and specialised institutions. It is aimed at individual



Fig. 2 – The collections currently available on the ArchaeoHub website.

scholars, publishers and cultural institutions in Italy and abroad who can access information on sites and locations particularly relevant to the history of studies and who can connect their data in a structured, interoperable environment that complies with international standards for digital sharing and preservation. In this way, ArchaeoHub serves as a tool for strengthening collaborative networks between researchers, institutions and scientific communities at national and international level.

A.C.

2. ARCHAEOHUB: CONCEPTUAL FRAMEWORK

ArchaeoHub was originally conceived as a repository for electronic resources related to digital archaeology; an approach that could rely on more than thirty years of scholarly tradition, with Italy emerging as a key player in the international panorama (MOSCATI 2019). During the initial planning

phase, the Digital Archaeological Record (tDAR) (KINTIGH 2006) was identified as the model for data archiving, metadata structuring, and presentation that best aligned with our project objectives – although it operates on a larger scale and with considerably greater funding. Developed and maintained by the Center for Digital Antiquity, a multi-institutional organisation housed within the School of Human Evolution and Social Change at Arizona State University, tDAR actively serves as an international repository for the digital records of archaeological investigations (documents, datasets, images, and other critical archaeological materials). It is designed to ensure the long-term preservation of digital archaeological data and to support their discovery, access, and reuse according to the FAIR (Findable, Accessible, Interoperable, and Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, and Ethics) data principles across cultural heritage disciplines.

Over time, tDAR has significantly evolved into a ‘full-service model’ (McMANAMON *et al.* 2017) that curates and preserves data and information about archaeological resources and related topics for future use. Currently, the service charges fees to fund the digital preservation of files, public data access, confidential data protection, data security, customer service, and professional training for the proper digital curation of archaeological materials. While valuable for sustainability and preservation, the service-oriented nature of tDAR diverged from the project’s original intent to implement a domain-specific repository serving the needs of digital archaeological scholarship by collecting research projects, data, and tools. Indeed, our aim was not to replicate a platform focused on long-term storage through fee-based access, but rather – following the tradition of A&C – to develop a scholarly resource intended for research, analysis, and dissemination.

This shift in perspective was also facilitated by the fact that we could already rely on a robust research infrastructure, such as E-RIHS, and a dedicated Data Space built within the planned DIGILAB – the first step towards a shared digital platform under the E-RIHS framework (BUCCIERO *et al.* 2023).

Therefore, as a pilot project of the H2IOSC collaborative cluster of European distributed research infrastructures involved in the humanities and cultural heritage, ArchaeoHub has evolved into a comprehensive scholarly hub composed of interconnected nodes aggregating and disseminating digital archaeology-related data based on geographical location and specific cultural contexts, primarily focused on the Italian Peninsula. This thematically oriented model differs significantly from that of a static repository, positioning ArchaeoHub as an active agent in monitoring, analysing, and legitimising the development of digital archaeology as a discipline with origins dating back to the 1950s.

In the international context, some examples are moving in a similar direction, aimed precisely at overcoming the broad focus of existing digital

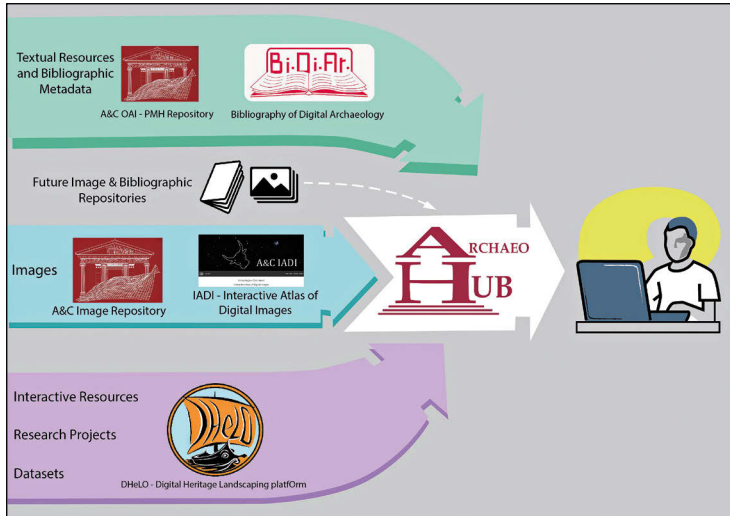


Fig. 3 – Conceptual map showing the interactions between the ArchaeoHub and its respective data sources.

infrastructures. A comparable methodological example is the geo-historical repository promoted by a consortium of researchers and engineers from various institutions within the Time Machine Projects related to the French research infrastructure Huma-Num. In particular, the open data platform ‘Fabrique numérique du passé’ (FNP - <https://www.fabriquenumeriquedupasse.fr/>) enables the spatialisation of historical data through the development of accessible, purpose-built tools. As Laurent Costa has clearly stated: «Contrairement à d’autres approches plus globalisantes, il s’agit ici, par une interface plus légère, de mobiliser et de capitaliser sur l’existant, au plus près des besoins de la communauté, d’agglomérer les compétences, les outils existants et les données pour les rendre disponibles dans les futurs programmes de recherche ... pour des approches à d’autres échelles» (COSTA 2023).

Today, ArchaeoHub fulfils a dual scholarly function. First, it addresses the specific needs of the Heritage Science community, positioning digital archaeology as one of its clearly defined and distinct sectors – an understanding recently reinforced by a survey employing AI-based methods (CARAVALLE *et al.* 2023). Second, it represents a pioneering initiative in the international arena, advancing digital archaeology beyond the conventional boundaries of data repositories and surpassing the general scope of digital infrastructures that serve the broader archaeological domain. With its networked structure, the hub-and-spoke model is well suited to supporting and integrating other projects that aim to make research data and analysis tools openly available.

Rooted in the concept of movement, this model conveys the idea of a continuous centripetal flow, reducing the need to equip each individual spoke with tools or services that can instead be centralised within a single, shared hub, supporting a broader network of decentralised research activities and projects across the field (Fig. 3).

P.M.

3. ARCHAEOHUB: TECHNICAL OVERVIEW

Operating under this conceptual framework, from a technical standpoint the Open Digital Archaeology Hub was conceived as an aggregator of metadata rather than a repository of primary data or digital objects. This choice reflects both practical and conceptual considerations. Practically, it allows the platform to remain lightweight and scalable, avoiding the need to store or manage heterogeneous datasets directly. Conceptually, it aligns with the broader objective of promoting a hub-and-spoke model to foster interoperability and transparency in research data infrastructures. In this sense, ArchaeoHub functions by indexing structured metadata drawn from a range of external sources, while leaving the original data in their respective repositories; an approach that mirrors the one adopted by the Virtual Language Observatory (<https://www.clarin.eu/content/virtual-language-observatory-vlo>) developed by the CLARIN infrastructure (BRANCO *et al.* 2023).

The aggregation of content within ArchaeoHub relies on differentiated data flows, each tailored to the nature of the source and the type of metadata involved. Bibliographic content is harvested through the OAI-PMH protocol. Currently, this protocol includes metadata from the Diamond Open Access journal A&C, which has adhered to this standard since 2005 (BARCHESI 2005; PARACIANI 2024). However, this format opens the possibility for further integrations. At present, the records exposed via this protocol provide structured, article-level metadata for over 1,300 contributions. This stream is further enriched by the integration of BiDiAr (see §4). Through this channel, ArchaeoHub offers direct links to the consultation of full-text publications and the exploration of their underlying citation networks, providing an entry point into the intellectual structure of the discipline.

Visual materials and structured metadata related to archaeological research outputs are retrieved through the RESTful APIs developed by the contributing platforms, exposing their metadata in JSON-LD format, and facilitating automated harvesting process. Currently the images are provided to the Hub both from The Interactive Atlas of Digital Images (IADI), that stores the images of the first 30 years of A&C (PARACIANI, ROSSI 2023) and the A&C digital repository for the latest issues. For both these resources a metadata enrichment process was carried out in collaboration with another

PNRR project in which CNR-ISPC is involved: Cultural Heritage Active Innovation for Sustainable Society (CHANGES), Spoke 8 (BUSCEMI, FAZIO 2024). Lastly, RESTful APIs feed the ArchaeoHub data from the DHeLO platform, providing information on research projects, datasets and interactive resources.

The integration of these diverse and inherently heterogeneous sources required a highly streamlined metadata schema, limited to the essential information needed for resource identification and aggregation within the platform. To achieve this, a minimalist approach to metadata harvesting and exposure was adopted. This method focused on a core set of descriptors that would support discovery and interoperability without imposing rigid formal requirements on resources that may follow very different metadata conventions. The structure is organised into four functional domains: (1) resource description – including title and abstract – which facilitates both basic identification and unstructured keyword searches; (2) authorship, indexing the creators and contributors associated with the resource; (3) subject indexing and classification, based on the dual-level strategy – technological and thematic – originally developed for A&C, and subsequently extended to

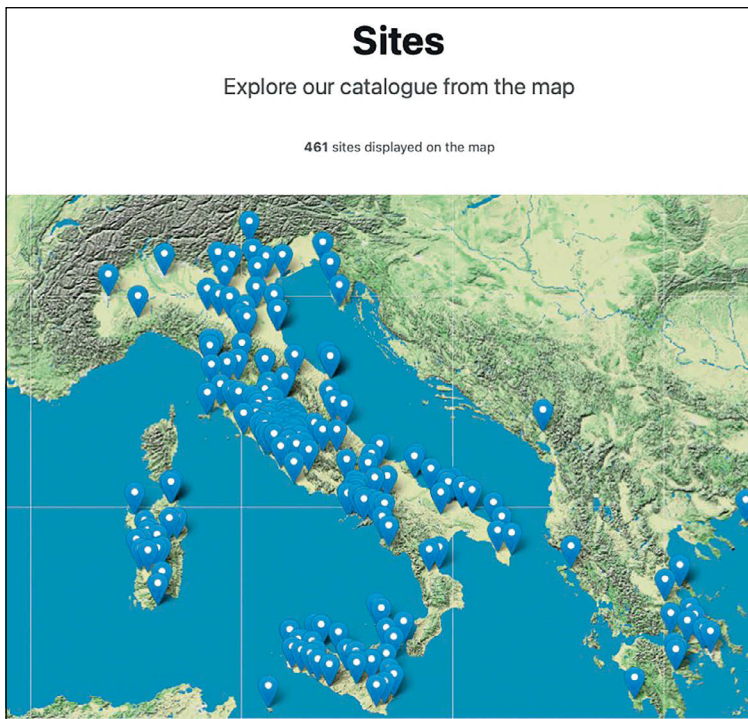


Fig. 4 – Map view of all the items currently available on the ArchaeoHub.

the classification of visual materials (BUSCEMI, FAZIO 2024); and (4) spatial referencing, achieved through alignment with the Pleiades gazetteer for the identification and disambiguation of geographic entities.

Geographical information plays a central role in the design and functionality of ArchaeoHub. As previously mentioned, spatial data serves both as a means of accessing individual resources via a WebGIS interface and as a foundational element for the creation and indexing of thematic collections (Fig. 4). From a technical perspective, the spatial dimension is handled in two complementary ways. In the case of collections, each thematic grouping is associated with a curated set of Pleiades identifiers, which are extracted from the metadata harvested from contributing repositories. These identifiers are used as filters to aggregate and display only those resources that relate to the relevant geographic entities. This approach ensures semantic consistency and allows the platform to structure collections around historically and archaeologically meaningful locations. For the interactive geographic interface, the system relies on geospatial coordinates contained within the harvested metadata, which are resolved and contextualized using the Pleiades database. This step not only enables map-based browsing but also supports the disambiguation of place names, linking them to authoritative spatial entities. In this way, ArchaeoHub reinforces the inherently locational nature of archaeological information, making spatial context an integral dimension of digital resource discovery and interpretation.

G.M.

4. BiDiAr: BIBLIOGRAPHY OF DIGITAL ARCHAEOLOGY

Another key component of the ArchaeoHub is BiDiAr (Bibliography of Digital Archaeology), a thematic collection of bibliographic references developed by the Rome research Unit participating in the work of WP2 (MANCUSO, D'EREDITÀ 2024). The BiDiAr platform is based on a body of metadata extracted from articles and citations in A&C and its primary goal is to provide a container where bibliographic data are collected and organised. These data can be used both for disciplinary purposes, namely, to create a bibliography of 'archaeological computing', following the model tested in previous experiences (MOSCATI 1999), and for more practical editorial needs, offering authors a citation database to draw from or contribute to when writing their own articles. The tool chosen for managing the database is Zotero (PUCKETT 2011), a well-known FOSS software for bibliographic management. This program offers numerous advantages, including effective structuring of sources thanks to the Zotero Connector plugin, which enables automatic harvesting and mapping of metadata, greatly simplifying the manual entry process. The platform also provides advanced features for sharing and

customising collections and allows data to be exported in various standard formats, promoting interoperability with other information systems. Each bibliographic record in BiDiAr is described using open and interoperable metadata schemas (e.g., Dublin Core, BIBO, SKOS, FOAF), and linked to controlled vocabularies and ontologies that support the semantic classification of publications by topics, technologies, theoretical approaches, and chronologies.

BiDiAr follows an approach similar to that adopted by DARIAH, the leading European research infrastructure for Social and Cultural Innovation in the digital humanities (https://www.zotero.org/groups/113737/doing_digital_humanities_a_dariah_bibliography). Projects such as DARIAH-EU, OPERAS, and E-RIHS promote a FAIR (Findable, Accessible, Interoperable, Reusable) approach (LARSSON *et al.* 2025) to data management, where Zotero can serve as an operational node for the collection, organization, and sharing of bibliographic and documentary sources. Thanks to its open architecture and ability to integrate with collaborative environments and institutional repositories, Zotero meets the interoperability and sustainability requirements set by European research infrastructures in the humanities and cultural heritage sectors, offering concrete support in the construction of shared digital ecosystems.

A similar strategy has also been recently implemented by «Umanistica Digitale», the Italian journal of digital humanities, which maintains a public Zotero library (https://www.zotero.org/groups/1624882/umanistica_digitale) as an extension of its editorial work. This curated bibliographic collection serves both as a tool for enhancing the visibility and accessibility of the journal's scholarly output and as a resource for the wider community of researchers. While the scale of the dataset managed by «Umanistica Digitale» is more limited compared to the extensive and thematically focused collection curated in BiDiAr, both initiatives aim to provide a stable, structured reference environment and serve as editorial support tools to enhance the production and dissemination of scholarly content.

The data entry work of BiDiAr has focused on three main groups of data. The first group concerns the corpus of 1278 articles published in the journal from 1990 to the present. The second group consists of the bibliographic citations associated with each article, that is, the references listed in the final bibliography of every contribution published in A&C. This task, considerable in both complexity and scale, has so far been limited to the volumes published between 2019 and 2024, which were selected as a priority within the project to facilitate the metadata collection of the most recent trends in digital archaeology. Over 10,000 bibliographic records have been extracted, normalised, and indexed for this timeframe. Based on a projection across the entire 36-year editorial history of the journal, the overall corpus is estimated to exceed 30,000 records.

The third group of data entered concerns the connection between BiDiAr and the ArchaeoHub project. The bibliographies included in the articles from the six geographical collections completed so far (Cerveteri, Etruria, Sabina, Pompeii, Sardinia, Sicily) have been integrated into Zotero and made accessible directly from the display page of each paper on ArchaeoHub (Fig. 5). In this way, users are provided with an interactive tool for orientation and research, allowing them to explore the documentation related to a site or area, ranging from pioneering studies on early technological and digital applications to the most recent digital archaeology projects.

Bibliographic research conducted within the collections provides insight into the methodological trends that characterise the geographical areas under examination. For instance, through the pages of the journal, it is evident that studies conducted in the Sabina region reveal a research tradition spanning over thirty years, with a particular emphasis on landscape archaeology. The Sabina collection nowadays includes 16 thematic articles from A&C and 346 associated citations, reflecting an evolving methodological approach, beginning with the adoption of statistical models aimed at producing probability maps of archaeological site locations (ARZIA, ESPA 1996). This approach later evolved into the use of Geographical Information Systems for managing and analysing geo-relational data (COLOSI *et al.* 1999) and culminated in the implementation of 3D digital terrain models and virtual reality navigation techniques. The analysis of the associated citations confirms that

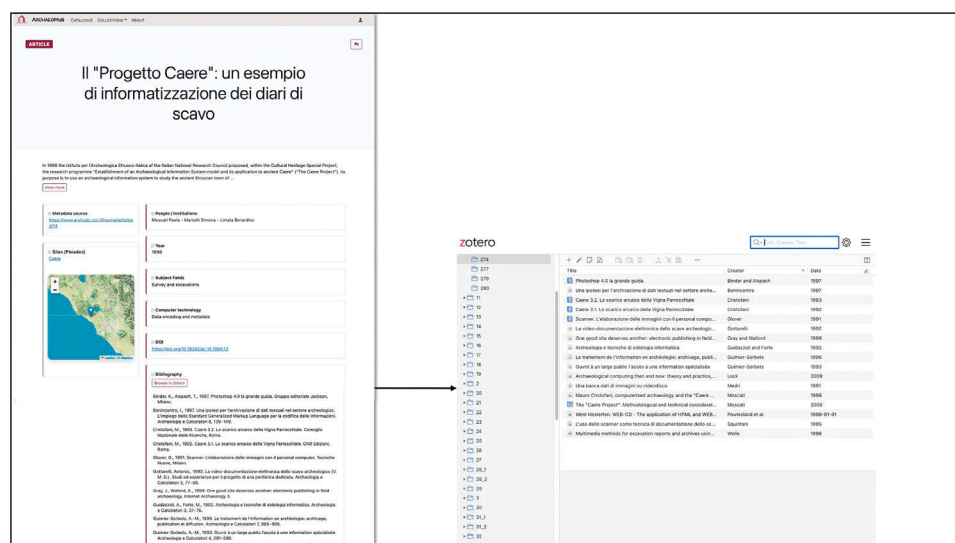


Fig. 5 – Screenshot of an article record in ArchaeoHub, with its corresponding bibliographic entries in the BiDiAr Zotero library.

the Tiber River has been a central focus in numerous studies, encompassing investigations into its original course (COSTANTINI *et al.* 1999), such as the comprehensive Tiber Valley Project (PATTERSON *et al.* 2000), and the Virtual Museum of the Tiber Valley (ARNOLDUS HUYZENDVELD *et al.* 2012).

In contrast, the Cerveteri collection draws scholarly attention to the study of Etruscan cities; this dataset includes 14 articles and 239 citations, documenting a wide array of research perspectives. Over the years Cerveteri has been the focus of original and innovative projects, such as the Caere Project, the first GIS specifically dedicated to the urban area (MOSCATI 1998), and the pioneering experimentation with electronic encoding of excavation diaries using markup languages, adhering to the TEI (Text Encoding Initiative) Lite guidelines (MOSCATI, MARIOTTI, LIMATA 1999). Among the most significant related works, citations concentrate on the urban archaeological investigations initiated by Mauro Cristofani in the 1980s (notably, the Series ‘Caere’: CRISTOFANI 1992, 1993, 2003), alongside the distinctive contributions of geophysical studies in the necropolis areas inaugurated by the Lerici Foundation (LERICI 1957; *Etruschi e Cerveteri* 1980), which today form the basis of new investigations in the Monte Abatone area (GILOTTA *et al.* 2022).

A future development involves the integration of a fourth dataset, the 1990s Bibliography of Archaeological Computing. This resource, currently accessible through the Virtual Museum of Archaeological Computing (<https://archaeologicalcomputing.lincci.it/bibliography>), has already been the subject of specific studies and is particularly significant for analysing the international cultural landscape of a transitional decade. The 1990s served as a bridge between pioneering experiments of earlier decades and the challenges of the 2000s, marked by the full establishment of digital technologies across all sectors of archaeological research (CARVALE, MOSCATI 2021).

A.D.

5. FUTURE PROSPECTS

ArchaeoHub and BiDiAr are digital infrastructures under constant development and implementation; designed from the outset as flexible, extensible tools, both platforms are structured to support continuous expansion, whether in terms of data volume, thematic scope, or technological integration. Rather than presenting themselves as finished products, they offer a framework for ongoing enrichment, capable of incorporating new datasets, refining metadata models, and aligning with emerging standards in digital heritage and research infrastructures. This open architecture makes them particularly well-suited for long-term deployment within dynamic academic and institutional contexts.

ArchaeoHub, which is already accessible as a free service, has been designed to accommodate new content layers and to interoperate with

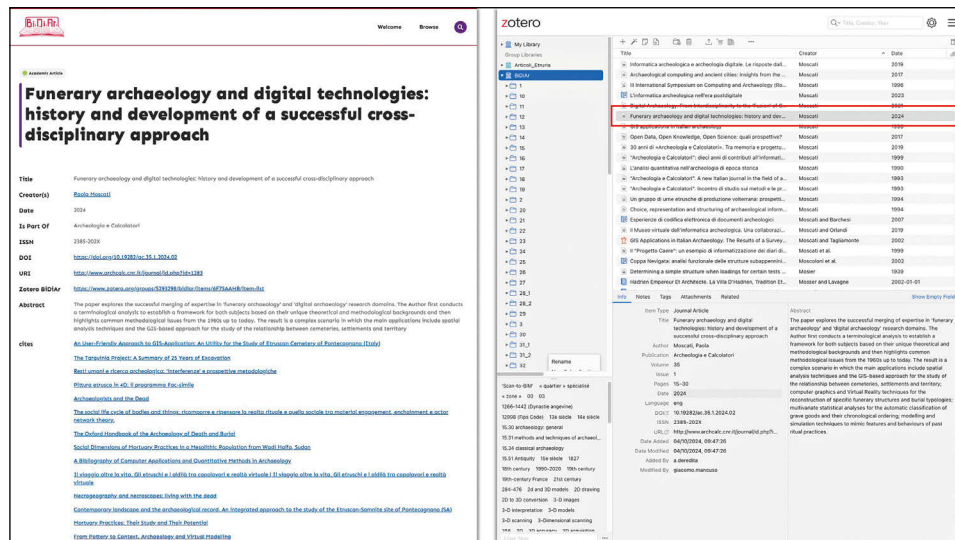


Fig. 6 – Example of the same record from the BiDiAr website (currently under construction with Omeka S) and its relations with the BiDiAr Zotero library.

national and international platforms through its own set of APIs. Its modular structure ensures that it can evolve in response to the needs of researchers, institutions, and wider user communities. Meanwhile, BiDiAr is progressively being migrated into the Omeka S environment (Fig. 6), a step that will enable greater autonomy of bibliographic metadata management while maintaining a strong connection with Zotero. This hybrid solution allows the platform to continue functioning as a collaborative citation tool while also benefiting from the semantic control, standardization, and analytical capabilities afforded by Omeka S.

Beyond their technical and infrastructural value, ArchaeoHub and BiDiAr also serve a broader epistemological purpose. As instruments for both dissemination and research, they enable scholars to access curated, interoperable, and reusable data in ways that foster collaboration, transparency, and methodological innovation. In this perspective, bibliographic and heritage data are not merely auxiliary to research but can become research objects in themselves, as structured environments that sustain scholarly practices and contribute to shaping the future of digital archaeology.

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ABSTRACT

The Open Digital Archaeology Hub (ArchaeoHub) is a modular and extensible platform developed within the H2IOSC project to support the aggregation and dissemination of digital archaeological resources. Conceived as a metadata aggregator rather than a repository, it integrates textual, visual, and bibliographic data from diverse sources, including the journal «Archeologia e Calcolatori» the BiDiAr bibliographic platform, and the DHeLO web app. Its structure is based on a hub-and-spoke model, designed to enable thematic collections organised around geographic entities, using Pleiades identifiers and WebGIS technologies to enhance discovery and contextualization. ArchaeoHub promotes interoperability through standards such as RDF, Dublin Core, and JSON-LD, and supports linked data connections with external resources. It offers scholars and institutions a lightweight, FAIR-compliant environment to access and cross-reference data. A key feature is its integration with BiDiAr, a curated bibliography of digital archaeology structured through Zotero, enabling citation tracking and semantic classification. The platform exemplifies a shift from static repositories to dynamic, research-oriented infrastructures aligned with national and international best practices. Positioned within the broader landscape of digital heritage infrastructures, ArchaeoHub serves as both a scholarly resource and a methodological prototype for managing complex archaeological information in a collaborative, open-access framework.