

# Object-related Research Data Workflows within NFDI4Objects and beyond

Florian Thiery<sup>1</sup>[\[https://orcid.org/0000-0002-3246-3531\]](https://orcid.org/0000-0002-3246-3531),  
Allard W. Mees<sup>1</sup>[\[https://orcid.org/0000-0002-7634-5342\]](https://orcid.org/0000-0002-7634-5342),  
Bernhard Weisser<sup>2</sup>[\[https://orcid.org/0000-0001-5262-2731\]](https://orcid.org/0000-0001-5262-2731),  
Felix F. Schäfer<sup>2</sup>[\[https://orcid.org/0000-0002-9867-5588\]](https://orcid.org/0000-0002-9867-5588),  
Stefanie Baars<sup>2</sup>[\[https://orcid.org/0000-0003-1100-6494\]](https://orcid.org/0000-0003-1100-6494),  
Sonja Nolte<sup>3</sup>[\[https://orcid.org/0009-0002-1843-8791\]](https://orcid.org/0009-0002-1843-8791),  
Henriette Senst<sup>4</sup>[\[https://orcid.org/0000-0003-2255-7478\]](https://orcid.org/0000-0003-2255-7478), and  
Philipp von Rummel<sup>4</sup>[\[https://orcid.org/0000-0001-7545-2181\]](https://orcid.org/0000-0001-7545-2181)

<sup>1</sup>Leibniz-Zentrum für Archäologie, Mainz, Germany

<sup>2</sup>Stiftung Preußischer Kulturbesitz, Berlin, Germany

<sup>3</sup>Verbundzentrale des GBV, Göttingen, Germany

<sup>4</sup>Deutsches Archäologisches Institut, Berlin, Germany

**Abstract:** n.a.

**Keywords:** NFDI, NFDI4Objects, Object Biography, Digitalisation Workflow, Semantic Modelling, Linked Open Data, Wikidata

## 1 Introduction

NFDI4Objects (N4O) represents a broad community dealing with material remains of human history from around 3 million years and involves numerous disciplines from the humanities, cultural studies and natural sciences with an archaeological and historical focus [1]. The objects examined include potsherds of common ware, artworks such as sculptures or jewellery, serially produced objects such as coins, organic remains such as wood, bones or pollen, inscribed clay tablets, papyri and stones, architectural remains, as well as human-modified landscapes. Modern research materials such as plaster casts, analogue photographs and drawings, archival documents, books and raw digital data are equally relevant.

## 2 Object biographies as challenges for RDM

Objects are in multiple relationships in terms of both their materiality and the actors, spaces and times associated with them. Within these networks, they are not static but are subject to change, which imbue them with individual biographies that can only partially be understood and reconstructed. Objects can appear in different contexts: the production by specific actors, the primary or secondary use in, for example, religious, military or sepulchral settings, their place of discovery as the physical context

set against their reception in the modern collection, mediation and research environments. Objects are constantly changing through use, decay and restoration. In the course of an excavation, their context is often irreversibly destroyed. In collections, the objects are often recombined and rearranged and reinterpreted according to changing research paradigms. The information about their find circumstances, preservation conditions and other contexts are decisive for their interpretation.

The NFDI4Objects' four-fold central task includes: a) comprehending the representations of these physical, three-dimensional objects as research data, b) relating them to the respective fluctuating contexts, c) transforming them adequately into digital space, and d) curating them according to subject-specific requirements. This involves overcoming various media breaks. Language, texts and images offer opportunities to bridge the media transfer. Machine-readable interfaces using community standards also enable computer-aided use. However, many uncertainties remain, often not sufficiently considered in the digital space. The digital FDM of objects opens up the potential for digital exploration of an object's diverse stories and meanings and for establishing further links.

This paper demonstrates the scope and vision of N4O and the challenges of an object-related RDM, exemplified by an object group of ancient pottery (African Red Slip Ware). It also addresses the questions and structures of further development and the transferability to other NFDI domains.

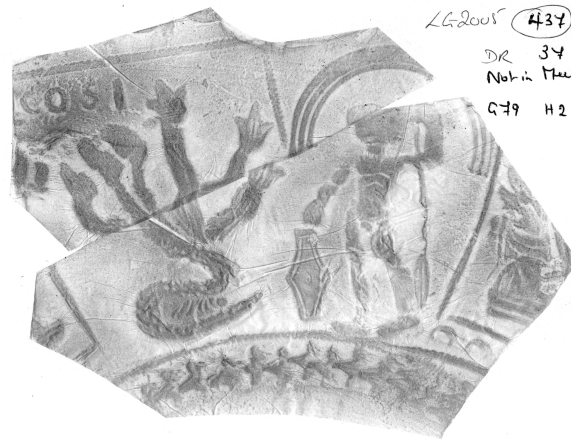
### 3 The African Red Slip Ware as Paradigm

An example of such archaeological objects is the African Red Slip Ware pottery (ARS), a category of fine ware produced in the Roman Imperial period [2], [3] (Figure 1). A feature of ARS is its applied relief decoration, which displays, e.g., mythological, Old and New Testament motifs, circus, arena and hunting scenes [4]. Thus, ARS is one indicator of exchange processes in the Roman empire.

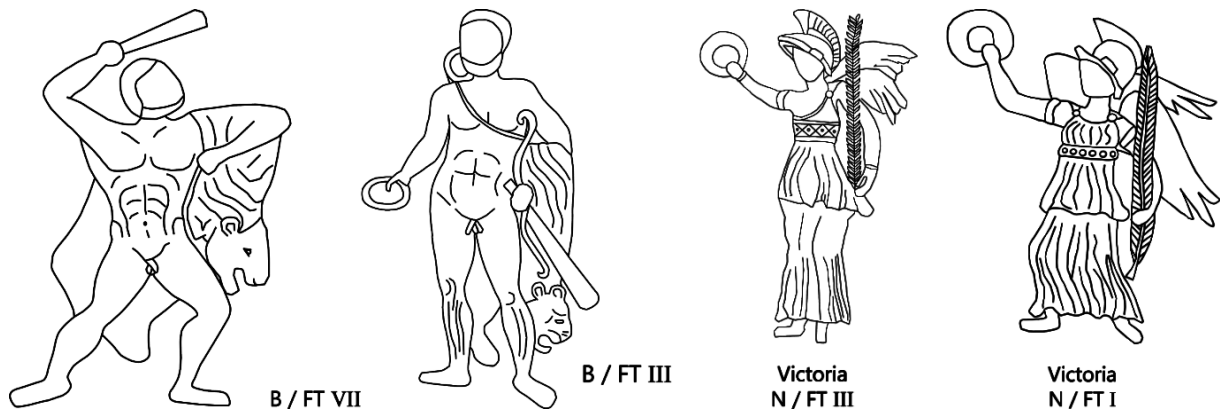


**Figure 1.** (Left) O.39675 "bowl with man and woman"; (right) Various ARS objects of the LEIZA collection. [left: object LEIZA, photo: Lübke & Wiedemann, Leonberg; left: CC BY-SA 4.0 ARS3D Project / i3mainz / LEIZA, published in [5]]

All German ARS collections comprise numerous objects originating from private collections or were acquired on the art market before the KultGüRückG (Act on the Return of Cultural Property) was implemented in 2007 [6]–[8]. Thus the acquisition history inevitably tackles ethical issues, thus being related to the CARE principles. This requires a historical investigation of the provenance and a critical debate about this research data [9].



**Figure 2.** Rubbing of a decorated Samian (Terra Sigillata) vessel, made in La Graufesenque, 100-120 AD, decorated by the potter L. Cosius. [Geoffrey Dannell and Allard W. Mees, CC BY 4.0, via Wikimedia Commons]

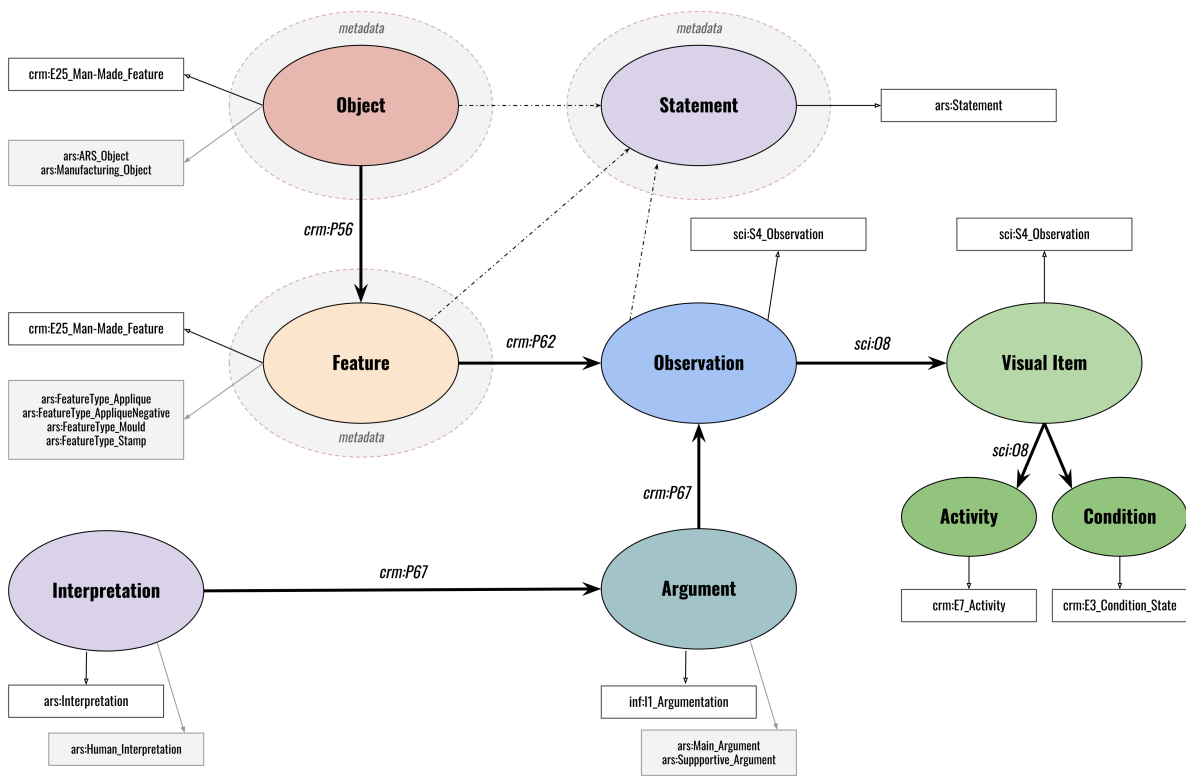


**Figure 3.** Examples for representations of Hercules (B) [10, p.702] and Victoria (N) [10, p.719] on Roman terra sigillata, reproduced with permission from Sophie zu Löwenstein, published in [10] and [11].

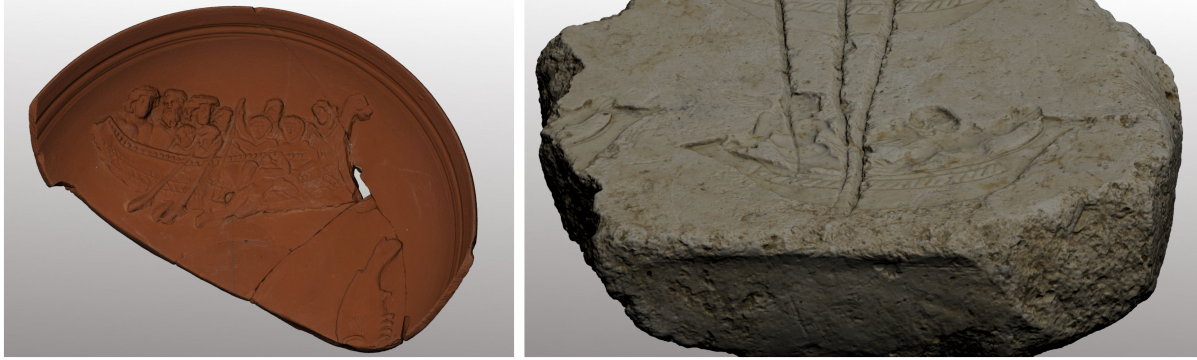
The previous practice of recording ARS pottery and its decoration involved photographs and drawings in analogue publications [4] (Figures 2 , 3). However, for reproduction and comparison of the appliqué and their figure types, this method is not entirely suitable, for it does not allow for an accurate recording of the plasticity of the objects. The lack of standardised assignments for figure types also hampers the comparison. For the current research, structured, machine-readable data enriched with specialised information is required to reflect the complexity of the object's information fabric. In a recent paper, a workflow for innovative, comprehensible and sustainable FAIR data access for this material has been developed [9]. The results and methods are being taken up and further developed in N4O and some overlapping consortia such as NFDI4Culture (N4C).



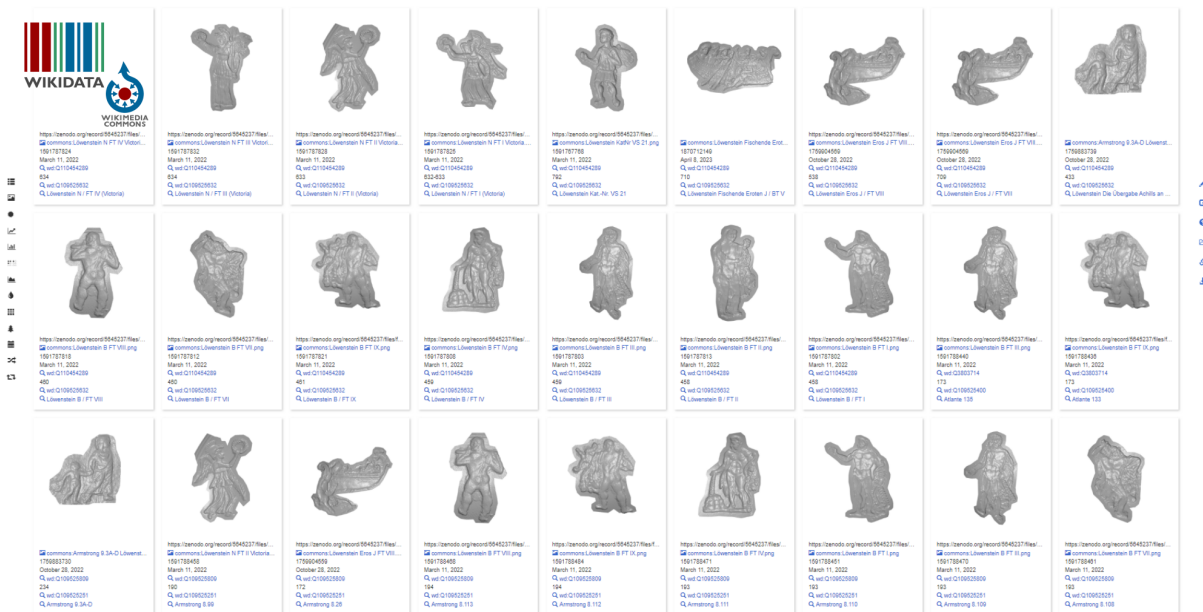
**Figure 4.** Data acquisition. [CC BY-SA 4.0 ARS3D project / i3mainz / LEIZA, published in [5]]



**Figure 5.** (Schematic illustration of the ARS3D semantic modelling approach. Objects, features, observations and interpretations are modelled based on CIDOC CRM and its extensions (Observation Modelling Scheme, containing visual items, activities and conditions). [Florian Thiery, CC BY 4.0, published in [9]]



**Figure 6.** (Left) Appliqués applied to vessel O.41260; (right) patrix impression in a mould in order to create the appliqué on O.41418 [ARS3D Project/i3mainz/RGZM, CC BY-SA 4.0, via Wikimedia Commons]



**Figure 7.** Wikidata query service: Iconographic items of the ars3d project. [Wikimedia Community, CCO, Public Domain]

The FAIRification workflow as a use-case consists of three steps to enable digital research, e.g. comparisons of appliqués on ARS [5], [9]:

1. Geometric capturing [5], [9], [12] by standardised 3D digitalisation workflows, e.g. using a structured light projection scanner and a camera to compute a textured model (Figure 4); this is addressed by N4O TA1 for Documentation and N4C. This process is accompanied by documenting the 3D capturing and processing metadata in an ontology [13].
2. Semantic (meta) data modelling (Figure 5) by community standards, ontologies (e.g., CIDOC CRM, PROV-O) and controlled vocabularies [9]. This enables annotating archaeological features in 3D models and referencing (e.g. the motifs on the ARS vessels) with links to IconClass, Getty AAT and Wikidata. These issues are addressed in N4O TA2 for Collecting and in N4C where similarities to the Kompakkt 3D-Web-Viewer exist, allowing for semantic enrichment of 3D-models by annotating them with Wikibase links.

3. The visualisation and publication of the semantically enhanced 3D models by web tools such as 3DHOP (Figure 6) and Linked Open Data [5], [9], [11], [14]. To enable the engagement of Citizen Scientists, this data is also integrated and published in Wikidata [15], [16] (Figure 7), as well as in iDAI.objects, to provide long-term availability. These tasks are addressed within N4O TA5 for Storage, Access and Dissemination, as well as in N4C.

## 4 From the Use Case to the NFDI

This exemplary workflow can be easily adapted to (1) other object groups and materials, e.g. semantic modelling of iconography in numismatics, (2) other contexts, e.g. highly precise documentation of excavations and surveys by using controlled vocabularies, (3) other data qualification methods, e.g. authority data enrichments for archaeobotanical samples (Arbodat), (4) enrichment of object data by Wikidata, as well as the integration of data into the Community Hub (semantic up-/downlift), (5) provision and modelling of material groups with ethical issues by applying the CARE principles, and (6) usage of the N4O infrastructure, e.g. iDAI.world, DANTE or archaeology.link. This workflow for and approaches to achieving and providing FAIR data suit the implementation in other NFDI domains, especially in the fields of controlled vocabularies such as ontologies and thesauri, as well as metadata and community standards.

### Data availability statement

Data described in this paper is available OSF (DOI: 10.17605/OSF.IO/6HJ7G), Zenodo (<https://zenodo.org/communities/ars3d> accessed on 26 March 2023) and on Wikidata. Especially: the comparison data (DOI: 10.5281/zenodo.5647827), comparison scripts (DOI: 10.5281/zenodo.5647864), graph data (DOI: 10.5281/zenodo.5642750), ontology (DOI: 10.5281/zenodo.5642891), images of features (DOI: 10.5281/zenodo.5645236), comparisons (DOI: 10.5281/zenodo.5645253), the source code of the web application (DOI: 10.17605/OSF.IO/P5TKW) and of the API (DOI: 10.17605/OSF.IO/WRJ7K).

### Competing interests

The authors declare that they have no competing interests.

### Funding

The African red slip ware in digital form – 3D documentation for the multi-perspective analysis of a central object category of the late antiquity period Project (ARS3D) was funded by the Federal Ministry of Education and Research Germany (BMBF), Förderkennzeichen: BMBF-01UG1888AX, BMBF-01UG1888BX.

### Acknowledgements

This paper is written with the help of the whole NFDI4Objects consortium. We would like to thank the Executive Director Christin Keller, and Coordination Office member Henrike Backhaus, and all Co-Spokespersons. We would also like to thank Vladimir Stolba for English support.

## References

- [1] D. Bibby, K.-C. Bruhn, F. Dürhkohp, C. Eckmann, U. Himmelmann, B. Höke, C. Keller, M. Lang, A. Mees, S. Metz, M. Renz, P. v. Rummel, F. Schäfer, H. Senst, J. Sessing, T. Stöllner, F. Thiery, B. Weisser, and D. Wintergrün, "Digitales Forschungsdatenmanagement in der Archäologie und die Initiative NFDI4Objects", de, *Blickpunkt Archäologie*, vol. 2, pp. 150–163, 2021. DOI: [10.5281/zenodo.5823867](https://doi.org/10.5281/zenodo.5823867).
- [2] J. Hayes, *Late Roman Pottery*. London, 1972.
- [3] M. Bonifay, *Études sur la céramique romaine tardive d'Afrique*, ser. British Archaeological Reports International Series 1301. Archaeopress, 2004, p. 525. [Online]. Available: <https://shs.hal.science/halshs-01956529>.
- [4] M. Armstrong, "A thesaurus of applied motives on african red slip ware", English, PhD thesis, New York University, 1993.
- [5] F. Thiery, L. Raddatz, and F. Boochs, "Close to the Original-Erfassung archäologischer Objekte und ihre webbasierte semantisch modellierte Bereitstellung zur fachwissenschaftlichen Analyse", in *Photogrammetrie - Laserscanning - Optische 3D-Messtechnik: Beiträge der Oldenburger 3D-Tage 2022*. Berlin: Wichmann, 2022, pp. 56–67, ISBN: 978-3-87907-726-7.
- [6] M. Mackensen, *Relief- und stempelverzierte nordafrikanische Sigillata des späten 2. bis 6. Jahrhunderts: römisches Tafelgeschirr der Sammlung K. Wilhelm*, ger, ser. Münchner Beiträge zur provinzialrömischen Archäologie Band 8, Teil 1. Wiesbaden: Reichert Verlag, 2019, ISBN: 978-3-95490-413-6.
- [7] J. Garbsch, "Spätantike sigillata-tabletts", *Rei Cretariae Romanae Fautores*, vol. Zur spätantiken Keramik aus Nordafrika, Supplementa, Vol. 5, no. Supplementa, Vol. 5, 1980.
- [8] M. Armstrong, "The köln römisch-germanisches museum study collection of african red slip ware", *Kölner Jahrbuch für Vor- und Frühgeschichte 24 (1991)*, vol. 24, pp. 412–475, 1991.
- [9] F. Thiery, J. Veller, L. Raddatz, L. Rokohl, F. Boochs, and A. W. Mees, "A Semi-Automatic Semantic-Model-Based Comparison Workflow for Archaeological Features on Roman Ceramics", en, *ISPRS International Journal of Geo-Information*, vol. 12, no. 4, p. 167, Apr. 2023, ISSN: 2220-9964. DOI: [10.3390/ijgi12040167](https://doi.org/10.3390/ijgi12040167). [Online]. Available: <https://www.mdpi.com/2220-9964/12/4/167> (visited on 04/26/2023).
- [10] S. von Löwenstein, *Mythologische Darstellungen auf Gebrauchsgegenständen der Spätantike: die appliken- und reliefverzierte Sigillata C3/C4*, ser. Kölner Jahrbuch 48. 2015.
- [11] S. C. Schmidt, F. Thiery, and M. Trognitz, "Practices of linked open data in archaeology and their realisation in wikidata", en, *Digital*, vol. 2, no. 3, pp. 333–364, Sep. 2022, Number: 3 Publisher: Multidisciplinary Digital Publishing Institute, ISSN: 2673-6470. DOI: [10.3390/digital2030019](https://doi.org/10.3390/digital2030019). [Online]. Available: <https://www.mdpi.com/2673-6470/2/3/19> (visited on 06/22/2022).
- [12] C. Justus, P. Atorf, and F. Boochs, "Gewinnung realitätsnaher virtueller Modelle als Grundlage für die Erkennung von ähnlichkeiten", English, in *Photogrammetrie - Laserscanning - Optische 3D-Messtechnik: Beiträge der Oldenburger 3D-Tage 2019*. Berlin: Wichmann, 2019, pp. 250–258, ISBN: 978-3-87907-660-4.
- [13] T. Homburg, A. Cramer, L. Raddatz, and H. Mara, "Metadata schema and ontology for capturing and processing of 3D cultural heritage objects", *Heritage Science*, vol. 9, no. 1, p. 91, 2021, ISSN: 2050-7445. DOI: [10.1186/s40494-021-00561-w](https://doi.org/10.1186/s40494-021-00561-w). [Online]. Available: <https://doi.org/10.1186/s40494-021-00561-w> (visited on 03/24/2022).
- [14] F. Thiery and L. Rokohl, "Linked open african red slip ware", *Squirrel Papers*, vol. 3, no. 1, No.3, Nov. 2021. DOI: [10.5281/zenodo.5722941](https://doi.org/10.5281/zenodo.5722941). (visited on 02/24/2022).

- [15] F. Thiery, A. Mees, and L. Rokohl. (2022). Wikidata: Wiki-project african red slip ware digital, [Online]. Available: [https://www.wikidata.org/wiki/Wikidata:WikiProject\\_African\\_Red\\_Slip\\_Ware\\_Digital](https://www.wikidata.org/wiki/Wikidata:WikiProject_African_Red_Slip_Ware_Digital) (visited on 06/21/2022).
- [16] Wikidata Community. (2023). Wikidata query service: Iconographic items of the ars3d project, [Online]. Available: <https://w.wiki/4paq> (visited on 04/26/2023).