No Cradle of Filth

Zero Data Waste through the 5Rs in Austrian Digital Archaeology?

Dominik Hagmann, Franziska Reiner, Christian Gugl | Austria

Abstract

At 2023's CHNT conference, the thought-provoking round table "No Cradle of Filth - Zero Data Waste through the 5Rs in Austrian Digital Archaeology?" discussed approaches, concepts, and principles initially focused on environmental sustainability and waste management - such as the 5Rs ("refuse, reduce, reuse, recycle, rot") - in Austrian digital archaeology and long-term archiving. Such principles can be applied in various ways to minimize the impact of unnecessary digital data waste while reducing the risk of data loss. Measures inspired by the 5Rs may include "refusing" to store redundant data or "recycling" existing data on features and artifacts rather than constantly creating entirely new field archaeological data for research and education purposes. Furthermore (and much more provocatively), redundant, unused, erroneous, incomplete, or other "data waste" must also be considered. Under exceptional (?) circumstances, such useless data (e.g., intermediate results produced on an experimental basis), sometimes formalized as "digital muda" in economic business process management, may be allowed to "rot" (i.e., be deleted), at least for the sake of creating new digital storage space. In light of such considerations, the roundtable aims to address (but is not limited to) the following key questions: Can applying such posthumanist principles to digital archaeology contribute to sustainable long-term archiving in theory and practice? Can the 5Rs be used to minimize digital waste in long-term preservation? What is the role of long-term archived lean research data as a cultural heritage resource for future generations? Based on such guiding questions, interested participants will discuss the topic in a lively exchange of practical and theoretical case studies, thus contributing to the further development of digital archaeological methodology in sustainable data management.

Thinking of sustainable digital archaeology

Since the beginning of 2023, the Go!Digital 3.0 project "IUENNA - openIng the soUthErn jauNtal as a micro-regioN for future Archaeology" has set the goal of providing a model study for a sustainable long-term archive of an elaborate excavation at one of the most critical Late Antique sites of the Southeast Alpine region – the Late Antique pilgrimage center of Hemmaberg and related sites (Globasnitz/Iuenna, Jaunstein, and St. Stefan). Consequently, digital archaeology and the long-term archiving of digital data are central points of the project (Hagmann & Reiner, 2023). The round table "No Cradle of Filth - Zero Data Waste through the 5Rs in Austrian Digital Archaeology?" at the 2023 CHNT meeting offered, therefore, an ideal opportunity and format for discussing the critical aspects of long-term data archiving:

Working with digital data in archaeology is a core domain of digital archaeology. Also known as computational archaeology or archaeoinformatics, digital archaeology is the application of digital

technologies to archaeological research, both in theory and practice. It utilizes computer software, hardware, and data-driven methods to process, analyze, and visualize archaeological data. In doing so, digital archaeology encompasses various techniques and technologies interdisciplinary. This includes geographic information systems (GIS), remote sensing, 3D scanning and printing, geophysics, geodesy and photogrammetry, artificial intelligence, virtual reality, and more. These tools and methods enable archaeologists to collect and analyze large amounts of data, visualize archaeological sites and artifacts in new ways, gain new insights, and reconstruct past events and scenarios. It thereby empowers archaeologists to better understand the relationships between different archaeological sites and the broader cultural and historical context in which they existed. However, digital archaeology does not replace traditional archaeological methods such as excavation, artifact analysis, and applied fieldwork using spades, shovels, and trowels. Instead, it is a complementary approach that can enhance and support traditional archaeological research and practice as a meta-discipline. As with archaeology itself, digital archaeology is a complementary medium for the recording, dissemination, and preservation of humanity's knowledge of archaeological sites through the analysis of complex datasets, reconstruction of past landscapes and environments, and the creation of immersive educational experiences (Hagmann, 2017, 2018a, 2018b; Huggett, 2020; McCoy, 2017; Morgan, 2022; Ortman & Altschul, 2023; Volkmann, 2021).

Nevertheless, to ensure that the digital data generated is not merely a fleeting flash of inspiration, it is crucial in digital archaeology to strive for sustainable, long-term data archiving. Archaeological data can take many forms, including field notes, photographs, maps, digital images, 3D models, and scientific data. Best practices for long-term preservation of archaeological data have been established repeatedly. These include creating data management plans, choosing appropriate file formats, and performing regular data backups stored in multiple, secure locations to provide redundancy. As various studies have highlighted, long-term data archiving is critical to archaeological research. It ensures that valuable information and knowledge about the past can be securely stored, distributed, accessed, and utilized by future researchers and scholars (Altschul et al., 2017; Atici et al., 2013; Berners-Lee & Hendler, 2001; Binding et al., 2019; Cai & Zhu, 2015; Carroll et al., 2021; Casarotto, 2022; Dawson et al., 2022; I. Faniel et al., 2021; I. M. Faniel et al., 2018; Garstki, 2022; Geser et al., 2022; Gupta et al., 2023; Hagmann, 2018a, 2020; Heilen & Manney, 2023; Huggett, 2018, 2022; Juty et al., 2020; E. C. Kansa et al., 2014; E. C. Kansa & Kansa, 2022; S. W. Kansa et al., 2020; Katsianis et al., 2022; K. Kintigh, 2006; K. W. Kintigh et al., 2014; Marwick, 2017; Marwick & Birch, 2018; Opitz et al., 2021; Ortman & Altschul, 2023, 2023; Richards et al., 2021; Romero et al., 2019; Sadiq & Indulska, 2017; Schmidt et al., 2022; Strupler, 2021; Trognitz, 2021; University of Liverpool & Sinclair, 2022; Wallis et al., 2013; Ward, 2022; Wilkinson et al., 2016; Wilshusen et al., 2016).

But how are such 'best practices' achieved? What epistemological impulses drive archaeologists to conduct 'sustainable' archaeological data curation? To make the underlying motives more scientifically observable and to document them in the sense of 'paradata recording' (Sköld et al., 2022), the proposed round table aims to discuss a set of principles commonly promoted to minimize waste and reduce environmental impact: the 5R's – refuse, reduce, reuse, recycle, rot (Balwan et al., 2022). While these principles are primarily associated with current environmentalism, they can also be applied in archaeology to minimize the drawbacks of archaeological research data management. However, the direct transposition of such concepts to archaeology can cause some interpretative difficulties and sometimes does not seem entirely coherent:

Refuse

Not to be confused with the cultural formation process described by Schiffer (1996), in archaeology, "refusing" can also be understood as an "environmentalist-associated concept," which might involve avoiding excavation or other forms of research that could potentially damage or destroy an archaeological site. This could involve using non-invasive techniques like remote sensing or surface surveys to study the site without physically disturbing it. In the context of data archiving, "refusing" might be applied to avoid the imprudent inclusion of all possible data sets in a repository.

Reduce

When excavation is necessary, archaeologists can use the principle of "reduction" to minimize the amount of material that needs to be excavated. This might involve carefully selecting excavation areas based on the research questions or using stratigraphic analysis to focus on specific site layers. In terms of digital data, "reducing" can denote not generating an unnecessarily disproportionate amount of data and not archiving an equally unreasonable amount of data.

Reuse

In the field of archaeology, and not to be confused with Schiffer's cultural formation process, "reuse" might mean using existing data and artifacts to answer research questions rather than excavating new material.

Recycle

In archaeology, "recycling" might involve repurposing research data and materials from field studies for other forms of research or teaching. This concept may be closely related to "reusing". As mentioned above, this principle should not be confused with Schiffer's cultural formation process. Artifacts too damaged or incomplete to be displayed in a museum can be used for educational purposes or scientific analysis. These artifacts are effectively "upcycled", as they are put to a higher-value use. The same applies to digital data, which could be used for large-scale statistical analysis or student training.

Rot

This concept may seem the most challenging, as it is in extreme contrast to preserving archaeological finds and features. Nevertheless, in archaeology, "rot" may refer to the critical consideration of redundant, unused, incorrect, incomplete, or other forms of "data waste" (Bietti & Vatanparast, 2020). Such useless data (e.g., interim results prepared on a test basis), sometimes formalized as "digital muda" in economic process optimization management (Alieva & Haartman, 2020), are not meant to be further used and may, under exceptional circumstances, be left to "rot" and "composted", i.e., deleted, at least for the sake of creating renewed digital storage space."

Conclusion

In conclusion, the digital age offers unprecedented opportunities for archaeological research, yet it also presents unique challenges that require a thoughtful and proactive approach. In this context, an environmentalist-associated concept like that of the 5Rs - refuse, reduce, reuse, recycle, and rot - can serve as a valuable framework for managing digital archaeological data. By conscientiously

acknowledging and actively addressing the digital waste generated through their work, archaeologists can contribute to creating "lean archaeological data." This lean data, in turn, can be archived more efficiently and sustainably, thus serving future generations of researchers more effectively and responsibly.

Moreover, the incorporation of principles inspired by ecology and economy - such as lean management - into archaeological data management can help minimize the tension between the need for comprehensive data collection and the practical limitations of data storage and analysis. By adopting these principles, archaeologists can ensure that the vast amounts of data generated by modern archaeological research are not just a fleeting burst of information but a sustainable resource that can continue to enrich our understanding of the past.

Thus, as we continue to delve continuously deeper and deeper into the digital age, it becomes ever more essential for archaeologists to engage with these issues, to strike a balance between the opportunities and challenges presented by digital data, and to strive for a sustainable future for archaeological research. The round table discussion, therefore, represented an essential step in this direction, providing a platform for open dialogue and shared learning among scholars in the field. As we move forward, it is our collective responsibility to ensure that the valuable insights gleaned from the study of the past are preserved and made accessible to future generations (fig. 1).

References

Alieva, J., and R. Haartman (2020), 'Digital Muda - The New Form of Waste by Industry 4.0', *Operations and Supply Chain Management: An International Journal*, 13:3, 269–78, https://doi.org/10.31387/oscm0420268

Alieva, J., and D. J. Powell (2022), 'The Significance of Employee Behaviours and Soft Management Practices to Avoid Digital Waste During a Digital Transformation', *International Journal of Lean Six Sigma*, 14:1, 1–32, https://doi.org/10.1108/IJLSS-07-2021-0127

Altschul, J. H., K. W. Kintigh, T. H. Klein, W. H. Doelle, K. A. Hays-Gilpin, S. A. Herr, et al. (2017), 'Fostering Synthesis in Archaeology to Advance Science and Benefit Society', *Proceedings of the National Academy of Sciences*, 114:42, 10999–2, https://doi.org/10.1073/pnas.1715950114

Atici, L., S. W. Kansa, J. Lev-Tov, and E. C. Kansa (2013), 'Other People's Data: A Demonstration of the Imperative of Publishing Primary Data', *Journal of Archaeological Method and Theory*, 20:4, 663–81, https://doi.org/10.1007/s10816-012-9132-9

Balwan, W., A. Singh, and S. Kour (2022), '5R's of Zero Waste Management to save our green planet: A Narrative review', *European Journal of Biotechnology and Bioscience*, 10:1, 7–11

Berners-Lee, T., and J. Hendler (2001), 'Publishing on the Semantic Web', *Nature*, 410:6832, 1023–24, https://doi.org/10.1038/35074206

Bietti, E., and R. Vatanparast (2020), 'Data Waste', *Harvard International Law Journal Frontiers*, 61, 1–11

Binding, C., D. Tudhope, and A. Vlachidis (2019), 'A Study of Semantic Integration Across Archaeological Data and Reports in Different Languages', *Journal of Information Science*, 45:3, 364–86, https://doi.org/10.1177/0165551518789874

Cai, L., and Y. Zhu (2015), 'The Challenges of Data Quality and Data Quality Assessment in the Big Data Era', *Data Science Journal*, 14:0, 2, https://doi.org/10.5334/dsj-2015-002

Carroll, S. R., E. Herczog, M. Hudson, K. Russell, and S. Stall (2021), 'Operationalizing the CARE and FAIR Principles for Indigenous Data Futures', *Scientific Data*, 8:1, 108, https://doi.org/10.1038/s41597-021-00892-0

Casarotto, A. (2022), 'Digitising Legacy Field Survey Data: A Methodological Approach Based on Student Internships', *Digital*, 2:4, 422–43, https://doi.org/10.3390/digital2040023

Dawson, I., A. M. Jones, L. Minkin, and P. Reilly (2022), 'Temporal Frankensteins and Legacy Images', *Digital*, 2:2, 244–66, https://doi.org/10.3390/digital2020015

Faniel, I., A. Austin, S. Whitcher Kansa, E. Kansa, J. Jacobs, and P. France (2021), 'Identifying Opportunities for Collective Curation During Archaeological Excavations', *International Journal of Digital Curation*, 16:1, 17, https://doi.org/10.2218/ijdc.v16i1.742

Faniel, I. M., A. Austin, E. Kansa, S. W. Kansa, P. France, J. Jacobs, et al. (2018), 'Beyond the Archive: Bridging Data Creation and Reuse in Archaeology', *Advances in Archaeological Practice*, 6:2, 105–16, https://doi.org/10.1017/aap.2018.2

Garstki, K. (2022), 'Teaching for Data Reuse and Working toward Digital Literacy in Archaeology', *Advances in Archaeological Practice*, 10:2, 177–86, https://doi.org/10.1017/aap.2022.3

Geser, G., J. D. Richards, F. Massara, and H. Wright (2022), 'Data Management Policies and Practices of Digital Archaeological Repositories', *Internet Archaeology*, 59, https://doi.org/10.11141/ia.59.2

Gupta, N., A. Martindale, K. Supernant, and M. Elvidge (2023), 'The CARE Principles and the Reuse, Sharing, and Curation of Indigenous Data in Canadian Archaeology', *Advances in Archaeological Practice*, 11:1, 76–89, https://doi.org/10.1017/aap.2022.33

Hagmann, D. (2017), 'Brave New World: Digital Archaeology at Molino San Vincenzo/Tuscany (ITA)', in Stadtarchäologie Wien (ed.), *Abstracts Volume – 22nd International Conference on Cultural Heritage and New Technologies (CHNT 22): Vienna, 08-10.11.2017* (Wien), pp. 82–83, https://doi.org/10.5281/zenodo.4419738 [accessed 25 August 2019]

——— (2018), 'Reflections on the Use of Social Networking Sites as an Interactive Tool for Data Dissemination in Digital Archaeology', *Interdisciplinaria Archaeologica*, 9:1, 7–20, https://doi.org/10.24916/iansa.2018.1.1

——— (2020), 'Überlegungen zur Digitalen Archäologie und zu ihrem Verhältnis zu den Digitalen Geisteswissenschaften', in M. Ernst, P. Hinkelmanns, K. Zeppezauer-Wachauer, and L. M. Zangerl (eds), *Digital Humanities Austria 2018. Empowering Researchers. November 29–December 01, 2018, University of Salzburg, Austria* (Wien: Austrian Academy of Sciences Press), pp. 74–78, https://doi.org/10.1553/dha-proceedings2018s74 [accessed 30 January 2020]

Hagmann, D., and F. Reiner (2023), 'IUENNA – openIng the soUthErn jauNtal as a micro-regioN for future Archaeology' (Open Science Framework Preprints), https://doi.org/10.31219/osf.io/5vwg8

Heilen, M., and S. A. Manney (2023), 'Refining Archaeological Data Collection and Management', *Advances in Archaeological Practice*, 11:1, 1–10, https://doi.org/10.1017/aap.2022.41

Huggett, J. (2018), 'Reuse Remix Recycle: Repurposing Archaeological Digital Data', *Advances in Archaeological Practice*, 6:2, 93–104, https://doi.org/10.1017/aap.2018.1

——— (2020), 'Is Big Digital Data Different? Towards a New Archaeological Paradigm', *Journal of Field Archaeology*, 45:sup1, S8–17, https://doi.org/10.1080/00934690.2020.1713281

——— (2022), 'Data Legacies, Epistemic Anxieties, and Digital Imaginaries in Archaeology', *Digital*, 2:2, 267–95, https://doi.org/10.3390/digital2020016

Juty, N., S. M. Wimalaratne, S. Soiland-Reyes, J. Kunze, C. A. Goble, and T. Clark (2020), 'Unique, Persistent, Resolvable: Identifiers as the Foundation of FAIR', *Data Intelligence*, 2:1–2, 30–39, https://doi.org/10.1162/dint_a_00025

Kansa, E. C., and S. W. Kansa (2022), 'Promoting Data Quality and Reuse in Archaeology Through Collaborative Identifier Practices', *Proceedings of the National Academy of Sciences*, 119:43, e2109313118, https://doi.org/10.1073/pnas.2109313118

Kansa, E. C., S. W. Kansa, and B. Arbuckle (2014), 'Publishing and Pushing: Mixing Models for Communicating Research Data in Archaeology', *International Journal of Digital Curation*, 9:1, 57–70, https://doi.org/10.2218/ijdc.v9i1.301

Kansa, S. W., L. Atici, E. C. Kansa, and R. H. Meadow (2020), 'Archaeological Analysis in the Information Age: Guidelines for Maximizing the Reach, Comprehensiveness, and Longevity of Data', *Advances in Archaeological Practice*, 8:1, 40–52, https://doi.org/10.1017/aap.2019.36

Katsianis, M., T. Kalayci, and A. Sarris (2022), 'Bridging Digital Approaches and Legacy in Archaeology', *Digital*, 2, 538–45, https://doi.org/10.3390/digital2040029

Kintigh, K. (2006), 'The Promise and Challenge of Archaeological Data Integration', *American Antiquity*, 71:3, 567–78, https://doi.org/10.2307/40035365

Kintigh, K. W., J. H. Altschul, M. C. Beaudry, R. D. Drennan, A. P. Kinzig, T. A. Kohler, et al. (2014), 'Grand Challenges for Archaeology', *Proceedings of the National Academy of Sciences*, 111:3, 879–80, https://doi.org/10.1073/pnas.1324000111

Marwick, B. (2017), 'Computational Reproducibility in Archaeological Research: Basic Principles and a Case Study of Their Implementation', *Journal of Archaeological Method and Theory*, 24:2, 424–50, https://doi.org/10.1007/s10816-015-9272-9

Marwick, B., and S. E. P. Birch (2018), 'A Standard for the Scholarly Citation of Archaeological Data as an Incentive to Data Sharing', *Advances in Archaeological Practice*, 6:2, 125–43, https://doi.org/10.1017/aap.2018.3

McCoy, M. D. (2017), 'Geospatial Big Data and Archaeology: Prospects and Problems Too Great to Ignore', *Journal of Archaeological Science*, 84, 74–94, https://doi.org/10.1016/j.jas.2017.06.003

Morgan, C. (2022), 'Current Digital Archaeology', *Annual Review of Anthropology*, 51:1, 213–31, https://doi.org/10.1146/annurev-anthro-041320-114101

Opitz, R., C. Strawhacker, P. Buckland, J. Cothren, T. Dawson, A. Dugmore, et al. (2021), 'A Lockpick's Guide to dataARC: Designing Infrastructures and Building Communities to Enable Transdisciplinary Research', *Internet Archaeology*, 56, https://doi.org/10.11141/ia.56.15

Ortman, S. G., and J. H. Altschul (2023), 'What North American Archaeology Needs to Take Advantage of the Digital Data Revolution', *Advances in Archaeological Practice*, 11:1, 90–103, https://doi.org/10.1017/aap.2022.42

Richards, J. D., U. Jakobsson, D. Novák, B. Štular, and H. Wright (2021), 'Digital Archiving in Archaeology: The State of the Art. Introduction', *Internet Archaeology*, 58, https://doi.org/10.11141/ia.58.23

Romero, D., P. Gaiardelli, D. Powell, T. Wuest, and M. Thürer (2018), 'Digital Lean Cyber-Physical Production Systems: The Emergence of Digital Lean Manufacturing and the Significance of Digital Waste', in I. Moon, G. M. Lee, J. Park, D. Kiritsis, and G. von Cieminski (eds), *Advances in Production Management Systems. Production Management for Data-Driven, Intelligent, Collaborative, and Sustainable Manufacturing* (Cham: Springer International Publishing), DXXXV, 11–20, https://doi.org/10.1007/978-3-319-99704-9_2

Romero, D., P. Gaiardelli, M. Thürer, D. Powell, and T. Wuest (2019), 'Cyber-Physical Waste Identification and Elimination Strategies in the Digital Lean Manufacturing World', in F. Ameri, K. E. Stecke, G. von Cieminski, and D. Kiritsis (eds), *Advances in Production Management Systems. Production Management for the Factory of the Future* (Cham: Springer International Publishing), DLXVI, 37–45, https://doi.org/10.1007/978-3-030-30000-5_5

Sadiq, S., and M. Indulska (2017), 'Open Data: Quality Over Quantity', *International Journal of Information Management*, 37:3, 150–54, https://doi.org/10.1016/j.ijinfomgt.2017.01.003

Schiffer, M. B. (1996), *Formation Processes of the Archaeological Record*, 2nd edn (Salt Lake City: University of Utah Press)

Schmidt, S. C., F. Thiery, and M. Trognitz (2022), 'Practices of Linked Open Data in Archaeology and Their Realisation in Wikidata', *Digital*, 2:3, 333–64, https://doi.org/10.3390/digital2030019

Sinclair, A. (2022), 'Archaeological Research 2014 to 2021: an examination of its intellectual base, collaborative networks and conceptual language using science maps', *Internet Archaeology*, 59, https://doi.org/10.11141/ia.59.10

Sköld, O., L. Börjesson, Department of ALM at Uppsala University in Sweden, and I. Huvila (2022), 'Interrogating paradata', *Information Research: An International Electronic Journal*, 27, https://doi.org/10.47989/colis2206

Strupler, N. (2021), 'Re-discovering Archaeological Discoveries. Experiments with Reproducing Archaeological Survey Analysis', *Internet Archaeology*, 56, https://doi.org/10.11141/ia.56.6

Trognitz, M. (2021), 'Saving Us from the Digital Dark Age: The Austrian Perspective', *Internet Archaeology*, 58, https://doi.org/10.11141/ia.58.2

Volkmann, A. (2021), *Digitale Archäologie Und Perspektiven Des Digital Cultural Heritage* (Heidelberg: Propylaeum), MMXXI, https://doi.org/10.11588/propylaeum.753

Wallis, J. C., E. Rolando, and C. L. Borgman (2013), 'If We Share Data, Will Anyone Use Them? Data Sharing and Reuse in the Long Tail of Science and Technology', ed. L. A. Nunes Amaral, *PLoS ONE*, 8:7, e67332, https://doi.org/10.1371/journal.pone.0067332

Ward, C. (2022), 'Excavating the Archive / Archiving the Excavation: Archival Processes and Contexts in Archaeology', *Advances in Archaeological Practice*, 10:2, 160–76, https://doi.org/10.1017/aap.2022.1

Wilkinson, M. D., M. Dumontier, Ij. J. Aalbersberg, G. Appleton, M. Axton, A. Baak, et al. (2016), 'The FAIR Guiding Principles for scientific data management and stewardship', *Scientific Data*, 3:1, 160018, https://doi.org/10.1038/sdata.2016.18

Wilshusen, R. H., M. Heilen, W. Catts, K. de Dufour, and B. Jones (2016), 'Archaeological Survey Data Quality, Durability, and Use in the United States: Findings and Recommendations', *Advances in Archaeological Practice*, 4:2, 106–17, https://doi.org/10.7183/2326-3768.4.2.106