The ARCS Project: A 'Middle Range' Approach to Digitised Archaeological Record

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Abstract: Just as they did with other technologies in the past, archaeologists have readily adopted and adapted a wide range of electronic tools to aid them in their collection and analysis of archaeological data. While this digital revolution has already begun to yield positive results, especially for projects that were born digital in the past decade, it is less clear what should be done with the older forms of documentation for projects with longer histories of archaeological exploration. With this in mind, and with an eye towards the growing costs of digitisation and storage, researchers at Michigan State University created the Archaeological Resource Cataloging System (ARCS). This open source, web-based program, developed with funding from the National Endowment for the Humanities, enables archaeological projects to manage collections of digitised documentation either for research or migration to a digital repository. From the beginning, the ARCS team has been guided by the philosophy that it is better to improve upon rather than replace methods and tools already in existence. This guiding principle applies as much to the desire to collaborate with archival solutions and linked open data initiatives as to the effort to emulate the experience of being present in an actual paper-based archive.

Keywords: Archives, digital archaeology, legacy data, open source software, archaeological metadata

Over the past few years, the archaeological world has seen explosive growth in the number and popularity of surveys and excavations that have gone 'paperless' in their field recording and data storage procedures.[2] To be sure, this digital revolution holds great promise in its ability to quicken and simplify the way archaeologists collect, analyse and share the information that informs their interpretations of the past. At the same time though, in our collective excitement over 'going digital', which is often coupled with a fair amount of anxiety over selecting the best combinations of off the shelf and custom-built software and hardware, we seem to have forgotten about the vast quantity of evidence that has been collected by archaeological projects in the past and is now stored in museums and archives around the world. The fate of these more traditional plans, illustrations, photographs and field notes should be a source of concern not just for those whose research combines records of past and present fieldwork, but also for those who are responsible for the maintenance of archaeological data in its 'born digital' form. It is a curious irony that a whole body of archaeological documentation, which for some projects has survived in remarkably good condition for close to two centuries, has recently come to be seen as deficient in comparison to the use of software and digital files that must be updated and migrated every few years in order to remain accessible.[3] Indeed, whether our archaeological predecessors have just as much to teach us about the effective long-term organisation and maintenance of archaeological recording systems as they do about the ancient peoples and places documented therein is worth considering.

The Archaeological Resource Cataloging System (ARCS) project seeks to bridge this gap between analogue and digital recording practices.[4] With the support of National Endowment for the Humanities Digital Humanities Startup (2011) and Implementation (2014) grants, a team of software designers, archivists, archaeologists and student programmers from the Ohio State University

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[2] Ellis – Wallrodt 2011; Paperless Archaeology. For examples of digital methods and techniques in archaeology, see: Kansa et al. 2011; Roosevelt et al. 2015; Averett et al. 2016.

[3] Jeffrey 2012; Dallas 2015.

[4] ARCS Online; Frey 2014; Frey et al. 2015.

Excavations at Isthmia, the Michigan State University College of Arts and Letters and the MATRIX Center for Digital Humanities in the Social Sciences has created an open source web-based software solution designed to enable archaeological projects to organise and share digital copies of the documents stored in their archives. While the following discussion aims to showcase some of the program's more noteworthy features, calling attention to the fact that many of these innovations concern not just the digitisation of documents in an archive but also the processes that made for their effective use in their original paper-based form is perhaps even more important. In this way the ARCS team can be said to have situated itself in a 'middle range' between technology and tradition by holding fast to the idea that, in the case of pre-existing excavation archives at least, it is far better to replicate than to replace the recording systems that are already in use.

Design Principles

While the ARCS project has grown in size and complexity over time, its initial inspiration lies in an effort to solve a relatively simple yet frustrating problem. As at many archaeological projects in the classical world and Near East, all records from past 50 years of research at the Ohio State University Excavations at Isthmia must remain on-site year-round. This restriction, enacted in an effort to preserve critical evidence concerning the context of the objects and monuments uncovered at the site, often serves as a significant impediment to research conducted by scholars outside of Greece. Thus, when the digitisation project began in 2009, the initial goal was merely to provide archaeologists with off-season access to electronic copies of the field journals from the excavation. Yet even by the end of the first season of digitisation, it had already become apparent that simply storing electronic copies of archival documents on personal hard drives was not a

Fig. 1 Archives at the Ohio State University Excavations at Isthmia (photo: J. M. Frey)

significant improvement in terms of universal access to the data. Instead, members of the excavation team began to think about ways in which digital migration might actually be used to improve the utility of this archive for a wider professional and public audience. Additionally, while many aspects of the software evolved organically as the ARCS team evaluated critically what could and should be accomplished, the development process as a whole has been guided by a limited set of design principles.

First it was important that ARCS enhance rather than replace an already strong system of record keeping that had been developed over several decades at various archaeological projects in Greece. This is because most excavation archives already function as an analogue form of a relational database. Pages in field journals, individual descriptions of artefacts, line drawings, photographs and ground plans are all connected to one another through the use of consistent naming conventions or supplemental notes. While all these different documents must work together in order to recreate the lived experience of an archaeological investigation, it is nevertheless possible to use any of these forms of documentation as a point of entry into the record-keeping system. The ARCS development team saw great value in maintaining both this organisational structure as well as the type of interactivity that is a benefit of work at a physical archive. Thus, ARCS utilises an interface that encourages users to browse by type the various archival documents, which in the system are called 'resources'. To be sure, a search utility is provided to allow one to find a specific resource, but it is hoped that users will continue to scan through digitised pages of a notebook or electronic copies of index cards in a catalogue of finds and in so doing, preserve an older tradition of identification through visual recognition. Incidentally, this form of electronic browsing holds the added benefit of producing unintended discoveries, which may not be so readily yielded by means of a keyword search.

In addition, just as a researcher who makes use of the Isthmia archive in person will regularly gather and consult several different document types at once, the ARCS program makes it possible

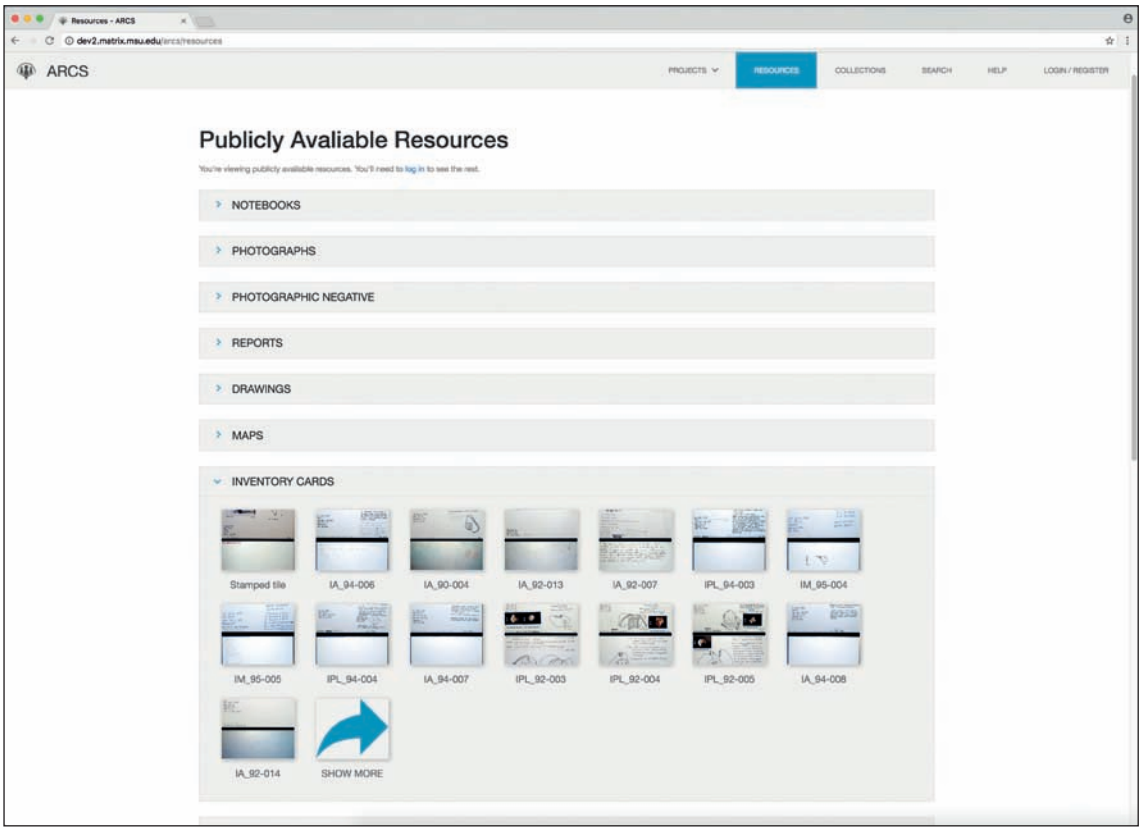

Fig. 2 Screen capture of ARCS program showing resources sorted by type (courtesy of MATRIX)

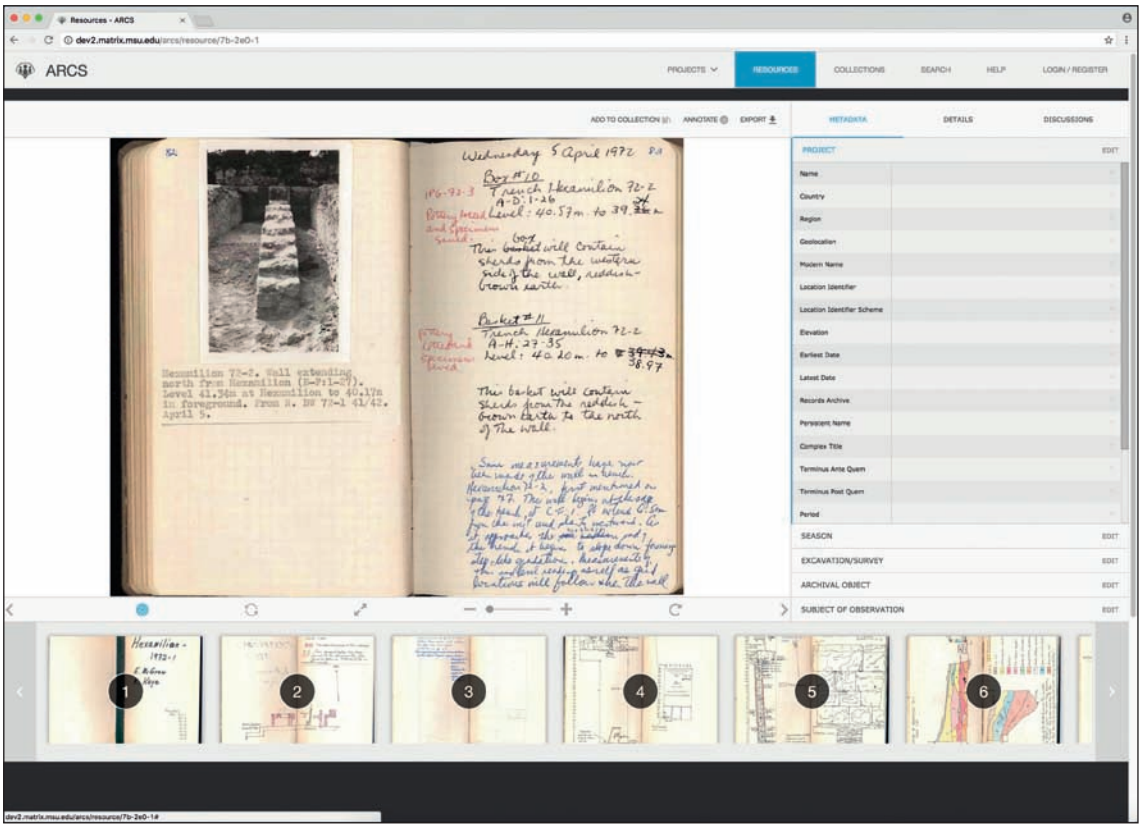

Fig. 3 Screen capture of ARCS program showing resource view of a field journal (courtesy of MATRIX)

to create collections of resources that can be saved and shared with other members of a research team by means of stable Uniform Resource Identifiers (URI). Actually, each individual resource has a unique, stable URI, which is an essential component of participation in linked open data initiatives.[5] Finally, because another advantage of work at an actual archive concerns the ability to draw on the institutional knowledge of more experienced researchers and specialists, resources are provided with their own discussion forums. Here individual users can ask the ARCS community questions concerning specific resources and collections in order to resolve issues involved with interpreting the documents from past seasons' fieldwork.

The idea of supplementing but not replacing the archive applies to the individual forms of documentation as well. For example, field journals, which serve as the principal record type within the Isthmia recording system, are remarkably complex and dynamic documents. From the written narratives to the sketch drawings of artefacts and archaeological features to the photographs pasted onto random pages, these field journals defy attempts to generate an accurate copy in machine-readable format. What is more, the fact that each journal is a living document that continues each season to be supplemented with descriptions and discussions penned in several different hands makes the automation of content processing, such as optical character recognition or even manual text encoding for that matter, especially difficult.

Thus, our approach has been to augment an image of the original document with additional information to help in identifying and understanding its content. This is done in a number of ways. Users can add transcriptions and translations should a certain resource prove difficult to read. They can also tag the resource with keywords that will help to generate more effective search results in the future or create hyperlinks to other documents within and outside of the system

[5] Heath – Bizer 2011. On linked ancient world data, see Elliott et al. 2014.

through an annotation utility. All of these tools, however, are supplemental to the display of the document itself, which must be experienced in a way that replicates as closely as possible its original appearance. For while it is clear that well-structured digital data can provide significant insights into the evidence collected through fieldwork, utilising information that has been separated from its unique documentary context can lead to misinterpretations.[6] To this end, by emphasising the visual representation of an archival document over a transcription of its content, the ARCS program enables users to recognise at a glance changes such as handwriting or colour of ink that may not be so readily noticed in encoded text.

Limited Budgets and Unique Needs

Another goal of the ARCS project has been to create an open source software solution that can be adapted to match the unique needs, organisational schemes and limited budgets of smaller archaeological projects. When one surveys the digital legacy data landscape, a number of projects already show the way forward with software built to address their own specific goals. Yet many older or inactive excavations and surveys lack sufficient funding, time and personnel to create their own custom-built solutions. Moreover, the unique idiosyncrasies of archaeological recording systems in different parts of the ancient world make it prohibitively difficult to copy the structure and source code from one project to another. Therefore, ARCS follows an approach that seeks to achieve modest goals by means of an intuitive user interface that imitates the interactivity of common operating systems and web applications. Thus it should be possible for the average user to begin to work with ARCS without any specialised training.

In addition, ARCS facilitates the batch upload of digitised documents as they are generated, either with or without supplemental metadata. Thus, projects can build their digital collections when they have sufficient time, personnel and funding. Moreover, because many research centres do not have a team of dedicated archivists and have always depended on the assistance of students in training or volunteers, ARCS has been designed to support a crowd-sourced approach to improving the accessibility and utility of a project's digitised legacy documentation. The ARCS design team has made an effort to simplify and streamline interactions with resources and collections so that a user can make improvements to the system with minimal distraction even while conducting research. In addition, all users of the ARCS program are given unique accounts so that individuals can be assigned different levels of access to sensitive information and, perhaps more importantly, be recognised for their efforts. The ARCS system also allows users to report errors in the upload and display of digitised resources that can be fixed by higher level administrators at a later time. All error reports and edits are logged in ARCS, thereby ensuring a degree of version control for each resource.

In the end, in spite of the team's efforts to create an easily adopted software solution, the greatest challenge in making the ARCS program available to a wide array of archaeological projects concerns the lack of a uniformly accepted set of standards for recording archaeological discoveries.[7] While such diversity is inevitable, given the number of places and periods that are under study, this nevertheless complicates the structure of the underlying database (ARCS is built upon the KORA Digital Repository and Publishing Platform[8]) to the point of rendering even simple searches for evidence across sites and repositories nearly impossible. At the same time, requiring any project to translate its organisational scheme and terminology into a completely new data

6 Huggett 2015, 89–93.

7 Kintigh 2006, 573–575; Faniel et al. 2013. For an account of the difficulties involved in normalising archaeological vocabularies, see Kansa et al. 2014.

8 KORA.

structure and ontology simply to make use of ARCS would doubtless discourage adoption and use of the program.

Again though, as with the creation of the ARCS interface, this problem was addressed by emulating the structure and organisation of archaeological archives more generally. For better or worse, the archaeologists who created these archives designed them to function well for their own specific sites but not necessarily on a larger scale. Moreover, the initiation of a new excavation often represented an opportunity to innovate and improve upon whatever recording system was most familiar to the project organisers, so that it is most unlikely to find two projects that collect their evidence in the exact same way.

In this tradition, scholars wishing to engage in cross-project research that goes beyond the identification of an individual artefact for comparanda has always been required to familiarise themselves with the unique aspects of each project's recording system before using its archive. At the same time, it has always been the responsibility of the archivist to assist the researcher in locating and retrieving specific documents, but not to extract and summarise the contents of those records on their behalf. While such traditions may slow the research process, they nevertheless serve the purpose of ensuring that scholars gain a better sense of the nature of their evidence before drawing their conclusions. With the prospect of big data extraction and analysis in archaeology on the near horizon, we should consider the potential drawbacks of a project-agnostic approach to archival information.[9] To be sure, working with non-compatible recording systems is one of the time-consuming complications that digital archaeologists seek to solve through the creation of uniform data collection standards and practices. Yet imposing standard terminologies and organisational schemes on legacy archives, especially when such translations are conducted in the absence of a specific research question, increases the chances that we will misuse the information we extract.

As a result, the ARCS team decided on a much more modest approach to legacy data that focuses upon the archival document itself rather than the archaeological information it contains. This dramatically simplifies matters, for in contrast to the vast array of systems for the classification of artefacts and monuments, the tools of archaeological record keeping are quite limited in number. Until very recently, excavators and surveyors alike have consistently documented the progress of their work on bound journals, paper reports, film photographs, maps and illustrations. For ARCS to function in the model of a traditional archive, the system must reliably deliver these documents so that researchers may discover for themselves what information they contain.

In order to achieve this more restricted goal, the ARCS team developed a metadata scheme that records as much information as possible about the archival object and its digital surrogate. ARCSCore, an adaptation of the ArchaeoCore schema, is organised in several nesting levels, beginning with general information about the project, then moving to specific seasons of fieldwork.[10] Next there is a level for describing the relevant details concerning a discrete unit of survey or excavation within a season. At the most detailed level is found information regarding each individual document, its electronic surrogate and finally the subject of observation that this document describes. In generating this last set of fields, the ARCS team attempted to avoid designating specific systems of classification. Instead, projects are encouraged to define their own terminology in order to aid the retrieval of information according to their system of documentation.

As a result of these decisions, an unmodified ARCS system will be much more effective at generating results for searches focused on certain periods of fieldwork, documents and individuals than a specific type of artefact. For example, ARCS will allow a scholar to gain rapid access

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9 Bevan 2015; Cooper – Green 2016. Note also the recent conferences on big data in Archaeology at the Leiden Centre of Data Science (12 May 2017: <https://www.universiteitleiden.nl/en/events/2017/05/18th-lcds-meeting-big-data-in-archaeology> [last accessed 18 Dec. 2019]) and the McDonald Institute for Archaeological Research (27–28 March 2019: <https://erikgjesfjeld.wixsite.com/big-data-archaeology> [last accessed 18 Dec. 2019]).

10 ARCSCore.

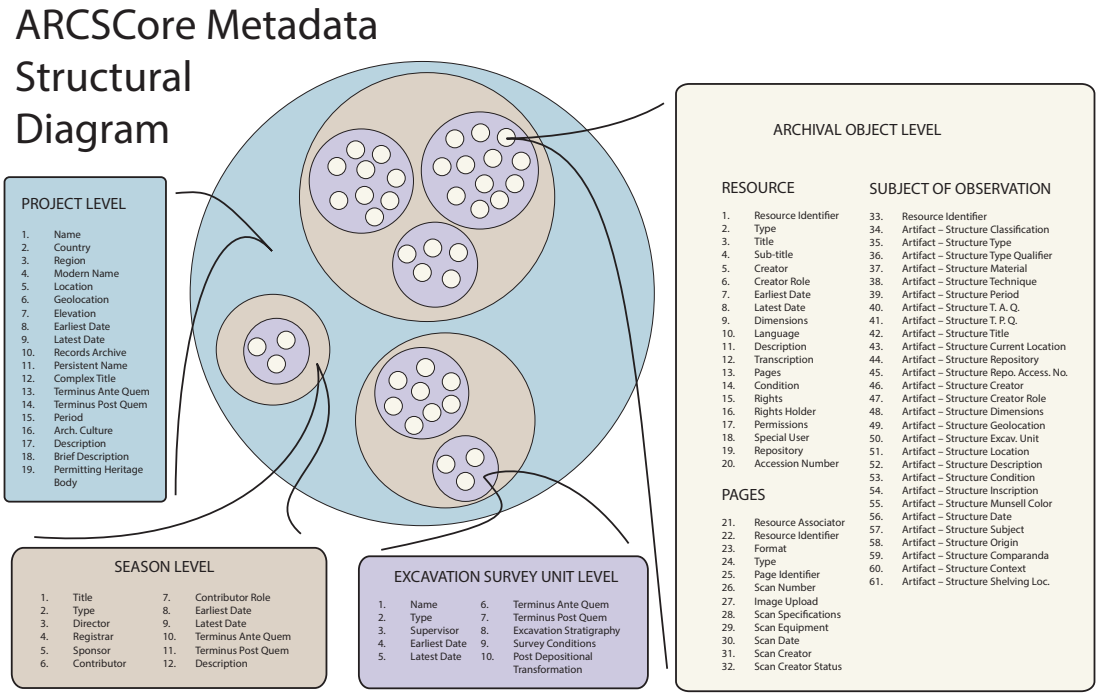

Fig. 4 Chart illustrating organisation of ARCSCore metadata scheme (graphics: J. M.Frey 2017)

to all objects catalogued in 1975 or all field journals penned by the project director. With small modifications such as the creation of a controlled vocabulary database in ARCS for subjects of observation, it will also be possible to retrieve all documents that mention the discovery of Latin inscriptions or Greek amphorae. However, it should be kept in mind that the results of such a search will not necessarily be machine-readable data. Rather, researchers will still be responsible for interpreting for themselves the contents of the documents they have retrieved.

To be clear, the ARCS team is not opposed to 'big data' style analyses and is currently in the process of building an import/export utility to accommodate the transfer of structured data into the ARCS system and out again for use in statistical and geospatial analyses or, even more importantly, for secure archival storage through services like tDAR, ADS or DANS.[11] At the same time though, it is hoped that simple keyword searches will not be an end unto themselves, but will function instead as a point of entry into a network of relationships that have been created among documents within a fully annotated ARCS catalog. Furthermore, we expect that this approach will allow a wider variety of archaeological projects to participate in the digital revolution in archaeology in a way that respects their often unique record-keeping systems.

ARCS at Isthmia

Although the ARCS program is still under development, researchers at Michigan State University and Ohio State University have already had great success in using this software as a teaching and research tool. In the classroom, students benefit from experiencing in a more direct way the primary archaeological documentation that lies behind the polished facts and interpretations that they are normally asked to accept at face value. For archaeologists in training, the opportunity to examine documents from the excavations or surveys where they will be conducting fieldwork

[11] tDAR; ADS; DANS.

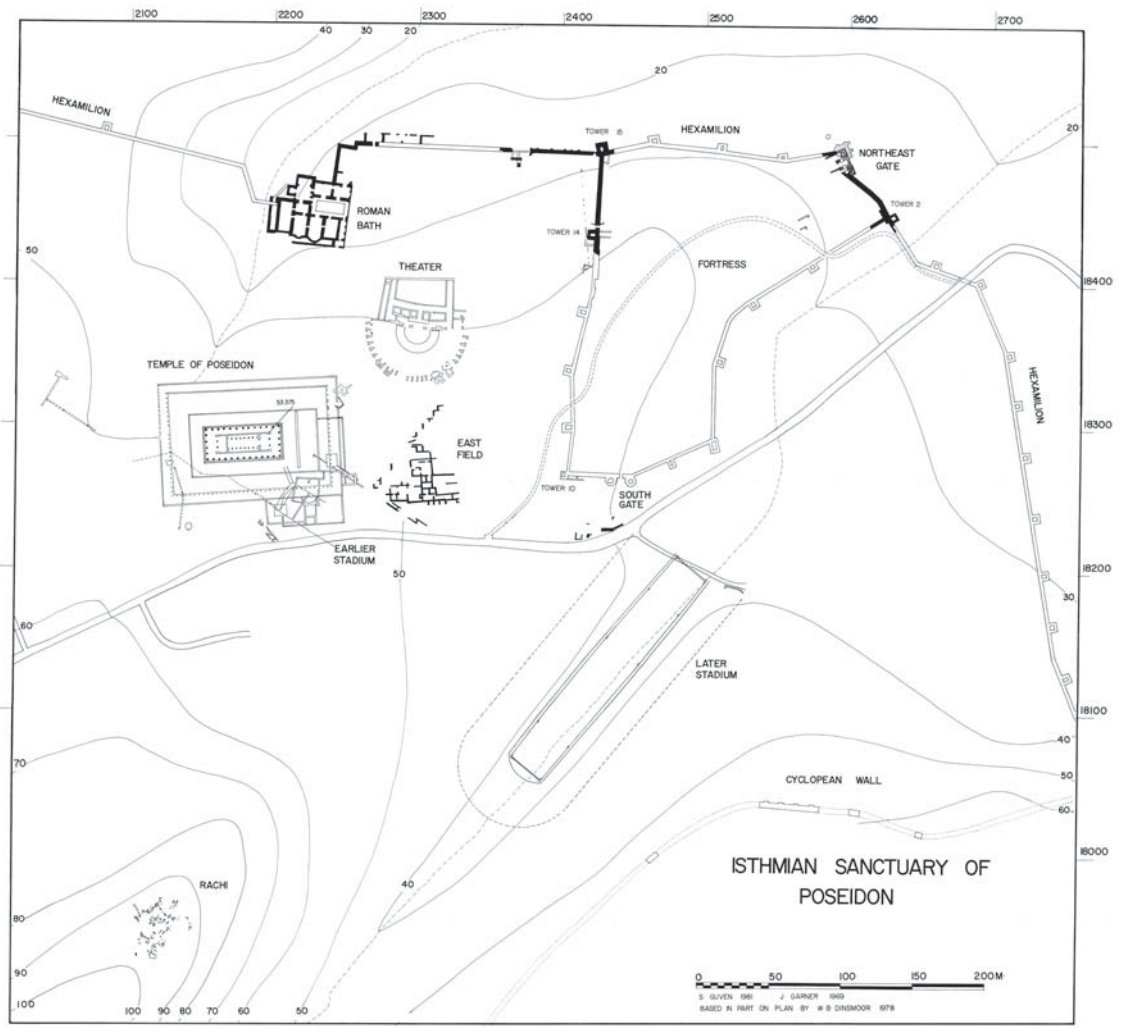

Fig. 5 Plan of Sanctuary of Poseidon at Isthmia (courtesy of the Ohio State University Excavations at Isthmia)

gives them time beforehand to familiarise themselves with the way a system of documentation works and more importantly doesn't work. Indeed, there is no better way to teach a student how to take effective notes in the field than to have them evaluate someone else's field journal. Most significantly in terms of research, archaeologists are already using ARCS as an effective tool for processing information from excavations that have taken place at one site in central Greece since the 1950s but remains incompletely published to this day.

The Sanctuary of Poseidon at Isthmia, located on the eastern side of the Isthmus between northern and southern Greece, was famous in antiquity as the site of the Isthmian Games, which along with the more well-known Olympics formed part of the quadrennial Panhellenic cycle of athletic competitions. As a result, in addition to its temples and altars, the site also featured a theatre, stadium and bathing/exercise facilities, all of which were extensively remodelled or, in the case of the stadium, replaced in Hellenistic and Roman times.[12]

The site is also famous in antiquity as a common meeting place for Greeks to respond to threats such as the 5th century BC Persian invasion[13] or receive important news like the Roman

12 Broneer 1973.
13 Herodotus, *Histories* 7.172.

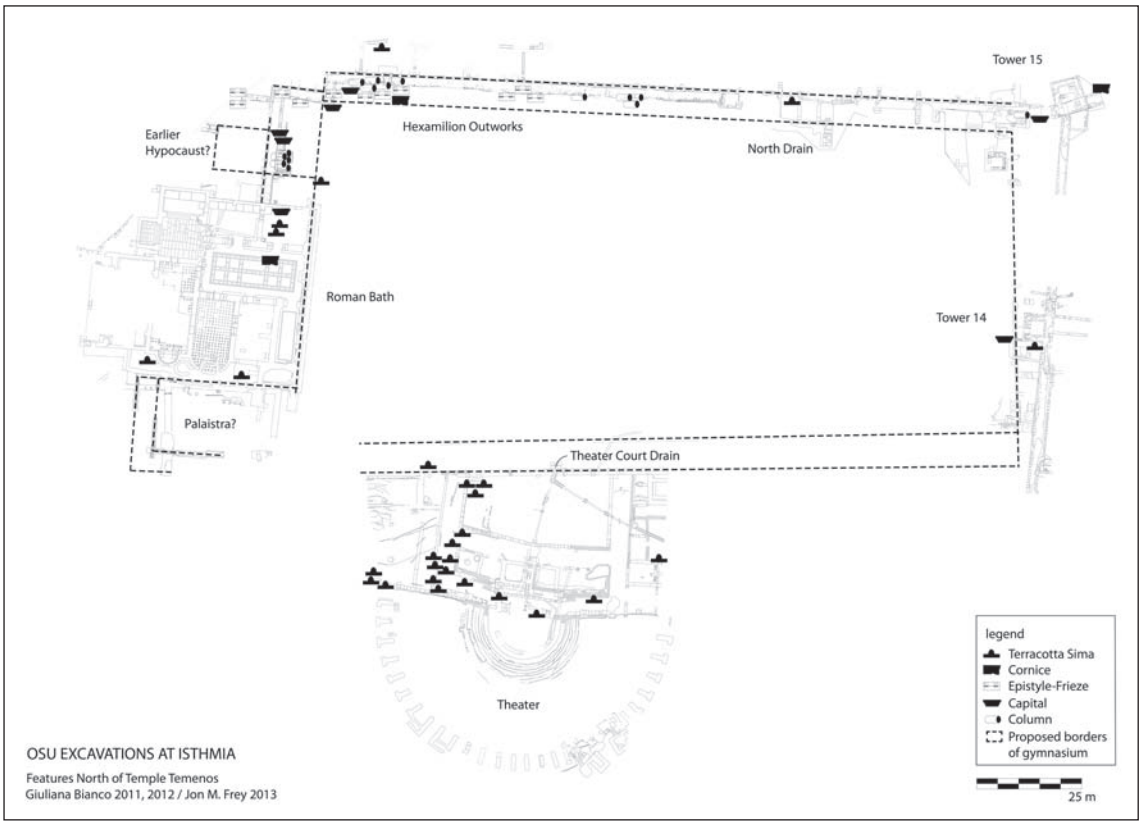

Fig. 6 Plan of lower sanctuary at Isthmia showing the locations of finds and proposed location of gymnasium (courtesy of the Ohio State University Excavations at Isthmia)

general Flamininus' declaration of the freedom of the Greeks from Macedonian rule in 196 BC,[14] a pronouncement that was repeated by none other than Emperor Nero in AD 66.[15] In the early Byzantine period, following the dissolution of the games, Isthmia served an equally important role as the location of a fortress connected to a nearly six-mile long barrier wall that spanned the isthmus and was intended to protect all of southern Greece against the growing threat of barbarian raids.[16] So many of the sanctuary's monuments were recycled for use in building these defences that the earliest modern investigations at the site mistook the fortress for the temple precinct.

The actual location of the Temple of Poseidon was established in 1952 when Oscar Broneer from the University of Chicago began systematic excavations in the village of Kyras Vrysi. In subsequent seasons, exploration of the temple temenos, both stadia, the theater, the Roman bath and its Greek precursor, as well as the fortifications continued under Broneer's direction and that of his successors, Paul Clement at the University of California Los Angeles, Betsy Gebhard at the University of Chicago and Timothy E. Gregory at the Ohio State University. These transitions in leadership often brought with them changes in procedures for record keeping so that the available documentation of the site is marked by a complexity that discourages analysis of the entire site across space and over time. Thus, the publication of sculpture, lamps, coins and other artefacts sorted according to type have preceded larger scale synthetic studies of the monumental landscape of the sanctuary. However, as the research team at Isthmia transitions from fieldwork to

14 Plutarch, *Flamininus* 10.3–5.
15 Suetonius, *Nero* 24.
16 Gregory 1993.

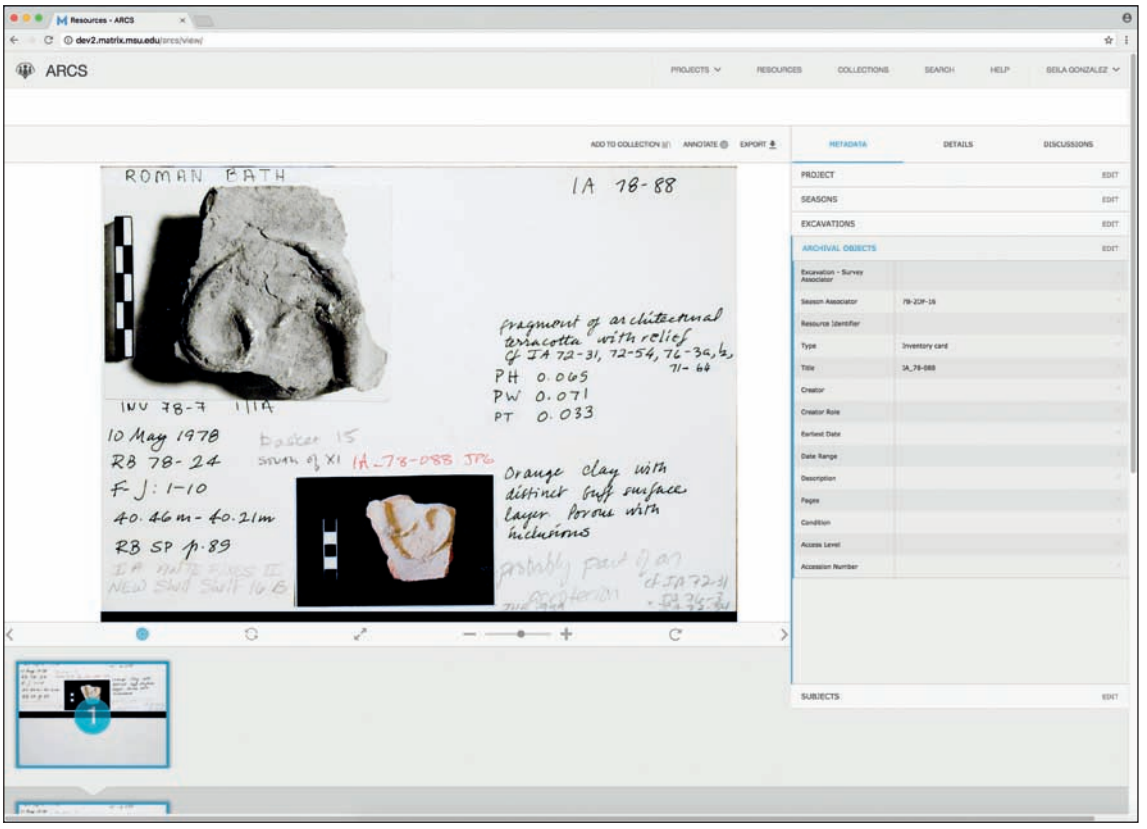

Fig. 7 Screen capture of ARCS program showing sima misidentified as an acroterion (courtesy of MATRIX)

archival research, a reinvestigation of the excavation records is beginning to reveal exciting new insights into the layout and history of the site.

For example, through a closer examination of the field journals, plans and catalogued artefacts that formed a part of the ongoing work to digitise the contents of the Isthmia archives, researchers have now been able to recognise connections among features that were excavated in seemingly isolated locations. What had once been interpreted as parts of the early Byzantine fortress in one location, the Roman period theatre courtyard in a second place and a staircase of indeterminate date in a third are now understood to be part of an enormous Roman period gymnasium/bath complex ringed by a Doric style colonnade.[17]

At roughly 175 × 70m in size, the rectangular plan of this facility is remarkably similar to a feature that is thought to have existed at Olympia.[18] Furthermore, because the distance of the north and south sides is equivalent to the length of a Greek stade, it is likely that the colonnades along these sides actually belonged to the same type of covered running track known from the excavations at Delphi.

This reinterpretation of the extant evidence was largely confirmed through the discovery of similarly shaped fragments of a terracotta sima at each of the separately excavated areas. This element, which functions as an elaborately decorated gutter along the roofline of monumental classical era architecture, would have given a sense of visual uniformity to the separate buildings lining large central open space. The ARCS software was instrumental in recovering this information, as excavators since the 1950s have classified these fragments variously as

17 Frey – Gregory 2016.
18 Wacker 1996.

antefixes, simas or simply unknown objects. A visual scan through the catalogs, which often took place remotely though the ARCS system, allowed archaeologists to recognise mistakes in interpretation and assign various examples of the same decorative moulding to trenches excavated all around this colonnade. Once properly identified, these artefacts were retrieved from storage for further study and in some cases even repaired from joining fragments. It is likely that this search for evidence could not have achieved the same result had we relied upon keyword searches of transcribed documents instead.

Conclusion

It is indeed an exciting time to be a field archaeologist, as surveyors and excavators now enjoy ready access to digital tools and techniques that previous generations of scholars could hardly have imagined. At the same time though, in the midst of our understandable enthusiasm for speeding and simplifying the process of discovery, analysis and dissemination of archaeological information, it is worth pausing to consider whether certain innovations are attempting to reinvent some archaeological recording procedures that were tested and perfected generations ago. This is a particular concern at ongoing archaeological projects that must make difficult decisions as to which innovations to implement in their fieldwork and which traditional practices to preserve.

These considerations have always been central to the design and implementation of the ARCS project, which, it is hoped, will enable projects with long histories but short budgets to take part in the digital movement in archaeology on their own terms. The ARCS team is currently in the process of implementing the system at excavations in Greece, Cyprus and the northern Black Sea coast to test the flexibility of the software, metadata scheme and database in other archaeological contexts. The next phase of the project involves the creation of an automated installation utility to assist projects lacking an information technology specialist to configure their own version of ARCS. The ARCSCore metadata scheme is freely available for anyone to use and modify to suit their own needs. Anyone interested in making use of ARCS to organise and share their own archival documents is encouraged to contact the author.

References

ADS
Archaeology Data Service
<http://archaeologydataservice.ac.uk/> (last accessed 18 Dec. 2019).

ARCSCore
ARCSCore Metadata Schema
<https://github.com/matrix-msu/ARCSCore> (last accessed 18 Dec. 2019).

ARCS Online
The Archaeological Resource Cataloging System
<http://arcs.matrix.msu.edu> (last accessed 18 Dec. 2019).

Averett et al. 2016
E. W. Averett – J. M. Gordon – D. B. Counts (eds.), Mobilizing the Past for a Digital Future. The Potential of Digital Archaeology (Grand Forks 2016).

Bevan 2015
A. Bevan, The data deluge, Antiquity 89, 348, 2015, 1473–1484. doi:10.15184/aqy.2015.102

Broneer 1973
O. Broneer, Isthmia 2. Topography and Architecture (Princeton 1973).

Cooper – Green 2016
A. Cooper – C. Green, Embracing the complexities of ‘Big Data’ in archaeology. The case of the English Landscape and Identities Project, Journal of Archaeological Method and Theory 23, 1, 2016, 271–304. doi:10.1007/s10816-015-9240-4

Dallas 2015
C. Dallas, Curating archaeological knowledge in the digital continuum. From practice to infrastructure, Open Archaeology 1, 2015, 176–207. doi:10.1515/opar-2015-0011

DANS
Data Archiving and Networked Services
<https://dans.knaw.nl/> (last accessed 18 Dec. 2019).

Elliot et al. 2014
T. Elliott – S. Heath – J. Muccigrosso (eds.), Current Practice in Linked Open Data for the Ancient World, ISAW Papers 7, 2014. doi:2333.1/gxd256w7

Ellis – Wallrodt 2011
S. Ellis – J. Wallrodt, iPads at Pompeii, 12 April 2011. Online <http://classics.uc.edu/pompeii/index.php/news/1-latest/142-ipads2010.html> (last accessed 18 Dec. 2019).

Faniel et al. 2013
I. Faniel – E. Kansa – S. Whitcher Kansa – J. Barrera-Gomez – E. Yakel, The challenges of digging data. A study of context in archaeological data reuse, in: J. S. Downie – R. H. McDonald – T. W. Cole – R. Sanderson – F. Shipman (eds.), JCDL’13. Proceedings of the13th ACM/IEEE-CS Joint Conference on Digital Libraries, Indianapolis, IN, USA, July 22–26, 2013 (New York 2013) 295–304. doi:10.1145/2467696.2467712

Frey 2014
J. M. Frey, Digitizing Isthmia with the Archaeological Resource Cataloging System (ARCS), 27 Aug. 2014. Online <https://corinthianmatters.com/2014/08/27/digitizing-isthmia-with-the-archaeological-resource-cataloging-system-arcs/> (last accessed 18 Dec. 2019).

Frey – Gregory 2016
J. M. Frey – T. E. Gregory, Old excavations, new interpretations. The 2008–2013 seasons of the Ohio State University excavations at Isthmia, Hesperia 85, 2016, 437–490. doi:10.2972/hesperia.85.3.0437

Frey et al. 2015
J. M. Frey – L. Tzortzopoulou-Gregory – T. E. Gregory, The Archaeological Resource Cataloging System (ARCS). A better way of working with digital archives, in: A. Traviglia (ed.), Across Space and Time. Papers from the 41st Conference on Computer Applications and Quantitative Methods in Archaeology, Perth, 25–28 March 2013 (Amsterdam 2015) 358–364.

Gregory 1993
T. E. Gregory, Isthmia 5. The Hexamilion and Fortress (Princeton 1993).

Heath – Bizer 2011
T. Heath – C. Bizer, Linked Data. Evolving the Web into a Global Data Space, Synthesis Lectures on the Semantic Web: Theory and Technology 1, 1 (San Rafael, CA 2011). doi:10.2200/S00334ED1V01Y201102WBE001

Huggett 2015
J. Huggett, A manifesto for an introspective digital archaeology, Open Archaeology 1, 2015, 86–95. doi:10.1515/opar-2015-0002

Jeffrey 2012
S. Jeffrey, A new Digital Dark Age? Collaborative web tools, social media and long-term preservation, World Archaeology 44, 2012, 553–570. doi:10.1080/00438243.2012.737579

Kansa et al. 2011
E. Kansa – S. W. Kansa – E. Watrall (eds.), Archaeology 2.0. New Approaches to Communication & Collaboration, Cotsen digital Archaeology 1 (Los Angeles 2011).

Kansa et al. 2014
E. Kansa – S. W. Kansa – B. Arbuckle, Publishing and pushing. Mixing models for communicating research data in archaeology, International Journal of Digital Curation 9, 1, 2014, 57–70. doi:10.2218/ijdc.v9i1.301

Kintigh 2006
K. Kintigh, The Promise and Challenge of Archaeological Data Integration, American Antiquity 71, 3, 2006, 567–578. doi:10.1017/S0002731600039810

KORA
KORA Digital Repository and Publishing Platform
<http://kora.matrix.msu.edu/> (last accessed 18 Dec. 2019).

Paperless Archaeology
<https://paperlessarchaeology.com/> (last accessed 18 Dec. 2019).

Roosevelt et al. 2015
C. H. Roosevelt – P. Cobb – E. Moss – B. R. Olson – S. Ünlüsoy, Excavation is ~~destruction~~ digitization. Advances in archaeological practice, Journal of Field Archaeology 40, 2015, 325–346. doi:10.1179/2042458215Y.0000000004

tDAR
The Digital Arachaeological Record
<https://www.tdar.org/> (last accessed 18 Dec. 2019).

Wacker 1996
C. Wacker, Das Gymnasion in Olympia. Geschichte und Funktion (Würzburg 1996).