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Open software, hardware, processes, data and formats in archaeological research

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Julian Bogdani, Riccardo Montalbano,
and Paolo Rosati

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Foreword

This volume represents the editorial outcome of the 14th edition of ArcheoFOSS international conference, which took place on 15–17 October 2020 on the World Wide Web. The event has been held annually since 2006 and is dedicated to the theoretical framework and actual application of free and open-source software solutions and the promotion and encouragement of the Open Data paradigm for archaeology and, more generally, for Cultural Heritage.

Compared to the past editions, the 2020 conference introduced some substantial changes. First of all, the pandemic crisis due to the COVID-19 outbreak, forced us for the first time to hold a Web-based conference, a solution that introduced some important advantages. For example there was the facility to overcome geographical distances and therefore greatly broadening participation, both in terms of speakers (presentations, workshops, demos) and audience. Additionally we had the possibility to share thoughts on the specific topics of the conference with foreign colleagues from different backgrounds (universities, research centres), widening consequently the network of collaboration. We hope that the effort to open the ArcheoFOSS conference beyond Italian national borders – and beyond a small circle of individuals who in the last years have tenaciously and with great difficulty tried to keep alive the spirit of the conference – will not remain isolated, but will be further pursued in the next editions.

Another innovative aspect was the introduction of a panel dedicated to open data, open formats and open standards. While these topics have not been absent in the previous editions, the main focus has always been on the development and application of FLOS software and hardware solutions for Cultural Heritage. By specifically calling for papers dealing with the free sharing of data, we tried to go beyond software and technological development. Open and reusable data publishing platforms, available in open formats, and distributed with open licenses with no bias on the tools with which the data were created. The aim was to encourage and enhance the creation and publication of open archaeological archives, easily re-usable by the community.

This volume well represents the approach taken at the conference and the extensive participation it received. Eighteen high-level and peer-reviewed papers, well distributed in two thematic sections – application cases and development, and open data – contributed by more than forty Italian and foreign scholars, researchers and freelance archaeologists working in the field of Cultural Heritage. For an event organized at no cost, without funding or support of any kind, these are significant numbers, which reward us for the great organizational and editorial effort. The most important budget line was invested in releasing this book as open-access, using a CC BY license. We strongly believe that the conference proceedings must strictly follow the spirit of the event, and that the free distribution and sharing of the volume is a *conditio sine qua* non for its publication. This also marks a break with the past, when open-access was not always a prerequisite. It is worth noting, furthermore, that these proceedings are being published only one year after the conference. This is a decisive turnaround, which testifies to the strong will to revitalize the ArcheoFOSS community. Technology is evolving very fast, and it is not uncommon to read on fresh publications about outdated software and workflows or scripts that have already disappeared, greatly reducing or nullifying the utility of the publication, if not (perhaps) for the academic careers of its authors.

Not strictly related to this book, but important to the ArcheoFOSS community, was the decision to accelerate the publication of the 2019 edition, which was neglected due to financial issues and the outbreak of the COVID-19 pandemic. Furthermore, it was decided to alternate 'lighter' versions of the conference, mostly focused on workshops and hands-on sessions, demos, etc. and more 'traditional' ones, based on paper presentations. This will hopefully facilitate the prompt publication of the proceedings and regain a closer relationship with younger and frequently more active researchers.

Looking to the future, we all hope for the end of the current pandemic emergency, but it is clear how much this crisis sped up many cultural processes already ongoing, by changing our lives, our way of researching, teaching, experiencing and communicating archaeology.

In the coming years, the financial resources earmarked to fund digital projects in the field of Cultural Heritage will be substantial (consider, for example, the Italian National Recovery and Resilience Plan). The challenge for our community is therefore to stand ready to proactively suggest solutions to govern and guide this change, rather than passively undergo it.

As editors, we would like to thank WikiMedia Italia and the Ministero della Cultura – Direzione Generale Educazione, ricerca e istituti culturali for financially supporting the publication of these Proceedings; the University of Pisa, which granted us the use of the infrastructure and support for the streaming of the three-day conference; the colleagues of the Organising Committee, who shared with us the organization of the conference; the scholars and researchers who supported us as reviewers in the evaluation process for the conference and for the publication. Last but not least, we thank the members of the outgoing and current Scientific Committee, whose experience and competence guarantee the scientific quality of ArcheoFOSS initiatives.

The Editors

Julian Bogdani
Riccardo Montalbano
Paolo Rosati

Fieldnotes for the development and publication of open standards for the vectorisation of archaeologic and architectonic topographic legacy data

Julian Bogdani

Julian Bogdani, Sapienza University of Rome; julian.bogdani@uniroma1.it
Correspondence: julian.bogdani@uniroma1.it

Abstract
The digitisation and vectorisation of archaeological/architectonic graphical legacy documentation is a step that any archaeological project deals with and solves by following its own specific requirements. The article introduces the Simple Vectorisation Protocol (SVP), a GIS-based protocol for acquiring in the digital domain sketches and maps by following a very concise yet rich syntax, able to reverse engineering published and archive data. The result is a multidimensional dataset, ready to be used in specific projects, easy to publish on online repositories and highly re-usable and remixable, while still maintaining a feature-level bibliographic reference to the original source.

Keywords: LEGACY ARCHAEOLOGICAL DATASETS; ARCHAEOLOGICAL DATAFICATION; COLLABORATIVE PROTOCOLS; ONLINE DATA PUBLISHING; GIS; OPEN STANDARDS.

Introduction

This contribution has been conceived in the context of PATHs, an ERC Advanced project directed by P. Buzi at Sapienza University of Rome[1] during the activities of the Digital Archaeology Lab at Sapienza.[2] Since the general aims of the project are well known,[3] it is more effective to shift the focus to the specific topic of this article, i.e. the digitizing, georeferencing, vectorizing and processing of archaeologic and architectonic legacy drafts, sketches and maps in order to include these documents in the already publicly available Archaeological Atlas of Coptic Literature.[4] In broad terms, and from the technological point of view, the Atlas has been conceived as a rather lightweight Single Page Application (SPA) written in HTML and JavaScript,[5] pulling structured data from PAThs centralized online relational database and from other custom web mapping services (Figure 1).[6] At present, the Atlas itself is only one

[1] The complete title of the project is Tracking Papyrus and Parchment Paths. An Archaeological Atlas of Coptic Literature. Literary Texts in Their Original Context. Production, Copying, Usage, Dissemination and Storage, project number: 687567, URL: http://paths.uniroma1.it/ (accessed 9/4/2021).
[2] LAD: Laboratorio di Archeologia Digitale, supervised by the author of this paper, http://purl.org/lad (accessed 17/6/2021).
[3] Buzi 2020; Bogdani 2020; Buzi, Berno, and Bogdani 2018; Bogdani 2017.
[4] https://atlas.paths-erc.eu (accessed 9/4/2021), DOI: https://dx.doi.org/10.5281/zenodo.3357946.
[5] The React.js Framework (https://reactjs.org/, accessed 31/3/2021), an open-source (MIT Licensed) project developed and maintained by Facebook Inc., has been used for the coding of the application.
[6] PAThs database has been designed and realized using BraDypUS (DOI: https://dx.doi.org/10.5281/zenodo.4642442) open-source software (A-GPL v3.0 license) that facilitates the creation and usage of relational databases such as MySQL/MariaDB, PostgreSQL or SQLite, with a particular focus on Cultural Heritage use -cases. For the source code: https://dx.doi.org/10.5281/zenodo.4642442. For another use case of a clear separation of data management and data presentation based on BraDypUS, cfr. Bogdani 2016.

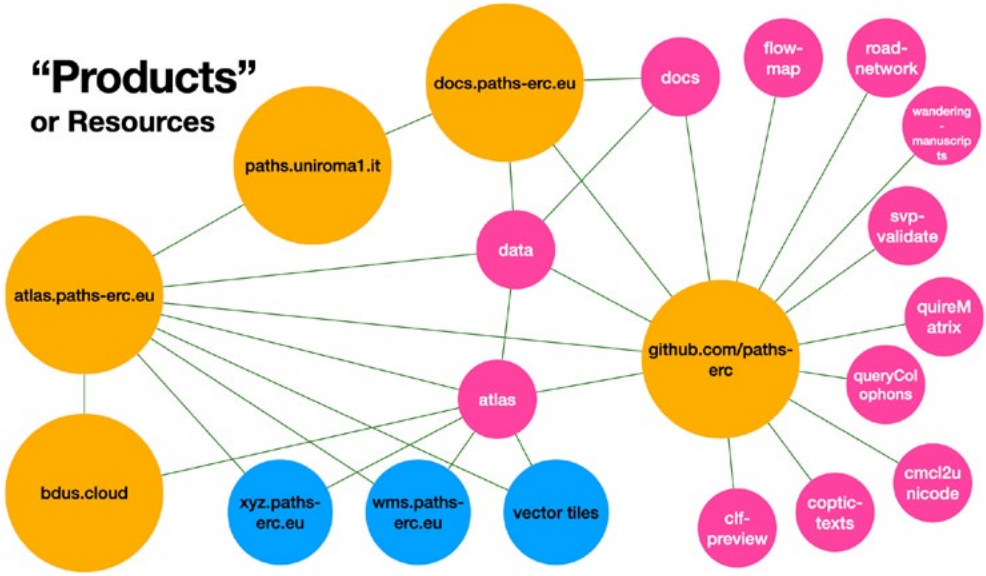

Figure 1: A graphical representation of digital resources powering the Atlas of Coptic Literature.

part of a rather complex net of digital resources, software packages, datasets and web services built to support the research project and released as open-source software and open-access databases.[7] It was important for the PAThs team to share data and algorithms being developed with the broader community of researchers focused on Egypt willing to study, experiment and adapt to their needs these resources, and hopefully also willing to provide feedback or contribute to their further development.

To facilitate data and software reusability, and also to support a complete transparency on the data production and publication processes, a specific documentation and data portal has been made available to the community, where a clear track of updates and new releases is being maintained (Figure 2).[8]

The Simple Vectorisation Protocol (SVP): the general picture

The Simple Vectorisation Protocol (SVP) is meant to provide a very easy way to implement the encoding in vectorial format of architectonic and archaeological drafts, sketches, and maps and to be able to provide, beyond geometry, additional informative and interpretative layers of structured data.

The need for this protocol originated when efforts were made to provide an archaeological context for most of the Late Antique and Medieval Egyptian sites related to the literary manuscript production, usage, and dissemination. It was decided to collect, digitize, georeference and finally vectorize archaeological and architectonic maps of buildings of

[7] All content is available under the terms of CC BY-NC-SA 4.0 (http://creativecommons.org/licenses/by-nc-sa/4.0/). The Atlas itself is released as GNU-AGPL 3.0 License.
[8] https://docs.paths-erc.eu/ (accessed 9/4/2021).

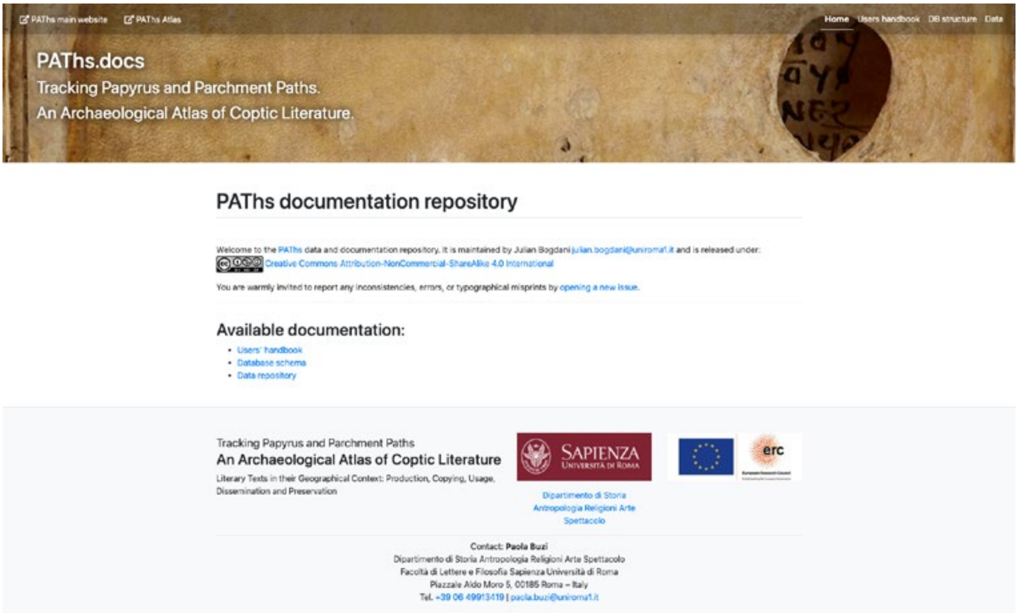

Figure 2: Screenshot of PAThs documentation and data portal, https://docs.paths-erc.eu.

religious destination (chapels, churches, basilicas, and similar) from previously published bibliographical and archival records. The preliminary phases of digitizing and, most importantly, that of contextualizing (i.e. georeferencing), required very attentive work and raised important research questions on the urban and topographical layout and on the diachronic stratification of many Egyptian sites. The detailed documentation and thorough discussion of these steps will be the object of a dedicated work aimed at providing the scholarly community with specific details on the grade of accuracy of the georeferencing process, the archive/bibliographic records involved, and to record and make explicit the not so rare arbitrary decisions that have determined the locations of a specific building inside the urban landscape. Dealing with legacy data often requires discretionary decisions on the interpretation of the available information. These questionable decisions must necessarily be taken to make data processable, but greater transparency must be made available on the *status quaestionis* and process that led to each conclusion. For this reason, the detailed recording of comprehensive *paradata*[9] is a paramount prerequisite for the vectorising process, most importantly in cases when uncertainty and lack of information are greater.

These considerations are also valid for the next step of vectorisation of the legacy raster-based sketches and maps, which beyond uncertainties about precise location, precise scale, and faithfulness of representation, require also great attention to the interpretation of the symbology, and finally to the date when the map was produced. In fact, published maps are to be considered a sort of snapshot of the archaeological situation at the time of the survey, more rarely embedding previous knowledge. Updates or corrections to these maps are never mere additions of physical features or structures, i.e. walls, pavements, doorways, etc., but come always with a deep reconsideration of the archaeological context. It is therefore important

[9] As defined in the London Charter, https://www.londoncharter.org/glossary.html (accessed 9/4/2021).

to precisely annotate the source of information and the relative bibliographic record to fully contextualize each archaeological feature in what we could call the archaeological *continuum* of knowledge production.

It is important to clearly highlight that the idea behind the drafting and implementation of this protocol is not that of obtaining a data model for the thorough representation of space and time in the archaeological domain, aiming at maximising the interoperability, as might be the Star model[10] or the proposed extension of CIDOC Conceptual Reference Model (CRM) to the archaeological excavations, named CIDOC CRM*archaeo*.[11] It is also not an extension of existing standard formats, such as for example GeoJSON-T,[12] developed to add temporal dimension to the GeoJSON format.[13] In particular, GeoJSON-T is of some interest for archaeologists, and more in general for humanists. It was developed to help interoperability for Digital Humanities projects dealing with space *and* time, two tightly interwoven entities. The encoding of time (duration) in addition to space (geometry) has always been problematic and each project has adopted *ad hoc* solutions that have inevitably turned into barriers to data comparison and exchange, i.e. interoperability. The solution proposed by JSON-T is adding a *foreign member* to GeoJSON, the *when* key, where time-related information can be encoded. This information can be one or more timespans, period definitions, labels, durations, or relative chronologies. Most interestingly, a further proposal to add a proper way to encode uncertainty and approximation has been advanced but not yet merged in the main branch.[14] The possibility for having *foreign members* is already present on the GeoJSON format specifications[15] but support for it is optional and depends exclusively on the implementation of the format. While some projects – mainly focused on web mapping and online data publication – are implementing the JSON-T format[16] there is no plan at present to see it adopted broadly on popular open-source GIS software, such as QGIS. This would be an initiative that would greatly ease the life of archaeologists dealing with geographical features through time.

Some conceptual and technical differences exist between SVP and GeoJSON-T that are worth listing, also in the perspective of future integration. While SVP can certainly be serialized and stored as GeoJSON, it does not rely exclusively on this format. Any GIS format able to manage coordinates and attributes can be used to implement SVP, consequently any GIS package can be employed to enter data, with no need to code *ad hoc* software and/or plugins. This implies that the data-structure defined by SVP does not rely on custom *foreign members*, but uniquely on the list of feature properties, their types and the vocabularies used to populate them.

Thus *simple* is a fundamental keyword, and simpleness means a plain structure – a flat list of attributes – that can be easily built (and eventually validated) by archaeologists who feel comfortable with GIS software in their daily workflow but that not necessarily have

[10] For an attempt in this direction, on the basis of ISO Standard 19100, cf. Migliorini, Grossi, and Belussi 2017.
[11] Doerr et al. 2019.
[12] https://github.com/kgeographer/geojson-t (accessed 9/4/2021).
[13] Standard RFC 7946, https://tools.ietf.org/html/rfc7946 (accessed 9/4/2021). In recent times, greater attention has been dedicated to a deeper consideration of data formats for the encoding of archaeological datasets with spatial capabilities, with particular regard to interoperability and standards, cf. D'Andrea et al. 2007; Forte 2019; and the contribution by D'Andrea and Forte in this volume.
[14] https://github.com/kgeographer/geojson-t#possible-extension (accessed 9/4/2021).
[15] Section 6 of RFC 7946, https://tools.ietf.org/html/rfc7946#section-6 (accessed 9/4/2021).
[16] For a list of the projects currently implementing the JSON-T format, cf. the 'Uptake' section of the official repository at https://github.com/kgeographer/geojson-t#uptake (accessed 9/4/2021).

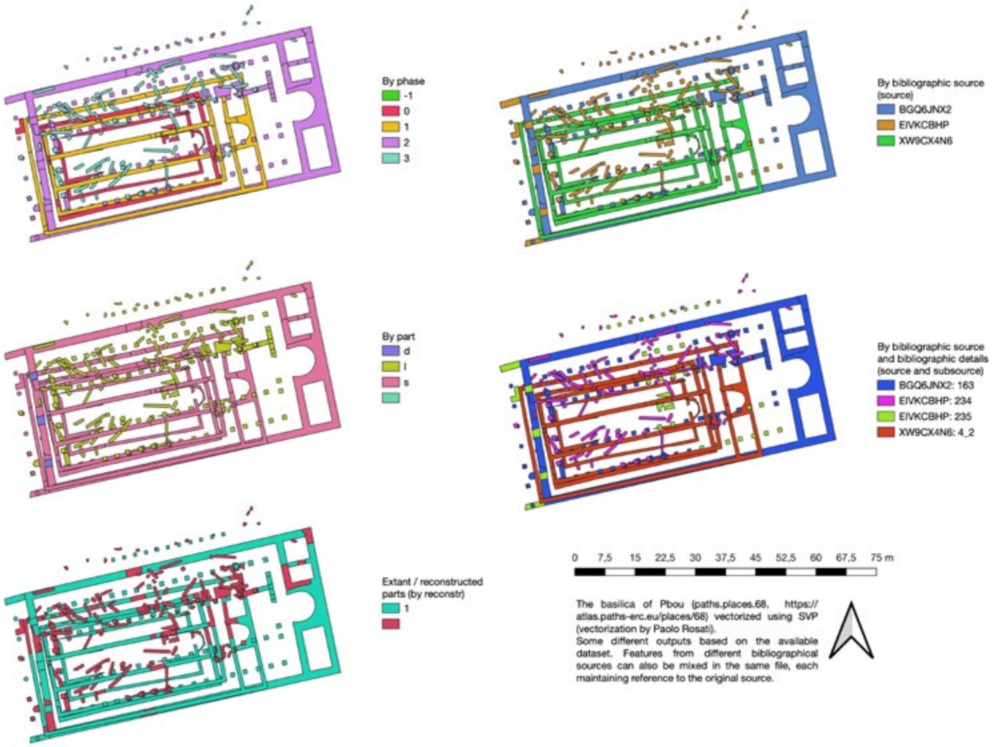

Figure 3: Different representations of the basilica of Pbou (http://paths.uniroma1.it/atlas/places/68) encoded using SVP.

coding experience. Ease of implementation and ease of usage results in consistent datasets embedding archaeological interpretation and providing a clear map, at feature level, of the epistemological process that produced each bit of information and interpretation.

SVP specifications

As already mentioned, SVP consists of a minimal list of attributes suited to extract and digitally encode virtually the full set of information that a paper drawing/sketch/map of an archaeological or architectonic complex conveys (Figure 3). The main effort has been spent on finding an equilibrium between a higher level of abstraction (a minimal set of attributes and vocabularies) and a yet intuitive and user-oriented experience of data-entry. The test-bench for the protocol was a series of GIS classes held at Sapienza University of Rome involving younger BA archaeology students who were partially aware of the graphical conventions of representing architectural and archaeological structures and who were also introduced to the use of GIS-based georeferencing of raster images and basic vectorisation.[17] They were also briefly introduced to the main specifications of the protocol, that were also corrected based on their feedback.

[17] A special note of thanks for their continued support goes to Domizia D'Erasmo and Paolo Rosati.

The attributes by which each feature is described in SVP are the following:

- *place*: a unique identifier of the place or archaeological site where the building represented is located. At PAThs Place ID (https://atlas.paths-erc.eu/places) is filed. URIs also can be used if a linked data output is planned. The usage of identifiers from well-known gazetteers[18] is strongly encouraged.
- *subplace:* eventually the name (ancient or modern) of part of the *place* where the building is located. This is used to provide a more direct (and human readable) topographical location of the represented building.
- *reconstr:* records whether the feature was visible when it was surveyed, or if the surveyor/digitizer reconstructed it based on an archaeological hypothesis. The following values are available:
    - 0: the feature was clearly visible and preserved when surveyed (usually a solid line is used to represent it on paper maps).
    - 1: the feature was not seen by the surveyor, who reconstructed it by hypothesis, based on archaeological analysis or by comparison (usually a dashed or dotted line is used to represent a reconstructive hypothesis on paper maps).
    - 2: as in the previous case the feature was not visible on the ground, and furthermore the original surveyor did not propose a reconstructive hypothesis. The reconstruction was made in the successive phase of the vectorizing. It is clear that SVP supports an active way of digitizing, by keeping a clear track of the source of information.
- *part:* part of the building the feature belongs to, indicating not the function (except for doorways) but relation to the section plane. The following values are available:
    - *null:* in cases when no information is available from the original source
    - *s:* for *sectioned*, used for walls or structures which are cut by the section plane
    - *u:* for *upper projection*, used for features located above the section plane, e.g. roofing, domes, beams, etc.
    - *l:* for *lower projection*, used for features lying below the section plane, e.g. pavements, altars, benches, etc.
    - *d:* for *doorways*, used for thresholds and doorsteps. This is the only exception for an indication of function, which is usually very difficult to recover from mute maps.
- *phase:* an indication of chronology when available. In PAThs an integer is used to indicate relative chronology. Also, URIs can be used, pointing to an external source describing in detail absolute or relative chronologies. The usage of identifiers from shared gazetteers, such as PeriodO[19] is highly recommended if the production of linked data is a priority.
- *lost:* whether the feature is currently preserved or not. Sometimes a feature was visible at the moment of surveying (*reconstr: 1*) but it is not preserved/visible nowadays (*lost: 1*). 0 or 1 values can be used.
- *height:* the maximum height, elevation, or altitude of the single element/feature, if available. In combination with *minHeight* it can be used to graphically and programmatically extrude elements to form a 2.5D representation (Figure 4).

[18] Such as Pleiades (https://pleiades.stoa.org/, accessed 9/4/2021) and World Historical Gazetteer (http://whgazetteer.org/, accessed 9/4/2021).
[19] https://perio.do/ (accessed 9/4/2021).

Figure 4: A screenshot from https://docs.paths-erc.eu/data/demo/#paths.places.16-Elephantine/BGQ6JNX2-186 showing the temple of Knum at Elephantine (blue) and the Late Antique garrison structures (in orange) on left and a 2.5D automatic representation of the structures.

- *minHeight:* the base height, elevation, or altitude of the single feature.
- *scale:* the denominator or the scale (when available) of the original map.
- *source:* unique identifier or URI of the bibliographic/archive record where the original map is published. In PAThs project the identifier of the official Zotero database[20] is being filed for each item.

[20] https://www.zotero.org/groups/2189557/erc-paths/ (accessed 9/4/2021).

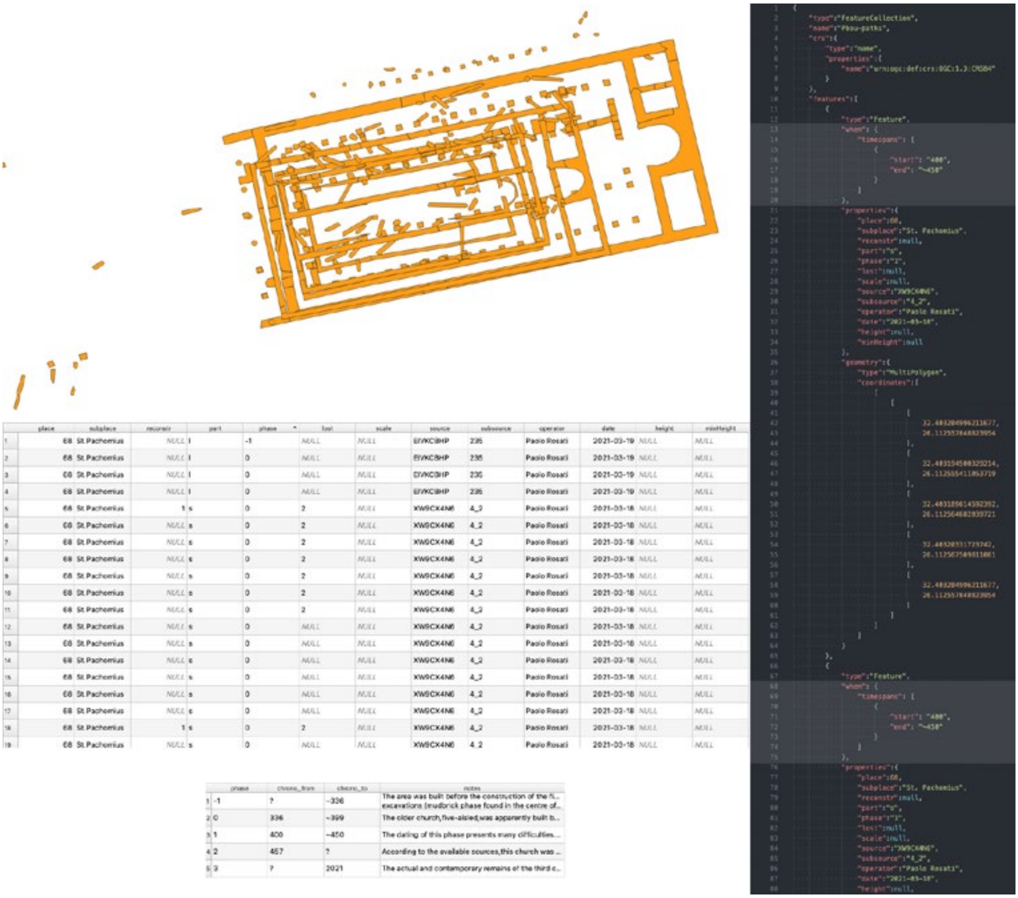

Figure 5: From SVP to GeoJSON-T: in the left-upper part the graphical representation of the basilica of Pbou encoded using SVP; in the left-middle part the SVP attribute list (excerpt); in the left-lower part a flat table mapping phases to absolute chronology; on the right excerpt of the resulting GeoJSON-T, embedding absolute chronology on feature level.

- *subsource:* if needed, further details regarding the bibliographic record, such as page, table, figure numbers, etc., can be provided here.
- *operator:* name, URI or any other string identifying the person who completed the vectorisation.
- *date:* date and time of the vectorisation process.

This structure does not imply strong assumptions on software or on file formats to use, the only requirement being the usage of a GIS format, able to handle geometry and non-geometry attributes. In addition, if a SVP implementation is serialized (or exported) in GeoJSON, it can be easily enhanced into a Linked Data format, by taking advantage of the implicit availability of external links expressed as URIs, as, for instance, for location, bibliographical reference, chronology, etc.[21] The same is true for other extensions, such as the above mentioned GeoJSON-T, that can be easily and programmatically obtained from SVP by *embedding* information on phasing and dating stored, for example, in a parallel database or also in the Linked Open Data Cloud (Figure 5).

While specific tools aimed at enhancing, converting, publishing, and visualising SVP encoded legacy data can be written in any programming language – especially if the dataset is serialized in JSON based formats – two very minimal examples can offer a glimpse on the potentiality and ease of implementation.

The first is a simple web-based demo, hosted inside the PAThs documentation portal,[22] allowing the visualisation about 150 georeferenced and SVP-encoded maps and sketches of churches, basilicas, and other religious buildings of the Late Antique and Medieval Egypt,[23] automatically styled by combining *part* and *phase* attributes (Figure 4, top) with support for 2.5D visualisation based on *height* and *minHeight* attributes.[24]

The second application[25] is a very simple validation tool written in HTML and JavaScript aiming at providing some grade of consistency in the implementation of SVP, with particular focus on the specific implementation of the protocol at PAThs.[26]

Conclusions. Some methodological considerations beyond (or before) practical implementations: digitisation vs. datafication

The digitisation of the archaeological record can be considered as a multi-level process, that too often stops at the very first steps of acquiring in digital format information previously published on paper. This output, be it a raster file or a CAD-based vector file, can be described as *analogical content on digital format*. Simply put, the use we make of these files is no different from the use we have made for a long time of the paper-based originals, reproducing in bytes – by analogy – the appearance of paper. Yet, paper is but a medium that conveys information, and *digitisation* should be intended as the process aimed at acquiring in the digital domain rich, complex, and multi-layered information stored in a rather flat and poor paper format. Datafication[27] should therefore be the fourth step in the archaeological workflow, following (1) digitisation, (2) georeferencing, and (3) vectorisation. SVP can be considered as a theoretical and practical attempt aimed at reverse engineering legacy archaeological geo/topographical data stored on paper support, seeking conciseness and completeness, trying not to introduce new tools or formats, but relying on GIS software that archaeologists have used for decades now. As such, the protocol can be perfectly integrated in workflows that look towards the future of data sharing and publishing, such as the Linked Open Data universe.

[21] This implementation can also benefit from the GeoJSON-LD implementation, https://geojson.org/geojson-ld/ (accessed 9/4/2021), combining GeoJSON and JSON-LD.
[22] https://docs.paths-erc.eu/data/demo/ (accessed 9/4/2021).
[23] The main source being Grossmann 2002.
[24] The demo application uses Leaflet.js (https://leafletjs.com/, accessed 9/4/2021) as web mapping library, Bing and Google maps as base satellite imagery and OSM Buildings (https://osmbuildings.org/, accessed 9/4/2021) as web-viewer for 3D buildings.
[25] Code at: https://github.com/paths-erc/svp-validate (accessed 9/4/2021), GNU A-GLP licensed.
[26] Available at https://paths-erc.eu/svp-validate/ (accessed 9/4/2021).
[27] Anichini *et al.* 2015: 153.

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