

# ##=DIGITAL CLASSICS ONLINE=##

## Online availability, impact and sustainability of digital papyrological resources

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**Abstract:** This article discusses opportunities and current issues of digital approaches for papyrology. It seeks to determine whether good practice is adopted in the development of the projects, thereby allowing use, reuse and sustainability over the long term, hence ongoing usefulness and usability. I shall reflect on how the growth and evolution of digital content and tools, which rely on novel ways of representing and sharing primary sources, analysis and interpretation, with their various purposes and audiences, is assisting the papyrologist's work with new modes of research practices and of scholarly communication.

### Digital resources and papyrological research practices

Most institutions that preserve papyri, whether in small- or large-scale collections, have created and made available online digital surrogates and catalogue information, whether following an individual approach (like POxy: Oxyrhynchus Online<sup>1</sup>, BerlPap<sup>2</sup>, Heidelberg's Papyrussammlung<sup>3</sup> and the papyrological section of Vienna's ÖNB Digital<sup>4</sup>, to cite some of the most extensive ones) or a federative model (like the former APIS catalogue now flowed into the Papyri.info platform,<sup>5</sup> the German Papyrus Portal<sup>6</sup>, the Italian PSIonline<sup>7</sup>, the Spanish DVCTVS<sup>8</sup> and the Berkeley & Regional Partners Database<sup>9</sup>), thereby enhancing access to their items and encouraging understanding of them. Several other types of digital resources for the discipline have been provided by classics departments and papyrological research centres. There are text corpora, notably the Duke Databank<sup>10</sup> and the Digital Corpus of Literary Papyri<sup>11</sup>, integrated into Papyri.info<sup>12</sup>; metadata databases for literary papyri, for example the

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<sup>1</sup> Last access to all links on 11.04.2022. <http://www.papyrology.ox.ac.uk/POxy>.

<sup>2</sup> <https://berlpap.smb.museum>.

<sup>3</sup> <https://www.ub.uni-heidelberg.de/papyri>

<sup>4</sup> <https://onb.digital/search/146659P5>.

<sup>5</sup> <https://papyri.info/browse/apis>.

<sup>6</sup> <https://papyri.uni-leipzig.de>.

<sup>7</sup> <http://www.psi-online.it>.

<sup>8</sup> <http://dvctvs.upf.edu>.

<sup>9</sup> <https://www.lib.berkeley.edu/visit/bancroft/tebtunis-papyri>.

<sup>10</sup> <https://papyri.info/browse/ddbdp>.

<sup>11</sup> <https://papyri.info/browse/dclp>.

<sup>12</sup> <http://papyri.info>.

comprehensive Mertens-Pack<sup>3</sup><sup>13</sup> and the Leuven Database of Ancient Books<sup>14</sup>, the latter now contained in the Trismegistos platform<sup>15</sup>; metadata databases for documentary papyri, including the Heidelberger Gesamtverzeichnis<sup>16</sup>, those available via Trismegistos (Trismegistos Texts, People, Places and Archives, among others), and the PapPal palaeographical collection of dated papyri<sup>17</sup>; word indices such as the WörterListen<sup>18</sup>; and lexica, for instance the Neues Fachwörterbuch<sup>19</sup>. We may pinpoint several reasons why many institutions and researchers have undertaken the effort of producing high-quality images of even extensive papyrological holdings, and of building collections of digital texts and data despite the complexity of this often damaged and lacunose evidence, in view of the opportunities that digital humanities resources offer to both users and the institutions in charge of them.<sup>20</sup>

Firstly, benefits of digital tools for papyrologists concern enhanced access to primary, secondary and tertiary sources in several respects. One is the possibility of more rapid access to items, including those requested by multiple users at the same time or difficult to obtain.<sup>21</sup> Indeed, in the case of papyri (and other handwritten sources), imaging has remarkably improved access to them as each item is unique and therefore available in only one institution. The accessibility of digital papyrological editions and reference works is also very convenient, as they are only present in specialised libraries. Furthermore, digitisation entails the benefit of enhanced access to components within items:<sup>22</sup> for papyri, to letters of difficult reading, with improved legibility through digital image capture, and to specific passages or words of the digitised text, as occurs in Papyri.info's comprehensive corpus of documentary papyri and, increasingly, literary ones, in thematic collections such as the Kyprianos<sup>23</sup>, devoted to Coptic magical texts, and Judaism and Rome<sup>24</sup>, and in the Codex Sinaiticus project.<sup>25</sup>

Access to the text of particularly challenging artefacts or three-dimensional objects has benefited from advanced imaging techniques.<sup>26</sup> Multispectral, especially infrared, photography<sup>27</sup> has been deployed for enhancing the contrast between ink and writing support in papyri, ostraca and tablets with faded

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<sup>13</sup> <http://cipl-cloud09.segi.ulg.ac.be/cedopal/MP3/dbsearch.aspx>.

<sup>14</sup> <https://www.trismegistos.org/ldab>.

<sup>15</sup> <https://www.trismegistos.org>.

<sup>16</sup> <http://aquila.zaw.uni-heidelberg.de/start>.

<sup>17</sup> <http://www.pappal.info>.

<sup>18</sup> <https://papyri.uni-koeln.de/papyri-woerterlisten>.

<sup>19</sup> [https://www.organapapyrologica.net/content/dictionary\\_start.xed?XSL.PortalType.SESSION=dictionary](https://www.organapapyrologica.net/content/dictionary_start.xed?XSL.PortalType.SESSION=dictionary).

<sup>20</sup> In the following discussion of opportunities and challenges of digital humanities methods and tools for papyrology, I take as a reference point the contributions by Bowman (2010), who focuses on issues of imaging of ancient handwritten documents, Terras (2012a, 49–50; 2012b, 72–75), who deals with the digitisation of text and image collections overall, and van Lit (2019, 51–63), who examines digitised collections of manuscripts and tackles questions of scholarly publication, citation and authority.

<sup>21</sup> On the enhancement of the access to primary sources in digital humanities and classics projects, see Terras (2012a), 49; van Lit (2019), 52; Bowman (2010), 104.

<sup>22</sup> Terras (2012a), 49; van Lit (2019), 52.

<sup>23</sup> <https://www.coptic-magic.phil.uni-wuerzburg.de/index.php/manuscripts-search>.

<sup>24</sup> <https://www.judaism-and-rome.org>.

<sup>25</sup> <https://www.codexsinaiticus.org>.

<sup>26</sup> For a detailed overview of the benefits brought by imaging, including advanced techniques, to reading papyrological sources, see Reggiani (2017), 137–50. On advantages of digital imaging for both ancient and medieval manuscripts, cf. Bowman (2010), 102–03; Terras (2012b), 75; Barker-Terras (2016), 12–13.

<sup>27</sup> On the method of infrared treatment with a focus on papyrological sources, see Bülow-Jacobsen (2020), 60–61, 78–79. For papyri, the use of infrared imaging, rather than of full multispectral imaging, is sufficient, as they are responsive only to this kind of wavelength (Macfarlane [2010], 460–61).

script, for instance finds from cartonnage (e.g., the Posidippus papyrus<sup>28</sup> and the Vienna epigrams papyrus<sup>29</sup>) and the Vindolanda ink tablets<sup>30</sup>, or with a very darkened background, typically carbonised papyri, such as those from Herculaneum<sup>31</sup> and Petra<sup>32</sup>. Furthermore, 3D recording, in particular reflectance transformation imaging (RTI) for the examination of fine surface detail, has recently started being explored for some papyrological sources with incised writing:<sup>33</sup> magical texts on metal tablets for the *Magica Levantina* corpus are being imaged with this technique;<sup>34</sup> it is currently being experimented on the Vindolanda stylus tablets;<sup>35</sup> and it was tested on a Herculaneum papyrus to clarify the complex geometry of the surface of fragments with different layers of text stratified.<sup>36</sup> Ostraca from the Leipzig collection have been provided with 3D interactive representations, along with infrared imaging, in Papyrus Portal,<sup>37</sup> which enable us to visualise these text-bearing objects in a novel way, more suitable to their three-dimensional nature than traditional scanning.

Access to elements within the texts can be enhanced by the application of semantic markup, so as to nuance searches and automatically create interactive indices, thus allowing functionality beyond basic word search and presentation. In the aforementioned Codex Sinaiticus project, structural markup allows digging within the text directly to the chosen textual or codicological element (fig. 1).

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<sup>28</sup> P.Mil.Vogl. VIII 309, vii–viii.

<sup>29</sup> CPR XXXIII, i.

<sup>30</sup> T.Vindol. III, 6, 14; Bowman (2010), 102.

<sup>31</sup> Macfarlane-Del Mastro (2018), 11–12.

<sup>32</sup> Chabries-Booras (2001).

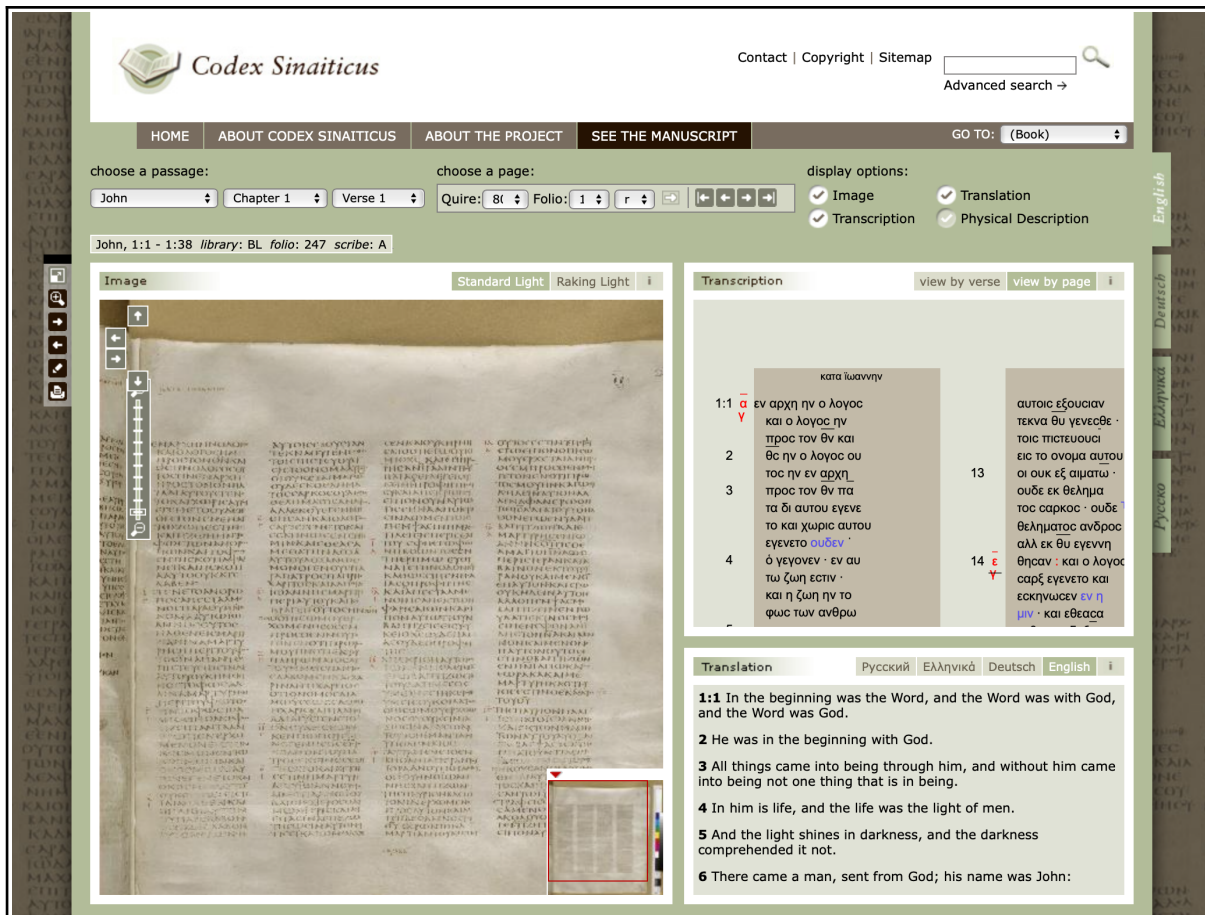
<sup>33</sup> On the RTI procedure for imaging wax tablets (both those in which the wax is preserved and those with traces on the wooden support only) and incised ostraca, see Bülow-Jacobsen (2020), 63, 76–77.

<sup>34</sup> <https://papyri.uni-koeln.de/magica-levantina/index.html>. See the *Magica Levantina* project's "About" page and Piquette (2017), 84 on the RTI imaging of the lamellae.

<sup>35</sup> CSAD, n.d.

<sup>36</sup> Piquette (2017).

<sup>37</sup> Blaschek-Quenouille (2016), 49–50.



**Fig. 1: Codex Sinaiticus.** It is possible to precisely browse the text of the Bible witnessed by this manuscript, with the aid of the two drop-down menus on top. They refer to subdivisions of both the content (books, chapters and verses) and the material support (quires and folios).

Linguistic annotation has been applied in the corpus of documentary papyri thereby allowing advanced exploration of linguistic phenomena: to access morphological information, in Trismegistos (TM) Words word-list (fig. 2), and both morphological and syntactic information in the PapyGreek treebanking project<sup>38</sup> (fig. 3). Semantic markup, in contrast, has been little deployed in papyrology. It has been utilised in the digitisation of corpora of ancient tablets, namely, the Vindolanda tablets, in the two Vindolanda Tablets Online databases (VTO<sup>39</sup> and the former VTO 2<sup>40</sup>), whose content has been merged in Roman Inscriptions of Britain (RIB) Online,<sup>41</sup> as well as in the more circumscribed Curse Tablets of Roman Britain.<sup>42</sup> But semantic markup has not been applied in projects relating to Egyptian papyri, which represent the vast majority of sources in the discipline, with the only exception of Papy-Greek, which encodes the relationship of the people mentioned in the texts with the text itself (thereby distinguishing author, actual writer, i.e. scribe, addressee and external official). Conversely, in the realm of epigraphy several place-based thematic collections are provided with semantically rich an-

<sup>38</sup> <https://sematia.hum.helsinki.fi>.

<sup>39</sup> <http://vindolanda.csad.ox.ac.uk>.

<sup>40</sup> <https://web.archive.org/web/20180611181929/http://vto2.classics.ox.ac.uk>.

<sup>41</sup> <https://romaninscriptionsofbritain.org>.

<sup>42</sup> <http://curses.csad.ox.ac.uk>.

notations, following the EpiDoc Guidelines;<sup>43</sup> indices distilled from the encoded texts thus enable fast access to textual information.

**Words**

Type in a word or translation: ?

To search for morphological features, click [here](#).

Your current selection: words beginning with **γ** ([remove last letter](#)). Click any of the letters below to add another letter to your selection:

α · β · γ · δ · ε · ζ · η · θ · ι · κ · λ · μ · ν · ξ · ο · π · ρ · σ · τ · υ · φ · χ · ψ · ω

✓ Any lemma type ▾

- Verb
- Noun
- Adjective
- Adverb
- Numeral
- Conjunction
- Preposition
- Article
- Relative
- Personal
- Particle
- Interjection
- Demonstrative
- Interrogative
- Indefinite

TM Word Id	Word ↕	Translation	Frequency ↓↑
	γῆ	earth	3823
	γράμμα	what is written, letter	3794
	γυνή	woman	3316
	γένημα	produce	3293
	γραμματεὺς	scribe, secretary	2653
	γεωργός	farmer	1961
	γεωμετρία	land-survey, land-tax	1373
	γείτων	neighbour	1371
	γεωργός	adjective farmer	1298
	γινώσκω	verb (come to) know	929
	γόμος	noun ship's freight, beast's load	812
	γεωργέω	verb to be a farmer	773
	γυμνασιάρχῳ	verb to be gymnasiarch	613

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**Fig. 2: TM Words.** Words attested in documentary papyri can be searched by lemma, part of speech and morphological information.

<sup>43</sup> Examples include Cretan Institutional Inscriptions, Inscriptions of Greek Cyrenaica/Greek Verse Inscriptions of Cyrenaica, Inscriptions of Roman Cyrenaica, Inscriptions of Roman Tripolitania, and RIB Online.

PapyGreek Collections Annotated texts People Variations Help Sign in

**PARATYPA**

## Variations

Regex mode *slow!*

BEFORE

ORIGINAL

AFTER

BEFORE

REGULARIZED

AFTER

ORIGINAL

POS	PERS	NUM	TENSE	MOOD	VOICE	GEND
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CASE	DEG					
<input type="checkbox"/>	<input type="checkbox"/>					

LEMMA

REGULARIZED

POS	PERS	NUM	TENSE	MOOD	VOICE	GEND
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CASE	DEG					
<input type="checkbox"/>	<input type="checkbox"/>					

LEMMA

RELATION

- ADV
- ADV\_CO
- APOS

RELATION

- ADV
- ADV\_CO
- APOS

Line initial  
 Line final  
 Sentence initial  
 Sentence final

METADATA

DATE

Strict   Strict

TEXT TYPE

HYPERCATEGORY	CATEGORY	SUBCATEGORY	STATUS
<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 100%; height: 20px;" type="text"/>

PEOPLE

PAPYGREEK	ROLE
ID	<input style="width: 100%; height: 20px;" type="text"/>
<input style="width: 100%; height: 20px;" type="text"/>	<input style="width: 100%; height: 20px;" type="text"/>

Finalized texts

**Fig. 3: PapyGreek.** This tool allows searching linguistic features of documentary texts: orthographic variants by type of replacement, and syntactical relations between words (as well as types of documents and person roles).

The most extensive textual corpus in the discipline, the Duke Databank of Documentary Papyri, as well as the Digital Corpus of Literary Papyri, also in Papyri.info, presents transcriptions encoded in TEI-based XML, in particular the custom EpiDoc guidelines for papyrological (and epigraphical) texts, which were also employed to encode the item metadata. The EpiDoc guidelines were followed



to encode features of the appearance and layout of papyri as well, such as gaps and divisions in columns or pages, and interventions of the ancient scribe and modern editor to be displayed in the apparatus, as well as to standardise datasets from different sources thus ensuring compatibility between them. The choice of EpiDoc was thus meant as a guarantee of long-term usability, being a TEI-compliant XML format used in several digital classics projects. On the other hand, the EpiDoc markup in Papyri.info was not harnessed to capture entities derived from the primary sources; rather, the digital paradigm of Papyri.info editions is based on linking metadata encoded separately from the texts. But one should note, too, that the Papyri.info platform was launched several years ago, in 2010<sup>44</sup> (at the completion of the three-year Integrating Digital Papyrology project funded by the Mellon Foundation),<sup>45</sup> and that it has not subsequently received funding for work on the semantic enhancement of its content, being now mostly based on volunteer effort. Moreover, the provision of semantically encoded texts was not the purpose of the IDP project. This rather focused on the aggregation of the main papyrological digital efforts into a single powerful web-based resource, so as to offer an environment (the Papyrological Navigator) with integrated access to information and the ability of cross-searches through one interface; furthermore, it aimed at the creation of an editing tool (the Papyrological Editor) to support user contribution for the addition of new items or corrections. It is also worth pointing out that papyrological resources such as the WörterListen, Trismegistos People and Trismegistos Places compensate for the lack of granular access to Papyri.info's corpus of documentary papyri, at least for some categories of words. Nevertheless, it would also be useful to provide sets of related texts with the ability of search and analysis directly pertaining to their area of research.

Overall, it can be said that the processes of text digitisation and digital image capture have been well-exploited in papyrology to improve access both on the item level and within items, although the latter aspect has lagged behind because of the lack of funding for projects involving the application of deep markup to enable complex and semantically rich queries. Also, access within items might be enhanced by allowing navigation not only within digitised text but also within images, taking as a model the Codex Sinaiticus project. Here, the structurally encoded transcription is aligned with the digital surrogate, hence it is possible to browse both text and images down to the select unit of the work or of the codicological structure, for a comparative view of the passage of interest and its material aspect in the original (fig. 4). With the help of automated alignment techniques, it would be advantageous to be able to browse more codices or rolls of a certain extent with such a parallel display of transcription and image.

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<sup>44</sup> See Sosin 2010, the text of the talk given by Joshua Sosin (Duke University) at the International Congress of Papyrology of the same year, to announce the launch of Papyri.info to the scholarly community.

<sup>45</sup> On the IDP project, undertaken by Duke University with the involvement of several institutions, see Baumann et al. (2011), focused on the methods and the standards used for aggregating and linking the databases in Papyri.info, and Bagnall (2010), which illustrates the vision and the goals that underpin the initiative.

The screenshot displays the 'Codex Sinaiticus' digital interface. At the top, there is a navigation bar with 'HOME', 'ABOUT CODEX SINAITICUS', 'ABOUT THE PROJECT', and 'SEE THE MANUSCRIPT'. A search bar is located on the right. Below the navigation bar, there are controls for 'choose a passage:' (John, Chapter 1, Verse 1) and 'choose a page:' (Quire: 8r, Folio: 1). A 'display options:' section includes checkboxes for 'Image', 'Transcription', 'Translation', and 'Physical Description'. The main content area is divided into three panels: 'Image' (showing a digitized manuscript page with a red box highlighting a word), 'Transcription' (showing the Greek text with a red box highlighting the corresponding word), and 'Translation' (showing the English translation with a red box highlighting the corresponding sentence). The interface also includes a vertical sidebar on the right with language options: English, Deutsch, Ελληνικά, and Ρωσικά. At the bottom, there are logos for 'Supported by DFG', 'Arts & Humanities Research Council', 'IIN SNF', and 'The European Commission', along with an RSS feed icon.

Fig. 4: Codex Sinaiticus. The transcription, the translation (when available) and the digitised manuscript are digitally aligned. Thus, clicking a word in the image of a manuscript page highlights the related word in the transcription (and the related passage in the translation) and vice versa.

Additionally, there is another opportunity for improving access within primary sources by resorting more often to visualisation techniques. Visual representations as charts and maps are already utilised, in the databases of the Trismegistos platform, to provide overviews of and allow exploring statistical data on papyrus texts and named entities extracted from them. However, visual approaches have found little application in the analysis of the exemplars themselves as book products, the only instances being the diagrammatic representations provided in Grammateus<sup>46</sup>, a metadata database devoted to the typological study of documentary papyri, which includes visualisations of textual structures in each papyrus record, and Les Collections de Papyrus digitised collection of Sorbonne's Institut de Papyrologie, whose "Virtualia"<sup>47</sup> section contains visual reconstructions of fragments with particular problems. Because the study of books and documents as editorial products plays a primary role in papyrology, in the wake of these two resources it would be interesting to create more complex visualisations, to be integrated into the images of the extant fragments, thereby highlighting characteristics of the papyri that are not immediately visible, such as textual structures or physical characteristics. Also, such visualisations might be aligned with the digitised papyrus text so as to make them interactive, enabling search

<sup>46</sup> <https://grammateus.unige.ch>.

<sup>47</sup> <http://www.papyrologie.paris-sorbonne.fr/menu1/Virtualia.htm>.



and browse mechanisms. Work on alignment of text and image, in particular in fragments of literary papyri digitised in the Digital Corpus of Literary Papyri (now merged into Papyri.info) was carried out at the University of Würzburg for the Anagnosis project, as a first step towards extracting samples of scribal handwritings for automated evaluation of space in lacunae and proposed supplements.<sup>48</sup> It might thus be interesting to complement research for Anagnosis with work to reveal patterns, highlight material and editorial features, and propose a reconstruction of the exemplar as a whole, as far as possible.

With the exception of Codex Sinaiticus, with its deep integration between text and imagery, papyrus image and transcription are usually presented separately in digital papyrology projects: they need to be accessed in two different resources, typically a digitised collection's catalogue and Papyri.info's textual database, although these are often conveniently interconnected. Some projects have made a step forward in the integration of the two data types, by displaying them juxtaposed in papyrus records, as occurs in Papyri.info for some items derived from the former APIS project,<sup>49</sup> in the Heidelberger Gesamtverzeichnis (HGV) database of documentary papyri,<sup>50</sup> and in a few digitised collections (Berl-Pap<sup>51</sup>, Heidelberg's Papyrussammlung<sup>52</sup>, DVCTVS<sup>53</sup> and Vindolanda Tablets Online/RIB Online<sup>54</sup>). However, this solution still somehow resembles the format of printed editions, where photographs are placed beside transcriptions or are reported in plates at the end of the volume (fig. 5). Visual methods and alignment between text and image can help further link the two aspects of materiality of fragments and text content, which in the papyrologist's work are closely interrelated, with the study of the appearance of the text and its reconstruction proceeding side by side. Visual representation of textual information helps us look at the complexities of a text in a different way from the form that this presents in the manuscript or in the print medium. In papyrology, too, this method can help rebuild research resources in the digital age, adding interconnections and interactivity to our extensive collections of digitised materials.

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<sup>48</sup> On the Anagnosis project, see its website, at <http://kallimachos.de/kallimachos/index.php/Anagnosis:Main>, and Ast and Essler's overview (2018, 71–73).

<sup>49</sup> See, e.g., the record at <http://papyri.info/ddbdp/c.pap.gr:2.1:9>.

<sup>50</sup> <http://aquila.zaw.uni-heidelberg.de/start>. See e.g. the record at <http://aquila.zaw.uni-heidelberg.de/ddb/P.Mich.:20::813:;#140156>.

<sup>51</sup> See e.g. the record at <https://berlpap.smb.museum/00038>.

<sup>52</sup> See e.g. the record at <https://doi.org/10.11588/diglit.33390#0001>.

<sup>53</sup> See e.g. the record at <http://dvctvs.upf.edu/catalogue/p-palaurib-inv-25>.

<sup>54</sup> See e.g. the record at <https://romaninscriptionsofbritain.org/inscriptions/TabVindol574>.

Fig. 5: A sample record from the Heidelberger Papyrussammlung, with papyrus image and text displayed alongside.

As well as improved access and opportunities for deeper integration between written content and external evidence, one more effect of the digital medium is that it has provided the means to virtually assemble many different types of objects, viz. diverse primary sources and scholarly aids, which tend to be scattered across libraries and museums, and analytical tools, so as to construct environments with supportive context for the research process.<sup>55</sup> In papyrology there are several instances of projects with such a heterogeneous but coherent aggregation of content, although the potentialities of the digital environment have not been fully exploited in this sense. Some resources gather papyri of related content in textual corpora and metadata databases, a few of them with the addition of tools for advanced search and analysis, notably the Papyri.info platform, the Mertens-Pack<sup>3</sup> and the Leuven Database of Ancient Books for literary papyri, and the HGV for documentary ones. Other efforts bring together diverse primary sources around a theme. The majority of them show a plain format with images and texts embedded in scholarly narratives. Notable instances of this kind are virtual exhibitions or the-

<sup>55</sup> Terras (2012a), 49; Bowman (2010), 103; Palmer (2004), 352–58.

matic collections constructed around place-based themes, displaying papyri alongside archaeological objects: Berkeley University's on Tebtunis<sup>56</sup>, Oxyrhynchus: a City and its Texts<sup>57</sup> and VTO's on the Vindolanda site<sup>58</sup>. There are also collections focused on classical literature, book production and palaeography as attested in papyri and medieval codices: those in the British Library's Greek manuscripts section<sup>59</sup> and the Vatican Library's Thematic Pathways<sup>60</sup>. Further projects with different kinds of primary sources also exploit the digital environment to structure the individual items thereby enabling search and analysis, and to provide additional types of media, viz. images captured with advanced techniques and visual representations such as charts, illustrations and maps. This is the case of the Trismegistos Texts database of papyri and inscriptions, and of the Excavations at Amheida<sup>61</sup> and Desert Networks<sup>62</sup> thematic collections of papyrological and archaeological documentation. As one may notice, archaeological sites constitute a theme dealt with in projects with both basic and advanced access to primary sources. By contrast, topics relating to literary and manuscript studies are explored in thematic collections designed with basic affordances of navigation and visibility (i.e., the aforementioned British Library's Greek manuscripts section and the Vatican Library's Thematic Pathways), but not with innovative research environments. The reason may lie in the fact that libraries that hold ancient and medieval manuscripts, which might be interested in the development of such a project, have rather prioritised funding of digitisation efforts and direct accessibility of digital surrogates of their primary sources. It might be worth building on the results achieved in the development of projects that mediate access to primary sources through analytic or interpretive layers, and applying them to support deep inquiry in those themes with interrelated and searchable materials.

The integration of tools for the study of the collected primary sources is a key feature of digital research collections. In papyrology, this characteristic is typified by the Papyri.info and Trismegistos platforms. These two resources are well-connected for the provision of papyrus images and information, from both internal and external tools and datasets. Nevertheless, an important research challenge will be to interlink their papyrus texts with the available online lexica. One is the Liddell-Scott-Jones Greek-English Lexicon (LSJ) major reference work, which includes some terms attested in the papyri, available online at the Thesaurus Linguae Graecae (TLG) website in a corrected version<sup>63</sup> and in Perseus Digital Library<sup>64</sup>; in both cases, the LSJ can be consulted individually or can be accessed from the text corpora. There are also specific papyrological lexica, i.e., the Neues Fachwörterbuch, *Léxico de magia y religión en los papiros mágicos griegos online*<sup>65</sup>, *Coptic Dictionary Online*<sup>66</sup>, which includes Greek loanwords, and the Words in Progress supplement to Greek lexica with its papyrological section<sup>67</sup>. Interlinking lexical tools and papyrological textual databases, as now occurs for Greek literary works in the TLG and Perseus, would allow immediate consultation of word definitions from

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<sup>56</sup> <https://www.lib.berkeley.edu/visit/bancroft/tebtunis-papyri/resources>.

<sup>57</sup> [http://www.papyrology.ox.ac.uk/POxy/VExhibition/exhib\\_welcome.html](http://www.papyrology.ox.ac.uk/POxy/VExhibition/exhib_welcome.html).

<sup>58</sup> <http://vindolanda.csad.ox.ac.uk/exhibition/index.shtml>.

<sup>59</sup> <https://www.bl.uk/greek-manuscripts>.

<sup>60</sup> <https://spotlight.vatlib.it>.

<sup>61</sup> <https://isaw.nyu.edu/research/amheida>. See especially, as well as its enhanced satellite images.

<sup>62</sup> <https://desertnetworks.huma-num.fr>. See especially its databases of sites, finds, networks and roads, and archaeological missions; its interactive map of archaeological sites; and its satellite views.

<sup>63</sup> <http://stephanus.tlg.uci.edu/lsg>. Cf. Pantelia (2011).

<sup>64</sup> <http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3atext%3a1999.04.0057>.

<sup>65</sup> <http://dge.cchs.csic.es/lmpg>.

<sup>66</sup> <https://coptic-dictionary.org>.

<sup>67</sup> <http://www.aristarchus.unige.net/Wordsinprogress/en/Home>. Searches can be limited to papyrological sources through the advanced search form.

within the texts and, vice versa, of relevant passages from their citations in lexica. Even more important, it would offer instant access to more updated information than in print lexica, in terms of new lemmata and new meanings and attestations of already known ones.

Papyrology has also harnessed digital approaches for improving the management of metadata catalogues,<sup>68</sup> e.g., for bibliographical records (with the Bibliographie Papyrologique<sup>69</sup>), information relating to literary texts (Mertens-Pack<sup>3</sup> and the Leuven Database of Ancient Books), prosopographical (Trismegistos People) and geographical data (Trismegistos Places). Thematic collections have emerged,<sup>70</sup> so as to facilitate the reconstruction of groups of texts. Like textual databases and linguistic corpora, they are scoped and bounded by features of the items rather than by physical proximity, as opposed to digitised real-world collections; but they show a more circumscribed focus, being customised for intensive study on a specific subject.<sup>71</sup> Purposes of papyrological thematic collections include grouping together texts found in or relating to the same city (Oxyrhynchus: A City and its Texts, Vindolanda Tablets Online<sup>72</sup>), reassembling ancient archives or libraries now dismembered (Trismegistos Archives, Les archives de Dioscore d'Aphrodité en images<sup>73</sup> and Guide to the Heroninos Archive<sup>74</sup>) and aggregating texts with specific content (e.g., Curse Tablets from Roman Britain and the Death on the Nile database of mummy labels<sup>75</sup>).

### Digital publishing in papyrology

Digital humanities methods provide opportunities not only for the research process but also for publication of research results, for teaching and dissemination, thanks to the possibilities of accessing immediately digitised or born-digital works, obtaining user contributions on source materials, supporting teaching with interactive resources, disseminating information on the discipline and, for memory institutions, increasing interest in their holdings and enhancing their visibility so as to raise their profile.<sup>76</sup>

As concerns publication of research results, the impact of the move from print to digital is evident in terms of more rapid access to resources, such as digital and digitised books and journals, and to elements within them, such as chapters, articles and specific passages, analogously to what happens with digital primary sources.<sup>77</sup> In the papyrological realm, digitisation of printed works<sup>78</sup> has also allowed their integration with online resources (via external links), so that they can be accessed directly from their related bibliographical reference. Thus, open access bibliographical items are linked from the Checklist of Editions reference tool, merged into the Papyri.info platform; also, freely available pub-

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<sup>68</sup> Reggiani (2017), 79, 257–58.

<sup>69</sup> <http://www.acre-egke.be/BP.htm>. The Bibliographie Papyrologique is also accessible via Papyri.info: <https://papyri.info/bibliosearch>.

<sup>70</sup> Reggiani (2017), 79, 115–17.

<sup>71</sup> For this definition of “thematic collection” see Palmer 2004, 348–49.

<sup>72</sup> <http://vindolanda.csad.ox.ac.uk>.

<sup>73</sup> <http://bipab.aphrodito.info>.

<sup>74</sup> [http://www.accademiafiorentina.it/?pg=cr\\_hero](http://www.accademiafiorentina.it/?pg=cr_hero).

<sup>75</sup> <http://deathonthenile.upf.edu>.

<sup>76</sup> Terras (2012a), 49–50.

<sup>77</sup> Van Lit (2019), 52; Terras (2012a), 49.

<sup>78</sup> For a survey of digitised and born-digital papyrological publications, both open access and available on subscription, see Reggiani (2017), 173–77.

lications with papyrus images are linked from the relevant Papyri.info records. By the same token, open access works are increasingly being pointed out in the *Bibliographie Papyrologique en ligne*.<sup>79</sup>

Another advantage of the flexibility of electronic publications, as shown by the Derveni Papyrus project,<sup>80</sup> is that it is possible to store multiple versions of a text, which can be accessed simultaneously and compared. Moreover, digital works can be easily changed and distributed in their new form; one may thus promptly introduce updates and corrections, integrating them with the existing material. In papyrology, as notably occurred with the development of the Duke Databank, this has allowed storing and making available a large amount of newly published and re-edited documentary papyri, of which printed indices and supplements to lexica could not keep abreast. Also, it is now possible to search texts altogether in one corpus, rather than consulting indices in supplements provided in separate volumes from their lexica or indices in single volumes of editions. Another instance of integration of recent editions is RIB Online, which adds new T.Vindol. texts, as they appear in print, to the earlier content digitised as VTO.<sup>81</sup>

There is, however, a drawback to the flexibility of the digital: mutability, in contrast to the stability of print sources, which are virtually impossible to alter. Updates and improvements added to the original digital edition introduce a new version that removes the previous one, and this entails a problem with citation, as the digital work may have become different by the time a reader consults it after finding it referenced.<sup>82</sup> In papyrology, the mutability of the digital medium may affect projects that offer new or revised editions, as opposed to reproductions of existing paper-based ones: Papyri.info, which includes a small number of born-digital editions, relating to both previously unpublished papyri and to revised texts; Derveni Papyrus, with two new transcriptions of the homonymous exemplar; Kyprianos, which offers revised editions<sup>83</sup>. A related set of challenges was introduced by the diffusion of Web 2.0 technologies. These have encouraged the development of interactive platforms to permit online users to aid research and memory institutions in the construction of large collections and to contribute to discussions. Thus, user engagement has allowed resource providers to expand and improve digital collections and has provided opportunities for conducting collaborative research; but it has also raised issues of quality control, leading to the introduction of mechanisms of moderation to assure the quality of the crowdsourced content,<sup>84</sup> a practice that the relevant papyrological projects follow. Among resources that offer born-digital papyrus editions (or re-editions), especially Papyri.info's texts can undergo a process of change, as this platform makes use of an interactive editing environment, the Papyrological Editor, open to contributions from any registered user, whether new items or edits of existing ones, for updating its corpus. But, exactly because of the dynamic nature of this scholarly workspace, particular measures are in place to deal with multiple versions of its papyrus texts, and to enforce correct editorial attribution and citation of the digital record. Proposed new entries and edits are subject to a peer review by an editorial board before publication; older versions of the text remain visible in a revision history available in the papyrus record, as well as being stored in a Git repository, so that it is possible to correctly attribute the editorial intervention to its author; the digital documents are associated with unique identifying URIs to facilitate their citation.<sup>85</sup> To further keep track of such changes, editions and emendations newly added to Papyri.info are collected in a *Bulletin of Online Emendations to Papyri* published by the Heidelberg Institute of Papyrology, reported with the indication of the scholars

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<sup>79</sup> Reggiani (2017), 28.

<sup>80</sup> <https://chs.harvard.edu/publications-projects-derveni>.

<sup>81</sup> <https://romaninscriptionsofbritain.org/tabvindol>.

<sup>82</sup> Van Lit (2019), 53; Berkes (2018), 80–82.

<sup>83</sup> <https://www.coptic-magic.phil.uni-wuerzburg.de/index.php/texts-search>.

<sup>84</sup> For an overview of digital humanities crowdsourcing, see Terras (2016).

<sup>85</sup> Reggiani (2017), 232–33; Baumann (2013), 94.



who proposed them and linked to the textual database.<sup>86</sup> Two more papyrological resources solicit user contributions for original evidence, namely, PapyGreek<sup>87</sup> and Words in Progress<sup>88</sup>, to which we may add the Dodona Online corpus of oracular *lamellae*,<sup>89</sup> and all of them allow for the examination of the proposals by an editorial board before their possible inclusion in the database, and provide scholarly attribution.

As well as for scholarly publication, online publishing has offered opportunities for disseminating papyrological information on the web, taking into consideration different levels of education. This activity is especially undertaken by digitised physical collections. Many of them offer rich information, in form of virtual exhibitions and overviews accessible to everyone, that contextualises and integrates the primary-source content: notably, Berkeley Database<sup>90</sup>, the University of Michigan's Papyrology Collection<sup>91</sup>, POxy: Oxyrhynchus Online<sup>92</sup>, and British Library's catalogue (Digitised Manuscripts)<sup>93</sup>. Another way to pay attention to students and non-experts of papyrology is to provide a glossary of papyrological terms for a first approach to the texts, as occurs in two digitised collections, Papyrus Portal<sup>94</sup> and Berkeley Database<sup>95</sup>. Among corpora and databases, the Kyprianos project resorts to podcasts to share the work of its curators with both interested specialists and non-specialists. Besides these resources with sections with accessible information, there are also two projects entirely realised for teaching purposes, namely, the MultiPal<sup>96</sup> interactive palaeographical database and the Papyrus to Print collection, on the website of the University of Manchester's Library<sup>97</sup>, created as an aid for teaching book history, with a specific section on papyri.

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<sup>86</sup> Reggiani (2017), 136.

<sup>87</sup> Vierros (2018), 106; <https://sematia.hum.helsinki.fi/help>, esp. "1) Sematia: Annotating papyri or inscriptions".

<sup>88</sup> See Words in Progress's home page at <http://www.aristarchus.unige.net/Wordsinprogress/en/Home>.

<sup>89</sup> <https://dodonaonline.com>, esp. <https://dodonaonline.com/ciod> for the invitation to scholarly collaboration.

<sup>90</sup> Extensive information is provided about the Berkeley papyri through content overviews, a historical note, thematic collections on types of papyrus findings and on ancient archives (<https://www.lib.berkeley.edu/visit/bancroft/tebtunis-papyri>). Related online exhibitions illustrate various aspects of daily life both in Tebtunis and in the rest of Egypt in the Graeco-Roman period: <https://www.lib.berkeley.edu/visit/bancroft/tebtunis-papyri/resources>.

<sup>91</sup> See the online exhibitions about the Michigan collection's highlights and the discipline of papyrology at <https://www.lib.umich.edu/collections/collecting-areas/special-collections-and-archives/papyrology-collection>.

<sup>92</sup> See the exhibition devoted to the city of Oxyrhynchus, its papyrological and archaeological findings, and the dedicated research projects, including the imaging of its texts: [http://www.papyrology.ox.ac.uk/POxy/VExhibition/introduction/greekpapyri\\_oxyrhynchus.html](http://www.papyrology.ox.ac.uk/POxy/VExhibition/introduction/greekpapyri_oxyrhynchus.html).

<sup>93</sup> British Library's papyrus collections is provided with a catalogue, along with the other Library's manuscripts ([http://searcharchives.bl.uk/primo\\_library/libweb](http://searcharchives.bl.uk/primo_library/libweb)), and with a catalogue relating to digitised items (<http://www.bl.uk/manuscripts>). But there are also by overviews of the overall collection (<https://www.bl.uk/collection-guides/papyri>) and of special items, such as Herculaneum papyri (<https://www.bl.uk/collection-items/charred-scroll-fragments-from-herculaneum>) and ostraca (<https://www.bl.uk/collection-guides/ostraca>). Furthermore, thematic collections in the Greek Manuscripts section (<https://www.bl.uk/greek-manuscripts>) and posts in the Medieval manuscripts blog (<https://blogs.bl.uk/digitisedmanuscripts>) regularly focus on papyrological material.

<sup>94</sup> <https://papyri.uni-leipzig.de/indexpage.jsessionid=84D2D19131359F40E7ADB63A02477075?searchclass=glossary&XSL.lastPage.SESSION=%2Findexpage%3Fsearchclass%3Dglossary>.

<sup>95</sup> <https://www.lib.berkeley.edu/visit/bancroft/tebtunis-papyri/collection>.

<sup>96</sup> <http://multipal.fr>.

<sup>97</sup> <https://www.digitalcollections.manchester.ac.uk/collections/papyrustoprint/1>.

### Current issues in digital papyrology: online availability and long-term sustainability

In regard to the online availability of digital resources, generally speaking there are the following possibilities among digital humanities projects.<sup>98</sup> Some have an online presence and are also fully and freely accessible; a few of them also make available their base documents in a standard format, thereby allowing reuse for further undertakings. By contrast, other digital humanities projects use a restricted-access subscription-based model and may be made instantly available upon payment; among these, some, like the TLG, serve non-subscribing users through an open-access selection of items and functionalities. Finally, there are initiatives that no longer have an online presence (e.g., *Chartae Latinae Antiquiores*, unavailable since 2021<sup>99</sup>).

While the vast majority of digital papyrology efforts are open-access, a few resources form notable exceptions. Among digitised real-world collections, overall, most of them make information on their published papyri freely available, in good part complete with online digital images, which allows scholars to obtain them rapidly. Sometimes there are even preliminary data on and high-resolution pictures of the unpublished ones (as occurs for Vienna's ÖNB Digital<sup>100</sup>, Heidelberg's Papyrusammlung<sup>101</sup> and Manchester Papyri<sup>102</sup>, among the most extensive catalogues). Thus, digitised papyrus collections provide a wealth of material for more in-depth investigation into already known texts and for the publication of the many still unpublished. Two collections, however, differ for their poor availability of images online: the Chartes database of Herculaneum papyri<sup>103</sup> and the papyrological section of the Bodleian Libraries' image catalogue (Digital Bodleian)<sup>104</sup>. The Chartes metadata database contains a sample image for each papyrus, whereas the complete pictures need to be requested from the holding library, the National Library of Naples; this, after granting clearance, will put the scholar in contact with the Brigham Young University,<sup>105</sup> the institution in charge of their digitisation.<sup>106</sup> A planned jointly sponsored catalogue of the two institutions, aimed at providing free online access to the whole digitised collection, was in fact not implemented because of unresolved rights issues.<sup>107</sup> The limitations to the development of this resource are therefore institutional, viz. relating to intellectual property rights, rather than technical, as Bowman observed about the difficulties involved in bringing together digital images and resources originating from different collections and countries.<sup>108</sup> The papyrus section of Digital Bodleian also differs from the other catalogues of papyrus collections. Albeit comprehensively catalogued online, with records of 1200 papyri in the Medieval Manuscripts in Oxford Libraries database, it has almost not been imaged, and pictures need to be requested. True, the Bodleian Libraries are not specialised on papyrological material, hence funding for digitisation pro-

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<sup>98</sup> Cf. van Lit (2019), 85.

<sup>99</sup> See the latest archived version of this resource, the digital version of the homonymous repertoire of Latin documents until the ninth century included, at [https://web.archive.org/web/20200721162543/http://www.urs-graf-verlag.com/index.php?funktion=chla\\_suche](https://web.archive.org/web/20200721162543/http://www.urs-graf-verlag.com/index.php?funktion=chla_suche).

<sup>100</sup> <https://onb.digital/search/146659P5>.

<sup>101</sup> <https://www.ub.uni-heidelberg.de/papyri>.

<sup>102</sup> <https://luna.manchester.ac.uk/luna/servlet/ManchesterDev~93~3>.

<sup>103</sup> <http://www.chartes.it>.

<sup>104</sup> <https://digital.bodleian.ox.ac.uk>, esp. "Greek and Latin Papyri" in the "Browse" section.

<sup>105</sup> G. Del Mastro, e-mail message to author, 15.04.2022.

<sup>106</sup> Macfarlane et al. (2007), 585–86.

<sup>107</sup> Macfarlane et al. (2007), 586; Macfarlane (2010), 460; BYU Library, <https://guides.lib.byu.edu/c.php?g=216482&p=1429231>.

<sup>108</sup> Bowman (2010), 105.

jects is necessarily distributed across a wide variety of primary sources. Thus, we do not know whether Bodleian papyri will be made digitally available in a comprehensive way, but it seems that we have little expansion to expect. Although the Bodleian Libraries are committed to imaging their special collections as much as possible,<sup>109</sup> their digitisation programme is mostly tied to external funding, granted by large charities, Oxford societies and donors, and thus addresses the specific requests of these groups; only occasionally are other images published online, following photography orders by researchers, according to the library's digitisation policy.<sup>110</sup>

If we move on to considering online availability of other kinds of resources than digitised collections, we may note that most of them are fully and freely accessible, hence they may be seen online instantly. There are however two remarkable exceptions. One is Trismegistos databases: the use of most of their improved functions is restricted to subscribers as, since January 2020, Trismegistos has been charging fees for the complete usage of its search interfaces and visualisations. We cannot fail to notice the high cost of the subscription, 1040 euros from 2022, which needs to be renewed yearly.<sup>111</sup> Hence, 118 institutions and 21 individuals have currently subscribed (as of April 2022, as is shown on Trismegistos's home page), which means that most potential users, who cannot afford this expense, have been excluded from access to the full functionality of this fundamental tool. Notice, though, that only recently has Trismegistos become limited to subscribers, as there was no more funding for sustaining it adequately, and that the resource serves non-subscribed users through many open-access functions.

Secondly, although digital papyrology efforts have had a continued online presence over the latest years, worth pointing out is the case of a resource, also concerned with ancient documents, which does not exist anymore as an individual project, Vindolanda Tablets Online (VTO) 2. Even though its textual content (namely, texts, contextual material and word lists) is still available via RIB Online, we can no longer avail ourselves of its most innovative functionality, the APPELLO service<sup>112</sup>. This search function, purposefully developed for the project, would automatically suggest words while one was typing a few, even median, letters of a term in the search interface of one of VTO 2's indices. As it permitted to call up words based on character patterns, it could also be used as an aid in text restoration. By obtaining suggestions for the integration of lacunae based on words from the same corpus, it would help confirm interpretations of extant traces and would support the reading process within documents from the Vindolanda corpus and related Latin texts.<sup>113</sup> In the cases of both VTO 2 and Trismegistos, importantly, direct access to the base material is still guaranteed. But the use of advanced analytical tools is no longer possible (VTO 2) or is accessible after subscription and payment (Trismegistos). The disappearance of the APPELLO search function has a smaller impact than the limitation of the access to Trismegistos, as it involves a much smaller set of texts. Nonetheless, it is significant of the difficulty to ensure sustainability of digital humanities resources: whereas visualisations and complex searches are still available in Trismegistos, albeit to a limited number of users, APPELLO has become altogether inaccessible, due to the disappearance of the VTO 2 website and its absence in RIB Online. It would have been particularly useful to make available not only the texts of the Vindolanda tablets but also the code of APPELLO under an open-source license, as was envisaged,<sup>114</sup> for anyone to reuse it in connection with EpiDoc-based content with minimal adjustments.

Besides simple open access, enabling reuse by making available their base of data in a structured format and licensing it in the public domain, is much welcomed too. This permits advanced users to

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<sup>109</sup> <https://digital.bodleian.ox.ac.uk/about>.

<sup>110</sup> <https://digital.bodleian.ox.ac.uk/faq>.

<sup>111</sup> Trismegistos, <https://www.trismegistos.org/registration.php>.

<sup>112</sup> <https://web.archive.org/web/20180617023659/http://vto2.classics.ox.ac.uk/index.php/about/appello-web-service>.

<sup>113</sup> Roued-Cunliffe (2010), 375–77.

<sup>114</sup> VTO 2, <https://web.archive.org/web/20180617023659/http://vto2.classics.ox.ac.uk/index.php/about/appello-web-service>.

obtain large parts of the collection for carrying out analyses beyond the functionality offered by the projects themselves or for creating custom collections with materials from these as well as from other sources. Indeed, most of the major efforts scrutinised in this chapter are open-source, namely, Papyri.info, HGV (in particular, its records integrated into Papyri.info), WL, PapyGreek, Grammateus and Codex Sinaiticus, which officially make available their XML-based content to the users, with the provision of bulk-download facilities. In part, Trismegistos also adopts an open-data policy, as concerns select information (in particular about people and places) and, limited to subscribers, item results, exportable as CSV files. The availability of open tooling is desirable too, which occurs for some Trismegistos services.

Although increasing amounts of digital content for papyrological research are being published, it is worth recognising too that there are questions about their sustainability, in its two aspects of online permanence and continued content curation. This problem may hinder maintenance in the long term and investment in further digital projects. It is acknowledged that it is highly expensive to maintain a digital resource, as hardware and software for storing the digital data have a life span of few years and thus need constant updating.<sup>115</sup> The issue is increased by the fact that most digital humanities enterprises are based on time-limited and finite grant funding, and that, after the resource has been developed with the available financial support, there is little opportunity for receiving continuation funding; it is likewise difficult to generate sufficient income from the resource itself. This results in a lack of curation of many efforts once their creation is concluded.<sup>116</sup> A further challenge is represented by changes in funding calls in recent years, asking for more requisites: they now rarely support mere digitisation, requiring that this process be included in the framework of a wider research project, and favour initiatives that will be embedded in an institution-based repository, e.g. a university library, to guarantee long-term availability.<sup>117</sup>

In digital papyrology, too, sustainability is uncertain for some resources. Some established projects, for example the Mertens-Pack,<sup>3</sup> the WörterListen and Papyrus Portal, are reliable in terms of both ongoing accessibility and continuing publication of digital content, in that they take advantage of institutional technological support and are supported by a university centre for papyrological research. The MP<sup>3</sup> is backed by an established papyrological centre with long-standing experience in literary papyri and enduring technological support such as the University of Liège's CEDOPAL. The WL is also potentially permanent, as it is hosted by the website of a centre for papyrological research, that of the University of Cologne (Kölner Papyri), and relies on collaboration with the Cologne Center for eHumanities for its technical implementation. While it has not been updated recently (its last update being in July 2020), the WL is potentially sustainable in terms of content curation as well, since it benefits from the continuous contribution of the scholarly community for the provision of source material (as indicated on the home page), and takes advantage of standards-based approaches to the delivery of reusable content, as its TEI-encoded source data is made available open-access on the GitHub repository under a Creative Commons Attribution license. On the other hand, one must note that other major digital papyrology efforts, such as Papyri.info and Trismegistos, do not show clear planning that will enable long-term access and curation. Papyri.info may be recognised as a permanent resource as it is being hosted on an institutional server, that of Duke University Library. Also, stable identifiers for the records are available in the form of permanent URIs. But it has to be mentioned that the continued curation of the content is uncertain. There is a problem of financial sustainability of Papyri.info that puts the enterprise at risk, as recently highlighted by the two main associations of papyrologists, the Association Internationale de Papyrologues and the American Society of Papyrologists, which have launched a joint call to support the resource by establishing an endowment (as one may see from the

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<sup>115</sup> Terras (2012a), 50, 58; van Lit (2019), 54; Meneses-Furuta (2019), i129–i30.

<sup>116</sup> Terras (2012a), 57–59; van Lit (2019), 54, 64, 99; Maron et al. (2009), 6; Bagnall-Heath (2018), 172, 186.

<sup>117</sup> Terras (2012a), 58.

notice displayed in Papyri.info's home page). Even if such a large fund as the endowment is eventually established, it seems however vital to diversify the revenue strategy in order to protect themselves if a revenue stream is insufficient or terminates, as has been recommended by JISC (the organisation for digital services for UK education and research) in their survey on sustainability models of digital research projects.<sup>118</sup>

Even though issues remain regarding the vulnerability of some resources to future funding, these efforts have provided a very valuable contribution to substantively improve research processes in the discipline, as I hope I have shown. Among the strengths of digital papyrological projects there is certainly the large amount of digitised materials, the vast majority of which is usable, and of digital data derived from them. Secondly, most digital resources are open access, with the exceptions of Trismegistos, which however serves non-subscribing users through many open access functionalities, and of papyrus images in Chartes, while its metadata database is offered free of charge, as well as a sample of each picture. Moreover, several projects are open source, free to download and modify, as already mentioned, and in turn adapted materials can be shared thereby fostering the continuous growth of digital papyrological tools.

To sum up, it may be said that both documentary and literary papyri are well-served by digital projects, not only for directly accessing primary materials, such as transcriptions and images, as allowed by text corpora and digitised collections, but also for consulting other related scholarly content, with more granular derivatives such as detailed metadata, statistics, prosopographical, geographical and chronological data, digitally enhanced indices, visual representations of text structures and bibliographical information. Literary and paraliterary papyri are extensively covered by the MP<sup>3</sup> and LDAB, and documentary papyri by the HGV; also, these text categories are taken into account by Trismegistos Texts to a large extent, as well as by the Bibliographie Papyrologique as far as bibliographical information is concerned. Other projects do not fully cover a category of papyri, but this is justified by their focus: the WL only takes into account documentary papyri published after the year 1995, when it was launched with the aim of integrating the Duke Databank in a period in which it lacked curation;<sup>119</sup> Grammateus also concentrates on a selection of documentary papyri, so as to examine their typologies, choosing items whose layout is well-identifiable in all its features. Documentary papyri have been comprehensively provided with information from the linguistic point of view as well, in terms of lemmatisation, POS tagging and morphological analysis, thanks to the PapyGreek and Trismegistos Words projects. While work on the development of software for automated syntactic annotation of Greek documentary papyri is ongoing, the creation of a treebank of a group of texts manually encoded has offered the opportunity to start investigating the syntax, variation and sociolinguistic phenomena on a representative sample of documents in PapyGreek. Finally, some sets of papyri, relating to specific topics, have been the object of dedicated collections and lexica. Papyrology has thus started taking advantage of the genre of thematic research collections with careful selections of the universe of available documentation, even equipping them with advanced metadata search and analysis, as shown by such resources as TM Archives, Guide to Heroninos Archive, the Death on the Nile database of mummy labels, the Water technology database and Karanis Tax Rolls. Other thematic collections have been provided with tools for deep analysis of the texts, as the former VTO 2 and, in part, RIB Online. Future challenges will be the enhancement of digital editions in Papyri.info through the connection with lexical tools, especially, given its predominance of documentary papyri, the Neues Fachwörterbuch; and the creation of more visual representations to support users' data inspection and to offer them a concrete way for understanding results, while accounting for decisions taken to model the uncertainty inherent to the visualisation of incomplete and fragmented data.

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<sup>118</sup> Maron et al. (2009), 21–22.

<sup>119</sup> WL, <https://papyri.uni-koeln.de/papyri-woerterlisten/ueber>.



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