The role of digital humanities in papyrology

Dissertation

for the degree of PhD in Digital Classics

submitted by

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I declare that the work presented in the thesis is my own

Abstract

My dissertation investigates the impact of digital resources and methods on papyrology, the study of the production of Greek and Latin books and documents as directly witnessed by archaeological findings. This is an extremely fruitful discipline to survey for insight into the changes that digital and Internet technologies have brought to humanities research, because of its long-standing and intensive adoption of diverse resources.

The goal of this thesis is to understand to what extent digital humanities methodologies have influenced the papyrologist's work, in terms of both changes in their research practices and evolution of their instruments. This has been achieved by contextualising papyrological resources against the backdrop of digital progress in other classics and humanities disciplines, and by placing them within the framework of digital humanities scholarship. It is the first systematic attempt to carry out a comprehensive analysis of papyrological projects from this perspective.

First, I present the methodological framework, illustrating the key characteristics to accessibility, usability and sustainability of digital humanities efforts to be evaluated in the resources under scrutiny (ch. 1). Then, I analyse a diverse range of collections, starting from the most common type, corresponding to the most familiar way in which humanities scholars and libraries interact with and organise digital content, namely, by making primary materials directly searchable and browsable. These projects were split into two groups: digitised collections that arise from material ones (ch. 2) and corpora and databases relating to a text category or a theme (ch. 3). The thesis then moves on to examining the less usual type of initiative, but one that prioritises advanced modalities of access to papyri, through interrelationships among primary sources, derivative information and functional layers (ch. 4). The final chapter draws the conclusion of the dissertation by discussing opportunities and current issues of digital papyrology efforts as a whole.

Overall, it can be said that among the strengths of digital papyrology is the remarkable work already carried out. Many institutions have made available online high-quality digital surrogates and catalogue information, to enhance access to their items and encourage understanding of them. Several other types of digital resources for the discipline have been provided by classics departments and papyrological research centres, in the form of theme-based collections of digital texts and data, despite the complexity of this damaged and lacunose evidence.

Benefits brought by digital methods to papyrological science often concern enhanced access to items and their components through digital surrogates, digital editions, metadata catalogues and reference works. On the whole, the processes of text digitisation and image capture have been well-exploited in papyrology, although access to papyrus texts would benefit from more extensive use of deep markup to enable more complex and semantically rich queries. Also, more granular access within items might be provided by allowing navigation not only within the text but also within images, with the help of automated alignment techniques. Additionally, there is another opportunity for amelioration by resorting more often to visualisation techniques, for deeper integration between written content and external evidence.

Another effect of the digital medium in papyrological research practices 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, as is typified by the *Papyri.info* and *Trismegistos* platforms. Nevertheless, an important research challenge will be to interlink papyrological textual databases with the available online lexical tools, for instant access to more updated information than in print reference works.

Although increasing amounts of digital content for papyrological research are being published, it is worth recognising too that there are questions about their sustainability, which may hinder their maintenance in the long term and investment in further digital projects. While some initiatives have taken steps to ensure ongoing availability, others do not show clear planning that will enable long-term access and curation.

Even though issues remain regarding the vulnerability of some resources to future funding, digital papyrology efforts have provided a very valuable contribution to substantively improve modes of research and communication in the discipline, as I hope I have shown. At the same time, I have delineated the challenges that need to be addressed so that the resources may not only continue to aid in the research process but also, increasingly, be themselves the expression of new research.

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Chapter 1

A framework for the analysis of digital papyrological resources

1.1 Introduction

Reflecting on the changes that computational technologies and the Internet have brought to humanities research, we may see that papyrology is an extremely interesting discipline to survey for obtaining valuable insights into the phenomenon, because of its long-standing and intensive adoption of diverse digital resources.

Papyrology is the study of texts that have been written on a portable support (often in the form of papyrus rolls or codices), date from the fourth century BC to the eighth AD, are mainly in Greek and have been unearthed mostly in Egypt. It is concerned with ancient manuscripts and documents, in their multiple aspects relating to both content and material support: as texts, with the immense variety of topics that they present; as writing materials, taking into account their bibliological features; and as objects found in a specific archaeological context.

The discipline thus involves different types of data, namely, textual, bibliological and archaeological. Accordingly, it avails itself of diverse research methods (philological, historical, palaeographical and archaeological) in order to read, restore and identify its fragmentary texts, reconstruct their original context, and trace those that made up ancient archives or libraries but are now scattered among several collections worldwide. In addition, though papyrus is the predominant writing medium for this kind of text, other movable supports were also utilised, such as ostraca (potsherds), wooden tablets, parchment, and so on; this, along with the various conditions of preservation in which artefacts have been recovered, implies the use of different methods of conservation and, in the digital realm, of image capture and processing.

Because of the diversity of data types and methods traditionally involved, papyrology lends itself to taking advantage of diverse digital approaches.[1] It has always been one of the disciplines best-provided with digital tools, among those concerned with

[1] Cf. Reggiani 2017, 3-6.

the study of classical literature and ancient history.[2] Since the early years of digital progress in classics, it has benefited from both established database projects and the development of standards specifically for the digitisation of texts and images of papyri.[3] The papyrologists' work has thus greatly been advantaged by the adoption of digital approaches, as they have acknowledged:[4] the digital turn has assisted them in expanding their knowledge of published papyri and in making available the many that continue to be discovered or lie still unpublished in museum and library collections, while paying attention to ancient groups of texts and virtually gathering together related documents or books.

My dissertation aims to offer a comprehensive and up-to-date analysis of papyrological resources in the context of digital humanities approaches. It is the first systematic attempt to examine papyrological projects on the basis of notions introduced in digital humanities literature, which define the hallmarks of digital scholarly resources and provide recommendations for them to be increasingly useful for humanities research.[5] A reconsideration of papyrological projects from this viewpoint will allow us to shed new light on their characteristics, on the opportunities for the research process and to discuss the challenges that these characteristics reveal, exploring solutions for possible issues. Moreover, given the wealth of established, varied and standards-based projects in papyrology, I hope that this analysis will take a step towards comprehending the range, breadth and complexity of the whole digital humanities scenario.

In this chapter, I will begin with an excursus of papyrology (1.2) and of the papyrologist's work (1.3), so as to describe types of papyrological sources, their most fundamental problems, and the methods devised to address them. The subsequent section (1.4) provides a general overview of digital papyrology resources, taking into account how they were born and have evolved, and how they assist research in the discipline. Then I will review the literature on digital papyrology, showing how this dissertation feeds into it (1.5). The methodological framework that represents the reference point for

[2] The intensive adoption of digital methods in papyrology has been noted by papyrologists (Millozzi 2004, 73; Capasso 2005, 227; Andorlini 2008, 169; Bowman 2009, 41; Quenouille 2016, 6) and, along with analogous progress in epigraphy, in literature of digital classics (Magnani 2008, 128; Goldberg 2016, 519) and digital humanities (Terras 2006, 12-13). The phenomenon has especially been discussed by Reggiani in his monograph on digital papyrology, trying to understand what its reasons are (Reggiani 2017, 2-8) and what advantages the discipline has received under many respects (ibid., 257-59, as discussed in the overview of digital papyrology projects in section 1.4).

[3] Terras 2006, 12-13; Id. 2010a, 47-48.

[4] Cf. Andorlini 2008, 169-71; Bowman 2009, 41; Schubert 2009, 198-99; van Minnen 2009, 649, 651; Bowman 2010, 102-03; Delattre-Heilporn 2014, 312-13; Fournet, n.d., "Qu'est-ce que la BIPAb?" (focusing on images); Reggiani 2017, 257-59.

[5] See the literature review on digital papyrology in section 1.5, esp. pp. 44-45.

my analysis will be introduced in section 1.6, thereby illustrating the research questions, drawn from issues raised in the digital humanities discourse, which will be explored in relation to papyrological projects. Lastly, the chapter provides a dissertation outline (1.7).

1.2 Papyri and papyrology: ancient writing materials, types of texts, and archaeological context

Among the disciplines of classics, papyrology is concerned with the study of texts preserved by ancient direct tradition, i.e., recovered in books and documents unearthed in archaeological sites, rather than handed down to us through medieval manuscripts, taking into account their materiality, in the variety of forms in which they have been produced.[6] These texts may be distinguished in two types, according to their use: those that may be qualified as "enduring," intended for intergenerational dissemination, such as books and some types of legal documents, and, conversely, those relating to everyday writing, namely, a wide range of documentary texts of practical and ephemeral nature created under the urgency of daily circumstances.[7] For this characteristic and their great variety of contents, papyri are a unique source for the study of antiquity, in spite of some limitations. Because of their fragility, papyri have been recovered in very fragmentary conditions; also, they are predominantly found in a single area of the Graeco-Roman world, Egypt, and far from its administrative capital and cultural centre, Alexandria. Nevertheless, they offer a particular perspective that integrates our other sources, and illuminate the reception of Greek and Roman culture, institutions and law outside central administrations in the Hellenistic and Roman ages,[8] with ample evidence amounting to almost 70,000 published papyri.[9]

Papyrus, utilised in the form of rolls, codices, or single sheets, is the most common text-bearing support in our documentation: for this reason, and because it is a typical material of antiquity, fallen into disuse in the subsequent ages, the word "papyrus" has been chosen to designate the discipline, referring, collectively, to all portable writing

[6] For this traditional definition of the scope of papyrology, see Turner 1980, vi; Bagnall 2009b, xvii; Bowman 2009, 37; Ast 2014; Fournet 2018b, 3.
[7] This distinction in two types of papyrological sources is proposed in Fournet 2020, 2.
[8] Fournet 2018b, 13-15. There is however a period, late antiquity, for which Egyptian data are representative of the entire Greco-Roman world, as Egypt saw then a greater integration than ever in the Empire (ibid., 13-14).
[9] For the number of published papyri, as resulting from papyrological databases, see p. 17.

supports.[10] Naturally, other media than papyrus, which also fall within the purview of papyrology, were employed in classical antiquity for texts of private character, such as parchment codices, ostraca (potsherds), wooden tablets and lamellae (metal leaves):[11] a variety, to which may be added the different state of preservation of the artefacts, which entails the use of multiple methods of conservation, reading and imaging.[12]

The time span documented by Greek and Latin papyri comprises twelve centuries, from the fourth century BC to the end of the eighth century AD, covering several periods of the Egyptian history: Ptolemaic, from the Greek conquest by Alexander the Great (332 BC) to the start of the subjection to Rome (30 BC), Roman (first to third centuries AD), and late antique or Byzantine (fourth to mid-seventh centuries),[13] as well as the beginning of Arab rule (started in 642).[14]

Papyri dating to this time span are predominantly written in Greek, the language of administration and culture in Egypt, which, introduced by the Ptolemies,[15] continued to dominate even under Roman rule.[16] Albeit to a lesser extent, papyri from Graeco-Roman Egypt also provide evidence for other languages and scripts, due to the coexistence of the class of Greek-speaking officials in the military and civil administrations with a Latin-speaking body of Roman citizens, if limited, and the substrate of the Egyptian population. This situation, along with the abundance of documentation, makes Egypt an ideal environment for the study of multilingualism and multiliteracy, including cases of diglossia, as the use of different languages was often related to a different function.[17] Latin is mainly attested in a relatively small number of military and administrative texts and private letters produced in military sites; it was also a "super-high" language (above Greek and Egyptian) of the highest officials, and a language of law, as evidenced by

[10] Cf. Turner 1980, vi, 7.
[11] For an overview of materials and book forms attested for papyrological sources, see Turner 1980, 1-16 and Bülow-Jacobsen 2009. In comparison to Turner's contribution, Bülow-Jacobsen's takes advantage of the more recent Vindolanda finds (ibid., 14), but does not mention metal tablets. The *Trismegistos Languages* database, in particular its Greek and Latin subsets, offers a comprehensive list of the texts attested for each writing medium (<http://www.trismegistos.org/language/30>, <www.trismegistos.org/language/37>).
[12] The most suitable imaging techniques for each writing support, in their different states of preservation, are reviewed in Bülow-Jacobsen 2020.
[13] For the beginning of the late antique or Byzantine period in the early fourth century, when important changes gave Egypt a more central role in the Mediterranean politics, see Bowman 1996, 46.
[14] In 642 the last Byzantine forces left Egypt, three years after the outset of the Arab invasion (Bowman 1996, 52-53).
[15] For the diffusion of the Greek population in Egypt under the Ptolemies and the consequent change in the language of rule, previously represented by the Aramaic of the Persian bureaucracy, see Thompson 2009, 399-406.
[16] Turner 1980, 75.
[17] Fournet 2009, 419, 445.

legal literature.[18] The scripts used for the writing of the Egyptian language, that is, hieroglyphs, hieratic and demotic, declined and eventually disappeared over the course of the Roman period. They were replaced partly by Greek and partly by Coptic, the newly created script for the Egyptian language, which expanded dramatically in the fourth century. Coptic, developed in a Christian Greek-speaking environment, was chiefly employed for translations of the Bible, hagiographical works and documentary papyri from ecclesiastical milieus, and continued to rise at the expense of Greek until the Arabisation of the country, being attested until the tenth century.[19] Greek continued to remain in use even after the Arab conquest, for two more centuries, during the Umayyad and early Abbasid periods (the latest dated Greek papyrus from Egypt being of 825 AD), employed by Egyptian scribes working in the Arab administration, and in churches and monasteries.[20]

Within Egypt, most papyri have been found in ruins now covered by the desert, which has afforded favourable environmental conditions for the preservation of this writing material. In particular, such sites are situated south the region of the Nile Delta, in the once cultivable land near either bank of the river; by contrast, the Delta, with the capital Alexandria, as characterised by high humidity, has normally not preserved papyri.[21]

Many ancient urban sites in Egypt where papyrus finds have been made were *metropoleis*, that is capitals of nomes (districts), such as Oxyrhynchus and Hermopolis, among those that yielded the greatest quantities of texts. Papyri from Oxyrhynchus and Hermopolis are today dispersed over several institutions worldwide, a frequent situation for papyri that yet were discovered in the same ancient site; they have also been published in different series and journals, even when belonging to the same collection, which, again, typifies a common situation in the discipline. The vast majority of the Oxyrhynchus papyri, i.e., those unearthed, in thousands, by the Oxford papyrologists B. P. Grenfell and A. S. Hunt with the support of the Egypt Exploration Fund (now Egypt Exploration Society) in six excavation campaigns from 1896 to 1907,[22] have been published in the P.Oxy. series and are mostly deposited in the Sackler Library; some

[18] For the phenomena of bilingualism and diglossia involving Latin and Greek in Egypt, see Fournet 2009, 421-30 (with a focus on late antiquity).
[19] On the emergence of Coptic and on its uses, see Fournet 2009, 430-45. For the decline of this script, along with the Egyptian language, and the concurrent rise of Arabic, see Sijpesteijn 2009, 459-60.
[20] On the usage of Greek in Egypt after the Islamic conquest, see Fournet 2009, 441, and Berkes 2019, 244. On the latest dated Greek papyrus from Egypt (*SPP* III^2 577: *TM* 39405), see Berkes 2019.
[21] On the geographical context of papyrus finds in Egypt, see Turner 1980, 26-27, 43-47; Bowman 2009, 38; Cuvigny 2009, 44.
[22] Turner 1980, 27-33.

hundred more, now in Florence, were subsequently recovered by Italian archaeologists, and have mainly been published in the PSI volumes.[23] The Hermopolis papyri are scattered among more different kinds of publications: the bulk of them, discovered by Rubensohn in 1902-06 [24] and housed in Berlin's Ägyptisches Museum und Papyrussammlung, can be found in the Berlin BGU and BKT series, but many others appear in volumes related to different papyrological collections, e.g. the Vienna CPR and the Manchester P.Ryl, or in journal articles.[25]

As well as district capitals, villages (*komai*) have also received insight from papyrological evidence. Among the best-documented villages there are those of the modern region of the Fayyum, the former Arsinoite nome, such as Karanis, Tebtunis, Philadelphia and Soknopaiou Nesos.[26] Karanis can be considered as the best-known in all respects, thanks to the excavations conducted by the University of Michigan in 1924-35, first led by F. W. Kelsey. These marked definite methodological progress in excavations of Graeco-Roman sites in Egypt, as they did not aim exclusively at the recovery of papyri, but also at the study of the site in which the owners of the texts had lived, by providing precise documentation of the excavated areas and recording the exact location where each papyrus or object was found.[27]

Within cities or villages, the archaeological contexts in which papyri have been found are, most frequently, ruins of ancient buildings or rubbish deposits.[28] Also, it is not uncommon to recover texts from cartonnage, a material utilised to create protective and decorative elements for human mummies, such as masks and pectorals; cartonnage was sometimes obtained by reusing scrap paper, purposely cut, glued, covered with stucco and painted.[29] Since the use of cartonnage was common throughout the Ptolemaic age, this material has revealed valuable finds of particularly ancient papyri, otherwise rarely extant. On the other hand, texts from cartonnage posit further problems of restoration and reading: cartonnage needs carefully disassembling and, even so, two

[23] Van Minnen-Worp 1993, 151; Houston 2007.
[24] Cuvigny 2009, 34.
[25] Cf. van Minnen-Worp 1993, 152-53, with a focus on the Hermopolis literary texts; as for the documentary ones, they can be retrieved in *Papyri.info* by means of a metadata search, selecting "Hermopolis" in the "provenance" field.
[26] Turner 1980, 78-81.
[27] Cuvigny 2009, 38-39; Turner 1980, 36, 78.
[28] A typology of archaeological contexts of papyrus finds is provided by Cuvigny (2009, 44-54).
[29] For an overview of texts obtained from mummy cartonnage, see Turner 1980, 31-32, and Cuvigny 2009, 45-46. The principal places where they have been discovered are mentioned in P.Mil.Vogl. VIII 309, 4.

different layers with text may remain overlapped; the text is also covered by traces of glue, stucco and colour.[30]

As the place of finding is sometimes different from that of provenance, we sometimes do have papyri written in Alexandria and even in localities outside Egypt, thus offering evidence on places from where papyri are not normally extant.[31] Also, substantial finds of papyri outside Egypt were made in a region with a similarly arid climate, the Near East, or where exceptional circumstances occurred, i.e., a fire or a volcanic eruption that caused the carbonisation of the artefacts in antiquity.[32] Although carbonisation is the condition that allowed for their survival, such texts have been exposed to particularly serious damage, hence they present specific problems of opening, conservation and reading.[33] The most extensive find of carbonised papyri is the well-known one of Herculaneum, the city buried by the eruption of Vesuvius in 79 AD; it has yielded almost two thousand literary rolls (P.Herc.) from a library focused on philosophical treatises of Epicurus and his school, one of the very rare cases of an ancient library found *in situ*,[34] as well as, together with Pompeii, around three hundred documents on wooden wax tablets, belonging to several private or professional archives.[35] Other notable cases of papyri preserved via carbonisation are the P.Derveni roll (*MP*^{3} 2465.1, *TM* 65795) from the namesake locality near Thessaloniki, and the Petra archive (P.Petra).

Other discoveries of non-Egyptian texts concern different materials from papyrus. The most substantial finds are those of wooden tablets, which have survived in anaerobic and humid environments.[36] This was a common writing medium throughout the Graeco-

[30] Cuvigny 2009, 46; Bagnall 1997, 154. The problems of reconstruction of papyri from cartonnage are documented, for instance, by Bastianini and Gallazzi (P.Mil.Vogl. VIII 309, 5) in their edition of the anthology of epigrams by Posidippus of Pella, one of the most recent finds from this material, as well as one of the most significant discoveries of the latest decades, as for new literary texts (P.Mil.Vogl. VIII 309: *TM* 62665).
[31] Turner 1980, 49-51.
[32] On the physical conditions for the preservation of papyri, see Turner 1980, 18, 43. Papyri recovered outside Egypt are surveyed by Turner (1980, 37-40) and Bowman (2009, 39-40); on the Near East in particular, with its substantial finds of Dura, Nessana, the Middle Euphrates and the Dead Sea caves, see also Gascou 2009, 475-81.
[33] For an overview of carbonised papyri, see Macfarlane-Del Mastro 2019, 7-9, Frösén 2009, 91-98 (which focuses on the conservation processes adopted), and Angeli 1994.
[34] Fournet 2018a, 186.
[35] Tablets from Pompeii (*CIL* IV, Suppl. I; T.Sulpicii) and Herculaneum (*TH*^{2}) provide important insight into the form of juridical documents in the Roman praxis, and into several social and economic aspects of the Julio-Claudian age (Camodeca 2011).
[36] Types of wooden tablets are surveyed by Turner (1980, 6-7, 39) and Bülow-Jacobsen (2009, 11-14, which includes the more recent Vindolanda finds). A comprehensive list of them can be retrieved in the Greek and Latin subsets of the *TM Languages* metadata database (<http://www.trismegistos.org/language/30>, <http://www.trismegistos.org/language/37>), selecting the

Roman world, employed for everyday writing such as letters, accounts and notes; also, as tablets could be joined to form a polyptych, closed and sealed, they were used for legal documents, as shown by the Campanian finds (as mentioned above); moreover, a particular use attested in Egypt was that of small tags utilised as mummy labels, bearing information for the identification of the deceased.[37] Wooden tablets present different problems of reading according to the chosen method of writing. Some were written in ink, just as papyrus texts. This is the case, for instance, of many documents from the remarkable find in the fort of Vindolanda, on the northern frontier of Roman Britain, consisting of some 800 published texts (T.Vindol.) dating to the late first and early second centuries AD. A unique set of problems, particularly challenging, is posited by many tablets that were written by incising a wax coating laid on the wooden surface.[38] The text-bearing layer of wax perished in the majority of tablets found outside Egypt: the humid environmental conditions that allowed for the preservation of the wooden support however caused the wax to dissolve, so that only the scratchings accidentally left by the scribe with the stilus in the underlying wood remain now visible. This problem particularly affects the Vindolanda wax tablets, which have all remained unpublished so far.[39] Albeit posing difficult challenges, sometimes impossible to tackle with traditional methods, this characteristic has led to the experimentation of new digital techniques for reading severely damaged documents, and to the close collaboration with experts outside the humanities domain, namely medical imaging and artificial intelligence, as has only rarely occurred.[40]

Another widespread writing medium throughout antiquity is represented by thin tablets of metal (usually lead), or lamellae. These were devoted to more specific kinds of texts: typically, inscribed amulets with protective charms,[41] also for the protection of the dead (as the so-called Orphic gold leaves),[42] or curses on enemies (*tabellae defixionis*) which would be hidden in underground places.[43] Being inscribed, they present similar problems and require similar methods of reading and imaging to the stilus

material "wood." With regard to Latin tablets more specifically, an overview is in T.Vindol. I, 33-35 (also in *VTO*, "Writing on wood"), to which the London T.Bloomberg may now be added; another one, though less complete, is in the T.Bloomberg edition itself (58).

[37] An extensive corpus of mummy labels in Greek and Egyptian languages is the *Death on the Nile* database.

[38] For an overview of wax tablets and the challenges that they present, see Bowman-Tomlin 2005 and T.Bloomberg, 15-19 (also in *RIB online* 2020), 58, with case studies from the Vindolanda and the Bloomberg texts respectively.

[39] Cf. the introductions of the T.Vindol. editions, e.g. T.Vindol. III, 6.

[40] Bowman 2010, 103-04; Terras 2012b, 78.

[41] Kotansky 1991, 114-16.

[42] Kotansky 1991, 114-15.

[43] Collins 2009, 546-48; Turner 1980, 6.

tablets that have lost their wax coating: they are characterised by a lack of contrast between the text and its background, in this case because of oxidation, to which are added fissures and corrosion of the surface.[44]

The large number of texts preserved by papyri concerns a great variety of aspects of the life of the Graeco-Roman world. In addition to texts with traditional genres of classical literature, we find some that reflect everyday life more closely, thus proving intermediate with documentary papyri: anthologies, drafts of poems, commentaries, school exercises, magical texts, horoscopes, medical prescriptions, etc.; called "paraliterary" or "subliterary" papyri, they have a unique value as a body of evidence almost entirely known from papyri only.[45] A reverse but complementary tendency is shown by documents that present literary traits,[46] or that illuminate the milieu in which literary works were copied and read.[47] Other interconnections between literary and documentary papyri concern writing and book practices: the same scribes produced documents and copies of literary texts, as witnessed by similar features found in documentary and literary hands;[48] also, it was commonplace for individuals to store books and documents in the same place, close to one another, and to reuse a documentary roll by writing a literary text on the blank *verso*, or vice versa.[49] These interrelations imply that the distinction between library and archive was also more blurred in antiquity than it is today.[50]

Though much less numerous than documentary papyri, literary and paraliterary papyri published to date amount to well over nine thousand, out of a total of almost 70,000 published papyri.[51] A search on the CEDOPAL's *Mertens-Pack*^{3} (*MP*^{3}) catalogue of literary papyri returns ca. 7,300 records, predominantly relating to classical literary works and ancient scholarship. To these, Herculaneum literary papyri, not included in *MP*^{3}, are added, which number ca. 1,800 exemplars, as appears on the respective database, *Chartes*. If we also consider Jewish and Christian papyri[52] (the greater part of

[44] Bowman et al. 1997, 173; *Curse Tablets*, n.d.
[45] The interrelations between literary and documentary papyri, a topic already touched on by Turner (1980, vi-vii), have been discussed by Fournet (2018a, 192-95; 2018b, 33-41) and Marganne (2016).
[46] Fournet 2017, 195; Marganne 2016, 772-74.
[47] Turner 1980, vii.
[48] Turner 1980, vi-vii; Cavallo 2009, 101.
[49] Fournet 2017, 192-94; Marganne 2016, 774-75.
[50] Fournet 2018a, esp. 171-74, 192-95.
[51] On the possible reasons of the disproportion between the number of literary and documentary papyri, as well as that, even greater, between ancient libraries and archives identified, see Fournet 2018a, 183-86.
[52] Jewish and Christian papyri comprise the Greek translation of the Septuagint and other Greek versions of the Old Testament, the New Testament, apocryphal literature, patristic works, liturgical texts, and amulets (Martinez 2009).

which does not fall within the scope of *MP*[3]), the number rises to 11,800, as shown by the *Leuven Database of Ancient Books* (limiting the search to items written in Greek or Latin).[53] Even when reduced to very small fragments, literary papyri may shed new light on some aspect of Greek (and, on occasion, Latin) culture, as they are chronologically closer to the original works than our other source, medieval codices, is. Among the fields to which they have contributed, one may mention: Greek literature, in all its genres and from all the periods of its production, through fragments of new works and textual variants of works already known by medieval tradition; ancient exegesis, as witnessed in marginal annotations, commentaries and treatises; the reception of Greek authors in the Egyptian readership; and practices of schooling.[54]

The number of published documentary papyri reaches almost 60,000, as appears from the *Duke Databank of Documentary Papyri* of the *Papyri.info* platform.[55] This vast quantity of texts encompasses a huge variety of content: sale contracts, loans of money, official correspondence and private letters, birth and death certificates, edicts, and much more.[56] They testify on every aspect of everyday life of people of all social classes and under the influence of the different civilisations that succeeded each other, thus bearing witness on how decisions concerning politics and administration, taken in Alexandria under the Ptolemaic rule and then in Rome, were concretely applied outside the capital cities. The evidence of papyri, on occasion, has consequences even on our understanding of historical events of the wider history of the Graeco-Roman world.[57] It is genuine and immediate evidence, pertaining to facts contemporary to them, which allows us to complement the information offered by historiographical and epigraphical sources.[58] From the linguistic standpoint, documentary papyri give insights into the Greek and Latin languages used in daily activities and in the administration,[59] and into their

[53] The only types of texts not included in *LDAB* are those, considered too distant from the literary domain by the project editor (W. Clarysse of KU Leuven), of documents with literary quotations, horoscopes, oracle questions, and magical papyri composed for a specific circumstance, as opposed to magical handbooks (*LDAB* 2018).
[54] For the contribution of literary and paraliterary papyri to our knowledge of classical literature, including its use and study, see Renner 2009, esp. 282-90, and Turner 1980, 97-126. While Renner focuses almost exclusively on literary works, Turner also contains an in-depth discussion of the many papyrological testimonies of ancient learning.
[55] See the *Papyrological Navigator* of *Papyri.info*, selecting the "All DDbDP records" value in the "Collection" field, which returns 59,300 items.
[56] Types of documentary papyri are reviewed in detail by Palme (2009). They are traditionally distinguished between private and public (Turner 1980, 129-30; Palme 2009, 361; Fournet 2020, 2), that is, exchanged between private individuals (e.g., private contracts, letters and memoranda), or sent from or received by officials (edicts, tax receipts, petitions, etc.).
[57] A survey of the evidence given by documentary papyri on both Egypt and the Mediterranean world in general, under Greek, Roman and Byzantine rule, is offered in Bowman 2009, 41-46.
[58] Turner 1980, 127; Fournet 2020b, 15; Falivene 2009, 521-22.
[59] Vierros 2018, 105; Fournet 2018b, 16, 28.

interaction with other languages spoken in Egypt, thus making Egypt a privileged setting for studying the phenomena of multilingualism, multiliteracy and diglossia.[60]

Papyri are testimonies of ancient life and culture not only through the content of the texts that they carry but also in themselves, as artefacts, through their writing, book form, layout and material. Therefore, besides ancient literature and history, both literary and documentary papyri cast light on the history of Greek and Latin palaeography, which previously chiefly concerned the Middle Ages, and on the history of the ancient book, witnessing the shift from the roll to the codex form, and the diffusion of different materials and practices such as writing on ostraca and reusing a roll on its blank *verso*.[61]

1.3 The challenges of the papyrologist's work

Notwithstanding the enormous variety of contents found in papyri, in editing and making them accessible to other scholars the papyrologist uses a method of work that is essentially the same for all the typologies of texts, since they present relationships among them and share similar problems (as we have seen).

From a preliminary examination of the papyrus, the papyrologist gathers information on its physical characteristics, script and dating, a work that, in this phase, is similar to that of the palaeographer. However, whereas, for the latter, the features of the writing and of the book as an object are the main focus, the papyrologist starts from the appearance of the text to come to its reconstruction and interpretation. He thus provides a transcription, making use of a set of conventional signs known as the "Leiden system,"[62] which represent gaps, uncertain letters, and editorial interventions both by the ancient scribe and the modern editor, by means of simple typographical marks (for instance, different kinds of brackets). He supplies lacunae as far as possible and seeks to illustrate all the various aspects of the content. The activities of transcription and interpretation, in practice, are not successive to one another, but they rather proceed in tandem: most of the times, the reading of the extant traces is only possible in the light of our knowledge of the language and of the historical and cultural background in which

[60] Fournet 2009, 419, 430, 445.
[61] Turner 1980, 98-99, and Fournet 2018b, 23, 29.
[62] The Leiden system, or convention, for editing papyrus texts, as well as inscriptions, was established at the 18th International Congress of Orientalists, which took place in Leiden in 1931 (Turner 1980, 70, 179 n. 22).

the papyrus was written, that is, in a continuous "collaboration" between the eye and the mind in the transcription process, to tackle a series of challenges.[63]

The first challenge that the papyrologist encounters arises from the state of preservation of papyri, which are fragmentary, lacunose, and often present warped or dislocated areas and abraded writing. To some extent, this problem affects medieval manuscripts and inscriptions as well, but is particularly evident in papyri, as they have been found in excavations, rather than having always been preserved in libraries, and are a fragile material; moreover, a papyrus may turn out to be scattered in fragments housed in different collections worldwide, because of events related to its finding (different archaeological missions in the same spot, as mentioned about the papyri from Oxyrhynchus, or illicit excavations) or to its possible sale on the antiquities market. As a consequence, papyrologists need to face the task of supplying lacunae more frequently than the other scholars. Since supplements need to fit the width of the lacuna and any extant ink traces, it is necessary for papyrologists, as well as for philologists and historians who are interested in a papyrus text and want to verify a reading or a conjecture, to resort to the original or avail themselves of reproductions, so as to be always aware of the material condition of the fragment.[64]

Besides the diffusion of lacunose passages, there are also difficulties inherent in the papyri, as for their writing and their content. While transcribing, the papyrologist needs to be able to recognise different types of scripts, dating to different ages, which may be particularly hard to read, such as the often rapid cursive used in documents. These difficulties are increased by the ancient practice of *scriptio continua*, i.e., writing without word separation, a typical feature of Greek papyri (also found in many Greek inscriptions), which does not concern medieval manuscripts.[65] In terms of content, the papyrologist seeks to interpret abbreviations, symbols and signs, as well as formulaic phrases used in documents, for example to indicate dates or official titles of emperors and state functionaries. Furthermore, already before completing the transcription, the key questions emerge of the identification of the content and of connections with other texts: if it is a literary papyrus, whether it is a new work or one already known, or else one known only in part; if documentary, to what category it belongs to, and how it relates to it.

[63] On the method of editing a papyrus, see Turner 1980, 54-73, and Schubert 2009, which includes references to the digital instruments that assist in this work.
[64] Bowman 2009, 40.
[65] Turner 1980, 57.

Therefore, the transcription, with the supplementation of lacunae as far as possible, does not exhaust the papyrologist's work. After describing the condition of preservation of a papyrus and classifying its script, the papyrologist tries to identify its content and situate it in relation to analogous texts. In this way, the different aspects (historical, juridical, literary, linguistic, and so on) of the content of the papyrus can be clarified, to the best of papyrologist's knowledge, in an analytical commentary, so that the edition may truly serve the purpose of specialists of other disciplines, who will follow up elements of the text according to their viewpoint.[66]

In such work of identification, contextualisation and clarification of a text, a difficulty is due to the sheer mass of papyri, especially in the documentary domain, which makes the search for parallels laborious. As for literary papyrology, when editing a work not known from other sources, not only may its identification and attribution to an author be problematic, but also, more in general, the ascription to a literary genre. Sometimes, it can even be dubious whether the papyrus is literary or documentary, due to its particularly fragmentary condition[67] or to its unique content, which may present both literary and documentary traits.[68]

Papyrology has always equipped itself with instruments for supporting these tasks. From the first decades of the last century it has seen the publication of tools and corpora, including lexica (Preisigke's *Wörterbuch der griechische Papyruskunden*), onomastic and prosopographical works (Preisigke's *Namenbuch*, and Peremans and van't Dack's *Prosopographica Ptolemaica*), gazetteers (Calderini's *Dizionario dei nomi geografici*), palaeographical albums (e.g., Seider's *Paläographie der griechischen Papyri*) and the *Sammelbuch der griechische Urkunden*, which gathers documents published in journals and proceedings rather than in series.[69] Nevertheless, it is commonplace for editions of documentary papyri to receive corrections, for example in the light of newly published texts. For this reason, an instrument, existing since the early 1900s, the *Berichtigungsliste der Griechischen Papyrusurkunden aus Ägypten*, has the purpose to record all the corrections proposed for such texts. These and other specialised print tools, with their updates, as much as comprehensive and thorough, could not however keep

[66] On the task of preparing an introduction and a commentary in a papyrus edition, thereby illuminating a fragment in all respects, see Schubert 2009, 197, 208-09.
[67] Marganne 2016, 769-72, 775.
[68] Marganne 2016, 767-69, 772-74; Fournet 2018a, 192, 195; Turner 1980, 128.
[69] For a comprehensive list of instruments for papyrological research, see the *Checklist of Editions*, esp. the sections "Instrumenta" and "Corpora."

pace with the accumulation of new editions, a problem that is at the origin of the development of digital text databases and catalogues.[70]

As said, every papyrus, whether literary or documentary, besides being transcribed and identified, needs to be related to the place and time in which it was produced, and to the person that copied it, as far as possible. This is particularly true for documentary papyri: whereas the literary ones may have value even singularly, documentary papyri allow us to reconstruct practices of historical or juridical significance and linguistic features of general relevance only if considered together with many other related texts,[71] for instance those of the same content type, belonging to the same ancient archive, or concerning the same person. It is especially in the latest decades that papyrologists have acknowledged the importance of examining books and documents not only in themselves, but also with a view to reconstructing the context of their drafters or readers, and the way they were organised in archives and libraries.[72]

On one hand, this task presents many obstacles, which make it hard, sometimes impossible, to trace the provenance of a papyrus from a specific archive, library, or even place. One is represented by the nature itself of the papyri, which may lack internal data on their production, as is especially the case with the literary ones: scribes did not report information on their name, on the date and the place of the copy (unlike many medieval and Coptic manuscripts), information that may however be found in documents.[73] To this we need to add, in many occurrences, the lack of evidence about the circumstances of the find, due to poor documentation of early excavations and to discoveries made illegally; the latter also entailed the separation of literary papyri from the documentary ones possibly found in the same findspot, which could have helped their contextualisation. Not infrequently, the acquisition of papyri was also problematic: those unearthed in illegal diggings were sold, sometimes after breaking them into further pieces, on the antiquities market with little tracking.[74]

On the other hand, despite all these challenges it has been possible to trace the provenance down to a specific place, and sometimes even to an archive or (more rarely) a library, of many documentary papyri and ostraca, and of a few literary papyri, by combining the evidence offered by several types of data: textual, especially for

[70] Schubert 2009, 198, 212; Willis 1984, 167; Oates 1993, 63; Bagnall 2009c, 193-94, in reference to prosopography.
[71] Turner 1980, 129.
[72] Fournet 2018a, 172, 194; Hickey 2009, 499.
[73] Fournet 2018a, 184-85; Turner 1980, 51.
[74] On the problems related to the early papyrus finds, see Fournet 2018a, 184, and Turner 1980, 26, 51.

documentary papyri; palaeographical and codicological; archaeological, when available; and data from museum archaeology. Whereas the textual, palaeographical and archaeological research methods have long been used for the contextualisation of papyri, as already illustrated by Turner,[75] museum archaeology, i.e., the reconstruction of the events that caused the dispersion of papyri, has been developed more recently. This method has helped to reassemble entirely scattered bodies of texts, notably the "Bodmer Library" (a third-fifth century library discovered clandestinely in the 1950s, containing both classical and Christian books and now residing in the Bodmer, Chester Beatty and Montserrat collections)[76] and a number of family archives from the town of Pathyris in Upper Egypt. It has also enabled us to extend already known archives, such as the Ptolemaic one, also found in Pathyris, of the Greek cavalry officer Dryton and his descendants, whose reconstruction had started on the basis of textual, especially prosopographical, data.[77]

1.4 An overview of digital papyrological resources

Papyrological methods and instruments have taken huge advantage of the digital medium and web technologies for the study of papyri in all their aspects (content, script and layout, belonging to ancient collections), with the production of a range of resources, including large-scale textual and metadata databases, digital images often in the framework of a wider project, typically a collection catalogue, and thematic collections.

The main digital papyrological resources, which will be referred to throughout this work, are introduced in this section, briefly accounting for their origin and showing the purposes that they serve as a complement to the more traditional methods and printed reference works.

1.4.1 The beginnings of digital papyrology with text-based projects

[75] Turner 1980, 74-96; Fournet 2018, 173, 186-89, which also takes into account the Coptic documentation, useful for the reconstruction of mixed archives and libraries of late antiquity. Nevertheless, Davoli (2020, 11-17, 26-27) argues for a more accurate interpretation of the archaeological context of papyri and ostraca, with a better documentation of the stratigraphy of the findspot, which requires a closer collaboration of papyrologists with archaeologists.
[76] Fournet 2018a, 187; Fournet 2009, 443.
[77] Vandorpe 2009, 228-29. The Dryton archive (P.Dryton, <www.trismegistos.org/archive/74>) contains Greek and demotic documentary texts, which offer us a glimpse of the mixed Greek and Egyptian environment of the military.

The earliest digital papyrology resource to be released was the *Duke Databank of Documentary Papyri* text database, which, after a work that lasted more than a decade, could claim near-completeness within the chosen domain. It was founded in 1983 by John Oates and William Willis of Duke University, at the suggestion of and in close collaboration with David W. Packard of the Hewlett-Packard company,[78] and first issued in 1986.[79] Now it continues to be one of the most prominent digital projects for this discipline, with a corpus of almost 60,000 texts. It also benefits from the integration into the *Papyri.info* online platform, where it is interconnected with other tools for the study of papyrology and is complemented by another text database, the *Digital Corpus of Literary Papyri*, which aims to integrate the *Duke Databank* on the literary side of the discipline.

The creation of the *Duke Databank* followed the impetus to digital progress in classics given by an initiative that marked a turning point in the field, the *Thesaurus Linguae Graecae* (*TLG*) digital library of Greek literature. Founded by Theodor Brunner of the University of California, Irvine, in 1972[80] and first distributed in 1976,[81] it is the earliest electronic resource for classical studies and one of the earliest in digital humanities altogether.[82] It is still the longest-standing digital classics project, and one of the most extensive. While not being a specific resource for papyrology, with its abundant material the *TLG* has enabled fruitful research on literary papyri (cf. below, pp. 25-26). Moreover, it does include some papyri of this kind: those not known from other sources, i.e., not handed down from medieval codices,[83] especially if their publication has been included in collections of classical texts (as can be seen by browsing the *TLG*'s content). Besides its usefulness in itself, the *TLG*, along with the technology employed for its creation and use, also developed by Packard and his collaborators, inspired the production of analogous databases for categories of texts not included in its scope, starting from the *Duke Databank* and the *Packard Humanities Institute CD-ROM* 1 of

[78] In 1983 the *Duke Databank* officially started (Willis 1984b, 169; Oates 1993, 62-63, 70-71) and was presented by Willis to the community of papyrologists at their International Congress (Willis 1984b). Its launch was preceded by a preliminary phase of planning and testing, begun the previous year (in July, according to Oates 1993, 70-71; in October, according to Willis 1984b, 169, and APA 1982).
[79] Willis 1988, 17.
[80] Brunner 1991, 63-64; *TLG* 2020, "First Planning Conference."
[81] For this date, see *TLG* 2020, "The Early Days."
[82] On classicists as early adopters of the new approaches, see Brunner 1987, 1; Hockey 2004, 9; Crane 2004, 46-48; Bodard-Mahony 2008, 1-2, 7; Unsworth 2012, 7-9; Barker-Terras 2016, 3-4; Nyhan-Flinn 2016, 2.
[83] Berkowitz 1993, 45-46.

Latin literature and Greek epigraphy (1987), and favoured the diffusion of technology in classicists' research practices.[84]

As anticipated, a decisive factor for the development of the *Duke Databank*, the *TLG* and the first digital classics projects in general was the availability of continued technical and financial support, made possible by the close collaboration with the key figure of David W. Packard, an expert in computing and a then member of the Hewlett-Packard company, who also has an interest and a background in classics. He and his team offered highly-specialised technical support to the development of the *TLG* a few years after its launch. They collaborated with other classics departments in the creation of new projects and in their subsequent updating, thus helping them face the technical challenges of classical computing for as many as two decades.[85] Packard specifically designed hardware and software for the development and use of the *TLG*, namely, for entering, editing, storing and searching polytonic ancient Greek texts, which computers were not hitherto able to handle:[86] the Ibycus System mainframe, with a Greek alphabet word processor and search and editing programmes, followed by the Ibycus Scholarly Personal Computer, which was capable of reading the then new CD-ROM support and became widely adopted in classics departments; and the Beta Code encoding and formatting convention for ancient Greek.[87] Beta Code was also employed in the *Perseus Digital Library*, at first,[88] in the *Duke Databank*, after a modification to represent papyrological editorial signs, and in text collections released by the Packard Humanities Institute (*PHI CD-ROMs*), where it was able to deal with Coptic and Hebrew characters as well.[89]

Besides the inspiration provided by the *TLG* and the cooperation with Packard, further collaborations, with the University of Oxford and with the University of

[84] On the impact of the *TLG* on research activities and technological development in classics, see Gagos 1996, 13-14; Pantelia 2000, 3; Magnani 2008, 136-37; Barker-Terras 2016, 3; Reggiani 2017, 210-11, 217-18; *Mertens-Pack*[3], n.d., "1971-1998" (focused on work at the CEDOPAL papyrological research centre in Liège).

[85] The importance for the *TLG* of technological innovation brought by Packard and his collaborators, and of financial support of his family's foundation (the David and Lucile Packard Foundation) has been underlined by Brunner (1994, 605) and Berkowitz (1993, 49-50). Their importance for classical studies has been remarked by Pantelia 2000, 2; *TLG* 2020, "David W. Packard," "The Early Days;" Crane 2004, 48-49; Reggiani 2017, 210-13, 217.

[86] Ancient Greek makes use of more kinds of accent than modern Greek, which is monotonic, and of unique reading signs, with which computers could not deal.

[87] Although simple to use in itself (it is employed still today to key in the *TLG* texts: *TLG* 2020, "David W. Packard"), Beta Code has portability limitations across different operative systems. The arrival of the Unicode character set, a widely adopted ISO standard, which can contain virtually any alphabet, has allowed cross-platform compatibility and the possibility to use different alphabets in the same document without changing font (Magnani 2008, 129-32; Gippert 2015, 12; Reggiani 2017, 12 n. 52, 203-04, 213; Tauber 2019, 140).

[88] Crane 2004, 51; Magnani 2008, 130.

[89] Willis 1984b, 168.

Michigan, brought other significant contributions to the implementation of the *Duke Databank*. A digitisation project of texts of documentary Oxyrhynchus papyri, which had been launched in Oxford in 1978[90] and was making much progress, gave input to the start of the *Databank*: a visit of Oates and Willis to Oxford, followed by the development of some experimental digital texts, convinced them about the feasibility of their enterprise and led them to apply to the Packard Foundation for the necessary funding.[91] Later, the Oxyrhynchus project, at an advanced stage, generously made available its substantial collection to the *Duke Databank*, given the overlap of their scopes.[92] The other collaboration, with the University of Michigan, concerned the essential work of proofreading the texts typed in at Duke, a process carried out with the participation of graduate students.[93] The process began soon after the establishment of the *Duke Databank*, as announced by Willis together with the project's launch,[94] and lasted for all the duration of the project at Duke,[95] until its content was merged into the *Perseus Digital Library.*

As Oates and Willis explained, the idea to create an electronic database of documentary papyri stemmed from the need for a flexible tool to promptly incorporate the new texts and corrections that are continuously published, since printed updates of lexica were no longer able to keep pace, and to easily store and manage such an extensive mass of data.[96] Another noteworthy feature of text databases for papyrological research is obviously their ability to look up even strings of letters and combinations of letters or words. This facilitates the retrieval of parallel texts for lacunose passages,[97] which is key to the fundamental tasks of restoring gaps, identifying the content of the fragments, and relating them to extant documents or literary works.

It has to be mentioned, however, that these text databases need to be used in the awareness of some shortcomings, as it is well-known. *TLG* texts contain no *apparatus criticus*, owing to copyright issues and technical difficulties of implementation;[98] only

[90] Keefe 1981.
[91] Willis 1984b, 169; Oates 1993, 70-71.
[92] Willis 1988, 15; Id. 1992, 129; Oates 1993, 63; Gagos 2001, 526, n. 37.
[93] The process was described in detail by one of the proof-readers, A. Loftus, in Gagos 1996, 15.
[94] Willis 1984b, 173.
[95] Willis 1988, 16; Id. 1992, 128, 129-30; Id. 1994, 628; Oates 1993, 63-64.
[96] Willis 1984b, 167-68; Oates 1993, 63.
[97] Cf. Willis 1984b, 167-8; Id. 1988, 16; Oates 1993, 63, 66-69, on the *Duke Databank*. On the use of the *TLG* in papyrology, see Willis 1984a; Brunner 1984; Id. 1986, 293-95; Id. 1988, 12; Id. 1994, 605-06; Magnani 2008, 136. Willis and Oates's contributions are reviewed in section 1.5.1.
[98] Pantelia 2000, 10, n. 9; Id. 2013, 1; Berkowitz 1993, 46. In addition, there was uncertainty on the selection criteria for the content of a possible apparatus (Brunner 1994, 605; cf. Reggiani 2017, 212, n. 46).

one edition is usually present for each work,[99] even though the availability of multiple editions might in part compensate the lack of apparatus; and the select edition may not be the most recent or the best, because of copyright restrictions, again, and problems in the text preparation for digitisation.[100] The absence of apparatus data makes the *TLG* incomplete as a scholarly instrument: it prevents readers who consult these texts alone from having a sense of the richness and the complexity of the textual tradition;[101] also, it affects the results of word searches, as variants and conjectures not included in the text of the select editions, of course, do not figure.[102] Moreover, texts in the *TLG*, the *Duke Databank* and the *DCLP* are only provided with basic information, without commentary (with the exception of a set of papyri of medical content in the *DCLP*, merged from the *Digital Corpus of Greek Medical Papyri*, which are accompanied by an introduction and notes summarised from the printed editions).[103]

The aim of these databases is therefore to provide texts in a fully and instantly searchable format to be consulted alongside critical editions, without replacing them, as Oates, Willis and Brunner themselves made clear.[104] Thus, even with their limitations, they have undoubtedly provided a significant contribution to research in papyrology and Greek literature, by enabling classicists to carry out extremely rapid and often successful investigations. They have allowed for word searches in a vast corpus much more quickly than with printed indices and concordances to single works or authors, and with more complete results in comparison to word attestations recorded in printed lexica. Some tasks, such as locating sequences of letters, even medial ones, and phrases, are even impossible, or at least extremely laborious, with traditional instruments.[105]

1.4.2 New developments with digital images and online catalogues

Not only did papyrologists, as well as classicists, make their sources soon available in digital format but, with the release of the web for general use in 1993,[106] they were

[99] Pantelia 2000, 4; Magnani 2008, 132; Reggiani 2017, 212.
[100] Hughes 1987, 2; Berkowitz 1993, 52; Pantelia 2000, 4; Magnani 2008, 132.
[101] Reggiani 2017, 212; Farrington 2017, "Conclusion." Cf. also Agnesini 2008, 112, 114, with reference to databases of Latin texts.
[102] See Willis 1984a, 165 and Magnani 2008, 135-37, about the *TLG*, and Agnesini 2008, 112, 114, on the same problem in databases for Latin literature.
[103] Reggiani 2017, 253, 275-76; 2018b, 3-4.
[104] Oates 1993, 63, 64; Willis 1988, 16; Id. 1992, 127; Brunner 1987, 8. The same view has been expressed by *TLG*'s current director, Maria Pantelia (2013, 1).
[105] Hughes 1987; Willis 1984a, 166.
[106] Although the advent of the World Wide Web is better understood as a time span rather than as a precise moment (Brügger 2018, 5), there are key dates that marked its development, notably its first demonstration in 1991 and its release by CERN for general use in 1993 (Elton-Carey 2013, 29). Also, from 1995 the

also ready to apply this technology as a vehicle for dissemination of their digitised content, thereby providing databases with instant access and advanced hyperlinking capability. An early version of the *Heidelberger Gesamtverzeichnis* (*HGV*) metadata database of documentary papyri was launched on the web in the very year 1993.[107] Shortly afterwards, in 1995, the *Perseus Digital Library* of collections of humanities texts, first released on CD-ROM, was transferred to the web;[108] it was followed by the *Duke Databank* the subsequent year, hosted by *Perseus* itself,[109] so as to take advantage of the opportunity to move online.[110]

Besides text databases such as the *Duke Databank* and the *TLG*, another large-scale instrument that soon took enormous advantage of web technologies, in terms of data storage, retrieval and sharing, is catalogues, complete with images, of physical papyrus collections. The evolution of the Internet was decisive in their creation, since only in a web-based environment can large sets of different data types, such as pictures and descriptive data, be effectively linked.[111]

Two of the most extensive collections, the University of Michigan's and Duke University's, initiated their digitisation process at the beginning of the 1990s, not long after memory institutions had begun experimenting with the creation of digital surrogates of their holdings, from the beginning of the previous decade.[112] The Michigan collection was the first to start being digitised, in 1991, on the initiative of its archivist, the papyrologist Traianos Gagos,[113] while the one at Duke was the earliest to become entirely available online, in 1995, with the *Duke Papyrus Archive* project, implemented by the papyrologist Peter van Minnen in cooperation with Duke's librarians.[114]

Then papyrus collections began developing a model of digitisation that was collaborative across institutions and that aimed at uniting their datasets into one cohesive framework.[115] In 1996, on the basis of Michigan's pathbreaking digitisation effort, the *APIS* federation was founded by Gagos, Roger Bagnall (then at Columbia University)

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number of sites and users started growing significantly, as CERN gave up charging royalties for the web, thus opening it to commercial use (Elton-Carey 2013, 38; Nesi 2009, 472).

[107] *HGV* 2008.

[108] *Perseus*, n.d., "Version history".

[109] See the announcement of 9 December 1996 reported in *Perseus* 2005.

[110] Sosin 2010; cf. Reggiani 2017, 222.

[111] Van Minnen 1995c.

[112] See Terras 2008, 104-10 on the beginning of digitisation in the humanities sector, before the advent of the web (1980s and early 1990s).

[113] Gagos 1996, 15-20, 22; Id. 1997; Koenen 2018, 137. The Michigan collection's catalogue is now available as *APIS UM*, with 18,000 records (as reported in its home page) relating to papyri in their different languages.

[114] Van Minnen 1995a; Id. 1995b; Id. 1995c.

[115] Pantelia 2013, 2; Reggiani 2017, 98.

and Oates,[116] an innovative enterprise that paved the way for comparable digitisation projects of collections worldwide.[117] *APIS*'s cooperative approach to digitisation consisted not only of the aggregation of datasets derived from several institutions, but also in the collective implementation and adoption of a set of standards for imaging papyri and cataloguing information on them.[118]

Gagos and Bagnall's objective was to build a joint online catalogue of papyri from a federation of institutions, beginning with the largest collections in the United States. Catalogue records should include translations, besides metadata and images, so as to support not only research but also teaching and engagement with wider audiences, in particular secondary education students, some of whom might be prospective papyrologists. Furthermore, having understood the possibilities offered by the newly launched World Wide Web, *APIS*'s founders envisaged the implementation of a comprehensive online environment for the study of papyri with different kinds of information integrated, also via external links, including texts from the *Duke Databank* and digitised reference works, for example the *Bibliographie Papyrologique*, the most comprehensive bibliographical tool in the discipline.[119]

By the end of the *APIS* project, in 2013,[120] almost 40,000 records with thousands of images and translations had been created, including several thousand unpublished papyri, thus covering a large part of the holdings of the collections involved. *APIS* data are now available on *Papyri.info* and on the catalogues of the collections formerly involved, among which the Michigan one maintains the *APIS* name (*APIS UM*). Although it is no longer ongoing as a separate resource, *APIS* unquestionably offered a valuable contribution to papyrology. Its wealth of material provided a basis for more in-depth investigation of published papyri and enabled work on unpublished ones, sometimes bringing to light collections hitherto neglected (e.g., St. Petersburg and Oslo),[121] and the realisation of the envisaged new model of papyrological database would later be continued by *Papyri.info*.[122] It stimulated further digitisation efforts, whether institutions decided to join *APIS* or to work independently, possibly following

[116] On the origin of *APIS* see Bagnall 1998a, 543, 545-46; Bagnall-Gagos 2007, 66-70; Reggiani 2017, 94-95; Bagnall-Heath 2018, 177, n. 49. On the role of the University of Michigan, see Koenen 2018, 137-38 and Gagos 2001, 526.
[117] Reggiani 2017, 98-102.
[118] Bagnall-Gagos 2007, 68.
[119] Bagnall 1998a, 546.
[120] Reggiani 2017, 95; *Papyri.info*, "APIS."
[121] Bagnall-Gagos 2007, 65-67; Reggiani 2017, 95.
[122] Reggiani 2017, 94-95.

APIS's standards as the *Oxyrhynchus Online Image Database* did,[123] or else to create analogous cross-collection resources, namely, the Italian *PSIonline*, the German *Papyrus Projekt* and the Spanish *DVCTVS*.

Digital imaging and cataloguing have brought major advantages to the papyrologist's work, as Bagnall, Gagos and van Minnen have well illustrated. Not only can digital pictures, naturally, be shared more readily than printed photographs,[124] but they also facilitate studying and comparing damaged letters in their context by enlarging a wide portion of text, rather than a few letters at a time as occurs with the microscope. In addition, one can adjust the contrast for enhancing legibility even of a single part of text that needs a particular manipulation. Finally, fragments originally belonging to the same papyrus but now dispersed across different collections can be easily virtually joined together on the screen.[125]

Digital images are even more useful if they are accompanied by detailed information on the papyri as part of a collection catalogue. In this resource, metadata records serve not only as a source of information on the single items, but also as a basis to create an extensive subject index of papyri, in both the literary and the documentary domain, and in other languages than Greek, thereby offering more integrated information than other available metadata catalogues.[126] Additionally, if a collection catalogue is built with a standardised approach, as were the *DPA* and *APIS*, following a universally accepted format for their data structure and a vocabulary for a uniform description of their items, this opens the possibility to build a joint catalogue with other collections, thus making their subject index even more comprehensive.[127]

1.4.3 The current landscape of digital papyrology

After the start, in the 1980s and 1990s, of the *Duke Databank* and of the digitisation projects later flowed into *APIS*, the growth of papyrological material online continued into the new century, with more text databases and digitised real-world collections, but also with new types of resources.

In the realm of text databases, research on digital methods for representing papyrus texts that may be compliant with current web standards led to the customisation of the

[123] CSAD 1997b; Bagnall 1997, 551.
[124] Bagnall 1997, 153; Id. 1998, 552.
[125] Gagos 1996, 14, 17, 19-20.
[126] Van Minnen 1995b.
[127] Van Minnen 1995b; Bagnall 1998a, 546.

EpiDoc specifications, first released in 2006 by a team directed by Tom Elliott (University of North Carolina).[128] Originally devised for Greek and Latin epigraphy, the EpiDoc specifications have been extended to allow encoding papyri, first documentary and subsequently literary, as well as texts in other ancient languages.[129] In its turn, EpiDoc is an adaptation of the TEI Guidelines, the *de facto* standard XML-based markup for the encoding of scholarly editions,[130] a characteristic that ensures standardisation of data and integration with other XML-based resources. Besides facilitating interconnection among resources, EpiDoc allows us to markup the information relating to a text by transposing the transcription signs, based on the Leiden convention, into XML. Furthermore, one can add more detailed information on the features of the text already at the level of the transcription and of the metadata section: for example, the transcription can be enriched with semantic information that defines more precisely the features of a gap, of an uncertain letter, or of an abbreviation, and that marks onomastic elements in their different types.

The use of EpiDoc for resource integration is well exemplified by *Papyri.info*, a comprehensive platform launched in 2010[131] at the completion of a three-year project, *Integrating Digital Papyrology* (*IDP*), undertaken by Duke University with the involvement of several institutions.[132] Based on the idea originally conceived by Bagnall and Gagos for *APIS*, *Papyri.info* provides simultaneous access to a range of data, juxtaposed in a single record: texts, mainly from the *Duke Databank*; metadata from the *Heidelberger Gesamtverzeichnis* (*HGV*),[133] *APIS* and, via external links, *Trismegistos* (a

[128] Bodard 2010, 164-65.
[129] For projects, both papyrological and epigraphical, that adopted the EpiDoc Guidelines, see the "EpiDoc" category page of the *Digital Classicist Wiki* (2019).
[130] Encoding is the application of markup, that is, information (e.g., structural, semantic or linguistic) in the form of code, to texts or metadata, thus making their features machine-readable (Nyhan 2012, 117, 121). Advantages are the ability to search data with sophisticated criteria, which can also be combined, and easier integration with other datasets and tools even from external projects, as long as they are built with the same standard (ibid., 126-27). The XML (Extensible Markup Language) encoding format is a set of elements and rules that has become the standard for the representation of content in web resources. Among the reasons of its popularity there are its long-term sustainability, as it is not tied to any software, which might become obsolete, and its interoperability, because, again, it is software-independent, and because its format, encoded text, is one of the simplest available, thereby being easily portable across different systems (Gartner 2016, 56-59; Liuzzo 2017, 188-89). Furthermore, XML enables us to encode not only the structure of a text, but also features of its content, which is key to the preparation of indices and to detailed word searches. These characteristics have been recognised as very suitable to support the sophisticated use of academic projects, hence the Text Encoding Initiative (TEI)'s effort of designing XML-compliant guidelines for the digitisation of texts for scholarly research.
[131] 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.
[132] On the *IDP* project, 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.
[133] On the *HGV*, see Reggiani 2017, 39-46.

set of metadata databases of papyrological and epigraphical sources); pictures from *APIS* and external institutional collections; and bibliography from the *Bibliographie Papyrologique*. *Papyri.info* avails itself of EpiDoc to establish a common ground for the documents derived from the different data sources, thus ensuring compatibility among them. In this way, it provides an environment (termed *Papyrological Navigator*) with integrated access to information and the ability of cross-searches through one interface, as well as a tool (the *Papyrological Editor*) to support user contribution for the addition of new items or corrections.[134]

While most of its texts are represented by documentary papyri, *Papyri.info* has recently expanded to literary material, with the contribution of the *Digital Corpus of Literary Papyri* (*DCLP*). The *DCLP* is also encoded in EpiDoc, which, though created for marking up documentary texts, can be expanded to include new tags, such as signs and editorial features found in literary papyri.[135] This corpus was developed at the Institute for the Study of the Ancient World of New York University and at the University of Heidelberg, under the direction of Roger Bagnall and Rodney Ast. Launched in 2013 and released in 2018,[136] it contains to date ca. 1700 texts, as well as records, which total 15,000, with information drawn from the *LDAB* metadata database of literary papyri (now part of the *Trismegistos* platform).[137] Besides the collaboration with *Trismegistos* for the provision of metadata, the *DCLP* has benefited from two further projects, which contributed two substantial groups of texts: numerous Herculaneum papyri from the *Thesaurus Herculanensium Voluminum* (a joint initiative of the Centro Internazionale per lo Studio dei Papiri Ercolanesi of Naples and the University of Würzburg),[138] and a set of medical fragments from the *Digital Corpus of*

[134] A comprehensive description of *Papyri.info* in its two components, the *Papyrological Navigator* and the *Papyrological Editor*, is in Reggiani 2017, 222-40. On the *Papyrological Editor*, see also Baumann 2013 for technical information on its development, and Sosin 2010 for a demonstration of its functioning.
[135] Reggiani 2017, 251-54; Ast-Essler 2018, 63.
[136] Reggiani 2017, 251; Ast 2018, which contains the announcement of the release of the resource; Ast-Essler 2018, 63-64. The *DCLP* was first made available on a dedicated website (<http://litpap.info>) and later merged into *Papyri.info*.
[137] *DCLP* texts on *Papyri.info* can be retrieved by selecting "All DCLP records" in the "Collection" field, and "True" in "Has Transcription." Alternatively, one can browse the papyrological series or the literary authors available in the *DCLP*, by choosing "DCLP" or "Authors" in the top bar menu of the *Papyrological Navigator*.
[138] Ast-Essler 2018, 68-71. Records of Herculaneum papyri in the *DCLP* (which number 271) are retrievable by selecting the "Campania" entry in the "Nome" field in the *Papyrological Navigator*; records complete with texts (166) can be found by choosing the "True" value in the "Has Transcription" field. The majority of these texts (158) were encoded within the *THV* project, as one can see from the list, with links to *DCLP* records, in the *THV*'s home page.

Greek Medical Papyri project of the University of Parma.[139] In comparison to the *TLG*, the *DCLP* evidently aims at more complete coverage of literary papyri, including the Latin ones; it also intends to describe the physical appearance of the fragments and to point out scribal interventions.[140]

Another group of texts that has been digitised according to EpiDoc standards is the Vindolanda tablets (T.Vindol.), discovered in excavations at the homonymous fort on Roman Britain's northern frontier and dating to the late first and early second centuries AD (cf. above, p. 15). The printed editions of these texts were digitally reproduced in two websites, now no longer available, both developed by the Centre for the Study of Ancient Documents (CSAD) of the University of Oxford: *Vindolanda Tablets Online* (*VTO*), built between 2001 and 2003 and containing the T.Vindol. I and II editions, and *VTO* 2 (2011), relating to T.Vindol. I-III. At present the texts of the former *VTO* websites are available via a broader collection, CSAD's *Roman Inscriptions of Britain (RIB) online*, also EpiDoc-encoded, which sets out to make digitally available every published Roman text from Britain on any support (inscriptions, tablets and lamellae).[141] The EpiDoc specifications, in a slightly modified version,[142] were applied as early as in the first *VTO* site, when they were still under preparation, since they were regarded as the best method to face the challenges of the development of this pioneer web edition of papyrological sources: marking up and displaying texts with specific editorial conventions, building a resource compatible with other corpora of ancient documents, and relying on a wide-spread and up-to-date standard such as one compliant with XML.[143]

The digital editions of the Vindolanda tablets, also in their current version on *RIB Online*, provide comprehensive information on their texts, reproducing the complete critical material present in the printed volumes. At the same time, they enhance access to the original editions with the possibility to search information in finer detail and with improved indexing and cross-referencing thanks to the specific content markup for this kind of sources provided by EpiDoc, and with a full photographic record with high-

[139] Reggiani 2017, 253, 275-76; Id. 2018b, 3-4; Ast-Essler 2018, 64, 67. Medical texts digitised in Parma number 285 (Reggiani 2017, 275); they are listed in the document available at <https://goo.gl/ZBbHkp> (cf. ibid.).
[140] Ast-Essler 2018, 64-65.
[141] Vanderbilt-Mullen 2019; Bagnall-Heath 2018, 178. Besides the Vindolanda tablets, *RIB Online* comprises other documents of papyrological interest: the Bloomberg wooden tablets (T.Bloomberg), found in London and relating to everyday life in first-century *Londinium*, and, as planned (Vanderbilt-Mullen 2019), curse leaden tablets. As for the latter, it seems likely that their texts will be drawn on those already available in electronic format in another CSAD project, *Curse Tablets from Roman Britain.*
[142] *VTO*, "Tablet XML;" Reggiani 2017, 242.
[143] Pierce-Ratcliff 2002, 1.

resolution images.[144] The Vindolanda digital editions have therefore fully exploited the capabilities of EpiDoc: not only with a view to compatibility with other resources but also to applying a detailed semantic markup to the texts, thereby indexing and categorising relevant information and making them searchable in many ways.

As far as imaging and cataloguing are concerned, following the example of *APIS* we have witnessed the growth of digitisation projects of papyrus collections, accompanied by a positive trend towards integration, with the production of other extensive federations of collections (cf. above, pp. 28-29).[145] Particularly challenging artefacts have benefited from advanced imaging techniques.[146] Infrared photography[147] has been deployed for enhancing the contrast between ink and writing support in papyri, ostraca and tablets with faded script, for instance examples from cartonnage[148] and the Vindolanda ink tablets,[149] or with a very darkened background, typically carbonised papyri, for example those from Herculaneum.[150] Furthermore, 3D recording, in particular reflectance transformation imaging (RTI), a technique for the examination of fine surface detail of inscribed objects, has recently started being adopted for some papyrological sources,[151] after witnessing successful applications in cuneiform studies and epigraphy.[152] Magical texts on metal tablets for the *Magica Levantina* corpus are being imaged with this technique;[153] it is currently being experimented on the Vindolanda stilus tablets,[154] and it was tested on a Herculaneum papyrus to clarify the complex geometry of the surface of fragments with different layers of text stratified.[155]

[144] Cf. Terras 2010a, 47.
[145] Reggiani 2017, 98-102.
[146] 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.
[147] For a description of 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).
[148] For example, infrared imaging has been applied to the Posidippus papyrus (P.Mil.Vogl. VIII 309, vii-viii) and to the Vienna epigrams papyrus (P.Vindob. G 40611; see CPR XXXIII, i).
[149] T.Vindol. III, 6, 14; Bowman 2010, 102.
[150] Macfarlane-Del Mastro 2018, 11-12.
[151] 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.
[152] Bevan et al. 2013, 221. Examples of projects that have made available online RTI images of inscribed texts are *Digital Marmor Parium*, *3D Scanning the Rosetta Stone* and *Cuneiform Digital Library Initiative.*
[153] *Magica Levantina* 2017; Piquette 2017, 84.
[154] Cf. T.Vindol. IV.1, 187, n. 1; T.Vindol. IV.2, 113, n. 1; CSAD, n.d. The RTI procedure used on the Vindolanda tablets (more exactly, one implementation of the RTI approach, the Polynomial Texture Mapping) is illustrated in Earl et al. 2010, 7.
[155] Piquette 2017.

Papyrology has also harnessed digital approaches for more effective management of metadata catalogues,[156] e.g., for bibliographical records (with the *Bibliographie Papyrologique*), information relating to literary texts (*Mertens-Pack*[3] and the *Leuven Database of Ancient Books*), prosopographical (*Trismegistos People*) and geographical (*Trismegistos Places*). Thematic collections have emerged,[157] 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.[158] Purposes of papyrological thematic collections include grouping together texts found in or relating to the same city (*Oxyrhynchus: A City and its Texts*, *Alexandrian Documents from the Reign of Augustus*), reassembling ancient archives or libraries now dismembered (*Trismegistos Archives*, *Dioscore d'Aphrodité en images* and *Guide to the Heroninos Archive*) and aggregating texts with specific content (e.g., *Curse Tablets from Roman Britain* and the *Death on the Nile* database of mummy labels).

1.5 Digital papyrological resources as an object of study

1.5.1 The literature on the earlier projects: reflections on the evolution of instruments and methodologies

The creation of digital papyrological resources has been accompanied since the beginning by the publication of literature (as anticipated in the previous section). In the contributions on the earlier major projects, that is, the *Duke Databank of Documentary Papyri*, the digitisation of the Michigan collection, the *Duke Papyrus Archive* and *APIS*, the papyrologists involved provided information about the project launch and subsequent progress in terms of both content updates and technical improvements. At the same time, their project descriptions constituted a valuable ground for more general considerations, relevant to papyrologists, classicists and digital humanities scholars, about the relationship between print and digital scholarship, between traditional and new methods, and about the setting of standards. The authors also illustrated the history of the

[156] Reggiani 2017, 79, 257-58.
[157] Reggiani 2017, 79, 115-17; Andorlini 2008, 171; Bowman 2009, 41; van Minnen 2009, 655.
[158] For this definition of "thematic collection" see Palmer 2004, 348-49.

resources, showing how these arose from their scholarly needs and in collaboration with related initiatives.

The first major resource, the *Duke Databank*, has been well illustrated by its two founders, Oates and Willis, in contributions published in the 1980s and early 1990s, from its launch to a few years before its merging into *Perseus*.

Willis's communications, presented at International Congresses of Papyrology, informed colleagues about the start of the project (Willis 1984b) and its developments (Id. 1988, 1992, 1994), mentioning the continued assistance of Packard and his team, while illustrating the advantages of a databank over print resources for several tasks of the papyrologist's work (Id. 1984b, 167-68; Id. 1988, 15-16; cf. above, pp. 25-26). A complementary discussion on the usefulness of the *TLG* for work on literary papyrus fragments was also presented by Willis, at the same 1983 Congress that saw the announcement of the *Duke Databank* (Willis 1984a: cf. above, p. 26), which was even prior to Brunner's first publication on this resource (Brunner 1984).

Differently from Willis's contributions on the *Duke Databank*, Oates's (1993) is a retrospective consideration on it, published ten years after the project's launch, when it was a diffuse resource. He offered a detailed history of the project, revealing how challenging its plan and its initial phase were, first to devise a sustainable plan from the technical and financial point of view, and later to customise the Beta Code encoding standard for ancient Greek to represent the papyrological editorial signs of the Leiden convention (ibid., 64-65). He offered a further reflection on the benefits of a text database for papyrology, with suggestions on future work to improve the resource (as will be mentioned below). As an appendix, he reported on the history of another papyrological tool created at Duke University on his initiative, the *Checklist of Greek and Latin Papyri* (later made available in electronic format and now integrated in *Papyri.info*),[159] showing how it originated from his need, shared by a number of colleagues, of assembling bibliographic information on editions and instruments and of promptly identifying new publications, for the purposes of research, teaching, and updating his department library.[160]

[159] The *Checklist* is a catalogue of bibliographical information on papyrological editions, journals, proceedings, corpora and instruments, complete with a standard list of abbreviations for them. First published in 1974, it was later issued in electronic form, included in the *PHI CD-ROM* 7 with the second edition of the *DDbDP* (1997). Its fifth and last paper version (2001), which comprised Coptic and demotic papyri, was eventually released and updated online, first hosted on the Duke University Libraries' website, then also integrated with other tools in *Papyri.info* (Reggiani 2017, 23-29).
[160] Oates 1993, 71.

Oates showed what use can be made of a text database for the study of Graeco-Roman antiquity, adding examples of successful word searches drawn from his experience,[161] while taking into account the drawback, for users, of the absence of lemmatisation, which entailed rather time-consuming searches of inflected forms.[162] Subsequently, this problem has been addressed with the implementation of lemmatised searching in *Papyri.info*.[163] However, this function does not perform well with searches of words whose forms vary remarkably, as often occurs in Greek, especially with verbs.[164] Nevertheless, today it is possible to search for lemmata of words attested in documentary papyri with other tools, notably the *Wörterlisten* collection of word indices (pp. 208-10).

For its usefulness, Oates contended, like Willis, that the *Databank* would render superfluous printed indices, both those of single volumes of papyrological editions and the comprehensive ones published as supplements of lexica, while not replacing the original papyrus editions, evidently because of the lack of commentary to the texts. Moreover, he believed that text databases would also substitute lexica (an opinion later expressed by van Minnen as well).[165] In this respect he seems to differ from Willis, who apparently intended the *Databank* only as a tool for indexing and concordancing.[166] Indeed, although, naturally, the *Databank* is more up-to-date than printed lexica and their supplements and offers enhanced possibilities of searching, one still needs to resort to lexica for word definitions, as Bagnall subsequently emphasised (cf. below, p. 38).

Oates concluded with some proposals for future developments of the resource, suggesting the addition of more metadata about the papyri and the entry of corrections to the texts, starting from those published in the *Berichtigungsliste*.[167] The former objective has been achieved with the merging of the *Databank* into the *Papyri.info* platform and the resulting integration of metadata from *APIS* and *Trismegistos*. The content updating has been facilitated, in terms of both adding new texts and correcting the present ones, by the implementation of the *Papyrological Editor*, with the possibility for users to contribute, as the literature will discuss later on (cf. below, pp. 39-41).

From the editorial point of view, Oates's contribution appears in a volume dedicated to digital projects for classics (Solomon 1993). The book contains chapters on other

[161] Oates 1993, 63, 66-69.
[162] Oates 1993, 66.
[163] Lemmatised searching is enabled by the "LEX" button on the *Papyrological Navigator* search form, as explained in the instructions available in the right-hand column of the form itself.
[164] Cf. *WL*, "Über die Papyri-WörterListen."
[165] Oates 1993, 68; van Minnen 2009, 653.
[166] Willis 1984, 167; Id. 1988, 15-16.
[167] Oates 1993, 68-69.

major textual resources, such as the *TLG* (Brunner 1993, Berkowitz 1993) and the *Perseus* digital library, as well as archaeological and bibliographical databases, which signifies the recognition of the *Databank* as a valuable resource in the landscape of digital classics.

The papyrologists in charge of the pre-*APIS* Michigan digitisation project, the *Duke Papyrus Archive* (*DPA*) and the *APIS* network of catalogues, namely, Gagos, van Minnen and Bagnall, also presented their resources in detail and looked at the different nature of printed and electronic tools, considering how they fit into the papyrologist's tasks, as Oates and Willis did. Based on their projects, they added to the literature on digital papyrology a reflection on the significance of a collection catalogue provided with comprehensive metadata and images; they show how it is an important complement to a database with texts and basic metadata such as the *Duke Databank*, not only for research but also for teaching (cf. p. 28). The key principles that later informed the development of the major *APIS* catalogue were expressed since the beginning, in Gagos's papers on the Michigan pilot project and in van Minnen's on the *DPA*.[168] Even then, there was the awareness that, in spite of the importance of imagery and the focus on a single collection, pictures should be made available within the framework of a catalogue with information on the content of the papyri, their state of preservation, bibliography, and copyright status. Subsequently, the *APIS* literature introduced the perspective of a comprehensive standards-based platform, with texts, images, translations and reference works, which may provide a starting point for an in-depth study of papyri and assist in teaching.[169] It was a completely new concept of papyrological database, whereby different data types and separate tools should be fully integrated and juxtaposed in an overall view, a ground-breaking effort now continued by *Papyri.info*.[170]

With regard to the relationship between printed and electronic tools, Bagnall offers a reflection on this topic in a 1992 contribution, later published as a premise to a report on the development of *APIS*.[171] He reflects, like Oates and Willis, on the advantages of the conversion of papyrological research instruments to the digital format, however taking into account the possible need for the continuing publication in print of some of them.

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[168] Gagos 1996, 17-19; Id. 1997; van Minnen 1995c.
[169] Gagos 1996, 20-21; Bagnall 1998a, 545-46; Gagos 2001, 516; Bagnall-Gagos 2007, 67. Cf. above, 1.4.2, pp. 18-19.
[170] Reggiani 2017, 222-23.
[171] Bagnall-Gagos 2007, 59-65, esp. 62-63. Bagnall's paper was not published in the proceedings of the 1992 International Congress of Papyrology in which it was delivered; but it was included in a 2007 report on *APIS*, so as to contextualise the latter within a general assessment of the instruments of the discipline.

Bagnall judges the electronic format particularly suitable for tools that are only used for consultation, rather than for reading, such as the *Berichtigungsliste* (*BL*); he also includes in this category onomastica and lexica, even though he is aware that some colleagues may prefer them on paper support. He then moves on to tools that involve both consultation and reading, noting that some may find them convenient in paper form as well, for the latter purpose: the *Sammelbuch* (*SB*), which contains the texts, besides the references, of the collected papyri; and the *Bibliographie Papyrologique*, used both for bibliographical searches and for reading updates with the latest publications. Given the higher cost of printed volumes, Bagnall considers that users may print out the single texts of interest of the *SB* from the electronic version. Furthermore, differently from Oates and van Minnen (cf. above, p. 36), Bagnall underlines that text databases have not substituted lexica, whether paper or digital, which are still necessary for the definitions and the analyses that they contain.

Finally, Bagnall correctly remarks that the digital format would be opportune for loading into other digital resources, better if directly rather than having to be typed twice (or transferred); in this way, corrections in the *BL* and texts in the *SB* might be entered more rapidly and systematically into *Papyri.info*.[172] Indeed, this is a desideratum still today, especially the addition of corrections. Whereas many volumes of the *SB* have been included in the *Duke Databank*,[173] even though they are still published in paper format, the entry of updates from the *BL* and other sources, started in the mid-1990s,[174] has been slower, so that the majority of them has not been added yet.[175]

Some users might have a different opinion from Bagnall's on the specific matter of the usability of formats, thus finding the digital one practical for reading as well, and the printed one also suitable for consultation. In fact, as well as the intended use of a text, for consultation or for reading, another factor that influences its format is length: while most users still prefer to read a book in print, they are willing to read a short text like an article on screen or print it out,[176] as Bagnall in part acknowledges regarding *SB* texts. But overall Bagnall's paper offers an interesting reflection on the importance of the

[172] The *BL* was first digitised in 2009, on CD-ROM support which contained volumes 1-11 (now however incompatible with current computer systems: cf. Reggiani 2017, 134). Its latest volume (13) was published again in a digital format, as a pdf file, in 2017.
[173] The digitisation of the texts gathered in the *SB* has occurred since the beginnings of the *Duke Databank* (Willis 1988, 19; Id. 1992, 130-31). To date there are circa 8,000 *SB* texts in *Papyri.info*, as can be seen by selecting "DDBDP: sb" in the "Series" field of the *Papyrological Navigator*; *SB* texts can also be found, divided by volume, by browsing among *Databank* ("DDbDP")'s collections.
[174] Van Minnen 2009, 651.
[175] Reggiani 2017, 134.
[176] Warwick 2012, 7.

nature and the purpose of papyrological instruments, together with user habits, in relation to their format and their connection with other resources.

The literature on the Michigan and the *APIS* initiatives has been published in proceedings of International Congresses of Papyrology (Gagos 2001, Bagnall-Gagos 2007), in digital classics volumes (Bagnall 1998a) like that on the *Duke Databank*, and in journals of information studies (Gagos 1996) and digital humanities (Bagnall 1997, Gagos 1997). Certainly, the authors believed that the experience of *APIS* could become a model of what information technologies can achieve in the "collaborative creation of field-wide standards" and in the "integration of different types of information resources," "for a wide variety of humanistic studies."[177]

1.5.2 The more recent literature: looking to a comprehensive corpus and to a standard method of editing

The issues involved in the development of an integrated system for papyrological research, first discussed by Bagnall and Gagos, have continued to be investigated in the literature on *Papyri.info*.

The researchers in charge of its construction have tackled questions of standards for encoding papyrus texts, sustainability and collaborative scholarly editing, showing the steps taken to face these challenges in the creation of the platform.

They argue that the construction of wide infrastructures of integrated resources, ideally shared with germane disciplines (epigraphy, in the case of papyrology), fosters long-term preservation and helps break barriers within research areas,[178] pointing to the methods and the standards employed for merging extensive and diverse datasets in *Papyri.info*: the EpiDoc and Unicode encoding standards[179] and the RDF (Resource Description Framework) model for interconnection of related content.[180] They emphasise the value of open data and open-source code, which enable reuse by any project, for facilitating connections among existing resources and the creation of new ones.[181]

The sustainability of *Papyri.info* was problematic in certain periods and this has aroused much comment, in particular for the delay in updating the *Duke Databank* after

[177] Gagos 2003.
[178] Bagnall 2010.
[179] Bodard et al. (2011) offer a detailed explanation of the conversion from the hybrid Beta Code and SGML legacy format, in which the texts of the *Duke Databank* were encoded in *Perseus*, to the EpiDoc and Unicode standards. A description of the process is also in Reggiani 2017, 222-23.
[180] Cayless 2011.
[181] Bagnall 2010, 2-4, 7-10; Baumann 2013, 92-93.

its migration to *Perseus*.[182] Already anticipated by Bagnall (cf. above, p. 38), this question was then tackled by Van Minnen, Bagnall and Sosin by resorting to the notion of community-sourcing.[183] Van Minnen, in his paper on the perspectives about the future of the discipline, invited the papyrologists working on institutional collections to take the responsibility to correct, on the *Duke Databank*, the texts of the papyri of their own collection.[184] More in general, Bagnall and Sosin, with the creation of the *Papyrological Editor*, asked for input from the entire papyrological community. This idea was inspired by the path-breaking *Suda On Line* enterprise, Ross Scaife's innovative project of translation of the Byzantine lexicon *Suda*, started in 1998, the first digital classics resource to be opened to user input.[185] In the wake of this initiative, Bagnall and Sosin believe that the co-creation of content is a way to support not only resource updating but also collaboration among papyrologists.[186] Part of the literature on *Papyri.info* (Sosin 2010; Baumann 2013, 100-04) thus focuses on the method used for the development of an editing environment, the *Papyrological Editor*, which may facilitate the addition of user contributions, through a light syntax for EpiDoc encoding, and on the measures taken to ensure quality of user content, through the submission to an editorial board for a vetting process.[187] Subsequently, Bagnall and Heath (2018, 177, 185) pointed out that, despite the simplification of the complex task of editing a papyrus text in XML, the number of texts contributed by users was not sufficient to keep the resource abreast of new publications. But today the *Duke Databank* proves up-to-date, as can be seen by browsing the list of papyrological series and journals included.[188] It has been noted, though, that the possibility to enter born-digital editions has been little exploited by users,

[182] Sosin 2010; Reggiani 2017, 222.
[183] Community-sourcing is a type of crowdsourcing, the process of outsourcing tasks, once exclusively performed within an organisation, to the general public, through an open call (Ridge 2014b, 1-2; Terras 2016, 420; Dunn-Hedges 2018, 1). Crowdsourcing has been allowed and encouraged by the diffusion of Web 2.0 since the late 2000s, with the development of online platforms that foster a dialogue between providers and users, and therefore the collaborative production of resources. Typically, crowdsourcing is harnessed to aid in the digitisation of vast amounts of data, as occurs in *Papyri.info*; sometimes, it represents a way to obtain content not easily accessible, such as digitised material of private collections, or to gather new ideas. Furthermore, it is a form of engagement of research and memory institutions with the wider public. When contributors constitute a more closed group, the process is better identified as "community-sourcing," whether the call is restricted to a specific pool of potential participants since the beginning (Dunn-Hedges 2018, 17), or it is the crowd who self-selects in projects that require specific skills (Ridge 2014b, 4; Byrd Phillips 2014, 257), as exemplified by *Papyri.info*.
[184] Van Minnen 2009, 651.
[185] Reggiani 2017, 232. For an overview of the editorial mechanism of the *Suda On Line*, which is open to user contributions but includes a peer-review process, also public, see Mahoney 2009, 9-18.
[186] Bagnall 2010, 5-6; Sosin 2010.
[187] Bagnall 2010, 5, 9-10.
[188] See *Papyri.info*, "ddbdp," <https://papyri.info/browse/ddbdp>.

as discussed by Berkes (2018) on the basis of his experience of publication on the platform.

A further contribution to the improvement of the content of *Papyri.info* was offered by van Minnen. He observes that the *Duke Databank* fails to include some texts that seem pertinent to its scope, documentary papyrology, whether by mistake or because they are halfway between documentary and literary papyri (e.g., magical texts produced for actual circumstances, rather than magical handbooks).[189] Van Minnen thus urged for the digitisation of these texts, which indeed are now being entered on the *Digital Corpus of Literary Papyri* in *Papyri.info.*

While the literature on *APIS* and *Papyri.info* discusses the model of an infrastructure for a digital library of papyrus editions, a complementary study on a new way of conceiving the editions themselves is carried out by Nicola Reggiani in a series of contributions.[190] He concentrates on literary and paraliterary papyri, building upon his work for the *Digital Corpus of the Greek Medical Papyri*.

Reggiani argues that literary and paraliterary texts on papyrus are characterised by an open tradition, whereby a high number of variant readings was passed "horizontally," i.e., introduced from different models, as opposed to a closed tradition from model to copy, which may be represented by a stemma of manuscripts descending from an archetype. As a consequence, in a digital critical edition of a literary papyrus, all the possible textual variants from other papyri and the codices, as well as all linguistic variations from classical Greek, should be considered of equal importance, rather than as deviations from the original or from the standard language to be corrected or regularised. Therefore, resuming the concept of "multitext" (which has found its main application in the *Homer Multitext* edition of the Homeric poems), Reggiani proposes the model of a digital space where multiple versions of a text are stored, as attested in papyri and possibly in codices; texts should be provided, rather than with a critical apparatus, with a network of references to the variant readings. Initially, in his 2017 and 2018 papers, Reggiani seems to propose the concept of multitextuality for all literary and paraliterary papyri;[191] subsequently, he apparently narrows it to one typology of paraliterary papyri, namely technical literature, and, within this, to medical works,

[189] Van Minnen 2009, 652.
[190] Reggiani 2017, 255-70; Id. 2018b, 3-13. Cf. also Id. 2019a, 237-38, 250-52; Id. 2019b, 186-88.
[191] Reggiani 2017, 265-67; Id. 2018b, 4-8.

especially prescriptions,[192] a particular genre whose texts were prone to continuous change, according to physicians' experience and patients' needs.[193]

On one hand, comprehensively collecting variants and other data relating to the witnesses of a work in its different stages, as increasingly allowed by database technology, albeit sometimes not relevant for the reconstruction of the text, is valuable for a broader study of the textual tradition in its cultural context.[194] Instances of linguistic variation from classical Greek, attested in both literary and documentary papyri, need to be recorded in digital editions, as Reggiani underlines, along with their normalised spelling or syntax, so as to provide a basis for the study of linguistic phenomena of the everyday Greek language;[195] conversely, spelling variations in documentary papyri are not reported systematically in the *Duke Databank* on *Papyri.info*.[196] Furthermore, just as prescriptions, some genres have a very open tradition, or circulation: we may also mention exegetical works (e.g., commentaries, glossaries and lexica), which were shortened or expanded according to the needs of the scholars and the teachers who owned them, and other texts that, like prescriptions, had a practical and ephemeral nature, thereby being adapted to the circumstances of the people who requested them, such as magical texts and horoscopes.[197] These types of texts may thus find a suitable representation through a multitextual ecdotic practice. By contrast, preparing a digital (as well as printed) edition of a classical literary text, whether preserved on papyrus or transmitted by medieval manuscripts, entails different problems. Literary works tended to be copied faithfully,[198] at least from a certain point of the tradition, when they were fixed in a canonical version, as occurred for Greek literature in the Alexandrian and then in the Byzantine age, although some technical or popular works show a complex tradition, for being subject to revision and alteration.[199] A multitextual approach, consisting of reproducing single manuscripts with minimal or no adjustments, is therefore not appropriate for the study of classical works, which rather can be

[192] Reggiani 2019a, 252; 2019b, 187.
[193] Reggiani 2019b, 167-68.
[194] Magnani 2018, 100.
[195] Reggiani 2018b, 3-4; Id. 2019a, 237-39.
[196] Reggiani 2019a, 238-39. Spelling variations were however always registered when the *Databank* started being developed, as Willis informed (Willis 1984b, 169-70).
[197] West 1973, 16.
[198] Turner 1980, 95-96, 113.
[199] West 1973, 16-17.

reconstructed to some extent, moving closer to the original or its medieval *paradosis*, through the method of textual criticism.[200]

To the concept of multitextuality, Reggiani adds that of "meta-papyrus," which had been envisaged by Gagos, to complete his idea of digital critical edition of papyri. He argues that an edition, to be truly innovative, rather than a mere representation of a printed one, should present a multidimensional and interconnected network of interpretive layers (i.e., with text analysis from several points of view, for example philological, linguistic, semantic and historical), images and links to outer resources.[201] He provides details on the workflow to realise this idea of digital document, offering an example of an ontology design to link the different layers,[202] describing the encoding strategy for the markup of a text in all its components, by means of the EpiDoc system,[203] considering the complex matter of the representation of linguistic variation from the conventional Greek spelling.[204] Finally, he underlines that a digital edition of a papyrus should support the encoding of all extant data, rather than of the text only, including layout features, critical marks and marginal annotations, for which he proposes a metatext layer connected to the relevant lines of the main text.[205]

Reggiani is well aware of the importance of representing a papyrus in all its features, both textual and material, and makes constant use of examples drawn from his experience on medical papyri. However, a weakness of his concept of digital edition, in particular of the notion of multitextuality, is that it does not sufficiently take into account the characteristics of the textual tradition of classical literature, thereby proving appropriate only for a restricted number of text categories. Nevertheless, his attempt to systematise an EpiDoc annotation markup for literary texts and to encode the external appearance of the fragments represents a firm basis for further research on these hitherto neglected aspects of digital editing of papyri.

The mounting number of resources and their diversity has led to the production of overall surveys of digital papyrology projects.[206] Furthermore, in 2017, the first

[200] Magnani 2018, 94-100; Battezzato 2009, 779-81. In philology, the notion of multitextuality has been suggested for one particular kind of text with a different transmission from the classical one, French medieval literature, because in that civilisation it was commonplace for scribes and even for authors to produce different versions of the same work (Battezzato 2009, 780).
[201] Reggiani 2017, 268-70; Id. 2018b, 8-10; Id. 2019a, 252. Cf. Gagos 2001, 514-16.
[202] Reggiani 2018b, 5, 51-52. For the method of ontology, see above, p. 46.
[203] Reggiani 2018b, 13-47.
[204] Reggiani 2018b, 26-29; Id. 2019a, 250-52.
[205] Reggiani 2018b, 12; Id. 2019b, 186-87.
[206] Ruffing 2000; Millozzi 2004, 73-80; Capasso 2005, 227-36; Otranto 2007, 443-68; Babeu 2011, 141-57; Delattre-Heilporn 2014; Quenouille 2016. Besides these general surveys, two contributions, Terras 2006, 12-15 and Bowman 2010, are devoted to imaging projects.

comprehensive monograph on digital papyrology appeared, *Digital Papyrology*, vol. I: *Methods, Tools and Trends*, by Reggiani. This work distinguishes itself from the previous overall contributions not only for the number of resources scrutinised and the exhaustive overviews of the projects' history and of their technical details, but also for the in-depth discussion of theoretical and methodological problems. He identifies common trends in the development of the resources (namely, derivation from tools on paper support, integration of the main projects, and standardisation of papyrological data),[207] demonstrates how digital tools meet papyrologists' research needs in several respects,[208] and finally proposes a new concept of digital edition (as mentioned above), anticipating the more detailed description provided in his 2018 contribution. Together with the collective 2018 volume of case studies edited by the same scholar, this work will naturally be a fundamental reference point for this dissertation.

1.5.3 Papyrology and digital humanities literature

As emerged from the above literature review, the vast proportion of the studies on digital papyrology has been produced by papyrologists, who have offered informative overviews of the projects, examining the relationship between these and the already existing instruments of their discipline. While doing so, they have often discussed the use of standards and the adoption of a collaborative approach in building the resources, as can be especially seen in the literature on *APIS* and *Papyri.info*.

On the other hand, there is only a limited amount of literature that addresses the numerous other questions that have arisen in digital humanities scholarship, and only a few papyrological resources are taken into account in these contributions. Central problems such as permanence, sustainability, data openness and connectivity across tools have been tackled by Roger Bagnall and Sebastian Heath in regard to a selection of digital resources for Roman studies, including some papyrological ones, namely, *Papyri.info*, *Vindolanda Tablets Online* and *Trismegistos*.[209] Among digital humanities scholars, Melissa Terras has dealt with issues of digital papyrology, providing insights into the application of concepts from computer science and engineering to this field. In particular, she showed how ideas from artificial intelligence and advanced imaging processing can be adopted to develop a system to aid in reading severely damaged documents, with the Vindolanda stilus tablets as a case study (Terras 2006). Also, in the

[207] Reggiani 2017, 10-12.
[208] Reggiani 2017, 257-60.
[209] Bagnall-Heath 2018, 172, 177-78, 184-85.

introduction to her work she reviews projects of advanced image processing of ancient manuscripts, highlighting questions of user needs: she notes that some of these efforts do not take into consideration input from the humanities scholars for whom they were meant, failing to understand their information needs and behaviour, thereby making the acceptance of these resources less likely.[210] In another contribution, focused on the problem of uncertainty inherent to digitised images, the same scholar provides a brief survey of *APIS* and the *Vindolanda Tablets Online* sites, with a positive assessment of their usefulness and usability.[211]

As topics dealt with in digital humanities literature have been little explored in relation to papyrological resources, it now seems to me opportune to complement the existing literature on digital papyrology by trying to understand how the resources are situated within the broader context of digital humanities. In order to comprehend their significance even more fully, I think that it is important to contextualise them against the backdrop of digital progress in other classics and humanities disciplines, and to place them more generally within the framework of the scholarship in this area. With this thesis, I thus aim to produce a first step towards a comprehensive reanalysis of papyrological projects from this new perspective. This will be carried out by following criteria proposed in digital humanities literature to describe and classify the resources, and by discussing problems with reference to debates in the field (as will be illustrated in the next section, 1.6).

This is thus the first attempt to provide a systematic examination of a large and representative set of papyrological projects from a digital humanities point of view. A comprehensive evaluation of papyrological collections, reference works and methods according to criteria suggested in digital humanities literature will allow us to describe the characteristics of the resources in all their variety and complexity, thereby revealing further opportunities and challenges for papyrological research. I also aim at producing results relevant to the improvement of the resources, proposing suggestions for specific issues. Furthermore, by identifying and illustrating types of projects, especially in a discipline like papyrology which is in the digital vanguard and makes use of diverse tools and methods, I hope to contribute to digital humanities scholarship, taking a step towards comprehending the breadth, diversity and complexity of the whole genre of digital humanities instruments.

[210] Terras 2006, 12-15.
[211] Terras 2010a, 47-48, 52-53.

1.6 Analysing digital papyrological resources

The analysis of papyrological resources will focus on some main themes, relating to important characteristics of digital humanities projects in that they determine their forms, functions and effectiveness, albeit from different angles: underlying data model, usefulness and usability of content and design, and long-term permanence and sustainability.

1.6.1 Exploring data models

A data model is the ensemble of the format and the structure used to represent the content of a digital resource. Therefore, it includes the format chosen for the digital documents, for example a markup language based on an XML schema, like TEI, for encoding textual data, or an ontology[212] for representing a metadata database or a library catalogue. Also, it concerns the method (or "metamodel") employed for the interrelation of the components of the resource, i.e., the documents and the tools for their search and analysis; this structure may be represented, again, by XML in text-based resources, by a relational metadata database, or by the Resource Description Framework (RDF),[213] typically used by memory institutions to express ontologies of linked data.[214]

[212] In computer science, an ontology is a set of definitions of related entities (e.g., artefacts, people, bibliographic records), describing their most general features and the relations among them, with the aim of modelling an information domain. Ontologies allow us to define objects and link them on the basis of relevant concepts (e.g., provenance and purpose) in a machine-readable way. They are thus used in the creation of infrastructures for the aggregation of related datasets, both within a platform and among external resources. This method has not been employed in papyrological resources. It is however diffuse in projects of cultural heritage institutions, as it helps to form coherent large-scale collections and to bring together localised information, thereby rendering it more discoverable (Jannidis-Flanders 2019, 81-82).

[213] The RDF method expresses information about entities and their relationships by means of web technology, so that they may be exactly identified and meaningfully processed by the web. In more detail, information is encoded with a graph, in particular a "triple" in the form of a three-part sentence whose elements are expressed with a URI (Uniform Resource Identifier), as this is a stable and unique identifier for any object on the Web. This method is used to merge datasets from different sources into one broad collection and to query them simultaneously, thus enabling easier discovery of items and more complex searches. It was devised with the aim of creating a "Semantic Web" of cultural heritage data, a vast collection of catalogues of many different kinds of artefacts interconnected with meaningful linkages. While this objective has not been fully achieved, the RDF model has been employed by numerous digital humanities projects and catalogues of memory institutions. Some of them have made their RDF datasets freely available on the web, namely as Linked Open Data, to encourage their access and reuse for other endeavours (Flanders-Jannidis 2019, 20; Jannidis-Flanders 2019, 81). In papyrology, RDF was adopted by the *Integrating Digital Papyrology* project for merging the content of the *Duke Databank*, *HGV* and *APIS* into the *Papyri.info* platform (1.5.2, p. 29); their material has been published as Linked Open Data (Baumann 2021).

[214] For this concept of data modelling in digital humanities, see Fenlon 2017, 526; Flanders 2014, 169; Flanders-Jannidis 2016, 229-30; Iid. 2019, 3.

As well as being the underlying structure that underpins the resources and the frame of reference in which they operate, the data model has become an object of study, to learn how resources are constituted and work, and what their purposes are.[215] Julia Flanders and Fotis Jannidis have shown the significance of this concept, derived from computer science, to digital humanities.[216] As they argue, humanities scholars already made use of models of strongly structured information, typically in reference works, libraries catalogues, and paratextual material such as critical apparatuses and indexes; however, the digital turn has contributed to existing modelling approaches in the humanities by adding a greater formalisation, with the specification of rules to govern the different types of data.[217] The informational areas of a resource in which data modelling takes place has been identified by Flanders as: metadata; interconnection, both between items and with external resources; constraints, for instance encoding schemas and vocabularies; interface design; and patterns that emerge from the exploration of the collection with tools for text analysis, possibly represented with a visualisation. These components of digital resources reflect their data model and hence help us identify their formal aspects.[218] Notwithstanding the progress of data modelling in the humanities, there are still challenges that need further exploration. A critical aspect is how to model uncertainty of humanities data in several domains, namely, digital editions,[219] quantitative analysis and data visualisation,[220] because of the difficulty to accommodate the complexity of humanities datasets to the abstract, formal representation required by computational systems. For certain disciplines, such complexity is further increased by issues related to the fragmentary nature of the dataset, as occurs in papyrology, as well as ancient history and archaeology.[221] In papyrology, as in other disciplines that rely on the use of digital images, it is also crucial to identify and address uncertainty in digital surrogates, into which the digitisation process may unintentionally introduce distortion.[222]

The data models of papyrological resources will be analysed with the aid of the typology proposed by Katrina Fenlon on the basis of Flanders's studies on the topic.

[215] Flanders-Jannidis 2019, 7.
[216] Flanders 2014, 169-71; Flanders-Jannidis 2016; Iid. 2019.
[217] Flanders-Jannidis 2019, 3, 5-7.
[218] Flanders 2014, 169-71. Even though her contribution focuses on digital collections, I think that her discussion of data modelling, as here briefly reviewed, is also appropriate for digital resources more generally.
[219] Flanders-Jannidis 2019, 16-23; Flanders-Jannidis 2016, 235-36.
[220] See Brughmans et al. 2016, 10-12, with a focus on the method of Social Network Analysis.
[221] See Brughmans et al. 2016, 11.
[222] Terras 2010a.

Although Fenlon's typology concentrates on the data model of one genre of resources on which her interest focuses, thematic research collections, I think that it may be extended to analyse papyrological projects in their various genres, whether centred on a specific theme or designed with a broad scope. In fact, this typology seems to me suitable for digital research projects in general, as the three aspects identified as key to the data model of thematic collections (as mentioned below) prove essential to all resources.

Three characteristics, or properties, of data models, are examined in particular by the chosen typology, which inform the development of resources, determining their design and their functions, and indicating their possible uses: the ability to provide access to primary sources, the level of markup, and the intended purpose.[223] These aspects imply a series of questions, which the typology aims to explore thereby clarifying the features of the resources, important differences among them and the implications for users.

As far as the first aspect, access to primary sources, is concerned, the typology asks: does a resource provide direct or mediated access to them? In other words, what is its priority? Is it the ability to gather and provide direct item-level access to the primary material, through searching and browsing functions? Or is it the provision of indirect access to it through a layer of derivative data, possibly intended for interactive use?

Projects that allow for direct access to the primary material, thus prioritising its visibility and use, are the most widespread in digital humanities. Fenlon's examples for this category comprise some thematic collections dedicated to a literary author, in which primary sources constitute the main content, whether in the form of digitised text or digitised visual material such as manuscripts (for instance, the *Walt Whitman Archive*).[224] In papyrology, projects that, analogously, concentrate on direct browsing and search of texts or images of the papyri are the most frequent as well. A genre that may be included within this type is digital institutional collections complete with images, usually included in the manuscript catalogue of the relative library. As this is the most common kind of resource in digital papyrology, a chapter, the second one, will be devoted to its analysis and assessment. One more genre that provides direct access to papyri, in this case to their texts, is textual databases, the most extensive ones being the *Duke Databank*, the *Digital Corpus of Literary Papyri*, and the first *Vindolanda Tablets Online* site, with its current version on *RIB Online*. This genre will be dealt with in the third chapter. Other projects (also discussed in chapter 3) that fall within this type may

[223] For an introduction to the chosen typology, see Fenlon 2017, 524, 526-29.
[224] On this type of resource, see Fenlon 2017, 530-31, 532-33.

be defined as thematic collections: *Les archives de Dioscore d'Aphrodité en images*; the *Derveni Papyrus*, which gathers three transcriptions of this text to enable their simultaneous display and comparison; and *Codex Sinaiticus*, which virtually reunifies the homonymous manuscript, currently divided across four institutions.

Another type of project provides access to primary sources in an indirect way, that is, mediated by an interpretive layer of data derived from the original texts or from the metadata.[225] The centre is not the sources, even though these may be present, but the data gleaned from them, which are given the greatest visibility in the design and the navigation of the content. Browsing and search functions therefore operate on the derivative information layer, rather than on the underlying original material. The interpretive information on which these resources focus may consist of more granular data,[226] obtained through advanced encoding of text or detailed classification of metadata, thus offering the possibility of searching for people, places, abstract concepts, types of texts, networks, etc. Or else, the analytical/interpretive layers added to data consist of visualisations displayed alongside data and item results, e.g., an (interactive) map, timeline, 3D model or graph of social networks. Among papyrological projects, we may classify in this category catalogues and thematic collections focused on metadata, including prosopographies, gazetteers and calendars. We may also include some text-based resources, such as textual databases with fine-grained access to sources through advanced encoding of named entities[227] or text mining tools;[228] treebanking corpora, which allow for more advanced explorations of linguistic phenomena than text databases;[229] reference works; and word lists. These resources will be analysed in the fourth chapter. Though less common than projects with direct representations of primary

[225] On this type of resource, centred on derivative data, see Fenlon 2017, 528, 531, 535-36.
[226] Granularity is the level of semantic segmentation in information: it is the detail in which information is divided into units of meaning (e.g., into web pages or parts of them, or words), so as to connect related objects with more precision and to allow more efficient information retrieval (Murray 2012, 223-25, 422). In order to truly support intellectual access, segmentation needs to be based on relevant concepts rather than, say, on size or format of the objects, and to reach a very fine level of granularity by means of an accurate classification (ibid., 69-70, 225).
[227] Named entities are specific names such as, in humanities texts, those of individuals and organisations, geographic locations and chronological terms, usually expressed with proper nouns. Named entities can be extracted and classified automatically through the process of Named Entity Recognition (NER); this also helps to provide contextual information, distinguish between people or places with the same name, and link historical and current names of a place (Crane-Jones 2006, 31). One of the first efforts in the humanities to experiment with NER was *Perseus*, which developed a system to extract dates and places from all its text collections (ibid., 32).
[228] Text mining is the automated extraction of linguistic or stylistic patterns from large sets of textual data, according to a distant reading methodology (cf. Hughes et al. 2016, 161-62).
[229] Treebanking corpora are morpho-syntactically annotated texts, usually displayed as a tree-like structure in order to highlight dependencies among words and clauses. For an introduction to the principles underlying dependency treebank corpora, see Celano 2019, 280-83.

sources, they are nonetheless very interesting as they often present a more interactive organisational form, which reacts dynamically to user input, and they are based on the relationships among the primary sources and on the functionalities built on them, rather than on the sources in themselves.[230]

As well as on the type of access that projects provide to papyri, my analysis will focus on the two other key properties of data models indicated by the reference typology: the level of markup and the kind of purpose. It will determine whether a project utilises minimal markup, thus allowing only basic keyword searches, or rich descriptive markup[231] that opens the content to more complex searches, advanced interpretation and linkages among the items.[232] As for the question of purpose, strictly speaking this is not a specific property of a data model like the two previous ones; however, it is closely related to it, as it affects decisions about the processes of the creation of a resource.[233] The analysis will consider for what purposes papyrological resources are intended, whether for research, teaching or the presentation of new evidence. Even though, naturally, papyrological resources are above all meant to support research, some are also designed for teaching, possibly for different levels of education and the general audience as well, and for publishing new evidence, also through the solicitation of user contributions, as opposed to the digitisation of already known sources and to the aggregation of existing digital content. I will examine the ways in which such purposes are reached, by pointing to related choices about the scope and the development of the projects.

The most advanced papyrological resources from the point of view of the data model will be identified with those that offer functionality beyond basic visibility of primary sources and keyword searches; that represent items in relation to one another, to contextual information, secondary sources and other projects; that support fine-grained access to their texts or catalogue records, especially through the encoding of meaningful features from the specific perspective of papyrology; and that include new, original content, whether in the form of new evidence or derivative data from the base collection.

Further questions to explore concern more specifically the data model of some genres of digital resources.

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[230] Fenlon 2017, 536.
[231] Descriptive, or semantic, markup indicates what a unit of content is, for instance, a noun or a place name, as XML does. It differs from presentational markup, e.g. HTML, which provides instructions on the format of a document (Nyhan 2012, 122-23).
[232] On the property of markup, see Fenlon 2017, 527-28, 533-34.
[233] On the property of purpose, see Fenlon 2017, 527-28, 531-32.

Digitised institution-based collections differentiate themselves from thematic collections and other databases as they concern papyri belonging to the same institution or to a federation of them, thus being a representation of real-world collections. The following specific issues to the data model of this genre will be explored, which Flanders has identified as important challenges of digital research collections born as representations of physical ones.[234] (1) Are these resources mainly based on the same principle of physical proximity as their original collections, or do they also virtually aggregate other materials? (2) Are they managed with a local agenda, or are they designed according to shared standards and best practice? (3) Overall, to what extent do they inherit constraints, in their creation and management, from their physical status? Or does the digital medium enable them to overcome such boundaries?

Differently from institutional online collections, text and metadata databases and thematic collections gather primary sources on the basis of their content type, regardless of the institution in which they are housed and their physical proximity. Virtual aggregation of related material in these resources offers many opportunities for scholarly activity, but also entails the risk of simple unboundedness and lack of cohesion. The following questions, drawn from those posited by Flanders about the data modelling of research collections, will be therefore addressed.[235] (1) What research questions define the bounds and the shape of the collection? (2) How does the digital space help achieve the intellectual purpose of the collection thus scoped? (3) Is the digital space actually modelled on the collection's scope and its intended audience, or are there limitations owing to technical problems and lack of financial resources?

1.6.2 Focusing on a genre of digital scholarly resource: thematic collections

Among genres of digital scholarship, one that has received increased attention in digital humanities literature is collections centred around research themes,[236] for their ability to allow deep analysis of a specific research subject. It may thus be worth describing this genre in more detail. This will allow us to point out instances of thematic collections in papyrology, reflecting on how the discipline might benefit from their further growth, whether with the creation of new ones or with the modelling of existing resources. The aim will be to assess how much significance papyrological thematic

[234] Cf. Flanders 2014, 165, 166-67, in her survey of the principles, or data models, around which digital research collections are constituted and organised.
[235] Cf. Flanders 2014, 168-69.
[236] This has been observed by Fenlon (2017, 524) in her contribution on these resources.

collections, as well as other kinds of projects, attach to the focus on a research subject, or possibly on a specific research question, to the provision of contextual accompanying material around the core primary sources, and to discovering previously unknown connections among items, so that they may become even more useful to the process of scholarly work and may be themselves an expression of new analysis.

Thematic collections are a coherent set of objects, customised for intensive study, for instance, of an author, a place or a phenomenon.[237] They are principally an informational construct rather than a consequence of a real-world collection, aimed at gathering ideally all the materials relating to a subject, usually dispersed in different libraries. Scholarship informs the design of this resource from the outset, proving particularly visible: its representation is shaped by the same inquiry that shapes the related research project, its accurately selected sources and methods are tied as closely as possible to the main research question,[238] possibly forging new and unexpected linkages between items.[239] As well as assisting in the production of new research, they thus have the potential to be a contribution to humanities scholarship in themselves. A problem that, however, characterises thematic collections is that, although they have long been acknowledged as a legitimate form of digital scholarship, they still lack integration with other projects, which diminishes their potential as online resources and affects discoverability and long-term preservation,[240] as will be discussed about the examples of this genre in papyrology.

Because of their tight alignment with a particular research interest, thematic collections may be likened to libraries' subject collections and their digital representations; however, in comparison to them, thematic collections add a range of materials (a "contextual mass")[241] and functions to support the research process, which a structured digital environment helps to integrate. In the most advanced instances, they display a rich contextual mass of diverse primary sources and scholarly contributions relating to their focus, obtained in collaboration with other scholars, publishers and memory institutions;[242] they are provided with tools to support scholarly tasks (from basic searching, browsing and linking, to creating personal annotations and contributing content); and they belong to an interdisciplinary platform to facilitate the discovery of

[237] Palmer 2004, 348-49; Fenlon 2017, 523-24.
[238] Palmer 2004, 348-49, 363; Fenlon 2017, 537.
[239] Flanders 2014, 170-73.
[240] Fenlon 2017, 524.
[241] Flanders 2004, 352-54.
[242] Palmer 2004, 353-54.

relationships among different fields of study.[243] While being a resource circumscribed in scope and homogeneous in theme, it should thus be heterogeneous in content.[244]

A resource that typifies the genre of thematic collection is *Woolf Online*, a joint project of the De Montfort University, King's College London and Loyola University Chicago.[245] It is in fact centred on a single literary work, Virginia Woolf's *To the lighthouse*, and it is the development of an even more circumscribed pilot project, *Time passes*, dedicated to the homonymous section of the novel. *Woolf Online* gathers a wide range of both textual and visual materials: primary sources such as drafts and early editions of the novel; contextual information, including Woolf's writings relating to the novel, reviews of the age, visual material and a map relating to places she visited, thereby providing insight into the novel's setting and characters; critical essays offered to the project by ten specialists of this author.[246] *Woolf Online* supports not only the intensive study of the novel altogether, but also deep inquiry in a specific research question, focused on the *Time passes* section, namely, how its composition can be traced in relation to the contemporary biographical and historical events; this can be carried out by examining her diary, correspondence and essays written at that time, and newspapers of that period, which provide evidence of the fluid process of Woolf's writing.[247] On the other hand, this collection presents the problem, which characterises this genre, of the isolation from other projects, as items do not interlink with external sources or publications.

1.6.3 Assessing usefulness and usability

As well as considering the internal modelling of papyrological resources to determine how they work and what they can be used for, my analysis will take into account issues of usefulness and usability, two complementary qualities that are key for resources to be accepted among the scholarly community. This theme is partly linked to that of data modelling, especially as far as the user interface is concerned, since interface

[243] Palmer 2004, 350-54.
[244] Palmer 2004, 361.
[245] *Woolf Online* is qualified by Peter Shillingsburg, its co-editor, as a "knowledge site," without reference to the notion of "thematic collection" (Id. 2016, 897). However, the two concepts appear overlapping, as Shillingsburg intends a knowledge site as a resource with, ideally, the full range of primary and secondary materials on a subject (ibid., 890-91). The mention of *Woolf Online* as a successful instance of this genre is in ibid., 897.
[246] For this description of the project, see *Woolf Online* 2013a and 2013b.
[247] *Woolf Online* 2013b.

design reflects not only usability choices but also the underlying model of the resource.[248]

Usefulness is the relevance of the project to the researcher's tasks and needs, depending on the comprehensiveness and the validity of the content. It therefore indicates the quality of user interaction with the information content. But, when using a resource to search and browse its content, one also interacts with the system, namely, with the integrated services that, through the user interface, help access, retrieval and analysis of the content. Such relation between the user and the system is termed "usability." It is, in other words, the capacity of the system to be effectively and easily interacted with by users, which occurs when they can exploit all the functionalities in a way that is easy to learn and remember, as the system is visually clear, error-tolerant and adaptive to their preferences.[249]

Problems of usefulness and usability of digital humanities resources have been discussed in three contributions by Gibbs and Owens (2012), Warwick (2012) and Bulatovic et al. (2016), who conducted user studies of projects of different humanities disciplines, using diverse methods. The authors have reached very similar conclusions on the characteristics of and the reason for these issues. As for resource content, they found that some projects lacked adequate documentation, which made scholars uncertain about their scope and their possible uses. Scholars needed more information on the breadth of the content and on the method of selection of the materials, as well as on the staff's expertise. Sometimes, even the name of the resource was found confusing as to what the content might be. They were also deterred from use by directions focused on technical aspects, which did not clarify, possibly with examples from real case studies, what the resources might be utilised for. The content itself was at times incomplete, of poor quality, or not up-to-date. In regard to usability issues, some tools proved complicated for the general humanities audience, with needlessly complex functionalities and unintuitive interfaces.[250] The authors are unanimous in attributing these problems to the lack of a relationship between designers and users. Their proposed solution is therefore to improve engagement and communication with the humanities scholars for whom the resources are created, thereby exploring more deeply their

[248] Flanders-Jannidis 2019, 13-14, 88.
[249] For these definitions of usefulness and usability, see Fuhr et al. 2007, 26-28, in their discussion of an evaluation methodology of digital libraries; for that of usability, see also Bulatovic et al. 2016, 335-36.
[250] Gibbs-Owens 2012, 9-10, 26-34; Warwick 2012, 2, 8-9, 11-13; Bulatovic et al. 2016, 341, 345.

information needs and building tools that fit well with their method of work and their requirements.[251]

On this premise, the characteristics of papyrological tools that predispose them for sustained use will be pointed out, while highlighting areas that might be improved and proposing suggestions according to the literature reviewed. I will thus consider the comprehensiveness of digital papyrological collections and databases, relatively to their scope; their online availability, which includes open-access availability and the ability to download; the copyright on the digital content; the interface, relating both to the portal and the single records, including the viewer in collections with papyrus images.[252] The quality of digital pictures, that is, image resolution, will be also assessed,[253] which for papyri should be set to 600 dpi.[254]

Editions of papyrus texts will be compared to the specific requirements of digital scholarly editions. They have been identified by Nyhan[255] grounded in recommendations shared by the digital humanities community, and by Sahle[256] while exploring the new possibilities of the digital medium for humanities texts. Some requirements concern the academic quality of the work, with the provision of essential material of scholarly editions such as the *apparatus criticus*, the illustration of the editorial method, and bibliographical data. From the point of view of the data model, digital scholarly editions should be interconnected with other texts and resources through an information system, and enable research that would not be possible with traditional methods, for example thanks to explicit textual structures or semantic information, or high-quality visual evidence. For their development, it is preferable to use open-access and open-source technology, in order to avoid obsolescence due to software updates, and to facilitate immediate access and reuse. Also, the documentation needs to illustrate the editorial theory that underpins the digital editions and the way this is reflected in their design.

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[251] Warwick 2012, 4, 9, 12, 14-15, 18-19; Gibbs-Owens 2012, 6-7, 36; Bulatovic et al. 2016, 344. The little focus given to the consultation with humanities scholars has also been noticed by Terras (2006, 14) with regard to projects of image processing of ancient manuscripts, by Fuhr et al. (2007, 27, 35) about digital libraries, and by Jannidis and Flanders about digital humanities endeavours in general (2019, 88-89).

[252] As well as from the aforementioned literature, I have drawn these criteria from van Lit's evaluation framework of collections of digitised manuscripts (2019, 64-72), which precedes his discussion of projects relevant to Islamic studies (ibid., 74-101).

[253] Other aspects of manuscript collections examined by van Lit, concerning the quality of pictures, do not appear relevant to papyrus collections, for the characteristics that papyri present: page numbers; problems of lighting, if pages are not fully flat; colour balance, relating to the features of the writing support, which in papyri are secondary to the legibility of the script (Bagnall 1997, 154; Bülow-Jacobsen 2020, 59, 66); and cut, as text margins are sometimes excluded from the picture, a problem not found in papyrological collections.

[254] Bülow-Jacobsen 2020, 66. This standard was set by the *APIS* project (Bagnall 1997, 15).

[255] Nyhan 2012, 118-19.

[256] Sahle 2016, 38.

1.6.4 Identifying sustainability challenges

Usefulness and usability are key qualities to the effectiveness of digital humanities endeavours, thus influencing their sustained use among humanities scholars. In addition to the quality of content and design, another important factor of projects' longevity is the development of a plan for permanence and sustainability.

Permanence may be defined as the long-term accessibility of a resource.[257] A characteristic that supports it is the interconnection with other projects. Besides reflecting data modelling choices, aimed at linking resources with related content, interconnection is also relevant to permanence, as it makes resources more stable, especially if one follows rigorous data modelling approaches and resorts to (customised) existing standards. Permanence is also supported by the inclusion of the resource in an institutional website (which is the case, for example, of *Papyri.info*, hosted and managed by Duke University Library) and possibly by the storage of its data with a third party,[258] for instance the widely-used *GitHub* public software repository. Finally, the use of non-proprietary and open-source software, as discussed above, helps to avoid the obsolescence risk.[259] While it is essential that a resource remains accessible over the long term, it is also necessary that it receives a continuing curation, with the publication of new content and the update of the old one. Sustainability is thus the plan to ensure that a project will continue not only to exist but also to be curated, thanks to the allocation of financial resources and personnel to support the continued entry and organisation of data.[260] On the whole, a strategy to support permanence and sustainability therefore aims to the long-term availability of technical infrastructure, staff, income and host support to allow ongoing access and usefulness of a resource.

A reference point for my discussion of permanence and sustainability in digital papyrology endeavours will be the 2018 contribution by Bagnall and Heath, from which the above definitions are drawn, which includes the analysis of these issues in the digital landscape of Roman studies. The discussion of economic sustainability will be followed up by referring to a relevant survey conducted by JISC, the organisation for digital services for UK education and research (Maron et al. 2009). The authors examined a sample of online research resources, mostly humanities (among which a digital classics one, the *Thesaurus Linguae Graecae*).[261] The features of these projects that were pointed

[257] For the definitions of permanence and sustainability, see Bagnall-Heath 2018, 172-73.
[258] Bagnall-Heath 2018, 177.
[259] Nyhan 2012, 119.
[260] Bagnall-Heath 2018, 172; Maron et al. 2009, 4.
[261] Maron et al. 2009, 8-9.

out as critical to financial viability provide a useful framework for the analysis of papyrological resources under this respect: a consistent and committed leadership (as shown, for instance, by *TLG*'s directors, Brunner and subsequently Pantelia); the creation of content or services not found in other resources in the field and based on an understanding of user needs (in the *TLG* through a unique all-embracing corpus of Greek literature and investment in search and analysis functionality specific to it);[262] the development of revenue sources, usually from multiple streams and with a mix of generated income and institutional support (as occurs in the *TLG*); and effective cost management.[263]

Particular attention will be devoted to integrated information systems, as they entail further risks for permanence and sustainability. As already mentioned, integration and interconnection among databases is a significant trend in papyrology,[264] of which *Papyri.info* is a remarkable example. On one hand, integrated platforms, with web documents spread across several collections maintained by multiple scholars in different institutions, have offered more possibilities of collaboration among researchers and easier access to information for users. On the other hand, they are particularly fragile, since curators do not possess all the web documents of the resource, stored in decentralised collections; as a consequence, they cannot control how documents change when affected by an unexpected event, such as technical failure, end of funding or decay in interest.[265] Such issues will be taken into consideration, assessing whether diverse information has been effectively brought into a coherent resource, by curating the aggregated data and ensuring interoperability over the long term.

1.7 Outline of this dissertation

The dissertation is constituted of five chapters.

After this first introductive chapter, the thesis analyses and assesses digital papyrological resources, divided into three groups based on their data model. Specifically, the second and the third chapter deal with the most common projects, those

[262] On *TLG*'s functionalities, including analytical tools, see *TLG*'s review in Farrington 2017.
[263] Maron et al. 2009, 13-26. On the sustainability strategy of the *TLG* in particular, see Maron et al. 2009, 109-16 (also published as Loy 2009).
[264] Reggiani 2017, 11-12.
[265] Degradation problems of distributed projects, i.e., in which the administrative control of information is spread across different online resources, have been analysed by Meneses et al. (2016; 2019, 1-2), surveying types of unexpected changes and user perception of this phenomenon.

that provide straightforward access to primary sources, whether in the form of images, text, or metadata records: digitised real-world collections (second chapter) and relevant textual databases and thematic collections (third chapter). Projects that, by contrast, offer mediated access to information on papyri through advanced functionality or data visualisations are discussed in chapter four. All the resources are evaluated in view of the following characteristics, key to effectiveness and preservation of digital humanities efforts: data model; focus on a specific research theme; usefulness and usability; plans for permanence and sustainability.

Finally, the fifth chapter draws the conclusion of the thesis. On the basis of the analysis carried out in the three previous chapters, I examine papyrological resources altogether, so as to gain insight into their impact on research practices and scholarly communication, suggesting improvements that may open up further opportunities for papyrological research.

Chapter 2

Digitised papyrological collections

2.1 Introduction

This chapter aims to analyse and assess digitised papyrological collections: resources that provide direct access to papyri, by gathering metadata and image content predominantly, and ones that arise as a representation of material collections. They thus differ from other projects that also provide straightforward access to papyrological primary sources (i.e., some text databases and some thematic collections) as they are mainly an effect of physical proximity, rather than a selection of materials held in different locations focused on a category of texts or on a theme (cf. pp. 48, 51).

In the literature on digital papyrology, an overview of digitised papyrological collections as a whole has been outlined by Reggiani (2017, 92-102), accompanied by an extensive inventory with a brief description of them (ibid., 103-14). After mentioning the emergence of these resources with the *Duke Papyrus Archive* and the *APIS* union catalogue, Reggiani concentrates on the presentation of the other federated projects developed in the wake of *APIS*, highlighting a trend to producing extensive joint resources and to integrating them with other papyrological databases, while noticing a lack of homogeneity that hinders a further integration into an all-encompassing database.

Building on the overview offered by Reggiani, my analysis addresses, besides federated collection catalogues, individual ones and more general library or museum catalogues that include papyri alongside other sources. I shall focus on a selection of institution-based collections, mainly drawing on Reggiani's aforementioned inventory, trying to include both the most extensive ones and those representative of different choices in imaging, cataloguing, accessibility and management. Moreover, I aim to shed light, as well as on integration and standardisation as discussed by Reggiani, on other aspects that fall under the key rubrics of usefulness, usability and sustainability (cf. above, pp. 53-57), while clarifying the purposes that digitised collections serve (p. 50).

More specifically, the analysis addresses: (1) the scope of these resources and their comprehensiveness in comparison to the institutions' holdings, taking into account their digitisation policy and their documentation on the physical and the digital collection; (2) online accessibility, including open-access availability and the possibility to download the images, as this allows scholars to obtain images rapidly, work on and annotate them on their computer;[1] (3) the related question of the copyright on usage and publication of images; and (4) the quality of the catalogue interface, of the image viewer and of the image itself. From the point of view of the purpose of collections, the chapter seeks to determine how they support research and whether they are particularly engaged with the solicitation of user contributions through the presentation of original evidence; for digitised collections, this may be identified with preliminary cataloguing data on and images of unpublished papyri, so as to solicit the publication of the collection by the scholarly community and the discovery of connections with texts preserved in other institutions, such as other fragments of the same item or the same archive. Moreover, we will note how digitised collections participate in scholarly communication on the web, catering to different levels of education and the wider public, whether within the resource itself or with the aid of collaborative platforms.

After this introduction, the chapter outlines a historical overview of digitised papyrus collections. I begin with an excursus of the *APIS* project, the groundbreaking initiative that paved the way for digitisation efforts of papyrological holdings worldwide, showing its relevance to current resources (2.2). I then move on to the diffusion of digitised papyrological collections in the wake of *APIS*, with more federated catalogues and the emergence of individual ones, both in the United States and in Europe (2.3). The core of the analysis is presented in sections 2.4-2.8. For the purpose of clarity, the numerous digitised collections have been split into different subdivisions. First, I examine the ones available through *APIS* data in *Papyri.info*, which mostly relate to United States institutions (2.4). Then, I concentrate on United States (2.5) and European collections, both federated (2.6) and individual ones (2.7), with dedicated catalogues. The last group of projects consists of wide-ranging catalogues of museums and libraries that include papyri alongside other materials (2.8).

[1] Van Lit 2019, 65.

The chapter closes with the conclusion, reflecting on the strengths, weaknesses and opportunities of this genre of resource (2.9).

2.2 A pathbreaking project: the *APIS* network of United States collections

Within the framework of the *APIS* collaborative project, from its launch in 1996 in the early years of digital papyrology to its end in 2013, as many as twenty-nine papyrus collections[2] of various sizes were extensively digitised and made available on a dedicated catalogue, hosted on the server of one of the founding institutions, Columbia University.[3] The enterprise, since its preliminary phase with the Michigan pilot digitisation project, was undertaken with the involvement of different interested parties, that is, papyrologists, conservators, cataloguers and librarians.[4] It was made possible by funding from the National Endowment for the Humanities, the agency of the United States government for supporting humanities projects.[5] While today the *APIS* catalogue is no longer ongoing, its legacy data still constitute an invaluable source of information in the databases where it has flowed, namely, *Papyri.info* and holdings catalogues of the owning institutions.

APIS collections may be roughly divided into three groups based on the geographical area of the holding institutions, namely, United States, European and other countries'. United States collections were the most numerous in the *APIS* network, totalling eighteen. Among them there were six major collections, belonging to university libraries, which are the largest ones in the United States and among the largest ones in the world; they were also the founding members of *APIS*: Michigan, Columbia, Duke, Berkeley, Princeton and Yale.[6] By the conclusion of the project, only a few United States collections had not been catalogued with its collaboration, for

[2] For a list of *APIS* collections, see *Papyri.info*'s "APIS" section, accessible from the top bar menu, or *Papyri.info*'s search form, in particular the "Collection" field; the latter also indicates the number of records, both of the single collections and of the *APIS* dataset as a whole.
[3] *Papyri.info*, "APIS;" Reggiani 2017, 95.
[4] Gagos 1996, 22.
[5] Bagnall 1997, 153; Id. 1998, 543, n. 1.
[6] Bagnall 1998a, 546; Gagos 2003; Bagnall-Gagos 2007, 66.

example those at the Morgan Library[7] and the Brooklyn Museum,[8] both in New York, and at Harvard University.[9]

Berkeley's was the most extensive real-world collection to join *APIS*, but Michigan's was the most widely catalogued, with over 8000 records, almost half of which provided with images (as results from *Papyri.info*'s *APIS* dataset relating to Michigan collection). The significant progress of the Michigan dataset was probably due to the earlier start of the cataloguing of the Michigan papyri, with a pre-*APIS* digitisation project (cf. above, p. 27), and to the presence of a team of papyrologists in charge of the collection, already previously involved in digital projects, i.e., the proof-reading of the texts entered into the *Duke Databank* and the mentioned pioneering digitisation of the Michigan papyri.[10] By contrast, it was as a consequence of the *APIS* initiative that work on the Berkeley collection revived after a long time.[11] Also noteworthy is Yale digital collection, for presenting the highest number of images, more than 6000, out of nearly 7000 records, which cover the entire collection (p. 77).

But, while initially showing a geographical, national character and addressing the digitisation of large-scale collections, later on the *APIS* federation expanded beyond the United States with two principal objectives: to create an ever broader network of collections searchable in a single information system, specific for papyrology; and to bring to light neglected collections, even small ones, which were not under the care of a papyrologist, lacked published images and were sometimes even difficult to access.[12] To these purposes, *APIS* involved other North-American academic institutions, whether with rich papyrological holdings such as New York University, the Oriental Institute of Chicago and Stanford University, or with small-scale ones; and expanded to European collections, not only in university libraries (Gothenburg, Leiden, Lund and Oslo) but also in museums (the Hermitage in St. Petersburg and the British Museum, in particular its section with Greek and Coptic ostraca from Wadi Sarga).

Furthermore, *APIS* extended to including collections in non-European countries, in collaboration with United States and European institutions. There are published

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[7] Available as an individual section (*Papyri*) in Morgan Library & Museum's website.
[8] Available via the museum's catalogue (*Brooklyn Museum Collection*).
[9] See the collection overview, Harvard Library, n.d., and the papyrus records included in the library's catalogue, *Hollis*.
[10] On papyrological research at the University of Michigan, including the development of digital projects, see Gagos 2001, 517-26.
[11] Bagnall-Gagos 2001, 66; Center for the Tebtunis Papyri, "History."
[12] Bagnall-Gagos 2007, 66-67.

papyri of recent discovery, digitised in the context of United States archaeological missions: the ostraca from Berenike (O.Berenike)[13] and Trimithis (O.Trim.),[14] housed in Egyptian institutions, and the Petra papyri (P.Petra), preserved in the American Center of Oriental Research in Amman, where they have been reproduced with the multispectral imaging method by a team from Brigham Young University.[15] One more Egyptian collection was added to the *APIS* database thanks to the collaboration with the Oxford Centre for the Study of Ancient Documents (CSAD) in charge of the related imaging project: the digitised photographs of Greek papyri at Cairo, also available as *Photographic Archive of the Papyri in the Cairo Museum* on CSAD's website, generously shared with *APIS*.[16]

The idea of creating an overarching catalogue of papyrus collections complete with images may have been suggested by two previous initiatives which, with the analogue technology then available, aimed at pursuing a similar objective: the *International Photographic Archive of Papyri* (*IPAP*), later digitised as a CSAD project (as just mentioned), followed by the *IPAP* American Center, particularly close to *APIS* for its focus on United States collections and the inclusion of unpublished material. Established in 1969 by a number of European universities and sponsored by UNESCO, the *IPAP* produced negatives and prints of Greek (and some Coptic) papyri in collections that lacked photographs, notably the published Greek papyri of the Cairo Museum.[17] By the same token, addressing collections in the United States and Canada, the *IPAP* American Center, launched in 1978, built up an archive of negatives and prints of papyrus collections with a focus on those of small extent or not curated by a

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[13] The Berenike ostraca are preserved at the Supreme Council of Antiquities in Qift, Egypt (see the introduction to the re-edition of O.Berenike II 226 in *Papyri.info*, at <http://papyri.info/ddbdp/ddbdp;2016;2>).

[14] The location of the Trimithis ostraca is not specified in their editions, nor in their *Papyri.info* and *Trismegistos Texts* records. But, as they were excavated between 2004 and 2013, they are certainly housed in Egypt, since exportation of antiquities from this country has been made illegal in 1983 (Cuvigny 2009, 56, n. 9).

[15] Chabries-Booras 2001.

[16] The collaboration between the CSAD (through Alan Bowman) and *APIS* was announced in 2002 (Crowther-Sasanow 2002, 2) and started shortly afterwards (cf. Evans 2004-05, 4; Bagnall-Gagos 2007, 68).

[17] See the presentation of the *IPAP*'s work in Reid-Koenen 1973, 201-04, 213, and the subsequent progress reports: Van Rengen-Bülow-Jacobsen 1980, Bülow-Jacobsen-Van Rengen 1985, Van Rengen-Bülow-Jacobsen 1986 and Bülow-Jacobsen 1987. The *IPAP* also owns photographs of two other Egyptian collections, at the Coptic Museum of Cairo (Robinson 1987) and at the Graeco-Roman Museum of Alexandria (Van Rengen-Bülow-Jacobsen 1986, 99), and of Athenian ones (Reid-Koenen 1987, 20).

papyrologist,[18] including unpublished texts.[19] Like the *IPAP* and especially its American Center, *APIS* saw digitisation as a means not only to enhance the originals in terms of legibility but also to improve access to the collections as a whole, soliciting scholars' collaboration to complete their study.

For *APIS* collections' data to be usable in a single catalogue, detailed guidelines for imaging[20] and cataloguing[21] papyri and ostraca were collectively implemented[22] and published online via the website of Columbia University. The steps taken in this process were explained in the literature by the project leaders, Bagnall and Gagos, who accounted for their choices about the technology used, the procedures elaborated and the standards adopted.[23] The project paid great attention to the use of widespread standard formats to structure and uniform the data entries, thereby ensuring compatibility across systems. They thus resorted to the subset of the US MARC format for the cataloguing of manuscripts and to the Library of Congress Subject Headings, at the same time customising them to make them more suitable to the description of papyri. As for standards for online publishing, the project availed itself of the SGML encoding method, the then standard for the digital representation of texts and metadata, thereby complying with other web-based resources.[24]

Although the *APIS* guidelines for cataloguing and imaging were meant for their contributors, as they are freely accessible online they may be taken as a reference point, along with Gagos and Bagnall's papers, by any digitisation project involving papyri and ostraca. In fact, even before the launch of *APIS*, the standards used in the preliminary Michigan digitisation project were followed by van Minnen, who drew on their experience on image capture for the completion of the *Duke Papyrus Archive*;[25] also, for data entry in the Duke catalogue records, van Minnen chose the US MARC standard that would be adopted by *APIS* so as to facilitate subsequent integration with it.[26] Later

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[18] Wall 1980, 81.
[19] For example, photographs were taken of numerous papyri from the Tebtunis collection in Berkeley, which is largely unpublished (Center for the Tebtunis Papyri, "History").
[20] *APIS* 2006. This document, cited in Terras 2010a, 52, while still available on the web, is however no longer visible, as it is not pointed out in the related *APIS* section of Columbia University Libraries' site (*APIS* 2009).
[21] *APIS* 2013.
[22] Bagnall-Gagos 2007, 67-68.
[23] Gagos 1996, 17-19; Id. 1997; Bagnall 1997; Id. 1998, 545-52.
[24] Bagnall 1998a, 546-47; Bagnall-Gagos 2007, 68.
[25] Gagos 1996, 20; cf. Id. 1996, 18.
[26] Van Minnen 1995c.

on, the same format was employed for the records of the *Photographic Archive of the Papyri in the Cairo Museum*,[27] and the principles established by *APIS* were applied in cataloguing and imaging the largest collection in the world, the Oxyrhynchus Papyri housed in the Sackler Library at Oxford (*POxy: Oxyrhynchus Online*).[28] Outside the papyrological realm, *APIS*, the preliminary Michigan project and the *Duke Papyrus Archive* provided a model and inspiration for another early undertaking in digital classics, that is, the imaging of Oxford University's collection of squeezes of Greek inscriptions carried out by the CSAD.[29]

We can therefore say that the *APIS* initiative, with its shared set of standards for the digital representation of papyri, provided a decisive contribution for member institutions and beyond, including those that later developed their own catalogues, to start a digitisation effort, make substantial progress and disseminate their content on the web. By its conclusion in 2013,[30] *APIS* had provided scholars with abundant material which, still today, no doubt stimulates investigation into many collections: searchable information about a huge number of papyri, 40,000,[31] covering a large number of participating institutions' holdings, estimated at 50,000 items;[32] images for the majority of records, 30,000; preliminary data on several thousand unpublished fragments, with a description and sometimes images; and almost 6000 translations, for the purpose of making texts accessible to non-specialists.[33]

2.3 The diffusion of digitised papyrological collections worldwide

After the launch of *APIS* in 1996, as early as from the end of the same decade other major analogous projects started being developed, individually and then also in federations, certainly inspired by Michigan and Duke universities' undertakings and by *APIS*, as some of the researchers involved expressly mentioned.

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[27] As announced in Crowther-Sasanow 2002, 2.
[28] CSAD 1997; Bagnall 1998a, 551; *POxy*, "Imaging and Marking Up."
[29] CSAD 1995, 3. The project is now available as *Squeeze Collection.*
[30] For this date, see *Papyri.info*, "APIS;" Reggiani 2017, 95.
[31] See *Papyri.info*, selecting "All APIS records" in the "Collection" field.
[32] Bagnall-Gagos 2007, 68.
[33] Bagnall-Gagos 2007, 67-69.

First, in April 1997, images of papyri from the University of Heidelberg, a vast collection of around 10,000 items,[34] were made available on the Internet,[35] the starting point of the ongoing *Papyrussammlung des Instituts für Papyrologie* catalogue. Then, two digitisation projects of real-world collections were launched within a few years by the University of Oxford, with its newly founded Centre for the Study of Ancient Documents, established in 1995.[36]

The earliest CSAD papyrological project, still ongoing, addresses the digital cataloguing and imaging of the fragments published in the *Oxyrhynchus Papyri* (P.Oxy.) series, in particular those housed at the Sackler Library in Oxford,[37] which, together with the Oxyrhynchus papyri at the Bodleian Library, constitute the largest collection in the world, with over 500,000 items.[38] A pilot digitisation effort started in October 1997, only a few months after the launch of the Heidelberg collection catalogue, which resulted in the publication of background material on the Oxyrhynchus finds (an introduction, a guide and a digital version of a related Oxford exhibition) on CSAD's website at the end of the same year. Shortly afterwards, by September 1998, a number of papyrus records were made available online, relating to four recent volumes of the P.Oxy. series,[39] based on the standards set by *APIS* for metadata cataloguing and image capture.[40] This material formed the first nucleus of the current *Oxyrhynchus Online Image Database*, included in the *POxy: Oxyrhynchus Online* thematic collection on Oxyrhynchus and its texts, hosted in a section of the university website specifically devoted to institutional papyrological projects, *Papyrology at Oxford*. After the start, the *Oxyrhynchus Online Image Database* could thus develop as an independent project from the CSAD, thanks to a grant from the then Arts and Humanities Research Board.

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[34] See the homepage of the Heidelberg catalogue (*Papyrussammlung*) (also in Universitätsbibliothek Heidelberg 2019).

[35] See the announcement reported a few months later in CSAD 1997a, 2. A different date is however mentioned in the homepage of the Heidelberg catalogue (*Papyrussammlung*; also in Universitätsbibliothek Heidelberg 2019): the papyri would have started being digitised two years later, in 1999, until 2002.

[36] CSAD 1995, 1, esp. "Introducing CSAD."

[37] For detailed information on the imaging and the cataloguing processes of the Oxyrhynchus papyri, see *POxy*, "Imaging and Marking Up." The project is also mentioned in University of Oxford, "Oxyrhynchus Papyri."

[38] Egypt Exploration Society, "The Oxyrhynchus Papyri;" University of Oxford, "Oxyrhynchus Papyri."

[39] CSAD 1998, 1999a, 1999b.

[40] CSAD 1997b; Bagnall 1998a, 551; *POxy*, "Imaging and Marking Up."

A few years later, in 2002, the CSAD started working on the *Photographic Archive of Papyri in the Cairo Museum*, digitising slides and negatives of the published Greek papyri at the Egyptian Museum in Cairo (cf. above, p. 63).

One more pioneering CSAD project was implemented in those years, between 2001 and 2003, *Vindolanda Tablets Online* (*VTO*), one of the earliest digital editions of papyrological sources after the *Duke Databank* (cf. above, pp. 32-33). The enterprise could start thanks to financial support from the Andrew W. Mellon foundation.[41] This is not altogether classifiable as a digitised real-world collection, but rather as a digital edition of texts gathered by content type. While the Vindolanda tablets are housed in one institution, the British Museum, the chief aim of *VTO* (as well as of the *VTO* 2 updated re-elaboration) is to provide access to texts linked by the same provenance, rather than belonging to a particular conservation place.[42]

In the same period as the launch of the Heidelberg and Oxyrhynchus catalogues, in November 1997, another remarkable collection started being digitised, that of the University of Cologne, whose first digital images were distributed on the World Wide Web from March 1998.[43] This digitisation effort formed the basis of the current *Kölner Papyri* catalogue, comprising 3400 papyri, the majority of them unpublished, out of a vast collection of 10,000 items.

In the years following the launch of these individual catalogues, some institutions developed a collaborative approach, joining together to form cross-collection resources on the model of *APIS*. First, in 2003, three German university collections, Leipzig, Halle and Jena, began developing the *Papyrus und Ostraka Projekt*,[44] later expanded to integrate several collections, mostly German, thus evolving into the current *Papyrus Projekt* (2009).[45] The subsequent years saw the development of *PSIonline*, which started being implemented at the end of the 2000s[46] and was officially launched in 2013;[47]

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[41] *VTO*, "About This Site;" Pierce-Ratcliffe 2002, 1.

[42] Based on their characteristics, as above mentioned, *VTO* will be examined in the following chapter, focused on resources that provide direct access to papyri based on their content type. *VTO* 2 will be dealt with in chapter four, about resources that offer indirect access to the texts, foregrounding the data derived from them.

[43] Lundon 2007.

[44] Blaschek-Quenouille 2016; Quenouille 2016, 16-17.

[45] For an overview of *Papyrus Projekt*, see Quenouille 2016, 18 (where it presented its original name of *Papyrusportal*). For more specific questions, see Freitag et al. (2016), who detail its technical aspects, and Reggiani (2017, 99-102), who discusses issues of integration, both within the resource and with other papyrological databases.

[46] On the development of *PSIonline*, see Del Corso 2007, 167-73.

[47] CSAD 2013, 7.

initially centred on papyri published in the PSI series, it quickly expanded to other published papyri housed in Florence (P.Flor. and P.Laur.) and then in other collections. The *DVCTVS* project was also developed, from 2009,[48] devoted to Spanish collections. Besides these European federations organised on a national basis, there is a United States one, led by the University of California, Berkeley, to which smaller regional institutions add, *Berkeley & Regional Partners Database*, formerly part of *APIS*.

Other institutions followed an individual approach, on the model of the Duke, Heidelberg, Oxyrhynchus and Cologne catalogues.

In the United States, the trend towards the integration of collections, set in with the *APIS* network, reversed with the conclusion of this project and the consequent creation of individual catalogues within libraries' websites, albeit based on *APIS* legacy data. Worthy of special mention are three large-scale catalogues of major collections: Michigan's *APIS UM*, *Yale Papyrus Collection* and the *Berkeley & Regional Partners Database* with the participation of a few small collections. Another notable collection has been comprehensively digitised, in this case independently from *APIS*: that of the Morgan Library & Museum in New York (*Papyri*). To these resources the *Duke Papyrus Archive* adds, the pioneer catalogue now integrated into *APIS* but still maintained to this day on Duke Libraries website.

In Europe, too, very extensive individual catalogues were implemented, such as the *Berliner Papyrusdatenbank*, the section on papyrological holdings in Vienna's *ÖNB Digital*, Manchester's *Papyri Collection* and the *Chartes* database of Herculaneum papyri, the vast majority of which is housed in the National Library of Naples.

Other collections, both United States and European, are not provided with a dedicated catalogue, so that papyrus records appear alongside other institution's holdings, as occurs, for instance, for the British Library and the Bodleian Libraries papyri. For these broad-ranging resources, the analysis will also consider whether papyri can nevertheless be easily discovered and called up from the portal of the library or museum website, and searched by relevant papyrological aspects.

Outside Europe and the United States, there are a few collections that were digitised within international projects, namely, the ostraca from Berenike and Trimithis,

[48] *DVCTVS*, "The project."

the Petra (pp. 62-63) and the Cairo papyri (pp. 62-64, 66-67). Also worth pointing out is the project devoted to the finds from the Dead Sea, *Dead Sea Scrolls*, launched by the Israel Antiquities Authority, noteworthy for the fruitful collaboration between humanities scholars and conservators on one hand, and computer scientists on the other hand; these comprised experts of advanced imaging and database technology, the latter from the Google Research and Development team in Israel. The resource thus offers outstanding features such as high-resolution images, including multispectral ones, of the complete collection, composed of almost a thousand items, which are both browsable and searchable;[49] rich background information on the physical and the digital collection;[50] and the possibility for users to comment on the source material.

It has to be noted that not all papyrological collections are provided with an online catalogue, whether specific or general-purpose, including very valuable ones, such as those at Milan's Università Statale,[51] in Strasbourg (at the Bibliothèque National et Universitaire)[52] and in Lille (at the Palais des Beaux-Arts).[53] Among the collections outside Europe and North America that have not been digitised, a remarkable one is that of the Graeco-Roman Museum of Alexandria, with nearly 500 papyri recorded in *Papyri.info*, almost all devoid of images, for which a catalogue complete with pictures is therefore a great desideratum.[54]

2.4 *APIS* collections in *Papyri.info*

2.4.1 Collections mainly available via *Papyri.info*

Among the collections digitised in cooperation with *APIS*, some are now accessible via individual comprehensive catalogues, fully searchable, notably those relating to Duke, Michigan and Berkeley papyri, which, for their wealth of materials, will be analysed in a dedicated section (2.5.3). By contrast, other collections rely on the

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[49] *Dead Sea Scrolls*, "About the Project."
[50] *Dead Sea Scrolls*, "Learn About the Scrolls."
[51] On this collection, see the information in *Trismegistos Collections*, at <www.trismegistos.org/collection/229>.
[52] On this collection, see *Trismegistos Collections*, at <www.trismegistos.org/collection/322>.
[53] On this collection, see *Trismegistos Collections*, at <www.trismegistos.org/collection/188>.
[54] On the announcement of this museum's catalogue, see Reggiani 2017, 93, n. 118.

APIS data flowed into *Papyri.info* as the only or the principal source of online information, as is worth pointing out in this section. Their owning institutions' websites usually provide overviews of the collections and point users to *Papyri.info* for records of the items; some also contain a basic catalogue, in which case it is interesting to make a comparison with the information available in *Papyri.info* and to note their degree of integration.

Examples of digitised collections based on *APIS* legacy data in *Papyri.info* include two major ones such as Columbia's and New York University's. Columbia's collection, comprising over 2000 papyri and 3600 ostraca, largely unpublished,[55] has been entirely catalogued in collaboration with *APIS* and provided with numerous images (1500); thus, Columbia University Libraries' website, besides providing an overview of the main contents of the collection, directs to *Papyri.info* for descriptions of all items and for pictures.[56] In a similar way, the website of New York University's Center for Ancient Studies[57] points to *Papyri.info* for a partial inventory of its fragments with some texts, consisting of 880 records.

Two European collections previously in *APIS*, pertaining to the universities of Leiden and Lund, are also provided with overviews in their institutions' websites and with references to *Papyri.info* for catalogue information on their texts.[58] The Leiden collection housed at the university Papyrological Institute contains nearly two hundred published texts, all digitised, and as many unpublished.[59] As for the Lund collection, which preserves eight hundred items,[60] mostly unpublished,[61] it has been completely catalogued and imaged within *APIS*, and all the images are available, embedded in the records. Unlike the collections hitherto mentioned, the staff of Lund's library have contributed information on their papyri to another catalogue as well, the *Alvin* platform for cultural heritage material from a consortium of Swedish university libraries. They have shared a selection of 60 papyrus records,[62] complete with the metadata created during the *APIS* project and linked to the respective *Papyri.info* records. Hence, *APIS*

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[55] Columbia, "Papyri & Ostraca."
[56] Columbia, "Papyri & Ostraca;" Id., "Finding ostraca and papyri."
[57] New York University, n.d.
[58] Leiden Papyrological Institute, n.d.; Lund University Library 2020.
[59] Leiden Papyrological Institute, n.d.
[60] Lund University Library 2020.
[61] See *Trismegistos Collections*, at <www.trismegistos.org/collection/207>, in "Inventarisation."
[62] Papyrus collections in *Alvin* may be retrieved easily, with searches by material, such as papyrus or wood, filtering the results by institution. Browsing by language and date (i.e., century) is also available.

data has also been useful to disseminate information on the collection across other resources, so as to raise further attention on the web about the discipline and the owning institution.

Other collections digitised in collaboration with *APIS* are catalogued in the respective library or museum websites as well, but to a small extent, with a limited number of papyrus records, interspersed with other materials. For them, too, *APIS* and now *Papyri.info* are therefore an indispensable complement to the institutional catalogue for comprehensive information.

Thanks to the cooperation with *APIS*, the Hermitage Museum's papyrological was assessed with regard to its conservation state,[63] was catalogued and partially imaged[64] after having been long inaccessible.[65] *Papyri.info* thus shows 560 *APIS* records for the Hermitage papyri,[66] mostly relating to unpublished fragments (400). As opposed to this, the museum's catalogue (*Hermitage Museum Collection Online*) presents records of only five papyri (as results from a search of the keyword "papyrus"), also with no reference to *Papyri.info* for further data. Yet we must note that most images of Hermitage papyri in *Papyri.info* have been inaccessible for some years, as their links, which point to the previous Columbia University's servers, no longer work; the platform thus provides pictures only for seventy of these items.

Another digital collection chiefly accessible through *APIS*/*Papyri.info* records is that of the papyri of the University of Chicago, preserved at the Oriental Institute and the University Library, the latter as part of the Goodspeed Manuscript Collection. Through the *APIS* dataset, *Papyri.info* contains many more records of Greek papyri of these collections than their catalogues do.

Some collections that also started their digitisation in cooperation with *APIS* are rather provided with a dedicated section in their library catalogue, complete with an overview, thereby being searchable separately from other holdings. However, only a few, basic search criteria are available, so that users need to resort to *Papyri.info* for more articulated search functions.

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[63] Lau-Lamb 2008.
[64] Bagnall-Gagos 2007, 66-67; Chepel 2018, 61.
[65] Bagnall-Gagos 2007, 66.
[66] The complete *APIS* dataset of the Hermitage papyri is retrievable with a search of this museum among *Papyri.info* metadata, whereas browsing among *APIS* collections will return a lower number of records for this institution.

One is the collection at Stanford University, available online via a section of Stanford Libraries' website, *Classics Department Papyri Collection*. These papyri are also included in the *Berkeley & Regional Partners Database*, of which Stanford is a member institution. *Papyri.info* and especially the *Berkeley Database* prove more complete than the Stanford catalogue, which also contains poor information on the papyri. Like Stanford Libraries, Princeton University Library has created a section for its papyrological collection within its catalogue (*Princeton Papyri Collections*), less comprehensive than *APIS* data on *Papyri.info*, but with a higher number of images.

The collection of the Museum of the University of Pennsylvania has also taken great advantage of the partnership with *APIS*. Like Stanford's and Princeton's, it is provided with an individual section in its institutional website, but in a different form, as it is included in Robert Kraft's personal page (Kraft 2009) rather than in the library catalogue. The page gathers an introduction to and a history of the collection, both very in-depth, a comprehensive inventory list and a substantial image database created in collaboration with the university's Schoenberg Center for Electronic Text & Image. This digitised collection is therefore a good example of collaboration between papyrologists, who provided detailed information on the collection and cataloguing data, and librarians, who catered for imaging and online publication. The images are only accompanied by the inventory number of the papyri, and they are not linked to the related information available in the inventory list; but the cooperation with *APIS*, mentioned in the project's home page, made it possible to implement connections of the two separate datasets, as can be seen in *Papyri.info*, where records are complete with external links to the related picture.

2.4.2 *APIS* data in *Papyri.info*: integration and usability

This sub-section analyses *APIS* collections in *Papyri.info*[67] from the viewpoint of the usability of their records, focusing on the integration of metadata derived from the other databases available through the platform.

In *Papyri.info* records, information is reported in different sections, each relating to a different source database (as can be seen in fig. 2.1 below, reproducing a sample record). The *APIS* data that we encounter first is descriptive metadata on the papyrus

[67] *APIS* collections are listed at <https://papyri.info/browse/apis>, each hyperlinked to its papyrus records.

reported in the central section. It is preceded by two other sets of metadata, from the *HGV* database of documentary papyri and from the *Trismegistos* platform for the study of papyrological and epigraphical texts. The records are thus rich in information, even though the manner in which the metadata is presented, divided by data source and reported in sections juxtaposed to one another, rather than distinguished by topic and amalgamated, while understandable from the standpoint of database architecture, leads to a few repetitions, concerning the fields of title, publication, subject, date and language. Nevertheless, the *APIS* section contains information not found in the *HGV* and in *Trismegistos*, and is in turn complemented by the data from these partner projects. In particular, *APIS* metadata includes more details on the papyrus content, reported in the "Summary" and sometimes in the "Subjects" fields, a reference to published images, the indication of corrections in the *Berichtigungsliste* (in the "Citations" field) and a description of the handwriting. Sometimes, *APIS* data is complete with information on the publication status of the papyrus, reported in the "Note" field: it may be expressly pointed out whether a papyrus is unpublished[68] and, if it is under publication, until when it is reserved, after which the holding institution may be contacted.[69]

In comparison to *APIS* metadata, the *HGV* and *Trismegistos* sections rather offer the possibility to gather related texts, whether via internal links within *Papyri.info*, as allowed by the *HGV,* or via external links to the *Trismegistos* platform. The *HGV* reports the place of origin of the papyrus, with the ability to retrieve more texts with the same provenance; it also allows browsing texts dating to the same years and, from the editorial standpoint, texts published in the same volume and in the same series. In addition to this, the *HGV* provides access to image-based resources that contain a picture of the papyrus, namely, collection catalogues, the palaeographical *PapPal* database of dated papyri, and the *Les archives de Dioscore d'Aphrodité en images* thematic collection. Further connections are established by *Trismegistos* data: with texts not only from the same city but also from the same nome, which mention the same people, and belonging to the same archive; other linkages, not directly pertaining to the content of the papyrus, concern texts from the same physical collection or edited by the same scholar. Importantly, *Trismegistos* contains a more complete reference to multiple

[68] E.g.: <http://papyri.info/hgv/3817a>, <http://papyri.info/apis/columbia.apis.p421>.
[69] E.g.: <http://papyri.info/apis/columbia.apis.p416>.

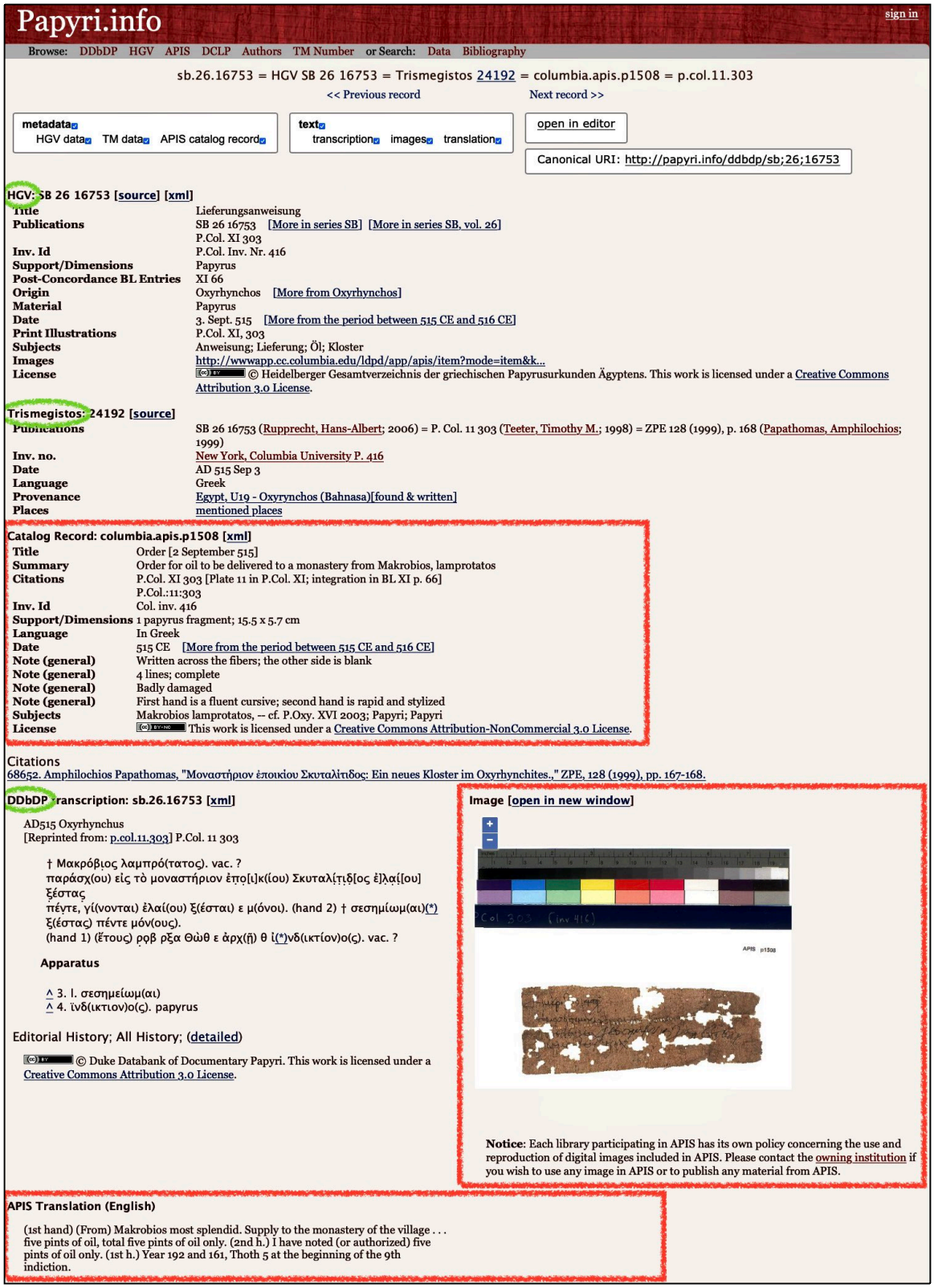

FIG. 2.1 A sample record of *Papyri.info* relating to an item from a former *APIS* collection, Columbia University's. Data merged from the *APIS* catalogue (highlighted in red) are displayed along with that from other partner databases (highlighted in green).

editions of a text:[70] in the example provided, *Trismegistos* reports three editions, as

[70] Zellmann-Rohrer 2018.

opposed to the two pointed out in the *APIS* section, viz., the *editio princeps* and the *BL* correction, and in the *HGV*, viz., the *editio princeps* and the latest edition, in the *Sammelbuch*.

Like the subsets in *Papyri.info*, *APIS* collections can be explored in several ways: by provenance (both city and nome), date and language, or with free-text searches into the metadata; the texts of the papyri, contributed by the *Duke Databank*, are also searchable.

Besides metadata, *APIS* provides a picture of the artefact created within the framework of this project, available in the record itself or via an external link reported in the *HGV* section, or in both ways (as in the instance in fig. 2.1 above); and a translation.

The viewer that can be opened in a separate window is efficient for browsing and downloading the images. Those embedded in *Papyri.info* records are of excellent quality, showing a high degree of legibility even at a strong enlargement. According to *APIS* standards, images were created at a resolution of 600 dpi/ppi. This standard was deemed by Bagnall and Gagos both practical to achieve and suitable for papyrologists' needs, that is, sufficient to represent the clarity of the ink in contrast with the background, legibility being the main purpose of papyrus imaging.[71] A 300 dpi resolution was employed to capture large documents, while also providing 600 dpi images of portions thereof.[72] Indeed, a resolution of 600 dpi is altogether appropriate, as it is recommended for images of manuscripts by a reference institution such as the Library of Congress;[73] it is considered suitable for digital surrogates created not only to provide access to the objects, for which a minimum of 400 dpi is sufficient, but also for research purposes and for reproduction.[74] Today, 600 dpi has become the normal resolution for papyrus images, 300 dpi being the minimum requirement when it is not possible to work with a flat-bed scanner but only with a camera and the original is of large size.[75]

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[71] Bagnall-Gagos 2007, 69; Bagnall 1997, 154; Bagnall 1998a, 549. On legibility as the aim of digital capture of papyri see also Bülow-Jacobsen 2020, 59, 66.
[72] Bagnall-Gagos 2007, 69.
[73] Terras 2008, 43.
[74] Terras 2008, 43.
[75] Bülow-Jacobsen 2020, 66.

To summarise, *Papyri.info* took benefited enormously from the merging of *APIS*, with the abundant material offered. In turn, while the individual *APIS* subsets have been maintained in the platform so as to enable specific research on the single collections,[76] at the same time they were enriched by further information and by papyrus texts from *Papyri.info*'s associated databases. Moreover, *LDAB* records can now be retrieved alongside papyri from other collections within an overarching papyrological resource, and have become open to contribution from the papyrological community through the *Papyrological Editor* collaborative editing platform.

2.5 Catalogues of United States collections

2.5.1 Introduction

Some United States collections are available via institution-based catalogues able to perform precise searches and to retrieve texts according to several papyrological categories. While still prioritising direct access to primary sources, they also allow advanced exploration of their collections, based on the custom encoding of metadata and on diverse modes of accessing and viewing the items, i.e., search by keyword and metadata, browse by multiple facets and exhibitions. They relate to three large-scale collections, that is, Duke, Michigan and Berkeley.

Besides these three major catalogues, on which the analysis will focus, there are a few other ones, with a data model centred on visibility on the institution's website and simple functionality through basic browsing options, at which we may now take a brief look.

Yale Papyrus Collection, built on the basis of a comprehensive *APIS* dataset, is worthy of note for its extent. It addresses the almost entirety of Beinecke Library's large-scale collection of almost 7000 papyri,[77] presenting records complete with images,

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[76] It has to be mentioned that, for some *APIS* collections, the individual subsets (cf. p. 49, n. 2) prove less complete than the data in the whole *Papyri.info* database. A fuller list of their items, therefore, is retrievable with an overall metadata search, as occurs for the Hermitage Museum and Oslo collections, or with the selection of the related publication in the "Series" field, as for the Petra papyri and the ostraca from Berenike and Trimithis. Seemingly, updates of these *APIS* collections have been entered in the general *Papyri.info* dataset only.

[77] Cf. Yale University Library, n.d., which informs that *Papyri.info* contains records of all its papyri. The *Yale Papyrus Collection* catalogue presents a slightly lesser number of items (6500) than *Papyri.info*. *Trismegistos Collections* rather reports the figure of 15,000 texts for the Yale collection (<www.trismegistos.org/collection/242>, esp. "Inventarisation").

made available in the public domain (as reported in each item). The papyri not yet catalogued therein, a relatively small number, can nonetheless be found in *Papyri.info*, provided with metadata records, to which the resource refers in the collection overview.[78] The images are usable, although their resolution varies: their quality is not always so high as would be required for manuscript materials, especially damaged.

The collection at the Morgan Library & Museum in New York (*Papyri*) is available in a dedicated section of this institution's digitised manuscript collection, with records of eight hundred items. Like *Yale Papyrus Collection*, it distinguishes itself for its comprehensiveness, as the whole papyrus collection has been catalogued and imaged;[79] moreover, it offers high-quality images, both conveniently viewable online and downloadable. On the other hand, a weakness is that it does not provide sufficient information on the papyri, as only the edition abbreviation is present, with no indication about the content, along with a mention of the acquisition of the collection.

Also worth mentioning, though relating to a single item, is the digital surrogate of a substantial portion of a papyrus codex, preserved at Brigham Young University. It contains a commentary by Didymus the Blind on the Old Testament (P.BYU I), imaged and made available as *Didymus Papyrus*; other leaves of the same manuscript are housed in four institutions worldwide. While a virtual reunification of the codex has not been possible, this surrogate is of great interest for the quality of the images and of the navigation through the codex pages, and for the thorough information included.

2.5.2 The *Duke Papyrus Archive*

Duke University's was the first papyrological collection to become available online, with the *Duke Papyrus Archive* (*DPA*), in 1995, a year before the launch of *APIS* (cf. above, p. 27). While preceding *APIS*, the *DPA* was created taking into account the future integration with it. Being aware of the plans for the development of *APIS*, Peter van Minnen, the papyrologist in charge of the *DPA*, and Duke's librarians chose the same standards for imaging and cataloguing as the federated catalogue (p. 64), and then shared their dataset with it. At the same time, the original *DPA* was maintained, and still

[78] Yale University Library, n.d.
[79] Bagnall 2021.

today this pioneering resource is accessible on Duke University Libraries' website, along with the other institutional digital collections.[80]

The work on the *Duke Papyrus Archive* was well documented by van Minnen in a series of contributions made available in the resource, comprehensively addressing the cataloguing (van Minnen 1995b), the imaging (Id. 1995a), the online publication (Id. 1995c) and the history of the project (Id. 1995c).[81] One of the contributions (Id. 1995b) was also published in a papyrological journal, a sign of recognition of the significance of this resource for research in the discipline.

The idea of implementing a catalogue of the Duke papyri, a vast body of almost 1400 items largely unexplored, was first conceived by John Oates, a papyrologist at that university, in charge of another major early digital project, the *Duke Databank of Documentary Papyri*, with William Willis. The enterprise started in 1993, having received funding from the National Endowment for the Humanities. It was undertaken by Duke's papyrologists and librarians in close cooperation from the very beginning, with their preparation of a successful funding proposal, and throughout the work of cataloguing and online publishing.

The digitisation process adopted at an initial stage, constrained by the limits of the then available technology, consisted of creating two independent datasets for the metadata and the images of the papyri, with no possibility of interlinking. The two types of data were also meant to be distributed with two different methods, viz., an online catalogue for the records and a CD-ROM for the images, which had to be consulted separately. But the resource providers became soon aware of the potentialities of the Internet, especially the World Wide Web, which was becoming wide-spread in those years (cf. pp. 26-27), for improving the usability of the digital collection: only web technology, with its enhanced hyperlinking capability, permits to interconnect large sets of descriptive data and images, thereby enabling instant access to the latter and the simultaneous consultation of the two datasets. As early as in 1995, only three years after the project's inception, the database of the whole collection was completed and released on the web.[82]

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[80] <https://library.duke.edu/rubenstein/scriptorium/papyrus/texts/homepage.html>.
[81] See the *DPA* home page (a reproduction of which is in fig. 2.2), esp. the section "Information about the Duke Papyrus Archive."
[82] Van Minnen 1995c.

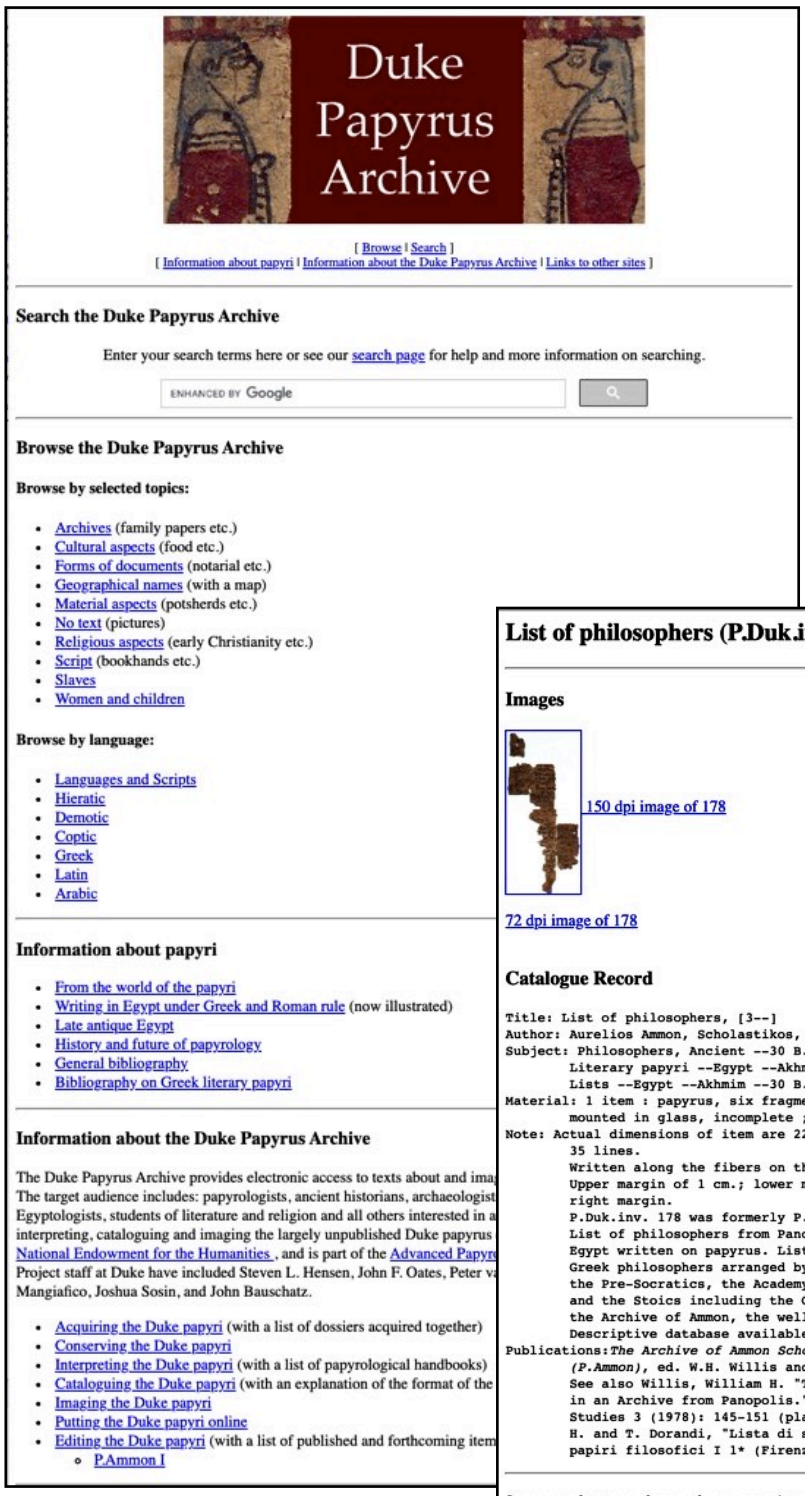

FIG. 2.2 The home page of the *Duke Papyrus Archive*

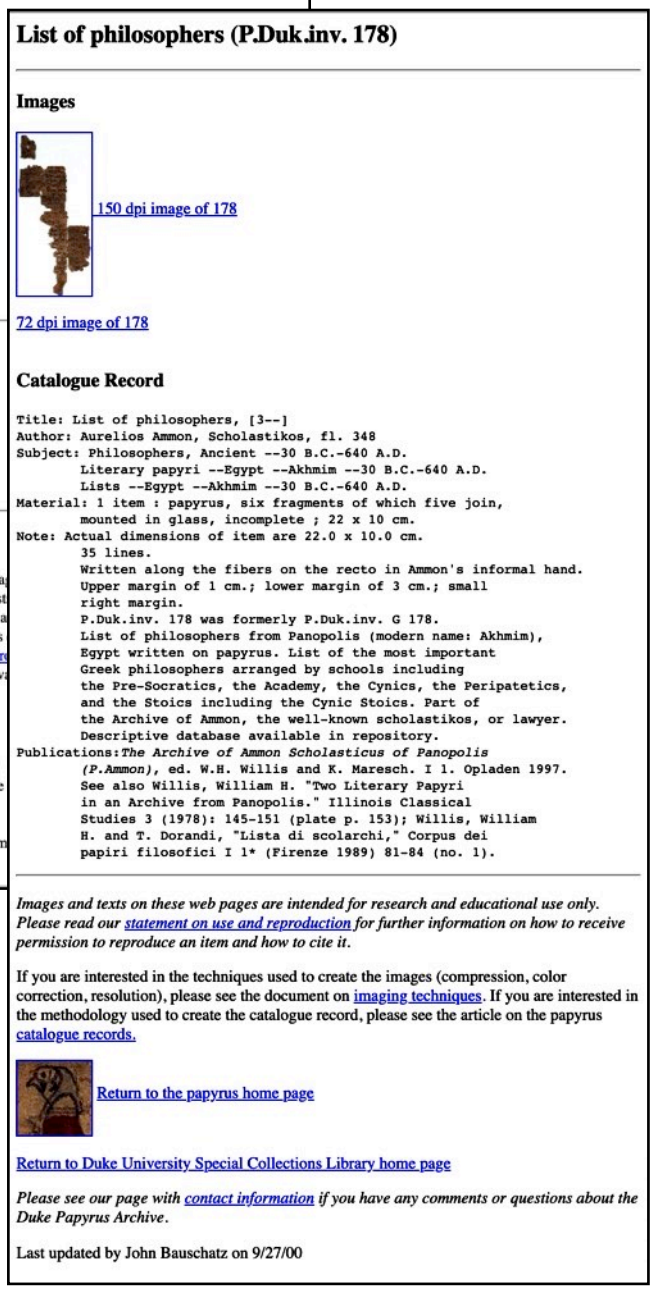

FIG. 2.3 A sample record of the *Duke Papyrus Archive*

The *DPA* records are almost entirely complete with images. These are usable, even though they are not in high resolution. Whereas the original images were captured at 600 dpi,[83] those uploaded on the database present a maximum resolution of 150 dpi (as indicated in the records; see the example in fig. 2.3 above), arguably to make them more manageable for storing on Duke's system and for downloading over the early networks. Images can be a little enlarged on the *DPA*'s viewer, but it is possible to download them and zoom in on them at a sufficient degree of legibility. The problem of a balance between high resolution and size of the resulting file was faced by another early project, the aforementioned CSAD's image database of Oxford University's squeeze collection,[84] which took inspiration from the early papyrological digitisation projects (cf. p. 65). The CSAD adopted a very similar solution to the *DPA*: as a compromise, while capturing the squeezes at resolutions of 300 and 150 dpi, images of 150 or even 75 dpi were made available for download, further reduced with compression techniques for rapid distribution without perceptible loss of definition. Such quality was deemed satisfactory for most epigraphical purposes:[85] for epigraphy, as well as for papyrology, the focus of imaging is on the writing, rather than on the features of the material support, so as to help reading problematic texts.

Records are provided with detailed information on the papyri, while a precise dating has not been included, but only a general one relating to the ancient age, and with bibliography. On the other hand, maybe owing to the limitations of the early technology, only free searches are possible (via a Google Search applet); however, the resource providers offered useful searching aids, such as vocabularies of terms and lists of named entities occurring in the descriptions, and browsing utilities. The papyrus images are intended for research and educational purposes, as pointed out in each record, while the payment of a fee is required for commercial purposes.[86]

As well as serving the purpose of research, this resource devotes particular attention to providing useful information for teaching and for engaging non-specialists. The instantaneous availability of pictures is already a relevant characteristic to teaching

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[83] Van Minnen 1995c.
[84] On this project, today available as *Squeeze Collection*, see the presentation in CSAD 1995, 3-4.
[85] CSAD 1995, 3-4.
[86] See the information reported in the latter part of each papyrus record. Even though the link to indications on use and reproduction is not working, they are accessible from the *Rubenstein Rare Book & Manuscript Library* section: see Rubenstein Library, n.d.

purposes, as van Minnen underscored.[87] Furthermore, the engagement with students and non-experts is fostered by the provision of general articles aimed at the contextualisation of the papyri, and of annotated bibliographies (see fig. 2.2, esp. the section "Information about papyri"). The ability to browse content by topics also makes it easier for new users to familiarise themselves with the variety of aspects of the ancient world to which this collection testifies (see fig. 2.2, esp. "Browse the Duke Papyrus Archive").[88] The pages dedicated to the select topics may serve research purposes as well, to retrieve papyri relating to specific subjects, which may be difficult to find with a simple free text search, as is the case, for example, of documents referring to women and children (in the "Women and children" section).

As for the aim of generating new evidence, a relevant aspect was the decision to digitise the whole collection, including the many unpublished texts and even very small fragments, for the possibility for these to join others, as van Minnen underlined.[89] A large number of records of unpublished papyri was made available, in fact almost all the collection, whose published texts only totalled forty at that time,[90] and van Minnen expressly invited the world of scholarship to provide their contribution.[91]

The outstanding features of the *DPA* are therefore the provision of contextual information on the papyri and on papyrology, the possibility of effective browsing by topic, hence by intellectual content in an articulated way, and the attention to the dissemination of papyrology among scholars of different disciplines, students and possibly the wider public. Another remarkable characteristic of the *DPA* is the extremely detailed information on the papyrus collection, in the form of thorough overviews (in the "Information about the Duke Papyrus Archive" section, especially "Acquiring the Duke Papyri" and "Conserving the Duke papyri"), while the browsing utility of main contents and attested languages integrates the information with relevant examples. Lastly, a feature of the *DPA* that is seldom found in collection catalogues is a comprehensive illustration of the digital project, focused on the advantages of online publication and on the key issues of standards and compatibility across resources.

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[87] Van Minnen 1995c.
[88] Van Minnen 1995c.
[89] Van Minnen 1995c.
[90] Van Minnen 1995c. Later on, in 2004, the number of published Duke papyri was nearly a hundred (*DPA* 2004).
[91] Van Minnen 1995c.

On Duke University Libraries' website, the *DPA* is already accessible from the *David M. Rubenstein Rare Book and Manuscript Library* and the *Duke Digital Collections* portals, with a search of the keyword "papyrus." Moreover, it might be useful to add information on the Duke papyri, providing access to the *DPA*, in another Duke Libraries' portal, the *Early Manuscripts collection*, for further increasing the visibility of this database.

2.5.3 The *APIS UM* Michigan catalogue and the *Berkeley & Regional Partners Database*

The papyrus collections at the University of Michigan and at the Center for the Tebtunis Papyri of the University of California, Berkeley, the largest ones in the *United States* (their size is estimated, respectively, at 18,000[92] and 26,000 papyri[93]) were extensively catalogued during the *APIS* project, as results from their datasets in *Papyri.info*. The cataloguing process has further progressed to a remarkable extent after the conclusion of *APIS* on their institutional catalogues: currently, the *APIS UM* catalogue, hosted by the University of Michigan Library, comprises as many as 18,000 records;[94] the *Berkeley & Regional Partners Database*, accessible from the website of the Center for the Tebtunis Papyri hosted by the University of California, Berkeley, Library, contains 11,800 items.[95] As for the imaging process, although this has not proceeded so rapidly as the cataloguing, the number of pictures is nonetheless considerable, as indicated in the datasets in *Papyri.info*: the Michigan papyri are provided with images in almost 4000 records, available via links to the *APIS UM* catalogue, and the Berkeley papyri with 1500 images, whether embedded or linked to the *Berkeley Database.* The updating of the two digital collections occurs on their institutional catalogues only, as we may infer from the number of records, higher in *APIS UM* and in the *Berkeley Database* than in *Papyri.info*, and from the two projects' overviews.[96]

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[92] University of Michigan, "Papyrology Collection;" Verhoogt 2017, ch. 1.
[93] Center for the Tebtunis Papyri, "Overview."
[94] See *APIS UM* home page (<https://quod.lib.umich.edu/a/apis>, esp. "Collection size") and Verhoogt 2017, ch. 1. In fact, the number of catalogued items seems to be even greater: the same *APIS UM* home page, in another section, "Collection access," mentions over 26,000 "images/descriptions," directing to the catalogue's papyrus list.
[95] <https://www.lib.berkeley.edu/libraries/bancroft-library/tebtunis-papyri>. The number of records in the Berkeley database results from a search performed without any value, which returns the complete results.
[96] See the notices in *APIS UM*'s home page, and in Center for the Tebtunis Papyri, "About the Database."

Both collections have made available metadata and images of unpublished papyri, which represent a substantial part of them.[97] The publication of the unpublished papyri of the two collections needs permission from the curators; the Michigan collection has a five-year limit for the reservation of a papyrus.[98]

Both the Michigan and the Berkeley catalogues adequately document their material collections in different formats and levels of communication, Berkeley's being especially notable for its exceptional wealth of information. The latter also distinguishes itself for its accurate illustration of the digital content and of the design of the database.

In more detail, the *Papyrology Collection* page of the University of Michigan's Library offers information for scholarly purposes such as a reference to *Papyri.info* for searches of texts held at other institutions and a very detailed explanation of the process followed for the papyrus conservation. Furthermore, a unique feature of the Michigan catalogue is the provision of reports and correspondence relating to the acquisition of papyri, available both as scans of the originals and as HTML text for browser display, with links to the records of the mentioned items;[99] although catalogues usually provide an overview or a list of acquisitions of papyri, the possibility of instant access to the related sources represents a further contribution to the study of museum archaeology with its complex events (cf. p. 22). The Michigan digitised collection also aims at the involvement of interested users in the wider public through virtual exhibitions, among which one in particular is specifically thought for school students, "Education in Ancient Egypt." For the same purpose, the *Papyrology Collection* page offers an enhanced digital representation of one of the collection's highlights: substantial remains of a codex with the letters of St. Paul (*TM* 61855), the oldest witness of this text, part thereof is preserved at the Chester Beatty Library in Dublin. The goal is to make the object known to an audience of all levels, with the addition of a literal translation alongside the image of each page, notes to point out differences from the canonical text, and modern references for the text divisions. The effect of virtually leafing through the codex pages aims at involving the public by simulating the real-world experience. The

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[97] See the information in Center for the Tebtunis Papyri, "About the Center," for the Berkeley collection. As for the Michigan papyri, the unpublished texts total two thirds of the holdings, as results from the *APIS UM* catalogue, whose advanced search mask offers a search option for retrieving items by publication status.

[98] University of Michigan, "Papyrology Collection;" Center for the Tebtunis Papyri, "About the Database."

[99] University of Michigan, "Acquisition Reports."

representation also includes information more specifically of interest to the papyrologist, such as a detailed description of the handwriting and of the punctuation system used.

Even more than the Michigan's *Papyrus Collection* web page, the website of the Center for the Tebtunis Papyri presents abundant contextual material. It offers extensive information about the physical collection through content overviews, a historical note, thematic collections on types of papyrus findings and on ancient archives (in the "About" and the "Collection" sections), and exhibitions on various aspects of daily life both in Tebtunis and in the rest of Egypt in the Graeco-Roman period (in "Virtual Exhibits"). The accessibility of the exhibitions to everyone and the provision of a "Glossary of Technical Terms" particularly signify the attention to students and non-experts. The online exhibitions have been created by virtually reunifying papyri and archaeological objects unearthed in the same excavations, but now preserved in two different institutions at Berkeley, viz. the Bancroft Library and the Museum of Anthropology.[100] For instance, the exhibition "Ethnic Identity in Graeco-Roman Tebtunis" explores the distinctive traits of Greeks, Romans and Egyptians in Tebtunis on the basis of evidence provided by papyrus texts, mummy portraits, writing tools and other archaeological objects, as well as digitised archival photographs of the archaeological site. Besides items from Berkeley collections, the exhibition shows a few ones preserved in other institutions, such as digitised photographs from the Egypt Exploration Society (London) and a picture from a manuscript in the Morgan Library in New York. As for the documentation on Berkeley's database, it addresses the types of information that is possible to explore, provides directions to perform complex and effective searches, and a reference to *Papyri.info.* It reports on their digitisation policy, namely, on the criteria according to which the cataloguing has been prioritised.[101] We are thus informed that the first papyri to be digitised were the most fragile ones and those that formed a representative sample of various text categories and aspects of the ancient world, so that there may be relevant material for scholars with different interests.

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[100] Center for the Tebtunis Papyri, "Online Exhibits."
[101] See Center for the Tebtunis Papyri, "About the Database."

The Michigan and Berkeley catalogues are searchable in many ways according to useful categories. However, whereas the *Berkeley Database* offers, when relevant,

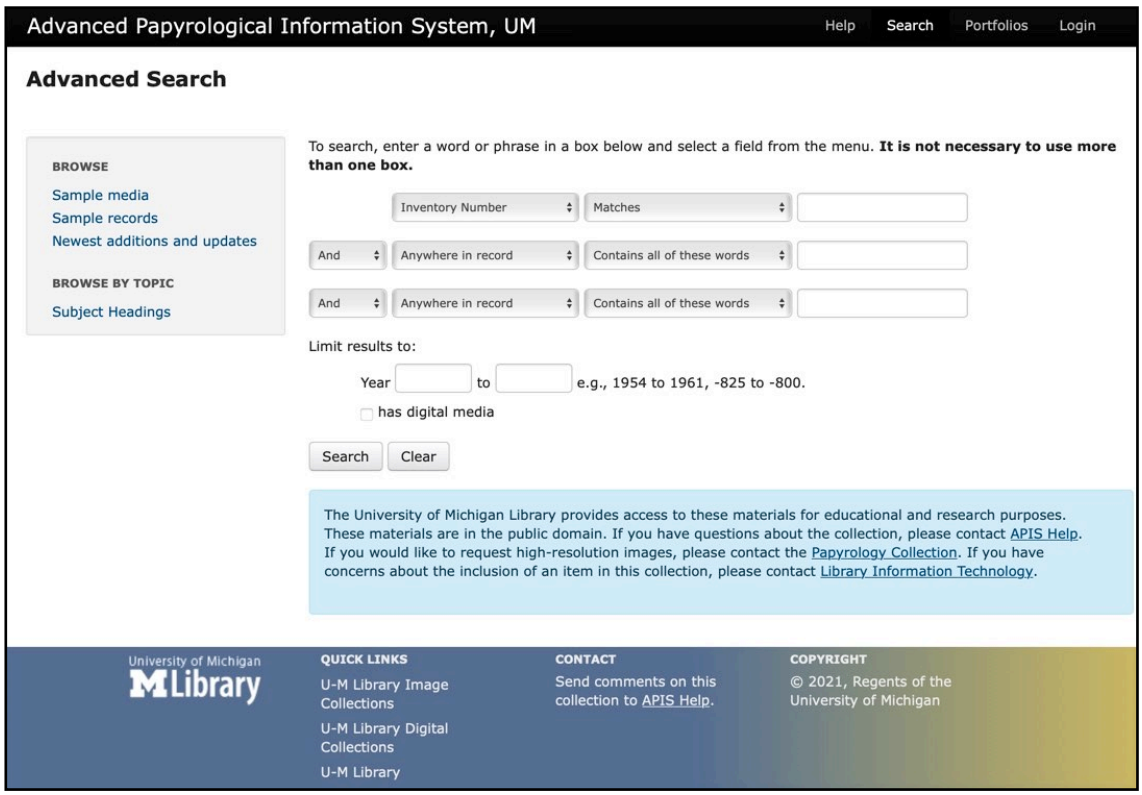

FIG. 2.4 The "Advanced Search" mask of the *APIS UM* catalogue of the Michigan collection

browsing lists in the cataloguing fields (fig. 2.6), *APIS UM* needs to be queried via free

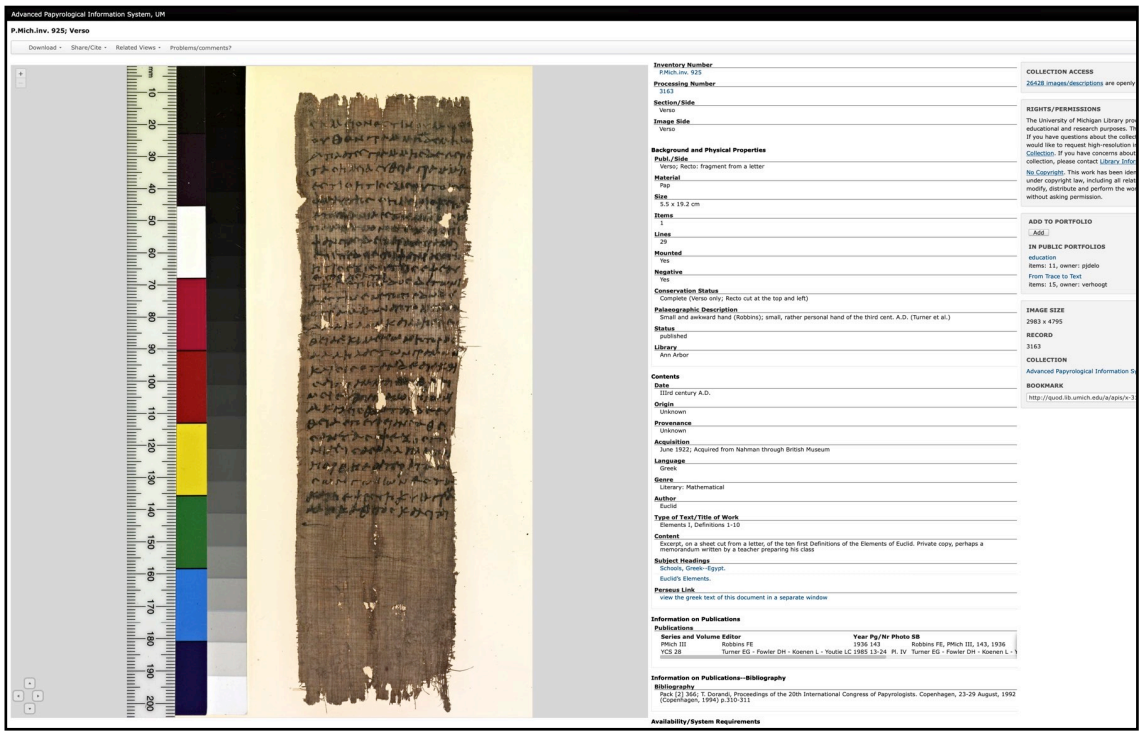

FIG. 2.5 A sample record of the *APIS UM* catalogue

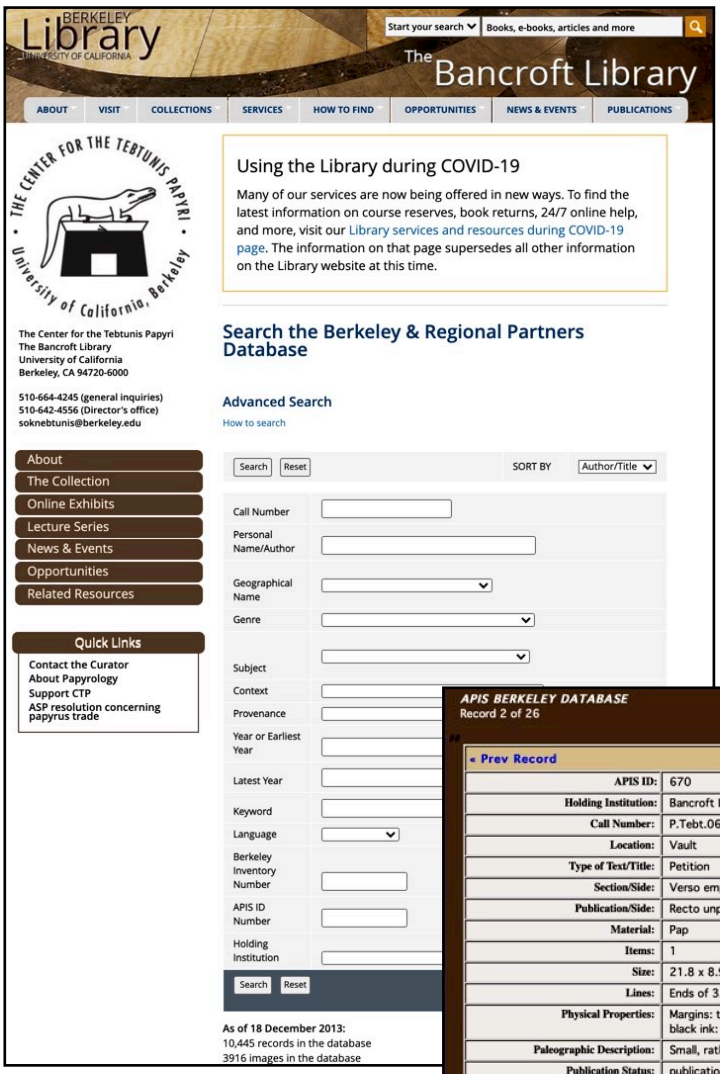

FIG. 2.6
The advanced search mask of the *Berkeley & Regional Partners Database*

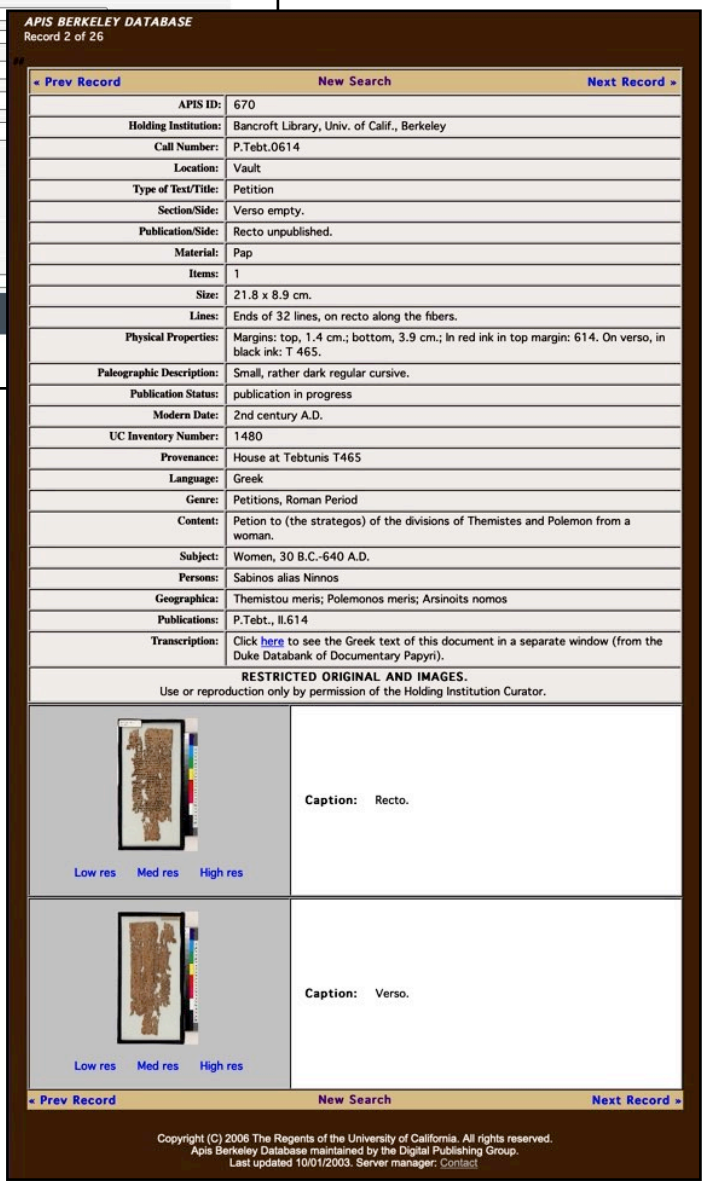

FIG. 2.7 A sample record of the *Berkeley & Regional Partners Database*

text searches (fig. 2.4); even though there are automated suggestions for the text entered by the user, relating to the available values (though sometimes with duplicates), the possibility to browse them would allow gaining insight more easily into the variety of information attested in the collection, as occurs for the Tebtunis fragments.

The *Berkeley Database* allows particularly precise searches for specific features of papyrological sources. The intellectual content of the texts is defined in a very articulated way: notably, the "Genre" and the Subject" fields are provided with a great number of values which define exhaustively types of literary, subliterary and documentary papyri; also, the "Provenance" field allows browsing according to the precise finding spot within Karanis, up to a specific house, mummy or crocodile cartonnage; and the "Context" field offers a browsing list of groups of texts identified in the collection, distinguishing between archives, dossiers and papers.

APIS UM and *Berkeley Database* have both expanded to gather smaller datasets of papyri in other institutions. *APIS UM* contains records of some papyri and ostraca, formerly at the University of Michigan, returned to the Cairo Museum in 1953;[102] of the mummy labels at the Kelsey Museum of Archaeology; and of the papyri at the University of Wisconsin.[103] The *Berkeley Database* includes some regional partners, notably, the collection of the Stanford papyri. The *Database* clearly mentions the presence of related collections in the guidelines for advanced searching,[104] and shows them as a browsing list in the "Holding Institution" field of the advanced search mask.

In addition to the aforementioned integrated collections, *APIS UM* can be searched together with other digital collections of the University of Michigan Library, through a single interface. An integrated search mask available from the *APIS UM* home page, via the "Search multiple collections" option, allows searching the papyrus collection together with those in the "Archaeology" and "Karanis Site Research" page, and with all those in the *Digital Collections* section; while this contains a variety of collections from both humanities and scientific disciplines, a filtering option permits to select the relevant ones. It is thus possible, for example, to retrieve all mummy labels found both in the papyrological collection at the Michigan Library and in the

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[102] On the return of many Karanis papyri to Cairo, see Verhoogt 2017, 10, and Gagos 2001, 525.
[103] These groups of papyri can be discovered by selecting the "Library" category in the advanced search mask; here, the names of these institutions are suggested among its values.
[104] Center for the Tebtunis Papyri, "How to Search the Berkeley & Regional Partners Database."

archaeological collection at the Kelsey Museum, with more numerous results than by querying *APIS UM* only, or both papyri and archaeological objects unearthed in Karanis, by searching simultaneously *APIS UM* and the Kelsey database. A small enhancement could be to flag the most germane collections to papyrological ones, briefly illustrating their content so as to enable the user to understand their pertinence to his/her research. Therefore, the overview of the joint database, which provides technical directions on how to search the collections, could also be used to offer a short guide to its contents, thereby improving the usability of the resource with richer documentation.

With its integrated "Search Multiple Collections" database, Michigan Library seeks to address the growth of interdisciplinary research, in this case between papyrology and archaeology, supporting related practices with an interdisciplinary platform of diverse thematic collections. This is a challenge that has long been recognised by research libraries.[105] For a long time, library collections have been created on the basis of academic structures, rather than of fields of research, for organisational reasons; but digitisation has provided an opportunity to aggregate collections with diverse sources (texts, images, maps, models and numerical data) from different fields of study and analytical tools, thereby facilitating practices of interdisciplinary humanities scholars.[106] The University of Michigan's facility for searching multiple collections, as well as the Tebtunis Center's online exhibitions with papyri and archaeological objects from different collections, are interesting instances of this trend, however simply based on two types of sources, mainly images, as well as texts available via links to *Papyri.info* in the Michigan collections. While not providing a range of data types nor more advanced tools, for example (interactive) maps of the archaeological sites, the Michigan joint catalogue and the Berkeley virtual exhibitions are well-integrated in this digital trend that seeks to blur institutional boundaries between physical collections and reunite them according to intellectual ones. They thus represent useful instruments for the study of papyri as artefacts found in a specific archaeological context, helping us to address the complex problems of reconstruction of the milieu in which they were produced (cf. pp. 20-22).

[105] Palmer 2004, 354.
[106] Palmer 2004, 354.

The papyrus records of the two resources contain detailed information on the papyri and are linked with *Papyri.info*. A small drawback of connections of *APIS UM* records with *Papyri.info* (aside from the old denomination "Perseus Link") is that it does not direct us exactly to the related item, but to a list of papyri (however little numerous) with similar inventory numbers, which one needs to browse to find the relevant one.

Images of *APIS UM* are of very good quality, and can be easily viewed and downloaded in different file sizes. The images of papyri and ostraca now at the Cairo Museum are reproductions of digitised photographs kept in Michigan, also high-resolution (in fact, they have enabled the publication of many of these texts).[107] While a viewer is not available in *Berkeley Database*, high-resolution images can be opened in a separate window and downloaded.

The policy on the use of images is different for the two institutions. Pictures of the Michigan papyri are available for free in the public domain,[108] whereas the use and reproduction of those of the Tebtunis papyri are by permission of the curator.[109]

On the whole, *APIS UM* and *Berkeley Database* are the most advanced United States catalogues of papyrus collections, for enabling effective searching and browsing according to intellectually salient categories, and for providing primary access to excellent digital surrogates with rich information. Indeed, thanks to the contextual material provided, they are not only catalogues but also wide-ranging resources for the study of their collections and the discipline of papyrology. In particular, the wealth of contextual information on the Tebtunis papyri makes the Center's website close to the notion of thematic collection devised by Palmer as ideal to support research: a set of primary sources surrounded by a "contextual mass" of tools and information in different data types for enabling deep study of a specific research subject (cf. pp. 51-53). While not offering advanced tools, such as generated maps and timelines and other techniques for visualising data gleaned from the collection, the Center offers metadata, images and texts (via *Papyri.info*) on the papyri and a tool, the *Database*, with precise search functions that permit not simply direct access to the items but also the exploration of the

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[107] Verhoogt 2017, 10.
[108] See the records of the Michigan papyri, esp. the "Rights/Permissions" section, and the *APIS UM* "Image Collections Help Guide."
[109] Center for the Tebtunis Papyri, "About the Database."

collection under many respects. Even more than *APIS UM*, the Tebtunis papyri website overcomes the boundaries of the physical collection and the academic institution, by aggregating datasets of several regional partner collections and by illustrating a variety of themes of general interest to the discipline, on the basis of select material from its holdings and beyond.

2.6 Federated catalogues of European collections: *Papyrus Projekt*, *DVCTVS* and *PSIonline*

2.6.1 The *Papyrus Projekt* catalogue of German collections

Since 2009, several papyrus collections, mostly German, have become gradually accessible online via the *Papyrus Projekt* federated catalogue,[110] hosted on the University of Leipzig's server, an initiative funded by the Deutsche Forschungsgemeinschaft[111] and built on the experience of the 2003 Halle-Jena-Leipzig *Papyrus und Ostraka Projekt* (cf. p. 67). *Papyrus Projekt* has expanded to encompass fifteen collections,[112] including large-scale ones such as Cologne, which numbers 10,000 papyri,[113] Leipzig and Giessen, with over 5000 and 3000 papyri respectively;[114] and a few small collections from neighbouring countries, viz., Basel and Budapest. The most extensively digitised ones are Leipzig's, almost completely covered,[115] and Giessen's, entirely recorded;[116] the Cologne collection is instead available only in a small part in *Papyrus Projekt*, with eighty records, whereas it is comprehensively represented in its institutional individual catalogue, *Kölner Papyri* (cf. p. 101).

While comprising major German collections, *Papyrus Projekt* does not include the largest ones in the country, namely, those of the Ägyptische Museum in Berlin and the University of Heidelberg, provided with their own catalogues (cf. p. 101), and it represents only a small part of the one in Cologne (as said). The digitisation of major

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110 <https://papyri.uni-leipzig.de/content/start.xml?lang=en>. Overviews of this project can be found in Blaschek-Quenouille 2016, Quenouille 2016, 16-18, and Reggiani 2017, 100-02.
111 Quenouille 2016, 18; *Papyrus Projekt*, "The Project."
112 *Papyrus Projekt*'s collections are listed in the top and in the left bars of the catalogue.
113 Lundon 2007.
114 *Papyrus Projekt*, "Das Leipziger Papyrus Projekt;" Id., "The project of the papyri of Giessen."
115 *Papyrus Projekt*, "Das Leipziger Papyrus Projekt."
116 *Papyrus Projekt*, "The project of the papyri of Giessen."

German collections thus differs from that of United States ones, which followed a collaborative model by participating in the *APIS* project or by sharing their dataset with it (as the *Duke Papyrus Archive* did: cf. p. 78). It may be said that *APIS* was an early digital papyrology project, hence even large-scale university collections needed collaborating to provide support to each other about issues faced for the first time, such as establishing standards for imaging and cataloguing. In contrast, subsequent projects could take advantage of the already available *APIS* standards and of technological progress, so that support from their institution was sufficient for the undertaking. Moreover, as regards especially the Heidelberg catalogue, which is in fact an early initiative, it is possible that some projects need to feature unique data, not shared with other databases, for institutional reasons, as the owning institution thereby aims to raise the profile of its digital resources.

A peculiarity of the scope of *Papyrus Projekt* is that, in a few cases, it moves beyond the focus on the institutions' holdings to shape the digital collection towards a specific research goal:[117] the virtual reunification of fragments scattered in different collections, belonging to the same item or relating to the same archive, through records with complete metadata and images virtually pasted together.[118] A notable example is the archive of Aurelius Ammon,[119] divided across Cologne's, Duke University's and Florence's collections, published in the *Papyrological Coloniensia* series (as P.Ammon); for it, *Papyrus Projekt* even gathers fragments of this archive that do not physically join those in Cologne,[120] on the basis of the printed P.Ammon volume.

Papyrus Projekt has been very well documented from the technical point of view, both in the literature (cf. p. 67) and in the resource itself[121] with the presentation of the MyCoRe open-source database software, collaboratively devised and employed by

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[117] On the significance of this feature for digital humanities resources, see Flanders 2014, 165-66 (cf. p. 51).

[118] These papyri of non-member institutions are retrievable in the "Collection" browsing list of the "Navigation" section and of the search mask.

[119] Online information on this archive is available in *Trismegistos Archives*, at <www.trismegistos.org/archive/31>.

[120] The P.Ammon can be retrieved with a search of the keyword "Ammon" in the "archive" field. See, e.g., the record of P.Ammon II 47 (recto) and 36 (verso), composed of fragments from Cologne, Duke and Florence (<
>).

[121] See Scholl 2018, available via the "Collections" and the "General" options in the left bar, and a section, by the title "Documentation," which enlarges on the illustration of the technical aspects, especially concerning the MyCoRe database software used. Given the relevance of its topic, Scholl 2018, now little visible, might be included in the "Documentation" section.

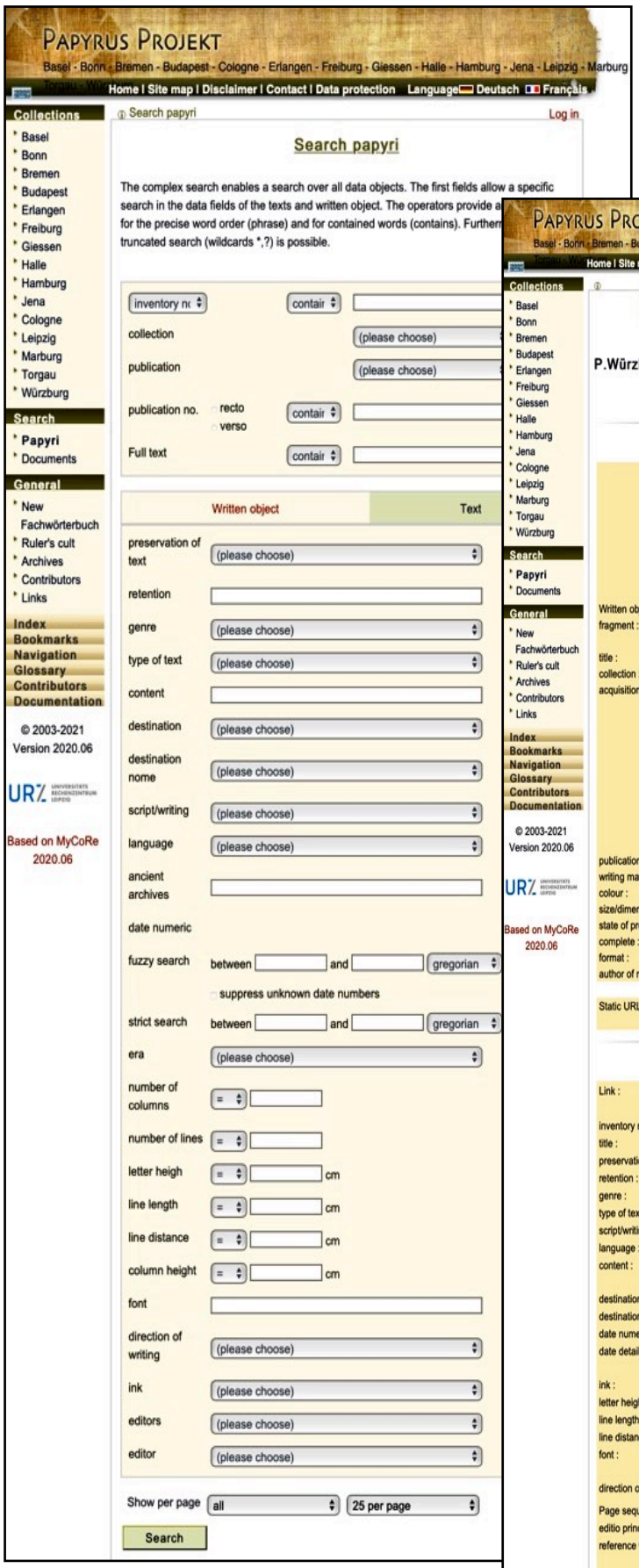

FIG. 2.8 The search mask of *Papyrus Projekt*, with facilities for searching on physical features of the papyri ("Written object" tab) or their layout and content ("Text" tab)

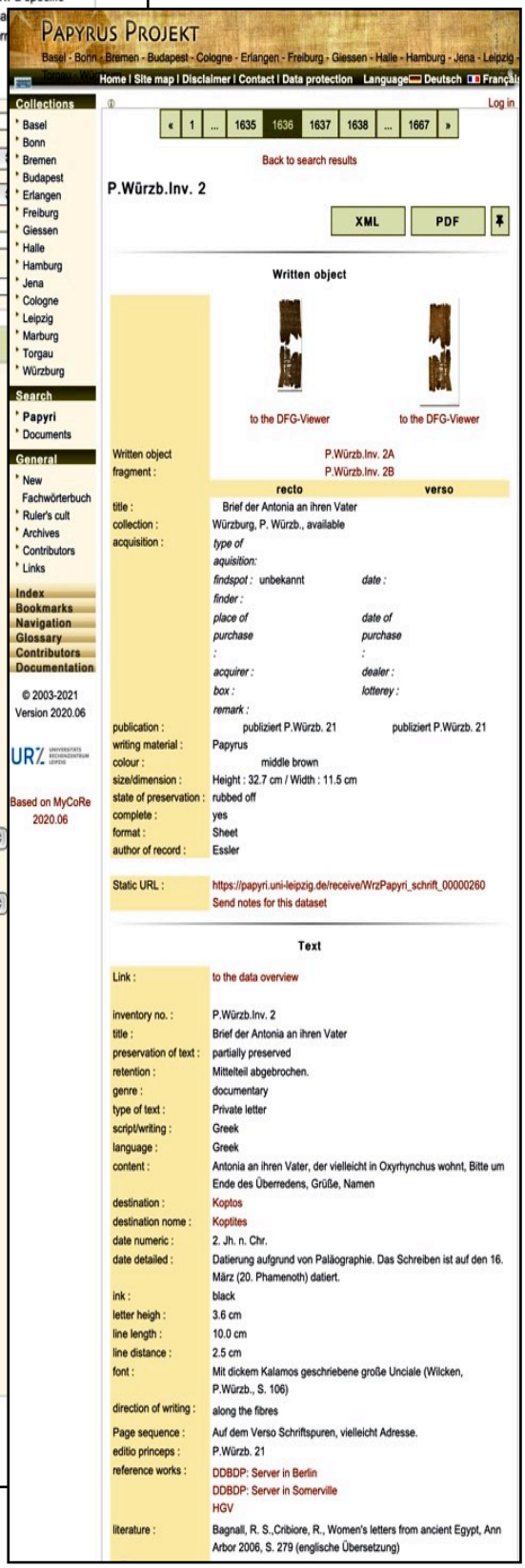

FIG. 2.9 A sample record of *Papyrus Projekt*

several German universities, and with a detailed description of the imaging process for papyri and ostraca, including the use of infra-red and photogrammetry techniques for the latter. The most extensive collections involved are provided with an overview, with links to the institutional catalogue, if existing (as occurs, for example, in the informative page on the Cologne papyri, Lundon 2007). In addition to this, it would be interesting to know more about the scope of the resource, namely, on the criteria whereby collections, both within and outside Germany, have been selected. Even though participation may depend on existing relationships among institutions, it appears that the project sets out both to provide extensive datasets of broad collections and to bring to light less-known ones, and to build a federated catalogue on a national basis, at the same time being open to the contribution of non-German collections that need support for their digitisation effort, in the wake of *APIS*, as could be mentioned in the project's overview.

Collections in *Papyrus Projekt* can be both browsed and searched, and can be queried, both altogether and individually, via a very articulated search mask (fig. 2.8 above) that offers numerous options based on specific aspects of the papyri. These comprehend both physical properties (gathered in the "Written object" tab) and intellectual ones (in the "Text" tab), including a great number of categories of text types with their subsets and the archives identified (which would be interesting to see listed in a drop-down menu, as occurs for other category fields).

The images are usually of high quality. Partner institutions generally followed the standard set by the project, which recommended a resolution of 600 dpi for the master images and of 300 dpi for those uploaded on the database.[122] However, a weakness is that download is not permitted, or some images can only be downloaded as a PDF file with a remarkable loss of definition. Images of the Hamburg and Bremen papyri are available via external links to their institutional catalogues, viz. Hamburg's *Handschriften* and *Bremer Papyri*; these provide high-resolution images, which can be effectively viewed and downloaded as PDF files maintaining a good definition. The images are intended for research purposes, but permission for the use for commercial purposes may be agreed with the owning institutions.[123]

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[122] Scholl 2018, esp. "2. Filming, digitalisation and 3D pictures."
[123] *Papyrus Projekt*, "Disclaimer."

The resource supports research purposes through the provision of usually high-resolution pictures, comprehensive metadata, bibliography, and links to other papyrological resources (see fig. 2.9). Records may direct to *Papyri.info*, or to its *DCLP* subset of literary papyri, for papyrus texts; and to resources for further metadata and bibliography, such as the *HGV* for documentary papyri, *LDAB* and *MP*[3] for literary ones, *Trismegistos Places* and *Trismegistos Archives*. However, the degree of connectivity varies across the collections, in terms of both number of linked resources and persistence of links, especially to *Papyri.info* and the *HGV*: there are records well-connected with other databases, such as those of Würzburg papyri, and others, for example those of the Cologne collection, that lack connection with *Papyri.info*. Another useful feature for research purposes is the provision of a reference work, specific for the papyrological domain, created by Leipzig University, the *Neues Fachwörterbuch*, a dictionary of the administrative terms attested in the papyri, which updates the original 1915 *Fachwörter* by Preisigke.[124] A glossary, composed of transliterated words, constitutes a simpler reference tool for a first approach to the texts.[125] This instrument, as well as some translations of the papyrus texts, produced within the earlier *Papyrus und Ostraka Projekt*, are meant to make the material accessible to students and scholars of non-classical disciplines.[126]

Papyrus Projekt solicits user contribution for the publication of unpublished papyri by providing metadata records for them, sometimes complete with images, and a specific search option to retrieve them (in the "publication" field, in particular the "unpublished - free" value). Unpublished texts qualified as "reserved" or "blocked" are instead devoid of images or are reproduced in a 72 dpi thumbnail format.[127]

On the whole, *Papyrus Projekt* is a remarkable resource for the study of papyri from German collections. With the exception of one of them, Cologne's, it offers comprehensive coverage of the numerous German collections (and beyond) included, with as many as 13,000 records. It fulfils well research needs, by offering images often of high quality, albeit not downloadable. It shows fully searchable records with all the relevant information, sometimes even on related fragments from other institutions. The

[124] Quenouille 2016, 14; Reggiani 2017, 125-26.
[125] Reggiani 2017, 123, n. 15.
[126] Quenouille 2016, 17, 18.
[127] Scholl et al. 2020, 27; Blaschek-Quenouille 2016, 50.

resource's content thus proves curated, generally speaking. The only noticeable lack of updating concerns the Cologne collection, as apparently the institutions have not reached an agreement about the sharing of data from the *Kölner Papyri* catalogue.

The permanence of *Papyrus Projekt* in the long-term is ensured by the inclusion in an institutional server, that of Leipzig university, and by the use of a database application, MyCoRe, which is open-source and is adopted by several German universities;[128] the project is regularly updated to MyCoRe's latest version.[129]

2.6.2 The *DVCTVS* catalogue of Spanish collections

Like *Papyrus Projekt*, *DVCTVS* is constituted on a national basis, with a view to unifying Spanish papyrological collections. It relies on a dataset of over a thousand records, covering to a fair extent the two largest collections in the country:[130] the Palau-Ribes's and the Abbey of Montserrat's. To them, the smaller Fundación Pastor collection is added.[131] For the development of the project, the owning institutions cooperated with the Pompeu Fabra university in Barcelona, which hosts the initiative on its website, and the Consejo Superior de Investigaciones Científicas.

In 2021 the *DVCTVS* site has been made available in a new version.[132] The previous one supported the purpose of papyrological research by providing a search interface with a large number of category fields based on specific features of the objects, including the presence of punctuation, marginal annotations, *kolleseis* and identification with the same scribe as another text. While the values could not be browsed via drop-down menus, directions in the "Help" page assisted in performing precise searches with given values, though not for all fields. It has to be mentioned that the current version of the project contains less detailed information than the previous one, relating to the material collections, formerly available in a dedicated page ("Collections"), and relating to the database content, especially to the available metadata categories and the presence of new transcriptions. The interface is now very basic, as it

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[128] Scholl et al. 2020, 2.
[129] Scholl et al. 2020, 3. The 2020 update is also indicated at the bottom of the left bar of the interface.
[130] For an overview of Spanish collections and their extent, see the dataset relating to Spain in *Trismegistos Collections*, filtering the results by the keyword "papyrus."
[131] The collections included in *DVCTVS* are mentioned in *DVCTVS*, "Project." An overview of them was provided in the previous version of the website, now archived, in *DVCTVS*, "Collections."
[132] <http://dvctvs.upf.edu>. *DVCTVS*'s previous version is archived at: <https://web.archive.org/web/20200226091854/http://dvctvs.upf.edu/>.

is possible to perform free-text searches only, with the indication of a small number of metadata fields (texts type, genre, language, format and material) with their values. Also, in the older version of *DVCTVS*, the availability of searchable papyrus texts, in particular ones not already available in *Papyri.info*, a very useful feature of the resource, was pointed out by the provision of a virtual keyboard in the search interface and was accounted for in the project overview.[133] As regards the papyrus texts, they are encoded in a TEI-based schema devised by *DVCTVS*'s staff.[134] They may have decided to provide papyrus texts embedded in the records, rather than entering them in *Papyri.info* via the *Papyrological Editor*, for a preference for their encoding model and to enrich the project with this further content.

DVCTVS assists the study of its collections by presenting, for the papyri already published, records with comprehensive information and bibliography, connected to the respective records in *Trismegistos* and *Papyri.info*, and accompanied by images of good quality (300 dpi)[135] that can be downloaded. There are also records with basic metadata of unpublished texts.[136] Images can be used for research purposes, whereas it is necessary to ask the owning institution for permission for their reproduction.[137] While it is not an issue of *DVCTVS* itself, it is noted that *Papyri.info* records are not linked with this catalogue, as can be seen by browsing texts of *DVCTVS* collections published in papyrological series such as P.PalauRib., P.MontsRoca and P.Matr. Linking *Papyri.info* to *DVCTVS* would allow to provide access to its images, texts and further metadata, and to make the Spanish catalogue more known.

The project seeks to solicit user contribution for a different purpose from the other catalogues: not so much for the publication of new texts, but for the addition of more collections, whether public or private, with a view to creating an overarching national catalogue.[138]

2.6.3 The *PSIonline* catalogue: virtually reconstructing a dispersed collection

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[133] *DVCTVS*, "The Project" and "Help about Digital Catalog" (archived versions).
[134] *DVCTVS*, "The Project" (archived version).
[135] *DVCTVS*, "Project."
[136] *DVCTVS*, "Help about Digital Catalog" (archived version). See, for example, the record of P.Matr. inv. 28, from the Fundación Pastor collection, available at <http://dvctvs.upf.edu/catalogo/ductus.php?operacion=introduce&ver=1&nume=881>.
[137] *DVCTVS*, "The Project" and "Help about Digital Catalog" (archived versions).
[138] *DVCTVS*, home page and "Project."

Unlike *Papyrus Projekt* and *DVCTVS*, the *PSIonline*[139] catalogue is not so much grounded on a geographical, i.e. national, basis, but on the reconstruction of a collection now divided among different holding institutions, although the majority of them is located in one country, Italy. Officially launched in 2013,[140] this international project led by a number of Italian institutions[141] primarily aims at virtually reconstructing the collection of the papyri of the "Società Italiana:"[142] a society constituted in Florence at the beginning of the past century, which, for two decades, funded the acquisition of papyri through archaeological missions and purchases.[143] The texts were mainly published in the related PSI series (*Pubblicazioni della Società Italiana*, now *Papiri della Società Italiana*) and are chiefly preserved in two Florentine institutions, the Biblioteca Medicea Laurenziana, which holds the majority of the published fragments (numbering 1700), including those appeared in the P.Flor. and P.Laur. series,[144] and the Istituto Papirologico "Vitelli," where the remaining published texts (700)[145] and the unpublished ones (over 4000) are preserved.[146] As well as bringing together the texts divided across the two principal conservation places, the project gathers the numerous fragments that were transferred to other memory institutions, mostly the Egyptian Museum in Cairo (circa a hundred) and the Graeco-Roman Museum of Alexandria (about forty), including those published outside the PSI volumes, i.e. in journals and miscellaneous works.

Subsequently to the PSI, two smaller collections have been added to *PSIonline*: the University of Padua's[147] and the National Library of Prague's, in particular those published in the P.Prag. series. While it is important that access to these collections has been enhanced through their digitisation, it would be interesting to clarify the linkage with the core content, for the database to be identified as a meaningful whole even as it grows and evolves.[148] For example, in the project's overview it could be highlighted that the Padua papyri were excavated in the same archaeological mission as some Florence

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139 <http://www.psi-online.it>. On this project see Del Corso 2007.
140 CSAD 2013, 7.
141 *PSIonline* homepage; Del Corso 2007, 167.
142 On the aim of *PSIonline* see the project's overviews in *PSIonline*, "Informazioni," and in Del Corso 2007, 168.
143 Bastianini, n.d.
144 See *PSIonline*, searching for "Laurenziana" as conservation place.
145 See *PSIonline*, searching for "Vitelli" as conservation place.
146 Istituto Papirologico 2021.
147 On this collection, see Fiorillo, n.d.
148 Cf. Palmer et al. 2004, 461 on foregrounding collection and sub-collection description in cross-institutional resources.

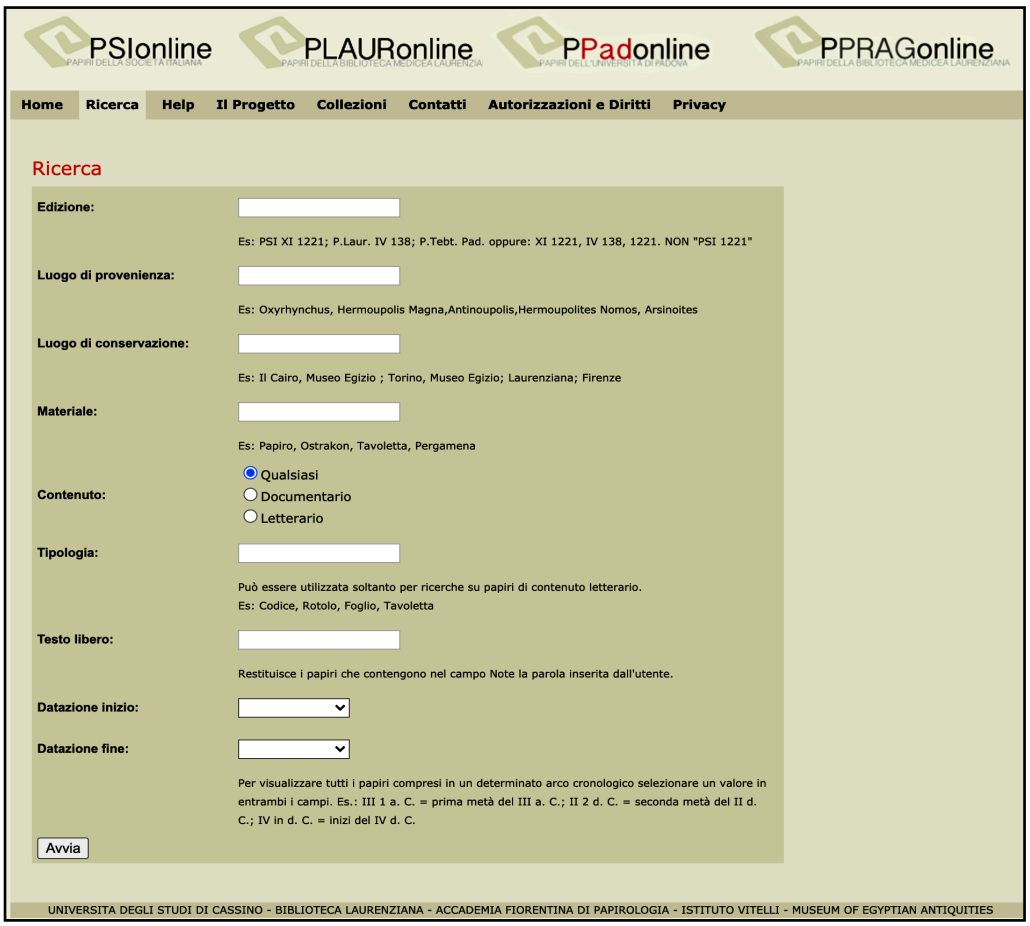

FIG. 2.11

The search form of *PSIonline*

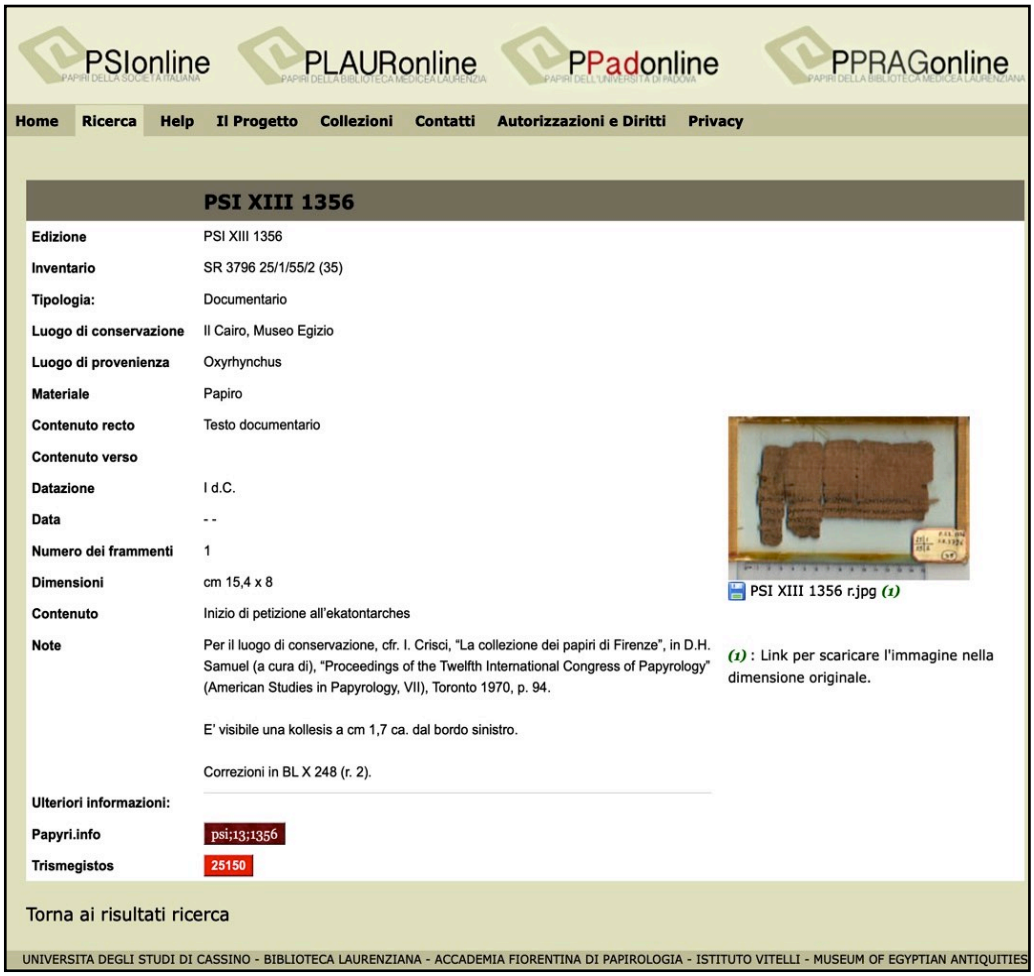

FIG. 2.12

A sample record of *PSIonline* with a papyrus housed in the Cairo Museum

papyri, as reported in the description of the Padua collection. For the P.Prag., it could be mentioned that their digitisation continues the collaboration initiated with the publication of these papyri in the *Papyrologica Florentina* series.

PSIonline thus gathers an extensive dataset of 3500 papyrus records in total. The project has been well documented in the literature from the technical viewpoint,[149] and provides information on the Florentine and Padua collections.[150]

The interface is simple, but allows for a full search into the metadata, via text string search (see fig. 2.11). The records contain useful information and bibliography, and are well connected to *Papyri.info* and *Trismegistos Texts* (fig. 2.12).

The images, while captured at 600 dpi,[151] are not available online at such a high resolution; nevertheless, most of them are fine to be used for scholarly purposes. Images can be both examined in a simple viewer and downloaded. Notice, however, that images of papyri housed in some participating institutions are not available, notably, most of the items at the Graeco-Roman Museum of Alexandria. Users who intend to reproduce *PSIonline* images need to ask for permission from the owning institution.

In sum, *PSIonline* caters for research needs with the provision of excellent images of a very large part of one of the most extensive collections in the world, encompassing holdings from different institutions, including the Cairo Museum for which only the digitised photographs of CSAD's *Photographic Archive* were previously available online. To a small part it is also possible to explore unpublished papyri, in particular the P.Pad., through metadata records and, at times, images; by contrast, records of papyri under scrutiny by collections' curators have been excluded from the database, in view of a possible substantial revision.[152]

PSIonline is a stable resource, in that it takes advantage of an open-source and well-supported database management system such as PostgreSQL,[153] and it has an institutional backing for its technical curation, from the University of Cassino.[154] As regards content updating, this has progressed little in terms of the addition of

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[149] See Del Corso 2007, 169-72.
[150] See, respectively, Bastianini, n.d. and Fiorillo, n.d.
[151] Del Corso 2007, 171.
[152] *PSIonline*, "Informazioni."
[153] On the use of PostgreSQL in *PSIonline*, see Del Corso 2007, 170. On this software, see Ramsay 2004, 186-87.
[154] See the project's home page.

bibliography: as the project overview informs, records of the PSI are updated to 2013, with small subsequent integrations, and those of the P.Pad. to 2015. But, more importantly, the entry of new records with recently published texts has continued, as one can see from the presence of the latest PSI volumes and of the papyri published outside the series (e.g., in journals and Festschriften).

PSIonline is therefore a high quality and potentially permanent and sustainable project, and it is hoped that more effective collaboration of the main institutions with other participating collections will allow completing the digitisation of their valuable material.

2.7 Individual catalogues of European collections

2.7.1 Scope: comprehensiveness and virtual reconstitutions

Within this group, some catalogues stand out for their large scale, with very broad collections digitised to a great extent. The largest one is that of the Vienna papyri, housed at the Österreichische Nationalbibliothek (ÖNB). This institution preserves one of the most extensive material collections in the world, with 180,000 papyri.[155] As many as 21,000 of them have been catalogued, including some unpublished ones, and imaged in large part.[156] They are gathered in a dedicated section of *ÖNB Digital*, highlighted in this resource's home page; they may also be easily retrieved in the main library catalogue (*Österreichische Nationalbibliothek*), with a search of the term "papyrus" as a medium, which encompasses the various material supports in the papyrological domain. Moreover, the library's website hosts two sections related to its papyrological collection: one devoted to Vienna's papyrus collection (*Papyrussammlung*, 2021), which includes an overview of the collection, and another one concerning the Papyrusmuseum (*Papyrusmuseum*, 2021), where select digitised papyri are gathered in virtual exhibitions. These two resources and the digitised papyrus collection are however not interlinked, although from *Papyrussammlung* it is possible to access the home page of the ÖNB general catalogue.

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[155] See *Papyrussammlung* 2021.
[156] Cf. *Papyrussammlung* 2021, esp. "Searching the collection."

The next largest resources concern German collections. Heidelberg's *Papyrussammlung* catalogue contains records for all their papyrological holdings, totalling more than 11,000, and is provided with 9000 images.[157] The *BerlPap* database is of a little lesser extent, comprising records (9000) for almost half of the vast collection of 20,000 texts from the Ägyptische Museum in Berlin.[158] A fair amount of the Cologne papyri has also been digitised in the *Kölner Papyri* catalogue, which contains records for 4200 texts out of approximately 10,000, mostly complete with images.[159]

Another large-scale European digital collection is the *Oxyrhynchus Online Image Database*, concerning the papyri published in the P.Oxy. series, in particular those preserved at the Sackler Library in Oxford, numbering over 4000.[160] It is available via *Pinax*, a portal of digitised Oxford papyrological collections, which also comprises a metadata database of another series of papyri housed at the Sackler Library, some texts from Antinoopolis (P.Ant.), and a digital surrogate of the Bodleian Library's Oxford facsimiles of Herculaneum papyri, the *P.Herc. Image Database* (as well as images of two papyri published in the *Supplementum Magicum* series, at the Sackler Library). The *Oxyrhynchus Online Image Database* may also be accessed from another University of Oxford's project, *POxy: Oxyrhynchus Online*, a thematic collection devoted to the city of Oxyrhynchus, its findings and the dedicated research projects, including the imaging of its texts.

The University of Manchester's *Papyri Collection* is a database of nearly 1000 records covering approximately half of the papyrological holdings of this institution,[161] housed at the John Rylands Library. Also worthy of mention, albeit covering only a little of the total collection, is the *Papyri* selection of thirteen highlights, included in the *Papyrus to Print* section on the Library's special collections; along with samples of

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[157] On the extent of the Heidelberg collection, see the overviews in the Heidelberg catalogue's homepage (*Papyrussammlung*) and in Heidelberg Library's section on digital collections (Universitätsbibliothek Heidelberg 2019), which report on 10,500 items. Similarly, the number of records in the catalogue is a little more than 11,000.

[158] On the extent of the Berlin collection, see *BerlPap*, "The Berlin Papyrus Collection." The number of catalogued items results by performing a search without values, which returns a complete list of the records.

[159] On the extent of the Cologne collection, see Lundon 2007. For the size of the digital collection, see its home page; it is possible to pinpoint records provided with images with the option provided in the browse and in the search interfaces.

[160] This figure results from a combined search of the keywords "P.Oxy." and "Sackler Library" on *Papyri.info* metadata.

[161] *Trismegistos Collections* records 2200 items for the Manchester collection (<www.trismegistos.org/collection/218>).

other rare materials from different ages, these digitised papyri provide specimens for teaching in manuscript studies, with a view to illustrating a wide-ranging history of the book.

The *Chartes* comprehensive database of Herculaneum papyri, with 1800 records, may be considered as situated between digitised real-world collections and resources that gather texts based on their content. On the one hand, it relates to a collection that is almost entirely preserved in one conservation place, the National Library in Naples. On the other hand, Herculaneum papyri have a specific provenance and a well-defined content, belonging to an ancient library focused on epicurean philosophical treatises (cf. pp. 14-15). Here, it seems important to point out that, while including information on the P.Herc. housed in other institutions, *Chartes* does not provide images for them, nor links to their catalogues, thus showing a focus on the material collection in Naples, which makes it closer to the type of resource dealt with in this chapter.

The digitised *Photographic Archive of Papyri in the Cairo Museum* is available in a dedicated section of the website of the Oxford Centre for the Study of Ancient Documents, responsible for the project (cf. p. 63). This catalogue, provided with a project's overview ("Introduction"), shows a notable extent: even though the precise number of items is not identifiable, we know that they represent the majority of the photographs of the Cairo Archive, which total 6000.[162]

Two more resources may be introduced here, albeit not so extensive as the aforementioned ones, because they will deserve mention for some important characteristics. One is the catalogue of the Fondation Martin Bodmer's library, housed in Cologny, Switzerland, implemented in collaboration with the University of Geneva (*Bodmer Lab*). The papyrological holdings of this foundation include some exceptionally well-preserved codices in Greek and Coptic languages, of remarkable interest.[163] The digital surrogates of a selection of fifty-six items can be viewed in the *Bodmer Papyri* catalogue; additionally, one of the foundation's highlights is enriched with a dedicated thematic collection, *Codex de Ménandre*. The other resource also relates to a former private collection now available to scholars as a research library, the Chester Beatty in Dublin. Their online papyrological holdings are collected in multiple

[162] See the descriptions in the catalogue's "Introduction" and in Crowther-Sasanow 2002, 3.
[163] Cf. *Bodmer Papyri* home page.

databases, according, for example, to their language or subject, the most extensive one being that of Biblical papyri, with three hundred items (see *Chester Beatty online*).

Worthy of note is also the particular case of the collection of the Hermitage Museum in St Petersburg. While having a very limited presence on its institutional catalogue, it has been possible to make it largely available online, with metadata records in part provided with images, thanks to an international digitisation project in the framework of *APIS*, whose data are now available in *Papyri.info* (cf. p. 71).

Though built around institution-based real-world collections, in a few cases these catalogues virtually aggregate some physically distant items so as to organise the material towards a specific research goal. This usually consists of the digital reconstruction of the original collection, with information on objects now belonging to other institutions, as seen in *PSIonline* and *APIS UM* especially in regard to papyri in the Cairo Museum. Analogously, *BerlPap* contains records for the P.Berol. housed at the Egyptian Museum of Cairo and in a few other institutions,[164] linked to CSAD's *Photographic Archive* and to the website of Warsaw university's department of papyrology for the provision of images; Sorbonne's *Collections de Papyrus*, too, includes records of papyri returned to Cairo, linked to CSAD's *Archive*.[165] *Chartes* comprises metadata records for the Herculaneum papyri preserved in other institutions than the National Library of Naples, mostly the British Library and the Bodleian Library,[166] however not connected with their catalogues for access to images and further information.[167]

Another common reason to include objects from other institutions on the basis of a research question is more specifically grounded on the content of the papyri, in particular on an editorial problem, that is, the rejoining of fragments of the same item,

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[164] See the "Location" field of the *BerlPap* search interface, which includes the P.Berol. preserved in Cairo, Warsaw and Torun.

[165] See *Collections de Papyrus*, especially Greek papyri.

[166] The conservation places of the Herculaneum papyri (i.e., besides the British Library and the Bodleian Library, the Institut de France in Paris and the Carlsberg papyrus collection in Copenhagen) can be pinpointed by cross-comparing the results of a search for the P.Herc. in *Papyri.info* (selecting the finding place "Campania" in the "Nome" field), in British Library's and Bodleian Library's catalogues, and the items mentioned by Macfarlane (2010) in his contribution on the application of the MSI technique to these artefacts.

[167] See the British Library catalogue's web page "Charred scroll fragments from Herculaneum," with images and a description on one of its Herculaneum papyri, P.Herc. 1042; and *Digital Bodleian*, with images of some of their P.Herc. (P.Herc. 118a, <https://digital.bodleian.ox.ac.uk/objects/c4248f2e-d319-4c22-9fb8-c79d263cfbd0/>; P.Herc. 149, 161 and 172, <https://digital.bodleian.ox.ac.uk/objects/f5ff4816-5dd8-4a3d-ba30-c5c31f6794a3/>).

as mentioned about *Papyrus Projekt*. There are different ways in which the papyri have been reunified. The most complete result is that, present in *Papyrus Projekt*, with metadata of all the pertaining fragments and a picture of the papyrus as a whole; the solution is also found in *Kölner Papyri*, as far as the records of the P.Ammon are concerned, which they share with *Papyrus Projekt*.[168] This is a positive example of agreement between institutions about copyright on images, both in the printed edition and in the online catalogues. The other two methods followed for virtually rejoining papyrus fragments have, too, produced good results. Also fruit of institutional cooperation are the digital images of two recomposed items in the *Collections de Papyrus* catalogue of the Institut de Papyrologie of the Sorbonne; they are included in a section purposefully devoted to showing reconstructions of images of texts with various peculiarities, "Reconstitutions virtuelles."[169] The same section contains two more relevant examples. A reconstruction has been realised in collaboration with a scholar who permitted to integrate material from her personal archive, i.e., a photograph reproducing a fragment now lost.[170] In another case, in contrast, a complete digital reconstruction, with fragments at the Biblioteca Laurenziana and the Istituto "Vitelli," has not been possible owing to image copyright issues.[171] This instance relates to the problem, highlighted by Bowman,[172] of the constraints on the digital reassembling of dispersed fragments, which are largely managerial and institutional rather than due to technical capabilities, with limitations such as copyright (as in the present case), varying conventions for the access and dissemination of antiquities in different countries, and lack of financial and human resources. Finally, the simplest method that is used to connect fragments of the same papyrus is the addition of external links to the databases of the other owning institutions for access to the relevant records, as *BerlPap* does.[173] In this way, information is accessed separately for each fragment, but we nevertheless obtain all the metadata, and images if available. This solution might be employed more

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[168] *Kölner Papyri* records of items held by multiple institutions result from a search into the "Sammlung" field, entering the value "mehrere Lokationen."
[169] Institut de Papyrologie de la Sorbonne, "Reconstitutions virtuelles," esp. "Raccord entre la Sorbonne et d'autres collections."
[170] Institut de Papyrologie de la Sorbonne, "Reconstitutions virtuelles," esp. "*Odyssée*, dite 'de Guéraud.'"
[171] Institut de Papyrologie de la Sorbonne, "Reconstitutions virtuelles," esp. P.Thmouis.
[172] Bowman 2010, 105.
[173] See, e.g., the record at <https://berlpap.smb.museum/00014/>, linked with the *Oxyrhynchus Online* and *PSIonline* catalogues for images of the pertaining fragments.

frequently, as it is noticed that some catalogues do not communicate with each other in this respect.[174]

One more motive, albeit infrequent, for reshaping the digital collection with physically distant papyri based on their content is the reconstruction of an archive, as we have seen about *Kölner Papyri.*

Though not related to Greek and Latin papyrology but to Egyptology, one may consider another example of a meaningful aggregation of content-based material from partner institutions, which might be taken into account in the formation of digital papyrological collections. It concerns the *Turin Papyrus Online Platform* (*TPOP*), the catalogue of papyri at the Egyptian Museum of Turin,[175] and addresses the history of the scholarship. The resource provides digitised scholarly descriptions and transcriptions, including unpublished ones, produced as preliminary work for editions or reference works, whose originals are housed at the University of Oxford's Griffith Institute and the Berlin-Brandenburgische Akademie der Wissenschaften.[176]

Finally, another reason, also uncommon, for going beyond the specific local institution agenda relates to managerial issues, in particular to the distribution of material from a little visible collection, based on a collaboration between the two stakeholders. This is a similar initiative to that of *APIS* but, in this instance, involving a private collection rather than university libraries and state museums: that of the P.Euphrate, whose digital images have been disseminated by the Institut de Papyrologie of the Sorbonne (*P.Euphrate – Photos*).

2.7.2 Usability: project documentation

The catalogues under scrutiny usually offer adequate documentation on their real-world collections. Not only do they present overviews of the collection and of their most significant pieces (note, for example, the insightful presentation of highlights in *Kölner Papyri*) but, occasionally, they add in-depth information on a particular topic,

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[174] See, for example, the records of a papyrus (*TM* 59419, mentioned in the previous footnote) divided across Berlin, Oxford and Florence. As opposed to *BerlPap*, *PSIonline* and *Oxyrhynchus Online* are not interlinked, although *PSIonline* accounts for the other fragments and provides a link to *Trismegistos.*

[175] *TPOP* contains 260 records of Turin Egyptian papyri, including a Greek-Demotic document (<https://papyri.museoegizio.it/o/784>), out of a total of 700 items in the material collection (*TPOP*, "History and content").

[176] *TPOP*, "Cooperations."

thus going beyond the boundaries of the single collection and further contributing to papyrological dissemination on the web.

The chosen topic is sometimes a single text of exceptional interest. An outstanding example is the *Codex de Ménandre* thematic collection in *Bodmer Lab*, created in collaboration with the University of Geneva, which provides insight into the works preserved in the codex, their literary author, their reception, and book production in antiquity. The section is also characterised by an aesthetically pleasing design, a feature that has been recognised as an important part of user experience, though sometimes neglected in digital humanities projects; it is a contribution to the resource's usability, since an effective use of space and colour aids navigation and helps make information memorable.[177] Also, the web page of the Giessen collection, while not provided with an individual catalogue as it was merged into *Papyrus Projekt*, is worthy of mention here. As well as offering a detailed collection description,[178] it gives access to an insightful and accessible thematic collection, focused on the edict known as *Constitutio Antoniniana* and on the Giessen papyrus that preserves part of its Greek text (P.Giss. I 40), enlarging on the related concept of citizenship identity in antiquity and beyond, an initiative made possible by the collaboration with UNESCO.[179]

Other catalogues offer insight into special aspects of their items, in different formats. *BerlPap*'s thorough collection overview comprises web pages on the most substantial archives and the major places of provenance, with internal links to relevant examples. Sorbonne's *Collections de Papyrus* offers virtual reconstructions of papyri with particular features.[180] They have digitally recomposed papyri with multiple extant fragments, showing the position that these occupied in the original roll or codex leaf; papyri scattered across different collections; and mummy cartonnages that yielded texts, determining the form that they presented before the process of dismantling to extract the fragments with writing. It would be interesting to implement the valuable reconstructions of the cartonnage elements with more advanced techniques. They might be represented as 3D models rather than with static images, so as to facilitate an overall

[177] Warwick 2017, ii140-42, ii146-47; Fuhr et al. 2007, 26-27.
[178] Universität Giessen, "Papyri, Ostraka, Keilschrifttafeln."
[179] Universität Giessen, *Constitutio Antoniniana.*
[180] Institute de Papyrologie, "Reconstitutions virtuelles."

view of their shape, as has been done with three-dimensional objects such as ostraca[181] and tablets,[182] and also with a few papyri.[183] Moreover, animation could be applied to visualise with continuity the phases of dismantling the cartonnage, selecting the text-bearing fragments, and situating them in the correct position within the original roll. The *P.Oxy: Oxyrhynchus Online* platform that hosts the *Oxyrhynchus Online Image Database* offers insights into their collection in the form of a virtual exhibition, *Oxyrhynchus: a City and its Texts*, aimed at an in-depth view of the city witnessed by these papyri: the archaeological site in which the P.Oxy. were unearthed, the society that produced them, and the history of their discovery, bringing together papyrological and archaeological evidence. Finally, Vienna's collection is illustrated with blog articles in the Österreichische Nationalbibliothek's research blog (*Forschungsblog*), retrievable via the "Papyri" tag, and with small virtual exhibitions, within the website of Vienna's *Papyrusmuseum*; the interesting blog posts are however not connected with the papyrological resources relating to this collection (the papyrological catalogue, *Papyrussammlung*, *Papyrusmuseum*), aside from one, *Die Klage der Artemisia*, also accessible from the *Papyrussammlung*'s home page.

Manchester *Papyri Collection* and *Chester Beatty online* constitute an exception, in that they do not present a general overview of their papyrological collections. The two catalogues might take advantage of a closer collaboration of their librarians with papyrologists. The Chester Beatty museum would benefit from the cooperation with a research institution to this purpose, as another memory institution, the Bodmer foundation, did for their papyrus collection description and the text of *Codex de Ménandre*, and as the Schøyen private collection did for its papyrological collection overview (Pintaudi, n.d.). The Manchester catalogue might also be interlinked with the *Papyri* selection of highlights provided in a separate section of the university's website; also, by consulting the *Papyri* section, users could access information on the history of the Manchester collection present therein, in each papyrus record.

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[181] Ostraca from Leipzig collection have been extensively digitised with 3D imaging within the Halle-Jena-Leipzig *Papyrus und Ostraka Projekt* (Blaschek-Quenouille 2016, 49) and are now accessible via *Papyrus Projekt*. The *Sketchfab* collaborative platform for 3D model sharing has instead been used by the *British Library* for the digitisation of a sample Coptic ostracon (<https://skfb.ly/6xyUL>).

[182] See the 3D model of a Greek-demotic mummy label, written on both sides, of Cambridge University Library, available in the related record of this library's catalogue (<http://cudl.lib.cam.ac.uk/view/MS-OSTRACON-00141/1>). The British Museum have instead resorted to *Sketchfab* for digitising samples of cuneiform tablets (<https://sketchfab.com/britishmuseum/collections>).

[183] A few 3D images of papyri are available on *Sketchfab*, including some created by the John Rylands Library in Manchester, for instance the "St. John Fragment" codex leaf (<https://skfb.ly/6SzYp>).

A lesser number of catalogues shows detailed documentation from the point of view of the digital project as well. *POxy: Oxyrhynchus Online* provides details on the imaging process and the selection of cataloguing metadata, discussing the challenges encountered and highlighting the significance of the experience of *APIS* as a basis for their choices.[184] While concerning a broad-ranging collection of manuscripts from worldwide civilisations rather than papyri specifically, the documentation on *Chester Beatty online* also deserves note here, not only for the insights offered into their method of work and for the discussion of issues of imaging, but also for being constantly up-to-date, through a series of posts on their *Digital Blog*. In comparison to the other catalogues, documentation on *BerlPap*, available both on the resource itself[185] and in the literature,[186] emphasises aspects of integration and cooperation with other resources, accounting for the use of standards for integration with the German digitisation system for research projects (DFG-Viewer), for connections with other papyrological databases, and for the collaboration with partner projects, *HGV* and *LDAB*, which made available for reuse their metadata on documentary and literary papyri.

As regards the documentation of other individual catalogues, it seems particularly opportune for *Chartes* to offer a more detailed description of the digital collection, above all explaining the method utilised for capturing the Herculaneum papyri and the features of the images thereby obtained. On the whole, the infrared images produced by a team of researchers from Brigham Young University have improved the legibility of these severely damaged artefacts, allowing us to distinguish the writing from the carbonised material support;[187] however, they need to be used in the awareness of some uncertainty that has been inserted into their representation, taking into consideration the special preservation status of these papyri. As the researchers in charge of the digitisation clarified in the literature,[188] because the camera utilised to capture the papyri was situated in a perpendicular position to them, the images fail to represent the three-dimensional nature of the papyrus surface caused by the stratification of layers of text. The strata, formed under the pressure of the mass of pyroclastic material where the rolls lay unopened for centuries, could not always be separated during the conservation

[184] *POxy*, "Imaging and Marking Up."
[185] *BerlPap*, "Project Description."
[186] Gerhardt 2016.
[187] Macfarlane 2010, 460; Macfarlane et al. 2007, 582; Puglia 2003, 238-39.
[188] Macfarlane 2010, 460; Macfarlane et al. 2007, 584-85.

process. Therefore, the two-dimensional images created may lead the papyrologist to misreadings, as ink strokes from distinct but adhered layers appear as belonging to the same fragment, and mere shadows caused by the uneven material support are altogether similar to traces of writing. Furthermore, the absence of colour in the infrared images accentuates the impression of a uniform surface. The consultation of the original alongside the digital image thus remains key to the study of the P.Herc. Such information about the degree of uncertainty inherent to the images provided, as demonstrated by the literature, could also be added to *Chartes*'s project overview, thereby making it readily available to all users who access the images on the database. It is also true, however, that this catalogue does not contain all the pictures produced in the imaging project, but only a specimen for each papyrus;[189] the complete digitised collection may be consulted on a CD-ROM available at the National Library in Naples or may be requested from Brigham Young University and created on demand.[190] Nonetheless, it would be useful to find information on the images in *Chartes*, to help users assess their quality and decide whether to resort to the whole dataset. Indeed, as Terras has underlined,[191] digital surrogates should be backgrounded by adequate documentation on their production, thus aiding scholars to fully comprehend their features, advantages and shortcomings; evaluating a digitised papyrus or manuscript is crucial for its use in an appropriate way, avoiding the risk of misunderstandings in the process of reading.

2.7.3 Usability of the navigation model

A few catalogues present a data model that focuses on the provision of direct access to primary sources very strongly, with basic access through a simple browsing facility. They are encoded minimally, to the extent necessary to the purpose of presentation on the institution's website; their priority is visibility, with the possibility of basic navigation. There are three instances of this type. One is the digitised *Photographic Archive of Papyri in the Cairo Museum*, which is browsable by publication series of the papyri. *Bodmer Papyri* offers very rich metadata and bibliography, along with links to *Trismegistos* and *DCLP* (the latter, though, now

[189] *Chartes*, "Su Chartes."
[190] Macfarlane 2007, 585-86.
[191] Terras 2010a, 57-58. The notion has been restated by van Lit (2019, 101).

unaccessible), while the searchability of the information is limited to language,[192] and items can only be ordered meaningfully by date. In the other instance, *Chester Beatty online*, papyrus collections may simply be filtered by time-span and sorted by date, a choice that however impacts on the navigation of a rather extensive one such as "Biblical papyri." Bodmer and Chester Beatty catalogues make use of a sharp and attractive design to enhance visibility and usability.

Other resources not only offer valuable information on the papyri but also structure it according to a meaningful data model, with the aid of advanced encoding of metadata. Thus, precise searching and browsing are supported, based on full coverage of the characteristics of the papyri as marked up in the data model. This helps gain a sense of the composition of the collection and the interrelationships among objects. In other words, these resources draw close to those prioritising indirect access to primary sources, opening up their materials to a wide-ranging exploration of the collection and to gleaning data from them.

FIG. 2.13 The search interface of *BerlPap*

[192] The two options for filtering the records by time period do not function correctly.

An outstanding example is *BerlPap*, which can be searched by many category fields, including several types of literary genres (see the reproduction of the search interface in fig. 2.13), ordering results lists by date or provenance; types of documentary texts are not searchable, but some of them can be retrieved via a browsing facility. Records are rich in information and bibliography, are well connected to all the relevant papyrological databases, i.e., *Papyri.info*, *Trismegistos*, *HGV* and *MP*^{3}, as well as, possibly, to collection catalogues with fragments pertaining to the same papyrus (cf. pp. 109-10); moreover, they contain searchable papyrus texts, when available on *Papyri.info*, from which they are integrated. The P.Berol. can also be effectively browsed, by publication or by meaningful groupings of materials, among which, notably, a rich selection of records for illustrating the evolution of the writing, classified into library and documentary script and ordered by century.

Similarly, *Kölner Papyri* is noteworthy for covering papyrological features fully and for facilitating discovery and retrieval of individual items and groups of them. It is possible to generate dynamic lists by filtering by content type, language and material. As in *BerlPap*, one may browse published texts by edition, perform searches by many fields, and find comprehensive information, along with the papyrus texts drawn from *Papyri.info* (here, however, not searchable). We are directed to external resources such as *Papyri.info*, *Trismegistos* and the *HGV* for further information.

Other catalogues are also worth pointing out for their coverage of papyrological data and for being designed for effective discovery and retrieval, even though they do not present so numerous metadata fields and browsing options as the two aforementioned resources.

Heidelberg's *Papyrussammlung* enables us to nuance a search according to several indexed data elements and to select the order of the results, while not offering browsing lists arranged by categories or publications. Its records contain the papyrus texts, when available on *Papyri.info*, as in *BerlPap* and *Kölner Papyri*, although they do not prove immediately visible, being accessible via the papyrus image; in the Heidelberg catalogue there is the further possibility to have different outputs of the text for the diplomatic and the interpretive transcription, with the option of displaying or hiding one or more kinds of editorial interventions such as the insertion of punctuation marks, regularised spelling variants, corrections and supplements.

Vienna's catalogue (in *ÖNB Digital*) offers the browsing and searching options for exploring the main features of papyri. There are filters by languages, broad text categories and types of documentary papyri (both reported under the "subjects" field, listed in order of frequency), and a utility for free-text searches. It is also possible to select a few literary authors and, for some items, the publication status; to filter results by time period; and to order them chronologically.

The University of Manchester's *Papyri Collection* supports a full search into its metadata like Heidelberg's and Vienna's catalogues, while being also browsable by some key categories. It distinguishes itself for providing a controlled list of values not only for data such as material, language, provenance and main text categories (i.e., documentary, literary and paraliterary) but also for numerous subjects, listed alphabetically, that is, a more complex area which requires a further judgement about the content.[193] It is indeed important to control subjects, to make them consistent and allow precise searches of topics. However, while the alphabetical order is suitable for place or person names, subjects, when increased to a significant number, are usually arranged by related concepts, indicating the linkage between them.[194] Hence, a small improvement would be to group subjects pertaining to the same text categories, as *BerlPap* did with genres of literary papyri. The same can be said about Vienna's catalogue, in which content types are listed on the basis of their occurrences.

Similarly to *Manchester Papyri*, the *Oxyrhynchus Online Image Database* allows for browsing metadata elements alphabetically arranged, including types of literary and documentary texts; metadata can be searched as well, although combined searches are not supported. Furthermore, a section enables us to browse through a hyperlinked list of editions.

Chartes is another database that gives the opportunity to search and browse the content according to specific metadata facets, though without all the possibilities offered by *BerlPap* and *Kölner Papyri* such as browsing by publication and displaying the results in the preferred order. The search interface and the browsing utility reflect a data model customised to the particular features of the Herculaneum papyri. Thus, metadata fields concern the procedure of unrolling of the scrolls and the production of apographs (or facsimiles): the status of the roll with regard to its opening, the person in charge of

[193] Gartner 2016, 62.
[194] Gartner 2016, 62-63.

this task, the year of the unrolling, the size of the fragments thereby obtained, and the author of the facsimile. Records are connected, as well as with *Trismegistos*, with specific resources for these papyri, such as the digitised facsimiles at the National Library of Naples (*Disegni napoletani dei papiri ercolanesi*) and at the Bodleian Library (*P.Herc. Image Database*). Links to the texts in the *Digital Corpus of Literary Papyri* are also present, although they should be updated to direct us to *Papyri.info*, where the *DCLP* has been merged.

Among smaller digital collections, two deserve notice for the usability of their navigation: University of Oslo's *OPES* and University of Genoa's *Papiri dell'Università di Genova*. The former provides metadata and images of almost all the published papyri of the Oslo collection, totalling 240 records.[195] Items can be not only searched but also sorted by several categories, and metadata fields in the results list can be revealed or hidden based on user interests. The latter records the published texts, ca. 250, of the University of Genoa's papyrological holdings. While not making use of so many database fields and indices as the above-mentioned projects, it can be precisely browsed by the main categories of content type, place of finding and age, and its data entry user interface provides controlled value lists to enforce the use of the necessary information.

2.7.4 Image usability: online availability, quality and policy on copyright

With regard to the online availability of digitised collections, generally speaking we find different possibilities among worldwide libraries, as pointed out by van Lit (2019, 85). Some have an online presence and are also fully and freely accessible, which is the most common situation, or they may be made instantly available online upon payment. Others are not on the web and may require to order their images, while some, previously available, no longer exist.

Almost all digitised papyrological collections, too, may be conveniently seen instantly on the web for free. However, they present a more nuanced situation, with further possibilities such as records with metadata only or with images in the form of thumbnail, and different situations within the same collection.

The different characteristics of online availability of digitised papyrus collections mainly depend on the distinction between published and unpublished papyri. While the

[195] *OPES*, "About the project." The number of records is reported in the search mask.

majority of catalogues focuses on access to published material, a few of them include records of unpublished papyri, with different policies. Heidelberg *Papyrussammlung*, Manchester *Papyri* and especially Vienna's *ÖNB Digital* offer online access to high-resolution images, besides metadata, of some unpublished fragments. The small digital collection of the University of Groningen has also made available its unpublished material.[196] Similarly, unpublished papyri of the Geneva collection (*Papyrus de la Bibliothèque de Genève*) are provided with metadata records comprising images, albeit in a somewhat low resolution. Another possibility is to make available images of unpublished texts on demand, as occurs for the Oslo collection.[197] Lastly, one more eventuality, as already seen in *Papyrus Projekt*, is the one in *Kölner Papyri.* Here, unpublished fragments,[198] as well as published ones that are being re-edited by Cologne papyrologists,[199] are provided with metadata and thumbnails, whereas high-resolution images are indicated as locked.

A further policy for the papyrological collections available online, which in part seems to relate to copyright reasons as well, is that of the *Turin Papyrus Online Platform*, whereby users need a free registration to consult the full digitised collection, whereas only a selection of items is otherwise available.[200] It is possible that registration is required for statistical purposes, to survey users' characteristics such as occupation, database experience level and motives for accessing the resource, on which they are asked to provide information. Moreover, since registered users gain access to images of unpublished papyri, not on display in the museum, and to new research such as transcriptions and translations by the museum's staff,[201] a further goal may be to verify who avails himself of these materials, in the event of litigations concerning attribution. An inconvenience of this solution is that access may be restricted to already registered users if the registration form is temporarily turned off, as I have experienced, though only for a few days.

In only one case are the images of a digitised collection almost entirely unavailable online, and need to be requested at the library. As anticipated (p. 115),

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196 University of Groningen, *Papyri.* The unpublished fragments, circa fifty, are located in a specific folder at the end of the browsing list of the items.
197 *OPES*, "About the project."
198 E.g. <https://papyri.uni-koeln.de/stueck/tm643381>.
199 E.g. <https://papyri.uni-koeln.de/stueck/tm128460>.
200 *TPOP*, "What is available to whom?."
201 *TPOP*, "What is available to whom?." Cf. also Id., "Policy on access and use," esp. "Authorship of text content."

Chartes does not contain the comprehensive infrared images produced by Brigham Young University, but only a sample for each papyrus. The complete images may be ordered from this university and obtained after receiving clearance from the owning institution of the papyri, the National Library of Naples.[202] A planned jointly sponsored catalogue of the two institutions, aimed at providing free online access to the whole digitised collection,[203] was in fact not implemented because of unresolved rights issues.[204] The limitations to the development of this resource are therefore institutional rather than technical, as also observed about the virtual reunification of fragments from different collections (p. 111).

Overall, most catalogues make their published papyri freely available, sometimes, additionally, with preliminary data on the unpublished ones, thus providing a wealth of material for more in-depth investigation into already known texts and possibly stimulating the study of new ones.

The catalogues offer images of very good quality, as they can be enlarged to provide enough detail to deal with lacunose passages. For example, *BerlPap* usually offers images at the high resolution of 600 dpi; papyri of large size may show a lower resolution, of ca. 300 or 400 dpi, but the images thereby produced are altogether usable. The digitised photographs of the Cairo Archive present a maximum resolution of 300 dpi, which nevertheless proves good enough for reading purposes. Only one resource contains low-resolution images, in a way that strongly impacts on their usability, for almost all its papyrological records, namely the *Schøyen Collection* catalogue.[205]

It is possible to download high-resolution images for working on them on one's computer, with the significant exception of the University of Manchester's *Papyri Collection*, which only allows obtaining a PDF file of the record with a low-resolution picture.

Some collections also allow examining the papyri online in an advanced viewer, which enables us to freely enlarge the images, move them around and rotate them. Even though a close inspection may also be carried out satisfactorily by downloading the

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[202] Macfarlane 2007, 585-86.
[203] Macfarlane 2007, 586.
[204] Macfarlane 2010, 460; BYU Library, "Papyrology: Herculaneum Project."
[205] This catalogue contains a selection of the Martin Schøyen private collection, including records of circa forty papyri out of a total of about a thousand (*Trismegistos Collections*, <www.trismegistos.org/collection/261>). Papyri may be found with a keyword search or by browsing some sections, e.g. "Papyri & Ostraca," "Literature" and "Palaeography."

image, an advanced online viewer is useful for quick browsing from fragment to fragment, if multiple fragments of the same object are extant, or from page to page in a codex.[206] Five catalogues are notable for making use of a viewer that follows a broadly-accepted standard. Heidelberg's and Berlin's resort to DFG-Viewer, developed for interoperability in German resources by the Deutsche Forschungsgemeinschaft (German Research Foundation).[207] An even more wide-spread tool is employed in *Bodmer Papyri*, *Chester Beatty online* and Manchester's *Papyri* teaching resource: Mirador, which is compatible with the IIIF (International Image Interoperability) technical standard for storing, displaying and sharing images, both as a whole and select parts of them;[208] it also includes a facility for immediate download and provides readily available information on redistribution rights. Other very good viewers are those of Manchester's *Papyri Collection* and Oslo's *OPES*, which allow freely navigating and zooming the pictures, and especially *Chester Beatty online*'s own viewer, provided in addition to Mirador, with a unique feature: a utility for instantly creating a reliable link, based on the IIIF ID of the image, for referencing and sharing online a specific area of the item selected by the user.

There are various policies whereby the copyright is asserted over the digital images of the papyri in European catalogues of individual collections. We may compare them to those pinpointed about digital surrogates of manuscripts in general, as highlighted by van Lit (2019, 86-87) on the basis of a large sample of worldwide libraries preserving Islamic manuscripts. Some institutions publish their images in the public domain, thus permitting any kind of redistribution, whereas others limit usage to non-commercial or only personal purposes. Another eventuality is that they require to be asked for permission under all circumstances. Finally, there may be an unclear description of the rights and permission or no indication at all. In the last two events, it is all the more important that options for contacting the staff are provided and are easy to retrieve. These attitudes on copyright are evenly diffuse among libraries, aside from the most restrictive one, only allowing download for personal use, which is rarely found.

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[206] Cf. van Lit 2019, 65, who mentions the utility of online viewers for browsing and skimming through pages, in regard to digitised medieval manuscripts.
[207] *DFG-Viewer* 2020.
[208] For an overview of the IIIF framework, see van Lit 2019, 160-67.

The same situation characterises papyrological digitised collections, among which we mainly find the most popular policies.

Most European individual papyrus catalogues present the second policy above-mentioned, requiring publication permission. Among the most extensive ones, there are *BerlPap*,[209] *Oxyrhynchus Online Image Database*[210] and *Chartes*.[211] The same applies for smaller catalogues such as *Papyrus de la Bibliothèque de Genève*, Oslo *OPES*[212] and *Papiri dell'Università di Genova.*[213] Among them, *OPES* provides information on their policy in a standardised way, by means of a Creative Commons license.

The first policy identified, which allows any kind of usage, is also found, among large-scale collections, too. It is adopted by Vienna's *ÖNB Digital*,[214] *Kölner Papyri*[215] and, among smaller catalogues, by Sorbonne's *Collections de Papyrus*[216] and *Turin Papyrus Online Platform.*[217] *Kölner Papyri* and *TPOP* make use of a Creative Commons license (CC BY), to indicate their license in a standardised way.

Another common possibility is to permit use for non-commercial purposes, as stated, by means of a CC BY-NC license, by Manchester collections,[218] *Bodmer Papyri* and *Chester Beatty online*, although, for this last resource, publication rights for commercial purposes may be requested.

Other attitudes on redistribution are less common. Requesting permission for any usage is necessary for the Heidelberg collection,[219] as well as for the Schøyen.[220] Also, a few small catalogues do not provide indications on redistribution, but there is clear information on how to contact their staff for further details (e.g., University of Groningen's *Papyri*). Only for one resource is the notice on copyright restrictions difficult to retrieve (Manchester's main *Papyri Collection*). As opposed to this, some catalogues conveniently provide the information straightforwardly in each record or

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209 *BerlPap*, "Terms of Use."
210 *POxy*, "Copyright and Credits."
211 *Chartes*, "Su Chartes."
212 *OPES*, "Rights."
213 *Papiri dell'Università di Genova*, "Contatti."
214 Österreichische Nationalbibliothek, "Nutzung."
215 The indication of the CC BY license is reported in each record of the Cologne papyri.
216 Institut de Papyrologie de la Sorbonne,"Du bon usage des images."
217 *TPOP*, "Policy on access and use." Some files provided in *TPOP* based on a collaboration with other institutions present a different license, CC BY-NC rather than CC BY, which does not permit use for commercial purposes, as agreed with their partners (ibid.).
218 University of Manchester, "Copyright and licensing."
219 Institüt für Papyrologie, "Terms of use."
220 *Schøyen Collection*, "How to use this website."

image, i.e. *BerlPap*, *Kölner Papyri*, Heidelberg *Papyrussammlung*, *Bodmer Papyri*, *Chester Beatty online* and the Manchester *Papyri* teaching aid.

2.7.5 Conclusion: purposes, sustainability and overall evaluation

The collection catalogues here examined serve very well the purpose of research, with which they are primarily concerned. To achieve this, almost all the collections offer high-resolution images, richly encoded metadata, at times exploring in-depth some aspects of their papyri. While the majority of catalogues aims at distributing material on published papyri, especially Heidelberg *Papyrussammlung* and *ÖNB Digital* actively engage in the creation of new evidence on unpublished texts as well, by offering high-resolution images for them and by making them retrievable altogether.

An opportunity for ameliorating digitised papyrus collections for the purpose of research could be the addition of more material on the history of the scholarship, following the example of the *Oxyrhynchus: A City and its Texts* virtual exhibition, also drawing on external projects, as the *Turin Papyrus Online Platform* did. To this end, virtual reunification might be used to integrate not only papyrus fragments and archaeological objects, but also archival scholarly materials, both related to the individual items and the collection as a whole, such as preliminary transcriptions of the papyri, correspondence and excavation documents, viz. photographs taken on the findspots, site plans and object records. For instance, collections with papyri unearthed in British excavations, that is, *POxy: Oxyrhynchus Online* and Manchester's *Papyri Collection*, could be linked to the digitised material available in *Artefacts of Excavation. British Excavations in Egypt 1880-1980*, in particular to correspondence and object records of Grenfell, Hunt and Flinders Petrie about their work in Oxyrhynchus, in several sites in the Fayum oasis and Hawara.

Some resources, while making research a central focus, also cater to different levels of education. A way of doing this is by creating a dedicated instrument within the same website that hosts the papyrus collection. This is exemplified by Manchester's *Papyri*'s selection of highlights, aimed at teaching support, the blog posts and exhibitions on the Vienna papyri, the *Oxyrhynchus: A City and its Texts*, *Codex de Ménandre* and *Constitutio Antoniniana* thematic collections. By the same token, *BerlPap* regularly publishes posts in an "Object of the Month" section, foregrounded in

the home page, and provide general insight into the discipline, with their "Papyrology" section.

Furthermore, curators of a few collections utilise external resources, namely, platforms for the general public, mostly *Google Arts & Culture* and *Sketchfab*, for the purpose of dissemination, harnessing their ability to share information widely, quickly and effectively. Dissemination has concerned both information on the collection, to enhance its online visibility by sharing an artefact of notable interest or a selection of them, and the papyrological science. The staff of the Vienna and Berlin collections have concentrated on the former possibility. A short history of the Vienna collection is included in the virtual exhibition "Treasury of Knowledge" created by the Österreichische Nationalbibliothek on its web page on *Google Arts*. On the same platform, a representative sample of literary, paraliterary and documentary papyri from Berlin's Papyrussammlung is available (*Papyrus*, Staatliche Museen zu Berlin), furthermore with a brief insight into education in antiquity.[221] The staff of the John Rylands Library in Manchester has used the *Sketchfab* platform for 3D models for sharing a three-dimensional image of one of its most famous papyri, the "St John Fragment" from a codex leaf,[222] and a digital reconstruction of a codex with a treatise on divination, by means of a facsimile, in order to show its original form in a closing position.[223] The latter record comprises an explanation of how the book was produced and an excursus on divination in antiquity. The Chester Beatty museum, on *Google Arts*, have focused on the provision of information on the discipline, in particular on the manufacture of papyrus rolls and codices, while also yielding insights into their papyrological collection.[224] Since *Google Arts* offers great help in publishing digital collections, it could be utilised more frequently, both for collections not yet digitised, so as to provide them with an online presence, and for those already online: not only for promotion and dissemination, but also for organising the content in further ways than on the institutional catalogue, by using the provided facilities for grouping items into categories and to create virtual exhibitions.

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[221] See the information in the records of two wooden tablets with extracts from the *Iliad* at <https://g.co/arts/Nqh1qzpmmyoiEZsR9> and <https://g.co/arts/1viUitjrAVRJMbKj8>.
[222] See <https://skfb.ly/6SzYp>.
[223] See <https://skfb.ly/6XVOU>.
[224] See <https://g.co/arts/E8xpCsKuzkCFXf9V9>, esp. "P is for papyrus."

These collection catalogues are identifiable as permanent resources due to the stability of their host institutions, which, with the exception of the Schøyen private collection, are university libraries, as well as national museums (*BerlPap* and *Turin Papyrus Online Platform*), city council libraries (*Papyrus de la Bibliothèque de Genève*) and established institutions (*Bodmer Papyri* and *Chester Beatty online*).

In some catalogues, sustainability is strengthened by the use of digital standards for the representation of images and metadata, which facilitate resource interconnection and reuse in complex ways: the EpiDoc Guidelines, adopted in *Kölner Papyri*;[225] the DFG-Viewer information system used for Heidelberg's and Berlin's catalogues; and the IIIF framework, deployed by Heidelberg's *Papyrussammlung*, Manchester's *Papyri Collection*, *Bodmer Papyri* and *Chester Beatty online* (as well as Manchester library's smaller collection). Moreover, through the DFG-Viewer, images and metadata of the Berlin and Heidelberg catalogues are integrated into a system that constitutes a guarantee of long-term storage and citability.[226]

The Heidelberg *Papyrussammlung* proves particularly advanced from the point of view of standards, with the use of DFG-Viewer, IIIF-encoded metadata and further methods of stable citation on the web such as DOI numbers and URNs (Uniform Resource Name) for each record.

Overall, individual catalogues of European collections are invaluable resources to serve research and teaching purposes. The number of images already present therein is vast; they can claim relative completeness and representativeness of a variety of papyri as for content types, time periods, languages and scripts. The great majority of them offers high-quality images that can be seen freely online and downloaded, and redistributed usually after receiving clearance from the owning institution. Especially noteworthy is *BerlPap*, which performs well in all respects: in terms of quality (of images, metadata and contextual information), in terms of delivery (online availability, navigation, viewing and download), in presenting information with different levels of communication, and in terms of sustainability. Other catalogues are very good in some respects, besides the provision of high-quality images: Heidelberg *Papyrussammlung*, *Kölner Papyri*, Vienna's *ÖNB Digital* and *Bodmer Papyri* for offering comprehensive

[225] The use of EpiDoc-compliant encoding is indicated in *Kölner Papyri* records.
[226] Cf. Universitätsbibliothek Heidelberg 2019.

metadata, bibliography and links to external resources; Heidelberg's and Cologne's catalogues are also notable for their navigation facility, and the former for the use of multiple standards as well; *Oxyrhynchus Online Image Database* for presenting the papyri in the meaningful context of a rich thematic collection; and Sorbonne's *Collections de Papyrus* for the creation of virtual reconstructions and for bringing to light material from private collections. Finally, there is an "anomalous" case that emerged: *Chartes*, while performing well in the provision of metadata, is characterised by the difficulty of accessing the digital surrogates, exceptional among papyrological catalogues overall.

2.8 Library and museum general catalogues with papyri (with a focus on European institutions)

2.8.1 An overview of the catalogues and their comprehensiveness

A number of real-world papyrological collections is available online in general holdings catalogues of libraries and museums that encompass a broad range of items, where papyrus records are found alongside other materials. For these resources, the analysis will thus also pay attention to how well the general catalogue's portal discloses its papyrological collection. Because of the large number of these catalogues, I have concentrated on those relating to European, rather than United States, institutions, which include the most extensive papyrus collections.

Two European library catalogues cover vast papyrus collections that have been extensively digitised with both metadata records and images. One is that of the British Library. Of the 3000 catalogued papyri, plus thousands of other fragments, of the material collection in this institution,[227] over 2000 have been provided with online metadata records, and images for ca. 1600 of them are available. Metadata records of the papyri are gathered in a specific subset of the library's catalogue of manuscripts and archival material (*Papyri*), whereas their images have been entered into the *Digitised Manuscripts* collection alongside other materials; they can nevertheless be called up

[227] British Library, "Greek and Latin Papyri."

with a keyword search. We know that this online collection is expanding, as the remaining catalogued items have been already imaged and the library staff intend to gradually integrate them into the database.[228] While not provided with a dedicated section in the library catalogue, the British Library's papyrological collection presents exhaustive background information online. There are overviews of the overall collection and of special items such as the Herculaneum papyri and ostraca,[229] and valuable additions such as thematic collections in the *Greek manuscripts* section, posts in the *Medieval manuscripts blog*, and a virtual reconstruction of a collection's highlight, the Sinaiticus Codex divided across four institutions.[230]

The papyrological collection of the Louvre museum is also of a wide extent: *Trismegistos Collections* lists little more than three thousand Greek and Latin papyrological texts for it.[231] It has been comprehensively recorded and imaged in the institution's holdings catalogue (*Collections*): a search for Greek and Latin papyri, ostraca and tablets yields over three thousand records, nearly always complete with images, however at a very low resolution. The collection is however not provided with contextual information and presents a small drawback for users who need precisely retrieving papyrus records: one has to know in advance in which museum departments the objects are housed, whether in that of Egyptian antiquities for papyri and ostraca, or in that of Greek, Etruscan and Roman antiquities for tablets (as indicated in *Trismegistos Collections*), and these have to be searched separately.

Another major papyrus collection, that of the Bodleian Libraries, for which *Trismegistos* contains 1600 records for papyri and related materials,[232] has also been comprehensively catalogued online: the database of the University of Oxford's medieval manuscripts (*Medieval Manuscripts in Oxford Libraries*) contains records of 1200 papyri, as results from a keyword search.[233] However, unlike the two previous collections, it has almost not been imaged, as only eleven records are complete with pictures, as a provided filter in the same catalogue shows. Albeit not numerous, the images form a sub-collection in the catalogue of Bodleian's digitised materials (*Digital*

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[228] British Library, "Greek and Latin Papyri."
[229] British Library, "Greek and Latin Papyri," "Ostraca" and "Charred scroll fragments from Herculaneum."
[230] British Library, *Codex Sinaiticus.*
[231] See <www.trismegistos.org/collection/274>.
[232] See <www.trismegistos.org/collection/265>.
[233] See <https://medieval.bodleian.ox.ac.uk/?utf8=✓&q=papyrus>.

Bodleian), provided with a general overview and listed alongside others in the "Browse" page of the database.[234] As regards scholarly dissemination among the general public, a papyrus preserving part of a poem by Sappho has been included in a virtual exhibition on women that made important contributions to culture or society, in the light of remarkable items of the libraries.[235]

Another digitised collection of artefacts preserved at the Bodleian Libraries is that of the Oxford *disegni*, i.e. hand-drawn facsimiles or sketches, of the Herculaneum papyri. While being visual materials, as opposed to the original papyri, they are precious documentation, since some P.Herc. have deteriorated or even got lost after the *disegni* were produced.[236] The Oxonian *disegni* have been catalogued, imaged and made available as *P.Herc.* via the *Pinax* portal of papyrological collections in Oxford, developed by the University's *Imaging Papyri* project, which includes collections housed at the Sackler Library; the Bodleian Libraries' website is linked to *P.Herc.* via its subject guide on papyri.[237]

We do not know whether Bodleian papyri will be made digitally available in a comprehensive way. Although the Library are committed to imaging their special collections as much as possible,[238] 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.[239] Hopefully, the papyri might be digitised in cooperation with an external project, as arguably occurred for the facsimiles of the Herculaneum papyri. It is also possible that images are occasionally made available in *Digital Bodleian* following photography orders by researchers, a possibility taken into account in the library's digitisation policy.[240]

Two further catalogues contain a few records and images of papyri, but this is proportional to the extent of their material papyrological collections. The *Gallica* catalogue of digitised materials from the Bibliothèque nationale de France contains images of circa 160 papyri, out of a total of 350, largely unpublished.[241] Their records

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[234] Bodleian Libraries 2020.
[235] *Sappho to Suffrage. Women who dared*, esp. "Sappho (c. 620 - c. 550 BC)."
[236] On the significance of the *disegni* of the P.Herc., see Gallazzi 1983, 182-84.
[237] *Finding Aids - Papyri, Medieval & Renaissance Manuscripts at the Bodleian Library: Papyri.*
[238] *Digital Bodleian*, "About Digital Bodleian."
[239] *Digital Bodleian*, "Frequently asked questions."
[240] *Digital Bodleian*, "Frequently asked questions."
[241] On this collection, see Blouin 2016, in part. 854 for its extent, and 879-81 for the digitisation project.

may be called up rather straightforwardly with a search by keyword of the term "papyrus," refining the results by document type ("manuscript").[242] The records mostly refer to unpublished papyri, in course of publication. It is likely that more images are actually accessible to scholars, since the papyrologists in charge of the collection aimed at its complete digitisation and considered making the pictures available to the scholarly community by request.[243] A few digitised papyri of the Vatican Library, which preserves circa 150 Greek, Latin and Coptic papyrological texts,[244] can be accessed via the *DigiVatLib* catalogue of its digitised items; they may not be retrieved altogether with a keyword search, but rather singularly by searching or browsing by shelfmark or title. As for the papyri at the Bibliothèque nationale de France, there is no collection overview, while some Vatican papyri feature in thematic collections for illustrating Greek and Latin palaeography and the transmission of classical literary works,[245] and among collection's highlights.[246] Possibly more papyri will be digitised, as the Library aim to make available online its entire collection.[247]

Finally, there are two extensive collections of texts relating to the papyrological domain which have been catalogued online, both belonging to the British Museum: the Latin wooden tablets from Vindolanda[248] and the Coptic ostraca from Wadi Sarga.[249] They can be precisely called up within *British Museum Collection online*, the museum's holdings catalogue of both metadata records and images, with the aid of an automated suggestion system. Records complete with pictures can be conveniently selected through the provided option. There are 1700 records of Vindolanda tablets, with four hundred images,[250] and 1400 Wadi Sarga ostraca, practically all provided with images,[251] whose digitisation started in collaboration with *APIS*.[252]

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[242] See <https://gallica.bnf.fr/services/engine/search/sru?operation=searchRetrieve&version=1.2&startRecord=0&maximumRecords=15&page=1&query=%28gallica%20all%20%22papyrus%22%29&filter=dc.type%20all%20%22manuscrit%22>.
[243] Blouin 2016, 881.
[244] On the Vatican papyrus collection, see the overview in *Trismegistos Collections*, <www.trismegistos.org/collection/348>, esp."History," based on a study by P. Canart.
[245] *Thematic Pathways on the Web*, esp. "Latin Paleography," "Greek Paleography" and "Latin Classics."
[246] Vatican Library, "Il Papiro Hanna 1."
[247] Vatican Library 2019.
[248] On this material collection, see p. 15.
[249] On this material collection, see O'Connell 2019, 69-70, 75.
[250] See <https://www.britishmuseum.org/collection/search?place=Vindolanda>, in *British Museum Collection online.*
[251] See <https://www.britishmuseum.org/collection/search?place=Wadi%20Sarga&object=ostracon>, in *British Museum Collection online.*
[252] O'Connell 2019, 75. Cf. p. 63.

Overall, the institutions with extensive papyrological collections have published a substantial amount of information online on them, in good part complete with images, as, in particular, the British Library, the Louvre and the British Museum did. The notable exception of the Bodleian Library, for the papyrus images, needs however to be mentioned. Other institutions with small papyrus collections, i.e. the Bibliothèque nationale de France and the Vatican Library, have also made available part of their holdings on the web.

Aside from Louvre's *Collections* and *DigiVatLib*, the other databases offer rather straightforward access to their papyrological sources through keyword searches. They thus provide great help to papyrologists in finding images, metadata and bibliography for a vast amount of texts. However, a small inconvenience in comparison to specific papyrological catalogues is that one needs to perform multiple searches to find texts on different supports than papyrus which also fall within the papyrological domain (e.g., pottery, parchment and wood),[253] and then to further refine the results lists by time period and language. It would be therefore useful that librarians of these institutions collaborate with papyrologists for the creation of a thematic sub-collection on this discipline. A papyrological sub-collection within a general catalogue would be thus defined by the scope of the discipline, that is, by the intellectual properties of the objects, rather than only by their external features, such as the writing support, and by managerial ones, such as the conservation department. This would make the contours of papyrology more visible in the catalogues, as they would be already inscribed into it, and enable interested users to retrieve papyrological sources as a whole.

Another small drawback of digital papyrological holdings in wide-ranging resources is the separation between catalogued data and images on one hand, and overviews (or subject guides) and thematic collections (or virtual exhibitions) on the other hand, as these materials are not fully interlinked. This issue, too, could be addressed by the development of a papyrological sub-collection, which would allow to conveniently gather together not only metadata and surrogates of primary sources, but also related secondary and tertiary materials. Indeed, digital humanities literature, in particular Palmer (2004) and Flanders (2014), has emphasised that it is important, for assisting research processes, to enrich digital resources with thematic collections in

[253] On types of texts that pertain to the papyrological domain, see p. 11.

which questions and methods of scholarly inquiry are already part of the representation (cf. above, pp. 52-53). As seen in the previous sections, thematic collections on papyrology-related topics have been developed within specific catalogues for this discipline. By the same token, papyrology might constitute a theme on which to centre a research collection in owning institutions' general catalogues, thereby gathering papyrological materials dispersed across the resource. This would also allow making more visible and valorising their papyrological holdings, as digital surrogates do not substitute the real-world collection, but augment it, raising further interest for it among users.[254]

2.8.2 Usability of metadata records and images

A few general catalogues offer overall information on their papyrological holdings. Also, they contain little or no documentation on the implementation of their papyrological digital collections. The British Library's papyrus collection is the one provided with most details, with an overview of both papyri and ostraca, and some information on the digitisation plan (cf. p. 122); a general survey of the physical collection is also present in the Bodleian Libraries' catalogue (cf. pp. 123-24).

In general, these catalogues show a data model based on the minimal encoding of named entities and relationships among items, rather than on advanced markup of specific metadata facets for papyrology. They thus usually present basic searching and browsing functions, by keyword and chronological span, affording less granular access to the texts than the catalogues purposefully dedicated to papyrological collections. Two resources are however worthy of mention: the *Papyri* section of the metadata catalogue of British Library manuscripts is built on the encoding of person names, which also allows retrieving texts belonging to archives, of place names and languages; the British Museum's collections of Vindolanda tablets and Wadi Sarga ostraca can be queried by person name, and the latter by subject as well (though as a free keyword search rather than as a metadata field).

The records of these catalogues usually present comprehensive metadata, with the indication of the papyrus edition, further bibliography and *Trismegistos* ID number.

[254] Warwick 2017, ii143, ii146.

Especially rich of information are those of the British Library and the British Museum, and the latter also offers a translation of the text of the tablet or ostracon. A small improvement for the British Museum digital collection of Vindolanda tablets could be the provision of links to the online editions of the texts, *Vindolanda Tablets Online* and *RIB online*, for viewing images of all the published items (as the British Museum website contains pictures for about half of the eight hundred published tablets) and for reading the original Latin texts with introductory material and commentary. On the other hand we may note *DigiVatLib*, which does not contain metadata aside from the shelfmark, whereas they report comprehensive bibliography; and the two catalogues of the Bodleian Libraries, *Medieval Manuscripts* and *Digital Bodleian*, which contain basic metadata, the former without pointing out the papyrus edition, while a link to the related *Trismegistos* record is sometimes present.

The provision of images has different characteristics across these resources: online availability, viewing, downloading and policy on copyright.

As for the online availability of images, we find some extensive digitised collections: those of the Louvre, the British Library, and the British Museum, especially the Wadi Sarga ostraca. The papyrological collection that has been imaged most extensively is that of the Louvre. However, the quality of its images greatly varies, and almost all items present a low resolution; some records[255] are nevertheless sufficiently usable, whereas most records prove of little use for research purposes.[256] The collections of the British Library and the British Museum, conversely, have been extensively imaged while offering high-quality pictures at the same time.

The other collections have been digitised in a small part, especially the Bodleian's, and images have to be ordered at the library. As for the quality of the images that they have made freely available, this is very good for scholarly purposes. Notice, though, that images of the Vatican Library show a watermark, which might make some readings difficult. The Bibliothèque nationale de France generally makes large use of digitisation of microfilms to build their *Gallica* repository, as it is comparatively inexpensive and fast; on the other hand, it is a process that reduces the quality of the digital surrogate,

[255] E.g. <https://collections.louvre.fr/en/ark:/53355/cl010049057>.
[256] E.g. <https://collections.louvre.fr/en/ark:/53355/cl010041816> and <https://collections.louvre.fr/en/ark:/53355/cl010001596>.

which results in a copy of a copy.[257] Their papyrological collection, however, has been affected to a very small extent by this problem, as only a few items are available in such form.

Some catalogues allow efficient online viewing of the images: those of the British Library, the Bodleian Library, the British Museum, the BnF and the Vatican Library. Notably, *Digital Bodleian* offers as many as three viewers: not only its own, like the other catalogues, but also two viewers that make use of the IIIF standard for image interoperability, viz., Mirador and Universal Viewer. Two viewers present a small drawback concerning downloading: that of British Library's *Digitised Manuscripts* prohibits users from downloading and that of *DigiVatLib* allows us to download medium- and low-resolution photos only. Note, however, that in 2016 the British Library started adopting the standard Universal Viewer, compliant with the IIIF framework and developed with open-source software. Its features include improved navigation of large-format items and, for a selection of them, the possibility of downloading. Items are gradually being made available with Universal Viewer until it eventually replaces the different viewers presently utilised in their website.[258] Digitised papyri have started taking advantage of this new functionality.[259] As one may notice, in comparison to the viewer currently in use for papyri and medieval manuscripts, the new one allows downloading the papyrus image, provides an indication of the usage terms, enables easier sharing, printing and providing feedback.

Most institutions allow non-commercial use of the images, provided that their attribution is indicated. This policy is followed by the British Library,[260] the Bodleian Library,[261] the British Museum,[262] the BnF[263] and the Vatican Library.[264] Next, two institutions allow for more possibilities of use: the British Library permits any kind of re-distribution, including publication, for images already available on their catalogue; the Louvre museum allows free publication of the images if this concerns catalogues

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[257] Van Lit 2019, 75-76.
[258] Ridge 2016.
[259] See the posts on the British Library's blog, about a recent digitisation project of papyrus fragments shared by the British Library and American collections: Micucci 2021a and 2021b.
[260] British Library, "How can I use the images I order?;" Id., "Websites and online services," esp. "2. Copyright."
[261] *Digital Bodleian*, "Digital Bodleian Terms of Use."
[262] See items' records.
[263] *Gallica*, "Conditions d'utilisation de Gallica."
[264] The copyright statement is reported at the bottom of the website's pages.

and scientific papers whose registered office is in the EU, or digital scientific and educational works.

2.8.3 Purposes, sustainability and overall evaluation

On the whole, general library and museum catalogues serve well the purpose of papyrological research, by offering an abundance of discipline-related material immediately available for free, often usefully described and complete with images. Also, a catalogue, *Gallica*, serves this purpose by presenting original evidence for the papyri at the Bibliothèque nationale de France, by providing images of many texts in course of publication.

A weakness pertains to the precise retrieval of papyrus records across the wide range of catalogued items. There is an opportunity for ameliorating this aspect by establishing closer collaboration with papyrologists, so as to create a sub-collection specifically designed for the purpose of supporting research in the discipline. This would allow bringing together in a single digital space primary, secondary and tertiary sources currently divided across the catalogue and often not interconnected; and to design search interfaces with more complex options based on a deeper encoding of domain-related entities and subjects.

Digitised papyri feature in the thematic collections built by some catalogues for pedagogical purposes, such as *DigiVatLib*'s on Greek and Latin palaeography, or for dissemination on various aspects of ancient culture and beyond, such as British Library's on Greek manuscripts, *DigiVatLib*'s on the transmission of classical Latin texts, and Bodleian Libraries' on women's history. The British Library have also availed themselves of the *Google Arts & Culture* platform as a means of dissemination, presenting a fragment of a handbook of magic.[265]

These online museum and library catalogues represent a type of resource that we may recognise as permanently published, owing to the stability of the institutions that host them. Some of them also resort to a standards-based approach for encoding image metadata within the framework of the IIIF initiative, namely *Digital Bodleian*, *Gallica* and *DigiVatLib*, as well as British Library's, to a lesser extent thus far.

[265] See <https://g.co/arts/JZQsM2NLMbN2rN9f8>.

Among these general-purpose catalogues, that of the British Library performs particularly well in terms of both delivery and quality of information on its papyrological holdings: for the extensiveness of its digitised material in comparison to the physical collection, for its rather easy access to papyrus metadata records and images, for its comprehensive information on both the single items and the papyrological discipline. Other catalogues distinguish themselves for some characteristics, notably, *British Museum Collection online* for the extent of its subsets relating to the Vindolanda tablets and the Wadi Sarga ostraca, the image quality and the usable and attractive interface design. Next, we may point out Louvre *Collections* for the wealth of digitised material, *Digital Bodleian* for the use of standards and multiple online viewers, *Gallica* for the image quality, too, and for offering pictures and preliminary data on unpublished papyri. It is worth mentioning, though, that *Digital Bodleian* differs from the other catalogues in that it offers very few papyrus images, which need to be ordered, and we have little expansion to expect.

2.9 Conclusion

To conclude, we may highlight strengths and weaknesses of digitised papyrus collections as these emerge from the analysis, and explore opportunities for improvement.

Among their strengths, there is the vast amount of material already available. They are comprehensive in relation to the material collections, especially as far as published papyri are concerned; they are sometimes also rich in preliminary data and images of unpublished papyri, especially United States collections, thus further soliciting research through the provision of new evidence. Although the quality of the papyrus images may vary, the vast majority is usable. Two collections, however, form notable exceptions, because of their poor availability of images online: the Bodleian Libraries' catalogues and *Chartes*.

Secondly, another positive aspect is that some collections mediate access to papyri by employing advanced metadata encoding, thereby affording fine-grained access to texts through multiple options for searching and browsing based on item-specific

metadata. Within this group, some representative collections are *Papyrus Projekt*, *BerlPap*, Heidelberg *Papyrussammlung*, *APIS UM* and *Berkeley Database*.

Additionally, several digitised collections offer rich information that contextualises and integrates the primary-source content, taking into consideration different levels of education, notably, *Berkeley Database*, *APIS UM*, *POxy: Oxyrhynchus Online* and British Library's catalogue.

Berkeley Database, *APIS UM* and *Oxyrhynchus Online* offer insights, among other topics, into the history of the collection, taking into account the archaeological expeditions, the papyrus conservation and the publication process. Giving an in-depth view of the history of the collection might be an approach worthy of greater consideration for this kind of resource, which arises as a representation of institutions' holdings. This could be achieved not only with scholarly narratives, image content and other sources devoid of markup, but also with descriptive metadata in XML for archival material, accompanied by encoded transcriptions, and with visualisations. A project that could be taken as a model is *Follow the Pots*, from the archaeological domain. This thematic collection reconstructs the movement of tomb pottery and other grave goods, with a focus on prehistorical tombs excavated in Jordan in the 1960s, whose objects were in large part looted and offered for purchase to memory and research institutions. The project aims to provide direct access to primary sources: its main presentation consists of images of objects and of documents attesting acquisitions, devoid of markup, often embedded within scholarly narratives that report on sales and transfers between institutions and between areas of the same museum.[266] Similarly, a collection catalogue might contain digitised documents on the acquisition of papyri, as *APIS UM* does, or a dedicated resource might be created, linked to the catalogues. Furthermore, a more advanced example that could be followed is the project *Sur la piste des œuvres antiques*, also archaeological, developed by the French Institut National d'Histoire de l'Art and by the Louvre museum. It investigates the sale of antiquities in France in the 19th century based on diverse archival sources, so as to shed light on European collections' development taking into account the influence of the Parisian market. It is composed of three databases, which prioritise information derived from relevant primary sources

[266] See, among the best documented case studies, the extensive description of the distribution of the "1978 Tomb Group Distribution," and the documentation about the transfer of a tomb group from the University of Missouri to the British Museum ("British Museum, London").

such as buyers' and sellers' names and sale values. The results of the analysis are displayed in the form of an interactive map, to trace the history of the objects from their creation to their discovery, sale and acquisition by the museum; and in the form of a graph, for price trends. Analogously, papyrological catalogues might represent and visualise in a map the history of a collection from the places where the papyri, or groups of them, were produced, to their discovery (if different from the place of origin, and if this circumstance is known) and to its current location, possibly through a sale on the antiquities market. This visualisation might be embedded in the catalogue, or indeed be part of a dedicated project, in which the histories of several papyrus collections might be compared, whose sections may be linked externally to the relevant collection catalogues. There are already relevant digitised materials for some collections, which could be used as primary sources for a similar project, after being enriched with interpretive encoding: *APIS UM*'s reports of and correspondence on the acquisition of papyri, *Artefacts of Excavation. British Excavations in Egypt 1880-1980*, and *Egitto – Gli archivi della memoria*, with photographs of Italian excavations in Egypt.

Chapter 3

Providing direct access to papyri through text corpora and thematic collections

After focusing on digitised collections, in this chapter the thesis aims to complete the analysis of resources that provide direct access to papyri, by examining some corpora and thematic collections in which primary sources constitute the main content, that is, which prioritise their visibility and direct use. Other corpora and thematic collections that rather offer derivative data from primary sources, through a deeper level of information (e.g., a deeper linguistic or semantic layer) or further content (e.g., data visualisations), will be the focus of the next chapter. The resources under scrutiny differ from digitised library or museum collections, which also foreground item-level access to papyri, in that they are not governed by a logic of physical proximity. Rather, scholarship has a shaping role in defining their scope, viz., in the selection of the items and in their organisation around a subject or a research question. They thus form a coherent aggregation of content, with texts of a specific category, or with heterogeneous sources however focused on a theme (cf. pp. 48-49).

Papyrological text corpora and collections have been surveyed by Reggiani, who has outlined their historical background from the origin of the *Duke Databank* to the implementation of *Papyri.info* in its various components[1] and the diffusion of projects concerning other textual categories or with more in-depth information (e.g., encoded named entities and commentaries).[2] Furthermore, he provides an exhaustive description of the standard used for representing papyrological editions of both documentary and literary texts, including their Leiden conventions and a basic apparatus criticus, by customising the EpiDoc guidelines originally devised for epigraphy.[3] A comprehensive number of thematic image- and metadata-based collections has also been reviewed by the same author.[4] This chapter builds on the contribution offered by Reggiani by

[1] Reggiani 2017, 214-24.
[2] Reggiani 2017, 241-50.
[3] Reggiani 2017, 223-27 (marking up documentary papyri in the *Duke Databank*), 250-53 (literary papyri in the *DCLP*).
[4] Reggiani 2017, 83-87, 114-17.

considering the resources from a different angle, viz., with a typological approach based on resources' data models and purposes (cf. pp. 46-51); it thus seeks to determine what types may be distinguished on such grounds and what these types, with their characteristics, reveal about resources' development and curation.

The chapter starts with an overview of the resources scrutinised, subdivided by content and main type of information provided. The core of the analysis is presented in sections 2 and 3, respectively devoted to the content of the resources and to their usability, taking into account relationships between the two categories. The chapter concludes with a consideration of how the projects are benefitting papyrological research and how they sometimes show issues of content and design, exploring opportunities for amelioration.[5]

3.1 Overview of text corpora and thematic collections by content and type of information

Corpora and thematic collections that afford direct access to digitised papyri can be introduced by dividing them on the basis of their content and of the predominant type of information provided (i.e., text, imagery, metadata or scholarly narratives).

From a content point of view, two groups may be identified, namely, text corpora, which encompass broad textual categories, and thematic collections, focused on a more narrowly defined topic.

The former group is represented by two resources devoted to the principal categories of papyri: the *Duke Databank of Documentary Papyri* and the *Digital Corpus of Literary Papyri* (*DCLP*), both merged into *Papyri.info*.[6]

The latter group, thematic collections, comprises several instances, which may be subdivided by topic. A number of them are constructed around a type of text, most frequently on genres of paraliterary papyri: the former *Digital Corpus of Greek Medical Papyri*, now flowed into the *DCLP*; *Scholia Minora in Homerum*, dedicated to Homeric

[5] References to the resources scrutinised in this chapter are reported in the "Bibliographical references" section of the dissertation, in particular in its latter part, "List of resources cited." For convenience, the address of their websites is also pointed out as they are mentioned at the beginning of their analysis, in section 3.2, along with possible bibliography on them.

[6] On the history of the *Duke Databank*, see pp. 23-26. On the creation of the *DCLP* and on the aggregation of this database and of the *Duke Databank* on *Papyri.info*, see pp. 29-32.

glossaries; the *Kyprianos* database of magical texts, mainly Coptic, and to a lesser extent Greek; and one of the metadata databases in the *Trismegistos* platform, also dedicated to magical texts, in the various languages attested in papyri, *TM Magic*. Sometimes these texts are further circumscribed by a specific provenance, as exemplified by *Curse tablets from Roman Britain* and *Dodona Online*, the latter devoted to lamellae with oracular questions from the sanctuary of Zeus at Dodona; to them, the planned *Magica Levantina* database will be added, specific for late Roman and early Byzantine magical texts from the Levant. Moreover, there are thematic collections dedicated to the other categories of papyri: literary, with the former *Thesaurus Herculanensium Voluminum*, merged into the *DCLP*; documentary, with *Chartae Latinae Antiquiores Online*, containing information on ancient and early Medieval Latin documents, including papyri; and Christian, with the *Digital Manuscript Collection* of the Center for the Study of New Testament Manuscripts, devoted to images of New Testament papyri. Other text-based resources rather provide access to data derived from them, through an analytical layer, as exemplified by linguistically annotated corpora, or through other content, such as lemmatised words and possibly definitions in word lists and lexica, as we will see in the next chapter. Analogously, other metadata databases foreground granular access to primary sources, relying on articulated information and multiple search and browse options, for example the *Mertens-Pack*^{3} catalogue of literary papyri and most *Trismegistos* subsets.

Another common theme based on the content of the papyri is ancient sites, with their complex reconstruction in the light of papyrological evidence. The most notable instance is *Vindolanda Tablets Online* (*VTO*), a pioneering textual database comprising the texts from the Vindolanda Roman fort (cf. 1.4.3, pp. 32-33). Its content is now also accessible via a larger database that encompasses all the tablets and inscriptions from Roman Britain, *Roman Inscriptions of Britain online*; but the earlier website is still available within the platform of the Oxford's Centre for the Study of Ancient Documents (CSAD). It was followed by a second version, *VTO* 2 (no longer existing), based on a mediated-access data model, whose content has also flowed into *RIB Online*. Unlike the more recent *RIB Online* version, the original *VTO* website includes virtual exhibitions that illustrate the Vindolanda site, drawing on both the tablets and archaeological evidence, hyperlinked to relevant texts in the database.

The other resources concerning place-based themes are *Alexandrian Documents from the Reign of Augustus*, which gathers translations and bibliography of relevant texts, divided by type of document; the *Oxyrhynchus: A City and its Texts* exhibition, which is part of the website dedicated to the digitisation project of the Oxyrhynchus papyri at the Sackler Library (p. 107); and the exhibitions on Tebtunis created by the Center for the Tebtunis Papyri, also belonging to a larger resource related to a digitised collection, the one at Berkeley (p. 84). Several projects investigate social and cultural phenomena, notably the exhibitions in British Library's section *Papyri* (e.g., "Women in Greek Papyri") and in Michigan University Library's *Papyrology Collection* (e.g., daily life in Graeco-Roman Egypt, in "Diversity in the Desert"), and the papyrus collection in the *Judaism and Rome* website, which helps gain insight into the Romanness of the Jews in the Roman empire. Some exhibitions combine the discussion of two different topics, illustrating more in-depth a place while looking at related phenomena: *Vindolanda Tablets Online*'s exhibition addresses military life at the fort and the scripts used in the documents, among other topics; those on Tebtunis address ethnic identity, readership and religion of this city's inhabitants; *Oxyrhynchus* illustrates everyday life and material culture of the homonymous city, among other topics. The virtual reunification of the texts pertaining to an archive, now dispersed across several institutions, is instead the object of the image-based *Les archives de Dioscore d'Aphrodité en images*, as well as of the *Guide to Heroninos Archive*, focused on metadata (the latter, dealt with in chapter 4 of this thesis, at pp. 221-22).

A few themes rather concern external features of the papyri, especially their palaeography, with a resource that collects instances of dated handwritings, such as *PapPal*; there is also a database primarily intended for educational purposes, with representative samples of different scripts and writing styles, *MultiPal: Tutorials de Paléographie*. Also worth mentioning here is one of *Trismegistos* subprojects, centred on seals and stamps found on papyri (*TM Seals and Stamps*).

Lastly, some resources show a very specific focus, constituted by a single papyrus, usually a highlight of a physical collection, for example the aforementioned Bodmer's *Codex de Ménandre*, Giessen's *Constitutio Antoniniana* (p. 106) and British Library's *Codex Sinaiticus*. But there are also the *Codex Sinaiticus* international virtual reunification project, and the Center of Hellenic Studies' *Derveni Papyrus* which brings together different editions of this text, displaying them in parallel columns for

comparison. At the same time, some of these resources extend beyond the boundaries of the single exemplar, with some forays into general phenomena and different ages: *Codex de Ménandre* contains excursus on book manufacture in antiquity and the reception of Menander, while *Constitutio Antoniniana* reviews other documents that throughout history governed citizens' civil and human rights.

Secondly, resources may be distinguished on the basis of the type of information provided, noting whether they mainly gather texts, metadata, images, scholarly narratives, commentaries, or heterogeneous media. The majority are text- or image-based, while most metadata databases mediate access through advanced browse and search functions, sometimes along with quantitative analysis of the recorded data (as will be discussed in the fourth chapter).

Papyrus texts feature in the databases merged into *Papyri.info* and in most thematic collections focused on text categories, with the exception of *TM Magic*, which concentrates on the exploration of the material through structured information, and CSNTM *Digital Collection*, meant for the provision of images. Like *TM Magic*, *Kyprianos* currently prioritises access through metadata, but it sets out to provide text editions as well, which are gradually being added.[7]

Resources that primarily offer access to images of the papyri are, naturally, palaeographical databases, besides CSNTM *Digital Collection*. *Les archives de Dioscore* also concentrates on imagery, explaining the rationale for the choice of this data type: the goal is to form a basis for the edition of the still unpublished texts of this archive, for the revision of those already published, which appear in editions by now out-of-date and mostly devoid of images, and for the identification of scribal hands, as an aid to pinpoint subsets of documents and to determine their chronology.[8]

There are also projects in which different types of information cooperate to the representation of the primary sources. Some combine texts and images to create complete digital surrogates: *Papyri.info*, *Vindolanda Tablets Online* and the collaborative *Codex Sinaiticus* project. A few projects offer texts accompanied by commentaries, such as *VTO*, both in their original website and in *RIB Online*, reproducing the material of the printed edition; and *Judaism and Rome*, in this case

[7] See *Kyprianos*, "Texts" search mask.
[8] Fournet, n.d.

purposefully produced for the resource.[9] Images appear alongside contextual information in virtual exhibitions; in comparison to the other projects, these aim less to afford access to primary sources and more to embed them into scholarly narratives, which are their central focus. A different data type, videos, is utilised in British Library's *Greek manuscripts* exhibitions (in the "Videos" section), to show interviews to scholars on key topics, while sometimes also illustrating details of papyri and manuscripts (for example, in "Athenian democracy and its legacy"). Similarly, *Kyprianos* resorts to podcasts to share the work of the database's curators with both interested specialists and non-specialists.[10] From this point of view of the diversity of data types provided, *Vindolanda Tablets Online* can be regarded as the most complete project. It affords full direct access to primary sources by means of texts, images, commentary (both to the single texts and the whole corpus, with an extensive introduction), and encoded named entities (e.g., people, places, subjects and military terms) for browsing by relevant concepts, while presenting its data in different formats such as editions, exhibitions and indices. The merging of its texts, with their introductions and commentaries, into *RIB Online* proves useful for research purposes: it enables us to search the texts alongside others documents from the same ancient region, and therefore to find words and references to a topic within an overarching corpus. The original site is however still valuable for the presence of the virtual exhibitions, which offer further scholarly content and a different mode of access to the collection, suitable to various levels of users.

3.2 Scope, comprehensiveness and documentation

This section examines the usefulness of the content of the resources, i.e., their relevance to the papyrologist's research activities, in terms of width, range and quality, on the basis of the recommendations proposed in digital humanities literature (as reviewed in the first chapter, at pp. 54-55). It thus assesses whether their content is comprehensive relative to their scope and whether they are well-documented, making clear the extent, selection criteria and provenance of their materials, and technical decisions for resource construction concerning the markup or metadata schema.

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[9] See *Judaism and Rome*'s home page.
[10] *Kyprianos*, "The Podcast."

Projects are divided into groups taking into account their content and their format, so as to gather together those that present similar questions. There are corpora (examined in subsection 3.2.1) and thematic collections with a more circumscribed scope. The latter, because of their number, are further subdivided according to their predominant data type, i.e., text (3.2.2), images and metadata (3.2.4), and, where necessary, also according to their scope, thus pinpointing collections focused on one exemplar (3.2.3) and palaeographical resources (3.2.5).

3.2.1 Text corpora

Among text-based resources there are two extensive corpora, the *Duke Databank* and the *Digital Corpus of Literary Papyri*, available via *Papyri.info*.[11]

The *Duke Databank of Documentary Papyri* is the largest papyrological database, gathering a very extensive collection of almost 60,000 documentary papyri.[12] It encompasses different types of information, integrated from *Papyri.info*'s partner projects. A large number of records, nearly 58,000, present the papyrus text,[13] provided with an *apparatus criticus* showing alternative readings and editorial normalisations of spelling variants. Most texts were entered when the project was developed at Duke University in the early years of digital papyrology. Then, after a period in which the resource was hosted by the *Perseus Digital Library*, since its merging into *Papyri.info* in 2010[14] the content update has relied partly on institutions in charge of the project (especially Duke University and the University of Heidelberg), partly on community-sourcing[15] through *Papyri.info*'s *Papyrological Editor* collaborative environment. This tool enhances usability for non-experts of computing, who thus do not need to work directly with the XML code, as they may use the provided light syntax for EpiDoc markup.

Besides texts, mainly merged from the *Duke Databank*, detailed metadata have been provided by the *HGV*, *Trismegistos* and *APIS* databases. Bibliographical

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[11] <http://papyri.info>. On the history of *Papyri.info*, see pp. 22-32. For bibliography on it, see the literature review at pp. 34-41.
[12] See the value "All DDbDP records" in the "Collection" field of *Papyri.info*'s search mask, which points out the figure of 59,300 records.
[13] See the "Has Transcription" field of the *Papyrological Navigator*, selecting the "true" value.
[14] On the history of the *Duke Databank*, since its beginnings at Duke University until its current *Papyri.info* version, see 1.4.1, pp. 14-17, 21.
[15] Bagnall-Heath 2018, 177. On the notion of "community-sourcing" see above, p. 40.

information, both reported in papyrus records and searchable in a dedicated database, is integrated from the *Bibliographie Papyrologique* (*BP*), the most comprehensive bibliographical resource for papyrology.[16] Moreover, images are embedded in records of papyri digitised in the course of the *APIS* project (2000 records);[17] or, when images are available on a collection catalogue, links to them are usually provided (in 29,000 records).[18] Finally, the *Databank* includes translations of some texts, mainly in English (ca. 5000) and German (ca. 300).[19]

The corpus of documentary papyri of the *Duke Databank* has recently been complemented, in the same *Papyri.info* platform, by the addition of the *Digital Corpus of Literary Papyri*. This database contains a comprehensive set of metadata records, 15,000, of which 1700 are complete with papyrus texts.[20] The metadata was integrated from the *Leuven Database of Ancient Books* (*LDAB*) catalogue of literary papyri[21] (now merged into *Trismegistos*), which includes some genres of paraliterary papyri and the Christian ones.[22] Other projects have been significant contributors of texts: the *Thesaurus Herculanensium Voluminum* (*THV*), which addressed many of the best-preserved Herculaneum papyri;[23] the *Digital Corpus of Greek Medical Papyri*, which digitised numerous texts of this genre;[24] late-antique juristic papyri were entered in the context of the *REDHIS* project, as preliminary material of their full publication in the forthcoming *Corpus of Latin and Greek juristic papyri*;[25] texts of various genres were typed in within the *Anagnosis* initiative, which intends not only to help expand the corpus but also to utilise it as a basis for the development of software for digital

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[16] On this resource, published by the Université libre de Bruxelles and available online as *Bibliographie Papyrologique en ligne* (while updates relating to the current year are reserved to subscribers), see Reggiani 2017, 14-22, 29-30, 228.
[17] Search the database with the option to show images from *Papyri.info* itself.
[18] See the "Show only records with images from" field, selecting the "Other sites" value.
[19] See the "Translation language" catalogue field.
[20] See the value "All DCLP records" in the "Collection" field of *Papyri.info* search interface, and the "Has Transcription" option.
[21] Ast-Essler 2018, 63.
[22] *LDAB* 2018.
[23] See *THV*. Herculaneum papyri in the *DCLP* can be retrieved via the "p.herc" hyperlink in *Papyri.info*'s "DCLP" collection, or by selecting the "Campania" value in the "Nome" field in the *Papyrological Navigator*'s search form. The latter option is preferable, as it returns a slightly higher number of records (271) and of texts (166).
[24] Medical texts from this project total 285 (Reggiani 2017, 275), a significant number out of a total of 349 papyri of this genre recorded in the *MP*^{3} database of literary papyri (under the rubric "Médecine et chirurgie").
[25] *REDHIS*, "Texts editions." *REDHIS* texts in the *DCLP* total 47, as can be seen with a keyword search of the project's or corpus's name.

alignment of papyrus transcription and image.[26] Like *Duke Databank* texts, those of the *DCLP* present a critical apparatus; furthermore, texts from *Greek Medical Papyri* show an introduction and notes summarised from the printed editions.[27]

Papyri.info is provided with detailed technical documentation.[28] The information takes into account both the datasets merged, i.e., no longer existing as separate resources (*Duke Databank*, *DCLP* and *APIS*, as well as the *Checklist of Editions* reference work), and those integrated from external partner initiatives (*HGV*, *Trismegistos* and *Bibliographie Papyrologique*). We are also informed on the methods used for the platform's development: the EpiDoc specifications for metadata and text encoding, the SoSOL service and the Leiden+ tag-free markup language for the creation of the *Papyrological Editor* dynamic platform, and the Resource Description Framework model for the aggregation of the components. Moreover, *Papyri.info* provides directions for using the search form and a clear indication of the terms of use, by including a Creative Commons Attribution license in each record, allowing for any kind of usage and redistribution of their XML files as long as attribution is given.

In addition to this documentation, it seems worth informing users on the possibility to download the XML files of the components of the corpus, for reuse in further projects. In fact, the platform enables one to download, from each record, the source code of the texts, of *HGV* and *APIS* metadata, and of *HGV* translations, as is clearly pointed out by links provided in the related sections. But, also importantly, further technical documentation is available externally to the platform, in *Papyri.info*'s account on the GitHub public data repository.[29] This allows downloading the XML of many components of the platform, where they are conveniently collected in a single bundle, divided into subsets. Both *Papyri.info*'s datasets and the tools used for its functioning are available, including *Duke Databank* texts in bundles by publication volume, *APIS* metadata by collection and *HGV* translations as a whole, as well as the code for running the *Papyrological Navigator* and the *Papyrological Editor.* The decision to make *Papyri.info*'s data and base code public, permitting any reuse, has been

[26] Ast-Essler 2018, 71-73; Reggiani 2017, 154-55. These texts, retrievable with a metadata search of the project's name, number 290.
[27] Reggiani 2017, 253, 275-76; Id. 2018b, 3-4; Ast-Essler 2018, 64, 67.
[28] See *Papyri.info*'s home page, "About papyri.info" and "DDbDP."
[29] See <https://github.com/papyri>, esp. <https://github.com/papyri/idp.data> for *Papyri.info*'s datasets, as reported in Baumann 2013, 93-95.

rightly emphasised in the literature.[30] Thus, in the "About papyri.info" page, one could point out the availability of the base material, providing access to the GitHub service.

Moreover, it seems opportune to integrate *Papyri.info*'s technical documentation with information on the papyrological content of the platform, specifying the text categories included. On one hand, the resource's name, which refers to papyri in general, already suggests the inclusion of all types of text; also, the home page mentions the *Duke Databank of Documentary Papyri* among the integrated databases, which signifies the presence of this kind of texts; and the inclusion of the literary ones is suggested by a "DCLP" hyperlink in the top bar, along with an option for searching literary authors. Clearer information on the *DCLP* and its subsets with their related text categories could also be presented, as well as on their coverage. It would be a recognition of these projects' contribution, and an indication for users on whether it includes types of texts not precisely classifiable as literary or documentary, such as paraliterary and Christian ones,[31] and on whether the corpus can be usefully deployed for quantitative research.

3.2.2 Text-based thematic collections

Among the thematic collections under scrutiny, *Vindolanda Tablets Online* (*VTO*)[32] contains the largest number of texts. This early database comprises the 450 texts published in the T.Vindol. II volume (where the T.Vindol. I texts have been re-edited, with the addition of new ones). It presents excellent documentation on both the material and the digital collection. Information on the base text materials consists of introductory chapters drawn from the printed edition, but with the addition of virtual exhibitions on the history of Vindolanda and on soldiers' and their families' daily life at the fort. The introduction clarifies the added value of the database in comparison to the T.Vindol. print editions, in terms of new readings of the texts (anticipating their print publication in T.Vindol. III), new images, hyperlinked cross-references,[33] to which one may add articulated search and browse functions. The site also documents every aspect of the digital project, with a general overview of its aim and its intended audience,[34]

[30] Baumann 2013, 93-95; Bagnall 2010, 7-8.
[31] On these types of texts, see pp. 16-17.
[32] <http://vindolanda.csad.ox.ac.uk>. On *VTO*, see Crowther-Sasanow 2002 and Pierce-Ratcliff 2002.
[33] *VTO*, "The print publication and the online edition."
[34] *VTO*, "About this site."

technical directions for using the database,[35] documentation on the XML files[36] and the imaging process.[37] Even though the *RIB Online* version of the Vindolanda texts includes more recent material, i.e. the tablets subsequently published as T.Vindol. III and IV, *VTO* is still a noteworthy resource: it is not merely a witness of a pioneer papyrological digital edition, but it also offers further content, including rich virtual exhibitions, complete with photographic documentation of the Vindolanda site and related archaeological objects, and a more articulated glossary.

The other text-based thematic collections are less extensive than *VTO*, either because, while aiming at building a large corpus, they have been launched recently and are still in progress, such as *Kyprianos* and *Dodona Online*, or because they address a more circumscribed topic, such as *Curse Tablets of Roman Britain*, *Scholia Minora in Homerum*, *Alexandrian Documents from the Reign of Augustus* and, insofar as papyrological evidence is concerned, *Judaism and Rome*. These resources are well-documented concerning their scope and their material collections, whereas they do not present technical information on their implementation.

The *Kyprianos* database,[38] developed at the university of Würzburg, focuses on Coptic magical papyri, a set of texts that testify to the transition from the traditional Egyptian religion to the Christian and the Islamic ones.[39] It is a very comprehensive resource that aims at collecting the five hundred published texts of this type, the majority of which appear in scattered publications.[40] It also intends to provide a large set of unpublished ones (150 items) and some Greek and Demotic texts of the same genre, with a focus on those included in the *Papyri graecae magicae* corpus. The *Kyprianos* database is part of a larger project of re-edition and study of texts of the chosen domain; it thus serves both to provide a basis for the preparation of new editions and, as these are ready, to share them promptly while they are in course of publication in printed form.[41] Since October 2020, when *Kyprianos* was launched online,[42] as many as 920 records have been gathered, building on existing resources for the provision of

[35] *VTO*, "Tablets guide."
[36] *VTO*, "Digitising Vindolanda."
[37] *VTO*, "Creating digital images."
[38] <https://www.coptic-magic.phil.uni-wuerzburg.de/index.php/manuscripts-search>.
[39] *Coptic Magical Papyri*, "2020 Review."
[40] See *Kyprianos* home page.
[41] See *Kyprianos* home page and *Coptic Magical Papyri* 2020.
[42] *Coptic Magical Papyri*, "2020 Review."

metadata and bibliography, including *Trismegistos Magic*.[43] A hundred items are provided with the papyrus text, which, in comparison to the printed editions, includes edits and translations by the project's team, as indicated in the "Editor" section of each record.

The project provides clear information on its content on its home page and, above all, in its blog, in regular posts with detailed content updates. The "Help" page (*Coptic Magical Papyri*, "About the Kyprianos Database") offers information on the structure of the database content and on metadata categories. To further clarify its scope, it might be useful to foreground information on the inclusion of the non-Coptic texts, which is only mentioned in the earliest blog post (*Coptic Magical Papyri* 2020).

The *Dodona Online* (*DOL*)[44] international enterprise, started in 2018,[45] addresses lead *lamellae* with oracular questions discovered in the archaeological site of the sanctuary of Zeus at Dodona in Epirus, one of the most noted Greek cult places. These texts shed new light on the study of the divinatory practice, complementing the literary sources by attesting the actual words used in the consultations of the oracle, which also impacts on the history of Greek dialects and alphabets.[46] Similarly to *Kyprianos*, *Dodona Online* falls within the framework of a project that aims not only at gathering into an online resource but also at re-editing the texts already published (exceeding 4000), and at making available the many that still await publication.[47]

Besides providing clear documentation on its content, the *DOL* team explain the rationale for the creation of an electronic corpus of the Dodona tablets, as regards both the necessity of their re-edition and the advantages of the digital medium.[48] The latter involves the possibility to make available the texts gradually, as soon as one of them is ready for publication, and to promptly enter corrections. To fully harness this possibility of electronic publishing, a second database, besides the *DOL Lamellae* corpus, has been created within the *DOL* website: *Choix d'inscriptions oraculaires de Dodone* (*CIOD*). This is devoted to a choice of the most interesting exemplars, temporarily published as PDF files while awaiting inclusion in *DOL Lamellae*; users are invited to offer

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[43] *Coptic Magical Papyri*, "About the Kyprianos Database."
[44] <https://dodonaonline.com>.
[45] See the *CIOD* (*Choix d'inscriptions oraculaires de Dodone*) subset of *Dodona Online*, in particular its "Fiches par date" section, which lists records by publication date, from 2018 to the current year 2021.
[46] *DOL*, "Background."
[47] See *DOL* homepage and *DOL*, "Background."
[48] *DOL*, "Towards A New Edition."

contributions, which, if accepted, will be integrated into the main corpus.[49] Other benefits of electronic publication highlighted in *DOL*'s documentation are enhanced searchability, which will be more fully achieved when the corpus is merged into the *Perseus Digital Library*, so as to take advantage of their functionalities;[50] the addition of translations in multiple languages without space constraints, namely, English and French in this project; and improved accessibility. To date, 24 *lamellae* have been published in the *DOL* corpus and ca. 150 in *CIOD*.

Like *Vindolanda Tablets Online*, *Curse Tablets of Roman Britain*[51] is a pioneer digital edition of the Oxford Centre for the Study of Ancient Documents, whose development was announced in 2002.[52] The database brings together a group of 28 tablets that originally appeared in scattered printed publications. It does not encompass all the texts of the select domain, notably, the important collection unearthed in Bath;[53] however, the absence of these and other exemplars is indicated in the project documentation, providing references to their printed editions.[54] It is possible that more curse tablets, as well as those already digitised, will be made available within the *Roman Inscriptions of Britain online* corpus, whose researchers have announced the inclusion of this genre of texts.[55]

Scholia Minora in Homerum,[56] one of the instruments for the study of Greek and Latin available within the University of Genoa's *Aristarchus* platform, is a comprehensive repertory of papyri with glosses to the Homeric poems, totalling ninety-two items. They mainly consist of glossaries, while some contain the literary text provided with marginal or interlinear annotations. The resource conveniently assembles texts of this genre, which in the other, general papyrological databases are less easy to call up altogether, being classified with various definitions.[57] Furthermore, the project sets out to provide a revised text of the exemplars, some of which are already available,

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[49] *DOL*, "CIOD."
[50] See *Dodona Online* homepage.
[51] <http://curses.csad.ox.ac.uk>. Cf. Crowther-Sasanow 2002, 3.
[52] Crowther-Sasanow 2002, 3.
[53] Cf. Crowther-Sasanow 2002, 3, and *Curse Tablets*, "Bibliography," esp. "Further Reading."
[54] See *Curse Tablets*, "Bibliography," esp. "Further Reading."
[55] Vanderbilt-Mullen 2019.
[56] <http://www.aristarchus.unige.net/Scholia/en/Home>. Cf. Reggiani 2017, 867.
[57] A search of *scholia minora* in the catalogues of literary papyri yields less results than *Scholia Minora in Homerum*: 36 in *Mertens-Pack*^{3}, searching for "scholia minora" in the content description, and 69 in *LDAB*, calling up "Homer" as an author and "scholia" as a genre. By the same token, the *DCLP* in *Papyri.info* shows 51 records that contain the definition "scholia minora" among their metadata.

in PDF format. This resource is directed to specialists, as shown by the lack of introductory information on this kind of text.

Alexandrian Documents from the Reign of Augustus[58] is developed by Peter van Minnen and is hosted on his personal space within the University of Cincinnati's website. It contains a bibliography and a new translation, in PDF files, for over a hundred papyri from the most important Egyptian city, dating to the select period. Like *Scholia Minora in Homerum*, *Alexandrian Documents* gathers information on papyri not so easily retrievable as a whole on *Papyri.info* and *Trismegistos Text*: in the former, the "Provenance" catalogue field contains numerous duplicates for the "Alexandria" value; the latter yields numerous records (123) for papyri of this provenance and of this time period (i.e., 27 BC - 14 AD), which, on the other hand, are accessible upon subscription, as occurs for combined searches in this database. Besides the author's translations, there is value added by integrating corrections, both already published and new ones which the resource provider will subsequently publish in papyrological journals.

The *Judaism and Rome* international project has identified eleven Greek and Latin papyri,[59] among other sources, attesting to the impact of the Roman empire on Jewish life. The items, gathered in a specific "Papyri" section, are provided with a text, reproduced from an existing edition; a translation, sometimes authored by the project's editors; and an extensive original commentary. The resource provides great help on the chosen topic, by collecting primary sources related to it, which would be difficult to gather with searches into papyrological databases, resorting to the categories usually employed for catalogue fields, such as provenance, date or genre of text. The project might consider adding a general overview of the contribution of the papyri to the theme and clarifying, in all the papyrus records, the linkage with the theme itself, which often remains implicit.

3.2.3 Thematic collections focused on a single exemplar

Two thematic collections that provide direct access to papyri focus on a single exemplar of primary importance: *Codex Sinaiticus* and *Derveni Papyrus.*

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[58] <https://classics.uc.edu/users/vanminnen/ancient_alexandria>.
[59] <https://www.judaism-and-rome.org/papyri>.

The *Codex Sinaiticus*[60] project digitally represents the homonymous fourth-century parchment codex (*TM* 62315), remarkable for being one of the earliest exemplars to preserve the text of the Bible in an almost complete way. It is currently distributed between four libraries: the British Library, which holds its largest portion, the Library of the University of Leipzig, the National Library of Russia in Saint Petersburg, and Saint Catherine's Monastery of the Mount Sinai.[61]

The digital surrogate of the Sinaiticus supports research in several ways. The most notable characteristic is the digital reunification of the artefact, realised with the close collaboration of the owning institutions. Their cooperation has permitted the digitisation of the entire manuscript, its online publication and the composition of a common, agreed text about the complex history of its discovery and subsequent dispersion.[62]

There are other instances, in digital papyrology and digital classics, of virtual reconstructions of items divided across different locations, with which *Codex Sinaiticus* may be compared. Some examples can be found in the framework of collection catalogues, namely, Sorbonne's *Collections de Papyrus* and the German federated *Papyrus Projekt*, as seen;[63] these provide a number of reconstructed exemplars with metadata and images, mostly from their material collections. Analogously, outside papyrology, the *e-codices* catalogue of medieval manuscripts in Swiss institutions devotes one of its sections, "Virtual Manuscript," to assembling exemplars distributed among Swiss libraries and, possibly, between them and foreign institutions.[64] In comparison to these resources, *Codex Sinaiticus* concentrates on one item to offer a complete digital surrogate, by presenting not only images but also a text, i.e., an encoded diplomatic transcription, provided with supplements and word division, accompanied by a translation for some passages, partly newly produced for this project, mostly in English.[65] There is another virtual reunification project also dedicated to this manuscript: the *Codex Sinaiticus* reconstruction within the *Virtual Books* selection of

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[60] <https://www.codexsinaiticus.org>. On this resource, see Reggiani 2017, 244-45.
[61] *Codex Sinaiticus*, "History of Codex Sinaiticus."
[62] *Codex Sinaiticus*, "History of Codex Sinaiticus."
[63] See pp. 104-05, and p. 91.
[64] See *e-codices*, selecting "Virtual Manuscript" as document type: <https://www.e-codices.unifr.ch/en/search/?iCurrentPage=1&sQueryString=&sSearchField=fullText&iResultsPerPage=20&iCurrentPage=1&sSortField=score&aSelectedFacets%5Bdoc_type_facet%5D%5B%5D=VIRTUAL_MANUSCRIPT>.
[65] The passages of the Old Testament have been provided with an original translation that reflects the actual text of the Sinaiticus. The passages of the New Testament rather present an already available translation of the Bible, which therefore does not corresponds entirely to the manuscript, and is simply provided as a reading aid (*Codex Sinaiticus*, "Translation of Codex Sinaiticus").

highlights on the British Library's website.[66] This resource represents the same digital surrogate produced in the collaborative project, but it differs from it for the kind of information provided, consisting of a comprehensive commentary to the text, rather than in the text itself. Moreover, it addresses a different audience from the homonymous collaborative project, that is, the wider public, as the absence of the original Greek text shows, as well as the image display, which resorts to a transition effect that simulates the real-life experience of leafing through the pages. Finally, one may compare the *Codex Sinaiticus* cooperative project with another digital classics resource focused on one artefact divided across different locations: *Digital Marmor Parium*. This thematic collection concerns the Parian Marble inscription of the Hellenistic age containing a list of events of Greek history, whose two extant parts are housed at the Ashmolean Museum and the Archaeological Museum of Paros. Like *Codex Sinaiticus*, this is an example of collaboration between institutions, namely, the University of Leipzig, where it was devised, and the Ashmolean Museum, which produced RTI scans of its fragment and made them available on the resource.[67] In comparison to the other virtual reunification projects mentioned, *Digital Marmor Parium* affords indirect access to the chosen primary source. In fact, it does not provide a text of the inscription (while it points to its digitised edition in *Digital Fragmenta Historicorum Graecorum*) nor a digitally assembled image, but separate pictures and drawings of the two fragments. Its goal is rather to make available for historical research, also with the aid of visualisations, a variety of digital data obtained from its primary source: prosopographical, geographical, chronological and linguistic, as well as images realised with an advanced technique. *Digital Marmor Parium* thus prioritises an analytical treatment of the underlying source over direct access provision. It would be interesting if *Codex Sinaiticus*, too, offered an interpretive treatment in addition to the papyrus texts and images; for example, linguistic annotations of some passages could be carried out via the dedicated *Arethusa* tool on the *Perseids* platform for digital editing[68] and made available as a treebank visualisation, as occurs in the Marmor Parium project.[69]

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[66] *Codex Sinaiticus* (British Library), <http://www.bl.uk/turning-the-pages/?id=b00f9a37-422c-4542-bfbd-b97bf3ce7d50&type=book>. Cf. Reggiani 2017, 150.
[67] *Digital Marmor Parium*, "RTI of the Marmor Parium."
[68] The *Arethusa* tool, available on the *Perseus*-related *Perseids* platform, assists in the creation of linguistic annotations by performing automatically morphological tagging and lemmatisation, through the *Morpheus* parser, while the contributor annotates the syntactic structure.
[69] *Digital Marmor Parium*, "Linguistics of the Marmor Parium."

Even though it does not present a literary transcription, nor does it afford granular access to the text through advanced encoding, the *Codex Sinaiticus* is unquestionably a very valuable project: both in itself, for the wealth of material in terms of imagery, text and translation, and as a starting point for other digitisation projects of manuscripts, thanks to its comprehensive documentation on every aspect of the material artefact[70] and its digital counterpart,[71] and to the possibility to build upon its encoded transcription. Indeed, the specifications of the markup schema devised are described in detail, and the transcription file is conveniently available as a bundle for download and reuse. The information on the imaging processes is also exhaustive: not only does it illustrate the solutions adopted, but it also discusses the challenges presented by the manuscript and the steps undertaken to face them, accounting for the aspects considered to choose the best lighting.[72]

The *Derveni Papyrus* project[73] is centred on the homonymous exemplar (*TM* 65795), noted for being one of the earliest literary papyri, dateable to the end of the fourth century BC. It preserves part of a philosophical and religious treatise, important for the understanding of the cosmological and theological thought in the classical age. The text can be divided into two parts: the first (cols. 1-6) concerns religious rites, whereas the second, which occupies the greater part of the extant roll (cols. 7-26), deals with the origin of the gods and the cosmos, commenting on numerous quotations from an Orphic theogonic poem.[74]

Derveni Papyrus is hosted on the *iMouseion* platform of the Center of Hellenic Studies, aimed at facilitating the simultaneous display and comparison of multiple editions. The text of the *editio princeps*[75] is thus presented with two more transcriptions in this environment. One, by F. Ferrari,[76] relating to the first six columns, has been published as a whole for the first time in this project, together with an *apparatus criticus*, an English translation and an introduction, based on the editor's previous

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[70] *Codex Sinaiticus*, "What is Codex Sinaiticus?"
[71] *Codex Sinaiticus*, "The Codex Sinaiticus Project."
[72] *Codex Sinaiticus*, "Digitisation."
[73] <https://chs.harvard.edu/CHS/article/display/5418>. Cf. Reggiani 2017, 246-47.
[74] Cf. Ferrari 2014.
[75] Kouremenos-Parássoglou-Tsantsanoglou 2006. The text reconstructed by the editors is available in *Derveni Papyrus* at <https://dp.chs.harvard.edu/index.php?col=1&ed=KPT>.
[76] <https://dp.chs.harvard.edu/index.php?col=1&ed=Ftac>. The publication date of Ferrari's edition (not reported in *Derveni Papyrus*) is indicated as 2014 in the bibliography on the Derveni Papyrus in Santamaría Álvarez 2019, 151.

studies on single parts of the section.[77] The other transcription, by A. Bernabé and V. Piano, relating to the remaining part of the surviving text (cols. 7-26), is also complete with apparatus, and is altogether new, anticipating these scholars' forthcoming printed edition.[78] The interface allows the user to display the *editio princeps* in parallel with each of the two following ones.

Even though the transcriptions provided are devoid of markup, the resource is useful for offering different editions of the papyrus, two of which complete with apparatus and containing a new, born-digital text, as opposed to the reproduction of an existing printed publication. Its usability is however somewhat limited by two issues, relating to lack of updates. One of them concerns poor documentation, in that the addition of the Bernabé-Piano edition has not been pointed out in the project's overview on the home page, but can be only noticed once we access the papyrus "multi-version." There is also a problem of link decay: the three links in the home page, which should direct to the editions and to Ferrari's introduction, do not function, while the material is still available on other web pages (as reported on the previous page), an inconvenience that may deter from use.

Because the text of the Derveni Papyrus is rich in quotations, albeit of a single work (the theogonic poem attributed to Orpheus by the anonymous author), an opportunity for digitally enhancing the editions of *Derveni Papyrus* could be to use the tools provided by the *Digital Athenaeus* project to deal with such quotations. This is a digital edition of the *Deipnosophists* of Athenaeus of Naucratis, a work that preserves many passages of Greek authors, which has therefore been utilised to experiment with the development of tools for retrieving citations.[79] The tools provided therein might be reused for annotating the quotations of the Orphic poem, so as to allow us to straightforwardly retrieve and visualise them, possibly not only within the text but also within a diagrammatic representation of the layout of the roll.

3.2.4 Metadata- and image-based thematic collections

TM Magic — Religious, Ritual, Magical and Divinatory texts[80] is an extensive database of papyri of the chosen subjects, containing 3700 metadata records.[81] It differs

[77] Cf. Ferrari's introduction to his digital edition (<https://dp.chs.harvard.edu/DP_FF_1_6.php>).
[78] Cf. Piano 2019, 20.
[79] On this project, see, besides the information in its home page, Berti 2019, 270-74.
[80] <https://www.trismegistos.org/magic>.
[81] Select the "List all" option in the menu on the left hand-side.

from *Kyprianos*, which addresses a similar topic, for its broader scope, encompassing texts in all the languages attested in papyri (as its "language/script" field in the search interface shows). Also, it is more comprehensive than *Papyri.info* for the chosen text categories, as can be seen by performing searches through the "type" field and into *Papyri.info*'s metadata (e.g., for oracle questions and spells); in fact, *DCLP* records, integrated from the *Leuven Database of Ancient Books*, do not comprise all genres of paraliterary papyri, excluding in particular those drafted for occasional circumstances, according to the scope of the latter catalogue.[82] *TM Magic* proves therefore useful in that it fills a gap between databases focused on literary papyri, such as *LDAB* and *DCLP*, and on documentary ones, such as the *Duke Databank* and the *HGV*. To highlight its usefulness for research on intermediate texts between literary and documentary, the project's documentation could be improved by defining more precisely the material assembled. The overview on the home page already mentions that the resource sets out to complement existing databases by addressing magical, religious, ritual and divinatory texts. Additionally, one might clarify whether all material supports are considered, whether papyri only or inscriptions as well, as occurs in *Trismegistos*; what geographical areas are encompassed, as, for example, oracular *lamellae* from Dodona are absent; and what ages or civilisations are represented, pointing out whether the religious domain comprises Christian papyri.

Another metadata database focused on direct item-level access, which however has been no longer available since 2021, was *Chartae Latinae Antiquiores*.[83] It was the digital version of the homonymous paper catalogue of Latin documents until the ninth century included,[84] developed and hosted by the same publishing house in charge of the printed resource, Urs Graf Verlag, which ceased its activity. The disappearance of this database from the web testifies to the importance, for the permanence of a resource, of having its data deposited with a stable host institution, for example a university library. In comparison to the *Duke Databank*, in which Latin documents can be retrieved by selecting the related language, *ChLA* was less comprehensive, as it did not include tablets but exclusively texts on papyrus and parchment. Nevertheless, it was useful for providing, for the selected materials, different search criteria from *Papyri.info*, such as

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[82] *LDAB* 2018.
[83] See its latest archived version at <https://web.archive.org/web/20200721162543/http:/www.urs-graf-verlag.com/index.php?funktion=chla_suche>. Cf. Reggiani 2017, 91.
[84] Urs Graf Verlag, n.d.

document type and the scribe's or drafter's name and role. It could also be employed for more precise searches by provenance than with the *Papyrological Navigator*; in the latter, the "Provenance" catalogue field does not always yield complete results, even if this indication is regularly reported in the records, so that one needs to resort to a search into the whole metadata, though less precise.[85]

Les archives de Dioscore d'Aphrodité en images: La banque des images des papyrus de l'Aphrodité byzantine (*BIPAb*),[86] launched in 2005[87] by Jean-Luc Fournet (École Pratique des Hautes Études, Paris), is a thematic collection that gathers and provides images of the documentary papyri of the most important archive of Byzantine Egypt:[88] the one relating to the family of the notary Flavius Dioscorus of Aphrodito, currently distributed between over twenty physical collections.[89] With its ca. 650 items,[90] *BIPAb* proves more comprehensive than *Trismegistos Archives* for the chosen archive in terms of the number of papyri included, as the latter records circa eighty texts less than the dedicated database.[91] It conveniently gathers the papyri pertinent to the chosen archive, which are rather difficult to pinpoint in *Papyri.info*, whether with a search by provenance, as there are multiple values for the city of Aphrodito, or with a search for the name "Dioscorus" into the metadata, which yields a relatively small number of results (about seventy).

BIPAb does not provide information on the papyri apart from the reference to their edition, although it cites a bibliographical reference for details on them;[92] nor does it contain technical documentation on the database development. On the other hand, it offers an insightful discussion on the choice of the digital collection's theme, its scope and limitations, emphasising the necessity of a reconsideration of the Dioscorus archive and the usefulness of an electronic database to that end, for its ability to manage a

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[85] For instance, a search of Latin papyri from "Ravenna" through the "Provenance" cataloguing field only returns four items, whereas a metadata search returns twenty of them, although in some cases the city's name refers to other categories than provenance.
[86] <http://bipab.aphrodito.info>. For detailed information on this database, see the extensive overview in its home page provided by the project's director, J.-L. Fournet (Fournet, n.d.). A short description is in Reggiani 2017, 115-16.
[87] Fournet 2008, 308, n. 4.
[88] Fournet, n.d., "Qu'est-ce que la *BIPAb* ?." The Dioscorus archive is recorded in *Trismegistos Archives*, with a list of its texts, bibliographical information and statistics, at <www.trismegistos.org/archive/72>.
[89] Fournet, n.d., "Pourquoi la *BIPAb* ?."
[90] Fournet, n.d., "Qu'est-ce que la *BIPAb* ?."
[91] See the related page of *TM Archives* at <www.trismegistos.org/archive/72>, which records 570 items.
[92] Fournet 2008, cited in Id., n.d., "Comment se servir de la BIPAb ?."

collection of such extent.[93] As is explained, *BIPAb* strongly focuses on the provision of images because this was a great desideratum for the Dioscorus papyri, since they have predominantly been published in early editions, devoid of pictures. Many images in *BIPAb* have therefore been made available for the first time, thus facilitating the work of identification of scribal hands, which helps pinpoint groups of texts and define their purpose, among both the published fragments and those that still await publication.[94]

Another thematic collection that gives a high priority to the provision of images, again as a basis for editing papyrus texts, is the *Digital Manuscript Collection* of the Center for the Study of New Testament Manuscripts (CSNTM)[95] directed by Daniel B. Wallace (Dallas Theological Seminary). The project's objective is to offer digital images of a large number of New Testament manuscripts, with a focus on Greek ones, to facilitate textual research on this work.[96] Consequently, records are nearly always complete with pictures, while being provided with basic information on the papyri. Not only does the CSNTM database contain pictures made available by owning institutions (as occurs, for example, for the Chester Beatty papyri), but they have also imaged manuscripts from several collections in the framework of their own digitisation project,[97] even with the use of multispectral imaging for severely damaged exemplars and palimpsests.[98]

The database, which totals two thousand items to date, includes 150 papyri and 110 parchment manuscripts prior to the ninth century.[99] This number is much smaller than that of New Testament papyri present in *Papyri.info* (1200 items)[100] and *LDAB* via *Trismegistos* (1300). On the other hand, *Digital Manuscript Collection* offers more detailed search options, relating to content and editorial features, and the possibility to consult ancient New Testament manuscripts alongside medieval ones.

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[93] Fournet, n.d.
[94] Fournet, n.d., "Pourquoi la *BIPAb* ?," "Remerciements."
[95] <https://manuscripts.csntm.org>.
[96] CSNTM, "Mission."
[97] See, for instance, the projects described in CSNTM, "Showcase."
[98] CSNTM, "Showcase." Images obtained with MSI may be retrieved by filtering items by "Image Type", in particular "Digital MSI."
[99] This result is obtained by selecting the values "Papyri" and "Majuscule" in the "Classification" field of the search interface, setting the ninth century as end date for the latter.
[100] These can be retrieved with a keyword search into *Papyri.info* metadata. It is also possible to browse, within the "Author" field or the "Authors" section in the top bar menu, New Testament papyri ("Testamentum Novum") divided by author and language.

The project presents good documentation on the digitisation process,[101] and on content updates through regular blog posts.[102]

3.2.5 Palaeographical thematic collections

Two resources focus on the provision of images, like the previous ones, but with a different research purpose than editing papyrus texts, viz., palaeographical analysis: *PapPal*, which resorts to palaeography as an aid to dating papyri, and *MultiPal. Tutorials de Paléographie*, which rather makes learning to read manuscripts a central focus.

PapPal,[103] a project of the University of Heidelberg, offers an extensive set of 3300 dated papyri, that is, containing the scribal indication of the date of the copy in their text. They consist of documentary texts in various types of writing and of different ages. The project sets out to provide an instrument for comparing papyri that are instead devoid of date, as is typical of literary texts, and that lack other elements that assist in dating, for example the presence of a dated text on the same exemplar, and a known archaeological context (cf. pp. 21-22). While the primary goal of this database is to assist papyrologists in dating fragments that present no other evidence than the palaeographical one, it is also relevant as a collection of samples of types of writing, thereby providing evidence of their evolution and assisting in the classification of scripts.[104]

The pedagogical purpose is the central focus of another palaeographical collection, *MultiPal*[105] by the Ecole Pratique des Hautes Etudes in Paris, a dataset encompassing a range of specimens in several scripts and languages, on various material supports and from different ages, i.e., papyri, ostraca, inscriptions, coins and medieval manuscripts.[106] Teaching purposes clearly determine the data model of this resource. Among the fifteen Greek and Latin papyri and ostraca available, usually from Parisian collections, there is a variety of scripts, concerning documentary and literary texts from the Ptolemaic, Roman and Byzantine ages.

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[101] CSNTM, "Digitizing;" CSNTM, "Archiving and post-production."
[102] CSNTM, "Blog."
[103] <http://www.pappal.info>. Cf. Reggiani 2017, 151.
[104] *PapPal*, "About," esp. "The Palaeography of the Papyri."
[105] <http://multipal.fr/en>.
[106] *MultiPal*, "Le project."

MultiPal is the only digital papyrology resource primarily created to support teaching. It achieves this not only from a content point of view, by providing accessible explanations to students' level of education as occurs in several virtual exhibitions as well, but also from a usability point of view, by actively engaging users in providing input and by reacting dynamically to it, by means of a functional layer built on the primary sources. Thus, *MultiPal* can be regarded as situated between direct and indirect access projects. On one hand, direct access to primary sources is provided through an image, through basic information, sometimes with the addition of a palaeographical description, and through a text, i.e., a diplomatic transcription or an interpretive one, or both, possibly accompanied by a translation. On the other hand, a key contribution of *MultiPal* lies in its functionality, enabled by the interactive layer that operates on the digital surrogate, an interface that assists in the transcription in several ways. While hiding the papyrus text provided by the author of the exercise, revealing it only when required by the user, it enables the student to transcribe the item with the help of digital alignment between the words in the picture and those in the transcription section. It allows zooming in the selected word and showing possible suggestions and illustrations of palaeographical or editorial features, e.g., a reading sign, an abbreviation or a scribal correction, while words correctly or wrongly transcribed are highlighted in different colours (green or red).

An improvement that might be applied to *MultiPal* involves its specimens: the collection could be more extensive and expand to include more examples from other collections than the Parisian ones, thereby showing a truly representative selection from the palaeographical viewpoint. Another improvement might concern the mode of access to the specimens. These might be selected not only by language/script but also by other criteria, especially, given the pedagogical aim of the resource, by the level of difficulty, an indication that is already present in the records and that might be made searchable. As long as the number of items is small this addition is not necessary, but it might become useful if more records are provided, especially since papyri are interspersed with other objects, viz. inscriptions and medieval manuscripts, written in the Greek language.[107]

[107] Besides the option to retrieve items by language/script, there is another one to filter by date, which however does not work properly.

As a clear example of the potentials of digital methods for teaching-related purposes in palaeography, we may consider two sister thematic collections, *French Renaissance Paleography* and *Italian Paleography*,[108] collaborative enterprises hosted by the University of Toronto Library. Here, manuscripts to transcribe can be browsed by numerous criteria, including reading difficulty, and the transcription task is aided by several secondary sources published on the projects for the first time. For instance, in *Italian Paleography*, particularly useful for beginners are an overview of the discipline in general, including the method of analysis of handwritten texts, a "New to Paleography" introduction with an illustration of types of scripts, lists of common abbreviations and particular letterforms, a more extensive excursus of Italian scripts and a glossary, as well as links to external dictionaries. Furthermore, the two resources set out to assist not only in reading manuscripts, through the mentioned instruments and a transcription tool, but also in learning about their cultural, social and institutional context.[109] To this end, they provide background original essays, digitised related primary sources (e.g., calligraphy books of the time) and links to bibliography available in online publications. By the same token, ideally, *MultiPal* or a new papyrological resource might form a rich thematic collection, with analogous contextual materials to further help users decipher ancient handwritings and to provide a starting point for the study of the written culture witnessed by the texts.

In conclusion, palaeographical thematic collections are useful for some aspects of the palaeography of papyri, namely, for chronological placement, through *PapPal*, and for practising the key task of reading papyrus handwritings, with *MultiPal*. As for another key objective of palaeographical analysis, scribe identification, this is one of the goals of the *BIPAb* collection of images of the Dioscorus archive. For the same purpose of the identification of scribal hands, but beyond a single archive, it would be interesting to gather papyri that have been identified as produced by a given scribe. Thus, one might collect literary papyri for which the attribution to a scribe has been proposed as they exhibit closely similar handwritings. Such a resource could rely on the documentation offered by W. A. Johnson (2004, 16-32), who has surveyed a selection of

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[108] *Italian Paleography* is still under development, hence it is not possible to carry out transcriptions yet. Nevertheless, it can be taken into consideration for its wealth of contextual material and of documentation, equal to that of *French Paleography*.
[109] See *French Paleography*'s home page.

twenty-one scribes who penned multiple literary rolls discovered at Oxyrhynchus. It would be a complement to the *Trismegistos Archives* database, which includes information of ancient libraries, to assist in the study of Graeco-Roman book production, with the provision of a term of comparison for discovering more instances of a scribal hand, which may also help formulate hypotheses on the identification of the papyrus content.

3.3 Usability evaluation

This section analyses the data model of the projects under scrutiny, classifying them into two main groups on the basis of Fenlon's typology of research collections.[110] The former (analysed in subsection 3.3.1), similarly to Fenlon's "type 2" collections, is made up of those that give direct access to primary materials and, for various reasons, present metadata, and possibly texts, encoded minimally or altogether devoid of markup. They thus tend less to enable fine-grained access to the digitised sources and more to afford other ways to support research, for example, comparative views of the material (texts or images) or provision of original evidence (e.g., high-quality images); or else, they rather support teaching or dissemination of the papyrological discipline on the web, e.g. through exhibitions. Conversely, the other group (analysed in subsection 3.3.2), based on Fenlon's "type 1" collections, while still providing direct access to digitised corpora or thematic collections of papyri, contains fully searchable metadata, XML-encoded or modelled in relational databases, and shows a higher level of text markup, if editions are present, thereby permitting functionality beyond basic searching and browsing.

I will evaluate the usability of the data models, investigating whether resources, as well as being useful from the content point of view notwithstanding some issues, as we have seen, fulfil common user needs such as the ability to search on item and bibliographic metadata, browse the items, identify similar texts in the collection based on metadata facets, consult scholarly papyrological editions and view high-quality

[110] Fenlon 2017, 526-36; cf. the first chapter of this dissertation, esp. p. 50.

images. For resources that include the papyrus text, its characteristics will be compared to those indicated by Nyhan and Sahle as proper to digital scholarly editions.[111]

3.3.1 Direct access to papyri through basic functionality

At the simplest level from the point of view of the data model there are virtual exhibitions, included in holdings catalogues or in thematic collections (cf. their overview at pp. 136-38). They feature narratives accessible to everyone, in which images and texts of primary sources are embedded, devoid of markup. Thus, they do not aim at affording access to primary sources through search and browse, which is the goal of other functionalities within their projects, but at contextualising and supplementing the primary-source content, catering to any level of education and to the wider audience.

Other projects, which serve research purposes more specifically, also present primary sources with no markup; these are arranged in simple lists or are provided with a browsing functionality, but at a base level.

The *BIPAb* archive of Dioscorus of Aphrodito shows the simplest format among these resources, that is, a list arranged alphabetically by edition, probably because it is conceived as a starting point for the implementation of a guide proper to the archive. The papyrus images are both viewable online (through a very basic viewer) and downloadable. Their quality greatly varies, as the project documentation makes clear, depending on the resolution at which the images were produced by the owning institutions.[112] Nevertheless, some papyri for which *BIPAb* presents images of poor quality have now been made available online at a high resolution in collections' holding catalogues, as occurs for the Berlin and Michigan papyri;[113] these might thus replace the corresponding pictures in *BIPAb*, via external links. The online availability of the images also depends upon the owning institutions: while almost all of them have provided the required pictures, at that time it was not possible to obtain scans of nearly twenty papyri, relevant to the archive, from one collection.[114] To sum up, the resource is still noteworthy for the identification of the exemplars pertaining to the chosen theme

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[111] The framework followed to analyse issues of usability is presented in the first chapter of this dissertation (pp. 54-55).
[112] Fournet, n.d., "Les limites de la BIPAb."
[113] See, for example, the items in *BIPAb* with the edition abbreviations "BGU," "P.Berl." and "P.Mich.," now digitised in *BerlPap* and *APIS UM*.
[114] Fournet, n.d., "Les limites de la BIPAb."

and for including papyrus images not otherwise available. However, it seems that, after the end of the funding granted by the Association Internationale de Papyrologues and by the University of Strasbourg for the development of the database and the imaging of the papyri not yet digitised,[115] the project has suffered a lack of updates. Thus, it would benefit from a revision of its content, by connecting with institution-based catalogues for newly available images and with papyrological databases for metadata and bibliography, and from a revision of its functionality, which could now make use of a more flexible viewer and of searching and browsing options.

Dodona Online, in its two sections, *DOL Lamellae* and *Choix d'inscriptions oraculaires de Dodone*, also presents lists arranged by edition, as well as one, in *CIOD*, by year of publication on the resource. *Alexandrian Documents*, too, gathers items in hyperlinked lists; however, papyri are ordered on the basis not only of their publication ("List of texts") but also of their content type, by categories of documentary papyri ("List of topics").

Other resources designed with a simple data model, without markup, however provide a basic browsing facility. *Derveni Papyrus* enables browsing by edition or by "multi-version" (i.e., comparative view of editions) and then by external features of the text, viz., by column and by set of fragments without a certain collocation. *Scholia Minora* contains a list of items disposed according to the Homeric poems glossed and their books; two filters generate dynamic lists of scholia on the selected book(s) or belonging to the selected modern collection.

As devoid of textual markup, these projects rather support research by gathering primary sources focused on a theme, mostly available in scattered publications; by helping compare the material, i.e., editions, in *Derveni Papyrus*; and by presenting original evidence, whether in the form of papyrus images, often made available for the first time (*BIPAb*), translations (*Alexandrian Documents*) or re-editions (*Derveni Papyrus*, *Scholia Minora* and *Dodona Online*).

Some of the aforementioned text-based projects can be qualified as scholarly editions, to a greater or lesser extent, as they provide all or some of the essential data needed by papyrologists. On the other hand, they do not fully harness the possibilities of the digital medium, so that they may not be regarded as digital scholarly editions proper.

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[115] Fournet, n.d., "Remerciements."

The simplest editions are those of *Alexandrian Documents*, which do not contain the original text, although they offer new translations and a comprehensive bibliography. *Derveni Papyrus* and *Scholia Minora* in contrast contain several elements of scholarly editions. In particular, Ferrari's edition of the Derveni Papyrus is the most scholarly one in the related platform: while only concerning a part of the exemplar, it provides a critical apparatus, a brief introduction with a summary of the content, bibliography and a translation; a commentary is not included, although the author points out bibliographical references for insights on several issues of his text. In a similar way, editions in *Scholia Minora* feature a short description, a papyrological and critical apparatus and a bibliography. The most complete scholarly editions among these resources are those of *Dodona Online*, especially the definitive ones in the *DOL Lamellae* section, which offer metadata, diplomatic and literary transcriptions, a papyrological and critical apparatus, bibliography, and also a commentary and translations in multiple languages (English and French, plus, sometimes, German and Italian). However, as anticipated, all these resources do not fulfil the requirements of digital scholarly editions in terms of design of the digital texts, that is, in terms of data model, as they do not demonstrate or enable research that cannot be done with traditional methods.[116] Indeed, three of them have been digitised in a static PDF format, viz. *Alexandrian Documents*, *Scholia Minora* and *Dodona Online*. The texts of the Derveni Papyrus are rather encoded in XML,[117] but in such a way as to allow only minimal interactive functionality, such as browsing by material features of the texts, as said, and displaying or hiding supplements in gaps, by clicking on them.

Some projects present more articulated direct search and browse mechanisms, though not advanced ones. Their ways to support research are thus in part similar to those of the previous resources, but they permit more various modes of access to papyri.

The *Trismegistos Magic* (and the former *Chartae Latinae Antiquiores*) metadata databases gather texts of select categories, like the aforementioned thematic collections, but also enable metadata searches, rather specific for the chosen topic. *PapPal* offers a comparative view of papyrus images, similarly to *BIPAb*. However, because of *PapPal*'s eminently palaeographical focus, images have a different possibility of access. They are

[116] On this requirement of digital scholarly editions, see Nyhan 2012, 119.
[117] Reggiani 2017, 247.

juxtaposed in a synoptic view, whether as a gallery or as a slideshow, and can be sorted by date to facilitate comparison; also, they can be filtered by language or by material. The image represents a small part of the exemplar and contains a high magnification of the text, to allow the simultaneous view of several samples; all the same, the complete picture can be accessed from the record, following the link provided to the owning institution's catalogue. The quality of the pictures is generally good, although, similarly to *BIPAb*, it varies according to the original resolution used in the source catalogues; in any case, their usability is sufficient for the purpose of this project, which is palaeographical analysis rather than reading and editing the text. An inconvenience, albeit limited to a small number of items (e.g., *HGV* 11620, 17129), is that their samples contain an excessively enlarged image, hence only a few letters are distinguishable, making it difficult to immediately have a general impression of the script without accessing the original catalogue.

3.3.2 Direct access to papyri through more advanced functionality, with a focus on metadata- and image-based resources

Some projects combine direct access to primary sources with a search interface that offers different options based on specific aspects of the data model, in particular based on specific metadata facets rather than on textual markup. Within this group, two databases, the *Digital Manuscript Collection* of New Testament papyri and *Trismegistos Seals*, do not contain papyrus texts, while they provide access to metadata and especially images (the former) and to metadata and bibliographical information (the latter).

Digital Manuscript Collection presents good interactive functionality in terms of browsing, whereas the usability of the images is somewhat limited, at least insofar as papyrological texts are concerned. Numerous browsing categories create interconnections between items based not only on general characteristics such as language and date, but also on specific aspects of the content (e.g., genres of text), of the layout (e.g., types of contextual material added by the scribe and icons) and of material features (e.g., origin from a palimpsest and types of ink). There is a sufficient degree of connectivity with other resources for supplementary information on the items: records are linked with possible collection catalogues that offer the same images, which

may present a better viewer and contain more metadata.[118] It might also be useful to link all the records to databases such as *Trismegistos* and *Papyri.info* for more information, including reference edition and bibliography, which are usually absent.

Concerning the usability of the images, their quality varies noticeably according to the resolution utilised to capture them in the different locations. Some images have a particularly good definition,[119] among which there are certainly those produced by the CSNTM team themselves. As opposed to this, others are digitisations of visual materials, for instance microfilms,[120] whose quality is somewhat low, being copies of copies; nonetheless, they are usable, and if more recent images are available online, they are made accessible via external links (as said). The online availability of the images, too, varies based on the holding institutions' policy, similarly to *BIPAb* papyri. However, differently from the latter, all the collections have provided scans of their fragments to *Digital Manuscript Collection*, while in a few cases they do not allow their online viewing, hence they need to be consulted at CSNTM.[121] A basic viewer allows to browse codex pages, even though it is not clearly indicated which folio and page the user is seeing; it is possible to freely navigate and to zoom in the images, albeit sometimes not very far, whereas downloading is not permitted.

Trismegistos Seals offers a functionality, in this case a search utility, that enables metadata searches on relevant aspects of the chosen objects; moreover, records allow access to another database within the platform, *Trismegistos Texts*, for information on the text that bears the seal and, from these records, in turn, to external resources.

3.3.3 Direct access to papyri through more advanced functionality, with a focus on text-based resources

Besides metadata and possibly images, some resources with (rather) advanced functionality offer transcribed primary sources. Some of them are devoid of markup, such as *Judaism and Rome* and *Kyprianos*; therefore, the modes of access to primary

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[118] E.g. <https://manuscripts.csntm.org/manuscript/Group/GA_P3> and <https://manuscripts.csntm.org/manuscript/Group/GA_P20>. The link to the external digital papyrological collection is found in the "More Manuscript Information" section.

[119] E.g. <https://manuscripts.csntm.org/Manuscript/Group/GA_P63> and <https://manuscripts.csntm.org/Manuscript/Group/Rahlfs_961>.

[120] E.g. <https://manuscripts.csntm.org/manuscript/Group/GA_P4>, <https://manuscripts.csntm.org/manuscript/Group/GA_P11> and <https://manuscripts.csntm.org/manuscript/Group/GA_P19>.

[121] E.g. <https://manuscripts.csntm.org/manuscript/View/PK_689>, <https://manuscripts.csntm.org/manuscript/View/GA_0267>.

sources are based on metadata facets or keyword searches, similarly to the three previous databases, and on simple free-text searches into the metadata and the text. Others, such as *Codex Sinaiticus* and *Papyri.info*, employ markup to encode textual structures and editorial interventions (both ancient scribes' and modern editors'). Or else, others deploy semantic markup for annotating the text from the content point of view as well, selecting entities belonging to a certain domain of knowledge, e.g. personal and place names, thereby opening up the texts to precise searches, as occurs in *Curse Tablets of Roman Britain*, *Vindolanda Tablets Online* and *Roman Inscriptions of Britain online*.

The *Judaism and Rome* database presents an intermediate data model between basic and advanced, as one may see from the functionality afforded to navigate its components.

The core component is the primary sources gathered around the theme, both textual, including papyri, as well as literary works and inscriptions, and archaeological objects. Information on the eleven papyri taken into account is expressed with metadata and transcription (in a few cases accompanied by an apparatus),[122] a translation and a commentary with bibliographical references. The content includes original material, as is the case of some translations[123] and, above all, of the detailed commentaries; the papyrus texts are in contrast reproduced from a reference edition, sometimes by taking advantage of its digital version in *Papyri.info*.[124] Information is also provided by forging connections with related items within the collection, sometimes expressed with links embedded in the commentary, in such a way as to clarify their relationship with the text discussed; other times, connected sources are simply reported in a separate list from the text. Moreover, there are external links to access the relevant papyrus image, if available in a collection catalogue, to consult a digitised copy of a reference edition, if in the public domain (typically from *Internet Archive*), and, though only in a few items, to access further information through *Papyri.info* and *Trismegistos Texts*.[125]

Through the resource's portal, retrieval of the items is possible by both searching and browsing, whether within the database as a whole or within a section, each

[122] See the records of "Papyrus Oxyrhynchus 3035," "Papyrus Rylands 12" and "Papyrus Rylands 112."
[123] See the records of "P.Giss. 40," "Papyrus Oxyrhynchus. 1089" and "Papyrus Oxyrhynchus 2177."
[124] See the records of "Feriale Duranum" and "P.Giss. 40."
[125] See the records of "Feriale Duranum" and "P.Giss. 40."

dedicated to a type of source, so as to perform searches limited, for example, to papyri. The user interface enables both free-text searches into the whole database, including the text of the primary sources, and searches into categories of metadata. While there are a few options available for metadata searches, the sections devoted to the various sources offer more search criteria, specific for their content: as well as by source type and century, one may search metadata by thematic keywords, also available in the original languages of the primary sources, whose entry is facilitated by an automated suggestion system.

Judaism and Rome's papyrus editions contain essential scholarly material, including the original text, in a few cases accompanied by an apparatus, both reproducing the reference edition, and in-depth notes, which are in contrast expression of new research, bibliography and, in a few cases, an apparatus. On the other hand, from the digital viewpoint, the editions would benefit from the encoding of content and from greater connectivity with papyrological resources. But overall the project serves well the purpose of research on the chosen subject by gathering heterogeneous primary sources and facilitating meaningful interconnections between them, especially thanks to the wide range of content-based keywords, thus enabling discovery beyond a single type of source and hence a single discipline. With this ability, *Judaism and Rome* offers the chance to discover and retrieve papyri, albeit in a small set, in a different way from resources specifically devoted to papyrology, that is, alongside a variety of primary sources. These consist not only of epigraphical sources, as in other multidisciplinary databases such as *Trismegistos* and *RIB Online*, but also in literary, numismatic and architectonic ones, and objects from figurative arts (sculptures, wall paintings and mosaics).

The *Kyprianos* corpus of Coptic magical texts presents a more advanced data model than *Judaism and Rome*, composed of tables with distinct categories of information in a relational database. The information consists of detailed metadata and a comprehensive bibliography for the manuscripts (searchable through the "Manuscripts" tab of the search interface), records with texts, basic metadata, translations and notes (via the "Texts" tab), and records with metadata for the identified archives ("Archives"

tab).[126] The search interface contains numerous search options, although it does not give us the possibility of searching for very specific features of these items, aside from text categories and archives; rather, it focuses on searches by reference number in several catalogues and collections, both printed and digital.

Links among records and with relevant external databases are an important aspect of the data model of this resource. Records are well interconnected internally, thereby linking information on the manuscript to the text, if already available, and possibly to an ancient archive, and thereby interlinking texts reported in the same artefact. The manuscript database is also very well connected externally to the site: to holdings catalogues for papyrus images; to subsets of *Trismegistos* for further metadata on the text, on the place of finding and on the relevant material collection; to two major Coptic databases, viz. *PATh Atlas*[127] for more insights into codicological aspects and the geographical distribution of the manuscripts, and *Coptic Scriptorium*[128] for text corpora with lexical and text analysis tools; and to specialised thematic collections for more details on illustrated items, with the *To Zodion* database of magical drawings in Graeco-Roman and Coptic papyri,[129] and on texts on amulets, especially gems, with the *Campbell Bonner Magical Gems Database.*[130]

The papyrus texts in *Kyprianos* present many elements of digital scholarly editions, especially as concerns the scholarly aspect. Hence, even though they are in a relatively limited number thus far, about a hundred out of over nine hundred metadata records, they are a key contribution of this collection. While they are not complete with an introduction and an extensive commentary, they offer a literary transcription accompanied by a papyrological and philological apparatus, notes, translation and a representation of a drawing possibly present in the papyrus; moreover, they are the result of new research, with revised editions and original translations. From the digital viewpoint, *Kyprianos* editions enable research by supporting a full search of the metadata and by providing useful information, also thanks to the interaction with numerous other digital resources for further metadata and analytical tools, although they

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[126] *Coptic Magical Papyri*, "About the Kyprianos Database." To the above-mentioned categories of information, which are publicly available, three more add, reserved to the project's team, devoted to places of origin of the papyri, identifiable scribal hands and visual tableaux drawn by the scribes (ibid.).
[127] See *Coptic Magical Papyri*, "Kyprianos Update (24 March 2021)."
[128] See *Coptic Magical Papyri*, "Collaboration with Coptic SCRIPTORIUM."
[129] See *Coptic Magical Papyri*, "Kyprianos Update (22 December 2020)."
[130] See *Coptic Magical Papyri*, "Kyprianos Update (30 April 2021)."

are not encoded to afford more advanced exploration and create more interrelationships among them.

The *Codex Sinaiticus* project's data model distinguishes itself for the deep integration between its components, i.e., imagery, transcription and a partial translation, achieved through automated alignment. It focuses on a single exemplar, as *Derveni Papyrus* does, but it shows a more advanced data model than this resource, with more types of information, such as images and a more extensive introduction, and more functionalities for navigating the text.

The two key components of the data model of *Codex Sinaiticus* are the encoded transcription and the digital surrogate. The transcription relies on the XML standard, indeed on a customisation of the TEI Guidelines for humanities texts, to accurately capture specific features of a manuscript: the occurrence of marginalia, with their exact collocation in relation to the main text, interlinear corrections, and scribal marks and indications that articulate the text. Also, encoding served to provide a basis for the digital alignment of transcription and images, as all words and punctuation were tagged with a particular element for developing the necessary database for this task.[131] The level of text markup deployed can be regarded as intermediate. It encodes the structure of both the text and the codex accurately, thereby enabling precise browsing according to the subdivision in books, chapters and verses, and according to codicological units such as quires and folios. On the other hand, the encoding does not capture named entities, so that the text can only be queried in an unstructured way with simple free-text searches. From the scholarly standpoint, the text offered by *Codex Sinaiticus* consists of a diplomatic transcription with the addition of supplements and word division, while a complete literary transcription, with accents, other reading signs and expanded abbreviations, is absent; indeed, the goals of the project are primarily the conservation, digitisation and transcription of the manuscript,[132] rather than producing a critical edition. By the same token, among apparatus data, scribal interventions are pinpointed, while a philological apparatus with the indication of variants is not provided. Worthy of note, as regards usability, is the mode in which apparatus information is displayed. However simple, it differs from that of the apparatus of printed editions, adopted in

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[131] *Codex Sinaiticus*, "XML Download of the Electronic Transcription of Codex Sinaiticus," esp. "About the XML."
[132] *Codex Sinaiticus*, "Translation of Codex Sinaiticus."

digital papyrus texts as well,[133] whereby critical annotations are arranged at the bottom of the text, or of a section thereof. In *Codex Sinaiticus*, the ancient editorial intervention is rather displayed in a small pop-up box when the user hovers over the relevant word, highlighted in a different colour. This solution is effective in indicating at once what words present apparatus data, by harnessing the interactivity of the digital medium rather than reproducing an existing paper-based editorial practice.

Together with the transcription, another important component of the data model of *Codex Sinaiticus* is the digital surrogate, formed by excellent images, digitally aligned to the text. They have been produced with two different techniques, standard digital photography and raking light.[134] Pictures shown in raking light enhance surface details; they are therefore intended to facilitate the inspection of the physical features of the material support. Even though, actually, this task may not be necessary for the papyrologist, who is mainly interested in legibility,[135] raking light images prove also useful for a further examination of the text with a different lighting condition. As regards the ability to view the images, the site provides a basic viewer, which allows seeing only a page at a time and requires to use buttons to move from a page to the subsequent one, rather than running through them. In part, this is compensated by the possibility of navigating the digital surrogate, as well as the transcription, by selecting passages of the text in a bar menu, which also shows the image of the corresponding page, thanks to digital alignment. Another small inconvenience of the usability of these images is that it is not permitted to download them in their original resolution, nor multiple images at a time, but only as a PDF of a single page in low quality.

The resource presents a high degree of integration between its two main components, imagery and transcription, thanks to digital alignment. Thus, by selecting any word in the text, the corresponding part of the picture (and of the translation, where available) are highlighted, thereby facilitating the identification of a passage in the manuscript to verify a reading or to observe the textual layout. One may compare this functionality with that of another digital classics project that deploys alignment

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[133] Resources that include papyrus texts with *apparatus criticus* are *Papyri.info*, *VTO* (as well as the former *VTO* 2), *RIB Online*, *Kyprianos*, *Curse Tablets of Roman Britain* and *Judaism and Rome.* Also, the creation of editions complete with apparatus is planned in *Magica Levantina* (2017).

[134] *Codex Sinaiticus*, "Digitisation." One more series of pictures was created with a further method, multispectral imaging (not published on the project's website), for the purpose of carrying out ink analysis, whose results are reported in the project's documentation (*Codex Sinaiticus*, "Multi-spectral imaging for the Codex Sinaiticus").

[135] Bagnall 1997, 154; Bülow-Jacobsen 2020, 59, 66.

techniques, in this case for teaching purposes: *Digital Rosetta Stone*, aimed at assisting in the study of the languages and scripts of the famous trilingual inscription (*TM* 8809).[136] In its digital surrogate, the section containing the Greek version of the text is aligned with a literary transcription, as well as with the other two sections in hieroglyphic and demotic scripts, with their transliterations and with an English translation. As occurs in *Digital Rosetta Stone*, an opportunity for *Codex Sinaiticus* might be to provide its digital images with a literary transcription; thus, it might become even more useful for pedagogical purposes, as an aid for students or interested users to practise Greek palaeography through an extensive papyrological text, rich in annotations in different hands,[137] and to practise translating.

Other components of *Codex Sinaiticus*'s data model are the partial translation, digitally aligned with the text and the images; a physical description of each page, which can be toggled alongside the corresponding image; and contextual information in the form of narratives, viz. an introduction to the manuscript, and technical and editorial documentation.

If we compare the characteristics of *Codex Sinaiticus* with those pinpointed by Nyhan and Sahle as hallmarks of digital scholarly editions, it can be said that the project presents some features proper to them, from the viewpoint of both its content and its usability, so that it may be considered as situated between a resource for dissemination and one for research purposes. Albeit devoid of literary transcription, philological commentary to the text and bibliography (aside from the indication of translations), the resource offers valuable scholarly materials, which are also new to a large extent, namely, the original Greek text in a semi-literary transcription, high-quality pictures, a (partial) translation, and abundant introductory information on the Codex. The rich documentation on the project accounts for the editorial conventions followed in the digital transcription and for the markup schema devised. Besides being the result of research, the data model devised in turn has the potential to enable new research, with its high-quality digital surrogate and its transcription precisely browsable thanks to explicit textual and codicological structures; also, it offers a basis for further projects, due to the possibility to reuse its freely available encoded transcription, based on a non-proprietary and open-source technology such as TEI-XML, also a highly compatible

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[136] See *Digital Rosetta Stone*, "Teaching," for a list of classes in which the resource has been utilised.
[137] For an overview of scribal interventions in the Sinaiticus, see *Codex Sinaiticus*, "The transcription."

one with humanities texts. On the other hand, the text is not provided with semantic markup that may enable access to the transcription beyond keyword searches (though this enhancement might be applied in a derivative project), nor does it interact with other digital texts or resources.

The images of the codex reunified already greatly help examine its material characteristics. Furthermore, since it is a well-preserved artefact and one whose text is also known from other sources, hence the extent of the missing parts can be reconstructed, an interesting opportunity might be to create a visualisation of the totality of the manuscript, to clarify the way it was produced and its status of preservation. A simple reconstruction of the original appearance of the roll was realised in the Sorbonne's *Papyrus Collection* catalogue (pp. 106-07), while, for a more complex representation, a project outside the papyrological domain, *Petrarchive*, could be taken as a model. This is a digital edition of Petrarch's songbook, realised with great attention to the material construction of the work, as witnessed by the author's autograph manuscript. Thus, *Petrarchive*'s edition is contextualised by a diplomatic transcription of the codex and by visualisations of its layout and material properties: there are "visual indices" of the content[138] and of the structure of the manuscript by fascicles and quires.[139] Analogously, a diagrammatic representation of the Codex Sinaiticus, with its subdivision in books, could give insight into its extent and that of the missing parts, the distribution of the four handwritings of the main text, and the belonging of the codex leaves to the different institutions. One more visualisation could address the material structure of the codex, showing how the text is divided across quires and folios, and how quires were folded and assembled.

Like *Codex Sinaiticus*, the *Duke Databank of Documentary Papyri* and the *Digital Corpus of Literary Papyri* in *Papyri.info* present transcriptions encoded in TEI-based XML, in this case in the custom EpiDoc guidelines for papyrological (as well as epigraphical) texts, which were also employed to encode the item metadata.[140] EpiDoc was utilised to standardise datasets from different sources, thus ensuring compatibility between them. Then, the RDF model for expressing relationships between entities was employed to merge collections from different sources into one larger database, and

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[138] *Petrarchive*, "A visual index to the *Rvf.*"
[139] *Petrarchive*, "Visual index arranged by fascicles."
[140] On the EpiDoc standard and its use in *Papyri.info*, see above, pp. 29-31.

therefore to integrate information on the same item in one record. The EpiDoc guidelines were also deployed to encode features of the appearance and layout of papyri, such as gaps and divisions in columns or pages, and interventions of the ancient scribe and modern editor to be displayed in the apparatus.[141] Their choice is also meant as a guarantee of long-term usability, being a TEI-compliant XML format used in several digital classics projects. EpiDoc markup, though, 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. For some entities, such as mentioned people and places in documentary papyri, the lack of semantic markup is however compensated by connections with the *Trismegistos People* and *Places* databases, which establishes linkages with other texts where the same entities occur.

The *Duke Databank* and the *DCLP* are built on the following components, held together by the two mentioned data models, the EpiDoc and the RDF specifications. There is EpiDoc-encoded item metadata, embedded into the records, being merged from the *APIS* dataset, the *HGV* and *Trismegistos*; and external metadata, linked, again from *Trismegistos*, for prosopographical and geographical data, and for information on the relevant material collection. Besides providing information on the papyri, encoded metadata has allowed forging linkages between them, both internally and externally to the site. Within the database, there are interconnections between texts penned in the same exemplar, and between papyri with the same dating, found in the same place, and published in the same series. Moreover, external links to *Trismegistos* connect the papyri to further primary sources, namely, inscriptions: for example, to those discovered in the same place, and to papyri and inscriptions that preserve an attestation of the same place name.[142] These connections established among primary sources are useful, though one has to notice that almost all of them reproduce those existing in *Trismegistos Texts* records. The linkage with items written in the same period is instead an original feature of *Papyri.info* records: while a search for papyri from a certain time span can also be performed in the *HGV*, in *Papyri.info* one can straightforwardly retrieve items relating to the one under scrutiny from the record itself.

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[141] For frequent markup elements used for encoding *Papyri.info* texts, see Reggiani 2017, 237-40.
[142] On the usability of *Papyri.info* records, see the analysis conducted in the second chapter (pp. 72-76), apropos of the integration of the *APIS* database into the platform.

Another element of the data model of *Papyri.info* is images, produced within the *APIS* project, embedded into records of some collections; more images are available via outside collection catalogues.[143] Note, for instance, the set of Herculaneum papyri, for which multiple digitised collections are available through dedicated projects, to document their complex editorial history. Besides surrogates of the exemplars themselves in *Chartes*, there are digitised Neapolitan and Oxonian *disegni* (i.e. sketches) on the websites of Naples's National Library and of the Bodleian Library, and digitised engravings, published as *Collectio Prior* and *Collectio Altera* on the website of Würzburg's Epikureismuszentrum. The images in *Chartes*, the *disegni* and the engravings are all accessible via links precisely embedded within the encoded text of every column; it is thus possible to consult the image of each column in the different visual materials available.[144]

As well as transcriptions of primary sources, metadata and images, *Papyri.info* texts sometimes contain more kinds of information. The degree of scholarship of the texts thus varies. They are usually provided with an apparatus, which points out reading signs in the papyrus and editorial corrections. Occasionally, conjectures and notes drawn from the reference edition are reported for literary papyri.[145] Some texts are also accompanied by a translation, mostly in English, sometimes also in German, integrated from *APIS* and the *HGV*, newly produced for these two projects.[146] Among the most complete scholarly editions there are those of medical papyri, from the *Greek Medical Papyri* project, which feature an introduction and notes taken from the printed edition. While the material is essentially reproduced from existing editions, there is a small group of six texts that have been first published on this resource or re-edited therein, almost all provided with introduction and notes.[147] The appearance of the texts sticks closely to the form of printed editions, with the *apparatus criticus* displayed at the bottom of the transcription.[148] A small innovation is the inclusion of an asterisk at the

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[143] On the usability of images in *Papyri.info* records, see above, pp. 75-76, within the discussion on images created in the framework of *APIS*.
[144] See, for example, the record of P.Herc. 26 (<http://papyri.info/dclp/62382>), which provides access to the digitised Oxonian disegni and to the *Collectio Altera* engravings.
[145] See, for instance, the record of P.Herc. 1577 (<http://papyri.info/dclp/62483>) and those of medical papyri and born-digital editions mentioned below.
[146] On *HGV* translations, see Reggiani 2017, 44, 224. Translations in *Papyri.info* number 6700, as can be seen from the "Translation language" field of the search interface.
[147] The texts, pointed out in Berkes 2018, 75-76, are indicated in the *Duke Databank* as DDbDP 2015 1, 2 and 3, and DDbDP 2016 1 (provided with transcription only), 2 and 3.
[148] Reggiani 2017, 224, 236, 264-65.

end of words that present an annotation in the apparatus, so as to show at once the occurrence of editorial intervention, in a similar way to *Codex Sinaiticus*, and so as to bring the user to the related annotation through a hyperlink; this method is especially useful for extensive texts, so that their apparatus notes are directly accessible even if distant from the lemmata. In fact, although such HTML output has been produced to show a similar appearance to printed editions, in the XML source code the apparatus data are embedded within the text, encoded with specific tags,[149] so that it would be possible to create a different visualisation, such as that used for *Codex Sinaiticus*, thereby displaying editor's notations closely to the lemma.

Even though the great majority of *Papyri.info*'s texts reproduce the reference printed editions rather than providing original content, and their format shows a traditional layout, their value as digital scholarly editions lies in their ability to be searched altogether as a corpus, both with free searches in the texts themselves or in the metadata, and according to the provided criteria. While search criteria are not numerous (being essentially limited to literary author, city or nome of provenance, date, language) they can be combined, also with free-text searches, in a way that is impossible, or at least very difficult, with printed indices to the editions, as was already noted by the *Duke Databank*'s founders, Oates and Willis.[150] Noteworthy, too, as digital texts that support research, is their interaction with other digital ecosystems, such as metadata databases (*Trismegistos* and the *HGV*) and collection catalogues, hence their interrelation with other digital texts, images, information and bibliographical data. Notable characteristics as digital humanities texts and resources are also the use of open-source technology, such as XML-based EpiDoc markup, the publication of the datasets as open data, and the availability of the tooling as open-source code, so that they may be transformed for new projects.

Another aspect of *Papyri.info*'s data model, again relating to information on the primary sources, consists of bibliographical data, integrated from the *Bibliographie Papyrologique* (*BP*) in 2012, converted into TEI-compliant XML from its original FileMaker format.[151] Since then, new entries, as occurs for the two textual databases, have been curated by the researchers in charge of *Papyri.info* and have been open to

[149] Reggiani 2017, 236.
[150] See the literature review at pp. 25-26, 35-36.
[151] Reggiani 2017, 17.

user contribution as well, through the *Papyrological Editor* platform. Note, though, that the coverage of the years since 2017 is incomplete. The facility provided (accessible via the "Bibliography" link in the top bar menu) enables us to query the bibliographical database according to the categories present in the original *BP*, with both free-text searches and ones by constrained values. Also, the XML encoding has permitted to create connections between the bibliographical entry and the papyrus text(s) mentioned in the related publication, which is an additional feature in comparison to the original resource; connections are thus expressed with a hyperlink to the related *Duke Databank* record(s).[152]

One more component that provides contextual, in particular bibliographical, information, again available internally to the platform after integration from an external resource, is represented by the *Checklist of Editions.* This is a much simpler tool than the *BP*, in terms of both content and functionality, consisting of a comprehensive list of papyrological publications, along with standardised reference abbreviations (cf. p. 35). The *Checklist* in *Papyri.info* supersedes the original one, still available on Duke University Library's website but no longer updated; notice, however, that the older tool is still useful for retrieving information on papyrological journals, listed in the "Periodicals" section, absent in the newer version. The current *Checklist* presents the advantage of interconnection between bibliographical entries and related papyrus records: listed volumes of papyrological series are linked to the corresponding volumes in the *Duke Databank* for accessing the texts; also, external links direct us to open-access digitised copies possibly available online.[153] The integration of the *BP* and the *Checklist* into *Papyri.info* has permitted to open up bibliographical data to useful connections for speeding up the online accession of relevant papyrus texts, although it entails a few issues of content, because of the lack of update of the *BP*, and of the loss of information on papyrological journals in the *Checklist*.

To conclude, among the strengths of the *Duke Databank* and the *DCLP* in *Papyri.info* there is the vast amount of digitisation work already done, especially for the *Duke Databank*, with its very broad searchable text corpus, representative of all types of documentary papyri from every age. Also important is the openness of the datasets and

[152] Reggiani 2017, 17.
[153] Reggiani 2017, 28.

of the source code of the tools for the functioning of the platform, for developing analogous integrated systems for searching and editing humanities texts.

Weaknesses of the platform pertain to a certain lack of project documentation, as regards the papyrological content and the availability of its data and code base, and to the absence of semantic textual markup relating to entities derived from the texts, which would allow more precise searching and indexing. However, there is the opportunity to build on the source files provided, so as to deeply annotate the papyri on further interpretive layers, or to extract information concerning specific aspects of the texts. Some digital papyrology projects have indeed benefited from this possibility. The University of Helsinki's *PapyGreek* platform is utilising the XML versions of the texts to create a corpus of morphologically and syntactically annotated documentary papyri, which will enable the analysis of their linguistic structures on an extensive scale.[154] Similarly, Alek Keersmaekers (KU Leuven) is also deploying the XML files for building a corpus of treebanked documentary papyri; whereas in *PapyGreek* the syntactic annotation is carried out manually, Keersmaekers is seeking to produce a software system for syntactic parsing of Greek fragmentary texts. The recently launched *Trismegistos Words* database is a first result of his research: an index of words of documentary papyri, both lemmata and inflected or conjugated forms, developed with the aid of morphological automated analysis performed on the *Duke Databank* corpus.[155] Two more projects made use of the *Papyri.info* textual database, by resorting to a different technique, viz. automated extraction, including Named Entity Recognition (NER).[156] One, also of linguistic scope, focused on the specific question of linguistic variation from classical Greek in documentary papyri. It took advantage of the occurrence of particular tags in the XML versions of the texts, which mark the modern editor's orthographic corrections and regularisations;[157] the extraction of these elements allowed creating the *Trismegistos Text Irregularities* database of linguistic variants,

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[154] Vierros 2018, 105. *PapyGreek* will be dealt with in the fourth chapter (in section 4.5), apropos of resources that prioritise the provision of data derived from the papyri, in this case the identification of recurring grammatical structures.

[155] Keersmaekers 2019, 67-68; *TM Words*, "About," esp. "Coverage & Accuracy." Like *PapyGreek*, *TM Words* will be examined in the next chapter (in section 4.5), along with other papyrological resources for linguistic analysis.

[156] On this process, see above, p. 49.

[157] For a description of these tags, see Reggiani 2017, 237.

phonetic and morphological, attested in the language of papyri.[158] Automated extraction, in this case NER applied to personal and place names, was also used by *Trismegistos* researchers for developing the prosopographical and geographical databases of the platform, *TM People* and *Places*, despite the lack of encoding of these entities, by filtering words with an initial capital letter.[159]

Together with the extraction of linguistic information from the XML documents provided, a further opportunity might be represented by the addition of a semantic layer to the texts. A project that can be taken as a model in this respect, for its use of advanced markup to facilitate fine-grained access to records, is *Cretan Institutional Inscriptions*, hosted by the University of Venice. EpiDoc-compliant markup was employed to encode the epigraphical documents, with a focus on the terms relating to Cretan institutions with their prosopography,[160] by means of annotations embedded in transcriptions (as results from the provided source files in the site). Thus, it is possible to browse not only by metadata categories such as the age of the inscriptions, current location, type of document and type of support, but also by elements of the text such as mentioned institutions and institutional roles, in their different types and spheres of competence, and mentioned divinities. Analogously, it would be interesting to apply deep semantic markup oriented to capturing terms from a certain domain, for instance the institutional one as in the database just mentioned, in documentary papyri, whether as an enhancement of *Papyri.info* or as a separate project reusing its XML base of data. Because the application of semantically rich markup is a time-consuming effort, such project might focus, as well as on a specific lexicon, also on select papyri, e.g. from a certain place, again as in *Cretan Institutional Inscriptions*, or dating to a certain age. Another example might be the markup of information that, conversely, relates to private individuals, with their different social and family relationships and professional activities, and to types of communities. Additionally, there is an opportunity for enhancing digital editions in *Papyri.info* by connecting them to lexical tools, especially the University of Leipzig's *Neues Fachwörterbuch*, which is specific for terms used in documentary papyri (cf. p. 94). Words could be linked externally to their respective

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[158] On the relevance of *Duke Databank*'s XML texts to *TM Irregularities*, see the "Methodology" web page in the resource, Reggiani 2017, 185, and Depauw 2018, 197. The results of a study of linguistic variation in papyri, carried out with the aid of this database, have been presented in Stolk 2018.
[159] Depauw 2018, 196-97; Reggiani 2017, 65.
[160] *Cretan Institutional Inscriptions*, "Il progetto."

dictionary entries, thus prompting a dictionary search in a separate window, or they could be annotated within their XML source code, referencing to *nFWB*. In the former case, the appearance of the text would remain close to that of printed editions; in the latter, lexical notes could be rather displayed in small pop-up boxes near the selected word.

Also, since *Papyri.info* partly relies on user contributions for its content update, it would be advantageous to invest in the enhancement of the interface of the provided editing environment, the *Papyrological Editor*. The *Integrating Digital Papyrology* project has already greatly facilitated the online editing task for non-experts of computing by creating, with the *Papyrological Editor*, a platform for working with a light syntax for EpiDoc markup, called Leiden+,[161] which does not make use of XML tags and is close to Leiden editorial conventions, rather than working directly with the XML code. A further improvement may be applied by taking as a model the interface of another collaborative editing project, which supports the creation of a range of editions of ancient sources, *Perseids*, developed by Tufts University. *Perseids*' editing interface was built on the basis of the open-source *SoSOL* application developed by the *Integrating Digital Papyrology* project, which in *Papyri.info* takes the name of *Papyrological Editor.*[162] It presents a clearer layout than the *Papyrological Editor* by supporting nesting for displaying the tokens of XML syntax, thereby helping the user identify the sections of the document and focus on the content. The fact that it is free and open-source[163] facilitates the possible reuse of its code for *Papyri.info*, while it needs to be adapted to work with complex texts such as those on papyrus.

In terms of sustainability, the permanence of the *Duke Databank* and the *DCLP* is ensured by being hosted on an institutional server, that of Duke University Library.[164] 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. They have

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[161] Sosin 2010; Baumann 2013, 100-04.
[162] On *SoSOL*, see Baumann 2013; Reggiani 2017, 232. On its reuse in *Perseids*, see Almas-Beaulieu 2016, 177.
[163] The source for all the code of *Perseids* is available on GitHub; it can also be accessed from *Perseids*, "Libraries and Tools."
[164] Bagnall-Heath 2018, 177; *Papyri.info*, n.d.

thus launched a joint call to support the resource financially, with the aim of establishing an endowment to cover a position for a project coordinator (as one may see from the notice displayed in a pop-up window on *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 in the JISC survey on sustainability models of digital research projects.[165]

The last two text-based resources that provide direct access to papyrological texts, *Curse Tablets of Roman Britain* and *Vindolanda Tablets Online*, differ from the previous ones for the ability of searching and indexing entities and particular terms, thanks to content-based textual markup.

Curse Tablets of Roman Britain's data model is composed of documentation on the material collection, in the form of a comprehensive introduction, transcribed primary sources, digitised visual materials, contextual information on the single texts, and indices. There is no documentation on the digital project on the website or in the literature; nevertheless, we know that plans for its development were announced in 2002, highlighting that the database would follow that of *Vindolanda Tablets Online* as a model, which was being completed in the same period, also by CSAD.[166] It is therefore very likely that, as occurs for the *VTO* texts, those of *Curse Tablets* have been encoded in EpiDoc. Thus, items can be accessed not only via a hyperlinked list of items and free text searches, but also, thanks to textual markup, via indices, concerning words whose reading is fairly certain, divergent forms from classical Latin, and entities such as personal names and gods.

Curse Tablets' editions can be qualified as digital scholarly ones in that they offer all the essential scholarly elements needed, reproducing closely the base printed editions, but at the same time enhancing them with the addition of new materials and functionalities according to the then available technology. Texts are provided with an introduction, a translation, notes (accessible from the link next to the relevant line), a sketch that reproduces the writing, and sometimes a thumbnail image. In comparison to the printed editions, the digital versions in *Curse Tablets* present the advantages of

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[165] Maron et al. 2009, 21-22. An overview of this survey is in the first chapter of this dissertation (pp. 56-57).
[166] Crowther-Sasanow 2002, 3.

integrated corrections published in subsequent contributions, standardised editorial conventions, and hyperlinked cross-references and indices, as highlighted in a purposeful section.[167] Moreover, *Curse Tablets of Roman Britain*, in a similar way to *VTO*, adds rich contextual material about the texts, with introductions newly published on the resource that aim at prompting further reading in the related bibliography.[168] There are detailed introductions to the archaeological sites where the tablets were found,[169] to several aspects of their content (genre of text, language, names of people and gods), to their production (material, script, manufacturing), discovery and processes of conservation and imaging,[170] and documentation on the editorial conventions employed.[171] The benefits of digital publication are discussed, especially of imaging, taking into account the necessity for incised tablets to be photographed from different angles, thereby taking advantage of contrasts of light and shade; web publication, without the financial constraints of printed editions, can offer a complete set of images, even with multiple images of the same exemplar, and disseminate them more widely.[172] Even though, actually, it has not been possible to provide *Curse Tablets* records with digital images proper (it is unclear whether because of limits of the then available technology or for copyright reasons), the idea of creating multiple digital images of incised texts with different lighting has been subsequently realised in other projects. The RTI imaging technique has recently started to be applied to ancient inscribed documents, whereby various RTI views of an object are synthesised in a single picture whose angle of light can be manipulated by the user. Since there are plans for the addition of curse tablets to the *RIB Online* database, and since RTI is currently being experimented with by CSAD on inscribed Vindolanda tablets, the new online publication might be an occasion for the acquisition of new images for the corpus, ideally with this advanced method.[173]

Like *Curse Tablets*, *Vindolanda Tablets Online* was a pioneer database of papyrological editions. Developed in the same period as *Curse Tablets* and by the same

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[167] *Curse Tablets*, "Bibliography," esp. "Notes on the use of these texts."
[168] *Curse Tablets*, "Introduction: archaeological sites."
[169] *Curse Tablets*, "Introduction: archaeological sites."
[170] *Curse Tablets*, "Cursing for Beginners."
[171] *Curse Tablets*, "Conventions."
[172] *Curse Tablets*, "Curses Recovered: reading and imaging."
[173] On RTI, see p. 33, with a focus on its application in papyrology.

institution, CSAD, *VTO* however shows a more advanced data model, probably because of the larger amount of items and the greater variety of topics dealt with in them.

Key aspects of the data model of *Vindolanda Tablets Online* are the information on the project, concerning both the source documents and the development of the database; primary sources digitised as text, encoded in XML, more precisely in the EpiDoc customisation; item metadata, also marked up; primary sources digitised as images; and internal links to the items provided throughout the resource, embedded in line notes, in the texts of the introduction and of the exhibition, and in the reference tools.

The modes of access to the primary sources consist of both a general search across all the contents, including the original Latin texts, and in browsing according to several criteria: by metadata categories, such as themes dealt with in a selection of highlights, general subjects, specific topics, document types and findspots within the site, and by elements of the text, namely, mentioned people and places, and military terms.

The documentation on the XML base of data clarifies the difference between the original EpiDoc specifications and the custom version employed, showing how the guidelines were adapted to the needs of the project and to papyrological, rather than epigraphical, sources. The information includes a table that shows the various solutions adopted in the two methods for representing features of the text, as well as the equivalent marks in the original printed sources.[174] On the basis of this documentation, it may be noted that there are a few differences mainly concerning the encoding of lacunae, uncertain letters and scribal interventions, which has been simplified. Often, these features are not encoded in the Vindolanda texts; more simply, the corresponding signs of the Leiden convention are straightforwardly added in plain text.[175] The simplification may be due to the fact that *VTO* editions only present the interpretive transcription, without the diplomatic one; hence, there was no need to display the texts in different outputs, which would be possible with a more sophisticated encoding. Conversely, in one case, viz. to mark up lines of text, the Vindolanda XML adopts a more precise markup: an attribute is created to specify not only the line number but also

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[174] *VTO* 2003.

[175] E.g., illegible traces are represented by dots in plain text, rather than with the related EpiDoc element <gap reason=”lost” extent=? unit=character>. Another example is provided by the blank space left by the scribe, represented with the indication "*vacat*", rather than with the element <space dim=”horizontal” extent=? unit=character>.

the fragment of the tablet to which the line pertains, in the event of multiple fragments.[176]

From the characteristics of its content, functionality and documentation, we can see that *VTO* shows the desiderata of digital scholarly editions, being a complete, updated and digitally enhanced version of the base print volumes, with full editorial and technical information. However, it has to be mentioned that the website has become outdated in a few aspects. Its content has not been updated with the new T.Vindol. IV texts, nor have external links been added for other relevant primary or secondary sources. Also, the image viewer is no longer functioning, hence one can only access a low-resolution image, albeit downloadable and viewable at a sufficient resolution on one's computer desktop. Nonetheless, these issues are now solved by the integration of the *VTO* texts into the *RIB Online* corpus. Here, they are connected with the corresponding records of *Trismegistos Texts* and *British Museum Collection online*, and through the latter their images can be examined in an excellent viewer. *RIB Online* takes advantage of the texts subsequently published and of the possibility of integrated searches alongside other documents from Roman Britain; for example, there are inscriptions also from Vindolanda, and other private documents preserved on tablets from different sites, notably the Bloomberg tablets from London. All the same, *VTO* remains a very valuable resource, especially for the possibility to access the text collection in a number of ways. This is in part possible in *RIB Online* as well, through the same introductory chapters; but in *VTO* we may also explore virtual exhibitions and consult a richer glossary, divided into categories, most of which provided with images and introductions,[177] hyperlinked to the tablet records.

3.4 Conclusion: challenges and opportunities of text-based papyrological resources

In conclusion, among the positive aspects of corpora and thematic collections that provide direct item-level access to papyrological sources there are the number and the

[176] I.e., <lb id=”line[fragment label]-[line number]” n=”[line number]”/>, rather than <lb id="line2" /> in EpiDoc. Another tag apparently created by the *VTO* project, to mark up the division in columns (<pb n=” i”/>), drawn from the TEI Guidelines where it refers to page breaks, is in fact present in the EpiDoc Guidelines (see esp. "Non-Structural Text-Parts," at <https://epidoc.stoa.org/gl/latest/trans-nonstructural.html>).

[177] See *VTO*'s *Reference* and *RIB Online*'s *Glossary of Latin Terms.*

variety of projects, which cover several types of papyri, offering metadata and sometimes transcriptions, images, detailed contextual information and functionality beyond simple presentation on the site.

Particularly rich in online information are documentary papyri, thanks to the extensive *Duke Databank* textual database and to its integration into *Papyri.info*, whereby texts are enriched with images and further data from external resources. Also noteworthy is the corpus of documents from Vindolanda in *VTO* and *RIB Online*, with a more circumscribed scope but comprehensive, well-documented and complete with full scholarly editions. As for the other categories of papyri, literary and paraliterary ones have been extensively catalogued in *DCLP*, by integrating data from the *LDAB* database, and in *Trismegistos Magic*. Moreover, as we will see in the next chapter, these texts are the focus of the *LDAB* and *Mertens-Pack*^{3} metadata and bibliographical databases. However, only a relatively small amount of them has been provided with digital texts: some literary papyri in *DCLP*, especially Herculaneum, medical and juridical ones; and paraliterary papyri from the domains of ancient scholarship (*Scholia Minora in Homerum*), magic (*Kyprianos* and *Curse Tablets of Roman Britain*) and divination (*Dodona Online*). Note, also, that *Scholia Minora in Homerum* and most texts of *Dodona Online* are published as simple PDF files, not searchable altogether as a corpus.

It is hoped that the abundant material already offered in *Papyri.info* and the other textual resources, with the related advantages of online, especially XML-based, publication, will stimulate the development of further projects, concerning the less digitised types of texts. A digitisation project might involve the entry of texts directly into *Papyri.info*, or the creation of a separate resource, whose texts might be integrated into the platform as well, so as to be also searchable alongside other papyri. It would be interesting to develop collections centred around research themes, customised for in-depth study of papyri of a specific content type. The theme might concern a literary genre or author, in addition to the philosophical papyri preserved in the Herculaneum finds already digitised in the *THV.* Or it might address other paraliterary papyri, for example more genres of ancient exegesis to classical works besides *scholia minora*,[178] on the model of the *Science in Ancient Egypt* corpus of Egyptian scientific, magical and

[178] For genres of ancient scholarship attested in papyri, see Turner 1980, 100-24, with a focus on the commentary (or *hypomnema*).

educational texts. Papyrology would also profit from the creation of more thematic collections with heterogeneous primary sources, as exemplified by *Judaism and Rome*. This can be achieved not necessarily by starting a new project, but also by building on existing thematic papyrological collections. For example, *BIPAb* and *Alexandrian Documents from the Reign of Augustus* could be supplemented with other primary materials (archaeological, epigraphical and numismatic) found in Byzantine Aphrodito and Augustan Alexandria, and with relevant passages from literary sources. By the same token, papyrus texts collected in *Kyprianos* could be integrated with literary texts and with archaeological objects relating to Byzantine magic.

The resources under scrutiny would benefit from adopting deep semantic markup to afford fine-grained access to the texts through advanced searching, as occurs, to some extent, in *Vindolanda Tablets Online* and *Curse Tablets of Roman Britain*. Markup might also be designed to support multimodal views that foreground different encoded parts of the texts, a feature present in several digital humanities research collections.[179] A typical use of this functionality, which could be adopted, is to reproduce both the diplomatic and the interpretive transcription, displaying them in separate outputs, as can be seen, for instance, in *RIB Online*, *Inscriptions of Roman Cyrenaica* and *Petrarchive*. A further opportunity offered by this functionality could be to foreground parts of text with specific content. In literary papyri, variants to the medieval manuscript tradition could thus be highlighted, as well as portions of literary works quoted in paraliterary papyri with scholarly texts or school exercises, including quotations in treatises, lemmata in commentaries, glossaries and lexica, or titles in summaries.

Digital papyrology resources that provide direct access to papyri might therefore take greater advantage of the notion of thematic collection, as a coherent aggregation of diverse primary sources and different data types to support interdisciplinary research, and of the use of interpretive markup for functionality beyond basic rendering. Even more so, they would help the production of new research while also being in themselves a contribution to scholarship.

[179] Fenlon 2017, 530.

Chapter 4

Providing mediated access to papyri: collections of papyrological data

4.1 Introduction

After seeking a better understanding of a range of papyrological projects that provide straightforward access to texts, images or information on the papyri, in the previous two chapters, the thesis now looks at projects principally concerned with the provision of derivative data obtained from the primary sources. Even though digital surrogates in the form of text or imagery may be present, they are accessible through an interpretive layer built upon the collection. This can thus be explored through advanced functionality, typically a user interface with complex options or tools provided for text analysis, data mining or data visualisation. The notion of data-centric collections in digital humanities literature has been fully defined by Fenlon (2017, 531, 535-36, as reviewed above, at pp. 49-50). But earlier contributions had also underlined the importance of the mentioned characteristics for digital humanities resources. Palmer (2004, 353-55) and Flanders (2014, 170-71) have placed stress on the need to enhance research collections with analytical tools that provide a supportive context for scholarly work, thereby enabling the discovery of implicit phenomena, i.e., patterns and commonalities among objects. Flanders and Jannidis (2016, 234-36) regarded modelling digital humanities resources, as opposed to a sciences context, not only as a description of the evident, objective features of the items, about which there is a clear consensus, but also of the features identified through disciplinary and interpretive viewpoints. Consequently, the data model should be somewhat adaptable to users' divergent perspectives, for instance through a "user tagging" approach or, in a more complex way, through the adoption of a markup language customisable by users, notably XML-based, documenting the choices made in the representation of the uncertainty inherent to humanities data (ibid.; cf. also above, pp. 47). On this premise, I will consider the

following papyrological projects and review them in light of the aforementioned characteristics.

The main resources under scrutiny can be introduced by distinguishing them on the basis of their scope and of their method for mediating access to primary sources. There are extensive metadata databases relating to the principal categories of papyri. The majority (six) are structured by a system for guided searching and browsing the papyri, as in many projects that afford direct access to items. However, search and browse include several abstract categories, pinpointed through analysis and interpretation of the texts; also, search results are sometimes provided with statistical analyses visualised as graphs. Three resources concern literary papyri, viz. *Mertens-Pack*[3], *Leuven Database of Ancient Books* (*LDAB*) and *Trismegistos (TM) Authors*; two address documentary texts, *Heidelberger Gesamtverzeichnis* (*HGV*) and *Grammateus*; *TM Texts* takes into consideration both categories, integrating metadata of literary fragments from *LDAB*. Other comprehensive resources rely on the corpus of documentary papyri as base text material, like the *HGV* and *Grammateus*, but their presentation of the collection is structured by mechanisms of textual analysis, in particular text mining as in *eAQUA* or linguistic analysis as in the *PapyGreek* treebanking corpus. Further projects on documentary papyri are realised by mechanisms of word indexing, as in the *WörterListen* and in resources focused on specific data elements like prosopographies, gazetteers and chronologies, mostly integrated within the *TM* platform. Another undertaking of general papyrological interest (as opposed to thematic collections focused on a group of texts) is the fundamental *Bibliographie Papyrologique en ligne*, also available via *Papyri.info*, the most complete bibliographical database for the discipline.[1]

A number of thematic collections and specialised lexica rather provides papyrological data on circumscribed topics. To cite those most closely related to the discipline, there are *Vindolanda Tablets Online* 2, built upon the related text corpus and based on the methods of text analysis and word indexing; collections relying on advanced search and browse functionalities, such as *Death on the Nile* (dedicated to mummy labels), *TM Archives, Guide to Heroninos Archive*, *Karanis Tax Rolls* and *Water Technology*; lexica, which combine word indexing with the provision of other

[1] On the *Bibliographie Papyrologique*, see the previous chapter (pp. 140, 172-73), apropos of databases integrated into the *Papyri.info* platform.

scholarly content such as definitions and attestations of word usage, viz. the *Neues Fachwörterbuch* lexicon of administrative terms, and the *Léxico de magia y religión en los papiros mágicos griegos online.*

A detailed overview of these resources, as concerns their history, content and facilities, has been outlined by Reggiani, who subdivided them into metadata databases,[2] indices and lexica,[3] palaeographical projects,[4] and quantitative analysis and linguistic corpora.[5] Keeping Reggiani's contribution as a reference point, the present survey aims to highlight the ways in which projects mediate access to primary sources, whether through the curation and encoding of content or through their functionalities and interactivity, by showing how they model the uncertainties of the papyrological record and of its digital representation, and by discussing their sustainability plans. The goal is to further clarify their features and underlying data models, while considering opportunities for possible ameliorations.

4.2 Mediated access to literary papyri

Two extensive resources offer indirect access to the whole category of literary papyri, in particular through advanced functionality: the *Mertens-Pack*[3] and the *Leuven Database of Ancient Books*. They do not contain texts or images of the papyri, although they provide links to external resources for accessing them; rather, they focus on the provision of detailed information and comprehensive bibliography on the items, and are equipped with user interfaces that allow multiple searches across a large number of fields, according to domain-specific metadata categories.

Mertens-Pack[3] (*MP*[3]), an initiative of the University of Liège,[6] is a comprehensive database of metadata and bibliography on literary papyri, for a total of 7400 items[7] and

[2] Reggiani 2017, 37-92, 114-17.
[3] Reggiani 2017, 118-36.
[4] Reggiani 2017, 151-60.
[5] Reggiani 2017, 178-97.
[6] <http://cipl-cloud09.segi.ulg.ac.be/cedopal/MP3/dbsearch.aspx>. For an overview of the *MP*[3], see Reggiani 2017, 47-51, with information on its history and a description of its search interface and of its records; he also comments on the positive integration between digital resource and outputs as printed volumes, or as embedded PDF files, of the cataloguing work. Moreover, the *MP*[3]'s previous director, Marie-Hélène Marganne, has illustrated its content in detail, accounting for its extension to further groups of papyri (2012) and to texts with both literary and documentary characteristics (2016).
[7] This number results from a search into the database with no selected values.

230 literary authors.[8] It stems from R. A. Pack's *The Greek and Latin Literary Texts from Greco-Roman Egypt* printed catalogue of literary papyri, compiled in collaboration with P. Mertens. The latter papyrologist, who also gives the name to the project, was the founder of the Centre de Documentation de Papyrologie Littéraire (CEDOPAL), which developed and continues to manage the *MP*[3] electronic version of the catalogue.[9] The move from print to digital has permitted editors to add new entries and correct the already existing ones more rapidly, and to handle such an extensive amount of data more easily.[10] Users have been given the chance to search texts in further ways than by author (the subdivision adopted in the printed resource) and with multiple criteria at the same time, so as to look for patterns for investigating the tradition and the readership of classical literature in Egypt in a more systematic and articulated way.

The scope of the resource has been well defined by the project's former director, Marie-Hélène Marganne, who has specified what text categories are included, especially discussing papyri with intermediate characteristics between literary and documentary, explaining how these are taken into account in the data model.[11] Thus, in the search interface, through the appropriate values of the "Catégorie" field, besides literary papyri it is possible to retrieve magical papyri, Jewish and Christian texts (especially paraliterary genres), illustrated papyri, and documentary ones with some connection with literary works, that is, containing literary reminiscences, quotations, or mentions of book titles. Also, the "subgenre" field in the search interface, through its values list, provides access to a wide range of literary and paraliterary genres; the latter comprises treatises on a variety of topics, exegetical works, school and writing exercises, medical prescriptions and tachygraphical papyri.

The presentation of the collection principally relies on records comprising item metadata, rich bibliography and links that connect the papyri with relevant external information. The data is structured by search mechanisms that foreground numerous specific aspects of literary papyri, as in part already mentioned. It is possible to perform an all-encompassing search for an author, retrieving not only papyri identified with certainty but also ones attributed to them, as well as works containing relevant quotations, for instance in texts with scholarly genres. The content can be searched both

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[8] This figure is reported in the "author" search field.
[9] CEDOPAL, n.d., esp. "1971-98;" Reggiani 2017, 47.
[10] Reggiani 2017, 47.
[11] Marganne 2016, 775-76; Marganne 2012.

with free keywords within the title and the description, and via a drop-down menu with a values list where papyri are classed in several genres. A small inconvenience is that these types of text (in the "sous-genre" field) are arranged without a clear criterion, rather than in alphabetical order or by meaningful subsets, which would aid in the selection within such an extensive list. The material production of the exemplars is also taken into consideration, again by recording and making searchable specific characteristics, both editorial (e.g., whether the text is an autograph or the title is extant) and bibliological (e.g., de luxe edition, preservation of the *protokollon* and roll written *transversa charta*). The records offer very valuable information. They give access to *TM Texts* for further metadata and links, sometimes to owning institutions' holding catalogues for images, and to bibliographical items available online.

One more component of the *MP*^{3} collection is rich contextual information on the papyri. This consists of tertiary sources purposefully created for the project: comprehensive catalogues and bibliographical lists (in PDF format) devoted to some text categories, chiefly addressing some paraliterary genres according to the team's research interests.[12] There is also information on the database, focused on editorial documentation, with lists of abbreviations used in the records and indices of literary authors, genres and collections catalogued;[13] but technical information on the implementation of the resource is lacking.

There are a few usability problems that make the *MP*^{3} not very flexible in navigating and viewing the papyrus records, as anticipated. On one hand, it is useful that most fields resort to predetermined value lists via drop-down menus to streamline data entry and facilitate consultation. On the other hand, it is noted that value lists are not straightforwardly accessible, as one needs to select the related field and wait for them to be uploaded. Subsequently, records are not shown in the results list, which only reports publication references, but it is necessary to select one or more items first. Both features make the search facility somewhat slow in use. Finally, records are arranged according to their *MP*^{3} ID number, and it is not possible to sort them in another, more meaningful order, for example chronologically.

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[12] This data is available in the "Recherches" and "Bibliographies" sections, through the main menu. Cf. Marganne 2012, 482-83; Reggiani 2017, 50-51.

[13] See the "Listes de codes" web pages available in the "Base de données MP^3" section.

Despite these disadvantages, the quality of the content and the reliability of the *MP*³ outweigh its interactivity issues. Also, the project is reliable in terms of permanence and sustainability, as it 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.[14] The *MP*³ proves a fundamental instrument for the study of literary and paraliterary papyri, for its comprehensiveness in terms of both range of texts covered and provision of the needed information on them. Worth noting is that it accounts for the problem of uncertainty inherent in fragmentary texts, in particular about the identification of works not known from other sources. To this end, *MP*³ provides separate catalogue fields to retrieve papyri attributed to an author with confidence and to retrieve works of uncertain attribution; one may thus choose to perform overarching searches for all the papyri of an author, including attributions, or searches focused on exemplars assigned with certainty. The *MP*³ is therefore of great usefulness for papyrologists and scholars interested in the reception of Greek (and to a lesser extent Latin) classics in the Hellenistic and Roman ages, especially in Graeco-Roman Egypt, both those who seek detailed information and bibliography on single texts, and those who wish to explore patterns across items' metadata, thanks to the ability to nuance searches with accurately indexed data elements.

The *Leuven Database of Ancient Books* (*LDAB*),[15] available via the *Trismegistos* (*TM*) platform, is a project devised by Willy Clarysse of the University of Leuven, first published on CD-ROM in 1998 and online in the early 2000s.[16] Like the *MP*³, it consists of a metadata database complete with bibliographical information, dedicated to literary and paraliterary papyri. There are however a few differences between these two major resources for literary papyrology. One concerns scope, as *LDAB* is a broader collection than the *MP*³, which encompasses all ancient languages, thus totalling almost 17,000 items[17] and 7000 authors;[18] also, it comprises a few more text categories, such as all types of Christian papyri, as well as amulets. On the other hand, *LDAB* does not take into account some genres present in the *MP*³, namely, some texts with an ephemeral

[14] On the history of CEDOPAL, see CEDOPAL, n.d., esp. "1971-1998," and Reggiani 2017, 47.
[15] <https://www.trismegistos.org/ldab>. Extensive information on the *LDAB*, as regards its history, its content and its functionality, can be found in its "About" page. An overview of this database is in Reggiani 2017, 51-56 as well, who also compares it to the *MP*³ and reports on scholarly uses of its data.
[16] *LDAB*, "About," esp. "History."
[17] *LDAB*, "About," esp. "Short Introduction."
[18] This figure is reported in *TM Authors* (home page and "About" page), a resource based on *LDAB* data.

nature such as documentary papyri with literary references, horoscopes, oracular questions and magical lamellae.[19] Another difference between the two projects lies in their data model. Like the *MP*[3], *LDAB* affords indirect access to primary sources by offering detailed metadata and search functionality with numerous options, including several abstract concepts derived from the texts; but, in addition to these, in the Leuven database there are dynamic visualisations available for some data, which give an overview of chronological, geographical and thematic distributions of the papyri.

In more detail, the data model of the resource consists of a relational database, which relies on the Filemaker software for data entry, on the MySQL language for data storing, and on the PHP framework for implementing the web application, as occurs for all *TM* datasets.[20] The main component of the data model, apart from an extensive introductory guide to the project's scope and to the metadata categories included,[21] are records provided with item metadata, bibliography and many links to other items in the collection, to other data in the platform's datasets and to texts and images in external resources.

LDAB records have been merged with those of the related *TM Texts* metadata database, dedicated to papyrological and epigraphical sources, the core of the *TM* network of databases, where literary papyri may thus be retrieved alongside other ancient texts. All the same, *LDAB* can also be consulted as an independent resource within *TM*, via its own query form, which is useful for specific searches on literary papyri, thanks to its custom catalogue fields for these texts. In contrast, the *TM Texts* interface shows fewer and more generic searching options.

The interconnection of *LDAB* records among themselves, with other *TM* databases and with external resources is realised through a unique numerical identifier, which also serves as a stable URL. In this way, hyperlinks bring users to other literary papyri containing the same work or relating to the same author, and to other items in *TM Texts* created in the same period and in the same place, among other possibilities. Several external links point to the corresponding records in the *DCLP* for the papyrus text, in the *MP*[3] for further metadata, in the owning institution's catalogue for the papyrus image, as well as to bibliographical items freely available online. Interestingly, where

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[19] *LDAB*, "About," esp. "Short Introduction."
[20] See the general overview of *Trismegistos* platform's structure in *TM*, "Database structure," and in Reggiani 2017, 57-58, 71.
[21] *LDAB*, "About."

relevant, there is a link to another resource, also of KU Leuven, not referenced in the other catalogues: a new version of the *Catalogue of Paraliterary Papyri* (*CPP*).[22] The current *CPP* website cannot be navigated yet, hence its records are only available from those of the *LDAB* to date.[23] Nevertheless, the possibility to access its records via *LDAB* permits us to find information not present in other online resources, namely, a description of the handwriting and the papyrus text complete with *apparatus criticus*. Even if the text is at times present in the *Digital Corpus of Literary Papyri* as well, this, as well as its apparatus notes, may present a few differences from the *CPP*'s.

The *LDAB* search interface is enriched with many metadata fields, some of which are not present in the *MP*[3]. Besides the "genre" category, there is one, termed "culture," that allows calling up some types of texts and is especially useful to retrieve all scholarly genres of paraliterary papyri, indicated by the "science" value. There are also purposeful options to find papyri belonging to an identified archive or library, reused in different ways, distinguished by script type, and relating to a specific religion. It may be noted, however, that, unlike the *MP*[3], searches for authors do not allow distinguishing between works identified with certainty, attributions and quotations within other texts, although this information is naturally present in the records. Therefore, the results will encompass all these possibilities, which makes the search for direct attestations somewhat slow for authors with many exemplars. This issue may affect quantitative searches of *LDAB* data, in terms of both visualisations of statistical data available within the resource, and possible investigations carried out by users based on their queries. However, the presentation of *LDAB* data has been improved in *TM Authors*, a database of authors and works attested in literary papyri based on *LDAB* documentation, available via the same *TM* platform.[24] Here, the type of attestation is indicated in the results list, which facilitates the selection of certain identifications. Also, the results table can be exported, thereby being available for scholarly reuses of the data.

The *LDAB* search mask offers lists of options for each field in the sidebar, which can be selected to enter the correct values for a complex search. Also, the results list contain some types of information along with the item's publication reference, including date, provenance, material and collection. It is dynamic, as it can be sorted by almost all

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[22] On the *CPP*, see Reggiani 2017, 83-85, 242.
[23] See, as a sample *CPP* record, <https://relicta.org/cpp/detail.php?CPP=0001>.
[24] Information on *TM Authors* is present in its "About" page.

the categories indicated, and, for subscribers, more categories can be selected and added to the default ones.

As well as through metadata records available via complex search options, the *LDAB* collection is accessible through interactive data visualisations. A graph function (*LDAB – Graphs*) enables users to create charts based on several criteria. For instance, one may gain insight into chronological distributions of the data, e.g. about the diffusion of authors and book forms,[25] and into the authors most commented (by selecting the "science" value of the "culture" filter, relating to scholarly works). Moreover, upon subscription, charts are available for statistics about languages and materials, and search results can be plotted on a map for an overview of their geographical distribution. Here too, however, one should take into account the uncertainty inherent in such fragmentary evidence, which may be introduced into the visualisations: there are fragments whose content, provenance and book form is dubious, and ones that do not provide direct evidence of a work, but only a quotation within another work.[26] This issue concerns *TM Authors* as well, which presents dynamic charts (upon subscription) about attested languages and the chronological distribution of the selected authors. Modelling uncertainty and level of precision in the representation and analysis of humanities sources is still a great challenge,[27] so that sometimes providing descriptions in purely natural language may be best.[28] Therefore, it is important, at least, to inform users about uncertainty in the underlying sources and hence in their analytical treatments, mentioning whether charts are based on certain documentation only or not, and showing their usefulness as a general overview of the phenomena investigated.

LDAB is a reliable resource in terms of permanence and sustainability, being supported by the integration in a larger project for the study of ancient texts with institutional assistance such as *Trismegistos*. Its dataset proves up-to-date, as results from the list of recent papyrological editions entered in *TM Texts*, updated to 2020.[29] To conclude, even with the issue of its limited free online availability (as will be discussed about the *TM* platform in general: see below, pp. 214-15), *LDAB* is unquestionably a valuable contribution to the study of literary papyri and ancient scholarly literature and

[25] Gonis 2001, 421; Delattre-Heilporn 2014, 319.
[26] On the challenges of the work of identification and contextualisation of a text, see p. 20.
[27] On the challenge of representing uncertainty in digital humanities resources, see p. 47.
[28] Schmidt 2019, 162-63.
[29] *TM Texts* 2020.

education. Overall, the abundant material and the analytical functionalities offered in both *LDAB* and the *TM Authors* supplementary project make them effective as a source for quantitative analysis; also, hyperlinks facilitate meaningful interconnections and the discovery of further information and related items beyond the boundaries of the single catalogue.

4.3 Access to documentary papyri through advanced metadata searches

Moving on to the text category of documentary papyri, one may pinpoint several resources that afford mediated access to this primary source as a whole, with different methods. Their greater diffusion than comparable projects for literary papyri may be explained by the availability of a digital text corpus, the *Duke Databank*, which has allowed reuse for further initiatives in various ways, and by the presence of many literary papyri in the *TLG* corpus, where searches can be conducted even with complex functions.[30]

Projects that offer indirect access to documentary papyri can be divided on the basis of the way they mediate users' experiences of primary sources. Two of them, the *Heidelberger Gesamtverzeichnis* and *Grammateus*, resort to advanced search options, as the previous resources for literary papyri, indexing several characteristics of the texts, which can be utilised to nuance searches according to specific aspects. Furthermore, *Grammateus*, as well as making available the collection via browse and search, affords access in a novel way through diagrammatic representations of textual structures.

The *Heidelberger Gesamtverzeichnis der griechischen Papyruskunden Ägyptens* (*HGV*)[31] is one of the first digital papyrology efforts: an early version, which allowed a limited set of information on the papyri to be accessible to users, was launched on the web in the very year in which this was released for general use, in 1993; a few years

[30] On the *TLG*'s scope and functionality, see above, 1.4.1, pp. 23-26, and 1.6.4, p. 57.
[31] <http://aquila.zaw.uni-heidelberg.de/start>. The complete bibliography on the *HGV* is reported in *HGV* 2008, including James Cowey's announcement of the project launch (1994) and Bagnall's review (1998b), to which Reggiani's overview (2017, 39-46) may now be added. Also, a detailed introduction is offered in the *HGV* "About" page (*HGV* 2008).

later, in 1997, the complete metadata on the papyri became publicly available.[32] It is a vast metadata database of Greek and Latin documentary papyri,[33] totalling approximately 60,000 papyrus records,[34] especially aimed at facilitating searches of document types and of texts dated to specific time periods, as well as at collecting digital images from owning collections' catalogues as comprehensively as possible.

The information on the primary sources available in the records is internally structured in fields of a relational database in the FileMaker format.[35] It consists of item metadata and links to the appropriate records in *TM Texts*, *Papyri.info* and catalogues of the material collections. Not only are records connected with these resources, but texts and images are conveniently embedded therein. Paying attention to the provision of original evidence, the *HGV* presents carefully checked datings of the papyri, obtained with a revision of the information given in the edition(s), which has been corrected where needed.[36] One more way in which the *HGV* has generated new evidence is by providing English and German translations of some texts, namely, of early BGU volumes for which no translation was hitherto available; these, along with other translations integrated from *Papyri.info*, make the collection more accessible to domain non-specialists.[37] Finally, there is a good introduction to the resource, with directions for using the search utility and with editorial information (i.e., a list of the bibliographical abbreviations used).

The interactive functionalities of the collection database allow both searching on the metadata and browsing the items through hyperlinked lists. The query interface affords granular access to papyrus records by enabling searches into many metadata categories relating to bibliographical references, content type, date and provenance. Notably, information about the dating of the papyri has been precisely modelled. This characteristic is reflected in the query form, with several options to retrieve documents written in a certain date or time period, by means of precise searches for dates up to a specific day of the year. Only in the latest years has this feature become available in other comprehensive databases, with the development of *Papyri.info* and *TM Time*.

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[32] On the history of the *HGV*, see *HGV* 2008. On the opening of the World Wide Web to general use, see 1.4.2, pp. 26-27.
[33] On the scope of the *HGV*, see *HGV* 2008.
[34] The updated figure of the number of *HGV* records is reported in the "Tabelle" and in the "Alle" sections.
[35] *HGV* 2008; Hagedorn 1994, 229; Reggiani 2017, 39.
[36] Reggiani 2017, 39-40.
[37] Information on *HGV* translations are in Reggiani 2017, 44.

While dealing with temporal modelling, the *HGV* researchers have tackled the question of the uncertainty of dating that affects the base documents, due to gaps in the text or to a partial indication of this information, which may even be altogether absent. They have thus created multiple records for papyri whose date is uncertain, for a maximum of three, each with a different dating.[38] Although the presence of more than one record for the same object may affect statistical research, there is the advantage of greater precision in modelling time, with the ability of more effective retrieval of dates and periods.

Other useful modes of accessing the *HGV* collection are browsing a list of papyrus editions[39] and a dynamic list that can be sorted by different keys, including dating,[40] and searching *Papyri.info*'s *Papyrological Navigator*, where *HGV* metadata are integrated. Indeed, the *HGV* is a resource of critical importance for the development of *Papyri.info*, as it plays a fundamental role in keeping the *Duke Databank* up-to-date with metadata records of new papyri and with corrections to existing metadata. Thus, records of documentary papyri are first created in the *HGV*, and only then can they be accessed in *Papyri.info*.

In conclusion, although the presence of browsing lists with basic sorting options is typical of collections that provide direct access to primary sources, the distinctive characteristic of the *HGV* is the searching mechanism that prioritises abstract categories generalised from the documents, with a focus on the accurate representation of chronology, which situates this project among those that mediate access to primary sources through fine-grained derivative information. Moreover, the presence of translations and revised datings makes distinctive this collection for the inclusion of original evidence. With its wealth of material, the project also provides a firm basis for more in-depth investigation with digital methods into other aspects of documentary papyri than chronology. Even though terms of usage are not indicated on the *HGV* website, we know from the indication in the *HGV* section of *Papyri.info* records that its metadata may be freely reused and transformed, giving appropriate credit and mentioning any change made, under the terms of a Creative Commons Attribution License. *HGV* metadata, especially that on subject, dating and provenance, has thereby

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[38] *HGV* 2008.
[39] This list is available via the "Texte" section.
[40] See the "Alle" section.

been utilised for *Papyri.info*, *Trismegistos* and the *Grammateus* database;[41] here, in conjunction with further metadata created by *Grammateus* researchers, it serves as a base for the exploration of scribal practices in the production of the various types of documents, including their evolution in time, as is now worth pointing out.

The other project that offers analytical data gleaned from documentary papyri, *Grammateus*,[42] is very recent, as opposed to the *HGV*, having started in 2019.[43] It thus benefits from digital progress, harnessing the digital medium not only to store and make searchable a broad text base but also to produce visualisations, albeit simple, of textual structures.

Developed at the University of Geneva and led by Paul Schubert, *Grammateus* aims at analysing the layout of Greek documentary papyri from Ptolemaic and Roman Egypt,[44] subdivided by type, in order to identify patterns and variations in the realisation of documents from the editorial viewpoint.[45] While this aspect has been studied for some types of documents, an overarching appraisal of all the existing documentation was a desideratum. *Grammateus* sets out to fill this gap, with the aid of an electronic database to manage the extensive amount of documentary papyri considered, taking advantage of the already digitised texts and the *HGV* metadata in *Papyri.info*, XML-EpiDoc encoded and licensed for scholarly reuse.[46] Thus, *Grammateus* allows retrieving a comprehensive number of documentary papyri in their different types by means of metadata searches, and visualising the "architecture" of the documents, by highlighting their content structure and their bibliological features. *Grammateus* researchers have addressed the problem of uncertainty in the base text material owing to the occurrence of lacunose texts, by focusing on a set of papyri, numbering 1100 to date,[47] preserved entirely or at least to a sufficient degree to describe their layout and their content with confidence.[48]

The principal component of *Grammateus*'s data model is metadata on the papyri, encoded in EpiDoc (as shown by the XML files available for each record), published in

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[41] *Grammateus*, "General Introduction," 9; "Papyri," esp. "Search Help & Tips."
[42] <https://grammateus.unige.ch>. The project is provided with an exhaustive overview on its website: see *Grammateus*, "About," "General Introduction" and "Key concepts."
[43] SNSF, n.d.
[44] On the scope of the project, see *Grammateus*, "General Introduction," 6, 7; and "Key concepts," 1-9.
[45] On the aim of the project, see *Grammateus*, "About;" "General Introduction," 1; and "Key concepts," 1.
[46] *Grammateus*, "About," and "General Introduction," 9.
[47] This figure (i.e., 1141 items) is reported at the beginning of the "Papyri" section, as of October 2021.
[48] *Grammateus*, "About," and "General Introduction," 7.

the papyrus records after transformation to HTML by means of the EpiDoc Reference Stylesheets.[49] Another important component, and an original contribution of this project, is represented by visualisations, termed "structural displays," of the format and the structure of the papyrus texts, embedded in records (as can be seen in fig. 4.1).[50] These graphic representations of the fragments foreground size, shape and orientation of the writing support, direction of the script against the papyrus fibres, and elements of the content. Even though the transcription is present, incorporated in the diagrammatic representation, it is not given priority of visibility and use in the design and navigation of the resource: it is not searchable and it is reported in a small-sized font, not being meant for reading but as a basis for the graphic representation. Nor do records provide papyrus images, although there are links to owning collections' catalogues, if relevant. Rather, access to primary sources, in particular to the texts, is mediated by an analytic layer that makes most visible the rules underlying the preparation of the document.

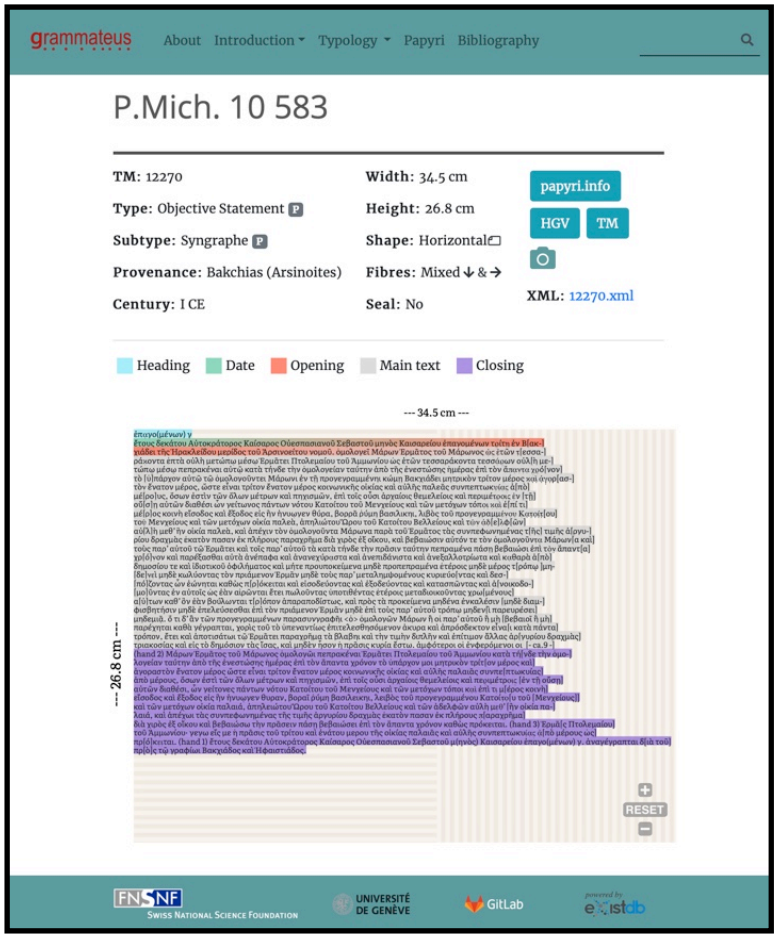

Fig. 4.1

A record of *Grammateus*, with metadata, links and structural display of the papyrus

[49] *Grammateus*, "About."

[50] On these "structural displays," see *Grammateus*, "General Introduction," 13.3. An instance of a papyrus articulated in several elements, as reflected in its representation, is <https://grammateus.unige.ch/show.html?document=12270.xml>.

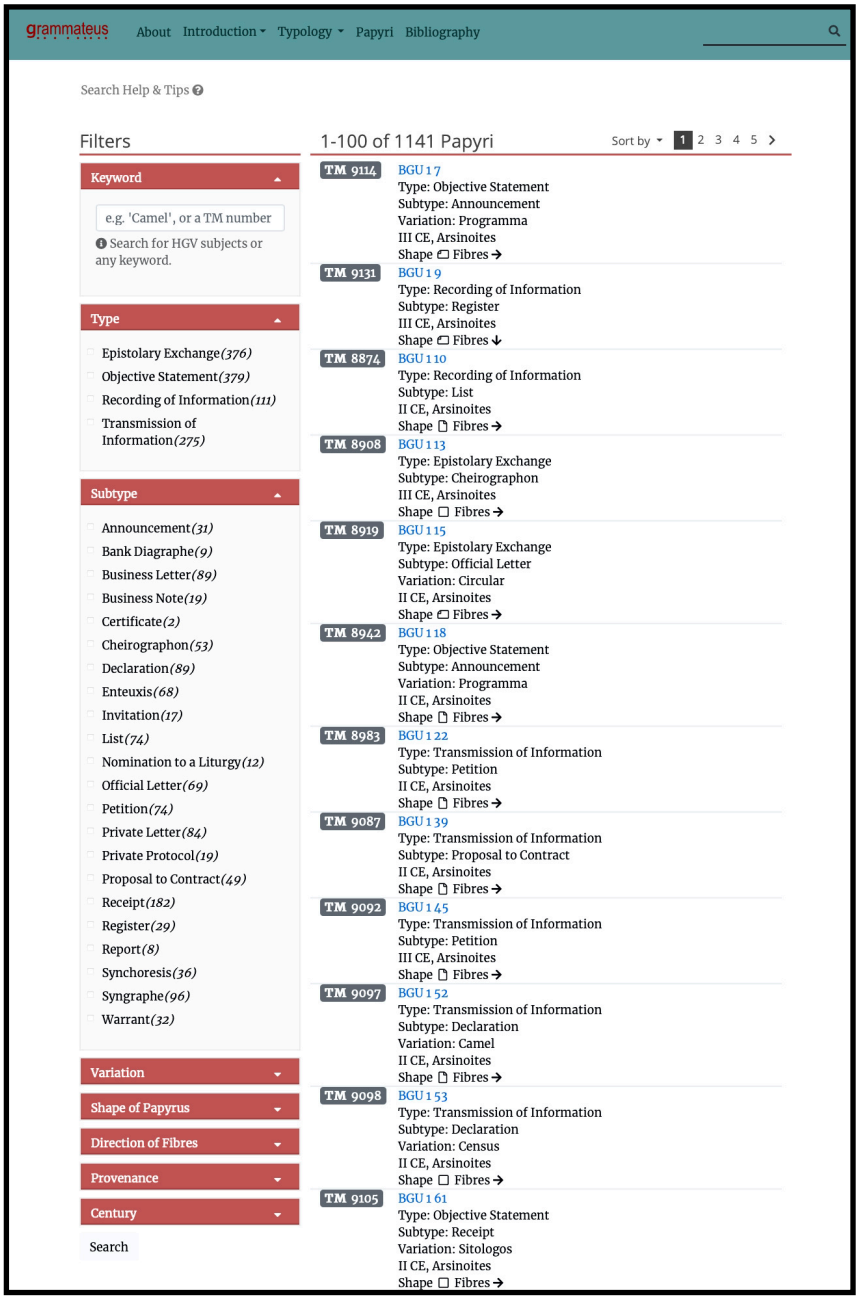

FIG. 4.2 *Grammateus*'s search and browse interface

By the same token, while the collection is presented through searching and browsing functions, with the possibility to both perform free keyword searches and browse the records with the help of drop-down menus, as for the previous kind of projects, at the same time more granular access is afforded through specific criteria resulting from analysis and interpretation, in part original of this project. Categories of documentary papyri are carefully indexed so that they can be used to nuance a search. Thus, the interface offers three fields to precisely browse items by type (see fig. 4.2 above). The "subtype" field and its more specific "variation" field allow browsing by

type of document identified on the basis of the content. Note that, in addition to this traditional classification, *Grammateus* researchers propose to group documentary papyri into four categories by considering the scribe's task, that is, by reflecting on how communication occurs, on how information is conveyed on the whole, taking into account both the content and the way in which the text is produced materially. This new typology, illustrated in the project's documentation,[51] is represented through the values of the "Type" field.

Besides encoded metadata and outlines of textual structures, another key component of the resource is information on the project and on the primary sources, notably that which defines and classifies documents types. This contextual information serves both to clarify their typology and to tie together taxonomy, descriptions of documents types and representative papyrus records.[52]

The XML files of the metadata records, downloadable both singularly from the records and as a bundle from the GitLab repository,[53] can be reused for further projects, as allowed by a Creative Commons Attribution-NonCommercial License.[54]

Grammateus is a remarkable resource for the work, both intellectual and technical, carried out to structure meaningful categories of primary sources, and for the new evidence offered in terms of typological classification and visualisation of the text structure. The range of information found in this project is of use to both scholars and students; the latter are well-served thanks to accessible overviews of the key concepts. Besides the contribution already offered, it seems likely that *Grammateus* will stimulate further research into the visualisation of editorial and content features of the papyri. Future work might involve making searchable the elements of the textual structures highlighted in the diagrams, by applying structural markup to the texts, for example to retrieve opening and closing phrases of the various document types, and dating formulas. Furthermore, taking *Grammateus* as a model, it might be interesting to create an analogous resource for literary and paraliterary papyri. This could focus on genres structured by elements repeated by constant schemes, for instance lyric poetry, dramas, commentaries, glossaries, lexica and medical prescriptions. Here, too, structural

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[51] *Grammateus*, "Typology" (also summarised in "General Introduction," 10-12).
[52] See especially the "Typology" section, for the close integration between primary sources and contextual information.
[53] A link to GitLab is available in the bar displayed at the bottom of each page.
[54] *Grammateus*, "About."

displays would help analyse the linkage between content and scribal editorial practices, investigating how these evolved over time.

4.4 Access to documentary papyri through analytical data

Two projects, *TM Texts* and *WörterListen*, primarily make most visible granular derivatives of the corpus of documentary papyri, such as indexes of lemmatised words and named entities, and visualisations of statistical data, although *TM Texts* also affords access to metadata records via search and browse.

Trismegistos (TM) Texts,[55] launched in 2006,[56] developed at KU Leuven under the direction of Mark Depauw, is a metadata database devoted to papyrological and epigraphical sources relating to a wide variety of ancient civilisations. While including both documentary and literary papyri (the latter merged from the *LDAB* database), it seems opportune to discuss it in this section about documentary texts, rather than in a separate one, because, through connections with other *TM* databases, it focuses on the provision of data about these sources, viz., prosopographical, geographical, chronological and linguistic. Also, for literary works it is more appropriate to consult the *LDAB* database in the same platform, which presents a more specific search interface for their aspects, as *TM Texts* itself recommends on its home page.

TM Texts, as well as the *TM* platform in which it is integrated, has effected three methodological contributions to papyrology, pinpointed by Depauw and Reggiani. The development of an integrated system of many individual but complementary databases has provided a broad base, totalling 680,000 records,[57] for performing quantitative analysis.[58] Second, *TM Texts* supports interdisciplinary research, having expanded

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[55] <https://www.trismegistos.org/tm>. Information on *TM Texts* may be found in the "About" pages of *TM* (*TM* 2017). They deal exhaustively with several aspects of the platform and of this database in particular: the history of the project, *TM Texts* content in terms of both scope and coverage, its usability and its technical implementation, namely, the structure of the platform and the use of stable identifiers. The salient characteristics of *TM Texts* and of the *TM* platform as a whole are also reviewed by Depauw (2018) and Reggiani (2017, 51-73, 193-97), as mentioned below.

[56] Depauw 2018, 195; *TM*, "History."

[57] Depauw 2018, 196.

[58] Reggiani 2017, 56, 71, 189-97; Depauw 2018, 198. For research grounded on quantitative analysis of *TM* data, see the publications cited in Depauw and Reggiani (ibid.); *TM*, "Trismegistos Corpus Data," also containing datasets derived from *TM*, used in published research; and *TM*, "Trismegistos Online Publications."

beyond its initial focus on Egyptology and papyrology to encompass an ever wider range of ancient languages and writing materials.[59] Finally, the unique numerical identifier, which is also a stable URL, used for compatibility across the databases of the platform, has become a digital standard to reference texts univocally in other projects and in publications.[60]

The data model of *TM Texts*, as usual in *TM* resources and as already seen regarding *LDAB*, is constituted by metadata structured in an SQL relational database integrated with the other *TM* datasets.[61] This structure allows management of the complex relationships among items and between these and the other data in the platform. Thus, although *TM Texts* records provide basic information on their primary sources, links embedded in metadata (highlighted in red, as can be seen in picture 4.3 below, with a sample record) enable access to more details and statistics visualised as charts on a variety of themes, and allow discovering related items by browsing. For instance, *TM Places*,[62] one of the most complex *TM* databases, developed from the extensive XML base of data of *Papyri.info*,[63] shows other texts unearthed in the same place as the select item, with the same provenance and with attestations of the same toponyms; moreover, upon subscription, through the *TM Places* interface, places filtered with diverse criteria can be visualised on a map, with a chronological overview of the related items and statistics on their languages and materials.

Another key component of the data model of *TM Texts*, available for documentary papyri, is the papyrus text, integrated from *Papyri.info*, embedded in the records (see again fig. 4.3). The text provided is a snapshot of an older capture of the version currently present on the *Duke Databank*, as clearly pointed out in *TM* records. Hence, *TM* transcription does not substitute the one in *Papyri.info* but has to be utilised in tandem with it, so that we may take advantage of *TM* functionalities and at the same time avail ourselves of a usually more up-to-date version of the text. Unlike projects with direct access to primary sources, transcriptions in *TM Texts* are not only available as such, but they are also mediated by an analytical layer built upon them, which makes

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[59] Reggiani 2017, 73; Depauw 2018, 198.
[60] Reggiani 2017, 57-58; *TM*, "About," esp. "Stable identifiers;" Depauw 2018, 199.
[61] See the description of *TM*'s structure in *TM*, "Database structure," and in Reggiani 2017, 57-58, 71.
[62] <https://www.trismegistos.org/geo>. On *TM Places*, see the detailed overview in its "About" page, focused on its scope and coverage. Its key characteristics have been surveyed by Reggiani (2017, 69).
[63] On the process of Named Entity Recognition applied to the *Papyri.info* base XML to extract the relevant toponyms (as well as personal names for the development of *TM People*) see Depauw 2018, 196-97, and Reggiani 2017, 65.

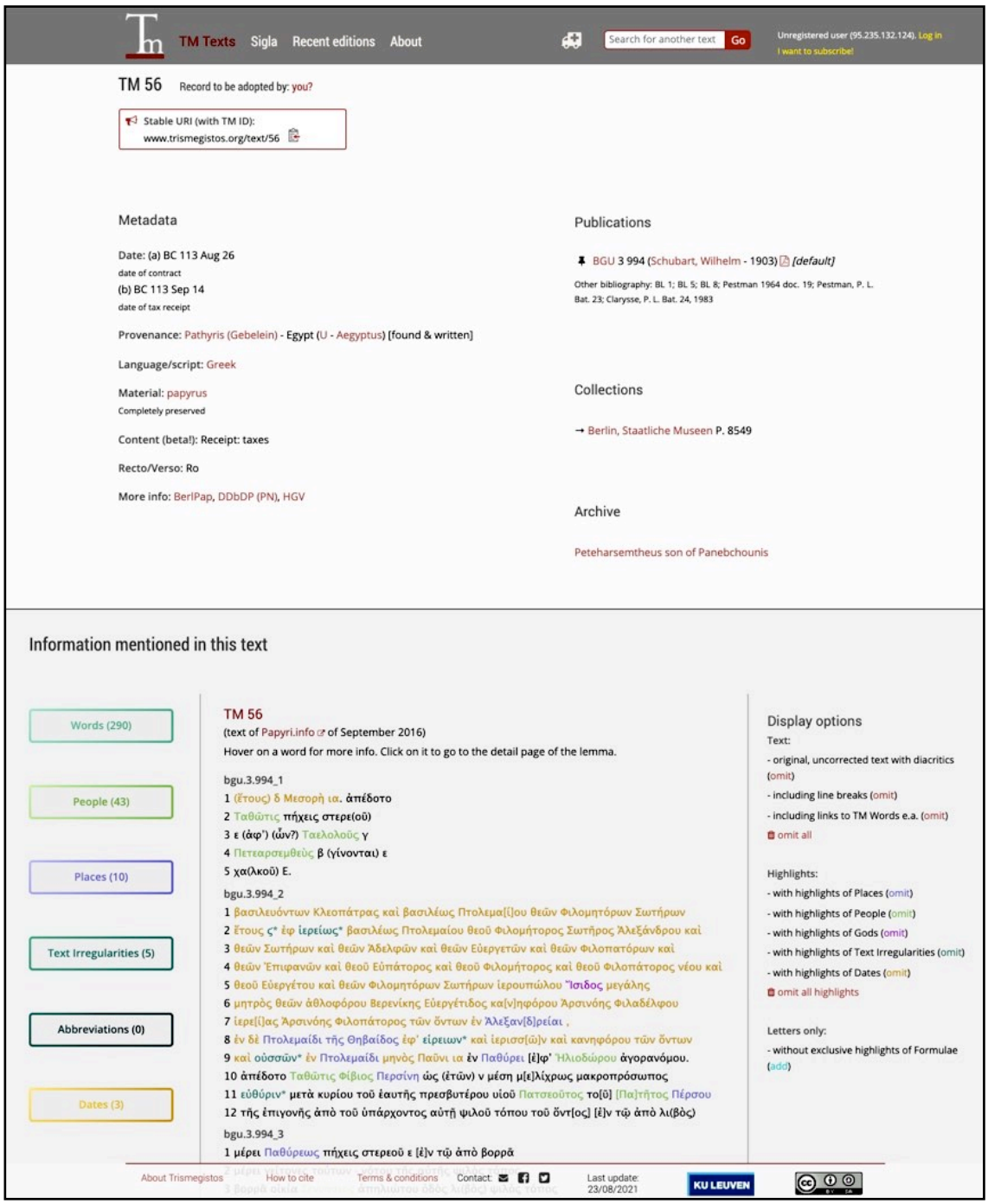

FIG. 4.3 A sample record of *TM Texts*: BGU 3 994, contract of sale with tax receipt (<www.trismegistos.org/text/56>)

visible derivative data and is the main component of the digitised primary source. The prominence of analytical information over the text as such is also indicated by the heading "Information mentioned in this text," which puts the stress on the informational layer provided rather than on the transcription in itself. The layer affords granular access to the text by highlighting words and phrases that present certain characteristics, showing information on them and linking to other *TM* databases for related statistics.

All the words are provided with morphological analysis and a translation, both integrated from the *TM Words* database, containing an index of all the words attested in documentary papyri. There is also information on named entities, i.e., toponyms, personal and deities' names, on words with linguistic variations from classical Greek, on dates, abbreviations and epistolary formulaic phrases. Furthermore, the layer is dynamic: the user may select what features to display; choose the type of transcription, diplomatic or interpretive; access information on the word of interest by hovering and then clicking on it to consult the related *TM* database. A slight enhancement could be obtained by showing the functional layer as a default option when one accesses the item record; conversely, it is omitted and needs to be activated through the display options menu. Even though statistics are visible alongside the text, the analytical layer might be presented at once, as this, rather than the content in itself, is the chief contribution of *TM Texts* to the papyrus text integrated from the *Duke Databank*.

Among the *TM* databases that contribute data to *TM Texts*, *TM People*,[64] along with the aforementioned *TM Places*, is particularly rich and complex. This undertaking, which follows up the *Prosopographia Ptolemaica* and its digitised version,[65] provides a set of interrelated databases devoted to onomastics and prosopography. It offers information on the names attested and on the people identified in the selected text, allowing us to discover items related to it in many ways: with the same name attestation, with variants of the same name, with the mention of the same person and other known members of his/her family (parents and children). Statistics about name attestations and people identified are appended to the documentation in the form of charts and network visualisations of their relationships. Moreover, the search interface of *TM People* facilitates fine-grained access to primary sources by providing advanced search options for people, names and their parent-child relation. While attestations of a personal name can also be found in *Papyri.info* with a search into its text base, the main contribution of *TM People* is the more granular access to texts afforded by manually derived identification of people and their family relationships, with the development of an online prosopography, albeit only a partial one, thus far.[66] In comparison to the other

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[64] <https://www.trismegistos.org/ref>. On *TM People* see the extensive description in its "About" page, concerning both content, including coverage and editorial decisions, and data model. Reggiani (2017, 65-68) appropriately synthesises information on its main features.

[65] Depauw 2018, 193-95; Reggiani 2017, 65.

[66] On the progress in the verification of prosopographical identifications in *TM People*, see its "About" page, esp. "Coverage."

major prosopographical digital resource for the Graeco-Roman world, the *Lexicon of Greek Personal Names* (*LGPN*), *TM People* responds to the papyrologist's needs more precisely, being focused on individuals attested as living in Egypt. By contrast, the *LGPN* has thus far drawn on papyrological sources for a relatively small number of attestations of people outside Egypt. However, currently *LGPN* work on Egypt is taking advantage of the material in *TM People*, as the first of the two volumes dedicated to this area, in the *LGPN* paper version, is being prepared in collaboration with Leuven;[67] Greek names attested in Egypt will thus be searchable alongside evidence for the other areas of the ancient world. An issue of *TM People*, as well as of the other databases related to *TM Texts*, as noted, is that it relies on transcriptions that represent an older version of the ones currently available on *Papyri.info*, hence users need to check the attestations of the individuals of interest in updated editions.

Finally, *TM Texts* comprises information on the project development in a variety of formats. There are a detailed introductory guide (*TM* 2017) and technical documentation about its content. The latter consists of CSV (comma-separated values) files with data obtained from the collection, which served as a base for research published in the accompanying contributions (*TM*, "Trismegistos Corpus Data"); and in open-source tooling (*TM*, "Trismegistos Data Service"), comprising APIs to automatically collect links to related projects for aggregating information about ancient texts and places, and services to convert information about people and places into a standard format such as CSV, GeoJSON, and RDF to facilitate its representation in terms of linked open data. In addition to this, search results in *TM Texts* are available for download as CSV files (for subscribing users). Aside from the underlying FileMaker metadata files of *TM Texts*, which are nonetheless available to scholars at request,[68] *TM* data may be freely reused according to a Creative Commons Attribution-ShareAlike license, which allows usage even for commercial purposes, provided that any derivative material is distributed under the same license.

One way in which the presentation of the collection occurs is through search options, as in resources that provide direct access to papyri. Most metadata fields are general, suitable for all the primary sources in *TM Texts*, both papyri and inscriptions: bibliographical data, inventory, material, language, provenance and date. But there are

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[67] See the home page of the *LPGN* and University of Oxford, *"Lexicon of Greek Personal Names*."
[68] Bagnall-Heath 2018, 172.

also a few search terms that allow retrieving more specific types of papyri, such as author and work, for literary texts; content type, although this information has not been systematically reported in records (as pointed out in the help guide relating to this field); reuse, to call up, for instance, papyri from cartonnage, palimpsests or items composed by multiple fragments joined together; and texts belonging to an archive. Furthermore, quantitative analysis of papyrological metadata is another goal of *TM Texts*, and especially this analytical emphasis distinguishes *TM Texts* from projects that afford direct access to items. Statistics on prosopographical, geographical and chronological data, among others, can be accessed from papyrus records via the hyperlinked related *TM* databases. Moreover, upon subscription, statistics visualised as charts or tables are appended to item results, for an overview of their languages, materials and chronology, while their geographical distribution can be viewed on a map.

Another way, related to quantitative analysis, in which the *TM* platform affords indirect access to primary sources, particularly documentary papyri, is the provision of network visualisations. This technique is based on the method of Social Network Analysis (SNA) for the automated representation of relationships between entities, introduced into the study of ancient history from the social sciences.[69] We have already seen how visualisation of network structures is used in *TM People* to reveal connections among name attestations and individuals attested in documentary papyri and inscriptions from Egypt. Another database integrated into the platform, *TM Irregularities*, also offers a visual representation of *TM* data, in particular of instances of linguistic variation from standard Greek and their co-occurrence, as evidenced by documentary papyri. But, above all, network analysis and visualisation are the primary focus of *TM Networks*.[70] This section of the platform contains the analytic results of published research, visualised as searchable network graphs, about onomastics for insight into naming practices, and about personal networks derived from prosopographical data. A future challenge for this resource might be to consider the application of SNA to geographical data as well. One may obtain information on relationships among places by taking into account papyri in which place of writing and finding differ (cf. p. 14) and papyri, especially letters, that testify to connections

[69] On the introduction of SNA in the humanities, see Jannidis-Flanders 2019, 74; Brughmans et al. 2016, 10-12, with a focus on ancient history and archaeology; Reggiani 2017, 189-97, for papyrology.
[70] <https://www.trismegistos.org/network>. For information on this database, see its home page and Reggiani 2017, 193-97.

between inhabitants of different places. Whereas frameworks for the representation and analysis of geospatial data have been adopted by archaeologists since the 1990s to visualise and query the spatial context of excavations and finds,[71] only recently have they been applied to texts rather than archaeological documentation. In particular, digital mapping has been deployed for studying representations of ancient geography in literary authors. On the ground of datasets of toponyms geoparsed (automatically identified and extracted) from hand-coded literary works and georesolved (associated with coordinates), researchers have created maps that make visible the geographical structure of the narratives,[72] and network graphs that highlight relationships among places, as well as peoples, as a means for further analysis.[73] In a similar way, based on the relational *TM Places* data about place attestations, places of origin and finding, relevant entries of this database could show a graph visualising the linkages of the place in question, together with a general overview of geographical networks.

As has been stressed in the literature, quantitative analyses and data visualisations relating to papyrological sources necessarily contain some degree of uncertainty, because of the uneven distribution of papyrological findings and because of the fragmentary nature of the texts.[74] Besides the uncertainty inherent to the base documents, there may be uncertainty in their digital representation, owing to the incompleteness of the dataset and to the inaccuracy of the recorded information. The latter dimension of uncertainty, concerning the information available in *TM Texts*, has been addressed by providing, in the project documentation, an estimation of the coverage of the dataset of each source, that is, papyri and inscriptions in different languages and from various geographical areas, from which it emerges that the database is almost complete for papyrology.[75] Moreover, a section devoted to recently published editions gives insights into the updating status of *TM Texts*, showing that it is covered up to the current year 2021.[76] Another approach that *TM* uses to address uncertainty in its data is to solicit user contribution, as regards the addition of new item records to make the dataset as complete as possible and the correction of mistakes in the already

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[71] Dunn 2019, 46-48.
[72] See the *Mapping the Catalogue of Ships* project, about the relating passage of book 2 of the *Iliad*, described in Dunn 2019, 66.
[73] See the *Hestia* project, focused on Herodotus's *Histories*, which has repurposed digital texts available on *Perseus* (Barker-Terras 2016, 8-10; Dunn 2019, 66-67).
[74] See Reggiani 2017, 196-97, with the literature cited therein.
[75] *TM*, "About," esp. "Current coverage."
[76] *TM Texts*, esp. "Recent editions."

published ones to make the information ever more accurate.[77] Besides tackling the issue of incompleteness and uncertainty in recording metadata, addressing the inherent uncertainty in primary sources seems an approach worthy of consideration. It might be useful to explain how *TM* statistical results deal with lacunose attestations of words, including personal names, toponyms and dates, clarifying whether they are included in quantitative modelling or whether only clear words are. If uncertain words are taken into account in quantitative analysis, *TM* researchers might make users aware of how this affects analytic results, and reflect on how the problem could be formally recognised and compensated for in terms of visualisation. Since an accommodation often adopted in digital humanities resources is to quantify certainty itself,[78] data based on a high number of uncertain (i.e. lacunose) words might be identified and highlighted in charts and network graphs, encouraging users to resort to the papyrus editions and available images to check the papyrus text in these cases.

TM Texts and in general the *TM* platform are in a good position to meet the challenge of sustainability for the next years, but it may be that their accessibility and curation become problematic in the long run. To date, the financial sustainability of *TM* is ensured by a twofold source of income: it is fee-supported, through institutional and individual subscriptions, and has financial backing granted by the Belgian branch of *DARIAH*, the European Digital Research Infrastructure for the Arts and Humanities, until December 2024.[79] To maintain the value of the platform to users, which in turn encourages subscriptions and renewals, the *TM* team keeps the database up-to-date with new metadata records of recently published texts,[80] and increasingly expands its scope forward in time to include sources from subsequent periods to antiquity, and widens to add texts beyond Egypt and the Graeco-Roman world.[81] Moreover, since merely entering new records may not be enough to guarantee the longevity of a project without curating its infrastructure, as again one may learn from the *TLG* model,[82] the team implements further functionalities such as specialised search options for its content and tools for the extraction of statistical data and their visualisation. The attention paid to

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[77] *TM*, "About," esp. "Help us!" and "Add a new text."
[78] Schmidt 2019, 163.
[79] See *TM*, "Partners & funding," esp. "Past funding," available from *TM* home page. Information on subscriptions is reported in the home page.
[80] *TM Texts*, "Recent editions."
[81] *TM*, "About," esp. "Coverage."
[82] Loy 2009, 4; Maron et al. 2009, 14-15.

interdisciplinarity and metadata analysis distinguishes *TM* from other extensive metadata databases for papyrology and is likely to support the resource in the competition with them. All the same, it remains unclear whether, when revenue from *DARIAH* ends, subscriptions alone will be sufficient to cover *TM* costs.[83] The addition of one more stream of income, such as funding from its host university as occurs for the *TLG*,[84] would be key to sustaining *TM* without raising the subscription price.

In conclusion, it can be said that *TM Texts* unquestionably constitutes a powerful resource for scholars of the Hellenistic and the Roman worlds, especially as far as Egypt is concerned, to gain insights into its literary culture and its political, administrative and social history, as revealed by papyri and inscriptions. *TM Texts* allows users to retrieve metadata and bibliographical references on primary sources similarly to other comprehensive papyrological databases such as *MP*^{3}, *LDAB* and *HGV*, but with the possibility to search for literary and documentary texts at the same time. In addition, by drawing on metadata for a vast amount of items and on texts of documentary papyri, *TM Texts* and its related *TM* databases have allowed conducting quantitative studies of the papyrological documentation, generating analytic results based on several criteria, often translated into graphical form aimed at comparative views of data.

Besides its analytical emphasis, another outstanding feature of *TM Texts* is connectivity, which encourages awareness of other resources that offer material on the same items. Moreover, connectivity is achieved with a rigorous approach, by unambiguously referring to items, whether texts, places, peoples or time periods, with a digital standard as a shared reference, constituted by a URL that acts as a stable digital identifier.[85] Also important to support integration across multiple projects through standardised links is the publication of *TM*'s geographical and prosopographical data in the RDF format, for reuse in linked open data projects. As well as using and publishing its own URIs, *TM* databases are well connected with external resources. Papyrus records in *TM Texts* point us to *Papyri.info*, the *HGV*, *PapPal* and collection catalogues. Places, in their relevant database, are linked with online historical gazetteers, both as sources of further information and as external authorities to ensure the identification of a place across languages and, since they can be hyperlinked with current places, across

[83] Cf. Bagnall-Heath 2018, 177.
[84] Loy 2009, 2-4.
[85] On the significance of connectivity in digital humanities resources, with an evaluation of this aspect in digital classics projects, see Bagnall-Heath 2018, 183-84.

time periods. Although ancient places are well served by digital classics projects as regards their interconnection through shared identifiers, this aspect can still be enhanced for other entities such as personal identity and time,[86] in which direction *TM* has brought a substantial contribution.

However, it has to be mentioned that since January 2020 *TM* has been in part a restricted-access product, charging subscription fees for the complete usage of its search interfaces and visualisations. While a subscription-based model helps sustain the project and while *TM* serves non-subscribers through many open-access functions, we cannot fail to note the high cost of the subscription, i.e. 1040 euros from 2022, which needs to be renewed yearly.[87] Hence, 112 institutions and 36 individuals have subscribed (as of October 2021, as is shown on *TM*'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 resource.

Granular access to documentary papyri through analytical data is also the aim of the *Wörterlisten* (*WL*),[88] a project devised by Dieter Hagedorn of the University of Heidelberg, realised in collaboration with Klaus Maresch of the University of Cologne, with the technical assistance of the Cologne Center for eHumanities. But, unlike *TM Texts*, its main offering is not statistical data and related visualisations, even though some word statistics displayed as graphs are present, but rather the provision of word indices, subdivided into several categories, and equipped with searching and browsing options. Thus, in a small part derivatives take the form of visualisations (*WL*, "Statistiken"), relating to different information from *TM*, including the distribution of the lemmata according to the indexed categories, to languages (Greek and Latin) and volumes of editions; however, unlike those in *TM* databases, *WL* visualisations are somewhat static and only concern broad categories of items. The *WL*'s priority is rather access through word indices, subdivided into a general index and lists of personal and geographical names, months and days, similarly to *TM* databases such as *TM Words*, *People*, *Places* and *Calendar*. While *WL* indices do not contain statistical data and information on lemmata besides the indication of the papyrus edition, nor can they be qualified as a prosopography or a gazetteer, unlike *TM* resources, the *WL* distinguishes

[86] Bagnall-Heath 2018, 184.
[87] See *TM*, "Registration."
[88] Reggiani 2017, 119-22; *WL*, "Über die Papyri-WörterListen."

itself for more user-friendly navigation of the word lists, thanks to the provided browsing utility and the alphabetical arrangement of the lemmata. One may also find some word categories not included in *TM*, viz. names of gods (although this information is highlighted in papyrus transcriptions in *TM Texts*), sacred names and feasts.

WL indices are obtained with a different method from *TM*, that is, not by extracting words and named entities from the *Duke Databank* digital text corpus, but by manually entering lemmata from word indices appended to volumes of papyrological editions and journals. The task is facilitated by the collaboration of the papyrological community, as numerous editors provide such indices in electronic format to the curators of the *WL* (as indicated on the home page). An advantage of this workflow is that the resource is fairly up-to-date, as the latest content update occurred in July 2020 (see, again, the home page). On the other hand, since the task is time-consuming, the *WL* only contains data sourced from subsequent editions to the year 1995, when it started being developed, although users may integrate their searches by resorting to the *Duke Databank* and *TM*. Indeed, the *WL* was born as a temporary supplement to the *Duke Databank* in a period in which the resource updating was difficult to sustain.[89] Because of its usefulness, it has however continued to be maintained still today as a valuable supplement to that database. Besides providing extensive browsable lists of terms attested in documentary papyri, as well as in relevant paraliterary papyri and inscriptions, it is especially useful for its mode of access to texts, represented by lemmata rather than attestations of inflected forms, which makes this resource distinctive from *Papyri.info*. While the *Papyrological Navigator* is provided with an option for lemmatised searches, this does not perform well with searches of words whose forms vary considerably, notably verbs.[90] For this reason, as well as for its convenient browsing facility, the inclusion of relevant sources beyond documentary papyrology, and its constant update of both content and technology (as reported on the home page), the *WL* constitutes a very helpful complement to *Papyri.info* and *TM* databases, especially now that, again, the sustainability of *Papyri.info* is at risk and some of *TM*'s functions are restricted to subscribed users. As well as valuable, the *WL* is also potentially permanent, being hosted by a centre for papyrological research, within the University of Cologne (*Kölner Papyri*), and relying on collaboration with Cologne's

[89] *WL*, "Über die Papyri-WörterListen."
[90] Cf. *WL*, "Über die Papyri-WörterListen."

digital humanities centre. It is potentially sustainable, as it benefits from the continuous contribution of the scholarly community for the provision of source material, and takes advantage of standards-based approaches to the delivery of reusable content, since its TEI-encoded source data (obtained from the original FileMaker version) is made available open-access on the GitHub repository, under a Creative Commons Attribution license.

4.5 Access to documentary papyri through textual and linguistic analysis

Other resources also address the study of documentary papyri by giving priority to the provision of other scholarly content over their visibility and direct accessibility, as occurs in the previous projects, but in this case through mechanisms of textual analysis. In particular, they enable advanced exploration of word patterns through text mining, in the *eAQUA* project, and of linguistic phenomena, in corpora with morphological and sometimes syntactic annotations, as exemplified by *Digital Grammar of Greek Documentary Papyri* (*PapyGreek*).[91] Both resources are built on the XML-based textual content of *Papyri.info*. While it is possible to carry out some kind of text analysis of the corpus of documentary papyri in *Papyri.info* itself, by performing multiple searches of words or phrases and manually comparing them, *eAQUA* and *PapyGreek* speed up and make operations and calculations more accurate, open the corpus to visualisations, and equip it with additional data by encoding linguistic information down to the level of single words.

The *eAQUA* (*Extraktion von strukturiertem Wissen aus Antiken Quellen für die Altertumswissenschaft*) platform,[92] developed at the University of Leipzig, gathers texts of primary sources from various projects, with a focus on Greek and Latin, including the material of the *Duke Databank of Documentary Papyri*, literary works from *Perseus Digital Library*, Greek inscriptions from *PHI CD-ROM* 7, and the text of *Codex Sinaiticus*. But, while present, the textual content underlies the resource. This prioritises

[91] On the techniques of text mining and linguistic annotation in general, see p. 49.
[92] An overview of *eAQUA* is in Reggiani 2017, 186. Information, especially technical, on the project is available on *eAQUA* itself, via the "Dokumentation" tab, esp. "eAQUA Wissensdatenbank."

the analytical treatment of the base documents through text mining techniques for automated identification of word co-occurrences and quotation extraction (the latter functionality being available for literary corpora only).[93] Unlike *TM Texts*, in which transcriptions can be accessed not only through an informative layer but also as such, by choosing to omit the related functionality, *eAQUA* only provides more granular derivatives of primary sources, thus being clearly situated among projects that mediate access to papyri. Derivatives of papyrus texts are offered in various formats: there are lists of co-occurring words for the select term sorted in order of frequency, related exportable CSV files, and network visualisations that represent the various degrees of relation between words. While *eAQUA* may be recognised as a permanent resource due to the stability of its host institution, it however could be enhanced by greater connectivity with other resources, and it presents some usability issues, especially regarding its documentation. These problems may have the effect of devaluing the resource and hence reducing its use, despite its ongoing availability. Although it contains extensive technical documentation about its functioning,[94] *eAQUA* lacks information on the base text material to clarify its nature, extent and provenance: only the names of the source projects are indicated, also in an unclear way for the corpus of papyri (i.e., "Epiduke" rather than "Duke Databank"). Documentation could be provided about network graphs as well, namely, about their underlying concepts, visual interpretation, and appropriateness to the context under scrutiny of documentary papyrology, as occurs in *TM Networks*, explaining how they can react dynamically to user input with the provided editing tool.[95] Another weakness of the project is that it has not clarified the usefulness of co-occurrence analysis for the specific domain of documentary papyri. The value of this technique for the study of literary texts is well-known, for stylistic research on associations of words in an author, or in multiple authors to explore intertextual connections and influences,[96] so that it can be purposefully applied to the literary corpora available in the platform. It would be helpful to explain the relevance of co-occurrence analysis also for a different text category such

[93] For co-occurrence analysis of documentary papyri, one needs to select "Demonstration Kookkurrenz-Analyse" in the "Tools" tab, and then "Epiduke" as a corpus.
[94] See the "Dokumentation" tab, esp. "eAQUA Wissensdatenbank."
[95] On the risk of poor understanding of network visualisations if their theoretical underpinnings are not considered, see Brughmans et al. 2016, 10-11.
[96] See Yarnell 2018, a review of the *Musisque Deoque* corpus of Latin poetry, which, in the "Search" section, assesses the provided co-occurrence search utility.

as documentary ones, for example for the study of the language of the papyri from the lexical point of view, through the examination of word frequency and combination of words, thereby increasing familiarity and confidence with this technique, and appreciation of its opportunities and challenges for the discipline.

Notwithstanding the large scale of resources such as the *Duke Databank* and *eAQUA*, which allow for some kinds of text analysis and text mining, their raw base documents do not permit advanced explorations of linguistic phenomena of the Greek attested in the papyrological documentation,[97] for example of syntactic roles or of semantically related words, which, in contrast, is the primary purpose of linguistically annotated corpora. Some linguistic corpora, in digital papyrology as well as in digital classics more broadly, have become available to papyrologists and historical linguists in the latest years. Their goal is to enable several kinds of analysis of linguistic patterns in large amounts of texts with linguistic information encoded in a standardised format in each token. Such information concerns morphological and sometimes syntactic categories; additionally, texts can be enriched by a semantic layer and accompanied by metadata, thereby allowing investigation from further points of view.[98]

The development of linguistic corpora has been facilitated by the availability of large-scale open-access and open-source text databases. Besides being freely accessible, these databases make the underlying XML source code of their texts immediately available for download as a bundle (or divided by collections), on their website or via public software repositories such as GitHub. The open-data policy is followed, among the most extensive resources, by projects of the *Open Greek and Latin* initiative, among which *First Thousand Years of Greek* and *Perseus Digital Library*, the latter utilised as a source for the *Diorisis* and the *Ancient Greek and Latin Dependency Treebank* linguistic corpora; by the *Epigraphische Datenbank Heidelberg*, devoted to Latin inscriptions from Roman provinces (*EDH*, n.d.), the core resource of the *EAGLE* federation of epigraphical databases, whose material is being employed in the *WoPoss* semantically annotated Latin corpus;[99] and by *Papyri.info* (cf. p. 141), which provided the XML-based textual content of the *PapyGreek* treebank. These text databases publish

[97] On the significance of papyri for the study of the Greek and Latin languages, see p. 18.
[98] For an overview of the methodology of corpus annotation, see McGillivray 2014, 7-8, 20-29 (focused on computational resources for Latin).
[99] On *WoPoss* see Dell'Oro et al. 2020, esp. 2 about the collaboration with *EAGLE* for the use of its aggregated epigraphic corpora.

their content under Creative Commons attribution licences, thereby granting public permission for reuse under copyright in a standardised way, aiming not only at enhancing accessibility to primary sources, but also at providing materials that, being in an open digital format, are ready for reuse, e.g., for being commented, annotated, or analysed with text mining techniques.

Among Greek and Latin linguistic corpora created from the available XML-based contents, some are provided with a single type of information, i.e. morphological, as well as being lemmatised. One notable instance is the *Diorisis Ancient Greek Corpus*, the largest linguistic corpus of ancient Greek,[100] constituted by literary works imported from open-access databases, which can be analysed with a dedicated application, *Diorisis Search.* In comparison to other morphologically annotated corpora for Greek or Latin,[101] *Diorisis* enhances the use of the annotated texts for research by enriching them with metadata so as to enable exploration of linguistic features by date and literary genre,[102] and by assisting in the formulation of complex queries in its search utility; it also facilitates the use of the corpus for pedagogical purposes, aiding in the creation and revision of parsing exercises.[103] Papyrology is also provided with morphologically annotated corpora, sourced from the *Duke Databank*: the *Morphologically Annotated and Lemmatized Papyri* (*MALP*), created by G. Celano (University of Leipzig), published as an XML base of data for further projects;[104] the *TM Words* lemmatised word index, also integrated with *TM Texts*; and *PapyGreek*, which has a much smaller extent but presents a search interface (available in the "Variations" tab) that allows complex and effective queries, and is also provided with syntactic annotation.

Some digital corpora, including *PapyGreek*, apply annotation on the level of both morphology and syntax, to perform even more advanced linguistic searches on the texts. These richly annotated linguistic corpora have been built by following shared guidelines based on the standard theoretical framework for syntactic annotation, dependency grammar, and are organised in the typical "treebanking" schema, or tree-like structure, so as to foreground dependencies among words and clauses.[105] The *Perseids Digital*

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[100] Vatri-McGillivray 2018, 1-2.
[101] For an overview of morphological annotation of Latin texts, see McGillivray 2014, 22-26. Analogously for Greek, see Vatri-McGillivray 2020, 181-83.
[102] Vatri-McGillivray 2018, 3.2.
[103] Vatri-McGillivray 2018, 1-2, 3.2.
[104] Celano 2018.
[105] For an overview of Greek and Latin syntactic corpora, or "treebanks," see Celano 2019.

Editions repository of the *Perseids Project* (a platform that supports the creation of a range of editions of ancient sources) has published a broad collection of them, relating to both Greek and Latin texts, among which the *Ancient Greek Dependency Treebank* is characterised by the addition of a semantic layer.[106] Another semantically annotated treebanking corpus is *PROIEL*, mainly focused on Latin literary works.[107] Documentary papyrology is also covered to some extent, with the *PapyGreek* treebank, which is being developed at the University of Helsinki under the direction of Marja Vierros.[108] Besides containing syntactic annotation, *PapyGreek* is provided with further information and presents a specific papyrological aim: the study of linguistic variation from classical Greek in scribal practices, i.e., in relation to the scribe's degree of literacy. Because of the complexity of the project, which takes into account various characteristics of the papyri (textual, linguistic and palaeographical), *PapyGreek* appropriately adopts a multi-layered representation as a data model, as opposed to a mono-hierarchical arrangement exemplified by a single TEI XML document. In particular, it follows the approach known as "multiply annotated text," to make more feasible the storage and curation of data fragments with multiple series of annotations, potentially concurrent.[109] Thus, papyrus texts are assigned with three layers, which mark the original text as penned by the scribe, the normalised version according to standard Greek, and the differences between the two. Moreover, they are enriched with metadata on the type of document, on shifts in the handwriting and on the degree of formality of the script. *PapyGreek*'s interface enables us to search for syntactic relations of the words in the sentence and to limit searches in several ways, by fields related to morphological annotation and by metadata fields, including a meaningful category of information rarely found in other resources, that is, person's role (e.g., author or addressee). Moreover, *PapyGreek* offers the option to retrieve orthographic variants from classical Greek, similarly to the *TM Text Irregularities* database, but with the possibility to limit searches by morphological information.

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[106] See *AGDT*, within *Ancient Greek and Latin Dependency Treebank*, available via *Perseids*.
[107] Semantic annotation of *PROIEL* is described in McGillivray 2014, 28.
[108] On *PapyGreek* see the overview offered by its director, Marja Vierros (2018). Shorter introductions are in Reggiani 2017, 182-85, and Celano 2019, 194. Information on *PapyGreek*'s website focuses on the procedures for applying annotations to the texts and for interrogating the database (in the "Help" page).
[109] For an overview of the approaches relating to multi-layered representation, see Bański-Witt 2019, 229-30.

In order to build linguistic corpora of classical languages quickly and efficiently, several software systems have been produced for linguistic processing of Greek and Latin, that is, for morphological and syntactic parsing (automated analysis) and lemmatisation. Digital classicists have taken advantage of existing natural language processing (NLP) techniques, trying to solve the problems posed by their adaptation to relatively small corpora of historical and highly inflectional languages. They have thus created tools for automated lemmatisation and part-of-speech (POS) and morphological tagging of Greek and Latin texts. Papyrology has benefited from them, despite the further challenge that papyri pose because of their fragmentary status,[110] for the creation of *TM Words*, *MALP* and *PapyGreek.*[111] Some inaccuracy inherent in the application of NLP tools, trained on classical Greek, to papyri, especially relating to Egyptian names and lacunose words, requires that lemmas and morphological information be manually checked and corrected.[112] *TM Words* takes into account this uncertainty, by resorting to community-sourcing, thus asking users to point out errors and providing a facility next to each lemma to facilitate their report.

In regard to automated syntactic annotation, the related software is at present only available for Latin.[113] There is, however, ongoing work in this direction, especially for the analysis of Greek documentary papyri, which follows up research on morphological parsing of this corpus within *TM Words*.[114] Because syntactic tagging of Greek texts currently needs to be carried out manually, a significant part of the annotation of the *PapyGreek*, *Perseids* and *PROIEL* corpora requires human resources; hence, they have a smaller scale than *Diorisis* and *TM Words*. In order to speed up the annotation process, *Perseids* and *PapyGreek* have decided to open their corpora to contributions from the scholarly community. In the two platforms that host these corpora, the editing occurs via an open dynamic workspace for creating linguistic layers from TEI-encoded texts, *Arethusa*, a sub-project of *Perseids*, until recently used by *PapyGreek* as an external

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[110] On the problems that papyrus texts imply for NLP tasks, see Keersmaekers 2019, 69-70.

[111] On NLP tools for ancient Greek and their accuracy in relation to documentary papyri, see Keersmaekers 2019, where the Leuven researcher reviews some existing resources tested within the development of *TM Words*. On the *Mate* POS tagger see also Celano 2018, where its adoption for the *MALP* corpus is discussed; it has to be noted, however, that *Mate* shows a lower level of accuracy than comparable tools when processing ancient Greek (Keersmaeker 2019, 73-74). On *Perseids*'s *Morpheus* lemmatiser and morphological tagger, used for *PapyGreek*, see Vierros 2018, 108-11.

[112] Vierros 2018, 108-09; *TM Words*, "About."

[113] McGillivray 2014, 27-28.

[114] Keersmaekers 2019, 76; *TM Words*, "About."

annotation environment,[115] a local version thereof is now available within *PapyGreek* itself.[116] In *Arethusa*, morphological tagging and lemmatisation are performed automatically by the *Morpheus* tool, whereas the contributor annotates the syntactic structure, as well as checking the automated POS tagging and adding item metadata. This collaborative editorial model, community-sourcing, is based on the involvement of any user with the necessary skills interested in contributing, by means of an open-access environment, at the same time provided with an editorial oversight to ensure quality control; it is similar to that utilised by *Papyri.info* for updating the resource with texts of newly published papyri, corrections or born-digital editions (cf. pp. 39-41). In *PapyGreek*, there are as of October 2021 circa four hundred documentary papyri syntactically annotated and finalised by the editorial board (as can be seen in the "Annotated texts" tab), also stored on *GitHub*. Although this number is high for a manually annotated treebank, it is still low for a linguistic corpus. An approach worth considering might be to concentrate on a group of texts that seems particularly interesting to explore from the viewpoint of language usage, such as private letters, which are likely to show a greater linguistic variety than official documents, written in a standardised form.

While syntactic annotation has so far focused on literary Greek and Latin, the work started with *PapyGreek* and *TM Words* on documentary papyri will provide an invaluable source for the analysis of a register of the Greek language closer to that used for normal communication in everyday circumstances, witnessed by scribes from a variety of sociolinguistic backgrounds. Moreover, it is probable that the material offered will stimulate research into the less investigated aspect of semantic annotation, in the wake of analogous projects for historical languages such as the aforementioned *PROIEL* and *WoPoss*, so as to track the emergence of variations of word meanings in the diachrony of the Greek language.

4.6 Mediated access to thematic collections

In addition to databases and corpora that offer data on very broad categories of papyri, useful for finding hidden connections and patterns among an extensive amount

[115] Vierros 2018, 108; Reggiani 2017, 183.
[116] *PapyGreek*, "Help," esp. "Annotate" and "Edit annotation."

of metadata or texts, there are some thematic collections focused on a more circumscribed topic, customised for intensive study of a specific research area. Besides thematic collections that provide direct access to items (as seen in the previous chapter) another group of them mediates access to papyri in terms of granular, detailed classification of content.

Yet, one has to notice that most thematic collections of the latter type, while offering analytical data on primary sources as well as comprehensive information and bibliographical references for contextualisation, lack visual representations (diagrams, maps, timelines, network visualisations and so on) that may work in association with analytical activities, to help interrogate the underlying model and synthesise the results.[117] Indeed, among papyrological resources thus classifiable, only two offer data visualisations, *TM Archives* and the *Water technology database*, and only *TM Archives* presents more advanced visualisations that react dynamically to input from users,[118] as is now worth pointing out.

TM Archives reconstructs archives and libraries, as well as mixed ensembles of documentary and literary papyri, identified in papyrological evidence in multiple languages,[119] a topic that reflects the increasing interest in ancient collections that has arisen in the discipline in the latest decades (cf. pp. 21-22). *TM Archives* is constituted by a relational database with information on almost six hundred archives and libraries. For each of them, it publishes a record with a list of all pertaining papyri, linked to *TM Texts*; there is also information in the form of metadata, derived statistics displayed as charts and word clouds and a comprehensive bibliography. Select results of the cataloguing work have been published in print, with descriptions of some of the main archives. In turn, the PDF files from which the books stemmed have been made available on the resource thereby providing further details on the chosen archives. This is an example of how digital and printed resources can positively interact, as the former provided a basis for research and assisted in the production of more traditional paper scholarship and in its dissemination, while the latter allowed enriching the database with

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[117] For an overview of information visualisation, in its two aspects of data exploration and synthesis of findings, see Meireilles 2019, 167-69.

[118] On the significance of interactive visualisations see Meirelles 2019, 175. This is one of the methods used to solve the problem of visualising much information without loss of legibility, with the advantage of the ability to refine the data.

[119] <https://www.trismegistos.org/arch>. *TM Archives*'s "About" page offers information on the scope of the resource and on the archives collected.

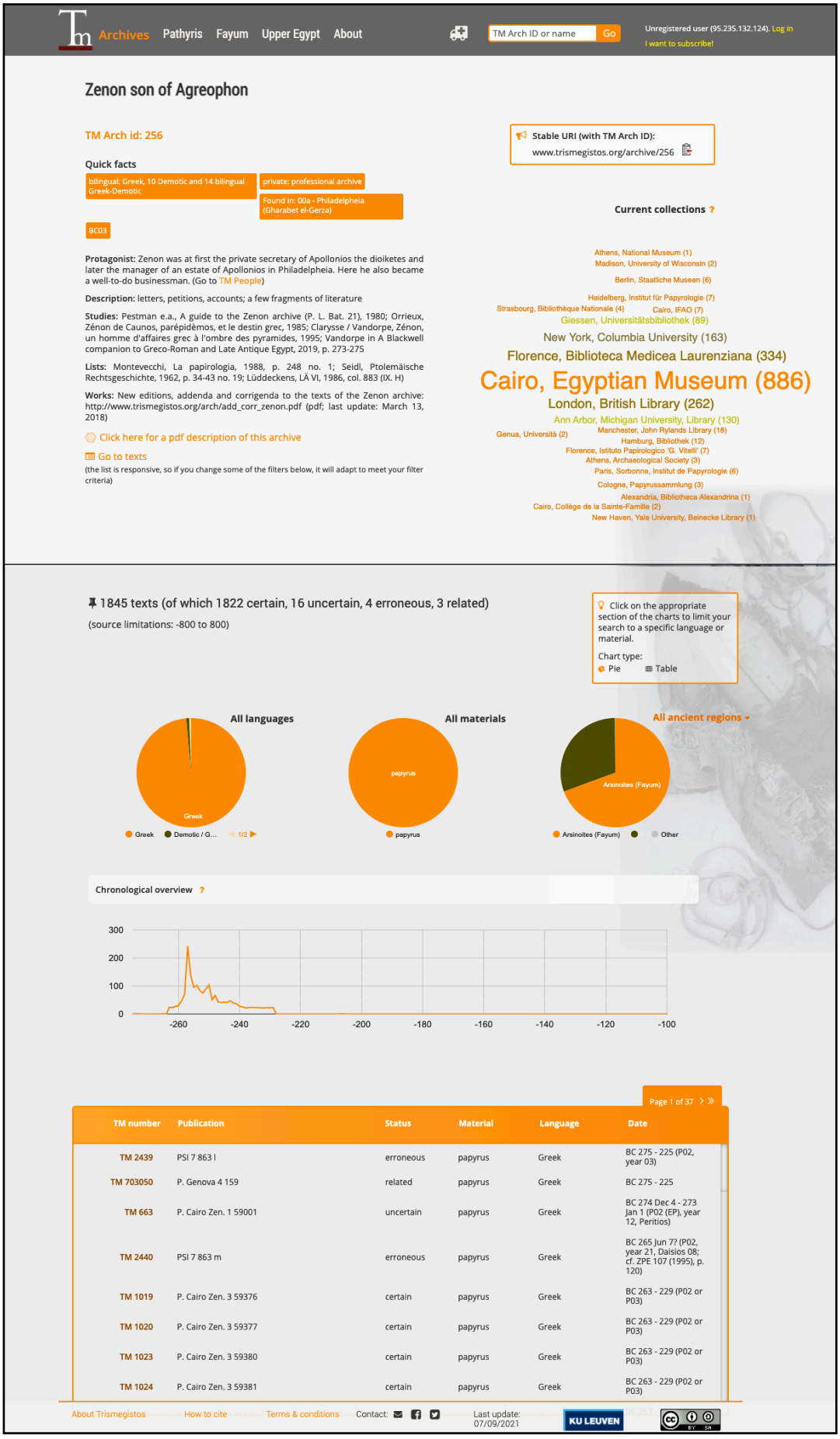

FIG. 4.4 A sample record of *TM Archives*: the Zenon archive (<www.trismegistos.org/archive/256>)

scholarly information.

The collection is organised by mechanisms of search and browsing, and of data analysis. As in projects with direct access to primary sources, searching and browsing provide rather basic options: one may type into a search box to query the data, or browse through a hyperlinked list of archive records. However, the list is provided with some options for the arrangement of the entries, for example by date and by number of items, which allow us to obtain statistics about the chronological distribution of the archives, their extension and the languages attested. Note that archives are also classified according to a more abstract criterion derived from the content of the pertaining papyri, namely, by type based on their owners, i.e., considering whether they are official archives, private ones or communities', with further subdivisions indicating the type of documentary text included or whether the collection is a library. The browsing function thus already shows, to some extent, that analysis, specifically metadata analysis, is a goal of the project, along with direct information on archives through metadata records. But the analytical emphasis of the project is mostly evident from the statistical data provided, visually represented as graphs appended to the list of archives and, within records, appended to the list of pertaining papyri. Data visualisations are interactive and hence serve not only to communicate information on the collection but also to interrogate the underlying model and reveal further characteristics. For example, selecting the option relating to the Greek language in the relevant chart also reveals bilingual archives with Greek and other languages, and generates new lists of archives and pertaining texts according to the chosen criterion.

In sum, for the features just delineated, *TM Archives* might be perceived as a collection that offers both direct and indirect access: it relies on searching and browsing functions and provides straightforward access to the archives through metadata and scholarly narratives; but the base collection of metadata is supplemented with statistics and interactive visualisations, which also allow generating dynamic items lists. Overall, it can be said that the analytical and interactive functionality builds on and goes beyond the base metadata, and this sets *TM Archives* apart from the thematic collections discussed in the previous chapter, making it closer to those in which analysis and interpretation play a key role in the presentation of the evidence.

Future work might involve providing slightly more granular access to the texts of an archive, by including content type as a category field for them, a piece of information

already present in papyrus records. This would allow deriving statistics on types of documents and on literary papyri in an archive, synthesising information on its profile. Also, a more complex future challenge might be to add social network analysis as a goal, to examine relationships among people mentioned within an archive and between archives, applying the techniques already developed for *TM Networks* and taking advantage of the prosopographical data available in *TM People*, which include parent-child relationships and onomastic network visualisations.

The *Water technology database*, a thematic collection embedded in the *Oxford Roman Economy Project* platform, gathers metadata on over six hundred papyri with evidence on mechanical irrigation facilities, in the context of a University of Oxford's study of technology of Roman agriculture.[120] It allows accessing indirectly the select sources through advanced functionality, consisting of precise search and browse options; also, data visualisations are added to items lists, though a much simpler one than in *TM Archives*. The primary focus of the *Water technology database* is the provision of advanced access to the collection through specific metadata fields relating, for example, to the type of device attested, its original Greek term and its description, and through searching and filtering criteria that enable numerous queries, with several sorting options. Visualisations in the form of a timeline (not interactive, albeit responsive to changes in the items list) facilitate the exploration of chronological data on the evidence provided and on its subsets generated by filtering.

Other papyrological thematic collections also record many different qualities of the items as metadata in a relational database and rely on this architecture to enable consultation and recognition of patterns of metadata, as shown by another database of the *Oxford Roman Economy Project*, viz. *Karanis Tax Rolls*, and by the *Death on the Nile* database of mummy labels. Furthermore, a resource customised for in-depth exploration of a single archive, *Guide to Heroninos Archive*, achieves this with the help of visual representations, albeit with limited interactivity. Its database can be queried according to several metadata fields, including sub-archives, types of documentary papyri and peoples attested, distinguishing their role as authors or addressees of letters and other documents, and there are statistical analyses of these categories, represented by bar charts.

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120 <https://oxrep.web.ox.ac.uk/water-technologies-database>.

Among broader thematic collections that include papyri alongside other primary materials, some likewise offer advanced search and browse of metadata to help reveal underlying features of the sources, possibly with the aid of visualisations. Two of them collect a heterogeneous mix of primary sources around a place-based theme. *Excavations at Amheida* records documentation on New York University's archaeological mission in the homonymous archaeological site in a variety of data types, including pictures obtained with advanced techniques such as enhanced satellite images of the whole area of the Dakhleh Oasis. The database embedded in the collection enables precise searches in the entire dataset to retrieve any object unearthed in the excavations, including papyrological evidence such as the Trimithis ostraca (O.Trim.), whose records are appropriately linked to and from those in *Papyri.info*. The other instance, a more advanced one, *Desert Networks*, reconstructs the social and economic world of the Eastern Desert of Egypt, especially the local populations' interconnections that appropriated and informed the region. While the collection includes a database of objects unearthed in the sites of the Eastern Desert (including papyrological sources from Berenike and Mons Claudianus, notably the O.Ber. and O.Claud.), its specificity is the mediated experience of these sources through an interactive map, a visualisation of itineraries of ancient roads, a gazetteer and, as a future, final goal, personal networks analyses within local societies. Place records in the *Desert Networks*' gazetteer might be usefully linked from those in *TM Places*: information on related papyri and inscriptions would be integrated with that on archaeological objects and with a very detailed description of the site.

Three more metadata-based collections worthy of note, also not strictly papyrological, rather focus on a text category. *Thesaurus Defixionum* is a comprehensive database of curse tablets with more than 1700 records with metadata and transcriptions (devoid of markup). The mode of access is via filtering categories that reflect a very thorough classification of the tablets, from the material and content point of view, with several abstract elements elicited from the texts: curse category, curse effect, gender of the curser and of the cursed person, type of formula used and so on. In addition, an interactive map provides an overview of the geographical distribution of the items and enables their interrogation by provenance. The two other resources offer more specific data visualisations of qualities of their select sources. *Earlier Latin Manuscripts*

is a database of metadata on non-documentary Latin manuscripts prior to the ninth century, based on E. A. Lowe's *Codices Latini Antiquiores*. Records are available via browsing lists, keyword searches and filtering fields, and via an interactive map that communicates information on the current location of the items. Moreover, a customised visualisation of properties of Latin manuscripts is available in the form of an interactive chart for inspecting the diffusion of a large number of script types and their chronological distribution. There is also value added by making data, whether relating to the collection as a whole or to search results, downloadable as a CSV file and accessible via a JSON API. Also worth pointing out is the onomastic database *Mapping Ancient Polytheisms*, which collects names and epithets of gods used in antiquity throughout the Mediterranean as a basis for the investigation of systems for naming the divine. Not only does it allow searching and sorting the items and their sources in many ways, but it also provides a webmapping interface and a tool that creates syntax diagrams for analysis, visualisation and comparison of the structure of onomastic sequences, from downloadable CSV files encoding search results.

Other thematic collections of papyrological sources are based on the analysis of text rather than of metadata. One of them grounds its analysis on text markup, *Vindolanda Tablets Online* II, whereas the other ones, namely, thematic lexica, focus on the provision of other scholarly content such as definitions of select lemmata.

Vindolanda Tablets Online II (*VTO* 2)[121] is an updated and enhanced version of the earlier *VTO* site. Launched by the University of Oxford's Centre for the Study of Ancient Documents in 2010, it has been in fact inaccessible as such since 2018, although its content has been merged into a larger collection, *Roman Inscriptions of Britain (RIB) Online*;[122] nonetheless, it is worth pointing out for the interesting modality with which it offered access to the texts. The items, published in the first three T.Vindol. volumes, were complete with all the material of the printed editions, viz. text, translation, introduction, commentary and pictures; furthermore, the material was

[121] The *VTO* 2 original website (<http://vto2.classics.ox.ac.uk>) has been no longer maintained since 2018, when its content flowed into *RIB Online*; see its latest archived version at <https://web.archive.org/web/20180611181929/http://vto2.classics.ox.ac.uk>. For an overview of *VTO* 2, see Reggiani 2017, 243-44, and CSAD 2009 (in which the launch of the resource was announced). Technical information is found in the "About" pages of its archived version and, as concerns the APPELLO knowledge base web service, in Roued-Cunliffe 2010.

[122] <https://romaninscriptionsofbritain.org/tabvindol>.

enhanced by the high quality of the digital images and by the ability to search tablets in finer detail.

Vindolanda tablets were directly available via a browsing list ordered by publication number, which could also be arranged by text category. Also, more advanced access was enabled by XML, specifically EpiDoc, encoding that allows indexing words directly from tags embedded in the texts. Markup thus wrote relevant concepts into the texts so that they could be used to nuance a search, enabling the system to extract information precisely. This resulted in several browsable word lists (of geographical, personal and consuls' names, and military terms) and searchable indices (of the aforementioned categories, of dates and a general one). The documents could also be consulted through a functional layer built on the transcription, also based on semantic annotation, as well as by lemmatisation. This layer allowed displaying linguistic information on each word: lemma, occurrences, and definitions from embedded and external dictionaries.[123] As we have seen, other thematic collections of papyrological sources employ semantic markup to represent the texts precisely, that is, the earlier *VTO* website and *Curse Tablets from Roman Britain*,[124] but at a less deep level.

An especially noteworthy contribution to text analysis was the APPELLO search function, purposefully developed for the project, which would automatically suggest words while one was typing even a few, median letters of a term in the search interface of an index; hence, the service could also be used to obtain automated suggestions for the integration of lacunae, thereby supporting the reading process in texts from the Vindolanda corpus or in other Latin texts pertaining to the military domain.[125] APPELLO was one of the methods that have been devised to help tackle problems of text restoration in ancient direct sources by using techniques from machine learning, together with the pioneer *Lacunology* software for papyrology,[126] the approach based on spell checking algorithms developed by M. Büchler (University of Leipzig), and the new *PYTHIA* model, trained on an epigraphical dataset.[127] These three efforts have so far remained at an experimental stage (although *PYTHIA* was developed only recently

[123] Reggiani 2017, 244.
[124] See pp. 177-80.
[125] Roued-Cunliffe 2010, 375-77; CSAD 2009.
[126] Reggiani 2017, 185.
[127] Assael et al. 2019.

and thus may well be further developed and adopted in the future, also considering that the tool and its dataset have been open-sourced). Therefore, 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,[128] for anyone to reuse it in connection with EpiDoc-based content with minimal adjustments.

At present the *RIB Online* database enables access to texts, contextual material and word lists formerly in *VTO* 2; however, it is no longer possible to utilise its most innovative service, which permitted to call up words based on character patterns so as to confirm interpretations of extant traces. While *VTO* 2 could have been qualified as a permanent resource, since it was hosted by an institutional site such as that of the University of Oxford, the availability of technical infrastructure alone has not been sufficient to ensure that it continued to exist over the long term. Apparently, there was no clear plan for the ongoing allocation of personnel, which is likewise necessary to support the continuing update of functionality and content, and which was deemed easier to achieve with the inclusion in a wider resource.

There are other thematic collections among digital classics projects, especially epigraphical ones, that likewise improve the source editions thanks to specialised text encoding and full photographic documentation. Some of these databases also offer new content in comparison to the printed editions, such as revised texts (*Ancient Inscriptions of the Northern Black Sea*, *Aphrodisias in Late Antiquity*) or even hitherto unpublished ones (*Inscriptions of Aphrodisias*, *Inscriptions of Greek Cyrenaica/Greek Verse Inscriptions of Cyrenaica* and *Inscriptions of Roman Cyrenaica*). Other initiatives have taken advantage of the digital format to widen their scope thereby including related non-epigraphical sources: *RIB online* is now entering texts on tablets and lamellae, besides inscriptions, with a view to building a comprehensive corpus of all the ancient texts from Roman Britain, regardless of their material support; *Inscriptions of Aphrodisias* has digitised pertaining contextual material used to prepare the editions, namely, a collection of earlier travellers' notebooks with transcriptions, squeezes and drawings relating to the texts and the archaeological site. Analogously, papyrological thematic collections, both those providing direct and indirect access to texts, while already entailing new opportunities for research on a specific topic, might consider sharing

[128] *VTO* 2, "About," esp. "APPELLO Web Service."

original evidence as a further goal, whether in the form of born-digital editions or related archival and archaeological material.

The same purpose, contributing fine-grained derivatives of texts of primary sources, characterises thematic lexica,[129] such as the *Neues Fachwörterbuch* (cf. p. 94), the *Léxico de magia y religión en los papiros mágicos griegos online*, and the former *Database and Dictionary of Greek Loanwords in Coptic*, now merged into the *Coptic Dictionary Online.* Another lexical tool, not focused on a lexical domain but rather on problematically attested words, is *Words in Progress* (*WiP*). Drawing on all ancient primary sources, it collects evidence on new and rare words as an ongoing supplement to general Greek and Byzantine dictionaries, inviting contributions from the scholarly community. Lemmata specifically attested in papyrological sources can be searched separately through the option provided.

4.7 Conclusion

Overall, papyrological resources that offer indirect access to papyri prove comprehensive relative to their chosen domain. Literary and paraliterary papyri are extensively covered by the *MP*^{3} and *LDAB*, and documentary papyri by the *HGV*; also, these text categories are taken into account by *TM 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. *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 *TM 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

[129] For an overview of these resources, see Reggiani 2017, 123-30.

encoded has offered the opportunity to start investigating the syntax, variation and sociolinguistic phenomena on a representative sample of documents in *PapyGreek*.

Moreover, some sets of papyri, relating to specific topics, have been the object of dedicated collections and lexica (as seen in section 4.6). 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 *TM Archives*, *Guide to Heroninos Archive*, *Death on the Nile*, *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 in *RIB Online*. A future challenge will be the addition of more visual representations to support users' data inspection and offer them a concrete way for understanding results. This can be achieved by looking to existing work in *TM* databases and projects not strictly papyrological (such as those above mentioned, at pp. 221-22), accounting for decisions taken to model the uncertainty inherent to the visualisation of incomplete and fragmented data.

As regards availability, most projects analysed in this chapter are fully and freely accessible, hence they may instantly be seen online. Two resources, however, form notable exceptions. In *TM* databases, including *TM Texts* and *LDAB*, the use of most of their improved functions is restricted to subscribers. The other resource, *VTO* 2, does not exist anymore as an individual project; while its textual content is still available, via *RIB Online*, we can no longer avail ourselves of its most advanced functionality, the APPELLO service for the automated suggestion of words, which could be used to aid in the text restoration. In both cases (*TM* and *VTO* 2), importantly, direct access to the base material (texts and images of the T.Vindol. and metadata records in *TM*) is still guaranteed. For the two resources, the problem rather concerns the use of advanced analytical tools, which is no longer possible (*VTO* 2) or is available only after subscription and payment (*TM*). The disappearance of the APPELLO search function has a smaller impact than the limitation of the access to *TM*, as it involves fewer texts, relating to a circumscribed topic, but it is nonetheless significant of the difficulty to ensure the sustainability of digital humanities resources: while *TM* visualisations and complex searches are still available 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*.

Besides simple open access, the enabling of 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 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, the *HGV* (through *Papyri.info*), *Grammateus*, *WL* and *PapyGreek*, which officially make available their XML-based content to the users, with the provision of bulk-download facilities. In part, *TM* also adopts an open-data policy, as concerns select information (i.e., 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 *TM* services.

On the whole, 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 the resources analysed in the two previous chapters, 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.

Chapter 5

Availability, impact and sustainability of digital resources in papyrology

5.1 Introduction

In the previous chapters of this dissertation, I have first sought to situate digital papyrological resources within the context in which they developed, considering different perspectives: a papyrological one, outlining the methodological problems of the discipline that they address (1.2, 1.3); a historical one, showing how they were born and evolved (1.4); and the scholarship on them, mostly papyrological, and in a few cases digital humanities (1.5). Then, on the basis of digital humanities literature, I have attempted to introduce a framework for classifying the projects under scrutiny, articulating the features and the methods that are salient to users and discussing what challenges confront their long-term access and curation (1.6).

On this premise, I have analysed a diverse range of collections, starting from the most common type, corresponding to the most familiar way in which humanities scholars and memory institutions interact with and organise digital content, namely, by making primary materials directly searchable and browsable. These projects were split into two groups: digitised collections arising from material ones (ch. 2) and corpora and databases relating to a text category or a theme (ch. 3). The second chapter set out trying to understand the variety of the landscape of digitised papyrus collections, the most frequent type of project, pinpointing different organisational forms such as federated collections (e.g., the German *Papyrus Projekt*), individual ones (e.g., *BerlPap*) and ones incorporated in larger papyrological resources (the former *APIS* federation now in *Papyri.info*) or in holdings catalogues (e.g., British Library's *Digitised Manuscripts*). The analysis shows how digitised collections are benefitting the user by making available online large sets of images and descriptive metadata, with the opportunity for scholars in distant locations to gain instant access to often high-quality digital surrogates, in many cases accompanied by detailed information and efficient search and

browse facilities. Chapter three aimed at comprehending the range and complexity of text corpora and thematic collections that provide direct access to papyri, from the *Duke Databank* large-scale corpus of documentary papyri to collections focused on a particular group of items, including *Vindolanda Tablets Online* (*VTO*), the *Kyprianos* corpus of Coptic magical texts and the *PapPal* database of dated papyri, or even resources centred on a single object, as *Codex Sinaiticus*. I have thus analysed the resources' data model, distinguishing those with a simple format such as exhibitions and databases with a basic browsing facility, and those with rather complex functionality relying on a detailed classification of metadata or on text encoding, as *Papyri.info* and *VTO*. As emerged in my discussion, the digital medium has allowed us not only to virtually gather related objects preserved in different library and museum collections, but also to provide many of these resources with a range of specialised tools and scholarly aids for their interpretation, as is well exemplified by the two projects just mentioned. Lastly, this dissertation has examined the less usual type of papyrological effort, but one that prioritises advanced modalities of access to papyri, through interrelationships among primary sources, derivative information and functional layers (ch. 4). I have analysed the data model and assessed the usability of fundamental, established resources such as *Mertens-Pack*^{3}, *Leuven Database of Ancient Books*, *Trismegistos Texts* and the *Heidelberger Gesamtverzeichnis* (*HGV*), among others, seeking to highlight the breadth and diversity of this genre of digital scholarship by identifying the different ways in which they mediate user experience of papyrological sources. A range of methods emerged, such as the enabling of fine-grained access to papyri thanks to detailed and specific metadata for texts of the chosen domain (*Mertens-Pack*^{3}, *LDAB* and *HGV*), to advanced text markup (the former *VTO* 2 database and *RIB Online*), to the encoding of linguistic information (*PapyGreek*) or to digitally enhanced indexing (*WL*); a further mode of access to papyri is the addition of content derived from the base documentation, such as statistical data with related visualisations (*Trismegistos* databases) and graphic representations of text structures (*Grammateus*).

After descriptions of individual collections and types, this final chapter draws the conclusion of the dissertation, examining digital papyrology efforts as a whole. Based on the previous analyses, I shall discuss opportunities and current issues of the new approaches for the discipline. Thus, this conclusion seeks to determine whether good practice is adopted in all stages of the development of the projects, thereby allowing

use, reuse and sustainability over the long term, hence ongoing usefulness and usability, while suggesting possible improvements. In other words, 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 scholarly communication.

5.2 Impact of digital methods on papyrological research

As we have seen, most institutions that preserve papyri, whether in small- or large-scale collections, have created and made available online digital surrogates and catalogue information, independently or in federated projects, to enhance access to their items and encourage the understanding of them. Several other types of digital resources for the discipline have been provided by classics departments and papyrological research centres, in the form of thematic corpora and databases, word indices and lexica. 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.[1]

Firstly, the 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.[2] Indeed, in the case of papyri (and of the 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

[1] 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, by Terras (2012a, 49-50; 2012b, 72-75), who deals with digitisation of text and image collections overall, and by van Lit (2019, 51-63), who especially examines the use of digitised collections, both of manuscripts and of printed works, tackling questions of publication, citation and authority (ibid., 51-56).
[2] Terras 2012a, 49; van Lit 2019, 52; Bowman 2010, 104.

specialised libraries. Furthermore, digitisation entails the benefit of enhanced access to components within items:[3] for papyri, to letters of difficult reading, whose legibility is improved by digital image capture, and to specific passages or words of the digitised text, as occurs in *Papyri.info*'s comprehensive corpus, as well as in the *Kyprianos* and the *Judaism and Rome* thematic collections, and the *Codex Sinaiticus* project.

Access to elements within the texts is enhanced by the application of markup, which can be used to nuance searches and to automatically create interactive indices, thus allowing functionality beyond basic word search and presentation. In the *Codex Sinaiticus* project, structural markup allows digging within the text directly to the chosen textual or codicological element. Linguistic annotation has been applied to access morphological information on the corpus of documentary papyri, in *TM Words* and *PapyGreek*; the latter database also permits exploration of syntactic structures. Semantic markup, in contrast, has been little deployed. While utilised in the digital editions of the Vindolanda tablets, i.e., in the two versions of the *VTO* database and in *RIB Online*, as well as in *Curse Tablets of Roman Britain*, it has not been applied in projects relating to Egyptian papyri, which represent the vast majority of sources in the discipline. By contrast, in the realm of epigraphy several place-based thematic collections are provided with semantically rich annotations, following the EpiDoc Guidelines;[4] indices distilled from the encoded texts thus enable fast access to textual information. Papyrological resources such as the *WörterListen*, *TM People* and *TM 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, as occurs in the aforementioned epigraphical collections.

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 would benefit from more extensive use of deep markup to enable more complex and semantically rich queries. Also, access within items might be enhanced by allowing navigation not only within the digitised

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[3] Terras 2012a, 49; van Lit 2019, 52.

[4] See *Ancient Inscriptions of the Northern Black Sea*, *Cretan Institutional Inscriptions*, *Inscriptions of Aphrodisias*, *Inscriptions of Greek Cyrenaica/Greek Verse Inscriptions of Cyrenaica*, *Inscriptions of Roman Tripolitania* and *Roman Inscriptions of Britain Online.*

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. 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.

Additionally, there is another opportunity for improving access within primary sources by resorting more often to visualisation techniques. We have seen how visual representations as charts and maps have been utilised to provide overviews of and allow exploring statistical data on papyrus texts and named entities extracted from them, in *TM* databases. 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* and the "Reconstitutions virtuelles" of Sorbonne's *Collections de Papyrus*. Because in papyrology the study of books and documents as editorial products plays a primary role, in the wake of these two resources it would be interesting to create more complex visualisations to highlight characteristics of the exemplars not immediately visible, integrating images of the extant fragments. One could foreground textual structures as in *Grammateus* or physical characteristics as in "Reconstitutions virtuelles," thus reconstructing the book form of the original papyrus as a whole if its text is otherwise known, indicating the presence of fragments housed in other collections or now lost, showing the previous shape of dismantled cartonnage, or marking the occurrence of physical features like *kolleseis* or ancient restorations. Also, such visualisations built on images of preserved fragments might be aligned with the digitised papyrus text so as to make them interactive, enabling search and browse mechanisms. Work on the alignment of text and image, in particular in fragments of literary papyri digitised in the *DCLP* corpus, is in progress 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. 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 *APIS* datasets, in the *HGV* and in a few digitised collections (*BerlPap*, *Kölner Papyri*, Heidelberg's *Papyrussammlung*, *DVCTVS* and *VTO*). 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. 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.[5] As Warwick argues (2004, 375, 379), visual representation of textual information has produced some of the most important developments in digital humanities and it is the area where digital progress can offer the greatest contribution to humanities research, as it 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.

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.[6] 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 thematic collections,[7] a few of them

[5] Cf. pp. 18-19.
[6] Cf. Terras 2012a, 49; Palmer 2004, 352-58; Bowman 2010, 103.
[7] See their overviews at pp. 134-38, 184-85.

with the addition of tools for advanced search and analysis.[8] Other efforts bring together diverse primary sources around a theme, the majority showing a plain format with images and texts embedded in scholarly narratives. Notable instances of this kind are virtual exhibitions or thematic collections constructed around place-based themes, displaying papyri alongside archaeological objects: Berkeley University's on Tebtunis, *Oxyrhynchus: a City and its Texts* and *VTO*'s on the Vindolanda site. There are also collections focused on classical literature, book production and palaeography as attested in papyri and medieval codices: those in British Library's *Greek manuscripts* section and in *DigiVatLib*'s *Thematic Pathways*. 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* and *Desert Networks* 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, but not with innovative research environments. 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. As seen, 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 *TLG* website in a newly corrected version[9] and in *Perseus Digital Library*; in both cases, the *LSJ* can be consulted individually or can be

[8] See their overview at pp. 184-85.
[9] Pantelia 2011.

accessed from the text corpora. There are also specific papyrological lexica, i.e., the mentioned *Neues Fachwörterbuch*, *Léxico de magia y religión en los papiros mágicos griegos online*, *Coptic Dictionary Online*, which includes Greek loanwords, and the *Words in Progress* supplement with its papyrological section. 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 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.

5.3 Impact of digital publishing on 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.[10]

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.[11] In the papyrological realm, digitisation of printed works[12] 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 publications with papyrus images are linked from the

[10] Terras 2012a, 49.
[11] Van Lit 2019, 52; Terras 2012a, 49.
[12] For a survey of digitised and born-digital papyrological publications, both open-access and available on subscription, see Reggiani 2017, 173-77.

relevant *Papyri.info* records.[13] By the same token, open-access works are increasingly being pointed out in the *Bibliographie Papyrologique en ligne*.[14]

Another advantage of the flexibility of electronic publications, as shown by the *Derveni Papyrus* project, 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*.

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.[15] 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* and *Dodona Online*, which offer revised editions. 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

[13] In particular, the *Checklist* in *Papyri.info* points us to digital volumes of editions, series, congress proceedings and instruments. Journals are instead not listed in this reference work. Nevertheless, articles that contain papyrus images are linked from the relevant *Papyri.info* record.
[14] Reggiani 2017, 28.
[15] Van Lit 2019, 53; Berkes 2018, 80-82.

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,[16] 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.[17] 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 who proposed them and linked to the textual database.[18] Three more papyrological resources solicit user contributions for original evidence, namely, *PapyGreek*, *Dodona Online* and *Words in Progress*, 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, addressed to students and the wider public, an activity especially undertaken within digitised physical collections, to which the *Kyprianos* project adds. This is achieved through the creation of specific sections, accessible to everyone, within collections, and even through the development of purposeful resources for teaching such as *MultiPal* and Manchester *Papyri*.

5.4 Current issues in digital papyrology resources

[16] For an overview of digital humanities crowdsourcing, see Terras 2016.
[17] Reggiani 2017, 232-33; Baumann 2013, 94; Sosin 2010; *Papyri.info*, "DDbDP."
[18] Reggiani 2017, 136.

Although increasing amounts of digital content for papyrological research are being published, it is worth recognising too that there are questions about their sustainability, which may hinder their 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.[19] This problem 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.[20] 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.[21]

In digital papyrology, too, as seen, sustainability is uncertain for some resources, while other initiatives have taken steps to ensure permanence and sustainability. On the one hand, there are digitised real-world collections, which consist of museum and library catalogues, and therefore are embedded in their institutions' websites and benefit from their support. They may thus be recognised as permanently available owing to the stability of their host organisations. Other established projects, namely, the *Mertens-Pack*[3] and the *Wörterlisten*, are also reliable in terms of ongoing accessibility and publication of digital content, in that both of them are supported by a university centre for papyrological research and take advantage of institutional technological support. On the other hand, other major digital papyrology efforts, such as *Papyri.info* and *Trismegistos*, do not show clear planning that will enable long-term access and curation.

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

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[19] Terras 2012a, 50, 58; van Lit 2019, 54; Meneses-Furuta 2019, i129-30.
[20] Terras 2012a, 57-59; van Lit 2019, 54, 64, 99; Maron et al. 2009, 6; Bagnall-Heath 2018, 172, 186.
[21] Terras 2012a, 58.

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 the 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. Instances are *Papyri.info*, *Grammateus*, *HGV*, *Wörterlisten*, *PapyGreek*, *Codex Sinaiticus*, *Codices Latini Antiquiores*, and some elements of *Trismegistos*. In turn, adapted materials can be shared and thus foster the continuous growth of digital papyrological tools.

5.5 Conclusion and future work

In this thesis I have sought to provide insight into digital papyrology efforts, clarifying their characteristics, underlying data models and purposes. I hope that, building on the existing digital humanities and papyrological literature, this analysis has added to understanding of the breadth and diversity of resources for this discipline, their functioning, and the problems we need to tackle for ensuring effective and ongoing access.

By integrating the reference typology (Fenlon 2017) with other reflections from digital humanities literature, concerning the methods through which resources are realised and their acceptance in humanities disciplines, I have pinpointed types of projects based on their data model, in particular on the access provided to primary sources, on the level of text markup or metadata encoding, and on their purpose. Also, in light of the above I have examined key aspects of resource development and use, such as online accessibility; technical implementation; scholarly design, i.e., comprehensiveness, documentation and editorial accuracy; engagement in the creation of new evidence, also by gathering user contributions; and long-term sustainability. Among genres of digital resources, the focus of this dissertation was to document the key role of two of them as an aid in the research process: integrated and interconnected networks of different types of media and research tools around the core set of primary

sources, and customised collections for the study of a specific theme, in which scholarship has a shaping role in the selection of primary materials and in the representation of their relationships.

This methodological framework, utilised to classify the projects and identify key issues to address, was meant to characterise digital papyrology efforts, but I hope it may also serve as a foundation for investigating more digital humanities initiatives. It would be interesting to try this approach to provide systematic and up-to-date outlines of the landscape of digital research and communication in other disciplines, starting from those for which handwritten primary sources are a central thrust, as in papyrology, including epigraphy and medieval studies. There are already insightful overviews of digital efforts in these domains, for example the contributions by Bodel (2012) on epigraphical projects, by Birnbaum et al. (2017) on digital medieval studies, and by Clivaz (2013) on digital resources for scholars of Judaism and Christianity in antiquity. But a closer and updated look at initiatives for other classical disciplines and for medieval manuscript studies, with systematic research on the aforementioned characteristics, might shed further light on them. It could afford useful observations on the less explored aspects of underlying data models and sustainability problems, to investigate more in-depth how collections are constituted, how they work, and what preservation and curation strategies imply.

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Series of papyrological editions and instruments are abbreviated as suggested in the *Checklist*, to which I also refer for more detailed bibliographical information on them.

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