

Management of archaeological information and knowledge in digital environment

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Abstract

Digital technologies have had a major impact on archaeological information work. This chapter provides insights into how archaeological information and knowledge is managed in the digital environment, what major challenges can be identified in that particular domain and what insights for information and knowledge management research and practice can be drawn from a better understanding of archaeological information work. From the perspective of information and knowledge management research and practice, a closer look at archaeological work as a domain can, for instance, inform the development of strategies for managing temporal and epistemological diversity. Major challenges in the management of archaeological information and knowledge include how to address diverse perspectives and needs of different stakeholders and how to better manage social information processes and socially mediated information in addition to formal data and documentation.

Keywords: archaeology, information management, knowledge management, social information, time, epistemology, information work, information processes, information use

1 Introduction

Archaeology is a knowledge intensive enterprise. As a field, it is working with a large and growing body of heterogenous information originating from a broad variety of multidisciplinary sources. In parallel, it has similarly wide-ranging implications in the society from cultural heritage and education to land use and infrastructural planning (Huvila, 2018b). Archaeologists are using material evidence, historical, geographical, geophysical, documentary, close and long-range observational data in their work and rely on analytical methods ranging from

qualitative and hermeneutical interpretation to physics and chemical laboratory analysis (Carver, 2009; Léglise et al., 2018). Calling archaeology a ‘total science’ (Fr. *une science totale*) (Mathias et al., 2018) captures in multiple ways the essence of that particular domain as a field of information and knowledge work.

Similarly to many others domains, digital technologies have had a major impact on archaeological information work, especially from the 1990s onwards (e.g. Zubrow, 2006; Kansa et al., 2011; Huvila, 2018a). In the context of humanities and social sciences, archaeologists have been early adopters of digital workflows even if the digitalisation of archaeological work has been criticised of being slow and uneven (e.g. Wallrodt, 2016; Uotila & Huvila, 2006), and in spite of the fact that archaeological inquiry is based on the analysis of, literally, material material often, as Olsson (2015) underlines, in highly bodily and physical terms.

The aim of this chapter is to provide, if not a comprehensive overview, a glimpse to archaeological information work and how archaeological information and knowledge is managed in the digital environment, what major challenges can be identified in that particular domain and what insights for information and knowledge management research and practice can be drawn from a better understanding of archaeological information work.

The focus of this chapter is on management on a domain level i.e. on typical and characteristic practices that are to a reasonable extent pertinent to archaeology as a field. The heterogeneity of archaeological work and the variation of the practices and processes of how information and knowledge are managed within particular organisations, countries, contexts and projects does obviously resist attempts to generalise. However, in spite of focussing on the local variation, which in many cases can be traced back to, for instance, organisational, policy, environment and leadership related issues, which tend to have communalities between domains, this chapter enquires into such factors that distinguish archaeology from, for example, engineering, financial services or retail as contexts of managing information and knowledge.

The chapter starts with an overview of earlier and contemporary approaches to how archaeological information and knowledge are managed followed by a review of the specific characteristics of information, information use practices and information processes in the domain of archaeology. The chapter is concluded with a discussion of how insights from archaeological work and information and knowledge management research and practice could inform each other.

2 Earlier and contemporary approaches to managing archaeological information and knowledge

Archaeology has a long history of struggling with the issues of managing collections of artefacts and information available in an extensive range of different formats (Braccini & Federici, 2010). Even if the problems are not new, they started to escalate in the developed world to an unprecedented extent during the

second half of the 20th century. Large scale post-war infrastructural projects and expansion of land use and parallel establishment of new archaeological heritage legislations that obliged land developers to finance archaeological surveys and rescue excavations led to a burgeoning of archaeological information production (Börjesson & Huvila, 2019). Archaeologists started to warn of a ‘curation crisis’ with rapidly increasing artefact collections already in the 1970s (Flexner, 2016; Marquardt et al., 1982). Similar concerns have since been expressed concerning the poor and uneven state of archiving other types of archaeological information (Huvila, 2016b), and with the digitisation of archaeological information work, regarding the importance of managing digital data and documentation (e.g. Richards, 2002, 2016).

If the roots of the information management crisis in archaeology date back several decades, the work on computerised management of archaeological information has also a long history (Lock, 2003). One of the best known of the pioneers was French archaeologist and documentalist Jean-Claude Gardin who started to develop concepts and practices for computerised management and processing of archaeological documentation from the 1950s onwards (Gardin, 1971, 1999b; Moscati, 2013; Dallas, 2015; Moscati, 2016). In spite of the relatively early start of computerised information and knowledge management in archaeology and apparent similarities between the challenges identified by archaeologists and professionals working in other fields, there has been conspicuously little exchange between archaeology and knowledge management field. Theoretical and practical work in the latter field has had conspicuously little impact on archaeological work, and when it has, the choice of approaches has tended to be highly selective and applied to a limited set of contexts in archaeological work. A partial explanation to this could undoubtedly be the endogenous long-term engagement of archaeologists in the management of information and documentation and the relative novelty of information and knowledge management as a discipline of its own.

However, in spite of the relatively dearth of reciprocal influence, there are examples of the cross-breeding of the two disciplines. Approaches stemming from knowledge management have been proposed and used for developing, analysing (e.g. Bloemers, 2010b) and conceptualising (e.g. Byrne, 2012) methods for eliciting, collecting, creating and administering archaeological knowledge. Several projects and teams have developed prototypes of both generic and specific archaeological knowledge management systems (e.g. Wattrall, 2011; Karmacharya et al., 2008; Valtolina et al., 2012, 2013), infrastructures (e.g. Richards, 2016; Gillissen & Hollander, 2017), meta-infrastructures (e.g. Meghini et al., 2017), and virtual research environments (e.g. Dunn, 2006; Mills & Baker, 2009; Warwick et al., 2009) for managing and working with archaeological data. In general, the existing systems have been geared towards data and information management according to the technical paradigm and epistemology of possession (Newell et al., 2009) in information and knowledge management rather supporting and managing social knowledge and knowing in the field or within a particular organisation. Geographical information systems (Wattrall, 2011) and especially recently, semantic web and linked data based approaches have been a common

starting point in the development of archaeological information systems (e.g. Geser, 2016; Valtolina et al., 2012; Missikoff, 2004). In parallel, natural language processing based methods have begun to attract attention especially in the context of addressing the problem of improving access to archaeological grey literature (e.g. Vlachidis et al., 2010; Jeffrey et al., 2009). Even if archaeology has put a lot of attention to visual representations including illustrations and photographs, the management of other types of visual information than GIS data has been discussed conspicuously little in the literature. Only rather recently, probably at least partly followed by an increasing awareness of problems related to the management, documentation and preservation of digital three-dimensional visualisations (Niven & Richards, 2017), the issues relating to visual archaeological information have begun to receive more attention. Another apparent reason is that the efforts to link and integrate all types of archaeological information together in virtual research environments and infrastructures (e.g. Zaslavsky et al., 2017; Meghini et al., 2017; Mills & Baker, 2009) have included also visual information. Reasons for the relative neglect of images can be only speculated but it seems reasonable that it can be explained at least partly by an assumption that photographs and illustrations are self-descriptive from the producer perspective and as such, objective representations that require less documentation and management. Simultaneously, it is broadly acknowledged that images can be difficult to describe and image metadata standardisation is not on the same level with textual and numeric data (Lim & Liew, 2011; Fear, 2010). Partly, archaeology has had an opportunity to rely on generic procedures, and later on, computerised systems for managing photographic information (e.g. Schlitz, 2007; Dorrell, 1994), without a blatantly obvious need to problematise the archaeological aspects of their management. Similarly to the management of visual information archaeology, so far, there has been only rather sporadic references to information and knowledge management in the work relating to archaeological visualisations (e.g. Kirchner & Jablonka, 2001; Stanco et al., 2017; Zaslavsky et al., 2017).

Regarding the paradigmatic directions of archaeological information and knowledge management, there are some exceptions to the predominance of the epistemology of possession i.e. technical objects based view (e.g. Engel & Grossner, 2016; Huvila, 2012b; Braccini & Federici, 2010) but even those cases tend to put their principal emphasis on managing data rather than knowing. The references to web-based collaboration opportunities (e.g. Kansa & Deblauwe, 2011), sharing of personal reflections in the form of video recordings (e.g. Hodder, 2000) and modelling of archaeological narratives (Kilfeather et al., 2003) are some examples that perhaps have come closest to the management of social knowledge and knowing. As a whole, as Kochan (2018) puts it, the focus on thinking rather than on feeling, is not a problem that is particular to archaeology and archaeological information management but that characterises science studies and philosophy across disciplines.

Unsurprisingly, information and knowledge management and ICT applications have been of specific interest in the context of archaeological heritage and cultural resource management. Another context of archaeological work

where knowledge management has been found as a potential approach relates to archaeological computing, digital archaeology, and more broadly digital humanities (Daly & Evans, 2006). Partly, there has been a strive to enhance the management of archaeological information by introducing successful methods from other disciplines and contexts. Partly, both researchers and professionals have acknowledged that archaeology differs from other fields to an extent that approaches that take the idiosyncrasies of this particular field into account are needed (Bloemers, 2010a).

3 Obstacles and opportunities

There is no doubt that the standard commentary of the lack of resources and effort is a useful partial explanation of the lack of emphasis of information and knowledge management in archaeology. This applies both to cross-breeding of the disciplines of archaeology and information and knowledge management, and archaeological information and knowledge management as an intra-disciplinary endeavour. The same reasons undoubtedly explain partly why the focus of the efforts has been on the management of data and information rather than the human processes of informing and knowing. Resources and effort are, however, only a part of the story and a closer look at the reasons for the current state of affairs can be helpful both in understanding the nexus of the fields and in reaching towards a greater convergence wherever it could be desirable. At the same time, a better understanding of the landscape of the premises of information and knowledge management in archaeology is a useful starting point for pondering how it can inform the management of knowledge and information in other contexts. The obstacles and opportunities relating to archaeological information, information use and information process are summarised in the Table 1 and discussed in more detail in the following.

3.1 Idiosyncrasies of archaeological information

Similarly to how information in general can be described as an 'ingredient' of knowledge (Huvila, 2012c), archaeological information functions as an ingredient of archaeological knowledge in the process(es) of archaeological knowledge-making. At the same time, it is an ingredient of the perpetuation of archaeology as a discipline and practice. There is no archaeology without archaeological information, archaeological knowledge-making and archaeological knowledge. In practice, however, archaeological information can be many things and many things can inform archaeological inquiry as earlier research has shown. Archaeologists and other users of archaeological information are informed by a broad range of things from printed, digital and oral to embodied documents, archaeological sites and artefacts (e.g. Huvila, 2006; Zahlouth & de Paiva, 2012; Huvila, 2014a; Olsson, 2016). The long temporal perspective of the discipline adds to the contemporary breadth and complexity of what informs archaeology making the processes of information seeking, use and production highly complex

and places a special demand on understanding the contexts of archaeological information work and of the past it studies.

Besides the diversity of sources, the information itself has characteristics that are peculiar to archaeology. Many issues could be brought up here, but in the following, four aspects that are related to the specific nature of archaeological work and tend to have particular influence on the making and use of archaeological information, are discussed in more detail.

Firstly, even if archaeologists work increasingly with non-destructive survey methods, the destructive nature of archaeological excavation (Kilbride, 2016) means that the information of the archaeological record is unique, it is impossible to go back to and equally beyond the bounds of possibility to collect more data of a location that has been excavated (Lucas, 2012). This places significant demands to the original investigation process and documentation work, and underpins archaeologists' strive for the utopia of retrieving and preserving the total record of 'objective and complete representation of what lies in or on the ground' (Lucas, 2012, p. 18).

Secondly, a feature that is characteristic to archaeology is the coexistence of multiple explicit and implicit intradisciplinary standards and assumptions of what archaeological information is and how information can be archaeological. There is a certain implicit consensus that archaeological information is assumed to be archaeological and as such, scholarly and scientific by its nature. In Sweden, the Historic Environment Act stipulates that archaeological investigations are expected to follow 'good scientific quality' (KML, 1988) – where the notion scientific (Swe. *vetenskaplig*) refers to both science and scholarship. The documentation guidelines issued by the Swedish National Heritage Board explain further that 'good scientific quality' is attained by adhering to a scholarly and scientific way of working (Swe. *vetenskapligt arbetssätt*) (RAÄ, 2015b). In other words, it is the process that makes information archaeological rather than a specific quality of the information itself. Considering this, it is unsurprising that the history of standardisation and quality control of archaeological documentation work is long (Pavel, 2010) even if the demands for uniformity and formal definitions of the qualities of good archaeological information have intensified first during the past few decades. A significant contributing factor has been the expansion of professional development-led archaeological work in developed countries after the Second World War and especially, the organisation of archaeological investigations as contracted work (Börjesson & Huvila, 2019). In addition to suggesting that the good scientific quality results as scientific and scholarly information, there has been already for some time, a rather widespread general assumption that archaeological investigations produce (or should produce) output with a broader relevance in the society (Perry, 2018).

The paradox of good scientific quality and, as the Swedish National Heritage Board stresses in the guidelines for documentation in development-led archaeology, how it is supposed to lead to the making of knowledge that is relevant for public authorities, research and the general public alike, can be explained at least partially by a focus and trust on information producers. As a result, the specific qualities of expected informational outcomes have been defined only

vaguely. There has been a certain implicit assumption that the investigation report should and could be made to be sufficiently informative for all possible audiences (Gustafsson & Magnusson Staaf, 2001) but at the same time, it is not uncommon that especially contract archaeologists consider themselves as information or data producers and that the actual making of new archaeological knowledge is supposed to take place elsewhere, primarily in universities (Ní Chíobháin Enqvist, 2018). More recently, it has been acknowledged that is probably not the case and different stakeholder groups need different types of information (Huvila, 2017b). Reflecting these views, the most recent edition of the Swedish documentation guidelines for development-led archaeology, distinguishes a basic report from scholarly in-depth analyses (Swe. vetenskaplig fördjupning) and public communication (RAÄ, 2015b) in an attempt to provide instructions and a standard for the outputs of archaeological information production.

Currently, the shift that has been taking place in a relatively large number of countries (even if not everywhere) of turning archaeology from an activity conducted by public authorities to a commercial enterprise (Demoule, 2016) puts demand on detailed instructions and criteria to determine the adequacy of its quality. A second contributing factor is the digitalisation of archaeological information and documentation work. Digital information can be analysed, processed and managed in entirely new ways and used to produce such knowledge that has been (at least in practice) unattainable in the past. At the same time, however, to be useful and manageable, digital information needs to be uniform and meticulously standardised. The need of standardisation extends beyond the quality of information production to the specifics of how it should be represented, what file formats should be used, how it should be stored to be available for others, and how the information should be documented to be usable for others and forthcoming uses that can be difficult or impossible to anticipate.

Thirdly, another characteristic quality of archaeological information is that it is highly fragmentary – to a degree that in the end, it is impossible to say how fragmentary it is. It is close to impossible to estimate what remains end up in the archaeological stratum: how much of the original deposits have been preserved, how representative individual sites are of all human activities in a given area and how much the investigating archaeologists are capable of noticing (retrieving) when they are studying a specific site (Lucas, 2012). The fragmentary nature of information and unknown sampling bias are not unique to archaeology. However, when combined with the nature of archaeological evidence that is seldom directly informative of the matters of archaeological interest, the proportions of the problem are considerable. Patrik (1985) has asked whether archaeological evidence forms a record at all. To avoid considering material remains as evidence of particular past events, Barrett (2006) has expressed a preference for the notion of archaeological evidence but perhaps, as Lucas (2012) asserts, the problem is how the notions of record (or information) are understood, not with the terms *per se*.

Fourthly, a peculiarity of archaeological information relates to its long time-

span and temporal diversities. Partly, the material residues that are available for interpretation from different times are different to each other. Stone-age artefacts differ radically from the ones from the Roman period and those are different from medieval and post-medieval ones. Also, the popularity and resilience of different materials vary. Pottery is generally durable in the archaeological stratum whereas organic materials are not. As a result, a larger number of artefacts will generally be available from periods and contexts when pottery use was common whereas from contexts where material culture was dominated by less enduring materials, there can be a lot material to analyse.

In addition, also the documentation produced by archaeologists in different times so differ from each other. The standards and epistemic ideals relating to archaeological documentation have differed considerably from the antiquarian and artistic ideals of the 19th century archaeology to the contemporary scientific and scholarly frame of reference (Lucas, 2012; Trigger, 2006). At the same time, however, because of the destructive nature of archaeological inquiry and deterioration of exposed structures over time, especially in places with a long history of investigations like Rome or Pompeii, unlike in many other academic and professional contexts, the older information has still equal (or at least, almost equal) value in comparison to newer observations.

3.2 Idiosyncrasies of the use of archaeological information

In addition to characteristics of archaeological information that have an impact to its management, the practices of archaeological information work do also frame information and knowledge management in the field. Studies of archaeological information use have highlighted the significance of archaeological artefacts and stratum as fundamental sources of information (Huvila, 2014a). The actual use of specific sources does, however, depend on the who is using archaeological information, for what purpose and in what kind of a role (Huvila, 2009). Archaeological heritage administrators have different information needs than archaeology contractors, academics and non-archaeologist users of archaeological information (Huvila, 2009, 2017b). Even within specific areas of archaeology work, the information sources use can differ on the basis of the institutional setting where the work is being conducted (Börjesson, 2015).

In the daily work of those who work with archaeological information, probably the most popular information source on specific archaeological sites is an investigation report (Gustafsson & Magnusson Staaf, 2001; Huvila, 2016a). In addition, archaeologists use scholarly literature, references works, databases, internet sources, plans and maps, photographs and use personal contacts to acquire the information they need in their work (Huvila, 2014a). Because of the diversity of information sources and of the purposes and approaches how they are used, it is crucial for archaeology that information and knowledge are managed on an appropriate level of complexity and standardisation to be useful for contemporary administrative and analytical undertakings and at the same time, that it leaves room for curiosity driven research (Bloemers, 2010a), including unexpected information needs and requirements and serendipitous discoveries

both at the present and in the future. As Börjesson and colleagues (2016) underline, the usefulness of a particular piece of archaeological documentation is not given for other stakeholders. Documentation, desirable information and knowledge making and management practices need to be actively negotiated to make them compatible, or at least hospitable, to each other.

In parallel to that different types of archaeological and archaeology related practices (Huvila & Huggett, 2018) influence the needed and used information, available information does also steer archaeological work. On a very fundamental level, the archaeological record, or the information about the past available for archaeology, sets limits to what is knowable. As noted earlier in this chapter, once a site has been excavated, it cannot be excavated again and any detail that goes unobserved and undocumented and information that remains undocumented will be lost forever. However, at the same time, new theoretical perspectives open up possibilities to reinterpret old material to an extent it is available and new documentation and analysis methods literally make new information available for new interpretations and knowledge about the past. In this sense, even if it is impossible (and unnecessary to try) to determine exactly what comes first (cf. Huvila, 2014b; Kristiansen, 2014), new paradigmatic perspectives but also the availability of information has an impact on what can be done and in very practical terms change how archaeological work can be, and is, conducted at a given time.

As Braccini and Federici (2010) note, in spite of the importance of information for archaeology, it is managed only seldom as a specific entity (Kintigh, 2006). One conceivable reason to the relative scarcity of the discussion and implementation of information and knowledge management based approaches is archaeology can be traced back to its epistemological traditions. Instead of building on one predominant positivistic tradition and conceptualising the process of managing information and knowledge as management, it is not uncommon in archaeology to frame it as interpretation and construction of narratives (van der Valk, 2010). The centrality of narratives and knowing beyond data has prompted several calls for a more careful consideration of different aspects of informing about and in archaeology that would consider and distinguish between information, messages, emotions, and media (e.g. van der Linde et al., 2018; Copplestone & Dunne, 2017; Gruber, 2017) especially in the public presentation of archaeological entities, but also in the professional archaeological work (e.g. Morgan, 2012).

In addition to the coexistence of interpretivist and positivistic modes of circulating archaeological knowledge, there are also other parallel lines of knowing and informing. In spite of the typical image of archaeology as a discipline of formal documentation *par excellence* and in fact, similarly to many other domains (Huvila, 2013), tacit knowledge and knowing are central to how archaeologists get to know what they need to know in their work (Kansa & Kansa, 2011). Even if archaeology aims at producing meticulous records of the observations conducted in field on the material remains of the human past, as Huvila (2016a) has noted, the archaeological record functions as much as a carrier and mediator of social exchange and a boundary object (Star, 2010) between differ-

ent communities of archaeologists and other stakeholders than as information containers. Similarly, the social organisation of how archaeological work, including information and knowledge management in the field is organised, has a strong influence on what information is produced in the first place and even more so, how it will be managed, kept and made available afterwards (Huvila, 2016b).

3.3 Conceptualising archaeological information process

The specific characteristics of archaeological information and information work have lead to several different approaches to conceptualising typical archaeological work and information processes in the literature. Starting from the work of Gardin (1980; 1999a; 2003) to formally explicate archaeological reasoning to more specific efforts of formally describing archaeological work processes in different countries (e.g. De Roo et al., 2016; Riksantikvarieämbetet, 2016; RAÄ, 2015a) and professional contexts (e.g. Huvila, 2006, 2016b) there has been many attempts to formally outline both specific instances and an overarching intellectual and practical process of how archaeology works. Similarly, there has been a strive for explicating the position of archaeology and its relation to other fields of enquiry (e.g. Gallay, 2018). Also the several efforts to standardise archaeological work processes for the purposes of archaeological heritage management (Börjesson & Huvila, 2019) are closely akin to these endeavours.

However, as Huvila (2018b) notes, archaeological work has a notable tendency to resist such formal descriptions. Olsen (2012) has discussed archaeological work in terms of Stengers’s notion of ecology of practices with a particular emphasis on its theoretical premises as a field characterised by its “particular kind of care, obligation, and loyalty to things” Olsen (2012, 1). The point of Stengers is that all practices differ from each other but it is still possible to inquire into work (and information work) and its peculiarities but it should be done without “insulting” (Stengers, 2005, p. 184) information workers and their own perspectives to the work they are doing. Drawing on another part of Stengers’ work, Huvila (2018c) has scrutinised the frictions between how archaeologists are standardising, or normalising, their work using a broad range of technologies and techniques and how the technologies themselves are framing what archaeologists do. The discussion of VanValkenburgh et al (2018) of the use of a mobile documentation system provides an illustrative example of how this can happen in practice. A significant observation in their study is that archaeologists may have a rather different idea of the impact of technology compared to how it affects their work practices and its outcomes in practice.

Another, partly related perspective to the arrangements of archaeological work is to explicate how it is organised and learned. Archaeology has often been described as craft-based discipline. A lot of archaeological knowledge is tacit and learning the practical aspects of archaeology and archaeological thinking are based on a long process of apprenticeship (Wendrich, 2012) rather than strong rules and explicit guidelines – even if there has been for a long time a parallel, pronounced drive to codify archaeological work (e.g. Pavel, 2010; Trigger,

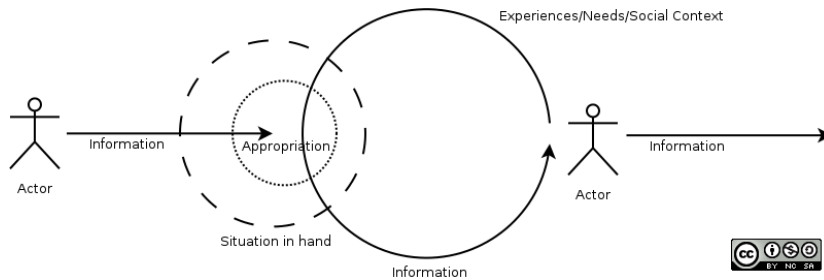


Figure 1: Archaeological information process as information making and information taking. Licence: CC-BY-NC-SA-4.0.

1989). The strive for and against standardisation extends over both actual work practices (e.g. Shanks & McGuire, 1996; Carver et al., 2015) and documentation who does what and how (e.g. Huggett, 2012; Huvila, 2017a). As a scientific and scholarly pursuit, archaeology differs from arts and crafts even if the significance of exploring the nexus of the two has been acknowledged and emphasised by several authors (e.g. Ingold, 2013; Russell & Cochrane, 2014). Therefore, there are both similarities and dissimilarities between archaeological and arts-based knowing. The differences between archaeological knowing are not necessarily related to the processes of how knowing happens in practice. For instance, it is possible to discern aspects of creative process Gherardi and Perrotta (2013) identified in a study of practices in artisan firms from formative process-sensible knowing and co-formation of ideas and materiality to experimenting with playfulness, translating and hybridising materials, realisation and repetition also in archaeology. The main difference is how much formal emphasis is put to each of these processes and how their outcomes are attached with meaning.

Even if it would be fair to assert that archaeological work does seldom follow the formal descriptions of its work processes, it does not mean that it would be completely disorganised. As Huvila (2018b) remarks, there is rather a multitude of local information processes that are fixed to a degree than a complete chaos or a single master process that everyone would follow. As he continues, rather than being guided by a process, archaeological work is quite obviously guided by an idea of processes. Archaeological knowledge should be an outcome of an orderly and at least to a degree, standardised line of action. The friction between a desire and self-image of standardised work and the practice that builds on a diversity of local processes can be distressing as, for instance, a recent study of the challenges of managing archaeological information in Sweden demonstrates (Huvila, 2016b). In this respect, archaeological work is an illustrative example of Suchman's (1987) situated action and, perhaps as Huvila (2018b) suggests of archaeological information work citing Blanford and Attfield (2010), a 'mixture individual and collective information journeys'.

From the perspective of archaeological information and knowledge management, a central result of enquiries into the circulation of archaeological inform-

Archaeological information	Information use	Information process
Uniqueness	Multiplicity of stakeholders	Standardisation vs. heterogeneity
Multiple standards	Multiplicity of information sources	Tacit vs. explicit processes
Fragmentation	Information steers information work	Multiplicity of processes
Multiple temporalities	Information not conceptualised as information	Disconnects
	Paradigmatic plurality	

Table 1: Characteristics of archaeological information, information use and information processes.

ation and knowledge is that there is not only one archaeological information process or that the ecology of individual information processes would form a linear flow or lifecycle of information starting with fieldwork and ending up with the use of information for different purposes with the aim of increasing our understanding of the past. Archaeological information process is (or rather, processes *are*), as Buchanan (2016) posits a *discontinuum*, or a continuum of *information making* and *information taking* (Huvila, 2018b) rather than a uniform flow of information (Fig. 1). It involves a number of professionals and stakeholders working independent of each other with different perspectives and questions in their mind (Wattrall, 2011). Combined with an apprehension of the pertinent aspects of the nature, making and use archaeological information, the understanding of archaeological information processes forms a workable basis for elucidating the nexus of information and knowledge management and archaeology, including how the both fields could benefit of a more comprehensive cross-breeding.

4 What is missing from archaeological information and knowledge management

It is not surprising that many of the challenges of managing archaeological information and knowledge can be traced back to the peculiarities of archaeological information and information work. The heterogeneity and fragmentary nature of archaeological information, destructive nature of archaeological work, coexistence of multiple epistemologies and standards of information work and representation of information and long temporal timespan of the archaeological subject matter and archaeology itself all impede effective and efficient management of archaeological information. Further, the large number of stakeholders, the different approaches and uses of archaeological information and the various

modes of the circulation (cf. Östling et al., 2018) of archaeological knowledge make it difficult to find ways to make it available for specific users and uses. Somewhat conspicuously, even if many of these observations are close to being a matter-of-fact for archaeology professionals if they are referred to, not all of them have been discussed and elucidated in detail. For instance, as Högberg and colleagues (2017) note – even if it is hardly a matter of discussion that archaeological information is kept and managed for future use – future tends to remain highly implicit and unarticulated in the context of archaeological heritage management. The same applies to the use and users of archaeological information (Huvila, 2018b). As Marila (2018) criticises, a widespread approach to prepare for radically different futures (similarly to users and uses) has been to focus on total preservation of the archaeological record as a more ‘neutral’ and future-proof alternative of managing archaeological information and knowledge in comparison to interpretation and meaning-making.

Both with managing artefacts and data, the challenges have been partly identified in shortcomings with existing and non-existing infrastructures (Voss, 2012; Benardou et al., 2018) but as some researchers have argued, the more significant problem than the lack of technologies and infrastructures, is how to ensure that they are used (Huggett, 2016). This underlines the timeliness of the recent calls for a need to obtain a better understanding of archaeological and archaeology related practices (e.g. COST-ARKWORK, 2016-2020; Huvila & Huggett, 2018; Geser & Selhofer, 2014) as a basis for the development of infrastructures and procedures of archaeological work. By referring to archaeology related practices, the scope of relevant activities for archaeological information and knowledge management covers not only archaeology *par excellence* but also the undertakings of various archaeology relevant and related stakeholder groups from amateurs to educators, land developers, tourism operators and researchers in a large number of adjacent fields (Laužikas et al., 2018).

While underlining the significance of a better understanding of human processes, it is equally important to explicate in detail the role, uptake and influence of new technologies as a part of the social sphere and to understand what happens when practices become digital, when they are influenced by digital technologies or the digital phenomenon (Huvila & Huggett, 2018) and on a rudimentary level, how particular technologies affect information practices and how people are using them to regulate their and other peoples’ endeavours (Huvila, 2018c). As the experiences of Braccini and Federici (2010) suggest, the exercise of developing an information management system and bringing together different stakeholders of archaeological knowledge can be useful *per se*, and contribute to sharing of information and knowledge. It is also highly apparent that in the context of archaeological information and knowledge management, very little attention has been paid to the management social information processes and socially mediated information. Considering the significance of social information exchange in archaeology, the field could benefit of a closer look at the insights in human-centred information and knowledge management and organisational learning research and practice.

As a whole, it is easy to agree with Perry (2018) in that a major challenge

in contemporary archaeological work practices is a lack of holism that pertains also to information work and the management of information and knowledge in the field. On the basis of the findings from a study of a project-based research and development organisation, Almeida and Soares (2014) warn of the risks of the emergence of an ‘information limbo’ – that information is trapped in an organisation out of the reach of its stakeholders. The risk for the emergence of an information limbo is high in a context where work is conducted in parallel temporarily limited constellations when situations, locations, people and tools vary from one undertaking to another. In broad terms, archaeology can be seen as a whole as this kind of a gargantuan project-based research and development organisation – with a lot of information in a limbo or quasi-limbo where it is effectively out of the reach of its potential but in many times, also principal stakeholders. Some of these limbos can be traced back to dysfunctional or non-existing technologies but as the earlier discussed observations of the organisational rather purely technical nature of the obstacles in archaeological information management suggest, there is no doubt that many of them can be better explained by organisational, social and administrative issues. Data from archaeological field work provides an illustrative example how a particular genre of information is considered to be valuable but in practice because it is heterogeneous and as such technically difficult to manage, it is poorly standardised and there is a lack of clear organisational processes how to handle it. As a result it is difficult find, obtain and use (Huvila, 2016a) and effectively ends up in a limbo.

It is easy to agree of the crucial importance of trying to counteract the emergence of such unreachable loci and to try to make sure that information does not end up in such a place or state. What can be more problematic is to ensure that in practice. A more systematic focus on the understanding and mapping of digital and non-digital information and knowledge processes is a necessary prerequisite of being to identify such limbos. A more comprehensive standardisation of both information processes and information itself would help in keeping information available but only when it is done to an extent that leaves room for the plurality of archaeological knowledge and knowing. A refined understanding of and catering for social information exchange is needed to bridge the unavoidable gaps in formal inscribed information. Identifying and managing these gaps is increasingly important when the implementation of new digital technologies and workflows changes not only how both inscribed and non-inscribed information is mediated and worked with but also the understanding and nature professional practices (e.g. Jarrahi & Thomson, 2017; Byström et al., 2017) and knowing (e.g. Huvila, 2019) as human endeavours. As a whole, it is conceivable that a more explicit focus on the management and leadership (Huvila, 2014c) of archaeological information work rather than a mere management of data and documentation would turn out to be useful in the context of archaeological work. In this respect, perhaps one of the most pivotal issue is to make a clearer distinction between processual problems that can be managed and the ones that remain unsolvable because they are at the heart of archaeological enquiry.

5 From archaeology to information and knowledge management

Similarly to how archaeology could benefit of a deeper engagement with information and knowledge management theory and practice, there are issues where archaeology and studies of archaeological information work can inform information and knowledge management theory and practice. Even if the use of archaeology as a case context in information and knowledge management literature has been rather uncommon, there are some examples where studies of archaeological work have improved the understanding of issues relating to metadata (e.g. Henninger, 2018), knowledge representation (Khazraee & Khoo, 2011) and organisation (Vatanen, 2005), information processes (Huvila, 2018b), information sharing and knowledge transfer (e.g. Huvila, 2011, 2012a, 2016a), and knowledge construction (e.g. Khazraee & Gasson, 2015). In addition, there are aspects of knowledge work and information that have been investigated and explicated particularly meticulously in the context of archaeology. Many of these insights have relevance beyond that particular domain. For instance, the results of archaeological scholarship on the use and relevance of material aspects of information could be exploited to a far greater extent in increasing the understanding of the role of materiality in other information contexts. Whereas bodily and material aspects of information have been discussed also elsewhere, they are in the focus of archaeological information practices (e.g. Olsson, 2016; Newman, 2011; Lucas, 2012). The significant temporal span of both archaeological information and information management, and the simultaneous contemporary, and historical and cultural significance of archaeological information is another factor that has made it an interesting cross-temporal context for investigating issues relating to long-term information and knowledge management. Examples of this can be found both in the work that focusses on the temporalities of archaeological information (e.g. Lucas, 2010; Barceló, 2002) and on archaeological perspectives on the management and use of, for instance, environmental (e.g. Schofield, 2010; Van de Noort, 2013) or nuclear information (e.g. Högberg & Holtorf, 2013; Holtorf, 2012). Further, from a very practical perspective, the multi and cross-disciplinary nature of archaeological work that spreads across a wide range of scientific and scholarly disciplines from natural and social sciences to medicine and humanities, and practical contexts from education and tourism to land development means that the span and relevance of archaeological information and knowledge work has a broad resonance in the society with extensive economic, cultural and practical repercussions. Considering its broad implications, archaeological information work has been so far a perhaps even surprisingly neglected domain of inquiry and practice from the information and knowledge management perspective.

6 Conclusions

In archaeological information and knowing, there is a lot to manage. As the existing research on archaeological information work demonstrates, the answers of how to do it effectively and efficiently are not as clear-cut as could be hoped. Partly, it is apparent that the present paradigm of archaeological information and knowledge management puts heavy emphasis on the management of specific types of data and information artefacts whereas others are lacking systematic attention. There are also issues of defining significant aspects of particular types of information artefacts, developing means to document information acquisition, management and use processes and establishing the priorities of documentation for maximising the contemporary and long-term usefulness of preserved assets. Even if the digitalisation of information reduces the need of manual recording and facilitates the automatic documentation of information processes, it does simultaneously change and increase the demand of documenting aspects of work that become less visible.

Apart from these partly technical and partly organisational issues there are two problems that call for a particular attention. First, in archaeology, very little attention has been paid to the management social information processes and socially mediated information. Considering the significance of social information exchange in archaeology, archaeological information management could benefit considerably of a closer convergence with human-centred information and knowledge management and organisational learning. This could be useful even if the long temporal timespan of archaeological work and information differs radically from the temporal focus of interpersonal information management.

The second problem that would require more attention in archaeological information management relates to stakeholder perspectives. Even if the problem with the contradictory expectation that archaeological documentation *a priori* should be scholarly and scientific information, which, at the same time, should satisfy the needs of all stakeholder groups has been acknowledged, there is still need to put attention to ensure that both the making and management of archaeological knowledge caters for the needs of, if not all, at least the most pertinent stakeholder groups. Also here, a closer convergence with information and knowledge management research could be useful for informing current practices in the context of archaeology and in developing means to address diverse and discrepant stakeholder needs.

In addition to the lessons that can be drawn from information and knowledge management literature and practice to inform archaeological information work in the digital environment, there are also possibilities for exchange to the opposite direction. In general, information and knowledge management can be criticised of the lack temporal perspective. This has been one of the main sources of conflict and misunderstanding between record keeping and information management fields. A closer scrutiny of information with a simultaneous contemporary and long-term historical and cultural relevance could be useful in developing means to bridge temporal gaps. In addition, archaeological information work provides an informative context for explicating the impact of

heterogeneity and diversity of information and epistemological differences for information and knowledge practices and the management of information and knowledge. This includes the multiple entanglements of the materialities and immaterialities of information sources and practices that are typical in archaeological information work.

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