Perspectives to Archaeological Information in the Digital Society

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Omslagsbild: The image represent 3D models generated by means of Image based 3D modeling techniques during the archaeological investigation of the Mesolithic site Kämpinge in Höllviken, south Scania in May 2014. The excavation was carried out by the Department of Archaeology and Ancient History, Lund University. Image by Nicolò Dell'Unto.

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INTRODUCTION

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One of the cornerstones of the digital society debate on the national, European and global levels is the digitisation of cultural heritage assets. Archaeology and material cultural heritage have often enjoyed a particular status as a form of heritage that has sparked the imagination of politicians and the general public. The physicality of objects and structures, the monumentality of the major archaeological sites and the popular interest in the past are only a few of the reasons why archaeology has in many cases become a linchpin in the discussions on new digital technologies and digitalisation of the society.

However, even though nations have made considerable investments in creating technologies, infrastructures and standards for digitalisation, preservation and dissemination of archaeological heritage, there is very little in-depth research on the consequences, opportunities and implications of digitalisation for archaeological work, the emergence of archaeological knowledge and how it is used by diverse stakeholder groups from ordinary citizens to researchers, museum professionals, landowners and property developers. The Swedish Fornsök (www. fornsok.se) database has information on over 1.7 million entities, the Dutch archaeology data service has over 25 000 datasets and reports and the Italian ministry of culture has been es-

timated to have about 2 million records in their digital archaeological archive. We know a lot about technical and practical challenges in the different phases of producing and using archaeological information, but significantly less about how the practices and technical, theoretical and administrative decisions affect and influence consecutive use and reuse of information. Paul J. Cripps remarked at the Computer Applications and Quantitative Methods in Archaeology 2012 conference that "information that goes into databases is far too perfect and too often a perfect view of the world", an apt remark on the current state of affairs which has obvious but poorly known consequences. This seems to indicate the possibility that models of reality may become convincing enough to be mistaken as "real". It is therefore crucial to highlight the choices and considerations involved in data collecting and in digital presentation: what is selected? what is excluded? what implications will this have for knowledge production and mediation?

The aim of this small book is to briefly discuss some of the premises for studying the implications and opportunities of the digitalisation of information and information work in the domain of archaeology and material cultural heritage. This book has been written under the auspices of the research project Archaeological Information in the Digital Society (ARKDIS) funded by the Swedish Research Council as a part of the work of the project to set the stage for researching the production and use of archaeological knowledge. The texts present a combination of musings and recapitulations on the earlier work of the authors as well reflections and entries to their on-going work. Instead of attempting to put together a single argument, the authors have been given an opportunity to write about aspects of archaeological information they consider to be important at the moment from the perspective they see as important and in a style that best fits the specific purpose of their text.

Rather than a conclusion, the texts in the volume are a new start in working towards understanding the complexities of working with archaeological documentation and information. The intricacies of managing archaeological information and documentation have been acknowledged for a long time (Reilly and Rahtz, 1992), but the rapid changes in premises, tools and the idea of how archaeology should be conducted in the digital age have shifted many of the parameters of the process. The introduction of computers into archaeological work has facilitated the processing of information and the integration of isolated datasets into massive data infrastructures. At the same time, new documentation instruments have enabled archaeologists to capture more precise data than before. The new technologies have not, however, provided any obvious automatic solutions to meet the fundamental challenges of an effective use of the data. On the contrary, the introduction of technologies has increased the amount of available data and underlined further the necessity of its effective management (Lock, 2003; Brown 2011) and the need to develop new approaches and techniques to take advantage of the processing power, data infrastructures and documentation equipment. The Big Data issues identified in the 2007 report of English Heritage and UK Archaeology Data Service are becoming increasingly topical for the management of archaeological information (Austin & Mitcham, 2007). At the same time, the societal expectations of increased cooperation together with the apparent opportunities and benefits of larger integrated data spaces and e-Science infrastructures have spurred archaeologists to address the challenges relating to the effective management and innovative and appropriate use of archaeological information by different stakeholder groups. The necessity of better understanding the fundamentals of archaeological information process has been discussed in several studies that have provided several examples of how it is necessary to combine technical innovations (such as three-dimensional representation of data or Semantic

Web technologies, e.g., Huvila 2006; 2012) with institutional and paradigmatic change.

The necessity of developing new strategies for addressing the use and management of archaeological and other cultural heritage data in the rapidly digitalising contexts of information use of the stakeholders the information has been underlined in the recent literature. The research agenda set by the European network of excellence in open cultural heritage EPOCH (Arnold & Geser, 2008) revolves around these two issues with a specific focus on integrative societal approaches to cultural (including archaeological) heritage, increased engagement and empowerment of traditional and non-traditional stakeholder groups and strategies and technologies of knowledge transfer and management. V-MUST NoE has similarly emphasised the lack of integrative approaches and understanding in the field of virtual museums (V-MUST, 2011) and the ARIADNE infrastructure in the field of the management of archaeological data (Papatheodorou, 2013). The Swedish National Heritage Board published in 2011 a white paper on 'net presence' (Swe. nätnärvaro) in the digital society (Summanen, 2011) that sees the presence in the digital sphere as an unavoidable necessity in the future. Further, the white paper identifies three challenges facing the management of heritage information in the digital society: 1) the amount of information and the need for new methods to manage it, 2) the broadening use of information by a growing number of stakeholder groups, and 3) the changing roles of producers and users of information. Both other national archaeological institutions and researchers have made similar remarks.

Even if the earlier literature discusses some of the challenges of the management and use of archaeological information by different stakeholder groups, the main body of literature relates to the issues and opportunities, and practical development of technologies and tools for data management and exploitation. As Ross (2007) has

noted of the state of the art of preservation research, the bulk of the necessary technologies and principal approaches exist, but there is a lack of comprehensive understanding and demonstration of their practical usability. As the report by Arnold and Geser shows (2008), there are technological challenges, but the major focus of future research should be on the interface of information and the processes of its use. The US-based tDAR data archive (https://www.tdar.org), the Dutch DANS data archive (http://dans.knaw.nl) and the pioneer in the field, the Archaeology Data Service (UK) have engaged in developing practical digital methods and techniques for the preservation and publication of archaeological data. A number of projects and initiatives both in Europe and the US, including STAR (http:// hypermedia. research.southwales.ac.uk/kos/star/), STELLAR (http:// hypermedia.research. southwales.ac.uk /kos/stellar/), CARARE (http://www. carare.eu/), ARENA (http:// ads.ahds.ac.uk/arena/), DARIAH (http:// www. dariah.eu/), Digital Antiquity (http://www. digitalantiquity. org/), 3DCOFORM (http:// www.3dcoform.eu/) and ARIADNE research infrastructure project, have conducted practical work on developing different aspects of data management and provision of access to the data e.g., in the case of CARARE, by integrating archaeological data to the Europeana gateway. There is also a growing body of mostly technology-oriented Semantic Web-based research on developing the management, accessibility and usability of digital archaeological assets (Isaksen, 2011).

In addition to the large-scale research on the management of archaeological data, there are a large number of examples of developing the use of archaeological data in various sites around the world for public presentation, preservation, management (Tsipopoulou, 2009; Caravale, 2009) and to promote the accessibility of archaeological data and information, often with museum- and cultural heritage-oriented underpinnings. The Public Archaeology (Skeates et al., 2012) movement has further promoted the principle of openness and par-

ticipation in archaeological contexts. In spite of the considerable political interest in the public archaeology initiatives, archaeological and cultural heritage data and the number of local case studies, there is still relatively little research on the qualitative impact of these efforts beyond individual stakeholder groups and contexts, and their broader implications to the use and reuse of archaeological information in the digital society.

The literature on theoretical archaeology has addressed some of the central issues of archaeological interpretation and reasoning, and how archaeologists use and should use archaeological data to make inferences of the human-activity part, but it seems that the theoretical discussion has had only a limited impact on the stakeholder practices (Thomas, 2006). The same limitation also applies to the relatively small corpus of ethnographical literature on the practices of archaeological work and knowledge production. (Edgeworth, 2006; Davidovic, 2009; Pyburn, 2009, and other articles in Public Archaeology 8/2-3). Some of the findings have been taken back to field in some individual cases (Edgeworth, 2006), but there is a clear lack of a comprehensive feedback loop and generalisation of the relatively isolated findings of the individual projects. The remark by Lönn (2012) on the need for developing a theoretically inductive way of working in archaeology is valid well beyond its original scope of archaeological fieldwork.

On the basis of the synthesis of the earlier literature in the field, it is possible to list some apparent challenges in the way of matching the emerging technologies with the practices of archaeologists and other stakeholders of archaeological information. An obvious challenge is the complexity of the different types of archaeological data and its uneven quality and accuracy. The body of relevant information consists e.g., of measurements, scientific analysis results, objects, samples, drawings and photographs. The different types of materials are seldom comparable per se, and because of the vary-

ing technical formats of representation, their management and use in a single system without the use of multiple parallel data structures and conceptual separation of the data models require new techniques and research approaches (Signore, 2009). The codification and representation of different types of archaeological data is an intricate problem (Orlandi, 1993). By allowing artificially high levels of precision, computers have been observed to feed this propensity and to support a false sense of accuracy even with technically inaccurate data (Kantner, 2000).

Some authors, especially in the field of theoretical archaeology, have raised the question of the consequences and implications of various analysis and information-management practices, but the scope of these remarks tends to be relatively limited. Some authors, including Gaffney and van Leusen (1995), Rajala (2004) and Haciguezeller (2012), have discussed the implications of GIS technologies for archaeological reasoning, but as Haciguezeller (2012) points out, these types of considerations have tended fall into the margins of the generally rather unproblematising mainstream use of the technologies. A central challenge of the use and integration of data is the incompleteness of available archaeological information and the ambiguous relationship between primary data and the consequentially emerging archaeological knowledge (Thomas, 2006). In spite of the increased precision of measurements and the growing amount of available data, the documented and documentable data always represent an unknown sample of the original data. Another challenge is that even the theoretical 'complete corpus of original data' consists of miscellaneous remnants of past human and natural processes and is capable of providing only indirect evidence of the past human activity.

Present archaeological information practices have also been suggested to lead to major discontinuities in the information process (Greene, 1998) and abrupt breaks in the information continuum (Oliver,

2010). In many cases only the field director and deputy directors have the direct responsibility and possibility of developing a general idea of the excavation, but in practice, there is often very little time and opportunities for an extended synthesis of the data during the field season (Huvila, 2009). The discontinuities do not end with the end of the archaeological investigation. From the perspective of cultural heritage managers and, for instance, museum professionals, the available data in reports and publications is not necessarily highly useful for their purposes (Huvila, 2006). As a result, there is often a major gap between the capture of data, the analysis and reporting and the use of the findings by the different stakeholder groups of archaeological information. A related problem of the effective use of archaeological data is that if the results are published (most of the data, especially from rescue excavations is never analysed or published properly, Greene, 1998, 83-84), even then the different groups of materials and aspects of excavation are very often reported separately. Thomas (2006, 30) has made the obvious argument that these discontinuities are a major problem and essentially lead to a suboptimal documentation of archaeological sites and investigation processes. The fundamental problem with the broken continuum is that the gaps will be extremely difficult to bridge in the future (Huvila, 2009; 2012). Because archaeological fieldwork and the use of archaeological data are interpretive in all stages (Thomas, 2006, 30), discontinuities tend to become cumulative and are difficult to remedy afterwards.

From the point of view of this volume, the interesting issue is to trace back some of the discontinuities in different areas of archaeological work and stages of archaeological information process. This volume contains altogether five texts from five authors working in the ARKDIS project. Daniel Löwenborg's chapter on the re-use of GIS data starts the volume with a focus on the exploitation of the data gathered in earlier excavations. In the second chapter, Isto Huvila

discusses in retrospect the findings of a study of archaeological information practices on the verge of digitalisation in 2004, and how these findings can help us to understand the changing landscape of information practices and infrastructures a decade later. The third chapter by Nicolò dell'Unto discusses the role of three-dimensional models in archaeological reasoning with a specific focus on his work in the Uppåkra project conducted near Lund in southern Sweden and in Pompeii. The following chapter, written by Bodil Petersson, discusses the influence of digital agendas and digital tools on heritage communication. The final chapter by Per Stenborg looks back to the presentation of archaeology in the Digital Time Travels project funded by the National Heritage Board (Sweden) and conducted in cooperation with the University of Gothenburg, Chalmers University of Technology and the Swedish University of Agricultural Sciences.

As a reader of this book, you are free to peruse this volume from the beginning to the end, or to read it in any other order of your choosing. If you think you have more questions after you are finished reading this small volume, we contributors to this volume will have achieved our goal with this small collection of texts. Seeing the complexity and open questions is only the beginning of making sense of archaeology and archaeological information in the digital society. What the answers might be is beyond the scope of this small collection of texts. They are the focus of the work we are currently engaged in and topics of future studies that not only we, but also many other researchers need to explore and study.

RECUPERATING GIS DATA FROM EXCAVATIONS

On the use, or lack of use, of digital archaeological information

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Introduction

How many settlements from the Early Iron Age have been touched by excavations in Uppland? How many burial grounds and how many traces of agriculture? How many square meters have seen some form of archaeological investigation in Östergötland, and where were the trenches put? These kinds of questions are fundamental to all archaeological enquires concerning these regions, but the answers are very hard to come by, since the information is largely missing or unavailable. While it may be possible to gather relevant information to answer similar questions of a limited scope, within a specific region, it is usually too time-consuming to get an overview if one aims at more comprehensive large-scale projects. This is regretful since the information produced in the numerous archaeological excavations that are carried out every year is the foundation for all empirical archaeological knowledge. These are the pieces of the puzzle that archaeologist would need in order to expand knowledge on prehistoric

development. Also for cultural resource management (CRM), this is crucial information.

The current situation in Sweden when the results of excavations are disseminated and archived as reports and perhaps artefacts in museum collections is unsatisfactory. Reports can only convey a limited set of all the information produced, from a fixed set of questions and perspectives. That means that the information is unsuited for renewed examination and inclusion in broader overviews and aggregated forms where the results from different projects can be combined. Anyone who wants to find information on a certain type of feature is left to read through a vast number of reports that may or may not have the information required in a form that is easily recognisable. The modern archaeologist will want the information available in a format that can be automatically searched and queried in a structured way, using the tools that information technology and the Internet provides, where information should be harvested from numerous sources simultaneously and made instantly available. While this situation may still be some years away, good technical solutions for disseminating digital information have been available for some time. For more than a decade, archaeological information has been mostly "born digital". Archaeologists have been using total stations and GPS, routinely creating high-quality digital information as part of their everyday work. What is missing today is an infrastructure that can facilitate the distribution of the data so that it can be reused by others. Since no infrastructure is generally accepted and used for archaeological data, the most of the data is left with the contractor, and thus difficult to access by others. This also raises questions regarding the security of the data, and to what extent the data is properly curated and maintained so that it will be available and readable in the future, should someone wish to look at it again. Working on making large datasets available for research is something that carries important potential for the further development of a discipline. However, the work is te-

dious and time-consuming, especially for manually converting data formats, and there is often a discrepancy between the workload being performed and the academic recognition it merits (Eiteljorg, 2011).

The unsatisfactory situation outlined above is now about to change for the better, as there are initiatives that aim at establishing the infrastructure that is needed, and in this paper I wish to discuss some of these developments: what is currently being done in Swedish archaeology and what we can expect in the future.

The Gamla Uppsala research project

One of the first Swedish initiatives towards collecting archaeological geodata from excavations, at the level of individual features and finds, and harmonising this information over several projects to facilitate reuse, was the project Gamla Uppsala (the development of a mythical site), funded by the Swedish National Heritage Board (2010-2012). The scope of this project was to gather all available information from excavations in Gamla Uppsala, to establish an overview of what has been found there. The aim was both to support further research in this area and also to make the information available to a wider public. During the collection of information, digital data was used when available, and otherwise plans from paper were georeferenced and digitised. All information was transformed into a uniform data structure so that it could be integrated seamlessly to provide detailed information on exactly where there had been excavations and what had been found in where. As part of the project a WebGIS platform was developed that provides an easy way to display the information via the Internet. This was complemented with georectified historical maps and laser scanned elevation data, together providing a detailed background of the landscape and the historical development of the area. The WebGIS platform is available from www.arkeologi.uu.se/webgis.

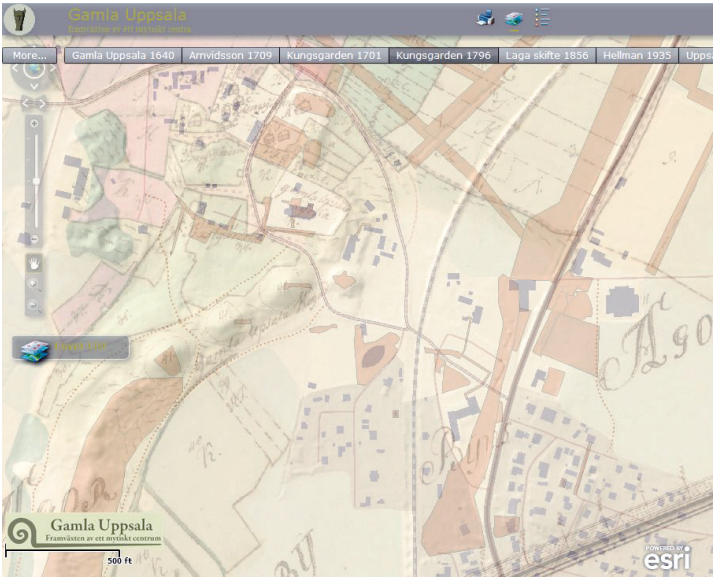

Figure 1. Screenshot of the WebGIS developed, available from www.arkeologi.uu.se/WebGIS

One of the first questions to be addressed when this project was started was how to describe the archaeological information, what to include and in what format. Since this was a limited project focusing on one complex, there was no ambition to design a standard for digital excavation data, but limited to creating something that would work for that specific project, and the research needs envisioned. A set of basic geodata layers were suggested to act as a generalised dataset which, although simple, could describe the result from any archaeological excavation at a level where they could be compared and combined. These templates have been further modified along the way, and have continued to be modified as part of continued projects, as described below. Most modifications were designed to make the files even more generalised, i.e. combining point layer of "finds" and "samples" into one single "point" file. The philosophy for making the files easier to compare and more suitable for combination, "harmonised" in GIS language, was borrowed from the INSPIRE EU directive (http://inspire.ec.europa.eu/). Thus, a fixed set of initial attributes were defined for each layer type, which consists of the fundamental and required attributes that all files of that type should have, including a free text attribute for any auxiliary information. This means that every file in a collection can be combined into a simple aggregated file that still contains enough information to be meaningful in most situations. However, if we received digital data that contained more information, then all additional information was maintained. There is thus no upper limit to how many attributes may be present in a file, and the additional data is only as structured as the original data was when it was delivered to the project. This is important, since it means that no data has been sorted out and deleted in the process of harmonising the data. Since the first attributes are the same, the data is at the same time well structured and easy to manage, and "complete" and true to the original data.

Project	Metadata about each project in a polygon shapefile
Trench	Excavated areas
Arch objects	Archaeological objects as polygons
Lines	Line features, both archaeological objects and other
Points	Point features, both archaeological objects and other
Multi points	Multi points, typically topography
Other	Non archaeological polygons

Table 1. Overview of the GIS files after harmonisation. All files are ESRI shapefiles in the coordinate system SWEREF99 TM. For a full technical description of the data structure used, please contact the author.

The data of the Gamla Uppsala project is available both from the WebGIS platform developed, and also as the harmonised GIS-data in ESRI Shapefile format. Since the area has seen considerable archaeological activities in recent years, this information has already proven to be of great use both for research, planning and for the renewed excavations as part of the construction of tunnel for a new railroad throughway.

Östergötland and Ostlänken

After the GIS work of the Gamla Uppsala project was finalised, it was tempting to try to apply the same methods to data from other excavations, since it is very rare that information is disseminated and reused outside the producing organisation, despite its apparent value for both research and CRM. In 2011 collaboration was initiated with the County Administrative Board (CAB) in Östergötland for a project on the use of the results from contract archaeology financed by

the Swedish National Heritage Board. Part of this was to provide the CAB with access to GIS data from excavations to facilitate infrastructural planning in the county. A similar method and data structure as were used for the Gamla Uppsala project was adopted, and two master's students were employed for two months each to work on the data. The focus was on collecting digital GIS data and harmonising it to facilitate reuse. Since the project used digital data and efficient methods to cut and paste this information into the templates were already developed, the project was very successful and within the limited time 230 projects were integrated into the dataset. In 2012 this collaboration with the CAB in Östergötland continued on a somewhat smaller scale and another 157 projects were included.

A challenge with this project was that five different contractors have been more or less active in the area. None of them had had much experience in providing their data to an external body, and it could be quite time-consuming for them to locate the data and export it in a meaningful form. Most, but far from all, of the datasets were in the Intrasis format, which must be exported from within Intrasis software before it can be used in other GIS programs. Exporting requires an available licence and installation of Intrasis. This is somewhat cumbersome, but when the data from Intrasis has been exported, it is fairly well structured and rich in content, although a lot of the internal relations between different data objects are not fully maintained in the export and would need to be fixed, something that was not done. It is thus a "basic" version of the Intrasis database that can be used once it is exported to other formats.

In 2012 a series of political decisions were made to start a major new infrastructure project of building a new railway would run from the Stockholm area to Linköping in central Östergötland. This is the so-called Ostlänken project, which will cover 150 kilometres and be the first high speed train connection in Sweden (http:// www. trafikverket. se/ Ostlanken/). The CAB realised at an early stage

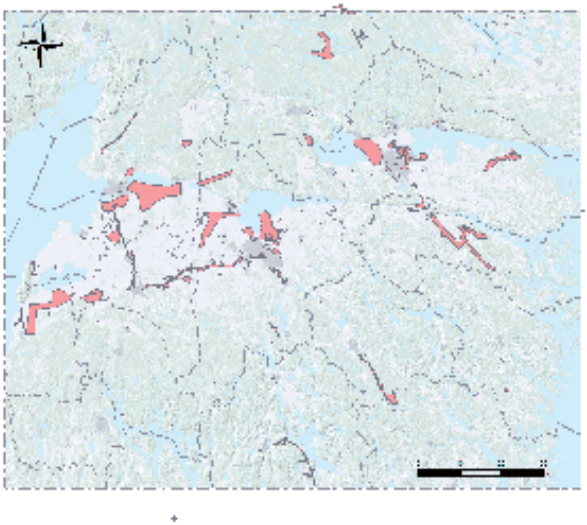

Figure 2. An overview of the 287 projects collected in Östergötland in 2011-2012.

that this project would affect a large number of archaeological sites, and would be a major undertaking for them in the years to come. To get better spatial control of where previous excavations had been carried out, a continued project working along the principles described above was designed that would collect all excavations from 1965 and later that had been done within and near the corridor of the railway with a 200-meter buffer zone. This project was funded by the Swedish Transport Administration (Trafikverket), the agency responsible for transport systems in Sweden including Ostlänken and thus the financer of all the necessary archaeological excavations in the railway line. While it continued along the same line of work as before, the Ostlänken project posed a number of new challenges. In contrast to the earlier work, the project covered a fixed set of excavations, and the first task was to identify what excavations had been conducted in the area. Since there is no comprehensive registry for excavations, this entailed time-consuming searches in different archives initiated in early 2013. The digitisation work was done by five archaeologists working full time in January and February 2014. In addition, two interns made major contributions to the project.

A technical challenge was to georeference plans that had been recorded in a few different regional coordinate systems. A program called MapTrans provided the algorithms needed to make correct spatial relationships between these systems and SWEREF 99 TM, which was used in the final dataset. However, quite a few of the excavation reports gave only the three last digits in the coordinates, whereas a full coordinate definition would be seven or eight digits. In order to georeference the plans, these coordinates first had to be reconstructed. While this is somewhat straightforward in areas where the location of the excavated can be estimated from overview maps, it proved much more difficult in areas where the landscape had undergone considerable change, or where the overview maps were of poor quality. In the majority of cases it was nevetheless possible

Figure 3. The GIS data generated for the Ostlänken project, 140 additional projects in total, in the counties of Östergötland, Södermanland and Stockholm.

to use the coordinates to georeference the plans with high accuracy. The methods used were documented along with standard errors of the accuracy of the plans in the metadata.

Achieving and disseminating the data

From the outset, it was decided that the data collected in the project would be submitted to the Swedish National Data Service (SND), so that they could archive and disseminate the data. SND is financed by the Swedish Research Council and the University of Gothenburg, and is a research data archive for researchers working with the social sciences, humanities and health sciences. SND is a facility for research and researchers and thus has an infrastructure suitable for this, and it also works closely with researchers who wish to deposit

data with them. From early on we had a dialogue for how the information would be managed and what structures would be used. Some of the changes that came about from these discussions were extended metadata for locations, both in how location was described in a number of separate fields, but also through fields with maximum and minimum coordinates, in order to create map search interfaces using a bounding box search function. Since SND had no previous experience with GIS they needed to modify their routines and systems to facilitate this, and SND has done a lot of work to start implementing geographical search functions and better structures for describing chronology. Ulf Jakobsson describes some of the work SND has done with archaeological data in Jakobsson (in press).

Outlook and future development

There is certainly a growing interest in having GIS data available for further analysis. Since there are more data and better techniques for analysing these, the academic interest in this information will surely grow over the coming years. This will open up for new lines of research and probably a revitalised methodological discussion, where quantitative methods that have largely been out of fashion in academic archaeological research for the last few decades will probably attract new interest. To ensure the wide availability of data it is necessary to keep in mind that modern national borders are often of little or no relevance, and there is thus a need for infrastructures that can accommodate efficient international cross searches. The EU research infrastructure project ARIADNE (http://www.ariadne-infrastructure.eu/) aims at facilitating this development. Because SND is a Swedish partner in ARIADNE, the Ostlänken database will become available for queries within this new infrastructure.

The Swedish Transport Administration is also showing increasing interest in how they can have access to the data that is being produced in excavations. Since the agency is providing the funding for the

main part of all rescue archaeology projects that are carried out each year, they have an economic interest in being able to predict and plan this aspect of their operations. There is also a great interest in making sure that the funding is used in the best ways, and that the information produced can be made available both for CRM and research. Similar ideas are of course a major concern for many of the CABs as well.

In addition, after some years of preparatory work, in early 2014 the Swedish National Heritage Board formally initiated the project DAP – the Digital Archaeological Process. The DAP project aims to address a number of issues in the management of archaeological information in Sweden, including the lack of a registry of excavations, poor availability of archaeological grey literature, lack of infrastructure for archaeological data, difficulties in linking information from different sources and inefficient communication of information between relevant agencies and bodies (http:// www.raa.se/ kulturarvet/ arkeologi- fornlamningar- och-fynd/ digitala- arkeologiska-processer/). DAP is a very ambitious project that will resolve many of the issues in information management in archaeology in Sweden today, and hopefully this will tie in well with the work already being done in Östergötland, providing even better possibilities for research and CRM in the future.

References

- Eiteljorg, Harrison (2011). What are our Critical Data-Preservation Needs?. In: Kansa, Eric Christopher, Kansa, Sarah Whitcher & Watrall, Ethan (red.) (2011). Archaeology 2.0: new approaches to communication and collaboration. Los Angeles: Cotsen Institute of Archaeology Press, University of California

- Jakobsson, Ulf. (in press) Swedish National Data Services (SND), the OAIS reference model and archaeological data. Gothenburg: SND.

ARCHAEOLOGISTS AND THEIR INFORMATION SOURCES

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Introduction

The information needs, behaviour and practices of researchers have been a topic of continuous scholarly interest since the 1960s (Case 2007). The literature shows that there are considerable differences between scholarly and scientific disciplines (e.g. Talja & Maula 2003, Tenopir & Rowlands 2007, Tenopir et al. 2005, Meho & Tibbo 2003, Tibbo 2003). Humanities scholars and social scientists have been studied to a lesser extent than scientists, even though the number of studies on the use of information in the humanities and social sciences has increased steadily in the last twenty years (e.g. Ocholla 1996, Weintraub 1980, Stieg 1981, Stone 1982, Broadbent 1986, Bakewell et al. 1988, Lönnqvist 1988, J. Wiberley S. E. & Jones 1989, Wiberley Jr. 1991, Ahlbäck 1992, Tibbo 1993 ; 1994 ; 2003, M. Bates et al. 1995, Brockman et al. 2001, Lönnqvist 2003, Talja & Maula 2003, Dalton & Charnigo 2004). In spite of the slightly growing general interest, there is only a little research on certain disciplines like archaeology. Academic archaeologists have been included in the group of informants studied by e.g. Corkill (1981), Stone (1983), and Lönnqvist (1988) (all the in-

formants were classical archaeologists) and (2003, 71) (six archaeologists, none representing classical archaeology), but they tend to represent a clear minority in the studies. Another shortcoming in the earlier literature is that the studies focus on academic archaeological research even though in practice, the vast majority of archaeological investigations are conducted by government agencies and private consultancies in many countries (e.g. Korkeakoski-Väisänen 2003, Aitchison 1999). As a rare example, Sufian (2009) has conducted a study of archaeologists' and heritage-management professionals' information behaviour, but the principal focus of the study is on the services of a single Indian library. The only comprehensive study of the information work of archaeology professionals so far was published by the author of this article (Huvila, 2006).

The aim of this chapter is to provide a retrospective of the patterns of information source use of archaeology professionals in the wave of digitalisation in order to form a baseline for future studies and to inform the management of archaeological information processes and development of information services for the archaeological domain. In this chapter, the notion of information source is used broadly to denote information channels, consulted sources and information objects (i.e. sources) contributed and created by the informants. Perhaps, in contrast to other chapters, this discussion is more about the past than the future, but here as elsewhere in this volume, the purpose is to underline the significance of the links between the past practices and the current and future state of the art.

It is rather safe to posit that the importance of understanding of how archaeologists use information has increased during the last two decades. Digitalisation of information processes has had a major impact on archaeological work (Lock 2003). The extent of archaeological fieldwork has exploded in many parts of the world because of increased land use and urban development. The growth of commercial contract archaeology is another factor that has changed the

landscape of archaeological work (Aitchison 1999). In developing countries, the growth of population, expanding land use and poorly resourced and developed cultural heritage administration pose direct threats to archaeological sites (Karlström 2009). In many parts of the developing world, rapid economic growth has put increasing demands on the efficiency of archaeological work. Besides the highest priority, the quality of fieldwork and documentation, the effectiveness of information use can have also a major economic impact (Brattli 2009, Skeates 2000).

Empirical study

This chapter and its observations on the information source use and non-use is based on an empirical investigation of the information work of Nordic archaeologists. The material consists of 25 thematic interviews of Finnish and Swedish archaeology professionals conducted in 2004. A typical interview took 150 minutes. The shortest lasted 105 minutes and the two longest 180 minutes. Work duties of the informants range from education to field archaeology, museum work and cultural heritage management. The empirical data were collected using an adapted version of a semi-structured approach called thematic interview (Hirsjärvi & Hurme 1995, 35-37). The qualitative nature of the study and fact that the informants represent Swedish and Finnish archaeologists limit the generalizability of the results beyond the specific context of the study. The richness of the data allowed, however, the making of analytical inferences that are likely to be relevant outside the specific context of the present study.

The interview data was analysed on the basis of digitised tape recordings and draft transcriptions. The use of digital transcription software allowed a simultaneous processing of the audio track and the text. The entire transcription and coding work was conducted by the author, which eliminates the bias caused by a possible lack of intercoder reliability. The simultaneous processing of transcription

and audio data reduced the need to complete a comprehensive transcription of every utterance and yet made it possible to work with a complete set of data (referential adequacy Lincoln & Guba 1985, 313-314). For the purposes of citation, each of the 25 individuals were assigned a random letter between A and Z written between brackets in the present article, for instance [A]. Furthermore, the approach allowed a continuous evaluation and revision of the transcriptions in order to increase their reliability. The data analysis was based on a combination of the constant comparative method (Strauss 1987, Corbin & Strauss 1990) and schema-based approaches Ryan & Bernard (2000, 782-784). The analysis was elaborated in the later stages using writing as an explicit form of inquiry (Richardson 2000).

Information work in archaeology

Archaeology can be described to be an information-intensive scholarly discipline and profession that has a specific aim of explicating past human activity on the basis of its material remains (referred as 'archaeological material') (Manacorda 2004, 3-7). A grounded theory (Glaser & Strauss 1967) based schema analysis (Ryan & Bernard 2000, 783-784) of the interview data from the interviews indicated that archaeological work may be structured in seven major non-exclusive categories, listed in Table 1.

The basic objective of archaeological work may be described as preserving and managing known and prospective sites (a place where some traces of past human activity have been preserved) and areas of archaeological interest, investigating them and maintaining the information acquired for present and future use, e.g. for the purposes of research and public interest (Darvill 2002, Trigger 1989, Renfrew & Bahn 1996). Archaeology incorporates both academic research and professional craftsmanship, and in practice, it is often difficult to distinguish the two.

Category	**Work profile**
Academic teaching	Education of future archaeologists at universities.
Field archaeology	Excavations and archaeological fieldwork.
Antiquarian	Collection management and artefact analysis duties at archaeological museums and research institutions.
Public dissemination	Popularization of archaeological knowledge in different forms: books, films, museum exhibitions and workshops.
Academic research	Academic research in archaeology.
Cultural heritage administration	Cultural heritage management duties in state organizations responsible for the preservation of archaeological heritage.
Infrastructural development	Development of methods and techniques for archaeological work, e.g. analysis methods, information systems or best practices.

Table 1. Categories of archaeological work

The empirical findings support the view of Gardin (1980, 5-7) of the layout of the archaeological information process. He describes archaeologists' intellectual process as an iterative cycle of observation, elaboration and publication. It is typical that the intellectual reasoning and all three phases of the cycle occur in all of the categories of archaeological work (Table 1), both in the 'more' professionally and 'more' academically oriented ones. The scope and extent of the process vary between individuals and categories of work, and they tend to be subordinated to the premises and objectives of the information activity that relates to the immediate goals of the assignments and duties at hand.

The empirical material shows that the principal source of archaeological information for all interviewed archaeology professionals is archaeological material and (first-hand) investigation reports. The daily use of archaeological material as a direct source of information varies across different categories of archaeological work, but all informants were very explicit about the origins of the information they use. Archaeological material consists of a variety of material objects that are capable of shedding light to past human activity. It comprises individual objects (e.g. shards of pottery, tools and relevant natural objects), buildings, and different kinds of structures such as fields, roads and their remains (Renfrew & Bahn 1996). The interviewees' descriptions of the archaeological investigation process follow the descriptions found in the archaeological literature (e.g. Roskams 2001, Joukowsky 1980). Archaeological sites are investigated by excavating or surveying, archaeologists document their findings and the investigation process and during a post-investigation phase, write up and draft the final archivable versions of their sketches and notes, and prepare any retrieved finds for storage.

The archaeological material is used as building blocks in a process of constructing an understanding of the past human activity at hand. The process combines information from the archaeological remains

with secondary information available from a variety of sources (e.g. Literature, personal communication). The nature of archaeologically relevant information varies considerably and comprises both quantitative scientific information, and qualitative and comparative inferences. Due to the heterogeneity of the information and the distance between the present-day archaeology professional and past human beings, the processes of information seeking, use and production are highly complex and place a special emphasis on the contexts of the study and of the studied past.

Information sources

Archaeological material

Archaeological material (artefacts, features, structures, non- artefactual organic or environmental remains, Renfrew & Bahn 1996) is used in field archaeology and antiquarian work roles as an information source on an everyday basis. The use of archaeological materials is frequent also in academic research and public dissemination. The informants emphasised the necessity of adequate meta-information about the location and the date of a find, and a description of its appearance, material and measures [All]. The descriptive information is needed for identification, and it also serves as a basic context for studying and evaluating the find and its function. Without the meta-information, the information value of the finds would be significantly lower.

Informants felt that original archaeological material would be difficult to substitute with aggregates such as textual descriptions, drawings, photographs or three-dimensional models. Visiting the museums and archaeological collections in person was perceived to be important by all of the interviewees. The informants saw the collections clearly as a form of 'capital' (Brockman et al. 2001).

However, the aggregates were indicated to be better than nothing if the original materials proved to be inaccessible. Of the aggregates, the informants tended to prefer three-dimensional models, photographs and drawings (in that order of preference). Secondary publications were considered to be useful, but they were generally seen to lack comprehensiveness and necessary details (cf. Lönnqvist 1988, 45). In contrast with Lönnqvist's study (cf. Lönnqvist 1988, 46), the bureaucratic problems did not seem to be a decisive issue for the informants interviewed for the present study. The difference may be explained by the better accessibility of the Nordic collections (majority in the current study) compared to the collections located in the Southern Europe (majority in Lönnqvist 1988, 46).

Literature

The scholarly and professional literature plays a central role for the informants. Articles were preferred by those interviewees who worked with specific questions and duties [e.g. B, C, I, L] that did not encompass the principal creation of primary information. Interviewees tended to resort to the institutional repositories and personal contacts in acquiring articles [e.g. A, C, F, H, I, L, M]. Most of the informants were members of the national archaeological associations, specialised associations, such as a society for medieval or maritime archaeology, or they subscribed to their journals.

As a whole, the significance of journals (both printed and electronic) in archaeology is clearly lower than in the sciences. In this respect the present study supports the earlier findings (Lönnqvist 2003, 160 cf. Corkill & Mann 1981). This compares to the general patterns observed in the humanities (Ahlbäck 1992, Tibbo 1994, Thompson 2002, S. E. Wiberley 2003, Larivière et al. 2006). The general observation on the prevalence of monographs (e.g. Thompson 2002) in the humanities did not, however, receive unequivocal support in this study. Some of the informants indicated that they probably used

more monographs than articles [V, S], but a significant group of them said that they actually used more articles [e.g. A, G, Q]. The findings of the present investigation seem to indicate that the actual preference between articles and monographs depends primarily on the precise nature of the purposes of the information work [A, O, P, S, U, X]. Journals provide focused and often technical descriptions and studies of relatively restricted themes [A, B, C, F, G, I, M, O, Q, V]. Articles were perceived to be more up to date [G, P, Q] Their significant role in supporting the general awareness function is also of consequence [A, O].

Most of the archaeological journals tend to be specialised both in terms of their subject and geographical coverage. In spite of the internationalisation of the research community and, especially, despite the broadening of the theoretical debate, archaeology is still a significantly national project in the Nordic countries. Some individual fields such as classical archaeology or archaeological science may claim the existence of a broader international community of researchers. Even then, however, the total number of participating researchers remains relatively low in comparison to the emphatically international disciplines such as the genetic science (cf. Star & Ruhleder 1996).

Many of the specialist themes and sub-disciplines of archaeology have their own journals (e.g. META and SKAS for medieval archaeology and International Journal of Nautical Archaeology for nautical and maritime archaeology). Besides their importance within the specific sub-disciplines, some of the individual journals were indicated to have significance also for the informants, who were occasionally in need of specialist information outside the precise focus of their own expertise (e.g. antiquarians and field archaeologists). The status of these publications varied considerably, however. As with journals, some of the nationally or thematically distinctive series were considered to be more relevant than the others (e.g. Fennoscandia

Archaeologica). Their number and general significance seemed to be rather low.

A simultaneous reason and explanation for the diversity of the publications is the high proportion of archaeological periodicals and literature that are published in national languages. This pattern is related to the social organisation of archaeology, which is rather nation-centric. Besides being an expression of 'tribalism', the patterns of publication contribute to the continuance of small-scale cooperation by reducing the international circulation of the information. The Swedish informants regretted their lack of skills in Finnish, while both the Finnish and the Swedish interviewees mentioned the problems caused by their insufficient knowledge of the neighbouring Slavic languages [e.g. H, O, T, W]. Such language skills would be highly relevant due to the proximity and similarity of the archaeological materials and material cultures in North-eastern Europe.

Monographs are typically favoured by those who seek extensive information on a relatively non-specific topic [e.g. O, Q] or work in teaching or in public dissemination, and by those who need to connect a specific piece of information to a larger context. A good monograph is a comprehensive overview e.g. of a site or a theme. High-quality illustrations and detailed information add to their value as references [H]. The novelty of both the monographs and articles play a central role in their usability as information sources, even though this aspect is not as important as in the sciences (Tenopir et al. 2003). Compared to the articles, the use of the most important standard monographs is likely to be more intensive. The interviews also indicated that the informants were more likely to return to a monograph than to an article. Especially observations and eyewitness reports on past investigations and visits that have been published in a monograph retain their value over time, even though some of the interpretations and propositions may utlimately be rejected.

In comparison to scientists and, to a degree, social scientists (e.g. Erdelez & Means 2005, Tenopir et al. 2005, Herman 2004), the informants were rather infrequent users of electronic literature. The most of the informants acknowledged the increasing significance of electronic resources and were aware of the growing number of the relevant journals and data sources available online [e.g. G, M] (M. J. Bates 1996) but used them only sporadically. The situation has likely changed since the interviews, although not as significantly as might be expected, because the majority of the journals and monograph series listed by the informants are still available in print-only versions.

Besides the apparent persistence of the habits of the informants, another clear explanation for the comparatively low usage of electronic materials is their relative scarcity in several specialist fields of archaeology. The informants who had cross-disciplinary contacts and research interests that coincided with the natural sciences emphasised the importance and value of electronic data services. They also contrasted the abundance of electronic data sources in the sciences to their scarcity in archaeology [D, N, V]. The present evolutionary phase of the electronic journal use might be related to the "evolving" phase in the categorisation proposed by Tenopir et al. (2003), even though the present study does not provide data for comparable longitudinal comparisons.

Reports

Archaeological investigation reports (a formal report written to document to an investigation process and findings) were interestingly mentioned as being important far more often than they were used and actually reported as being useful. A typical comment was: "I use them less than I could" [e.g. O, Q]. The typical problems with the reports included that they usually are too specific to small excavations or too general about large ones, and that the reported results

are not very well tied into a larger frame of reference. On several occasions the reports were stated to be difficult to access, because the consultation required travelling to the capital city or another distant place.

Regardless of the problems, a report was seen as a primary source of archaeological information on a particular excavation and site. Secondary publications were often seen as abridgements, which did not give enough information on the subject matter to be useful in further scholarly considerations. The principal importance of the reports as first-hand accounts was also emphasised by the academic educators. They also underlined that it is necessary that their students use original reports in order to become acquainted with this particular type of information source [M, Z], (see also Raninen 2005).

Academic theses

The perceived role of theses and dissertations as information sources shows some variation. Most of the informants agreed that the value of a thesis depends on its contents. The scholarly nature of a thesis does not affect its quality as a source of information. Field archaeologists tended to be interested in everything that might touch upon the subject of their research. They were generally not emphatically concerned about the formal qualifications or level of the theses. An undergraduate essay was assessed to be potentially useful, not unlike a doctoral dissertation. Academics and, interestingly, younger archaeologists tended to be more sensitive to good formal qualifications (i.e. grade) and the high, preferably doctoral, level of the theses [D, G, Q, V, Z]. Considering the usefulness of the theses, some of the interviewees remarked that the formal scholarly criteria did occasionally make a thesis difficult to read [C, N, P, W]. Unpublished theses are often also rather difficult to obtain, which was noted to reduce their usability as an information source [e.g. I, K].

Reference works

Specialised reference works are relatively scarce in the Nordic archaeology and in many of its special fields [Z]. The annual Nordic Archaeological Abstracts (NAA) monographs were the prevailing general reference mentioned by the interviewees. Kulturhistorisk lexikon för nordisk medeltid (Eng. The Lexicon of the Cultural History of the Middle Ages in the Nordic Countries) was mentioned by several (primarily) Swedish respondents as a basically non-archaeological, but still important general reference work on early-medieval and medieval culture in Sweden [O, R, S, G, V, J, K, N]. In spite of the scarcity of archaeological reference works, the informants could rely on the relevant reference works from related disciplines, such as shipbuilding in maritime archaeology. In many cases some meticulously compiled standard works such as comprehensive dissertations or monographs may serve as a reference work [H, V]. In contrast to classical archaeology (Lönnqvist 1988, 75), most of the special fields of archaeology lack a similar comprehensive apparatus of reference works.

Databases

The interviewees were relatively active users of small-scale databases that are specifically built for their personal needs or for their home institution. Most of the informants described that they work with the proprietary databases of their own institution or small databases made by themselves for their very specific research and reporting needs [e.g. A, B, C, D, I, J, N, P, Q, W]. The national heritage authorities have centralised collection and site registers although they tend to be far from comprehensive. Old legacy systems exist and are being used together with the new systems. Besides the several central repositories, additional cataloguing may be done in yet another system in order to serve some special needs, such as the maintenance

of a loans inventory [e.g. F, I]. The existence of multiple databases is largely explained by a chronic lack of funding for integration, conversions and cataloguing of the unregistered data. Most institutions have begun to register their new data in electronic repositories, typically from the late 1990's onwards. The database is typically parallel to a physical archive [O, P, Q, R, V, W, A, C, D, F, I, J, N].

Unfortunately, the quality of the repositories also shows considerable variation. As one of the informants pointed out, not all of the data entry work has been professional and consistent [D]. In spite of the immanent shortcomings, the databases were considered to be vital tools especially in cultural heritage administration. In general, the archaeologists working in cultural heritage administration were most active in their usage of databases and electronic information resources. Individual respondents indicated that they mostly use databases that are published and maintained by their home institutions [e.g. A]. Most of the relevant external databases cover secondary subjects such as the natural sciences, not archaeology. Library OPACs and web pages with contact information were also mentioned as useful databases [e.g. P, Q, R, T, V, W, X, Z]. The overall lack of useful and complete archaeological databases was widely acknowledged. The same notion applies to all forms of electronic media. Only one informant, who works with a specialised natural science topic in the field of archaeological research, was a heavy user of electronic resources. In spite of the scarcity of such resources, many of the interviewees were enthusiastic about them (cf. Lönnqvist 1988, 75). Part of the enthusiasm may be credited to the attempts to satisfy the interviewer, because the invitation to the interview could be read as an indication of a special interest in computerised information systems. The tendency of satisfying the interviewer is, however, unlikely to ground all of the optimism. The interviews gave a clear indication of the generally positive experiences of and expectations for electronic data and information resources. Therefore, it may be

suggested that these positive attitudes should be taken as an explicit impetus to work further with computerised information management and the development of electronic information resources for archaeological use.

Plans and maps

Topographic and thematic charts and excavation and site maps as well as profile plans were used by all informants. Their importance appeared to be lower in artefact-centric work [B, G, I, Z] than in fieldwork, cultural heritage administration or landscape-related studies. The interviewees expressed, however, that an understanding of spatial relations and dimensions is necessary in all archaeological work, and it is based on maps and plans. The cartographic material provides vital information on the stratigraphic and subsequently chronological relations, spatial distributions and relations of the points of interest. A map also helps to situate and contextualise the entire intellectual process that is related to a specific site. The essentiality of plans and maps is accentuated in the field archaeology. Excavating archaeologists use multiple small-scale plans and maps to document the excavation work. Surveyors use a variety of detailed and larger-scale topographic, historical and thematic maps for identifying potential sites [F, N].

Photographs and the moving image

Photographs are another central instrument of archaeological communication (cf. unlike in Lönnqvist 2003, 161-162). Every single archaeologist almost invariably uses photographs. Apart from a visit to an archaeological site or a first-hand contact with a find, photographs are the most important instrument for mediating information on primary materials.

A couple of informants had considered using moving images in field documentation [N, F]. Only a few individuals had had any direct experiences, and for most the idea of using a video as an information source in archaeology was a new one. Most of the discussed trials actually done in land archaeology were purely experimental and primarily directed towards producing video footage for public dissemination purposes [P, N]. No one had made any major attempts to use video in photogrammetrical documentation (Cosmas et al. 2003) of sites or in the documentation of the excavation process (Hodder 2000). In contrast to land archaeologists, maritime archaeologists use video extensively. The primary reason to resort to the moving image is the limited time that can be spent on an underwater site. The use of a video camera allows continuous documentation throughout the dive and thus maximises the input [All maritime archaeologists]. The theoretical possibility of covering an investigation completely by filming and later rewinding the process, attracted several land archaeologist informants [e.g. E, P]. The problems of archiving and browsing, however, would limit the usability of such comprehensive video documentation.

Social practices of information sharing

In spite of the importance of physical and literary source materials, the most significant source of information for the interviewees was the social contacts with colleagues and experts of several related disciplines. Because of the convergence of practical work and academic research, the archaeologists only seldom work entirely alone (unlike e.g. historians in Tibbo 1994). The stereotype of 'lone humanities researchers' is not accurate in the context of archaeology.

Even if an academic and research-oriented archaeological activity itself were to involve considerable periods of independent work, this does not imply that the researchers would not use or benefit from informal communication (ref. Lönnqvist (2003, 66)). Excavations are

a group effort both practically and intellectually, although the ultimate intellectual authority is held by the director of the investigation. Academic research in archaeology is partly an individual enterprise, although the cross-disciplinarity of the data tends to require occasional consultation of colleagues and other specialists. Similarly, work in public dissemination, academic education, infrastructural development and cultural heritage administration is a collective effort. Individuals are free to make their own decisions, but colleagues are consulted with such frequency that they maintain strict collective control of the intellectual work. Colleagues provide direct information, pointers to things they are aware of, affirmation and confirmation [All]. The role of the community of colleagues as an important source of information is emphasised, because the formal publication channels are relatively scarce, resources for adequate and thorough publication of research results are generally lacking, and the number of active practitioners in archaeology is relatively small in both Finland and Sweden.

The complexity and important role of social information sharing was made apparent in the interviews. The strategies of sharing utilised in professional archaeological work groups, and teams engaged in field archaeology projects and other similar undertakings, do seem to bear a noticeable resemblance to the strategies and resons for sharing described by Cronin (1995). The reciprocal sharing of information resembles a system of giving and receiving gifts (Mauss 1925; Cronin 1995; Talja 2002; Hall 2003). Social exchange is based more on an expectation of emerging benefits than on direct needs and the setting of goals.

Only a few academic research, teaching and field-archaeology-oriented archaeologists said that they frequently relied on information specialists such as librarians. These results conform with several other investigations and observations on (academic) information behaviour (e.g. Kuhlthau 1993, 76; Hjørland 2002; Simmonds & An-

daleeb 200)). The situation was slightly different with the informants who worked with public dissemination, collection management and cultural-heritage-administration-related duties, but the overall picture may well be described as "disappointing" (Hjørland 2002) from a library and information service protagonist's point of view. Several informants indicated that they frequently consulted information technology specialists and specialists in a particular type of information, such as natural science, geographical or statistical data [e.g. C, E, M, S, W, X]. Those informants who did indicate that they consulted information specialists during their explicit information-seeking, shared the characteristics of being typically elderly and less computer literate, and of working in a relatively large public organisation [E, M, P, S, W]. Academics consulted specialists most infrequently. The reluctance to consult an information specialist seems to correlate with a rather narrow perceived horizon of relevant information, existence of well-established and stable publication and information dissemination channels, the small size of the closely relevant archaeological community, and the traditions and habits of esteeming personal information-seeking and access. Several informants acknowledged that they might benefit from consulting an expert in information-seeking matters, but were altogether rather dubious whether they would do so in the future. The results are comparable with the observations of, for instance, Steinerová (2001) and Singh (2005, 224-225) that libraries and information professionals need to struggle with the problems of new information environments, the service encounter, and identities and visibility in the rapidly evolving processes of information access, which have shifted the focus to the users' desktops and made the information-access providers increasingly transparent in the process of information-seeking and use.

Discussion

The findings of the present study show that the core sources used by the archaeologists interviewed in the mid 2000s consist of archaeological primary materials (e.g. finds and sites), scholarly literature and personal communication. Registers, catalogues and databases were indicated to be of a direct importance, but most of the informants reported that the records tend to be lacking in comprehensiveness and often also in relevant information. The general patterns of information source use are in line with the findings of the earlier and contemporary studies on the humanities scholars. The cross-disciplinary and scientific tendencies of the archaeological practice became apparent on the level of individual information sources and information-seeking archaeologists. The general tendency to make distinction between primary and secondary materials, a variety of information sources utilised, and the long lifespan of the relevant literature seem to be, however, a common characteristic shared by the archaeologists and the majority of humanities scholars (e.g. Tibbo 1994 ; 2003). In this respect, archaeology is clearly one of the humanities in Finland and in Sweden, as also the placing of the departments within the university faculties suggests. This is in contrast with the North American conception of archaeology as a social science and a branch of anthropology (Darvill 2002, Renfrew & Bahn 1996).

The use of information sources by the archaeologists interviewed was highly specific to the purposes of the work at hand. It varies according to the situation and context of the information work. Besides being dependent on personal habits of information source use, the choice of sources shows distinct work-profile-specific variation on the level of the characteristics and the specificity of the resources. The information source use tends to be more specific when the work duties incorporated academic research, collection management, field

archaeology, development of methods and tools and cultural heritage administration. In contrast, archaeologists working with public dissemination of archaeological information and academic teaching were likely to use general sources of information. Similarly, the sources are consulted to extract different types of information depending on the work duties, even if the source itself is the same one.

Academic research seems to be the only exception to the general rule. For researchers, their use of information sources tends to be specific to current research topics, but at the same time, the information itself may serve multiple functions in its various contexts and situations. The nature of the information is determined by the specific research questions, their meaning, purposes and values, not the horizon of the work itself.

Basically all source materials, including archaeological material, serve a dual purpose of being both information containers and pointers to new information. Sources may contain direct links such as bibliographical references, but also indirect references to potentially interesting follow-ups, such as the material, the find spot and the form of an object. General non-scholarly information sources such as newspapers, television and magazines were considered to be of a relatively little use. Informants who work as cultural heritage administrators gave some weight to news broadcasts and newspapers for keeping abreast of the public debate and various public matters, such as current land use plans [e.g. C, W]. Otherwise their relevance was considered low, with the exception of providing occasional pointers to other sources.

A general remark made by several informants is that published, accessible and altogether existing archaeological information is only sporadically available. The problem is especially immanent in field archaeology. Reports on earlier investigations may be entirely nonexistent or consist of some scattered notes, uncatalogued finds and fragmentary data (e.g. Rímon (2005).The occasionally lacking doc-

umentation, the small number of researchers, and consequently of the publications, in many special fields of archaeology, limits the total amount and quality of the information resources. These kinds of shortcomings show a striking resemblance to the observations of Ocholla (1996) in a third-world context. Like the academics in a third-world university, the archaeologists are forced to resort to alternative information acquisition methods. Archaeologists need to congregate around the available resources and channels (cf. the library in Ocholla's 1996 study) and to forge them to fill the place of the non-existent resources in their communal discourse. This type of a formation of the information use behaviour is natural, but it signals of an inefficiency in the general information process in the profession. If the financial and practical possibilities are available to conduct investigations, there should be enough resources and pressure to finish the documentation process adequately and to manage the information properly.

The archaeologists' information work resembles an unnecessary degree archaeological work itself. Archaeologists need to 'excavate' their information from inadequately organised resources, combine several sources and information channels and rely heavily on social information acquisition even for rather simple tasks. The functional and economic reasons do not, however, provide a comprehensive explanation of the patterns of information use. The kind of tribalism and information use described, which resembles the archaeological work itself, is not a direct consequence of analogy between archaeological fieldwork and information work. Not even the scarcity of resources necessarily begets such behaviour outside a social milieu where shared information sources are a precondition per se.

When interpreting the findings, it is necessary to consider their retrospective nature. Several aspects, both technical and administrative ones, have changed since the empirical material was gathered a decade ago. More archaeological literature and especially data is

available in digital formats, though seldom in centralised digital repositories. Also, the use of computers and digital tools has become more common in both fieldwork and later stages of the work process. From a structural point of view, the commercialisation of rescue archaeology has had consequences for the availability and production of information, even though the situation is still very much in a state of development, and it is difficult to say how the responsibilities will be defined in the future.

Even if archaeological work has changed during a decade, it is hard to see that any of the observable changes would have been radical enough to have revolutionised the general picture of information source use in archaeology. The development of centralised archaeological data archives, for instance, in the UK and the Netherlands, and similar projects in other countries, and the work for a European archaeological research infrastructure in the EC-funded ARIADNE infrastructure project can be factors that have the capability to function as significant game changers. From a structural point of view, the organisation of rescue archaeology and the addressing of questions of archiving archaeological materials are two others issues that may cause major changes in how archaeologists use information sources in the future.

Conclusions

In conclusion, the findings show that the information use patterns and source selection of the informants was at the same time dependent on the demands of the multifaceted nature of archaeological work and the limitations imposed by how information is managed and disseminated in archaeology. Tribalistic and rationalising information source use patterns are a consequence of the existence of multiple small specialist fields, but also of the persistence of the formalities and traditions of producing archaeological and publishing results primarily in national languages. The retrospect shows that more

open forms and processes of disseminating information and systematic development of relevant finding would contribute to increasing the impact of archaeological information and facilitate the work of both archaeologists and other stakeholders of archaeological information. At the same time, the findings imply that the development of such systematic processes is not merely an administrative or a technological task. The choice of information sources and the emergence of information practices in archaeology are social practices with a broad range premises that are only indirectly related to how archaeological information should and could be disseminated, made available and used.

References

- Ahlbäck, T. (1992). Humanities information – cultural heritage and humanities research: Problems and possibilities in the light of new technology – proceedings of the fourth Anglo-Nordic seminar, held in Copenhagen on 7-9 June 1991. In R. Enmark (Ed.), (p. 109-116). Helsinki: Nordinfo.

- Aitchison, K. (1999, September). Profiling the profession: a survey of archaeological jobs in the UK (Tech. Rep.). Council for British Archaeology, English Heritage, the Institute of Field Archaeologists.

- Bakewell, E., Beeman, W. O., & Reese, C. (1988). Object, image, inquiry: The art historian at work: Report on a collaborative study by the Getty Art History Information Program (AHIP) and the Institute for Research in Information and Scholarship (IRIS), Brown University (Tech. Rep.). Santa Monica, CA: AHIP.

- Bates, M., Wilde, D. N., & Siegfried, S. (1995). Research practices of humanities scholars in an online environment: The

Getty Online Searching Project Report No. 3. Library and Information Science Research, 17, 5-40.

- Bates, M. J. (1996, Fall). Learning about the information seeking of interdisciplinary scholars and students. Library Trends, 45(2), 155-164.
- Brattli, T. (2009). Managing the archaeological world cultural heritage: Consensus or rhetoric? Norwegian Archaeological Review, 42(1), 24–39.
- Broadbent, E. (1986). A study of humanities faculty library information seeking behavior. Cataloging & Classification Quarterly, 6(3), 23-37.
- Brockman, W. S., Neumann, L., Palmer, C. L., & Tidline, T. J. (2001, December). Scholarly work in the humanities and the evolving information environment (Tech. Rep.). Washington D.C.: Digital Library Federation, Council on Library and Information Resources.
- Case, D. O. (2007). Looking for information: A survey of research on information seeking, needs, and behavior (Second ed.). Burlington, MA: Academic Press.
- Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. Qualitative Sociology, 13(1), 3–21.
- Corkill, C., & Mann, M. (1981). Doctoral students in humanities: a small-scale panel study of information needs and uses 1976-79 (Vol. 5). Sheffield: University of Sheffield.
- Cosmas, J., Itegaki, T., Green, D., Joseph, N., Gool, L. V., Zalesny, A., et al. (2003). Providing multimedia tools for recording, reconstruction, visualisation and database storage/access

of archaeological excavations. In D. Arnold, A. Chalmers, & F. Niccolucci (Eds.), VAST 2003 4th international symposium on virtual reality, archaeology and intelligent cultural heritage.

- Cronin, B. (1995). The scholar's courtesy: The role of acknowledgements in the primary communication process. Taylor Graham.

- Dalton, M. S., & Charnigo, L. (2004). Historians and their information sources. College and Research Libraries, 65(5), 400-425.

- Darvill, T. (2002). Archaeology. The Concise Oxford Dictionary of Archaeology.

- Erdelez, S., & Means, T. (2005). Measuring changes in information sharing among life science researchers. In S. Hawamdeh (Ed.), Knowledge management: Nurturing culture, innovation and technology. Proceedings of the 2005 international conference on knowledge management (p. 29-40). Singapore: World Scientific.

- Gardin, J.-C. (1980). Archaeological constructs: an aspect of theoretical archaeology. Cambridge University Press.

- Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory: Strategies for qualitative research. Hawthorne: Aldine.

- Hall, H. (2003, Autumn). Borrowed theory: Applying exchange previous termtheoriesnext term in information science research. Library & Information Science Research, 25(3), 287-306.

- Herman, E. (2004). Research in Progress Part 2 – some preliminary insights into the information needs of a contemporary academic researcher. Aslib Proceedings, 56(2), 118-131.
- Hirsjärvi, S., & Hurme, H. (1995). Teemahaastattelu. Helsinki: Yliopistopaino.
- Hjørland, B. (2002). Domain analysis in information science: Eleven approaches – traditional as well as innovative. Journal of Documentation, 58(4), 422-462.
- Hodder, I. (2000). The interpretation of documents and material culture. In N. K. Denzin & Y. S. Lincoln (Eds.), Handbook of qualitative research (2nd ed., pp. 703–715). Thousand Oaks, CA: Sage.
- Joukowsky, M. (1980). A complete manual of field archaeology. London: Prentice-Hall.
- Karlström, A. (2009). Preserving impermanence : The creation of heritage in Vientiane, Laos. Unpublished doctoral dissertation, Uppsala University, African and Comparative Archaeology, Uppsala.
- Korkeakoski-Väisänen, K. (2003). Arkeologia tarvitsee humanistisia tieteitä, luonnontieteitä, yhteiskuntatieteitä, lääketiedettä... mitä arkeologi tarvitsee? Muinaistutkija(1), 29-39.
- Kuhlthau, C. (1993). A Principle of Uncertainty for Information Seeking. Journal of Documentation, 49(4), 339–55.
- Larivière, V., Archambault, E., Gingras, Y., & Vignola-Gagné, E. (2006). The place of serials in referencing practices: Comparing natural sciences and engineering with social sciences and humanities. Journal of the American Society for Information Science and Technology, 57(8), 997–1004.

- Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Beverly Hills: Sage.
- Lock, G. (2003). Using computers in archaeology: Towards virtual pasts. Routledge.
- Lönnqvist, H. (1988). Humanister söker information eller ”mötet med den litauiske skoputsaren” (Vol. 13). Esbo: NORDINFO.
- Lönnqvist, H. (2003). Humanistiska forskningsprocesser och informationssökare. Unpublished doctoral dissertation.
- Manacorda, D. (2004). Prima lezione di archeologia. Roma – Bari: Laterza.
- Mauss, M. (1925). Essai sur le Don, forme et raison de léchange dans les sociétés archaïques. Année sociologique, Ser. 2, 30-186.
- Meho, L. I., & Tibbo, H. R. (2003). Modeling the information-seeking behavior of social scientists: Ellis’s study revisited. Journal of the American Society for Information Science and Technology, 54(6), 570–587.
- Ocholla, D. N. (1996). Information-seeking behaviour by academics: A preliminary study. International Information & Library Review, 28(4), 345-358.
- Raninen, S. (2005). Tuskan teatteri Turun Kärsämäessä. Muinaistutkija(4), 40-71.
- Renfrew, C., & Bahn, P. (1996). Archaeology: Theories, methods and practice (2nd ed.). Thames and Hudson.
- Richardson, L. (2000). Handbook of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), (p. 923-948). Thousand Oaks, CA: Sage.

- Rímon, I. (2005). Arkeologista aaltoliikettä – Porwoon tutkimushistoriaa 1800-luvulta nykypäivään. SKAS(3), 21-29.
- Roskams, S. (2001). Excavation. Cambridge: Cambridge University Press.
- Ryan, G. W., & Bernard, H. R. (2000). Handbook of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), (pp. 769–802). Thousand Oaks, CA: Sage.
- Simmonds, P. L., & Andaleeb, S. S. (2001, Spring). Usage of academic libraries: The role of service quality, resources, and user characteristics. Library Trends, 49(4), 626-634.
- Singh, R. (2005). Marketing culture of Finnish research libraries. Unpublished doctoral dissertation, Information Studies, Åbo Akademi University, Åbo.
- Skeates, R. (2000). Debating the archaeological heritage. London: Duckworth.
- Star, S. L., & Ruhleder, K. (1996). Steps towards an ecology of infrastructure: complex problems in design and access for large-scale collaborative systems. Information Systems Research, 7, 111-133.
- Steinerová, J. (2001, January). Human issues of library and information work. Information Research, 6(2).
- Stieg, M. F. (1981). The information of [sic] needs of historians. College & Research Libraries, 42, 549-560.
- Stone, S. (1982, December). Humanities scholars: Information needs and uses. Journal of Documentation, 38(4), 292-313.

- Stone, S. (1983). Inter-library loans : a study of antecedents and outcomes of inter-library loan requests (Vol. 7). Sheffield: University of Sheffield.
- Strauss, A. L. (1987). Qualitative analysis for social scientists. Cambridge: Cambridge University Press.
- Sufian, A. (2009). Information seeking behaviour of archaeology and heritage management professionals of Delhi: A study. Pearl: A Journal of Library and Information Science, 3(4).
- Talja, S. (2002). Information sharing in academic communities: Types and levels of collaboration in information seeking and use. New Review of Information Behaviour, 3, 132-159.
- Talja, S., & Maula, H. (2003). Reasons for the use and non-use of electronic journals and databases: A domain analytic study in four scholarly disciplines. Journal of Documentation, 59(6), 673-691.
- Tenopir, C., King, D. W., Boyce, P., Grayson, M., & Paulson, K.-L. (2005, June). Relying on electronic journals: Reading patterns of astronomers. Journal of the American Society for Information Science and Technology, 56(8), 786-802.
- Tenopir, C., King, D. W., Boyce, P., Grayson, M., Zhang, Y., & Ebuen, M. (2003, May). Patterns of journal use by scientists through three evolutionary phases. D-Lib Magazine, 9(5).
- Tenopir, C., & Rowlands, I. (2007). Information Behaviour of the Researcher of the Future; Work Package II: Age-related Information Behaviour (Tech. Rep.). London: CIBER, UCL.
- Thompson, J. W. (2002). The death of the scholarly monograph in the humanities? Citation patterns in literary scholarship. Libri, 52, 121–136.

- Tibbo, H. R. (1993). Abstracting, information retrieval, and the humanities: providing access to historical
- literature (No. 48). American Library Association.
- Tibbo, H. R. (1994). Indexing for the humanities. Journal of the American Society for Information Science, 45(8), 607–619.
- Tibbo, H. R. (2003). How historians locate primary resource materials: Educating and serving the next generation of scholars. In ACRL 11th National Conference Papers.
- Trigger, B. G. (1989). A history of archaeological thought. Cambridge University Press.
- Weintraub, K. J. (1980). The humanistic scholar and the library. Library Quarterly, 50, 22-39.
- Wiberley, J., S. E., & Jones, W. G. (1989). Patterns of information seeking in the humanities. College & Research Libraries, 50, 638-645.
- Wiberley, S. E. (2003). A methodological approach to developing bibliometric models of types of humanities scholarship. Library Quarterly, 73(2), 121–159.
- Wiberley Jr., S. E. (1991). Habits of humanists: Scholarly behavior and new information technologies. Library Hi Tech, 9, 17-21.

3D MODELS AND ARCHAEOLOGICAL INVESTIGATION

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Background

During the 19th century, before the introduction of computer graphics and virtual reality as main systems of three-dimensional simulation, constructed three-dimensional models in wax, plaster or wood were already realized with the purpose of educating and entertaining. Those prototypes were used to document and revisited what was once observed on site (Jensen, 2011 p.42), and despite the paucity of extant examples, those objects still today represent an important reference for many archaeological projects.

An interesting example can be found in the model of the archaeological site of Pompeii, realized between the late 19th century and the early 20th century by Felice Padiglione and currently displayed at the archaeological museum of Naples, Italy. This model represents a replica on a scale of 1:100 of the state of the art of the site during the 20th century, and it displays, with incredible accuracy of detail, structures and frescos visible at the moment of its construction (Fig. 01). Due to the rapid process of deterioration, most of the frescos and part of the structures represented in the model are no longer detectable on site. The incredible accuracy of this replica in displaying a holistic and complete representation of the site makes

this model a unique opportunity to revisit information no longer accessible. For this reason, this work has been used in several studies (Kockel, 2004), and – as a point of reference – it has been employed by different research projects. An example where the use of this model represented an important reference for the 3D interpretation of several Pompeian houses can be found in the Swedish Pompeii Project (http://www.pompejiprojektet.se/). The Swedish Pompeii Project was started in 2000 by the Swedish Institute in Rome as a research and fieldwork activity. The aim was to record and analyse an entire Pompeian city block, Insula V 1. Since autumn 2011 a new branch of advanced digital archaeology, involving 3D reconstructions and documentation methods, was added to the project agenda. In the framework of this new acquisition activity the insula was completely digitized by means of laser scanner technology and image-based 3D reconstruction techniques. The results of this acquisition were employed to develop different research activities in the area of digital visualization. Due to the lack of material references in situ and to the presence of few historical documents attesting the original frescos, the work realized by Padiglione has been largely used as a reference to analyse and reconstruct the original aspect of several structures that characterized the insula V 1, which are no longer visible on site (Dell'Unto et al. 2013).

The introduction and the diffusion of digital technology have strongly affected the way archaeologists manage and perceive the information detected during the field investigation process. In the last two decades digital instruments have been used in archaeology at any level, and their constant employment increased the opportunities for researchers and scholars to detect, document, analyse and visualize almost all the information collected during the field investigation. In particular, in the framework of archaeological practice, the introduction and diffusion of instruments dedicated to documentation and mapping, and the development of powerful visualization platforms,

Figure 1. Model of the archaeological site of Pompeii located at the Archaeological National Museum of Naples and realized by Felice Padiglione between the end of 19th and the beginning of the 20th century. This detail shows the house of the Torello di Bronzo, located in the South-East part of insula V 1. The image presents frescos and structures represented with great level of detail. Today, most of the frescos documented in this model are no longer visible in the house. Picture taken by Hans Thorwid, and used through the courtesy of the Swedish Pompeii Project (www.swedishpompeiiproject.se).

such as the Geographic Information System (GIS), have created the opportunity to reconstruct and visualize, with high accuracy, the spatial and temporal relations between the different data detected during the field investigation process (Kaztanis et al., 2008). In particular, the implementation of such tools and the development of new integrated digital techniques allowed (i) the systematic production of digital referenced maps representing the on-going investigation activity performed on site (ii) and the possibility of non-professional users employing mathematical tools to process the data imported into the GIS and generating new archaeological information (Connolly and Lake, 2006).

An interesting perspective on how digital technologies affected the field investigation has been provided by Ezra Zubrow (2006), who in his article "Digital Archaeology: A historical context" describes how communication and visualization technologies have irreversibly changed the dynamics that characterize the archaeological excavation, transforming an environment traditionally considered isolated (the excavation) into an active and connected "digital village", where the information is shared in real time with a larger community of researchers and scholars connected from different geographical locations (Zubrow 2006).

In his book "The archaeological process" Ian Hodder (1999 pp. 180-181) explains how the production of digital datasets allows an easier connection between the fragmented information detected on site, and highlights how the use of digital technologies promotes reflexivity, multivocality, interactivity and contextuality. New technologies offer a large number of new options for recording archaeological data, and their use during the on-going archaeological investigation is strongly related to the technologies' ability to fit within the logistic framework and time constraints of the field campaign (Dell'Unto, 2014).

As previously mentionedat the beginning of this paragraph, an important improvement, in terms of visualization and analysis, has been achieved by the introduction of digital three-dimensional models for the documentation and analysis of archaeological contexts. The use of this typology of information has always been considered an important opportunity in archaeology to represent, with accuracy of details, 3D interpretations of the past.

3D models and intra-site investigation

Since the 1990s the introduction of computer technologies to realize virtual interpretations of archaeological sites has allowed the start of several projects focused on using and combining archaeological and historical data to build 3D simulations of the past. This approach was not developed in direct connection with the field investigation, and it was mainly used to communicate – to a public of non-experts – the results of archaeological investigations through the use of a digital visual language.

Despite their obvious potentials in the area of cultural heritage and archaeology, the introduction of these new simulation tools was anything but easy. In particular the main obstacles in using 3D models to visualize and simulate archaeological interpretations consisted of: (i) the lack of technical competences in using specialized software (ii) the lack of an interdisciplinary language capable of bridging researchers and scholars from different areas, such as technical and humanistic disciplines, (iii) the technical limitations of the software and hardware available at that time and (iv) the absence of infrastructures able to host and present the results of these research activities.

The systematic technological implementation and the increase use of computer-based visualization techniques to visualize the results of archaeological and historical interpretations allowed the creation of interdisciplinary projects and networks, which are designed to stimulate a critical and constructive discussion to define the role and the

proper use of computer-based visualization tools as instruments of interpretation and visualization.

An example of this phenomenon can be recognized in the Londoncharter for computer-based visualization of cultural heritage (http:// www. londoncharter.org/).

This document is the result of an initiative conceived in 2006 which aimed to instil robust methodological rigor in the use of computer-based visualization to visualize and communicate cultural heritage information (http://www. londoncharter.org/ introduction.html).

The gradual diffusion of new instruments of documentation, such as terrestrial laser scanners, photogrammetry and image-based 3D modelling, represented a crucial step for the integrations of the 3D models in the framework of the archaeological investigation process. Moreover the constant development of more user-friendly interfaces and the construction of efficient workflow of data acquisition and analysis established the conditions to experiment and discuss the use of three-dimensional models (as result of 3D surveys) also in the framework of the on-going investigation activities. The incredible possibilities offered by these tools in realizing accurate and resolute digital replicas of the sites and monuments highlighted the importance and the urgency in researching new methodologies that would enable archaeologists using the data realized by these instruments to answer specific research questions (Campana, 2014).

Only recently, experiments have been performed to test the production and use of 3D models in support of an on-going investigation. In the context of these research activities, questions have been discussed concerning the capacity of these data to increase the perception of archaeological information (Callieri et al., 2011; Dellepiane et al., 2012; Opitz, 2012) and several examples have been presented in order to demonstrate how the production of 3D models can be employed in support of archaeological documentation methods (Doneus & Neubauer, 2005; Kaztanis et al., 2008; Dell'Unto, 2014;

De Reu et al. 2013; Forte et al., 2012; Doneus et al. 2011; Losier et al.,).

One of the first approaches in this direction has been tested and described by Doneus and Neubauer in the framework of several research activities, where a terrestrial laser scanner has been systematically used to record in three dimensions the excavation stratigraphy detected during the site investigation (Doneus, Neubauer & Studnicka, 2003; Doneus & Neubauer, 2004; Doneus & Neubauer, 2005).

Despite the encouraging results achieved in the framework of this research activity, very few similar experiments have been realized afterwards in this direction, and it is probably possible to recognize the reasons for this reticence in (i) the high costs of the instruments available at that time, in (ii) the expertise required to manage these new tools, and in the (iii) skills and time necessary to post-process those data.

An encouraging signal in this direction comes with the introduction of imaged-based 3D modelling techniques. Unlike laser scanner technology or photogrammetry, where cost and operation time usually discourage their employment during field activities, these techniques allow documenting the stratigraphic units detected during the field activity through the generation of texturized 3D models. This method allows providing, within the time frame of the excavation and with a low budget, an accurate 3D description of the ongoing investigation process (Fig 02) combining algorithms of structure from motion and multi-view stereo reconstruction to build an accurate three-dimensional model of a scene starting from an uncalibrated set of images (Dellepiane, et al., 2012; Verhoeven et al. 2012).

In a first stage, the software estimates the camera parameters associated with each picture and extracts and matches common features between each pair of images (SfM). Then it calculates their corresponding position and orientation in space. The results of this first

process allow the association of each feature point extracted from the images to a 3D point in space, providing: (i) a point cloud of a few thousand points, and (ii) the estimation of the intrinsic and extrinsic camera parameters associated with each image of the set. Then, using the pre-estimated camera parameters, multi-view stereo algorithms are applied in order to create a detailed model of the scene (Verhoeven, 2011; Verhoeven et al., 2012; De Reu et al., 2013).

Despite the encouraging results – in terms of quality and sustainability – in acquiring and generating these data in the framework of the archaeological field campaign (Dellepiane et al., 2012; Callieri et al., 2011, Forte et al., 2012), the obstacles to using 3D models in a direct spatial relation with all the other information acquired during the documentation process have always presented an enormous limitation. In order to bridge this gap several experiments has been performed and discussed in the literature. An interesting example that goes in this direction can be found in the framework of the archaeological excavation of the Abbey of Boudelo, Belgium, where 3D models – generated using this technique – have been extensively used to extract horizontal ortho-photos, and vertical ortho-images to be imported and used in a 2D GIS environment. The goal of this work was to test the efficiency of this technique in realizing a complete documentation of the field investigation (De Rue et al., 2014). Other experiments, engaging a more direct connection between Geographic Information Systems and texturized 3D models, have been presented and discussed in the literature. In particular in the framework of research activities such as: "Gabii goes digital" (http://gabiiserver. adsroot.itcs.umich.edu/ gabiigoesdigital/ index.html), "Çatalhöyük research project" (http://www.catalhoyuk.com/), "3D Digging at Çatalhöyük" (http://www.catalhoyuk.com/ uc_merced.html) and "Uppåkra project" (http://www.ark.lu.se/ projekt/293). All these research activities are currently employing 3D models (generated in the framework of the field activities) directly into a spatial database with the aim of

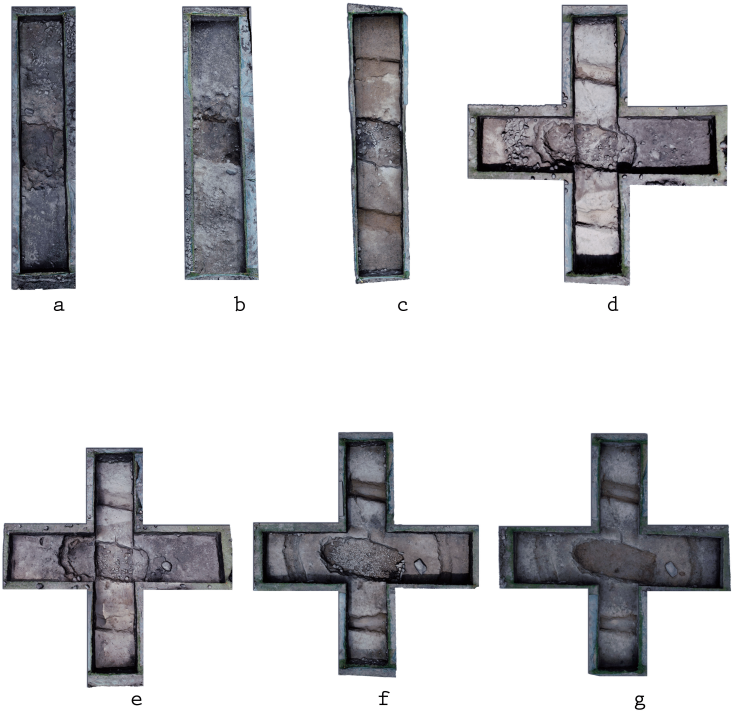

Figure 2. This image shows the sequence of the excavation process recorded in Uppåkra during the excavation of a late Neolithic grave investigated in the autumn season 2011. The stratigraphic sequence has been recorded in the field by the archaeologists and used in the framework of the excavation to plan the investigation strategy in the field. Those models have been used to achieve a better understanding of the relations that characterize the different stratigraphic units.

achieving a better description of the excavation context, and mapping how these new typologies of data affect the perception of the archaeological information.

The possibility of creating and managing large datasets of texturized 3D geometries into a spatial geo-database allows the experiencing of new ways to visualize complex information and the testing of new methodologies to describe and connect to each other the fragmented archaeological data detected during any investigation.

On the other hand, this approach raised new questions connected to the way information will be stored and shared in the future, and concerning the effects that this approach (the fast production of 3D models in the range of the archaeological excavation) will have on the interpretation process performed during and after the investigation activities.

The use of 3D models in Uppåkra

Since 2009 a team of archaeologists from Lund University have been testing the use of these methods on a regular basis, within the framework of the archaeological excavation of Uppåkra, Sweden.

The archaeological site of Uppåkra is considered one of the most important examples of an Iron Age central place in Sweden. The site is located 5 kilometres south of Lund and has an extension of approximately 100 acres. So far the archaeological investigation has revealed the presence of a settlement established at the beginning of the 1st century BC and existing till the end of the 11th century AD. This settlement has many different typologies of structures and finds. The site, which was discovered in 1934, has been the subject of archaeological investigations since 1996. It has proven from the very beginning to be an extraordinarily rich site. During the initial phase of the investigation (1996-2000), a metal-detector survey highlighted the presence on site of approximately 20,000 finds, which supported

the continuity of human activities at this site from the Pre-Roman Iron Age until the Viking Age (Larsson, 2007).

From the very beginning this site represented an ideal environment for conducting our research. The rich stratigraphy and the large variety of structures discovered during the years allowed for the testing of tools and instruments across a large variety of archaeological situations.

After an initial phase of experiments based on the employment of different instruments and methods to test in the field the creation and use of resolute 3D replicas of the site, the team started a systematic use of image-based 3D modelling techniques to map the limits and the potentials in realizing geo-referenced three-dimensional (3D) models in support of the on-going field investigation (Dellepiane et al., 2012). Since 2012, texturized 3D models have been systematically imported into a 3D Geographic Information System (GIS), with the aim of (i) using the 3D models in direct spatial relation with the data recorded during the excavation, of (ii) achieving a better knowledge of the cultural relations among the different strata detected during the investigation process, and of (iii) building 3D documentation of the diachronic investigation of the site, in order to visualize with detailed accuracy the specific "momentum" of the investigation activity (Dell'Unto, 2014) (Fig. 3).

This on-going research activity proved this approach to be sustainable and easy to integrate with the traditional documentation methods thus far performed in Uppåkra (Dellepiane, 2012). Moreover the possibility of having access to the 3D models of the site during the excavation process enhanced the opportunities for the archaeologists to gain a more complete overview of the on-going investigation activity and to re-visit the excavation during different stages of the investigation process (Callieri, 2011; Dell'Unto, 2014).

Despite these encouraging results, this work raised questions concerning the storage of this new typology of data and highlighted the

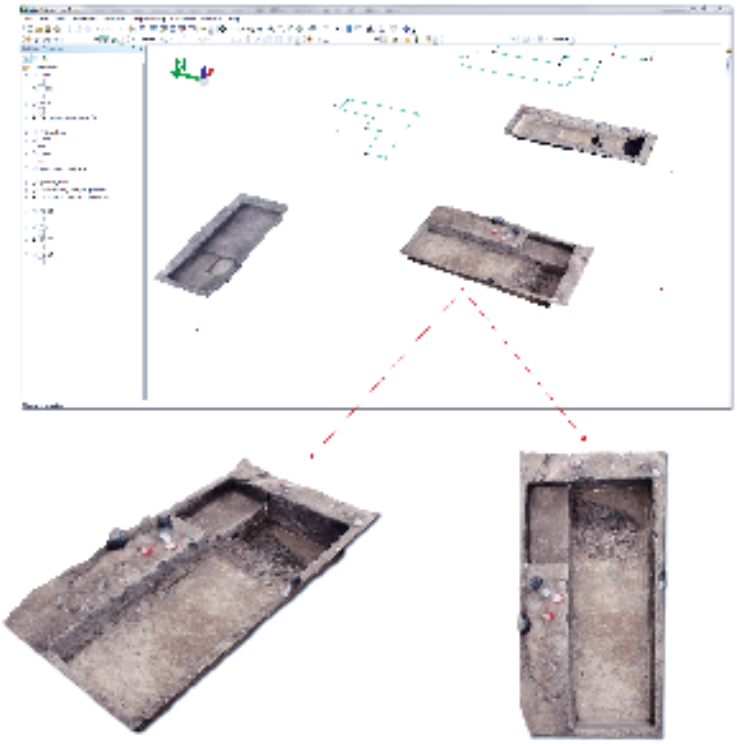

Figure 3. This image shows the integration of the 3D-surfaced models realized in Uppåkra during the field excavation campaign into 3D GIS.

lack of infrastructures for the sharing of these new kinds of visual systems.

Conclusions

3D models (digital and non-digital) have always proved to be an incredible instrument to document and visualize archaeological information. Nowadays the possibility of building large libraries of 3D geo-reference models of the site at different stages of the investigation allows the simulation of different archaeological scenarios recombining and brainstorming the information in a unique way, e.g. combining models of the site belonging to the same temporal phase, but acquired and stored in the system during different archaeological campaigns.

However the possibility of connecting and visualizing 3D models together with all the other typologies of data recorded in the field in the same geo-referenced environment requires that we (i) engage in a deeper discussion in order to define the limits and potentials in employing 3D models in the framework of the interpretation process, and (ii) define guidelines and standards to make this new data more available in both field activities and the post-interpretation phase.

Moreover the work so far developed and described in the literature highlights the importance of starting to define new ways to describe this information using metadata capable of providing a complete description of the different features displayed in the 3D models.

References

- Callieri M., Dell'Unto N., Dellepiane M., Scopigno R., Soderberg B., Larsson L., (2011). Documentation and Interpretation of an archaeological excavation: an experience with dense stereo matching, VAST: The 11th International Symposium on

Virtual Reality, Archaeology and Cultural Heritage, pp. 33-40.

- Campana S., (2014). Archaeological needs. I Campana, S. & Remondino, F. (Red.) 3D surveying and modeling in archaeology and cultural heritage. Theory and best practices. BAR international series Oxford.

- Conolly, J., and Lake, M. (eds.) (2006). Geographical Information Systems in Archaeology. Cambridge Manuals in Archaeology. Cambridge University Press, United Kingdom.

- De Reu J., De Smedt P., Herremans D., Van Meirvenne M., Laloo P., De Clercq W. (2014). On introducing an image-based 3D reconstruction method in archaeological excavation practice. Journal of Archaeological Science.

- De Reu J., Plets G., Verhoeven G., De Smedt P., Bats M., Cherretté B., De Maeyer W., Deconynck J., Herremans D., Laloo P., Van Meirvenne M., De Clercq W., (2013). Towards a three-dimensional cost-effective registration of the archaeological heritage. Journal of Archaeological Science.

- Dell'Unto, N. (2014). The Use of 3D Models for Intra-Site Investigation in Archaeology. I Campana, S. & Remondino, F. (eds.) 3D surveying and modeling in archaeology and cultural heritage. Theory and best practices. BAR international series Oxford.

- Dell'unto, N., Callieri, M., Dellepiane, M., Leander Touati, A., Lindgren, S. and Larsson, C. (2014). Pompei revived: Scanning Mission- insula V 1. In Earl, G., Sly, T., Chrysanthi, A., Murrieta-Flores, P., Papadopoulos, C., Romanowska, I.

and Wheatley, D. (eds). The Computer Applications and Quantitative Methods in Archaeology (CAA). Southampton, 26-29 March 2012. Amsterdam University Press.

- Dell'Unto, N., Ferdani, D., Leander Touati, A., Dellepiane, M., Callieri, M. & Lindgren, S. (2013). Digital reconstruction and visualization in archaeology Case-study drawn from the work of the Swedish Pompeii Project. Addison, A., Guidi, G., De Luca, L. and Pescarin, S. (eds.) Digital Heritage International Congress (pp. 621-628)

- Dellepiane M., Dell'Unto N., Callieri M., Lindgren S., Scopigno R., (2012) Archeological excavation monitoring using dense stereo matching techniques, Journal of Cultural Heritage.

- Doneus, M. & Neubauer, W. & Studnicka, N., (2003). Digital Recording of Stratigraphic Excavations. In: Proceedings of the XIXth International Symposium CIPA 2003 "New Perspectives to Save Cultural Heritage". The CIPA Int. Archives for Documentation of Cultural Heritage, Vol. XIX, 2003, pp. 451-456.

- Doneus, M. & Neubauer, W., (2004). Digital Recording of Stratigraphic Excavations. In: Ausserer, K.F. & Börner, W. & Goriany, M. & Karlhuber-Vöckl, L. (eds). Enter the Past. The E-way into the four Dimensions of Cultural Heritage. CAA 2003, Computer Applications and Quantitative Methods in Archaeology. BAR International Series 1227, Archaeopress, Oxford.

- Doneus, M. & Neubauer, W., (2005). Laser scanners for 3D documentation of stratigraphic excavations. In: International Workshop on Recording, Modeling and Visualization of Cultural Heritage, Ascona, May 22-27, Taylor&Francis 2005.

- Forte, M., Dell'Unto, N., Issavi, J., Onsurez, L. and Lercari, N. (2012). 3D Archaeology at Çatalhöyük. International Journal of Heritage in the Digital Era, 1 number 3 2012, 351-377.
- Hodder, I., (1999). The Archaeological Process: An Introduction. Wiley-Blackwell.
- Jensen, O. (2012). Histories of archaeological practices, The National Historical Museum Stockholm, Studies 20, Stockholm.
- Katsianis, M., S. Tsipidis, K. Kotsakis, and A. Kousoulakou, (2008). A 3D Digital Workflow for Archaeological Intra-site Research Using GIS. Journal of Archaeological Science 35(3): 655–667.
- Kockel, V., (2004). Towns and Tombs. Three Dimensional Documentation of Archaeological Sites in the Kingdom of Naples in the Late 18th and Early 19th Century, in: I. Bignamini (Hrsg.), Archives & Excavations, London 2004, 143-162.
- Larsson, L. 2007. The iron age ritual building at Uppåkra, southern Sweden, Antiquity 81, pp. 11-25.
- Losier, L.,M., Pouliot, J., and Fortin, M., (2007). 3D geometrical modeling of excavation units at the archaeological site of Tell 'Acharneh (Syria). Journal of Archaeological Science 34, (pp. 272-288)
- Opitz, R., &Nowlin, J. (2012). Photogrammetric modeling GIS. Better methods for working with mesh data. ArcUser. Resource document. http:// www.esri.com/news/ arcuser/ 0312/files/ archaeology- inventory.pdf. Accessed 20 March 2014.
- Verhoeven G., (2011). Taking computer vision aloft archaeological three- dimensional reconstruction from aerial photo-

graphs with photoscan, Archaeological prospection 18, (pp. 67-73).

- Verhoeven, G., Taelman, D., Vermeulen, F., (2012). Computer vision-based orthophoto mapping of complex archaeological sites: the ancient quarry of Pitaranha (Portugal-Spain). Archaeometry 54 (6), 1114–1129.
- Verhoeven, G.J., Doneus, M., Briese, C., Vermeulen, F., (2012). Mapping by matching: a computer vision-based approach to fast and accurate georeferencing of archaeological aerial photographs. Journal of Archaeological Science 39 (7), 2060–2070.
- Zubrow, E., (2006). Digital archaeology, an historical context, I Evans, T., and Daly, P., (edi.) Digital Archaeology: Bridging Method and Theory. Routledge Taylor & Francis, NY, USA

Websites

- http://www.catalhoyuk.com/
- http://www.londoncharter.org/
- http://www.pompejiprojektet.se/
- http://gabiiserver.adsroot.itcs.umich.edu/gabiigoesdigital/

DANCES WITH PETROGLYPHS

On Digital Agendas, Digital Tools and Heritage Communication

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Dances with Petroglyphs

The day I got into archaeology I never thought of the possibility of one day getting the chance to dance with petroglyphs. This possibility was recently, in 2013 and 2014, realised at a local Swedish museum in Simrishamn, in southern Sweden. Here you can swing and sway together with bird-like procession partakers in a funeral dance. The source material for this artistic interpretation, made by 3D artist and researcher Magali Ljungar-Chapelon, is the so-called King's grave from the Bronze Age in the nearby municipality of Kivik. It is an extraordinary experience to have the opportunity to take part in a procession like this. It is made possible by the use of motion-capture technology, which allows your own movements to be registered by a camera and transformed into an interactive screen. Your movements become part of an act, in this case a funeral procession to honour the dead individual/s that are to be buried in the Kivik tomb. You are given the opportunity to interact with a setting that interprets petroglyphs and their meaning based upon both the archaeological record and recent insights about body gestures. This

happening would probably not have been realised at a museum if this specific digitally based motion capture technique had not made the approach possible. But why do we find this technique in use at a cultural historical museum today?

A Digital Agenda

For a decade or so the discussion about digitization and its effects has intensified in different fields. Also at museums this digitization discussion is intense, and economic advantages are offered to those who decide to promote the development of new digitally based techniques by integrating them in documentation as well as display. Museums that already have technology on their agenda for display have had a general advantage, as technical museums, for example, that wish to convey technological achievements in recent years have been able to present these directly in their exhibitions for the sake of technology in itself. Technology in different settings is displayed for example at Norrköping Visualiseringscenter C, Sweden (www.visualiseringscenter.se). Shown here are applications of different techniques that can be used in scientific, technical, medical, architectural, social and community-planning sectors.

If, instead, you go to museums of cultural history or view presentations that deal with the distant past in archaeological historical settings, the use of digital technologies is not always obvious. Here the focus has been on exhibiting authentic remains of the past. In order to offer a further dimension with the aid of new technologies, some extra thought and innovation are required. There is no immediate point in replacing authentic objects with three-dimensional computer simulations if the purpose is not clearly to contribute to the revitalization of our understanding and/or experience of some kind.

Museums in a Digital Age

A few books and articles published during the last decade provide insight into the challenges that museums of today face when they take on digital technology for purposes of both preservation and public display. Such perspectives are represented by the books Theorizing Digital Cultural Heritage – A Critical Discourse (Cameron & Kenderdine 2007), Recoding the Museum (Parry, 2007) and Museums in a Digital Age (Parry, 2010). These books have the ambition both to try to explore the history of museum digitization and to go beyond the state of the art and look into the future. Because of the continuous and rapid development of technology, such books tend to become obsolete, but some fundamental issues remain relevant over time, such as how to relate to the use of technology in a (historical) museum context and how to relate to the concept of authenticity when original objects are digitized. The main concern when descriptions are made of the history of digitizing in museum contexts is most often that of documenting and preserving collections. In comparison very little discussion has focused on the use of digital tools in exhibitions for the cause of storytelling in public display. This has been left as an issue primarily of interest to those working with communication aspects (cf. Roussou, 2010).

Questions

My questions in this study in relation to the digitization process in museum display situations exemplified by the Petroglyphic exhibition in Simrishamn are the following:

- Who are the actors in digitization work relating to this specific local museum of Österlen, in southern Sweden?

- What are the aims of digital solutions at the museum?

- How are the chosen solutions used to enhance visitors' experience?

- Why have they chosen to apply these specific digital techniques?

- To what extent do the presentations in the exhibition rely on existing archaeological digital data/documentation?

At this stage I have not performed any analysis of the visitors' experience, since this has become secondary to the aim of my text. An on-going evaluation of visitors' experience is being conducted by Magali Ljungar-Chapelon, the creator of the idea of immersive procession interpretation through body movements at the museum (see Ljungar-Chapelon, 2008; forthcoming).

My overall aim in studying this specific exhibition in the light of digitization in society has been to analyse the impact of general digital agendas through the example of a local museum that has performed digitization of exhibitions with the aid of regional governmental funding.

The Concept of Digitization in a Museum Exhibition Context

How can the concept of "digitization" be defined in a museum exhibition context? Digital comes from the Latin "digit" which means "finger" or "toe". In a figurative sense, it is about how data are represented by numbers in a number system. In a computerized context this refers to how information is converted into computer language and then presented with new technology as images, text and sound. Digitization as a concept in this context therefore refers to computerized technology gaining ground in our daily life at work and in our leisure time. Digital tools both control and facilitate our lives today.

Museums have mainly worked with the digitization of collections that have been successively transferred into a digital format, i.e. traditional documentation in the form of texts, images and objects has been converted to digital format for use on PCs, and via websites on the Internet. Traditionally this kind of in-depth documentation information has been used in exhibitions as extended information accessible via computer screens.

There is a widespread view of digitization as a way of disseminating cultural heritage digitally regardless of the geographic location of the original (see for example the aims for the EU-funded Virtual Museum Transnational Network, V-Must, www.v-must.net). However, in the example of the King's grave in Kivik, we see geographical independence of the site but a dependence on the museum as a location, since digitizations carried out for exhibitions in museums are usually not made available through the Internet, as the museum space is needed for the performance.

Petroglyphic and its Contents

If we now return to Österlen Museum in southern Sweden to describe the setting and exhibition contents more thoroughly, the museum decided as early as 2011 to start working with the idea of an exhibition with digital tools and content. The final result was the exhibition called "Petroglyphic" that opened to the general public in May 2013. The exhibition is to be shown at the museum until the autumn of 2014, and the wish from the museum is that the exhibition could have a future life at a regional centre for rock carvings if there is the political will to work in this direction. This possibility is still hypothetical, since there is no definitive political support for these ideas yet.

The exhibition is located in a large room on the ground floor of the museum. With the aid of temporary partitions, this room has been divided into smaller parts. Within the room of the exhibition there is

a motion-capture room, touchscreens of different formats from iPads to a full table, and a room for experiencing stories relating to Bronze Age mythology with pictures and sounds. Every single station is digital in the sense that digital tools are used in each case.

Some of the technical solutions were created in collaboration with small IT companies, and the museum also collaborated with the Lund University Humanities Lab (www.humlab.lu.se).

At the very entrance of the exhibition the visitor encounters a probably rather well-known technique, the iPad displaying three different Bronze Age objects that are displayed in 3D format. The objects can be rotated and zoomed to check details more thoroughly (Fig. 1). The on-screen 3D solutions are a perfect example of how visitors can get closer to the objects and even touch them in a sense without damaging them, and it is also a technique that is in use at many museums nowadays to make collections more accessible through the individual museum's Internet site or via other collaborative sites for museums and their collections (see e.g. www.digitaltmuseum.se). But of course not every single object in a collection can be scanned in this way, so there is an explicit focus on displaying more elaborated or well-known and appreciated objects to start with.

In one of the experience rooms a procession in connection with a Bronze Age burial is portrayed. The technique in the exhibition is a motion-based experience. The visitor participates in the procession with the help of a technique that makes it possible to record movements and make the visitor's movements become part of the procession. The colour of the procession partaker shifts, so that the visitor can see if he or she moves in line or out of step with the rest of the procession. If you move together with the others' movements, the figure projected on the screen remains red, but if you move differently, the figure instead turns white (Fig. 2).

In another part of the exhibition, it is possible for visitors to create their own petroglyphs on a digital rock. Technically it is a kind of

Figure 1. The iPads with scanned 3D objects at the entrance of the exhibition. Photo: Jes Wienberg 2014.

Figure 2. Ingrid Wienberg showing how to act in the Bronze Age procession. Photo: Jes Wienberg 2014.

Figure 3. Asger and Ingrid Wienberg showing how temporary rock carvings are made. Photo: Jes Wienberg 2014.

digital screen with a coordinate system, where you create your own ”rock carvings” with designs you choose yourself. On an adjacent wall a number of works of art are hung that seem to be casts of existing petroglyphs. These casts can serve as inspiration for the visitors’ own rock carving attempts. After a short time the temporary screen carvings are erased, and it is possible to start over again (Fig. 3).

In a small room the visitors are given the opportunity to sit on chairs or on a large soft pad to view at a slideshow and hear the voice of a storyteller as the pictures shift. As you enter the room the slideshow begins, depicting the Bronze Age mythological world and a story about how the sun is brought around partly in the sky, partly down below the surface of the seas. The myth presented is an interpretation of Bronze Age mythology made in our time, but the

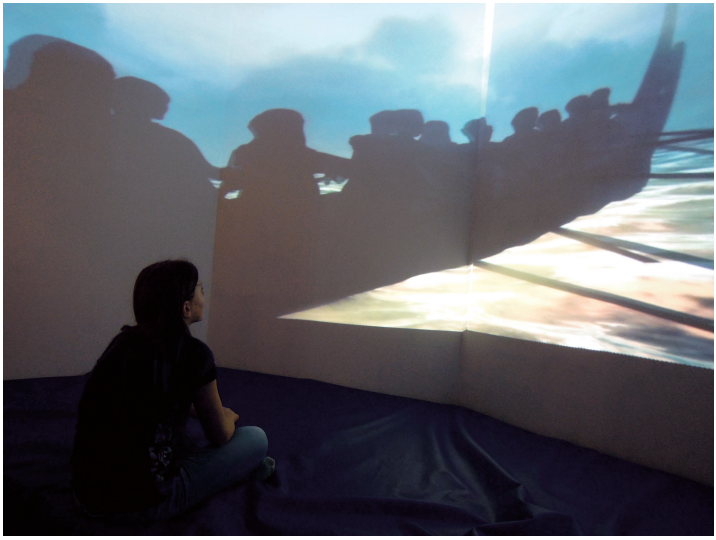

Figure 4. On the soft pad in the storytelling room. Photo: Jes Wienberg 2014.

way the story is told allows it to be perceived as credible, and it is also related to various authentic Bronze Age objects and interpretations made by archaeologists (Fig. 4) (Kaul 2004).

A generally informative station is present through a horizontal touchscreen table at a comfortable height for standing. Here the visitor finds facts behind various objects and themes relating to the Nordic Bronze Age. Here, the technique is not primarily a basis for experience, but rather a way to search for more in-depth information. The technology consists of a computer that provides search functions and more detailed information through the touchscreen (Fig. 5). It is also possible to use a QR code function to download the detailed information to a cell phone. Touchscreens might offer more intuitive

Figure 5. Museum curator Jeanette Gimmerstam showing the touch screen. Photo: Bodil Petersson 2013.

interaction with contents, but whether you prefer this or traditional computer solutions is probably a question of what you are used to.

To supplement and explain the different parts of the exhibition, textile prints are hanging on the walls with images and lyrics that present the background for interpretations made through the exhibition. There are also a few exhibition cases with selected items from the Bronze Age. These cases contain the relatively small number of authentic objects present in the current exhibition (Fig. 6).

The museum staff have produced a ”travel guide” leaflet entitled The Rock-carvers Guide to the Bronze Age (2013). This leaflet is the starting point of a journey in time to the Bronze Age, where shopping, accommodation, adventure and entertainment are described to the visitor.

Figure 6. Ingrid Wienberg checking out one of the exhibition cases. Photo: Jes Wienberg 2014.

Collaboration

The museum staff of antiquarians have been collaborating with both university researchers in the fields of artistic expression and archaeology, technically skilled university labs, IT engineers in small companies and professional storytellers. These collaboration partners are presented on a textile print in the exhibition.

Reflections on the Exhibition

In general the technical solutions in the exhibition at Österlen Museum are of two kinds: experience-based and factual. Probably this is a good strategy that provides the visitor with a varied experience. The technologies used are also good for different purposes, with some providing more detailed knowledge and others offering bodily experience.

The techniques used in the exhibition are described within the museum context with expressions such as ”projections”, ”full-body motion capture”, ”digital pen” and ”multi-touch screen” (www. simrishamn.se/ museum). These technical terms target the technically initiated visitor who already knows the names of devices. As a thought experiment, if one were to choose to go the other direction and instead describe what happens when you experience something, the description itself would probably be differently formulated, with a focus on the experience itself rather than the technology used. The focus on technology is probably an effect of the reason why the exhibition was created in the first place, as an investment in new techniques for the purpose of enhancing digitization in society.

Digital Tools in Exhibitions

New techniques are increasingly being adopted in exhibitions, alongside other modes of exhibiting. When did digital techniques start to be used in Swedish exhibitions, and how were they used initially?

Computer screens started to appear in exhibitions in the 1980s (ref.). Screens and keyboards offered the visitors an opportunity to find extended knowledge relating to the exhibited objects and themes. This way of using computers in exhibitions has been a common solution for a long time, but the technology does not in itself provide an enhanced experience of the exhibition but should instead be viewed as an extended opportunity to place further information within the exhibition context. These screens have then been used for displaying digitized material being displayed in the exhibition. Here a direct relationship can be seen between digitization for preservation and digitization for communication, and it becomes clear how these different aims have become more closely connected in recent years.

Another exponent of the use of new techniques in museum context is Per Stenborg's experiment with a time-travel exhibition at Lödöse museum in western Sweden. The aim was primarily to make the museum exhibition accessible in several ways by involving different senses. One experiment was a table where changes in landscape in a long-term perspective were shown in a tactile way so that they could be felt by touch. This was a way to experiment with enhancement of visitors' experience for people who have a need for complementary information, because of poor vision, for example. When the experiment was carried out, it also became obvious that all visitors found the tactile experience enriching (Stenborg 2012).

In our time, when the gaming industry has developed techniques for immersive experience in computer games of all kinds, the heritage sector has adapted and found immersive technologies useful in exhibition contexts. There is a general curiosity as to how immersion can be realised, but as yet there has been no explosion of such technology use in exhibitions. Instead, an emerging interest can be discerned, slightly increasing as immersive techniques become more widespread and therefore more affordable. Another important reason for the emerging interest in the heritage sector is that you also

can make contact with interested IT developers who are prepared to work within the sector but who usually do not have many financial resources at their disposal. One important reason why IT developers wish to work with heritage is probably the money available from authorities wanting to enhance technical development in general in society.

One upcoming event where digital tools are used in a historical exhibition is at the Mediterranean Museum (Medelhavsmuseet) in Stockholm, where they have made use of the so-called "digital autopsy table" for displaying in 3D one of the mummies belonging to the museum. Actually the digital autopsy table has been exhibited at the Visualiseringscenter C in Norrköping for some time now, inspiring culture historical museums and their staff to adopt the technology. This specific mummy display is made in collaboration with Visualiseringscenter C (www. varldskulturmuseerna.se/ medelhavsmuseet). Another example is at the Historical Museum in Stockholm, where an exhibition on the 1361 battle of Visby opened in March 2014 and contains a 3D display of wounds on bodies of those who took part in the battle. With the aid of motion-capture recording technology, they are able to show how wounds were caused on bodies. It is obvious that formerly expensive technologies are now cheaper, available and sufficiently well developed for use in culture history/ historical museums.

Superstructure: Digital Agendas in Europe and Sweden

The ambition to increase the use of digital tools in different social contexts is evident in society's general formulations and objectives regarding digital technology and its benefits. In recent years official and normative documents have been produced by committees at European, national and regional levels, where digitization facilities are described in positive terms. It is obvious that there is virtually

no part of society that can do without digitization, as it seems to remedy almost everything from segregation to exclusion and disability (European Council of Ministers in 2010; Cabinet Office 2011a). The agendas and their course from overall guidance at European and national levels to national, regional and local practices in museum exhibitions, for example, is made explicit in a study like this. Here I wish to elucidate some of the superstructures that seem to support activities such as these in the making of exhibitions of the Petroglyphic kind.

Digit@l Heritage, a National Strategy

The general nature of the official Swedish National Digital Agenda makes it necessary for various businesses, sectors and functions to create their own agendas and strategies, and for the cultural heritage sector a national governmental strategy called Digit@l Heritage (in Swedish: Digit@lt Kulturarv) was formulated, with the purpose of supporting the work of digitizing, digital preservation and digital availability of heritage material and heritage information. The strategy was formulated for the 2012–15 period (Regeringskansliet 2011b). It encompasses 23 local and regional governments and institutions engaged in the cultural heritage sector in Sweden, and these have been directed to plan for the work of digitizing and making available archives, collections and libraries. Some of the museums and antiquarian institutions that are on the list of 23 participants in this initiative are the Swedish National Historical Museums, the Swedish National Heritage Board, the Nordiska Museet Foundation and the Skansen Open-air Museum Foundation. All of these cultural heritage institutions are seen as covering nationally relevant perspectives, i.e. they are not regarded primarily as local or regional actors.

The objective of Digit@l Heritage is formulated as follows:

The goal of the strategy is that cultural activities, collections and archives are increasingly to be preserved digitally and made available electronically to the general public. All state institutions that collect, preserve and make available heritage material and heritage information must have a plan for digitization and accessibility. (Regeringskansliet 2011b, p. 4, author's translation)

The strategy goals to digitally preserve and make heritage available is not identical with the kind of digitization I examine in this article, namely, how digitization also affects exhibition presentations. I am therefore in a way going beyond the themes agreed in this governmental strategy, namely that heritage matters in general should be preserved and made accessible. My exploration here concerns how digitization also affects public presentations of cultural heritage such as exhibitions. Within this branch of digitization, the explicit focus is on artistic expression and innovation in relation to a digital culture that has increasingly been emphasized as the only sustainable way into the future.

A Regional Digital Agenda

When we go further down the lane and approach regional strategies, it is possible to find regional agendas as well. For example, in the year 2012 Region Skåne, the regional government of southern Sweden, began an investment in digitization in relation to culture. This investment encouraged regional and local culture developers to focus on the use of new techniques in their different areas of work (Region Skåne 2012; Region Skåne 2013). The initiative is still on-going. One of the areas of investment was the Petroglyphic exhibition. This regional initiative is a direct result of the Swedish National Digital Agenda. If a museum or cultural institution chooses to initiate digitization projects within the region, it is possible to be partly financed by the regional government. The example of Region Skåne is

just one of several examples in Sweden where regions are working with digital initiatives on a regional level as a consequence of general national and European agendas. The exhibition Petroglyphic at Österlen Museum in Skåne is only one of several projects that have received regional funding for digitization. This exhibition is a direct investment in a case study for enhanced use of digital techniques for the future. Funding from the region has also been allocated for an evaluation to be executed by Magali Ljungar-Chapelon.

In this way it is easy to see that European and national agendas have an effect on a regional and local level, but it is far from self-evident what form digitization will take when it is launched. It can comprise traditional accessibility efforts via databases. It can also be in the shape of innovative interpretation through digital storytelling. The initiatives at a regional and local level would probably never have been realised had there not been digital agendas paired with economic support available from regional authorities. Therefore a large part of the incentive for going digital is agendas and available funding. It also helps that special competence from IT engineers can be afforded and realised in collaborative form today.

Answers to Questions

Now it is time to return to the questions posed at the start of this text. By going through the analysis of the museum exhibition and asking questions to the staff, some facts have become apparent.

Who are the actors within digitization work at this specific local museum of Österlen, in southern Sweden? The actors at the museum are a mix of museum staff: antiquarians, pedagogical staff, technicians and receptionists, working together with artists and IT engineers and storytelling experts to create an exhibition with the ambition of both conveying knowledge about the Bronze Age and

creating immersive experience and discussions relating to contemporary issues.

What are the aims of using digital solutions at the museum? The aim is to fulfil the terms under which funding was provided by the regional government, namely to serve as a guide for upcoming initiatives of the same kind, showing how new technology can be used in innovative ways in connection with cultural heritage communication.

How are the chosen solutions used to enhance visitors' experience? Especially the motion-capture room with the funeral procession is an immersive experience partly based on archaeological facts, partly being a personal experience today. The storytelling room also has an immersive aspect, but the rest of the presentations are mainly factual.

Why have they chosen to apply these specific digital technologies? Primarily the choice is driven by economic factors, as funding for creating an exhibition was available for the digitization of culture. The availability of IT companies willing to work with cultural heritage matters is crucial. Contacts were established through cross-border work emanating from collaboration between the museum and Lund University technical education and research, where an infrastructure of contacts has been established in recent years.

To what extent do the presentations in the exhibition rely on existing archaeological digital data/documentation? It is clear that most of the data in the Petroglyphic case was produced for the exhibition itself. Some texts were extracted from existing material but the production largely relies on newly produced material. This is not to say that earlier recorded material is unnecessary

for putting together an exhibition, merely that the digital "infrastructure" in this case does not cover the whole process from examination of a specific site (the King's grave in this case) to its display at the museum.

Digitization as a Means for Conveying Knowledge, Experience and Artistic Experiment

The dreams of the heritage management society, including archaeologists, are global:

(...) very few projects should (...) be carried out in isolation, one specialized team working without the help or input from other disciplines. Digital heritage is indeed a transdisciplinary team endeavour that can only succeed through the meeting of minds and the sharing of ideas and research from around the world and across cultures." (Thwaites 2103, p. 344)

The general ambition, as can be read in this quote, is to be covering everything everywhere in a very global sense, and the hope is to be supported by the great database that is both global and transgenerational:

(...) the formalization of a digital heritage database, establishment of a global infrastructure, institutionalized archival standards for digital heritage and most importantly the on-going curation of work forward in time as the technology evolves so that our current digital heritage projects will not be lost to future generations. (Thwaites 2013, p. 344)

More than mirroring the actual capacity of the technology, these ambitions formulate the global ambitions in general of our time in relation to digitization as a phenomenon. It is not seen as good in

itself to be “local”, and a more general view on matters is therefore promoted. In the case of technology, the inherent value of digitization as a process is to be general in nature. But then the data input should also be “general” and possible to compare with other data sets across the globe. In relation to this generalising goal I am rather sceptical. The example of Petroglyphic shows instead how uniqueness and individuality are promoted and supported by technology, not in a general sense but in a very personal and non-generalising way.

Finally I would like to establish that the use of digital tools in museum exhibitions has the potential of renewing the experience and experimental tradition of museums in several ways. Even if we see a massive turn towards digitization in the whole of society, in some cases without really having the tools yet to use this matter in good ways, we can see through the example from Petroglyphic a renewal of museum communication when skilled specialists in the field of artistic interpretation and IT engineering are deliberately involved and collaborate with the museum staff. It may be that not all archaeologists or historians feel comfortable with freely made interpretations consciously directed towards ourselves in our time, but it is obvious that any interpretation made can both inspire new interpretations and provoke debate.

Object-centred or Story-centred Presentation?

An interesting circumstance that has become obvious is that of museum data and objects and their digital accessibility compared to that of digitization for digital storytelling. Both these endeavours, object accessibility and storytelling, are seen at museums today, but they represent two different tracks and attitudes within the area of digital heritage communication at museums. One is centred on objects, their preservation and authenticity, the other is concerned with the stories that can be told. Digital heritage might emanate from ma-

terial backgrounds, but it is also a process and a redefinition to tell stories filtered through our own cultural perception.

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References

Literature

- Cameron, Fiona & Sarah Kenderdine (eds.) (2007). Theorizing digital cultural heritage: a critical discourse. Cambridge, MA: MIT Press.

- Cameron, Fiona (2007). Beyond the Cult of the Replicant: Museums and Historical Digital Objects – Traditional Concerns, New Discourses. In: F. Cameron & S. Kenderdine (eds.) Theorizing digital cultural heritage: a critical discourse. Cambridge, MA: MIT Press, pp. 49–75.

- Ch'ng, Eugene, Vincent Gaffney & Henry Chapman (eds.) (2013). Visual Heritage in the Digital Age. London: Springer.

- Europeiska Ministerrådet (2010). Europeana Strategic Plan 2011 –2015.

- European Union (2010). Digital Agenda for Europe (DAE) 2010.

- Kaul, Flemming (2004). Bronzealderens religion: studier af den nordiske bronzealders ikonografi. Nordiske fortidsminder Serie B, 2. København: Det Kongelige Nordiske Oldskriftselskab.
- Ljungar-Chapelon, Magali (2008). Actor-Spectator in a Virtual Reality Arts Play. Towards new artistic experiences in between illusion and reality in immersive virtual environments. Göteborg: Univ.
- Ljungar-Chapelon, Magali (forthcoming). The Kivik Grave, Virtual bodies in ritual procession
- Towards new artistic experiences for time travellers. In Cornelius Holtorf & Bodil Petersson (eds.) The Archaeology of Time Travel. BAR International Series. Oxford: Archaeopress.
- Pescarin, Sofia, Alfonsina Pagnano, Mattias Wallergård, Wim Hupperetz & Christie Ray (2012). Evaluating Virtual Museums: Archaeovirtual case study. CAA 2012 Proceedings of the 40th Conference in Computer Applications and Quantitative Methods in Archaeology, Sout hampton, United Kingdom, 26–30 March 2012.
- Parry, Ross (2007). Recoding the museum. Digital heritage and the technologies of change. London: Routledge.
- Parry, Ross (ed.) (2010). Museums in a Digital Age. Leicester readers in museum studies. London/New York: Routledge.
- Regeringskansliet (2011a). IT i människans tjänst – en digital agenda för Sverige. Stockholm: Näringsdepartementet.
- Region Skåne (2012). Strategi för digital kultur. Kulturmämnden.

- Region Skåne (2013). Handlingsplan för digital kultur 2013–2015. Kulturnämnden.
- Roussou, Maria (2010). Interactivity and collaboration: new forms of participation in museums, galleries and science centres. In: Ross Parry (ed.) Museums in a Digital Age. Leicester readers in museum studies. London/New York: Routledge.
- Stenborg, Per (2012). Digitala tidsresor: Nya strategier för arkeologin och kulturmiljövården? Gotarc Serie D Nr 105. Institutionen för Historiska Studier, Göteborgs universitet.
- The Rock-carvers guide to the Bronze Age 2013. Museum leaflet.
- Thwaites, Harold (2013). Digital Heritage: What Happens When We Digitize Everything? In: Ch'ng et al. (eds.) 2013. Visual Heritage in the Digital Age. London: Springer.
- Internet sources
- DigitaltMuseum. www.digitaltmuseum.se; www.digitaltmuseum.no Accessed January 24, 2014
- Lund University Humanities Lab. www.humlab.lu.se Accessed March 21, 2014
- Medelhavsmuseet. www.varldskulturmuseerna.se/medelhavsmuseet Accessed March 17, 2014
- Virtual Museums transnational Network (V-MusT). http://www.v-must.net Accessed January 27, 2014
- Visualiseringscenter C www.visualiseringscenter.se Accessed January 13, 2014.
- Österlens museum. www.simrishamn.se/museum Accessed January 13, 2014.

Verbal information

- Interview with Lena Alebo, Österlen Museum, December 9, 2013.
- Interview with Jeanette Gimmerstam, Österlen Museum, December 9, 2013.

THE DIGITAL TIME-TRAVELS PROJECT IN RETROSPECT

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Introduction

"Digital Time-Travels: New Strategies for Archaeologists and Cultural Heritage Management" (http://www.time-travels.org) was an interdisciplinary research and development project aiming at developing, testing and evaluating digital and computer-aided forms of mediation and communication of cultural heritage information (Stenborg et al. 2009, 2010a, 2010b; Thuvander et al. 2008). The project was funded by the Swedish National Heritage board and was organized as a joint venture between the Department of Historical Studies at the University of Gothenburg, the Department of Architecture at Chalmers University of Technology and the Department of Soil Sciences at the Swedish University of Agricultural Sciences. This project explored possibilities of combining different kind of presentation techniques addressing the question of accessibility. Emphasis was placed on exploring options to use digital data and technologies for combining visual, auditory and tactile forms of presentation. The main mediation and communication work took place in a museum environment and was designed as an exhibition. In addition to the general museum audience the mediation and communication had two particular two specific target groups: schoolchildren and

visually impaired museum visitors. Parts of the exhibition content were also used for mediation in school environment. Feedback was collected from different groups of users and the evaluation included educational, scientific and public perspectives.

The exhibition

The exhibition "The River Journey" ("Älvresan") was designed to function as a complement to Lödöse Museum's permanent exhibition ("Bilder av våra förfäder") on historical and archaeological research in the region of the Göta river valley in West Sweden. The construction phase was carried out in collaboration with the museum pedagogues and the representative of the Swedish Association of the Visually Impaired.

A combined audio-visual and tactile model of the valley region was designed and used in the exhibition to describe and explain the natural and cultural landscape development from the end of the last Ice Age (c. 12,500 B.P.) to the present (Figure 1). The model was based on data from various sources: basic information included a digital elevation model (DEM) for Western Sweden, datasets generated by a mathematical algorithm for land rise and shoreline displacement in West Sweden (Klingberg et al., 2006; Påsse, 2003; Påsse & Andersson, 2005) and excerpts from the Swedish National Record of Sites and Monuments (FMIS). In order to help visually impaired visitors to access the information the visual representation was combined with auditory and tactile forms of presentation. An animation of the landscape development was projected onto a three-dimensional model which served as the projection screen. The physical model was based on the same geodata as the animation itself, and the shoreline displacement process (hence the temporal dimension) was integrated with the physical model by giving land surfaces of different ages different surface structures (glossy, rasterized, roughened, etc.). Braille was used to convey site names and

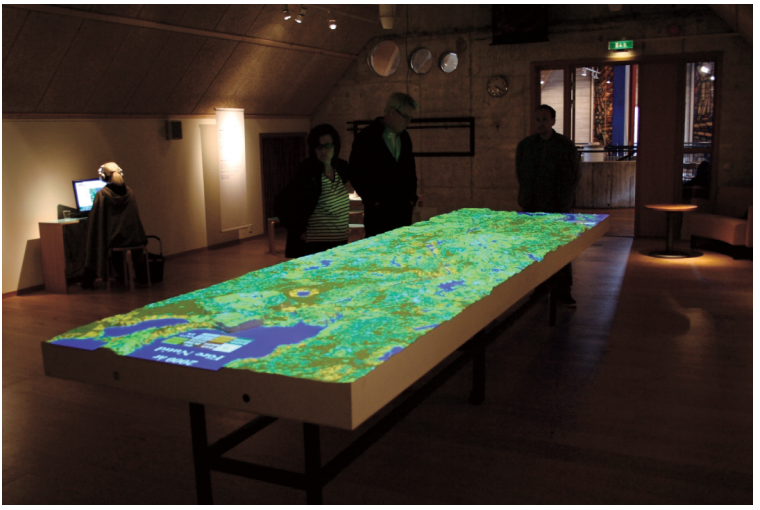

Figure 1. A combined audio-visual and tactile model of the valley region.

other information tactilely. The animation was synchronized with a soundtrack which described and supplemented the visual presentation.

The landscape model demonstrated how the Scandinavian landscape development since the last Ice Age is the result of the shoreline displacement process. Shoreline displacement is, in turn, the product of the combination of a relatively rapid uplift (isostasi) and a (slower) rise in sea level (eustasi). The land had been depressed by the ice masses during the last Ice Age. As the ice melted away a land uplift process began, and still continues today. "Regression" implies a process where new land rises above the sea and the marine shoreline retreats. During the period from 9,000 to 6,000 years ago the shoreline withdrawal stagnated. This was linked to a climate change towards warmer climate that gave rise to the rapid melting of glaciers fur-

ther north (eustasis exceeded temporarily isostasis). The sea level therefore temporarily increased at a faster rate than that of the land uplift. This phenomenon is called ”transgression” (unlike the aforementioned ”regression”). Transgression was of great importance in for example the Gothenburg area where the sea rose from 15 meters above the present level up to about 25 meters above today's level (the postglacial maximum), and then – from the about 6,000 years ago until today the shoreline begun to withdraw again (regression) (cf. Klingberg et al. 2006). In this perspective, therefore, a future increase in the mean level of the surface of the sea may lead to new episodes of transgressions in Sweden. The speed of the land uplift varies across different areas; hence, regression may continue in one area, while another area is experiencing transgression.

In addition to the landscape model the exhibition included two touchscreen-controlled stations where the visitors could look for information on sites (Figure 2) and artefacts and digital and physical models of the Vittene gold objects (Figure 3). The models of the gold objects were created from 3D scans of the artefacts, which are kept in safe custody at the Museum of National Antiquities in Stockholm.

Methods

TGIS

The models of landscape development were primarily based on Temporal GIS. In a geographic information system (GIS), data are stored thematically, i.e. the spatial objects are separated based on categories of thematic layers. Both spatial relationships and properties (attributes) of objects in GIS databases may be analysed, which has made GIS widely used in many areas of societal management and business development. The information in a GIS, unlike the information on traditional paper maps, can be continuously updated and

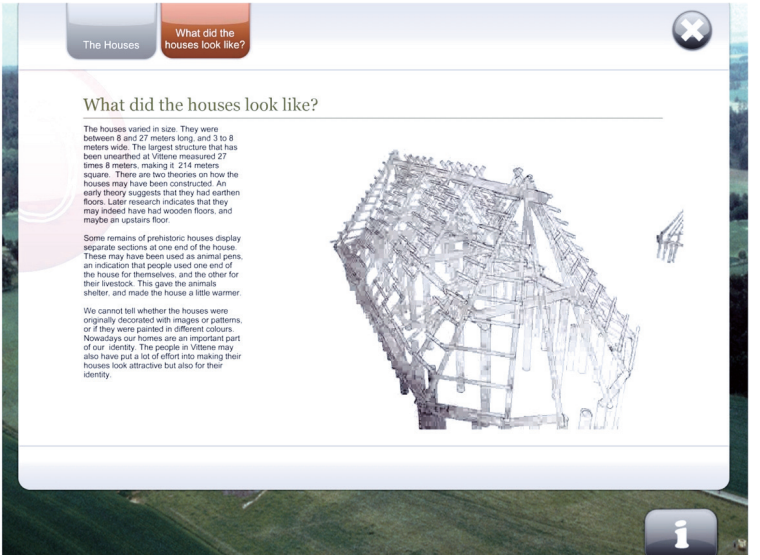

Figure 2. Touchscreen-controlled stations where the visitors could look for information on sites.

Figure 3. Digital and physical models of the Vittene gold objects.

upgraded, but the ”traditional GIS” usually reflects the conditions at a given point in time.

The temporal dimension must somehow be integrated into the GIS to allow for visualization of processes of change. This can be done in several ways, but one common solution is to add attributes to one or more fields that describe the period for which information on the location, topology etc. is valid (this can be called “temporal data”). A GIS that can handle the dimension of time, e.g. “time depth” can be referred to as Temporal GIS (TGIS, see Christakos et al. 2002), Spatiotemporal GIS, and Time-integrative GIS (see Ott and Swiaczny 2001). In the same manner as TGIS can be distinguished from what can be called ”traditional GIS”, it may be useful to distinguish between visualizations based on TGIS and GIS, respectively. Processes and change over time can be described as a model of spatiotemporal conditions, while the visualization based on traditional GIS data is normally designed to illustrate the spatial relationships of various types of objects at a given point in time (cf. Ott and Swiaczny 2001).

As the landscape in reality is in constant transformation, it is desirable from a societal protection and emergency point of view to include this variability in the assessment of future risks.

Application of spatiotemporal analysis for simulation, prediction and planning of landscape and environmental development has been examined in Europe and the US, for example by Börjeson et al. (2006), Schrot et al. (2009). In Sweden, the official investigation of the threat of climate change (Klimat- och sårbarhetsutredningen, 2006; 2007), to some extent made use of TGIS technology to provide data for the report.

An interactive interface

An interactive, touchscreen-based interface was developed for presenting information on particular areas and archaeological sites within

the region dealt with in the exhibition. The spatial extension of the start view on the touchscreen was the same as that of the landscape model. In this case, however, the user could move a pointer along a time axis to see the relationship between land and sea at a particular time. By pointing at one of the sites marked by floating icons on the map, the view switched to that of the site area and the user could then choose to search for various kinds of information about the selected area.

Digital models of artefacts as a basis for physical reproduction

3D scanning techniques were used in creating digital models of gold artefacts. Subsequently the digital models have been used as the basis for creating physical copies of the original artefacts.

Results

The evaluation of this pilot exhibition was designed to take into account both the visitors' declared views on the exhibition as their actual use of the exhibition area and its "stations". Visitors' feedback was collected through a questionnaire (in Swedish and English) where the respondents not only were asked to rate the exhibition's capacity of conveying cultural and natural heritage information, but also had to consider how future digital exhibitions should be designed. Feedback was also collected from museum staff, representatives of the visually impaired, the project-group members, and through an external study of the possibilities of using parts of the exhibition contents in secondary education (Andersson 2010).

The results of the survey showed that the majority (71%) of the visitors felt that the exhibition had given them a better understanding of the history of the Göta River Region and that the exhibition format offered new perspectives on time and space.

Some components of the exhibition, such as the "narrator's voice" and the possibility of investigating objects and landscape models with your hands, were primarily intended as an aid for visually impaired museum visitors in their perception of the exhibition. Interestingly, a great majority of the sighted museum visitors (86%) indicated that these components enhanced their experience of the exhibition.

Conclusions and a discussion of the possibilities to use the results in future work

In the case study used in the Digital Time Travels project the audience of the exhibition was quite easily definable as the museum visitors of the Lödöse Museum and followed the museum's focus on specific groups (visually impaired visitors and schoolchildren). As the museum (and exhibition) was physically situated inside the region that the exhibition dealt with, the geographical frame did not have to be specially defined or established and also corresponded to that of other exhibitions at the museum. The temporal extent of the information in the exhibition was decided to cover the time from the end of the last Ice Age up to what was then the present (c. 12,500 B.P. – 5 B.P.), followed the geological perception of the date when the region became free of ice.

Principally, then, the River Journey exhibition was designed to meet the interest of a regional audience and was restricted concerning its spatial and temporal scope. The methods of presenting information that were used for the exhibition, however, were developed with the intention that they should be applicable in other contexts, at other scales and for other audiences. As described above, the project used a variety of techniques in creating the digitally based exhibition "The River Journey". Assessments of the usefulness of the methods used in the exhibition in other contexts and for other purposes therefore vary between the different methods.

The methods for the visual simulation of environmental and landscape changes over time are undoubtedly applicable in numerous other historical cases. Lack of positive and detailed data on the shoreline position, vegetation distribution etc. concerning many parts of the region enforced considerable generalization and rendered the TGIS model a simulation, rather than a reconstruction. As with any simulation, the output depends on the input. This also implies that – methodologically – the same TGIS techniques could be used to analyse and visualize different future scenarios based on – for example – different estimates of climate developments. A future rise in average temperature would lead to increased melting of glaciers and a rise in sea levels (as happened in West Sweden during the period between 9,000 and 6,000 B.P according to our exhibited model). Future shoreline displacements will also depend upon changes in both sea level and land elevation, so such simulations should be valuable as tools in environmental and climate work in order to assess the implications of different possible future developments, and in identifying particularly vulnerable environments and areas as well.

The uses of tactile and audial forms of presentation proved to not only serve as support for visually impaired museum visitors – but also to enrich the experiences of fully sighted visitors. This then suggest that efforts to improve the accessibility of information for particular groups may be designed in ways that are also appreciated by the public in general. By developing innovative ways of presentation intended for different human senses – as was the case with the multimodal landscape model in our exhibition, it is possible to address audiences with varying capacities for assimilating what is presented. Such an approach may be termed "inclusive" and it has several advantages compared with solutions involving the creation of several parallel exhibitions targeting different groups. Nevertheless, exhibits specially designed for particular groups naturally offer spe-

cial pedagogical opportunities beyond those that can be incorporated in a multimodal model, so they are still preferable in certain contexts.

The interactive, touchscreen-based, interface could be used as part of other exhibitions (with other content), or in school environments and the like. Work on an online version of the interface was initiated within the Digital Time Travels project but owing to time constraints could not be finished. A transfer of the interface to an online version would make it useful for a much larger number of cases – but would also place new demands on the interface, as it would have to function in an environment outside an exhibition or a curriculum. A graphic interface could be used as a tool for an audience to get access to information about materials that are not physically located in the same place but which share a common provenance. This would be particularly useful in cases where a region's cultural heritage is scattered among museums in various parts of the world.

The initial work will survey previous and on-going attempts to use digital resources to reconnect scattered heritages. It will also address issues of ownership of cultural heritage, access to and use of cultural heritage, as well as the various interest groups that can be identified with regard to cultural heritage.

References

- Börjeson, L, M Höjer, K-I Dreborg, T Ekvall, G Finnveden 2006. Scenario types and techniques: Towards a user's guide. Futures 38 (7), 723-739
- Christakos, George, Patrik Bogaert och Marc L. Serra 2002 Temporal Geographical Information Systems: Advanced Functions for Field-Based Applications. Springer, Heidelberg.
- Klingberg, F., Påsse, T. and Levander, J., 2006. Bottenförhållanden och Geologisk Utveckling i Göta älv. Sveriges Geologiska Undersökning, K43, Sweden.

- Ott, Thomas och Frank Swiaczny 2001 Time-Integrative Geographic Information Systems: Management and Analysis of Spatio-Temporal Data. Springer, Berlin.

- Påsse, Tore 2003 Strandlinjeförskjutning i norra Bohuslän under Holocen. In Strandlinjer och Vegetationshistoria, ed. by Persson, P., GOTARC Series C., No 48, pp. 31–88.

- Schroth, Olaf, Ellen Pond, Sara Muir-Owen, Cam Campbell och Stephen Sheppard 2009. Tools for the Understanding of Spatio-temporal climate scenarios in local planning: Kimberley (BC) case study. SNSF Report PBEZP1-122976.

- Påsse, T. and Andresson, L., 2005. Shore-level displacement in Fennoscandia calculated from empirical data. GFF, vol 127, pp. 253–268.

- Statens Offentliga Utredningar 2007 Klimat- och sårbarhetsutredningen. Slutbetänkande. SOU 2007:60. Stockholm.

- Statens Offentliga Utredningar 2006 Översvämningshot: Risker och åtgärder för Mälaren, Hjälmaren och Vänern. Delbetänkande av Klimat- och sårbarhetsutredningen. SOU 2006:94. Stockholm.

- Stenborg, Per, Chris Sevara, Jonas Tornberg, Johan Ling, Mats Söderström, Liane Thuvander 2010a On the line between Fact and Fiction: Tools and procedures for digital mediation in Cultural Heritage Management. In COMMUNICATE THE PAST: Ways to present archaeology to the public. Proceedings from the European Association of Archaeologists (EAA) 14th Annual Meeting, Valletta, Malta 16th to 21th September 2008, red Anna Arnberg och Tove Stjärna, s. 87-98. Kulturmiljövård i Mälardalen Skrifter 2. ISBN: 9789174530063b

- Stenborg, Per, Jonas Tornberg, Johan Ling, Mats Söderström, Chris Sevara, Liane Thuvander 2010b Piloting Time-Tours: Experiences from the Development and Implementation of a Computer Based Exhibition in West Sweden. In Fusion of Cultures: Abstracts from the XXXVIII Annual Conference on Computer Applications and Quantitative Methods in Archaeology, CAA2010, red. F. Javier Melero, Pedro Cano, Jorge Revelles, s. 115-118. ISBN: 978 8469 30 7724.

- Stenborg, Per, Jonas Tornberg, Johan Ling, Mats Söderström, Liane Thuvander, Chris Sevara 2009 Digital Time-Travels: Communicating Historical GIS and TGIS-Information in Museum Environments. In GIS in the Humanities and Social Sciences International Conference — Innovating — Collaborating — Sharing. Proceedings, 365–380. Academia Sinica, Taipei.

- Thuvander, L. P. Stenborg, J. Ling, C. Sevara , M. Söderström och J. Tornberg. 2008. From the ice age to the present – an audiovisual and tactile model of the Göta River Valley in Western Sweden. In Digital Heritage: Proceedings of the 14th International Conference on Virtual Systems and Multimedia, red. M .Ioannides, A. Addisin, A. Georgopoulos, L. Kalisperis, 146–151. Archaeolingua. ISBN: 978-963-9911-01-7

EPILOGUE

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It is impossible to single out the single most significant implication of the digitisation of archaeological work and information flow. All of the chapters in this volume show that one of the keywords is change, change that permeates different stages of creating, recreating, organising and using archaeological data and information. This change is not always a direct consequence of digitisation or the availability of technologies. There are more ingredients to consider. At the same time, however, the digital tools are true game changers in the way they catalyse various wants, likes and needs of archaeologists.

As Huvila shows, digital publishing and the availability of data and literature is changing the ways in which archaeologists use and find information. Dell'Unto and Löwenborg show further how digital tools and the proliferation of born-digital and digitised information open new opportunities to conduct archaeological research and seek answers to archaeological research questions from new perspectives and indeed, to change the questions altogether. It is no coincidence that Dell'Unto writes about 3D technologies and visualisations and Löwenborg about GIS and data. Without downplaying the significance of digital tools for the entire spectrum of archaeological research questions and approaches, these two broad and par-

tially overlapping areas of interest have perhaps been the most successful ones to capture the imagination of digital archaeologists. In the final two chapters of this volume, Petersson and Stenborg discuss how the digital information and interestingly enough, visualisation and GIS-based tools have influenced the presentation of archaeology in museums. The capability to put together data and to see and experience aspects of the past is just as useful for a professional archaeologists as it is for the general public.

In addition to hinting at the magnitude of change in opportunities and the daily practice of archaeology, the texts point to an explicit need for critical reflection on the consequences of the technological choices. Technology allows researchers and practitioners to do things, but at the same time, it is problematic if large aggregate data sets contain only part of the original information. Similarly, while the use of digital information sources may allow archaeologists to do certain things, but it can also marginalise the use of highly relevant non-digital materials. Further, even if the visualisation of archaeological sites and processes is undoubtedly an asset for both professionals and museum visitors, critical reflection on that what is being observed and why is a necessary part of the process. If the visual story emanates from a political agenda based on the intrinsic value of technology or an uncritical admiration of spectacular visually attractive images, the outcome might quite different from the positive aspirations expressed by the authors of this volume and those expressed in the literature.

Finally, the texts in this volume show a tendency that archaeology is becoming more and more embedded in our contemporary political and societal processes. Archaeology has always been part of society, but it seems fair to say that the connection is becoming more multi-faceted and complex than before. The role of the public and the society is an increasingly central premise of archaeological work. In Sweden, the vast majority of archaeological documentation is pro-

duced in the context of rescue archaeology. In spite of the relative freedom of academic research, the political climate of the society has an influence on what is being studied and what kinds of projects receive funding. Further, the presentation of archaeology and the role of the archaeologist as a mediator are affected by the same societal context. The increasing significance of storytelling and hands-on experiences as a part of public archaeology is bringing contemporary culture and archaeological scholarship closer to each other. There is a need to be critical of these influences and to understand the implications of these developments, but at the same time, as this volume shows, the digital society can also be seen as a potentially positive frame of reference that offers opportunities for increasing the understanding of the past, producing and using better archaeological information and conducting better archaeological research.